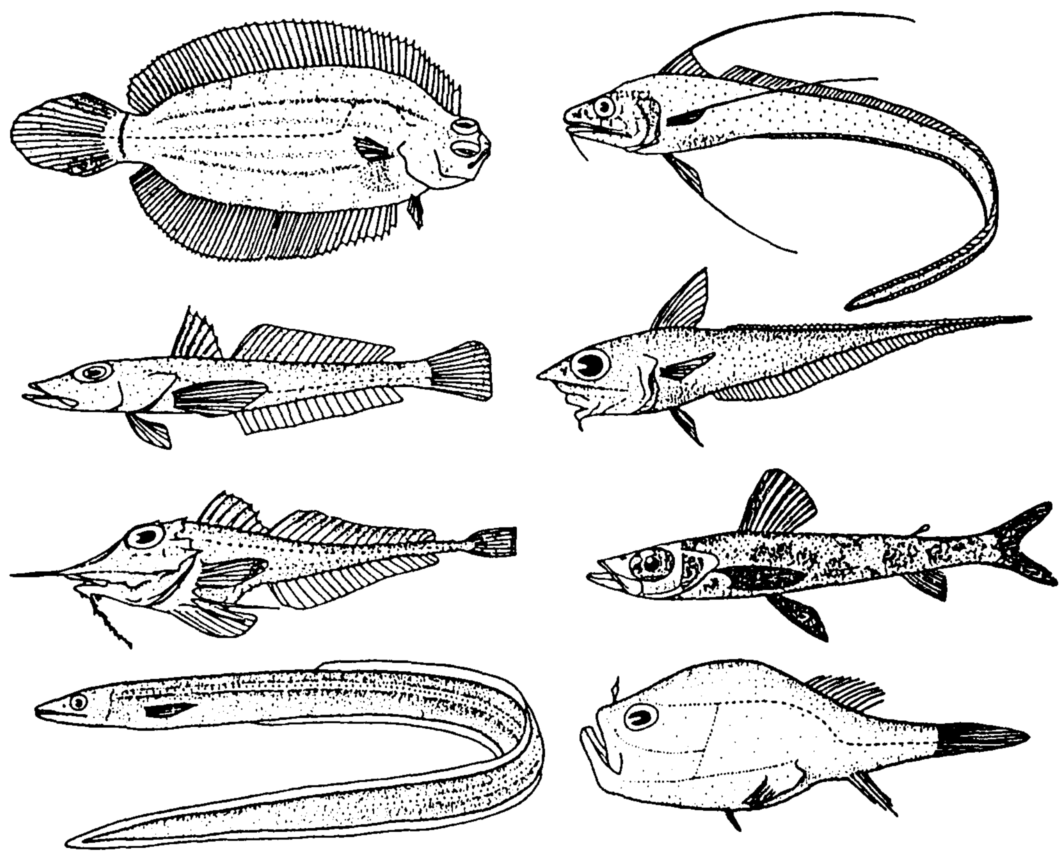
Gulf of Mexico OCS Region

OCS Study
MMS 88-0035

Proceedings: Eighth Annual Gulf of Mexico Information Transfer Meeting

December 1987



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Poecilopsetta beani	*Gadomus longifilis*
Bembrops gobioides	*Coelorinchus coelorhynchus*
Peristedion grayae	*Chloropthalmus agassizi*
Synaphrobranchus oregoni	*Chaunax pictus*

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PREFACE

This Proceedings volume presents summaries of the presentations and discussions of the Eighth Annual Information Transfer Meeting (ITM) held on December 1-3, 1987, in New Orleans, Louisiana. These ITMs are sponsored by the Minerals Management Service (MMS), Gulf of Mexico Regional OCS Office, to foster fruitful exchanges of information among federal and state agencies, the petroleum industry, academia, and the interested public at large. This volume includes session overviews by the respective session chairpersons, each of which is followed by short accounts of presentations by the authors.

A "Proceedings Overview" volume (OCS Study MMS 88-0027) was released by MMS in July, 1988. That short volume included only the session overviews and was a summary document for those requiring less technical detail than appears here.

The Minerals Management Service wishes to thank all ITM participants: the MMS staff responsible for planning and conducting the meeting; the invited speakers who have given their time and energies to share information with all attendees; and to the staffs of Geo-Marine, Inc., the University of Southern Mississippi's Department of Conferences and Workshops, and the Doubletree Hotel, who have provided excellent logistical support for the meeting. The Minerals Management Service also thanks Geo-Marine, Inc. and the Economic Development Council and its Petroleum Committee of the Chamber of Commerce/New Orleans and River Parishes, who each provided attendees with an enjoyable reception.

The Minerals Management Service invites comment and constructive criticism on the annual Information Transfer Meetings and the resulting Proceedings documents.

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OPENING PLENARY SESSION

Session: OPENING PLENARY SESSION

Co-Chairs: Dr. Richard Defenbaugh
Mr. Ruben G. Garza

Date: December 1, 1987

Presentation Title	Author/Affiliation
Session Welcome, Introductions, and Announcements	Dr. Richard Defenbaugh Minerals Management Service Gulf of Mexico OCS Region
Environmental Research: How Much Is Enough?	Dr. Robert J. Livingston Florida State University Center for Aquatic Research and Resource Management
Environmental Risk Research: How Much is Enough?	Dr. John Cairns, Jr. Virginia Polytechnic Institute and State University University Center for Environmental and Hazardous Materials Studies

Opening Plenary Session Overview

Dr. Richard Defenbaugh
Minerals Management Service
Gulf of Mexico OCS Region

The primary purposes of the Opening Plenary Session are to welcome attendees to the Information Transfer Meeting (ITM) and to initiate the meeting with one or two major presentations that are of interest to a broad cross-section of meeting attendees and are pertinent to the interests of the Minerals Management Service's (MMS) Gulf of Mexico Outer Continental Shelf (OCS) Regional Office.

The ITM was called to order by Mr. Garza, who welcomed attendees, introduced the staff responsible for meeting logistical support, made appropriate housekeeping announcements, and introduced Dr. Defenbaugh, who discussed the purposes and functions of the ITM and introduced subsequent speakers.

The primary purposes of the ITM are to provide a forum for "scoping" topics of current interest or concern relative to environmental assessments or studies in support of offshore oil and gas activities in the Gulf of Mexico OCS Region; to present the accomplishments of the MMS Environmental Studies Program for the Gulf of Mexico, and of other MMS research programs or study projects; to foster an exchange of information of regional interest among scientists, staff members, and decisionmakers from MMS, other Federal or State governmental agencies, regionally important industries, and academia; and to encourage opportunities for attendees to meet and develop or nurture professional acquaintances and peer contacts.

The ITM agenda is planned and coordinated each year by the MMS Gulf of Mexico OCS Regional Office staff around the three themes mentioned above--issues of current interest to the Region or the MMS oil and gas program, accomplishments of the agency, and regional information exchange. All presentations are invited, through personal contacts between session chairpersons and the speakers, and meeting support funding is provided through the MMS Environmental Studies Program. All meeting logistical support is provided by a contractor (Geo-Marine, Inc.) and subcontractors selected through the usual Federal procurement process. A proceedings volume is prepared for each ITM, based on abstracts of brief technical papers submitted by each speaker and on session overviews prepared by each session chairperson.

Mr. Pearcy, Regional Director of the MMS Gulf of Mexico OCS Region, formally welcomed the audience on behalf of the MMS and extended special welcomes to members of the MMS Director's "Take Pride Gulf Wide" Task Force (a group concerned about marine and littoral debris) and of the Gulf of Mexico Regional Technical Working Group (a committee of the MMS OCS Advisory Board) holding meetings concurrently with the ITM. Mr. Pearcy commented briefly on the scope and nature of ITM sessions and presentations and on the utility of the ITM in sharing information on current issues of concern to MMS.

Our two Plenary Speakers were Dr. Robert Livingston and Dr. John Cairns, Jr., who spoke on the themes of "How much environmental research is enough?" and "How much environmental risk research is enough?", respectively. These themes were selected because the trend for the MMS Environmental Studies Program for the Gulf of Mexico is clearly shifting away from descriptive studies to studies of assessment and prediction of the impacts of offshore oil and gas activities, including chronic and toxicological effects and to long-term monitoring of both natural sites and sites of OCS development. Banes of previous research have included wide-ranging natural variability and inconclusive or unconvincing results. Dr. Livingston has conducted long-term (>20 years) environmental studies focused on understanding natural variability of coastal study sites in the northeastern Gulf of Mexico, and Dr. Cairns has conducted extensive research on marine and aquatic ecology, toxicology, and hazard assessment.

Dr. Livingston pointed out that the answer to the question "How much environmental research is enough?" depends on the specific question at hand, but involves hypothesis testing using an appropriate, well-managed database.

Marine ecology is a young science, still in its early, descriptive phase. Our understanding of how marine ecosystems work is still poor and is impeded by the scale of natural variability of populations of marine organisms and by variability and interactions of subsystems of a marine ecosystem.

Dr. Livingston advised that key points include scaling of the research effort appropriate to the resource under study for protection or understanding; identification of "key" environmental factors; planning appropriate field monitoring studies; quantification of sampling techniques to be used in field studies; and analysis of data supported by an effective data processing system and aimed at modeling for predictive purposes.

To illustrate these points, Dr. Livingston presented data from his studies of Choctawhatchee Bay, where various communities reflected influences of environmental factors (salinity, habitat type, severe storms, etc.) or interactions with each other. Especially interesting were points made by Dr. Livingston of "guild organization" of organisms, and of use of microcosms to link field and laboratory studies.

Biologic guilds identified by Dr. Livingston and his co-workers were characterized by feeding mode, by trophic level, by reproductive mode, by locomotive means, and by body form. It was observed in the ecosystem under study that particular species of organisms might appear or disappear, but that each guild was always represented. Also, that some species (pinfish were presented as an example) progress through various habitat niches and biologic guilds throughout their life cycles, providing a continuum of guild associations over time and space in which various life stages coexist rather than compete.

Dr. Livingston presented a very interesting series of slides, which addressed the question of sampling frequency and timing. Using an extensive database of weekly sampling at study sites, data subsets were graphed to see how well monthly sampling represented environmental trends observed in the entire database. Also, a database of monthly sampling was examined to see how quarterly sampling, initiated during January, then February, then March, represented trends observed in the complete database. In some cases, the data subsets represented the full data sets well; in other cases, major environmental trends or events were "lost." Interestingly, the three quarterly subsets of monthly data showed major differences when compared to each other.

Dr. Livingston closed his talk with remarks on his use of microcosms (small to large artificial ecosystems, representative of natural ecosystems) based on biologic guilds, which have shown good potential for studies aimed at predictive environmental assessments.

Dr. Cairns focused on the theme of "How much environmental risk research is enough?" He began his presentation with a figure that related hazard identification, hazard assessment, and hazard control. And he stated that "enough" information is needed to define uncertainty for informed decisions about risk, considering the known or expected concentration of a pollutant in the environment, and the concentration at which adverse biological effects are observed.

The amount of information needed for decisionmaking varies, depending on (1) relative concentrations of a pollutant in the environment and the concentration at which adverse biological effects occur; and (2) on the social benefit derived by allowing pollutant occurrence, as compared to the environmental consequences.

Dr. Cairns described phases of hazard evaluation: (1) screening toxicity tests, (2) predictive toxicity tests, (3) confirmative or validating toxicity tests, and (4) monitoring. Validation that considers "real world" conditions, as contrasted to laboratory test conditions, is of paramount importance. Primary data, developed by laboratory testing procedures, must by validated in a natural system or a test system with a high degree of "environmental realism." Mesocosms of various designs can provide appropriate realism.

Plenary Session attendees learned from Drs. Livingston and Cairns that the remark of one scientific quipster that "There's never enough data" is not always true. The questions that may be answered will depend on the nature of data at hand, on the means for analyzing those data, and on the nature of the decision to be made. Prudent research design must ponder the eventual application of results to assure that appropriate data are gathered.

Dr. Richard Defenbaugh is Chief of the Environmental Studies Section of the MMS Gulf of Mexico OCS Regional Office. His graduate work at Texas A&M University led to a M.S. in 1970 and a Ph.D. in 1976. He has been involved with the MMS/BLM environmental studies and assessment programs since 1975.

Environmental Research: How Much is Enough?

Dr. Robert J. Livingston
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Center for Aquatic Research
and Resource Management

INTRODUCTION

The actual answer to the question of the title of this paper is relatively simple: enough to answer the questions. The real problem, and the reason why there is so much discussion concerning the development of an adequate research program, is that the question is rarely enunciated in a clear fashion. Even worse, the answer (e.g., the research results) is often totally out of scale with respect to the original question. While this situation can be applied to a broad variety of environmental research projects, the vast expanse and great depth of the oceans make this particular habitat even more difficult in terms of adequate scaling, in space and time, to account for variation and the impact of anthropogenous activities.

MONITORING: IS IT IMPORTANT?

There are as many forms of monitoring as there are reasons to monitor. Monitoring programs give a continuous measure of the pulse of a given system. Taken alone, the results of a monitoring program are rarely decisive in producing an answer to a given problem. However, properly carried out, a monitoring program can form the basis for experimental efforts that are able, in an effective way, to pose adequate hypotheses for testing.

Theoretically, the scope, timing, and eventual definition of a monitoring program should fit the proposed reason for monitoring. The establishment of so-called "baseline" characteristics is a very complex issue. Often, monitoring studies are based on inadequately defined objectives. Such lack of definition risks circularity since setting limits for a given baseline study requires assumptions about environmental variability that cannot be disposed of in a reasonable way. Without preliminary estimates of such variability, the limits of the sampling effort cannot be set in a scientific fashion. Unless such limits are set before the sampling program is established, the parameters to be measured cannot be evaluated adequately. In addition, each form of variable (physical, chemical, biological) has its own level of variability that cannot be ascertained intuitively. Consequently, an interdisciplinary approach is essential.

The associated problems of what and how to monitor underlie the basic research questions. The scaling of both the extent and intensity of the monitoring effort depends on the interrelationships between form and process. Each ecological system is a manifestation of unique responses to essentially the same basic processes. Even closely related systems vary considerably in the timing, interactions, and relative importance of the driving factors. The specific impacts of important physical/chemical parameters (including human wastes), thus, vary from system to system making extrapolation difficult, if not impossible. There is no question that monitoring is an important component of any given environmental evaluation; the questions are whether or not such monitoring, designed to meet the dimensions of the system under study, meet the appropriate spatial/temporal scales of the question that is to be asked.

SITE SELECTION: SPATIAL VARIABILITY

The selection of sampling sites depends on the factors to be monitored, the size and habitat diversity of the system in question, the eventual (inevitable) tradeoff between the breadth of coverage and intensity of sampling, and the temporal consideration in a given project. The marine environment has depth as a primary complicating factor in the sampling design. There are different spatial characteristics at the various levels of biological organization. Microbes, meiofauna, and macroinfauna in benthic communities have significantly different scales of spatial variation; such differences have to be considered when the boundaries and dimensions of the sampling area are established. Planktonic groups such as phytoplankton, zooplankton, meroplankton, and ichthyoplankton have the added dimension of depth to consider. Mobile organisms are notoriously difficult to quantify because of the limitations of available collecting techniques. The response of such groups to spatial (three-dimensional) changes in water quality, toxic substances, nutrients, and currents are complicated by individual (often population-specific) responses to natural history characteristics, to biological interactions such as predation and competition. It is, consequently, necessary to assign priorities to the factors under study and the relative importance of spatial heterogeneity in the distribution of subject populations and communities.

Ideally, a fully random distribution of sampling sites is optimal. In most marine situations, this option is not realistic. Even the stratified random approach, wherein random samples are taken within designated habitat types, becomes somewhat subjective without adequate data concerning the area in question. The necessity of getting a representative sample for a given area is fundamental. Within-site variability (pseudo-replication) must be evaluated so that sampling breadth, which varies with the factors involved, can be established. Quantification of sample adequacy is an important process at both the within-habitat and between-habitat levels of observation. Spatial variability is thus a major problem when establishing a given environmental program.

TEMPORAL VARIATION

Each ecological system is subject to changes in time that can be ordered in diverse families of cycles and episodic events. Factors that drive the system include habitat quality, productivity, population interactions, and food-web structure. Each of these variables has a specific temporal aspect that must be determined if the system in question is to be evaluated adequately. Reproductive cycles and recruitment often play a decisive role in the temporal sequence of biological response. Superimposed over the usual cyclic phenomena (day-night, lunar, seasonal, interannual) are the episodic events (storms, temperature fluxes) that can change the temporal sequences of variable relationships. The reconciliation of temporal sequence of sampling effort, with the intensity of sampling and the spatial breadth of the program, is, perhaps, the most difficult part of a given monitoring program. There is a real need for the development of new statistical approaches that can combine the stratified random approach with a weighted timing of data collection based on pre-determined system-specific responses to season and interannual changes in driving factors and biological components.

DATA MANAGEMENT AND ANALYSIS

Even a well conceived environmental program will fail without a well developed analytical/computational system that can be used to evaluate the relationships among complex sets of long-term data. Entry programs, data storage capabilities, computer access systems, and adequate hardware facilities should be an integral part of the environmental program that is developed as an integral part of the study. A centralized database management system is fundamental to the generation and analysis of complex, interdisciplinary data sets. Statistical programs should be available before they are needed. Such programs should be prepared so that diverse factors can be simultaneously compared and analyzed as part of an integrated effort to determine the relative environmental importance of these factors.

THE COMBINED APPROACH: BACKGROUND DESCRIPTIVE AND EXPERIMENTAL

There is a real need for the creative combination of the advantages of both the descriptive (background monitoring) and experimental approaches to environmental studies. Hypotheses cannot be tested with descriptive data alone; on the other hand, without background information, meaningful hypotheses cannot be developed without monitoring data. There is a great strength in programs that can combine both of these methods of analyzing marine systems. These combined programs should include in situ experiments (with and without manipulation) that are based on known biological processes. Experimental exposure to various toxic substances under varying environmental conditions can be an effective way to evaluate the impact of known distributions of such wastes. Field-verified, deep sea microcosms can be used in conjunction with various monitoring strategies to evaluate the impact of a given anthropogenous variable. Such an effort would require more information of the life histories of important deep sea populations, along with some new approaches to the laboratory use of such organisms. This will be necessary if we are to ever understand the basic processes of marine systems.

CONCLUSIONS

When the present state of environmental science is considered, it is probable that there are few areas of modern science in which so little has been done to standardize data collection techniques and approaches. Until now, scaling problems of marine systems have been largely ignored. The tacit acceptance of broad assumptions in the development of marine monitoring programs is matched by a lack of interdisciplinary cooperation and the almost complete absence of integrated descriptive/experimental programs. Area to area extrapolations are not yet possible; any such attempts to develop truly predictive models should be based on long-term, multidisciplinary studies that combine the attributes of different experimental approaches. Such comparisons can only be made if some attention is given to quality control of data collection and analysis. Unless such an integrated approach is used with vigorous tests of data reliability and proven techniques of data collection, there will be a continuation of the present-day 'sorcerer's apprentice' approach to environmental science that combines the dual disadvantages of baseless experimental work and the piecemeal collection of background information.

Dr. Robert J. Livingston is currently a professor in the Department of Biological Sciences and Director of the Center for Aquatic Research and Resource Management at Florida State University. For over 20 years, Dr. Livingston has worked in aquatic ecology, pollution biology, and resource management. He has published over 90 papers in reviewed journals and books, chaired the committees of over 40 graduate students, and now heads a research team of 40-50 people.

His research effort for 15 years has involved continuous, long-term analyses of various river and coastal systems with an emphasis on the north Florida Gulf Coast. Coupled with laboratory and field experimentation, this work has included multidisciplinary systems analyses, population/community structure, trophic interactions, and the impact of various forms of anthropogenous stress on physico-chemical and biological processes.

Environmental Risk Research: How Much Is Enough?

Dr. John Cairns, Jr.
Virginia Polytechnic Institute and State University
University Center for Environmental and Hazardous Materials Studies

INTRODUCTION

Since most attendees at the Eighth Annual Minerals Management Service Gulf of Mexico OCS Region Information Transfer Meeting are involved in decisionmaking, I am going to liberally interpret the word "research" to mean evidence necessary for decisionmaking rather than "ivory tower" research. The concomitant statement is: How much uncertainty is tolerable in making a decision about the environmental consequences of a specific course of action? Since some of the public and some of its elective representatives still feel it is possible to reduce uncertainty to zero, recent precipitous decline of the United States and other major stock markets should act as a warning that we must always live with uncertainty. Nevertheless, good management practices require that protocols be developed for making decisions about environmental consequences that will be cost effective and in which the reasoning is relatively easily communicated. Although the evidence base itself may be understood in detail by a relatively small group of experts, it should be possible to communicate the degree of confidence the experts have in the evidence and the probability of harm if certain limits are exceeded. Once this has been demonstrated in a scientifically justifiable manner, the process of decisionmaking should be easily communicated to any reasonably well informed person. A major transitional period in ecotoxicology was reached in the late 1970s, beginning with the series of symposia now commonly called, in the profession, the "Pellston Series," after the name of the town and airport near the University of Michigan Biological Station where the first and some of the succeeding symposia were held (Cairns et al. 1978; Dickson et al. 1979; Maki et al. 1980; Dickson et al. 1982; Bergman et al. 1986). There were two main focal points in the first symposium, which were elaborated upon in succeeding symposia: (1) that the degree of acceptable uncertainty about two important types of evidence--(a) environmental concentration of the chemical and (b) concentration of the chemical below which there were no observable deleterious environmental effects--was a function of the proximity of these concentrations and (2) that a systematic and orderly process of gathering information in these two categories would lead to a scientifically sound decision.

ACCEPTABLE LEVELS OF UNCERTAINTY

Figure 1.1 from Cairns (1980) shows the relationship between the degree of uncertainty regarding the environmental concentration of a chemical and the highest test concentration producing no-adverse-biological effects. Note that on the left, roughly above number 1, the uncertainty is so sufficiently large that the confidence intervals overlap. Despite the still large degree of uncertainty, the area to the right of the point of intersection (that is to the right of the area above number 1) has been sufficiently reduced so that one can say with reasonable confidence that the environmental concentration is below the no-adverse-biological-effects concentration. In terms of the decisionmaking process, one might decide that no further evidence is necessary. However, this is not always true, as my discussion on validation will show.

The actual amounts of information required to make a decision vary on a case-by-case basis. The three most common situations are illustrated in Figure 1.2, which is a modification of Figure 1.1, in which the "confidence limits" are not displayed in order to make the illustration clearer. In Figure 1.2A, the environmental concentration of a chemical is markedly below the no-adverse-biological-effects concentration. In this situation, a high degree of uncertainty about each of the two critical concentrations can be tolerated although, of course, some evidence must be gathered. Nevertheless, this situation would require the least sizable evidence base. Figure 1.2B picks the same general relationship, namely, that the environmental concentration is still below the no-adverse-biological-effects concentration, but the two are so close together that considerable precision in estimating both concentrations is mandatory. Under these circumstances, a very large evidence base is required since very little uncertainty can be tolerated. Therefore, the confidence limits must be narrow. In Figure 1.2C, the environmental concentration is markedly higher than the no-adverse-biological-effects concentration, and adverse effects are highly probable should the chemical be used at the estimated environmental concentration. Therefore, a large evidence base to document this relationship is probably even less justifiable than validating the relationship depicted in Figure 1.2A. In Figure 1.2D, the relationship is as close as in 1.2B, but the position of the two concentrations is reversed. Therefore, damage would probably occur, but if the chemical had a large number of beneficial effects, it might still be used if these benefits far outweigh the adverse effects likely to occur. In this situation, a large evidence base would also be required in order to make appropriate management decisions.

Thus, in these four different scenarios, two call for relatively small information bases; one calls for a very large information base, and Figure 1.2D calls for a very large information base if the benefits of the proposed course of action, such as using a chemical, may outweigh the damages. Of course, all sorts of gradations exist between these illustrative examples, and special cases exist involving chemicals that undergo biological concentration or biological magnification that would require a particular kind of evidence in order to make an informed decision. This discussion cannot adequately cover all possibilities. The important point here is that no particular array of evidence, either in quality or amount, is suitable for all decisions! To state this differently, <u>the size of the evidence base required is a function of the decision being made, and preliminary evidence is required to determine the relationship that will ultimately determine the size of the evidence base</u>.

VALIDATION

Even if the results of the toxicity tests described above show that the no-adverse-biological-effects concentration is well above the predicted environmental concentration of the chemical, some additional evidence should almost certainly still be gathered. Book one of the Pellston Series (Cairns et al. 1978) recommended at least four steps in the hazard evaluation protocol: (1) screening or rangefinding toxicity tests, (2) predictive toxicity tests,

(3) validating or confirming tests, and (4) monitoring activities. Figures 1.3 and 1.4 in Kimerle (1979) show clearly one reason for gathering additional data: the biological response in natural waters may not be the same as in the laboratory water for a complex series of reasons not likely to be precisely the same in any two situations. As a consequence, validation or confirmation is necessary to determine the reliability of the predictive component based on laboratory tests. The other way to view this is that it acts as an error control loop (Figure 1.5) to correct predictive algorithms. The discrepancy between the prediction and the reality, and possibly even the cause of the difference, is identified. Validation processes can be relatively simple or quite elaborate. More detail can be found in Cairns (1986a, in press). The point is that a specific prediction about response in natural systems should be made on the basis of evidence provided by the laboratory toxicity tests and validated in a natural system or surrogate thereof. The amount and type of evidence necessary are functions of the decision being made. Protocols for both field and laboratory evidence gathered were developed by a colleague and me in 1973 in a limited distribution report entitled "Protocol for Evaluating the Effects of Ammunition Plant Discharges Based on Aquatic Life." The report was prepared for the U.S. Army Medical Research and Development Command. After the validity of this approach was checked a number of years, it was subsequently published in a journal of the American Society for Testing and Materials (Cairns and Dickson 1978). A detailed discussion of protocols used worldwide may be found in Dickson et al. (1979). In all of these, the emphasis is on how the information gathered will be used to make a specific decision. As is the case for decision analysis (e.g., Maguire, in press), information not affecting the decision is considered inappropriate, however useful the information may be in other circumstances.

EXPOSING THE SAVINGS MYTH

The savings resulting from using an inadequate information base is almost certain to be offset by a substantial margin by the problems associated with making a bad management decision. One belief seems to recur: if a short-term single species laboratory test on a "most sensitive species" shows no cause for concern, then elaborate tests, including validation, are not necessary. I have elsewhere indicated at some length (Cairns 1986b; Cairns and Niederlehner 1987) that serious flaws are present in the assumption that the most sensitive species can be selected for laboratory tests. However, when, as shown in Figure 1.1, the evidence base is small, then the competence around the probable concentration causing a no-adverse-biological response is rather broad even for a laboratory test. If one adds the uncertainty depicted by Kimerle (1979) in Figures 1.3 and 1.4 about the difference between the laboratory response and the response in the natural system, it is quite likely that a too small evidence base might well err either on the side of underprotection, resulting in fish kills and other events likely to attract public attention, or overprotection, resulting in expenditures for waste treatment systems that provide no additional biological benefits. Thus, a bad management decision will cost substantial sums of money if an adequate evidence base results in under- or overprotection. By including some form of validation, errors in the laboratory-based evidence can be identified, and if they are significant, corrected.

Cost of these processes is relatively modest, especially when compared with some of the legal costs alone associated with environmental damage. This audience needs no additional information on the cost of waste treatment systems, as is apparent to all. Therefore, when deciding on the size of the evidence base, one must give serious consideration to the possible economic consequences of a bad management decision and compare these to the cost of the evidence base itself.

MULTISPECIES TOXICITY TESTS

In recent years, multispecies toxicity tests have received increased attention (e.g., Cairns 1985). This attention has not always been favorable (Brungs 1986), although some reviewers (Meyer 1986) felt that controversial matters of this sort deserve to have all viewpoints expressed rather than trying to reach a consensus before publishing the final results. In any case, one of the characteristics of multispecies toxicity tests is a higher degree of environmental realism than single species tests now commonly used. This increase in environmental realism permits environmental fate studies for chemicals and environmental effect studies to be carried out in the same system. Thus, instead of carrying out a series of toxicity tests on each species separately, a large number of species are tested in the aggregate. This testing is done in systems usually sufficiently environmentally realistic to carry out environmental fate studies for chemicals simultaneously. Thus, cost savings results because, while the tests are more complex, the number of test units is reduced. More important, the validation can be done at the same level of biological organization, which is not always desirable in single species tests when determining their effects in natural systems. Mesocosm tests (for a discussion of mesocosm testing see the excellent article by Odum 1984) are now being utilized extensively for pesticide testing as the most cost-effective way of getting information leading to a defensible decision. Techniques developed in this area will quite likely result ultimately in methodology sufficiently inexpensive to be used for a wide variety of chemicals. As a consequence, ecotoxicology will evolve into laboratory tests with a higher degree of environmental realism, thus simplifying both the validation problem and the number of assumptions (Cairns and Niederlehner 1987) necessary to predict natural responses and validate them.

CONCLUDING REMARKS

Gathering the same amount of information for each and every chemical or mixture of chemicals is not possible. Therefore, flexibility in determining the size of the information base is essential in regulatory measures. This calls for considerable scientific judgement, but so does the extrapolation of a small laboratory database to complex natural systems. Therefore, the amount of evidence or research needed for environmental protection is a function of the specific decision being made and will vary from one case to another. In this way, resources and professional attention can be effectively focused on those cases requiring a substantial evidence base, and those requiring very little evidence can be resolved with dispatch. This approach is quite different from the present system, but it is scientifically justifiable as evidenced by the report of the National Research Council (the operating arm of the National Academy of Sciences and the National Academy of Engineering) published in 1981. In all cases, the reasoning used to arrive at the decision should be carefully documented so that if the decision proves incorrect, the process can be changed to avoid a repeat situation. The unfortunate Challenger incident shows us the difficulty of determining the reasoning process after the event, and, therefore, documenting it in reasonable detail before the decision is mandatory.

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Dr. John Cairns, Jr. is Director of the University Center for Environmental and Hazardous Materials Studies and University Distinguished Professor in the Department of Biology at Virginia Polytechnic and State University. He has been an ecotoxicologist since 1948.

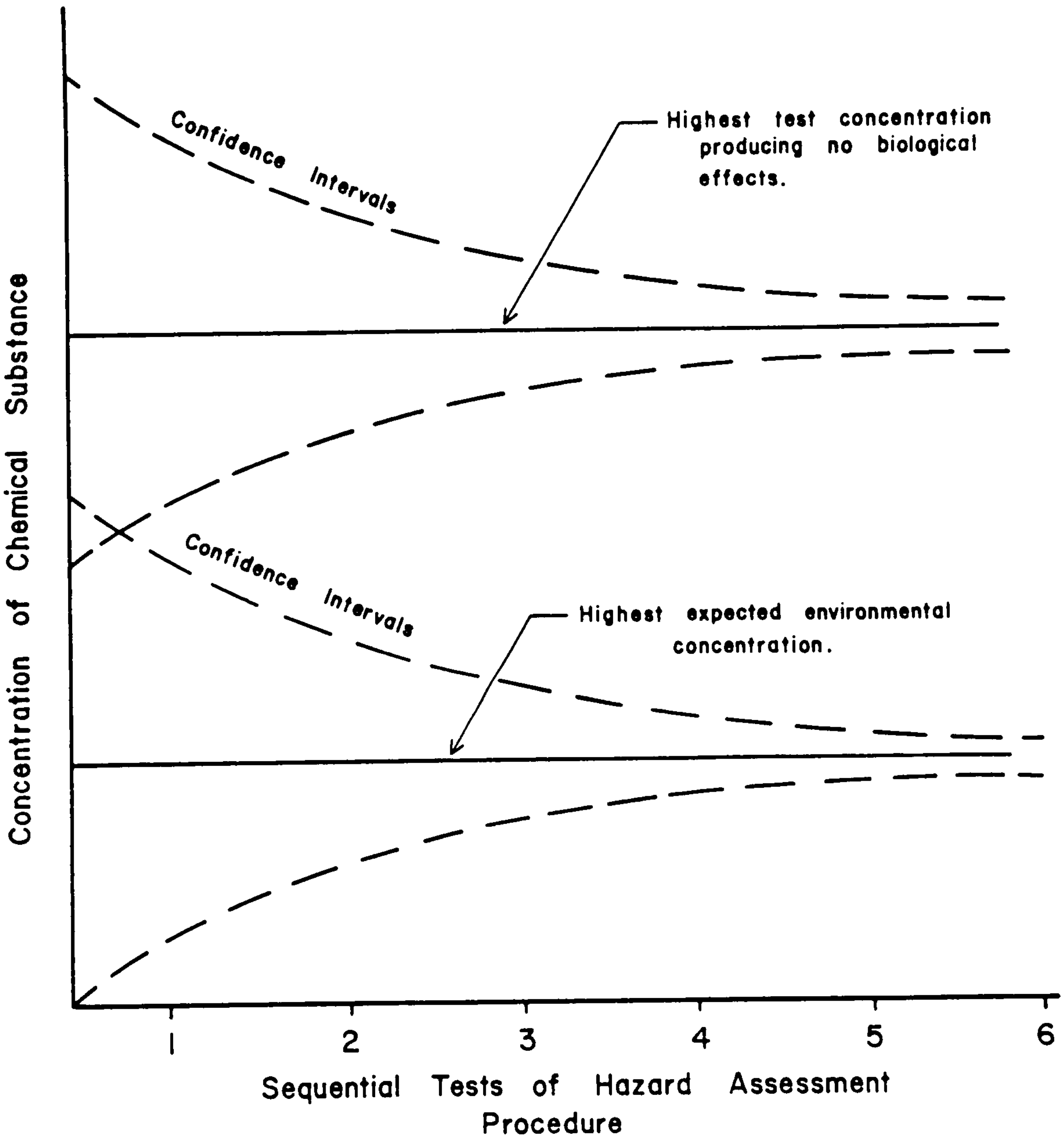

Figure 1.1.--Diagrammatic representation of a sequential hazard assessment procedure demonstrating increasingly narrow confidence limits for estimates of no-biological-effects concentration and actual-expected-environmental concentration (From Cairns, J., Jr., K.L. Dickson, A.W. Maki, eds., Estimating the Hazard of Chemical Substances to Aquatic Life, STP 657. American Society for Testing and Materials, Philadelphia, Pa., pp. 191-197. Reprint with permission, Copyright ASTM, 1916 Race St., Philadelphia, Pa., 19103).

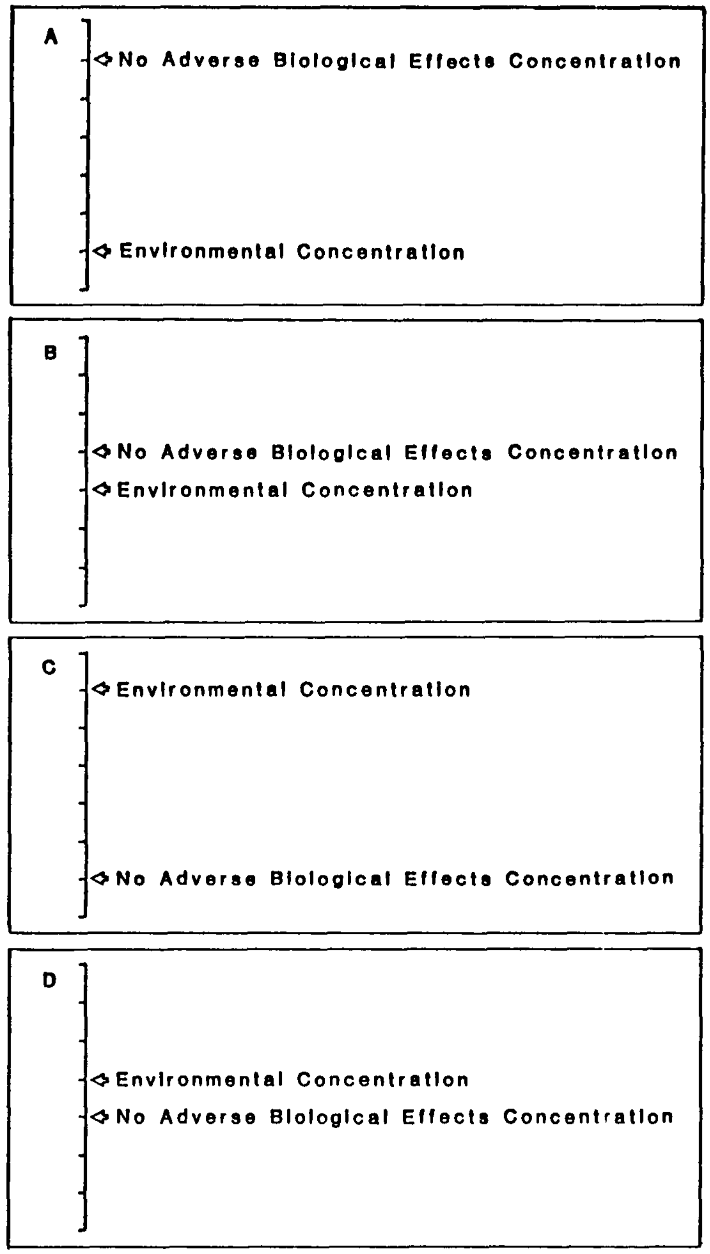

Figure 1.2.--Common situations dealing with the relationship of the no-adverse-biological-effects concentration and the environmental concentration. A.--the environmental concentration is markedly below the no-adverse-biological-effects concentration. B.--environmental concentration is below the no-adverse-biological-effects concentration, but the two are close together. C.--the environmental concentration is markedly higher than the no-adverse-biological-effects concentration and adverse effects are highly probable. D.--environmental concentration is higher than the no-adverse-biological-effects concentration and the two are close together.

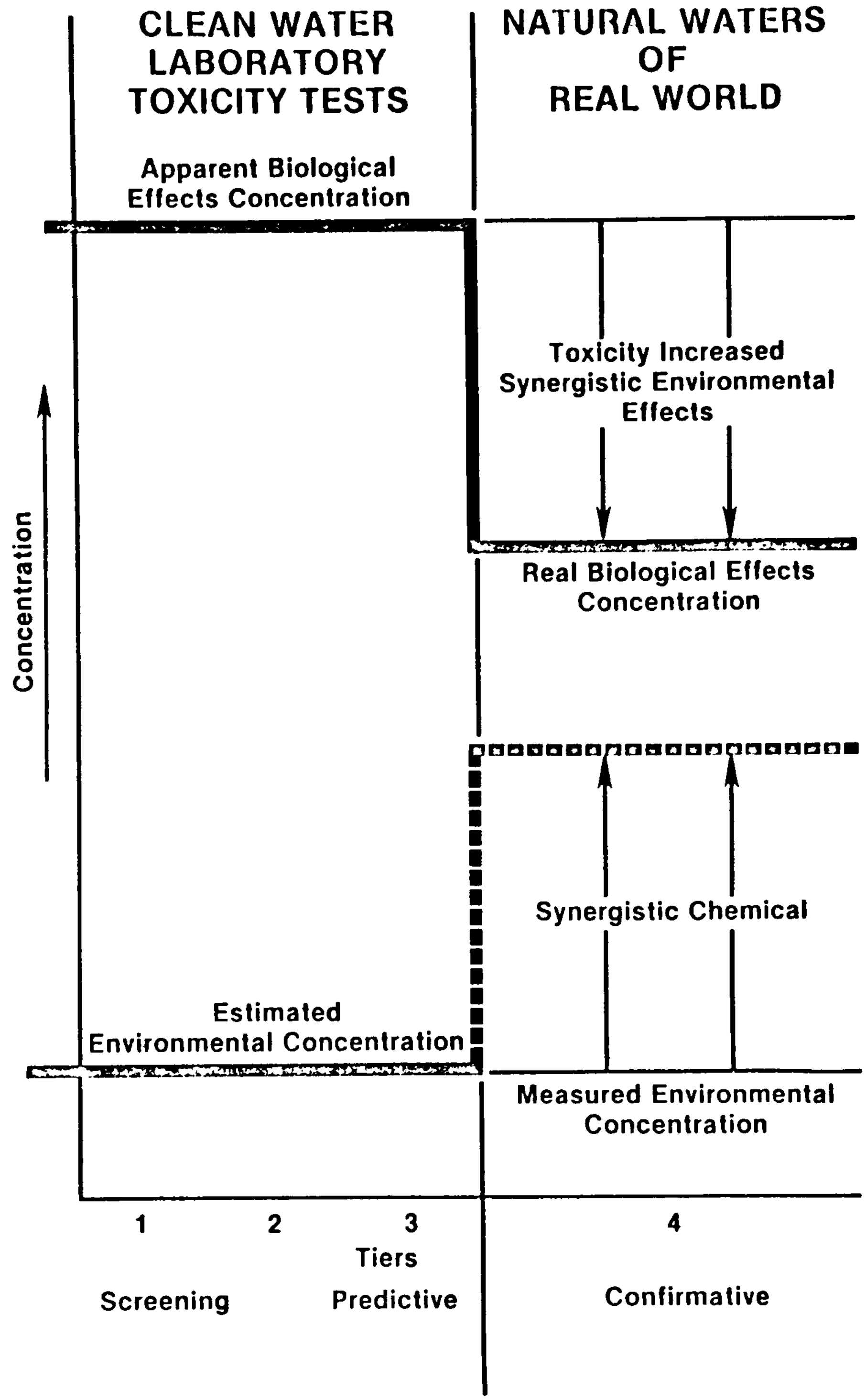

Figure 1.3.--Hypothetical situation of an apparent small margin of safety from clean water laboratory toxicity data actually being much smaller because of synergistic effects of natural waters.

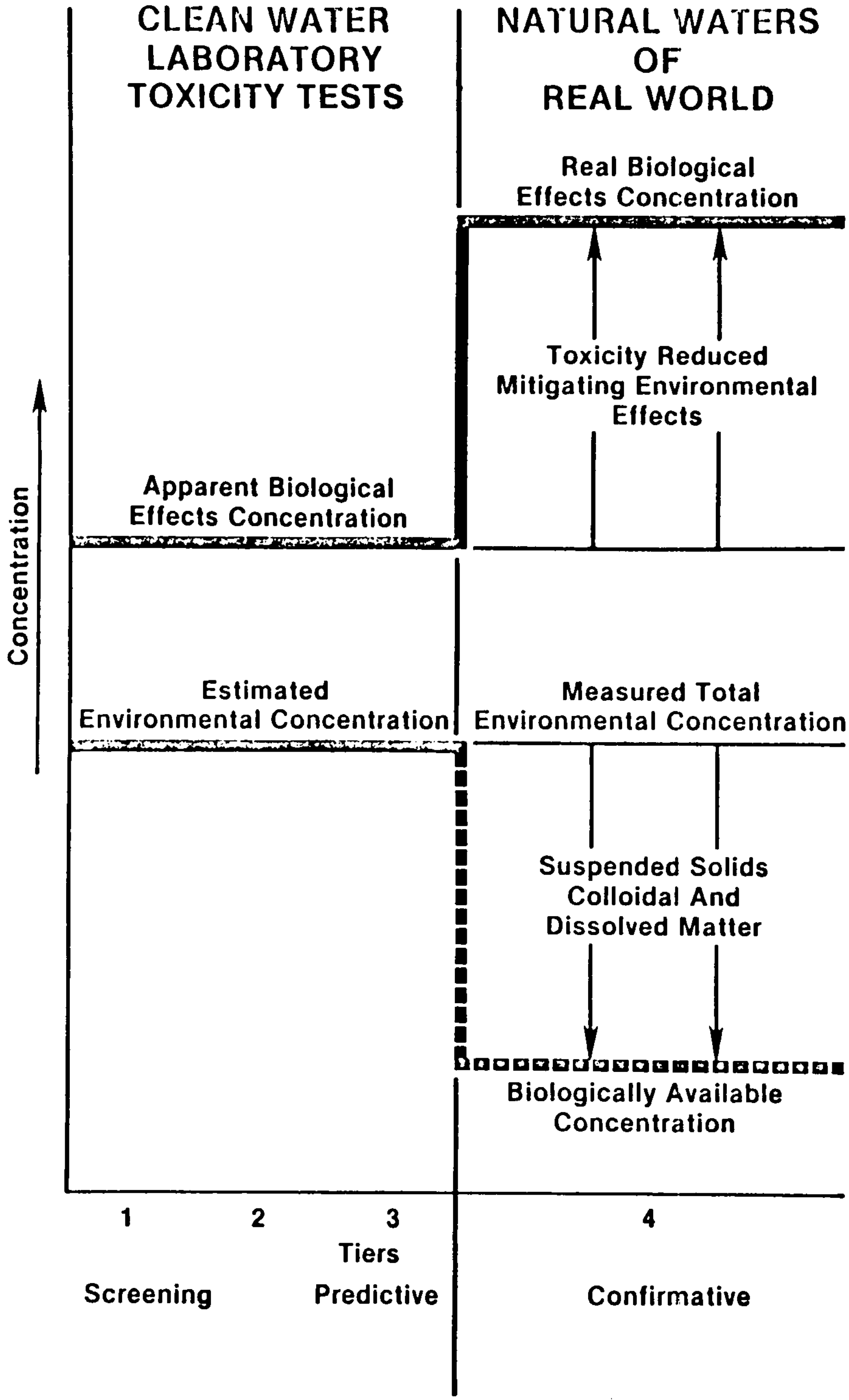

Figure 1.4.--Hypothetical situation of an apparent large margin of safety from clean water laboratory toxicity data actually being much greater because of mitigating effects of natural waters.

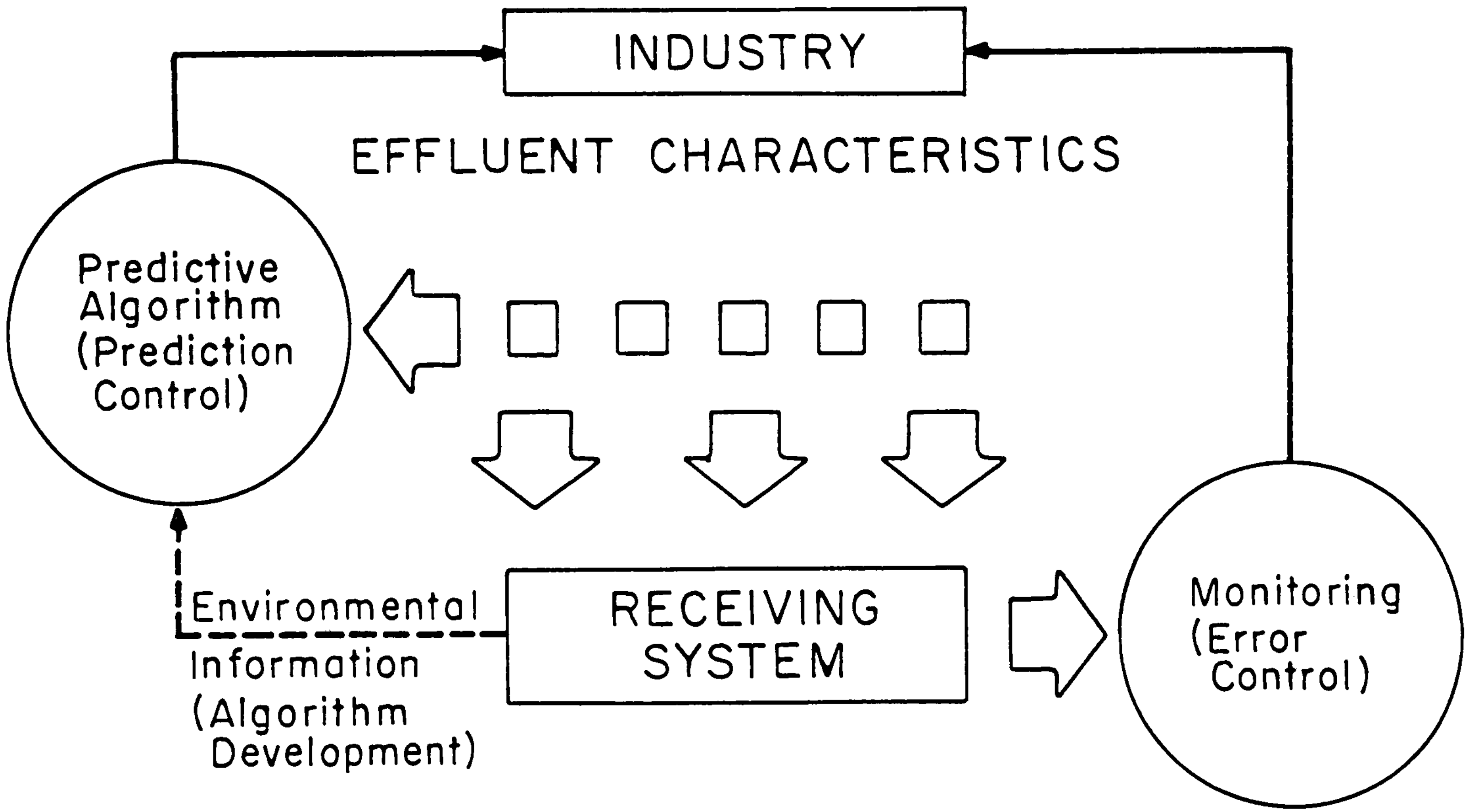

Figure 1.5.--Information flow in environmental control processes.

SOCIAL AND ECONOMIC EFFECTS OF THE RECENT DECLINE
IN OCS ACTIVITY ON GULF COAST COMMUNITIES

Session:	SOCIAL AND ECONOMIC EFFECTS OF THE RECENT DECLINE IN OCS ACTIVITY ON GULF COAST COMMUNITIES
Co-Chairs:	Mr. John Rodi Ms. Vicki Zatarain
Date:	December 1, 1987

Presentation	Author/Affiliation
Social and Economic Effects of the Recent Decline in OCS Activity on Gulf Coast Communities: Session Overview	Mr. John Rodi and Ms. Vicki Zatarain Minerals Management Service Gulf of Mexico OCS Region
Social and Economic Effects of the Decline in OCS Activity on the Houston Area	Mr. Albert Ballinger University of Houston
Social and Economic Effects of the Decline in OCS Activity on the New Orleans Area	Ms. Virginia Simons The Chamber/New Orleans and the River Region
Social and Economic Effects of the Decline in OCS Activity on the Lafayette Area	Dr. David P. Manuel University of Southwestern Louisiana
Discussion of MMS In-House Research into OCS-Related Impacts on Tourism and Recreation	Mr. Douglas J. Elvers Minerals Management Service Gulf of Mexico OCS Region

Social and Economic Effects of the Recent Decline in OCS Activity on Gulf Coast Communities: Session Overview

Mr. John Rodi
and
Ms. Vicki Zatarain
Minerals Management Service
Gulf of Mexico OCS Region

The Gulf of Mexico offshore oil and gas industry has experienced significant changes over recent years. Indicative of these changes is the trend in Federal offshore mobile rig utilization. Offshore rig utilization increased dramatically from mid-1983 through the fourth quarter of 1984. By the first quarter of 1985, the recognition of a continued excess supply of oil and gas worldwide halted the growth of offshore drilling activity in the Gulf of Mexico. Wellhead prices of oil and gas showed a declining trend throughout 1985 before plummeting to about 50 percent of the 1985 year-end prices by the second quarter of 1986. In that period, mobile rig utilization had decreased accordingly. The first three quarters of 1987 have shown an increase in energy prices and, therefore, an increase in offshore mobile rig utilization, but the current demand is still about half of the peak of 1984.

The purpose of this session was to discuss the socioeconomic effects of the decline in OCS oil and gas activity over recent years on specific coastal communities throughout the Gulf of Mexico region. The coastal communities represented were Houston, New Orleans, Lafayette, and the Mississippi Gulf Coast. Additionally, status of an MMS in-house study on the impact of the oil and gas program on recreation and tourism was presented.

Mr. Albert Ballinger with the Center for Public Policy of the University of Houston presented the effects of the decline in oil and gas activity on the Houston area. The Center for Public Policy has been conducting research on the Houston economy and updates its findings on a quarterly basis with a "Houston Update."

Houston's role as an "energy economy" is that of manufacturing capital goods for exploration and production, and supplying technology for the industry. As a result, when the rig count plummeted, manufacturing employment in Houston (which was very heavily tied to energy) fell precipitously.

Because of the rapid growth in the 1970's and early 1980's of employment in the primary sector (those industries contributing to the export base of the economy), including rapid expansion in manufacturing and mining, and the growth lag in secondary employment, Houston found itself with an oversupply of residential, manufacturing, office, and retail space when the decline in oil and gas activity was felt. This is illustrated in the home price index. Demographic shifts have also been striking. The dramatic decreases in housing prices have allowed traditional minorities to pretty well settle where they desire, leaving Houston a city achieving a measure of radical integration unrivaled even by cities where targets of integration exist.

The post-1981 economic downturn is separated into two phases: 1982-1983 and 1985-1986. The earlier phase was felt largely by blue-collar workers while the second phase was primarily a white-collar recession.

Houston has begun to diversify, although the city will remain heavily energy dependent for the foreseeable future. Houston is expected to achieve modest growth through 1989 due to stabilizing energy prices and the diversification of the area's economic base.

Ms. Virginia Simons, the Manager of Petroleum and Chemical Development for the Economic Development Council of The Chamber/New Orleans & the River Region, presented the effects of the decline on the New Orleans area.

Louisiana has been the center of offshore activity since 1947. With offshore exploration and production activity came oil and gas company employment in southern Louisiana. Direct oil and gas mining employment now accounts for 22,000 jobs in the New Orleans area, increasing 600 percent since 1950. Oil- and gas-related employment grew rapidly during the 1970's as a result of world market conditions and the importance of Louisiana offshore activity. From 1981 to 1986, New Orleans lost 5,500 direct oil and gas jobs and 28,800 related jobs. However, New Orleans, as an offshore exploration and production center fared proportionately better than many other Gulf Coast communities.

The worst effects of the decline in OCS activity were felt in the indirect support businesses--the drilling, crewboat, fabricating, and offshore service companies. The downturn in employment led to decreases in other sectors--retail sales, real estate, and banking. Hotels and restaurants soon realized that a lot of what they called "tourism" was oil and gas travel.

Another major effect of the decline in prices was on State government revenues. Louisianians are now realizing that State revenues were too dependent on one source and that Louisiana's windfall from oil and gas has not been invested wisely. These problems lead to changes in State government leadership and to a campaign for fiscal reform.

Economic diversification is now underway. The Gulf of Mexico is a proven market and is the first offshore area showing strong signs of recovery with the stabilization of energy prices. Being a center for offshore activity, New Orleans is experiencing a slow but steady improvement in economic conditions, but the situation will never equal the boom of 1981.

Dr. David Manuel, Professor of Economics and Dean of the College of Business Administration of the University of Southwestern Louisiana, presented the social and economic effects of the decline in OCS activity on the Lafayette area.

Activity in the Gulf of Mexico OCS has greatly affected Lafayette because of the area's energy-industry dependence. The extraordinary rise in oil prices from 1977-1982 and the resultant increase in offshore oil and gas activity have caused significant growth in real per capita income in Lafayette as well as an influx of population and, therefore, a growth in the labor force.

The decline in OCS activity has resulted in the most precipitous decline in economic activity in Lafayette since the Great Depression of the 1930's. As a result, it has been estimated that 19,000 jobs have been lost in the Lafayette region since 1980, and a total of $2.0 billion in retail sales have evaporated.

While recovery is estimated to be slow to moderate, there is evidence that it is occurring. The unemployment rate, which had virtually tripled in a 6-year period, stabilized at about 10 percent in September 1987. The Lafayette Index of Help-Wanted Advertising confirms this modest improvement, showing greater employment availability in 1987. Similar to the experience in the New Orleans area, the recovery is being driven by OCS activity.

Mr. John Rodi, presenting information gathered through contacts with Mississippi Gulf Coast representatives, concluded that the impacts of the decline in OCS activity on the Mississippi Gulf Coast have not been devastating or even totally negative. Tourism in Mississippi coastal areas was generally unaffected or, in some cases, slightly increased throughout the decline in OCS activity. Some of those contacted hypothesized that this may have resulted from both increased travel by those recently unemployed in nearby Louisiana, as well as those still employed who chose to economize on vacation plans by remaining close to home. Another positive impact experienced by the Mississippi Gulf Coast has been the increase in ship and rig repair in the Pascagoula area due to companies' taking advantage of slack time to repair their fleet, or new owners refurbishing a fleet that was acquired during the downturn.

The final presentation was by Mr. Douglas Elvers, Chief of the Environmental Assessment Section of the Leasing and Environment Division of MMS, Gulf of Mexico OCS Region. He presented current leasing statistics and is currently preparing a paper that relates offshore oil and gas activity to tourism and recreation throughout the Gulf of Mexico region. Particular emphasis will be placed on the following areas where tourism and recreation are felt to be historically important: South Padre Island, Corpus Christi, Galveston/Point Bolivar, New Orleans, Grand Isle, the Mississippi Gulf Coast, Mobile, Gulf Shores, Dauphin Island, and the Florida Panhandle. This paper will be presented in August 1988 at the International Geographers' Union to be held in Australia.

Mr. John Rodi has been employed as staff economist with the MMS Gulf of Mexico OCS Regional Office from April 1980 to the present. He holds a B.A. in economics from Tulane University (1974), an M.A. in economics from the University of New Orleans (1978), and was employed for six years as an economist with the U.S. Army Corps of Engineers (1974-1980).

Ms. Vicki Zatarain is an economist with the Leasing Activities Section of the MMS Gulf of Mexico OCS Regional Office. She earned an M.A. degree in economics and a B.S. degree in marketing from the University of New Orleans and a B.S. degree in computer information systems from Tulane University.

Social and Economic Effects of the Decline in OCS Activity on the Houston Area

Mr. Albert Ballinger
University of Houston

The Center for Public Policy, University of Houston, is an academic research facility organized within the College of Social Sciences. Since one of the goals of the center is to foster communications between the university and the community in which it resides, research is focused on those issues of current interest to that community.

The center researched the economic history of Houston to determine how the economy had evolved. This research was first revealed in February 1986 in a seminar and through publication of the "Handbook on the Houston Economy." The research has been ongoing, and we have updated our findings on a quarterly basis with a "Houston Update."

Everyone knows that Houston was an "energy economy." The real questions were to what degree, and how elements in its economy responded to energy prices. The oil price shocks of 1973 and 1979 stimulated growth in Houston reminiscent of the California Gold Rush. The ten-fold increase in oil prices stimulated high-risk exploration in areas that were previously economically unattractive. Houston's role was to manufacture capital goods for exploration and production, as well as supply technology for the industry. It is important to recall that labor requirements are greatest in gearing up for production. As an example, the building of petrochemical complexes after World War II created great employment opportunities in construction and engineering. These facilities are not especially labor intensive once they are up and running. Over time, technology has allowed substitution of capital for labor, with the result that, although the facilities today are producing at near record output, the employment levels are much below previous levels.

An accelerator model demonstrates that to have sustained growth in capital goods manufacturing employment, one must have an ever-increasing growth in the requirement for those goods. Had we simply leveled off at the requirement implied by the December 1981 rig count of over 4500, the requirement for those goods would have diminished to the depreciation rate. As we all know, the rig count did not remain at 4500; it plummeted, leaving excess quantities of these capital goods all over the countryside. Predictably, manufacturing employment in Houston (which was very heavily tied to energy) fell precipitously (Figure 2.1).

I would like to introduce our notion of primary and secondary employment in Houston. A regional input-output model allowed the derivation of weights that could be applied to various categories of employment to measure their contribution to the export base of the economy. Those contributing to that export base are considered primary. Those categories that exist to serve the primary sector are called secondary. As an example of primary categories, most manufacturing and mining is considered primary. Business and personal services are largely secondary.

The 1970's and early 1980's saw a rapid expansion of primary employment (Figure 2.2) to the extent that the secondary sector lagged in the creation of this employment. As a matter of fact, the entire infrastructure of the region lagged the growth in the primary sector and the induced growth in the secondary sector. Houston's infamous traffic congestion was evidence that the roads and highways portion of the infrastructure was inadequate to support the increased population.

Our topic today is the social and economic effects in the decline in OCS activity on the Houston area. One indicator is the foreclosure rate and its implications for savings and loan industry, private mortgage insurance companies, GNMA, FNMA and others (Figure 2.3). Another indicator is the home price index (Figure 2.4). As you can see from Figure 2.5, all sections of the city have been affected, but not to the same degree. Are these dismal numbers solely due to the fall in energy prices? The graph illustrating the change in households and housing units (Figure 2.6) shows that most of these problems are due to oversupply. In 1983, we added 63,000 housing units at the same time that 10,000 households left town. We estimate that, through attrition in the stock of housing and modest increases in households, the vacancy rate will decrease. However, the market will not experience normal vacancy rates until 1992.

The story in manufacturing space, office space, and retail space is the same as in the housing market -- one of oversupply. Not only did we build too much, we built in inappropriate (largely suburban) locations. We can confidently predict that we will see new construction of office space and retail space while some of the suburban space remains vacant.

We have chosen to separate the post-1981 economic downturn into two phases: 1982-3 and 1985-6 (Figure 2.7). The table (Table 2.1) on unemployment shows very different effects on various sectors of the population. The earlier recession was felt largely by blue-collar workers. Large layoffs by headquarters of oil companies in Phase II was primarily a white-collar recession.

The demographic shifts have been most striking. Dramatic decreases in housing prices have allowed traditional minorities to pretty well settle where they desire. Racial and ethnic composition of many neighborhoods bears little resemblance to that depicted by the 1980 census. Houston is a city where there are no zoning restrictions, yet it has probably achieved a measure of racial integration unrivaled by cities where zoning and targets of integration exist.

I would like to close with our employment forecast for Houston. As you can see, we expect modest growth through 1989. Although Houston will be heavily energy dependent for the foreseeable future, we have begun to diversify. Our estimate is that the primary sector was eighty-one percent energy dependent in 1981. That has fallen to sixty-seven percent today. The leaders in future growth will be those businesses included in the energy independent category.

Mr. Albert Ballinger obtained his B.S. and M.A. degrees from the University of Houston. He has been associated with the Center for Public Policy since 1985. Publications in progress include The Futures Market in West Texas Intermediate Crude.

Social and Economic Effects of the Decline in OCS Activity on the New Orleans Area

Ms. Virginia Simons
The Chamber/
New Orleans and the River Region

The decline in Outer Continental Shelf (OCS) activity since 1981, resulting from recent significant price declines (Table 2.2), has negatively affected every community in the Gulf Coast area. With Louisiana offshore waters dominating Gulf of Mexico activity, New Orleans--the administrative center of this activity--has experienced decreases in employment, income, real estate, tax revenues, retail sales and corporate contributions.

Louisiana has been the center of offshore activity since 1947. From the late 1940's to 1982, Louisiana produced 89 percent of U.S. offshore gas and 70 percent of U.S. offshore oil. Texas produced nine percent of the gas and less than one percent of the oil. The remainder was produced off the West Coast. Since 1953, the U.S. government has received a total of $51.8 billion in revenues from Louisiana's federal offshore waters.

This represents 63 percent of all federal offshore revenues (1953-1985).

With exploration and production activity came oil and gas company employment in Southern Louisiana. Direct oil and gas mining employment now accounts for 22,000 jobs in the New Orleans area, increasing 600 percent since 1950 (Table 2.3). About 50 percent of this employment is based in downtown New Orleans in the offices of major companies such as Amoco, Chevron, CNG, Exxon, Freeport-McMoRan, Louisiana Land & Exploration, Mobil, Shell, and Texaco.

From the direct mining activity, the spin-off impact to the rest of the economy is enormous. A total of 125,900 jobs, or one out of every four, is still related in some way to the oil and gas industry in the New Orleans area.

Oil and gas related employment grew rapidly during the 1970's as a result of world market conditions and the importance of Louisiana offshore activity. However, New Orleans was somewhat overshadowed by the tremendous boom going on in Houston. At one time, the Houston Chamber of Commerce estimated that 1,000 people a week were moving into Houston. New Orleans did not have the same level of influx and, consequently, experienced less of an outflow when oil prices fell.

From 1981 to 1986, New Orleans lost 5,500 direct oil and gas jobs and 28,800 related jobs (Tables 2.4 and 2.5). However, New Orleans, as the offshore exploration and production center, fared better than many other Gulf Coast communities. Since 1982, major oil companies (Amoco, Chevron, Exxon, Freeport-McMoRan, Mobil, Shell, and Texaco) have actually added jobs in downtown New Orleans, sometimes at the expense of Lafayette, Lake Charles, Jackson, Tulsa, and even Houston.

The worst effects of the decline in OCS activity were felt in the indirect support businesses--the drilling, crewboat, fabricating, and offshore service companies. The downturn in employment and income in these businesses led to decreases in other sectors--retail sales, real estate, banking, and so forth. Hotel and restaurants soon realized that a lot of what they called "tourism" was oil and gas travel.

The Chamber of Commerce was not immune. We did not lose any major oil company memberships, but saw a severe cutback by support firms, especially on the West Bank. Our organization was forced to layoff staff and discontinue certain programs.

By far, the major effect of the decline in prices was on state government revenues. Louisiana's huge current deficit has finally forced Louisiana residents to realize that state revenues were too dependent on one source and that Louisiana's windfall from oil and gas has not been invested wisely. It can be suggested that the decline in oil prices has led to our recent change in state government leadership and to the campaign for fiscal reform that is now underway. Even the news media are beginning to pay attention to economic diversification, so there are signs of hope.

Earlier this year crude oil prices began to stabilize near the $20 level. Soon, fabrication contracts, formerly on hold, were being let; the rig count began rising; work boat rates began improving. If the current price level holds, economic conditions will show slow but steady improvement for the coming year. But the situation will never equal the boom of 1981, when nearly every statistical indicator related to the oil industry peaked. Nineteen eighty-one was a fluke year, brought on by unstable market conditions. The distorted oil and gas market did not originate with OPEC in the 1970's. It began with the U.S. Federal Government setting wellhead prices in 1954 with the infamous "Phillips Decision."

In retrospect, the boom leading to the 1981 peak disguised the changing character of the offshore industry. Offshore exploration and production is now a high technology industry--one of the largest high-tech markets for products and services in the world.

Many local companies that survived this downturn should see an increase in business next year. If prices hold, employment will continue to increase. Lingering problems will include tight bank credit for all but the strongest companies and the lack of access to improved technology for smaller firms. More foreign firms will be investing in the Gulf of Mexico--in exploration, production, and support services.

The Gulf is a proven market and is the first offshore area showing strong signs of recovery. In New Orleans and Louisiana, oil and gas will remain the leading industry for the foreseeable future. Let's hope we can learn from the events of the past in planning for our future.

Ms. Virginia Simons is Manager of Petroleum and Chemical Development for the Economic Development Council of The Chamber/New Orleans and the River Region. She holds an M.A. degree in economics from the University of New Orleans and a B.A. degree in geography/economics from the University of Southwestern Louisiana. She is involved in various aspects of the oil industry in Louisiana, including the attraction/expansion of industrial facilities and administrative offices, economic research and surveys, and legislative issues. She previously worked for Kaiser Engineers on the economic and environmental impact analysis for the LOOP project.

Social and Economic Effects of the Decline in OCS Activity on the Lafayette Area

Dr. David P. Manuel
University of Southwestern Louisiana

Activities in the Gulf of Mexico, particularly in the OCS regions, serve as an excellent example of export-based, regional growth effects. Unfortunately, they also serve as an example of the downside of such a phenomenon.

Major stimuli include

a. Extraordinary rise in oil prices from 1977-1981; precipitous decline beginning in early 1982, exacerbated by the total collapse in 1986.
b. Significant growth in real per capita income in Lafayette, Louisiana.
c. Influx of population and resulting growth in the labor force.
d. Extraordinary growth in oil-related capital expenditures prior to 1981; collapse in oil prices subsequently resulted in anticipated decline since 1981.

Although the initial decline in offshore drilling activity began in 1982, some recovery occurred in 1983 and 1984. Subsequent years (1985 and 1986) exhibited drastic declines, and 1987 has marked some improvement.

Total employed persons in Lafayette Parish averaged about 80,400 in 1982; by 1984, this number had increased to 82,800, representing the peak of employment. A decline followed which has been stunning--76,100 in 1986. In the first half of 1987, employment has averaged 70,000 per month and shows signs of stabilization.

As expected, the unemployment rate increased significantly. Averages are shown below:

1982	5.7
1983	9.4
1984	7.5
1985	8.7
1986	13.3
1987 (J-S)	11.0

Having peaked in January 1987, at 16.2 percent, Lafayette's rate essentially tripled. Since that peak however, unemployment has declined dramatically to 10.0 percent in September 1987. The decline in the unemployment rate was clearly a function of some improvement in economic conditions; however, it was also caused by the reduction in the labor force--flight of unemployed persons to other geographical areas.

Confirmation of these latter developments is gleaned from the Lafayette Index of Help-Wanted Advertising (1977=100). Averages for 1983 and 1984 were 150.4 followed by dramatic declines to 132.9 in 1985 and 97.4 in 1986; however, the January-October, 1987 average was 102.8. It appears, therefore, that some improvement has been visibly translated into greater employment availability in 1987.

The decline in OCS activity had truly significant impacts on employment and income in the Lafayette region. Precipitous declines in personal income led to a dramatic decline in retail sales. After recovering in 1984 from a low of $144.6 million per month, retail sales declined further to $131.6 million per month in 1986. Improvement has been in the form of stability in 1987; January-August retail sales are 4.7 percent below the same period in 1986.

Lafayette Taxable Retail Sales
(million dollars per month)

1981	$176.4
1982	170.7
1983	144.6
1984	158.3
1985	160.6
1986	131.6
1987 (J-A)	125.7

An important aspect of consumer spending is that associated with residential construction. In this arena one can gain a rather complete view of the dynamics of income, population, and labor force. In 1982, residential building permits averaged 115 per month; by 1985 the number declined to 42 per month; there were only 18 per month in 1986. Thus far in 1987, an average 10 permits were filed per month. Surely national economic factors were at work as well; however, negative regional impacts outweighed most of the benefits of lower interest rates.

The decline in OCS activity has resulted in the most precipitous decline in economic activity in Lafayette since the Great Depression of the 1930's. As a result, it has been estimated that 19,000 jobs have been lost in the Lafayette region since 1980, and a total of $2.0 billion in retail sales have evaporated.

While recovery will be slow to moderate, there is evidence that it is occurring. As many of us surmised earlier, the recovery is being driven by OCS activity. As long as Lafayette and all of south Louisiana are energy-industry-dependent, any recovery will be dominated by offshore forces.

Dr. David P. Manuel is a Professor of Economics and Dean of the College of Business Administration at the University of Southwestern Louisiana.

Discussion of MMS In-House Research into OCS-Related Impacts on Tourism and Recreation

Mr. Douglas J. Elvers
Minerals Management Service
Gulf of Mexico OCS Region

The issue of the impacts on tourism and recreation from OCS oil and gas leasing and production has been treated in Department of the Interior environmental impacts statements since 1972. In most US-OCS areas, excepting the Central and Western Gulf of Mexico, concerns are expressed that the OCS program will cause degradation of existing tourism and recreation activities. Yet, in the Central and Western Gulf of Mexico, where the bulk of the OCS production occurs, both the oil and gas program and recreation and tourism have continued to grow with a lack of serious impacts being demonstrated.

Session organizers of the 26th Congress of the International Geographical Union expressed an interest in the interaction, impacts, and co-benefits of these two industries in the Western and Central Gulf of Mexico. Mr. Elvers and members of the Leasing and Environment Staff are presently researching the history of oil and gas development and tourism for the States of Texas, Louisiana, Mississippi, and Alabama and the Federal OCS portion of the Gulf of Mexico. A general call for information on the subject was issued at this session to supplement the present information that MMS has collected. Final results are expected to be available in August 1988 and at the next Information Transfer Meeting.

Mr. Douglas Elvers is Chief of the Environmental Assessment Section, Gulf of Mexico Region, Minerals Management Service (MMS). He and his staff prepare the OCS oil and gas pre-lease environmental impact statements for the Gulf of Mexico. This staff has prepared twenty pre-lease documents since 1974 covering the major environmental issues relating to OCS oil and gas development managed by MMS.

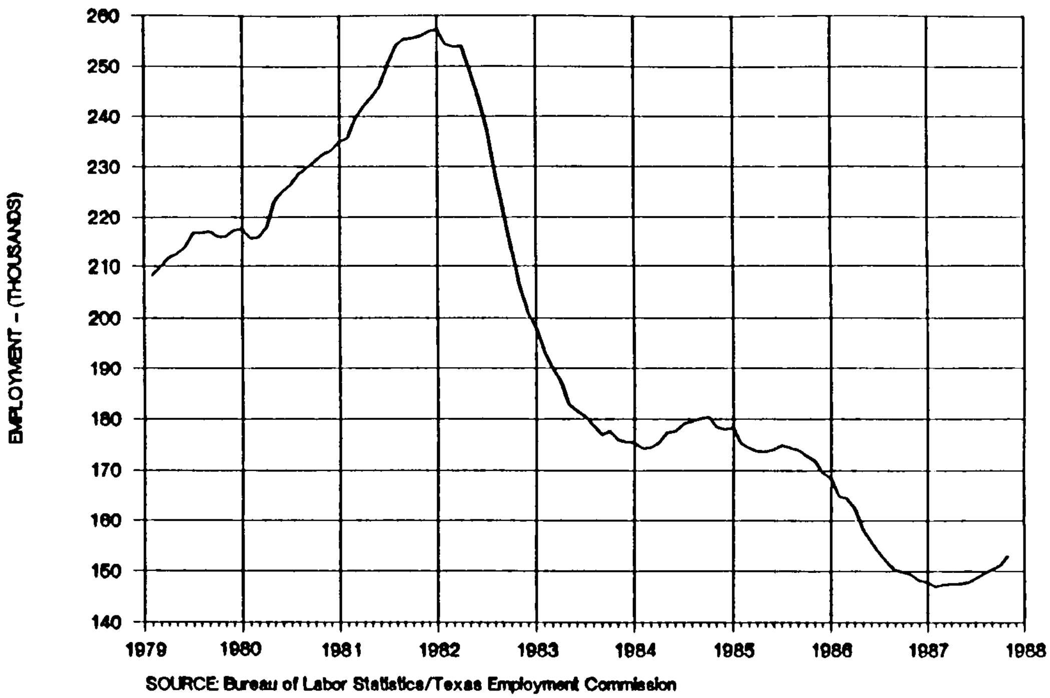

Figure 2.1.--Manufacturing employment, Houston PMSA.

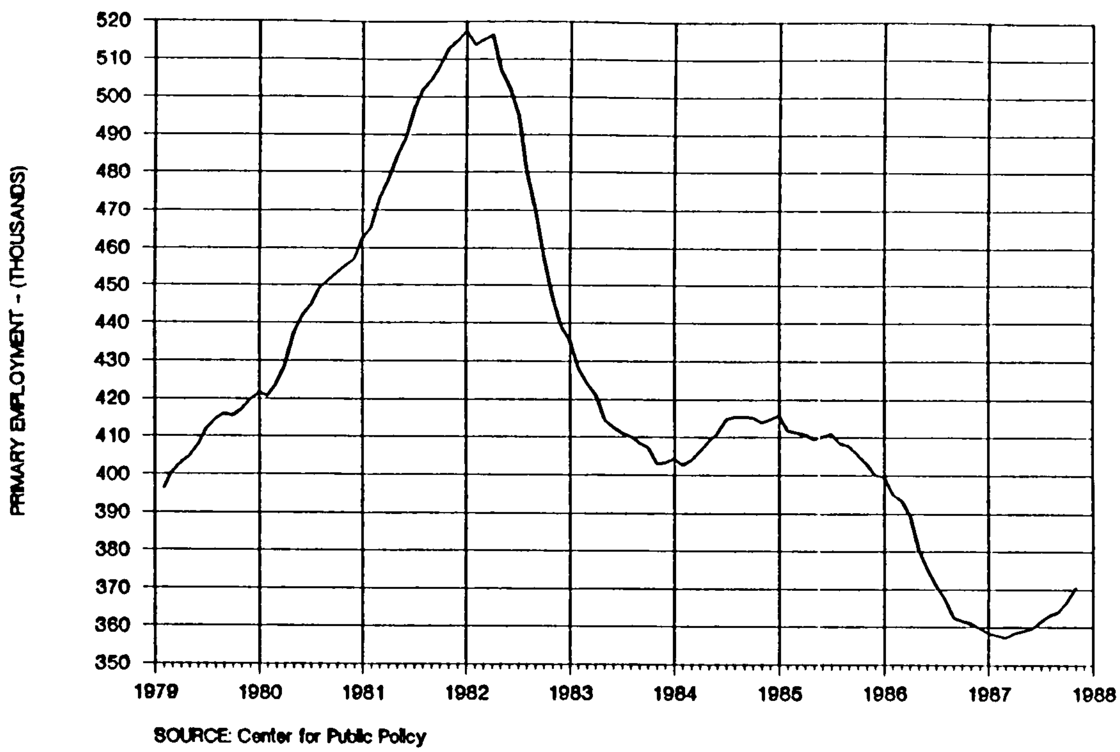

Figure 2.2.--Primary employment, the economic base - Houston PMSA.

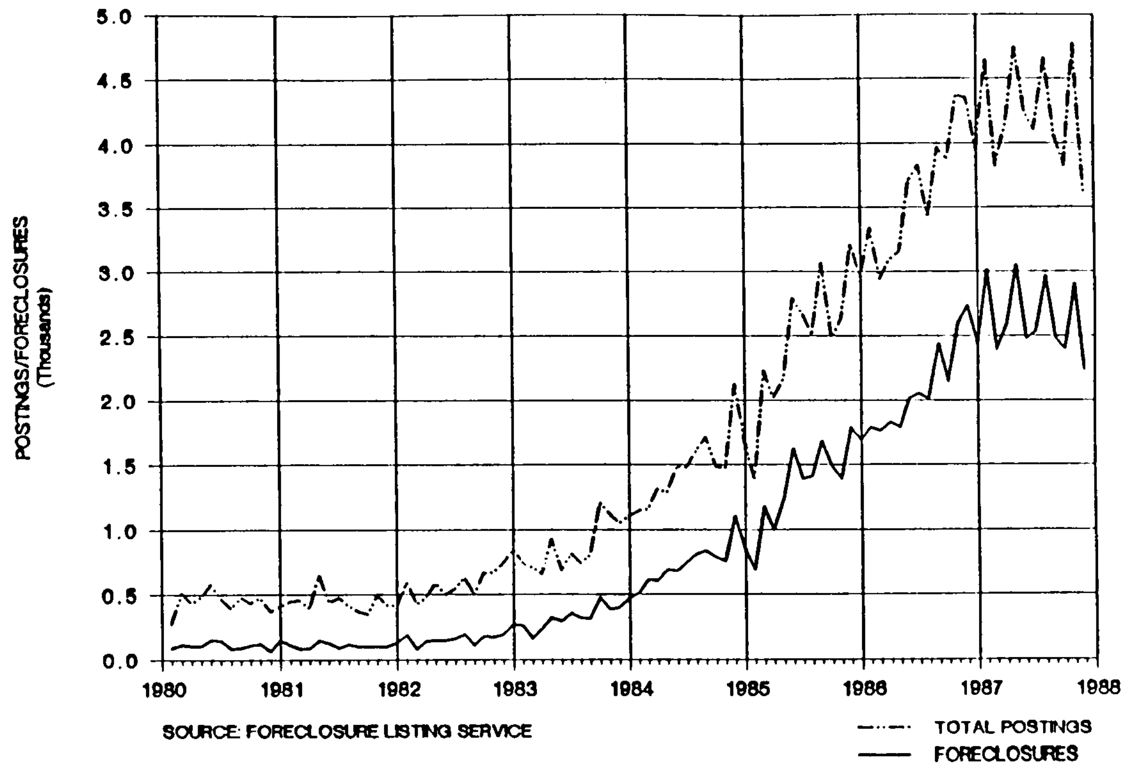

Figure 2.3.--Foreclosures, postings & foreclosures - Harris County.

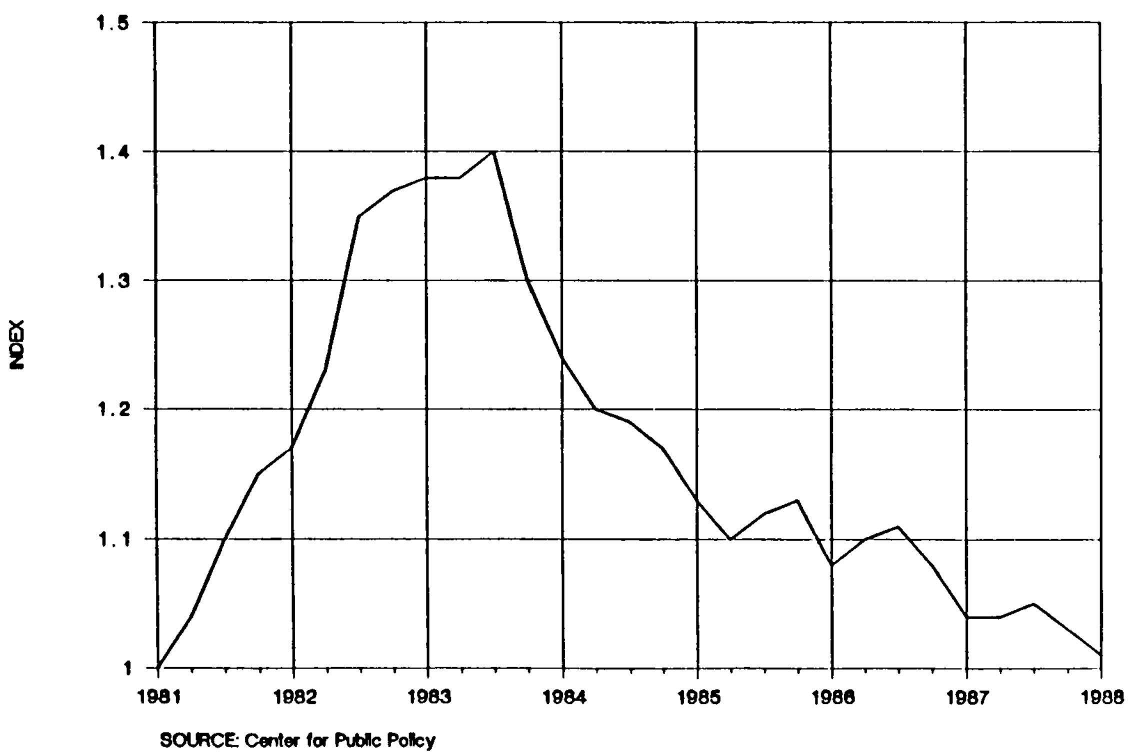

Figure 2.4.--Home price index, quarterly - Harris County.

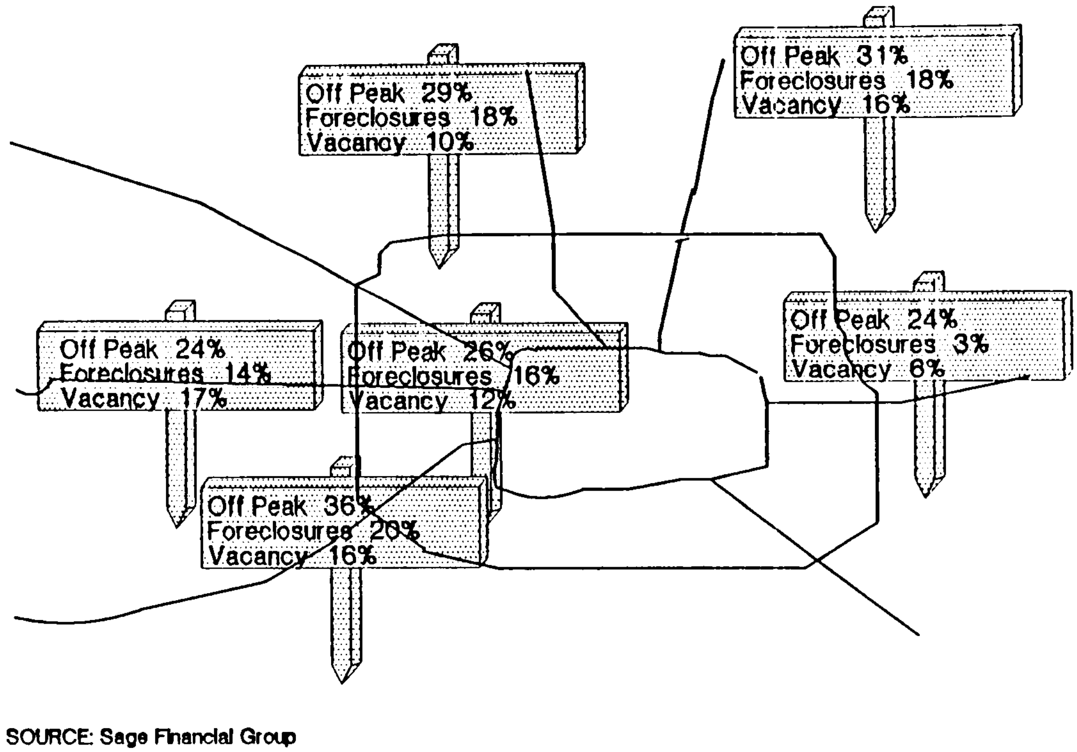

Figure 2.5.--Neighborhood property values.

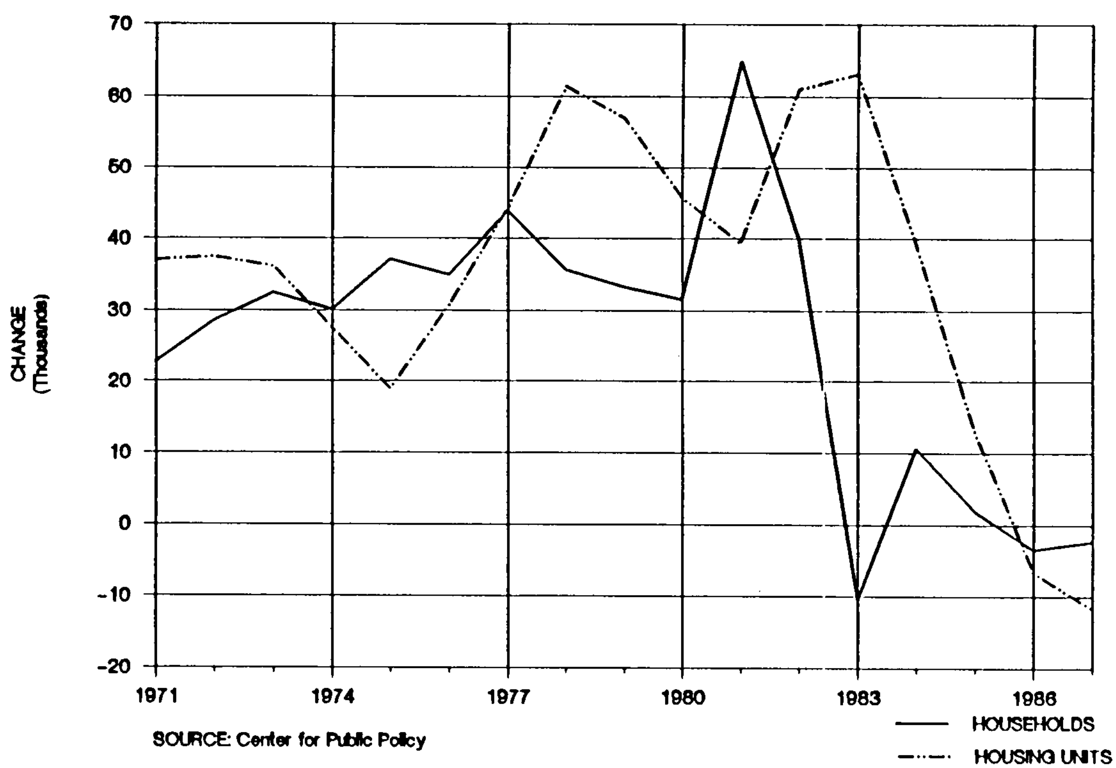

Figure 2.6.--Changes in households & housing units - Harris County.

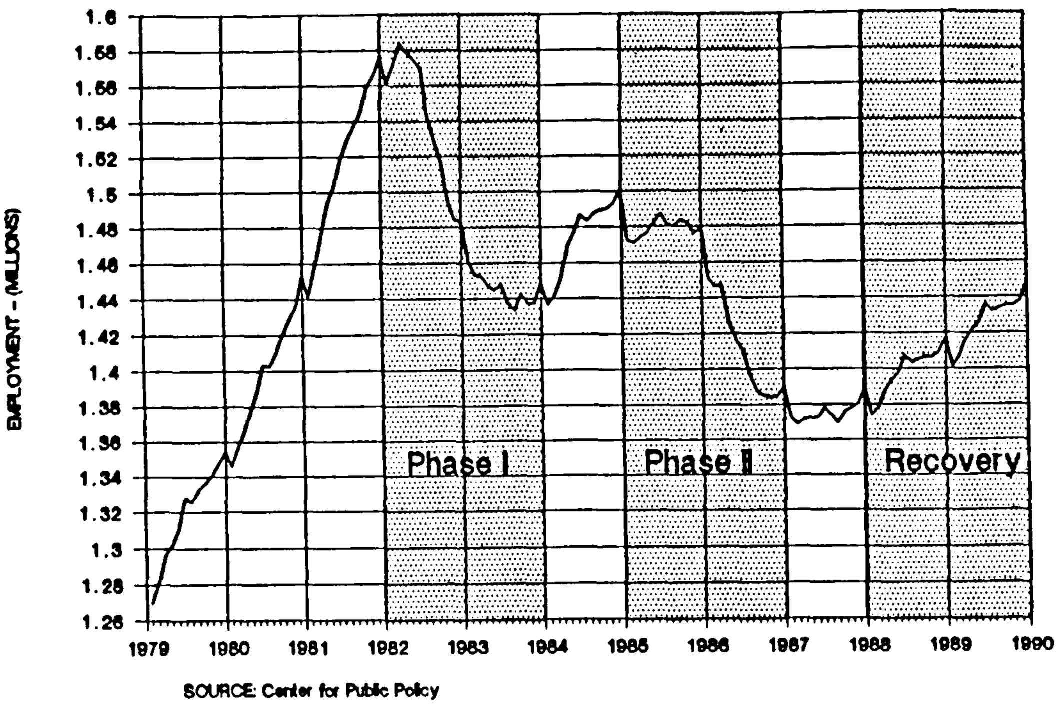

Figure 2.7.--Total employment, non-agricultural wage & salary - Houston PMSA.

Table 2.1.

The Number of Jobless Houstonians

	Percent Change	
	Phase I	Phase II
White	48%	82%
Black	78%	17%
Hispanic	242%	0%
Male	106%	57%
Female	43%	30%

Table 2.2.

Crude Oil Prices, 1960-1987

Louisiana Average Wellhead Price ($/BBL)		Average Import Price ($/BBL)
Year	Price	Price
1960	3.14	2.23
1965	3.10	2.23
1970	3.38	2.35
1973	4.00	3.27
1974	6.53	11.17
1975	7.09	12.45
1976	7.51	13.34
1977	8.33	14.31
1978	9.03	14.38
1979	11.42	21.65
1980	19.82	33.95
1981	35.45	36.52
1982	32.44	33.18
1983	30.02	28.93
1984	29.67	28.46
1985	27.24	26.72
1986	16.05	15.48
1987 (1Q)	16.73	17.14

NOTE: When Col. Edwin Drake brought in the first oil well in 1859, lamp oil producers gathered at the site to buy Drake's oil at $20 per barrel.

SOURCES: American Petroleum Institute, U.S. Department of Energy

Table 2.3.

New Orleans and the River Region
Direct Petroleum and Chemical Employment
(1950-1986)

Year	Oil & Gas Mining (000)	Chemical Manufacturing (000)	Petroleum Refining (000)	Total Direct (000)
1950	3.1	1.7	2.4	7.2
1955	8.6	2.9	2.9	14.4
1960	10.1	3.3	2.7	16.1
1965	14.5	4.9	2.7	22.1
1972	15.7	5.9	2.9	24.5
1973	15.8	5.7	2.7	24.2
1974	15.5	6.2	2.8	24.5
1975	17.0	6.4	2.9	26.3
1976	17.7	6.8	3.0	27.5
1977	18.5	7.6	3.3	29.4
1978	19.4	7.4	3.9	30.7
1979	20.4	8.1	4.4	32.9
1980	22.8	8.4	4.4	35.6
1981	25.4	8.7	4.8	38.9
1982	26.2	8.4	4.6	39.2
1983	23.4	6.9	5.6	35.9
1984	23.9	6.9	5.5	36.3
1985	23.3	6.7	5.2	35.2
1986	20.8	6.6	5.6	33.0
1987 est.	21.0	6.3	5.4	32.7

Table 2.4.

New Orleans and the River Region
Oil and Gas Industry-Related Employment

Category	1977	1981	1986
Direct Production			
Mining	17,900	25,200	20,800
Chemicals Mfg.	7,700	8,600	6,600
Petroleum Ref.	3,400	4,700	5,600
Total Direct	29,000	38,500	33,000
Indirect Support	49,800	65,900	48,600
Induced Consumer Effect	42,000	55,800	44,300
Grand Total	120,800	160,200	125,900

SOURCE: Louisiana Department of Employment Security and Economic Development Council

Table 2.5.

New Orleans and the River Region
Oil and Gas Industry-Related Employment

Category	1986 Related Employment
Direct Production	
Mining	20,800
Chemicals Manufacturing	6,600
Petroleum Refining	5,600
Total	33,000
Indirect Support	
Construction	15,100
Manufacturing	
Machinery	700
Shipbuilding	4,300
Miscellaneous Manufacturing	1,600
Transportation	11,400
Wholesale Equipment and Supplies	4,000
Finance, Insurance, Real Estate	6,900
Business Services	4,600
Total	48,600
Induced Consumer Effect	
Communications, Public Utilities	2,200
Wholesale Trade	3,800
Retail Trade	13,100
General Building Construction	1,500
Personal Services	1,600
Repair Services	700
Entertainment Services	500
Medical, Health Services	3,700
Educational Services	3,800
Other Services	1,800
Government	11,600
Total	44,300
Grand Total	125,900

SOURCE: Louisiana Department of Employment Security and Economic Development Council

INFORMATION DEVELOPMENTS AND SOLUTIONS TO MARINE DEBRIS IN THE GULF OF MEXICO

Session:	INFORMATION DEVELOPMENTS AND SOLUTIONS TO MARINE DEBRIS IN THE GULF OF MEXICO
Co-Chairs:	Mr. Villere C. Reggio, Jr. Mr. Richard T. Bennett
Date:	December 1, 1987

Presentation	Author/Affiliation
Information Developments and Solutions to Marine Debris in the Gulf of Mexico: Session Overview	Mr. Villere C. Reggio, Jr. Minerals Management Service Gulf of Mexico OCS Region
Marine Debris on the Beaches of Padre Island National Seashore	Ms. Leslie Peart Corpus Christi State University
Survey and Findings of Beach Debris on Mustang Island, Texas	Mr. Anthony F. Amos The University of Texas at Austin Marine Science Institute
Preliminary Findings for Beach Debris in Louisiana	Ms. Dianne Lindstedt and Mr. Joseph Holmes Louisiana Geological Survey
Louisiana Coastal Recreation and Tourism Assessment Team: An Innovative University Approach	Mr. Michael L. Liffmann Louisiana Sea Grant College Program
NOAA's Marine Entanglement Research Program: Goals, Products, Information, and Plans	LCDR Alan R. Bunn National Oceanic and Atmospheric Administration
The Offshore Oil and Gas Industry's Campaign to Stop Offshore Littering	Mr. Wayne Kewley Offshore Operators Committee
Education and Awareness: Keys to Solving the Marine Debris Problem	Ms. Kathryn J. O'Hara Center for Environmental Education
Texas Adopt-A-Beach Program	Mr. Frank H. Morgan Texas General Land Office
Panel Reports: 1987 Gulf of Mexico Beach Cleanup Highlights (Texas, Louisiana, Mississippi, and Florida)	Ms. Linda Maraniss Center for Environmental Education, Mr. Calvin Fair Louisiana Coastal Cleanup, and Ms. Gail Bishop Gulf Islands National Seashore

Information Developments and Solutions to Marine Debris in the Gulf of Mexico: Session Overview

Mr. Villere C. Reggio, Jr.
Minerals Management Service
Gulf of Mexico OCS Region

When mineral revenues to state coffers in Texas and Louisiana started to tumble several years ago, state support for many local programs, such as beach maintenance in Texas, suffered precipitous declines as well. Texas coastal communities began to look anew at the economic potential of Gulf of Mexico beaches at the same time the financial resources for maintaining those beaches were drying up. Hence, coastal trash and litter became an issue, and people began to question its source. Surveys, opinions, information, and reports from Padre Island National Seashore (PINS) and coastal communities indicated the ever visible offshore oil and gas industry was a major source of the beach litter problem.

A 1985 formal report by the State of Texas concluded 75-90 percent of beach litter and trash came from offshore sources and implied the oil and gas industry was the primary contributor. Furthermore, over 300 unidentified 55-gallon drums, many of which were determined to contain hazardous waste, washed up on PINS in 1985. Hence, Federal and State regulatory agencies responsible for the environmental implications of oil and gas leasing and development in the Gulf of Mexico, as well as the petroleum industry itself, were called to task to correct this unacceptable and costly problem.

The MMS and the Texas General Land Office (TLO) began their own investigations of the problem while they were reviewing regulations pertaining to solid waste handling and disposal associated with oil and gas operations in the Gulf of Mexico. Even though State and Federal regulations already prohibited the disposal of solid waste materials from oil and gas activities anywhere in the marine environment, regulatory reminders and stern warnings were issued and communicated to the oil and gas industry with a call for special compliance efforts and exceptional voluntary actions to counter indiscriminate disposal and careless loss of solid waste from oil and gas operations. Also in 1986, the MMS, the TLO, several major oil companies, and others accepted the invitation of the Center for Environmental Education (CEE) to join their advisory committee in preparation for the first Texas statewide beach cleanup designed to remove beach litter, generate information on its source and contents, and foster public understanding on the scope, nature, and deleterious effects of marine debris.

For the third consecutive year, the Gulf of Mexico OCS Regional Office of MMS organized a session at the annual ITM focusing on marine debris. In 1985, the National Park Service, the U.S. Coast Guard, the State of Texas, and representatives of the major Gulf industries (petroleum, shipping, fishing, and recreation) were asked to present their views on the problem (OCS Study/MMS 86-0073, pp. 295-314). In 1986, the petroleum industry and the U.S. State Department described legal and educational actions underway to effect a significant reduction in marine litter. Specifically, the educational video "All Washed Up," produced by the Offshore Operators Committee (OOC), and Annex V of the MARPOL International Treaty were reviewed as major new measures pursued by the petroleum industry and the U.S. Government in response to this problem (OCS Study/MMS 88-0058, pp. 323-348). Since last year's ITM, the U.S. Congress has drafted and is favorably considering implementing legislation for Annex V, and the TLO has spearheaded a special initiative to have the Gulf of Mexico declared a special area under Annex V, thereby prohibiting disposal of all solid wastes from all ships (industries) throughout the Gulf of Mexico.

Presentations at this year's ITM were designed to share new information on the sources and nature of the debris on beaches of the Central and Western Gulf Planning Areas and to review the progress of institutions, individuals, and organizations active in litter removal and educational campaigns.

Ms. Leslie Peart, a candidate for a master of science degree at Corpus Christi State University, reported on the results of her two years of research on the trash load impacting PINS. Her findings indicated a total annual accumulation of 580 tons of trash and litter on the 58 miles of Gulf front beach associated with the seashore, and she attributed up to 40 percent of this trash by weight to the oil and gas industry. From data collected on her survey plots, she estimated a standing mass averaging between 1 and 3.3 tons per mile over the length of the seashore with greater density in the winter than in the summer. Importantly, she noted a 70 percent decline in standing mass and density of trash and litter within her survey plots when comparing early samples from those collected in the latter part of her survey. Using these findings, she urges continued support for volunteer beach cleanups as an effective means to reduce beach trash loads, and encourages public and private educational programs targeted on the problem. Legislative remedies imposing deposits on recyclable containers were also recommended by Ms. Peart.

Mr. Tony Amos, a Research Associate at the University of Texas Marine Science Institute at Port Aransas, has been regularly surveying the same 7.5 miles of beach at Mustang Island for over 10 years. He has made over 1,300 daily observations of the flotsam and jetsam found on Mustang Island Beach and has noted that items associated with the oil and gas industry have definitely declined in the last year or two. Besides keeping tabs on natural and manmade items found on the beach, Mr. Amos also keeps accurate records on local wind, current, tide, and temperature data so as to be able to correlate these factors with the type and amount of debris inventoried. He reviewed the most recent data he had collected from his 1987 weekly counts of natural and manmade items found on the beach. Overall, most items derived from the offshore environment, such as plastic sheeting and rope, show peaks during the spring and fall seasons. Noted exceptions are beverage cans, that show a strong peak in the summer that obviously correlates with public use of the beach, and rubber gloves, that peak in mid-July, which he attributes to the onset of the offshore shrimping season. Although Mr. Amos claims to be an expert at spotting foreign debris, which he estimates constitutes about 10 percent of the total litter load, overwhelmingly the trash on Mustang Island Beach, such as the thousands of 1-gallon milk jugs and egg cartons he has inventoried, is of U.S. origin.

One of the more interesting natural items Mr. Amos inventoried is stranded sea turtles. He claims to find 40-60 turtles per year and is currently cooperating with another researcher who does necropsies on turtle finds. He noted only two of the dead turtles in the last year were likely to have died from interaction with marine debris. Interestingly, he has inventoried more dead sea turtles in the last year, when there were few explosive removals of offshore platforms, than in the previous year, when explosive removals were routine.

Mr. Amos' goal is to calibrate the last five years of his estimates by actual counts in hopes of determining increases or decreases in the amount and specific content of the marine litter and beach trash associated with Mustang Island Beach.

Ms. Dianne Lindstedt, a research assistant from the Louisiana Geological Survey, is cooperating with coworker Joe Holmes in compiling and analyzing data on marine debris impacting beaches throughout coastal Louisiana. Ms. Lindstedt provided a report on the preliminary findings from Louisiana's first coastwide beach cleanup resulting from compilation of data submitted by volunteers participating in the September 19, 1987, cleanup and described their quarterly sampling of six Louisiana beaches over the past year. Findings from the State sponsored sampling of six Louisiana beaches were unavailable at the time of this meeting.

The State received about 500 data sheets from the September 19 volunteer cleanup of 16 Louisiana beaches. It was able to use 400 for this analysis and half of these were from two beaches--Grand Isle and Fourchon Beaches in the eastern part of the state. From almost 100,000 pieces of litter recorded, 40 percent was made of plastic and 23 percent of styrofoam. Statewide, 36 percent of all the items collected were drinking containers. The five most common items were styrofoam cups, followed by pieces of styrofoam, plastic cups and lids, 1-gallon milk or water jugs, and plastic bags. Other very common items were plastic pieces, glass and metal pop and beer containers, styrofoam food trays, and rope. Styrofoam cups, the most common items found at beaches throughout the state, are believed to come predominantly from offshore sources such as oil and gas, merchant shipping, or fishing operations. Items collected and believed to be solely from the oil and gas industry include hard hats, write-protect rings, and pipethread protectors. Although items from several foreign countries were noted, only a very small portion of the litter originated in foreign countries. Ms. Lindstedt noted that the proper disposal of everyday food and drink waste by industries and individuals associated with the marine environment would eliminate at least half of the litter found along the Louisiana beaches.

Mr. Mike Liffmann, Assistant Director of the Sea Grant College Program at Louisiana State University, described a new and innovative project initiative designed to foster economic development interest in Louisiana's coastal zone. Mr. Liffmann has organized a multidisciplinary Louisiana Coastal Recreation and Tourism Assessment Team (LCRATAT), which has been conducting a series of rapid, intensive, and low-cost studies designed to provide local interest with guides for the development of recreation and tourism resources.

From experience, personal communication, and limited data, he reviewed the recreational assets, recent use, and limitations of Louisiana's coastal beach developments (Grand Isle, Holly Beach, and Cypremort Point). Sport fishing was identified as the single largest attraction for visitors to the state's beaches. Louisiana officials and local leaders are aware that if they wish to expand public use and development of the state's coastal resources, they must be concerned with the aesthetics of coastal beaches, marshes, waterways, and roadways. It is the consensus of leaders of coastal parishes and communities that (1) there is an urgent need to diversify the region's economic base by reducing dependence on oil and gas and the cyclical fishery industries; (2) their parishes and communities possess the natural and cultural attractions sought by tourists and recreationists; and (3) only a few dollars, technical assistance, and a sense of stewardship are needed in order to convert the tourism development opportunities to a reality.

A major impediment to the realization of coastal recreation and tourism objectives identified by LCRATAT is lack of tourism preparedness. There is currently no tourism development strategy for the state and region beyond publication of promotional material on attractions and events. Mr. Liffmann, through LCRATAT, is encouraging more strategic planning that would concern itself with how a community/parish/region wishes to relate to its environment and, thus, how its resources can best be developed. The state, its regions, and most of its communities have confused strategic and project planning and have embarked on projects in anticipation of, or in reaction to, near-term economic circumstances rather than trying to shape the future through careful analysis and extensive input. Every coastal community must decide (1) whether there is broad-base community interest in tourism development, (2) what community needs could tourism meet, and (3) whether the benefits of such a program outweigh the costs.

Lieutenant Commander (LCDR) Alan Bunn, Assistant Program Manager of the National Oceanographic Atmospheric Administration's (NOAA) Marine Entanglement Research Program, reviewed the program's history, focus, and funding levels. The increasing awareness of the level and persistence of marine debris and its threats to living marine resources, endangered species, and coastal aesthetics led Congress to fund the program in 1985. Program research is categorized into three major areas: (1) education and public awareness, (2) research and impacts assessment, and (3) mitigation. Some of the more important projects of interest to the Gulf of Mexico region, that have been funded, include (1) development and implementation of an educational program for the Gulf of Mexico, (2) beach cleanup information and standards, (3) impacts of plastics on sea turtles, (4) disposal technologies for handling refuse on ships, and (5) investigation of port reception facilities for marine debris. Distributed at the session and available through the Northwest Alaska Fisheries Center in Seattle, Washington, is the report "Descriptions and Status of Tasks in NOAA's Marine Entanglement Research Program for Fiscal Years 1985-1987" by James Coe, program manager, and Alan Bunn (telephone 206/526-4009). This report gives comprehensive descriptions of all the projects supported by the Marine Entanglement Research Program including a note on the status and funding of each, as of July 31, 1987.

The Marine Entanglement Research Program is recognized as one of the leaders in existing studies and information directed at the problem and solutions of synthetic marine debris. Renewed interest and research in a number of alternatives, including recycling, incineration, compaction, recovery, and degradability is a direct result of the new information and awareness stimulated by the program. Plastic manufacturers, fishing organizations, environmental groups, the petroleum industry, and other Federal agencies have been stimulated and/or assisted through this program in furthering the goal of reducing the hazards of marine debris in our oceans. LCDR Bunn's presentation concluded with the truism, "If we as a society are going to utilize and benefit from the advanced technology of synthetics, then we must accept the inherent responsibilities of proper disposal."

Mr. Wayne Kewley, representing the Offshore Operators Committee (OOC), an association of 70 companies representing essentially all of the petroleum activity occurring in the Gulf of Mexico, presented a status report on their ongoing campaign to stop offshore littering. Mr. Kewley reviewed the evidence associating the offshore oil and gas industry with the beach trash problem. Industry's major and initial response was development of the educational video "All Washed Up," reviewed at last year's ITM not long after completion of its production. Subsequently, more than 160 copies have been purchased by 45 member companies of the OOC. Based on an industry survey specifically soliciting information on use of this educational video, which is now a standard part of training and safety programs, it was estimated that 10,500 employees of the oil and gas industry and their contractors have already seen the beach litter movie. Other public and private groups outside the petroleum industry have also acquired the video for their public awareness and education programs targeted at marine debris. The National Park Service put several copies to work as part of the PINS visitor information program. The value of the video as an educational tool was formally recognized last year when the OOC was presented the Department of the Interior's "Take Pride in America" Award for developing and using the video in promoting a sense of stewardship throughout the petroleum industry. Conoco produced a colorful hard hat decal with the slogan "Clean Rigs, Clean Water, Clean Beaches." OOC member companies have purchased over 15,000 decals from Conoco and make it a practice to present one to each employee who views the educational video. The message is now on and, hopefully, in the head of many of the offshore oil and gas workers in the Gulf of Mexico. Several companies have also issued statements on company policies regarding proper waste control and disposal, inserted stipulations in contractual agreements explicitly prohibiting contractors from disposing of solid waste in the marine environment, and developed posters for company bulletin boards. One company has even instituted a ban on the use of styrofoam cups at offshore platforms.

The oil and gas industry has also been very visible and responsive in the efforts organized to remove trash and debris from coastal beaches in Texas and Louisiana. They provided manpower, machinery, money, and supplies for these stewardship and data-gathering endeavors. Two companies have even adopted Texas beaches, agreeing to clean them up at least three times a year. Mobil Oil donated most of the bags used in both the Texas and Louisiana cleanups. For Louisiana's first and very successful statewide beach cleanup, the petroleum industry accounted for 25 percent of the sponsorship (19 companies); 10 percent of the volunteers were company employees and their families (over 300); over half the food provided for worker celebration parties, statewide, was donated by oil companies; and most of the heavy equipment used in accessing and removing trash from Louisiana's island beaches was provided by oil companies (7 helicopters, 7 crew boats, and 1 barge). Institutionally, the offshore petroleum industry manifested a renewed commitment to responsible disposal of solid waste generated offshore, and it has been very responsive to public and private efforts designed to encourage others to share stewardship responsibility for our coastal beaches. Although remnants of pervasive operations from our active offshore industries will likely always be detectable on our coastal beaches, expert opinion and research findings would indicate a substantial reduction in the loss of solid waste from offshore oil and gas operations.

Ms. Kathryn O'Hara, Marine Biologist and Science Advisor for the Washington, D.C. Office of the Center for Environmental Education (CEE), reported on the Gulf of Mexico marine debris education and awareness program they are developing and helping to implement. Noting that persistent marine debris is a national and international issue of increasing public concern throughout the United States, Ms. O'Hara related how the national Congress is increasingly supportive of legal and educational means aimed at reduction and elimination of marine debris, especially plastics.

In 1986, CEE was commissioned by NOAA to develop and distribute special marine debris education materials for the Gulf of Mexico. Educational efforts are currently targeted at groups and industries most closely associated with the problem, namely commercial fishing, merchant shipping, the petroleum industry, the plastics industry, and the general public. Public service advertisements and brochures are being distributed to industry trade journals and through industry associations explaining the problems caused by dumping plastics at sea, with recommendations on how each group can minimize its contributions to the problem. Slide shows, briefing sheets, and video educational products available to the petroleum and commercial fishing industries were viewed at each session. Additionally, CEE has been the lead organization in organizing, coordinating, promoting, and documenting the "Beach Buddy" Texas Coastal Cleanups in 1986 and 1987.

Through these cleanups, the public is made aware of the problems associated with marine debris and is encouraged and provided an opportunity to contribute to the solution. All educational and informational materials and reports on the marine debris developed and distributed by CEE are available through its office in Washington, D.C. (telephone 202/429-5609).

Mr. Frank Morgan, Deputy Commissioner for Land Management from the Texas General Land Office (TLO), described the popular and successful Texas Adopt-A-Beach Program. The program was instituted in 1986 by Land Commissioner Garry Mauro after his participation in the coastal cleanup organized by the CEE convinced him Texas beaches were beset with a garbage problem. Realizing Texans were spending big bucks on beach cleaning ($14 million a year), the Commissioner formed a 55-member Beach Task Force and began recruiting an all volunteer beach cleanup army. The task force is composed of representatives of the petroleum industry, local governments, environmental groups, and civic organizations that formed four very active subcommittees (legislation, education, research and prioritization, and finance), which already are impacting significant legal and attitudinal changes designed to effect long-term waste reduction.

Probably the most visible and successful task force accomplishment is the Adopt-A-Beach program, which relies heavily on volunteers and donations from the private sector. Adopting groups agree to maintain a designated segment of Texas beach for one year and are required to participate in two scheduled and one discretionary cleanup. Mr. Morgan indicated three essential elements for the success of the program: volunteers, county coordinators, and incentives for adopters. Most impressive is the accomplishment of the program to date. In less than a year all of Texas' 172 miles of accessible beach has been adopted by 139 groups. Texas now leads the nation in volunteer support for beach maintenance. Emphasis will now be placed on adopting less accessible beaches, expanding public awareness of the problem and its solution, and educational initiatives targeted at children. In his concluding statements, Mr. Morgan emphasized that state and local efforts and beach adoptions are only short-term remedies for a problem with national and international ramifications. The TLO has shown great leadership in seeking national and international support for legal mandates and in prohibiting the disposal of all solid wastes except foodstuff anywhere in the Gulf of Mexico.

The final presentations of the session consisted of a panel focusing on 1987 Gulf of Mexico beach cleanups. The cleanup coordinators from Texas, Louisiana, and the Gulf Islands National Seashore in Mississippi and Florida presented highlights of their cleanup day events. Impressively, over 10,000 volunteers from throughout Texas and Louisiana volunteered to "Lend a Hand in the Sand" on September 19, 1987, removing trash and litter from more than 200 miles of Gulf of Mexico beaches.

Linda Maraniss, Director of the Gulf States Regional Office of the CEE, reported on the second annual statewide Texas Coastal Cleanup and data collections. CEE has organized, promoted, and coordinated these cleanups primarily to focus attention on the increasing problem of marine debris, especially plastic, and its effect on living marine resources. Over 7,500 volunteer "Beach Buddies" combed 157 miles of Texas coastline for three hours on September 19 removing an estimated 309 tons of marine debris and beach trash. CEE has developed data forms that encourage volunteers to record trash items under the categories of plastic, glass, metal, paper, styrofoam, and wood. They analyze the data, attempt to identify sources, and publish reports on their findings with recommendations aimed at solutions to the problem. The 1987 cleanup produced 1,580 data cards from which preliminary analysis would indicate the litter load was composed of the following: plastic-56 percent, metal-13 percent, glass-11 percent, styrofoam-10 percent, paper-7 percent, and wood-3 percent. Plastic bags and bottles were the most common items recorded. Beverage containers composed 20 percent of the items collected. Their findings are very similar to those resulting from the 1986 Texas Coastal Cleanup. Final analysis will also rate 1987 findings by source in four categories including cargo, galley, operational wastes, and fishing gear. Many foreign items were noted, representing 14 different countries as well as stranded animals including fish, crabs, birds, sea turtles, and marine mammals. The TLO and oil and gas industry are among the major supporters of the Texas Coastal Cleanup.

Mr. Calvin Fair, director of the Louisiana Clean Team, summarized the highlights of the 1987 Louisiana "Sweep of the Beach." He, along with Margie Schoenfeld of the Louisiana Nature and Science Center's Recycle New Orleans Program, coordinated

Louisiana's first statewide beach cleanup. The previous two years they had organized and coordinated a beach cleanup at Grand Isle, Louisiana, as part of National Coastal Week celebrations. Mr. Fair was pleased to report over 3,300 volunteers from over the state picked up nearly 16,000 bags of trash, representing an estimated 200 tons of beach litter and debris from 85 miles of Louisiana beach front. Analysis of the trash load is being carried out by the Louisiana Geological Survey, and preliminary results were discussed previously by Ms. Dianne Lindstedt.

The MMS and the Louisiana Sea Grant College Program were instrumental in planning and organizing the 1987 Louisiana statewide cleanup, that was generously supported by the oil and gas industry with tremendous cooperation from local governments, the Sierra Club, other environmental organizations, civic and church groups, scouts, and private business.

Ms. Gail Bishop, National Park Service Interpreter for the Mississippi District of the Gulf Islands National Seashore, reported on the highlights of cleanup and marine debris education and awareness projects in Mississippi. With a late start, lots of enthusiasm, and valuable support and cooperation from the Mississippi Department of Wildlife Conservation, Bureau of Marine Resources, volunteers and staff were able to mount a marine litter campaign under the slogan "Stash Your Trash=Marine Litter is More than an Eyesore." Coastal newspapers, radio, and television stations were responsive to the campaign, which culminated in volunteer cleanups of several island components of the Gulf Islands National Seashore in Mississippi and Florida in mid-October. Approximately 100 volunteers worked over 700 hours and bagged an estimated 9,500 pounds of beach trash in Mississippi, and 50 volunteers removed 6,000 pounds in Florida. The Park Service provided data forms during these cleanups and determined an order of prevalence: metal cans, plastic bottles, plastic bags, and plastic lids are the major types of litter items impacting their recreational beaches. The Service concluded that the apparent sources of the majority of marine litter include people involved in commercial fishing and recreational boaters who accidentally or deliberately dump trash overboard.

The general concern and distaste for the deleterious effects of marine litter are evident by the increasing public and private response to the awareness campaigns and beach cleanups organized throughout the Gulf Coast region. Continued efforts to encourage public awareness of the problem through beach cleanups can reduce the blight and produce a database that will be useful in determining content and trends in beach trash over time and in targeting educational programs. This should continue to aid in identifying sources and effects on living marine resources as well as charting progress, encouraging institutional commitment to resolving the program, and developing individual pride in our coastal and marine resources. Taking the lead from the exceptional accomplishments of the TLO, the MMS Gulf of Mexico OCS Regional Office is the first group to adopt a Louisiana beach in hopes that other groups and states from Brownsville to Key West will do likewise and become part of the solution instead of the problem. The Director of MMS, through his "Take Pride Gulfwide" Task Force is encouraging the leaders of major Gulf industries and their regulators to work together in voluntarily finding and implementing feasible solutions to this problem. We are most pleased to note on page five of the report recently prepared by the CEE for the

TLO in support of Special Area Designation for the Gulf of Mexico under MARPOL Annex V that, "It is estimated only 10 to 15 percent (of the marine debris) has come from oil and gas operations, and with the combined efforts of the Texas General Land Office, the U.S. Minerals Management Service, and oil and gas operators themselves, that percentage is being reduced." This report was carried by the U.S. Delegation to the International Maritime Organization meeting in London, England, concurrently with the timing of the Gulf of Mexico ITM. We take pride in our progress and challenge all Gulf industries and states to join our efforts to solve this problem.

Mr. Villere C. Reggio, Jr., is an Outdoor Recreation Planner with the MMS Gulf of Mexico OCS Regional Office. His responsibilities include research, assessment, and reporting on the interrelationship of the OCS oil and gas program with the recreational elements of the marine and coastal environment throughout the Gulf of Mexico region.

Marine Debris on the Beaches of Padre Island National Seashore

Ms. Leslie Peart
Corpus Christi State University

The Environmental Affairs Committee of the Texas Coastal Marine Council (TCMC) reported that beach debris is an increasing problem beyond the control of Texas coastal governments. TCMC expressed concern that the debris reduces tourism, poses a health hazard, and has negative environmental effects. The committee also estimated that 75 to 90 percent of beach debris originates from offshore sources such as river, commercial fishing and shipping vessels, and offshore energy activities (TCMC 1985).

As a result of those statements by TCMC, the Minerals Management Service (MMS) formally solicited information about the beach debris problem and its relationship to the oil and gas industry through survey of Gulf of Mexico beach park administrators. The "Trash and Debris Scoping Report" of July 1985 listed unsubstantiated estimates of debris generated by the oil and gas industry, ranging from 70 to 95 percent of the offshore litter (Reggio 1985). In response to the survey by MMS, the Padre Island National Seashore (PINS) initiated this study of the accumulation of oil and gas generated debris.

The seashore was divided into three zones, reflecting the natural longshore drift zones occurring just offshore. Each natural drift zone was divided into 160.9 m (0.1 mi) units yielding zone lengths of 177, 100, and 300 units, respectively. Random numbers were used to locate a point in each zone from which a 160.9 m (0.1 mi) x beach width quadrant was established.

The polarity of the next random number, following that which established location, determined whether the quadrant was measured north or south of the sample point, even numbers being north. One site was determined for every ten miles of beach. All beaches that receive either regular or sporadic cleanup efforts were excluded from the study.

Once the sample plots were established, trash removal began. All trash was examined and classified as either "Domestic" or "Oil," and placed into a corresponding plastic bag. The bags were transported to the PINS Gulf Ranger Station where each was weighed. The "Oil" classification included only those items such as drilling mud containers and seismic equipment indigenous to the oil and gas industry. All items too large for transport were recorded but not removed from the beach. Sites were to be sampled monthly for one year.

Forty samples were taken from seven sites. Between 12 August 1985 and 12 July 1986, sampling was limited by availability of the PINS vehicle as well as beach driving conditions. Two clusters of data were obtained: 12 August -- 24 November and 13 April -- 12 July. Because the clusters of data coincided with the seasonal current patterns, it was decided that two easily accessible sites would be chosen and sampled bimonthly during October, November, April, and May. Daily accumulation rates were determined and expanded to estimate the annual accumulation of debris on PINS.

The mean total accumulation rate was 5.51 lbs per site per day. Daily total accumulation ranged from the minimum 0.81 lbs per site per day to a maximum of 17.06 lbs per site per day. Mean accumulation rates and ranges for domestic oil and gas debris are listed in Table 3.1. The mean total accumulation rate was expanded to estimate an annual accumulation rate of 580.21 tons per year on PINS during the period of this study (Table 3.1)

Total, domestic, and oil and gas accumulation rates were uniform from zone to zone, but each rate varied significantly from season to season. In all cases, the fall-winter rates exceeded the spring-summer rates. For example, the total fall-winter accumulation rate was 7.49 lbs per site per day compared to the mean spring-summer rate of 3.25 lbs per site per day (Table 3.2). Accumulation rates also vary by sampling period. The second sampling period was consistently lower than all other periods. Rates compared by sampling period can be found in Table 3.3.

Density was calculated in lbs per mile of beach face. The mean density for all samples was 1.4 tons per mile which translates to a mean standing mass of 80.70 tons of debris over the 57.7 miles of the PINS. When calculated, using data from the seven initial cleanings only, the density was 3.3 tons per mile and the standing mass was approximately 190 tons. If the initial cleanings are excluded when calculating density, the mean density drops from 3.3 tons per mile to 0.98 tons per mile. At this density, standing mass drops to 56.53 tons. These numbers represent a 70 percent decrease in standing mass and density. The decrease was achieved through an average cleaning rate of six times per year. Approximately 40 percent (40.06 percent) of the standing mass was oil and gas related debris, or 32.33 tons of the mean standing mass. The minimum standing mass of oil and gas debris was approximately 7.35 tons on PINS.

Recommendations for beach litter abatement must include efforts by all Gulf of Mexico and Gulf beach user groups. It seems a simple matter to estimate contributions to standing mass by each user group, but many items, such as galley wastes, are common to many user groups. Future studies might include relationships between fluctuations in user groups and standing mass or accumulation rate. It is clear that almost any amount of beach cleaning is effective in decreasing standing mass, so all cleaning efforts should be supported and/or maintained. Industrial and public school education programs should continue and should include some volunteer beach cleaning. Gulf states should legislate deposits on recyclable containers, such as aluminum cans. All Gulf and beach user groups must be involved or must share the blame for the beach litter problem.

Ms. Leslie Peart teaches chemistry and marine science at Mary Carroll High School in Corpus Christi. Miss Peart also conducts workshops on interactive teaching methods in chemistry education in association with the Institute for Chemical Education. Miss Peart is a candidate for the master of science degree in the Division of biology at Corpus Christi State University, and conducted this study as her thesis research.

Survey and Findings of Beach Debris on Mustang Island, Texas

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The University of Texas at Austin
Marine Science Institute

The survey has been conducted since April 1978 to study the long-term variations in bird population along a 12-km stretch of Mustang Island Gulf beach in South Texas. Demographic and environmental variables have been measured in an attempt to assess the effect of human activities and seasonal variability of the beach environment in this area. During the study period, an increase in its use for commercial and recreational fishing, merchant and military marine transportation, offshore oil and gas activities, tourism, and residential and industrial development has occurred. Despite a recent downturn in some of these activities, the incidence of man-made debris and litter on the barrier island beaches continues to be a problem for marine and beach animals, as well as severely detracting from the aesthetic appeal of the beach. The economies of local communities have been hurt by the negative publicity, as have the various industries (offshore oil and gas, shrimping, sport-fishing, tourism) frequently cited as the source of this debris.

Since 1983, the survey has included estimates of the quantity and type of beach debris, both natural and man-made. Over 1,000 observations have been made using a 0-5 rating system for some 40 categories of debris. In 1987, with the assistance of a grant from the Texas A&M Sea Grant Program, weekly counts of beach debris were taken, using the same technique developed for the bird surveys. A hand-held computer, with its keys reconfigured to allow single-keystroke entry for up to 256 categories of debris, was used to map the location and quantity of items along the entire 12 km (7.3 mi) study site. Distance-travelled was automatically entered into the record via an electronic odometer interfaced between the truck and computer. While this was being done, three 10-meter wide transects were cleaned from the shoreline to the high-tide line. Debris was collected and later sorted, categorized and weighed.

This method gives three scales of estimates on the amount and types of debris on Mustang Island beach: (1) the bi-daily gross estimates; (2) the weekly counts of items large enough to be seen from a slowly moving vehicle, and (3) the weekly "micro-trash" weighings. Methods 2 and 3 are being used to "calibrate" method 1. It must be pointed out that the error bars are often quite large for 1 and for some categories in 2, but are small for 3. Method 3, however, covers only three small beach zones, and extrapolating over the whole study site introduces further errors. The beach litter study business does not lend itself to high-precision results, and much remains in the realm of "detective work." This complexity is illustrated in Table 3.4 showing some of the factors, in addition to those introduced by the methodology, affecting the study of debris and litter on a barrier island beach.

How can these data identify the source of the debris and litter found on the Mustang Island beach? More specifically, can the data show what may be attributed to the offshore oil and gas industry? There is not room here to discuss all the aspects of this problem, and the large amount of data is not yet fully analyzed.

Manufactured items from at least 34 countries (identified principally from bottles of galley-type litter) have washed up on Mustang Island beach in the past three years (Table 3.5). Only man-made litter from the U.S.A. and Mexico can definitely be said to have floated from the country of origin. Although natural debris is known to come to our shore from Central America and the Caribbean (C. McMillan, personal communication), as have bottles (Corpus Christi Caller Times 1987), the bulk of the foreign "household" (galley) materials have come from fishing boats, or more often, merchant-marine vessels. Except for the U.S.-originated litter of this type, oil and gas platforms and rigs cannot be the source of such materials.

The foreign material is the most conspicuous because of its exotic nature, not because it is the most abundant form of litter. By far the greater amount of galley material is of U.S. origin: 1-gallon milk jugs, egg cartons, styrofoam frozen-food packs. The great majority of these are typical Texas supermarket brands such as HEB, Park Manor, IGA, and Hygeia, as well as items designated for institutional use. This leaves shrimping, commercial fishing, U.S. merchant marine transport, and oil and gas operators and their service industries as potential culprits. I exclude the recreational fishing industry from this list because of the institutional container sizes and product labels frequently found.

One category that I estimate under the code CHEM(icals) is definitely attributable to offshore oil and gas activities. Under this category come 55-gallon drums and the more abundant 5-gallon plastic pails and carboys of chemicals used in exploration and drilling. A decrease in the incidence of these items on the beach has occurred in the past two years. The decrease coincides with the downturn in drilling rigs operating in the Gulf and an increase in the companies' campaigns to educate offshore oil workers and to tighten littering regulations. Debris peculiar to associated activities, such as seismic surveying and the service and supply boats, continues to be found on the beach. These included write-protect rings, marker floats, and large plastic sheeting used to cover palletted cargo. The plastic sheeting has a long residence time on the forebeach and is difficult to remove during cleanup operations.

Rubber gloves, shrimp baskets, onion and sea-salt sacks, and Mexican bleach bottles can be attributed to the shrimping industry, while cold-chemical light sticks come from the longline fishing industry. Beverage cans, glass beer and liquor bottles, fast-food containers, and disposable picnic supplies may come from recreational fishing boats or may originate on the beach itself. Some kinds of driftwood, seagrasses, water hyacinth, mangrove seeds, and some household items originated in bays or rivers and were transported out to sea before being deposited on the beach. Certain items like cans, bottles, and food containers could have come from any or all of these sources.

Table 3.6 shows the results of all three methods of debris-estimating used for a single day, 28 May, 1987. Figure 3.1 is a map of certain categories of litter as they were distributed along the 11.8 km of beach on that same day. Notice that (a) the effects of beach-cleaning can be seen in the first 1/2 mile (City of Port Aransas jurisdiction) in the distribution of plastic bags, bottles and beverage cans; (b) a single, large Memorial Day weekend beach party at mile 1.4 shows as a spike in all of these (party-goers had left by the time of observation); (c) the location of people on the beach at the time of observation bears no relationship to the location of litter items; (d) the scavenging laughing gulls are attracted to the more littered beach areas; (e) the probing shorebirds are not affected by litter distribution; (f) natural debris is evenly distributed along the beach transect.

Mr. Anthony F. Amos was born and educated in England. He has training and experience in electronics research and oceanic circulation with special interest in polar oceanography. He is presently a Research Associate at the University of Texas' Marine Science Institute at Port Aransas.

Mr. Amos is the local observer for the National Stranded Marine Mammal and Turtle Networks, official cooperative observer for the U.S. Weather Service, and he maintains the tide gauge at Aransas Pass. He has an interest in photography and was awarded three prizes in the Audubon Society's 1983 Salon of Photography. Mr. Amos writes a regular column on the beach environment for a local newspaper and is editor of UTMSI's Newsletter and the institution's brochure.

Preliminary Findings for Beach Debris in Louisiana

Ms. Dianne Lindstedt
and
Mr. Joseph Holmes
Louisiana Geological Survey

PROJECT HISTORY

Litter along Louisiana beaches has become an increasingly significant issue: Every beach in Louisiana is marred by visible litter. Many local residents blame the offshore oil industry, shrimpers, or other fisherman for the litter problem, while others blame recreational fishermen, the shipping industry or the local residents.

The Coastal Management Division (CMD) of the Department of Natural Resources has developed a campaign to promote public awareness and to improve public education about litter in Louisiana's coastal zone. The Louisiana Geological Survey is conducting two studies to help determine the extent and the sources of beach litter in Louisiana. This will help CMD to focus its campaign where it will accomplish the most.

ACCOMPLISHMENTS

To assess beach litter, the Louisiana Geological Survey is conducting quarterly beach surveys and collected data during the statewide beach cleanup. These studies will provide the first quantitative information about the litter accumulating on Louisiana beaches. In addition, the studies should help determine some of the sources of the litter.

The first survey involves quarterly sampling of six beaches in Louisiana. Three of the beaches are in the eastern part of the state (Grand Isle, Fourchon, and Belle Pass), and three are in the western part of the state (Rockefeller Refuge, Oceanview, and Holly beaches). The beaches at Belle Pass and Rockefeller Refuge are not easily accessible to the day user and, therefore, should have acquired only litter that has drifted onshore.

On each beach, three 50-meter transects are checked four times a year. All pieces of litter within the transect are recorded by size and material. Notes are taken to indicate the type of item such as cleaners, food, condiments, or personal items (toothpaste, shampoo, shaving cream, cologne). Because we are still in the process of collecting these data, we have no findings on this part of the study to present at this time.

The second survey was generated by the statewide beach cleanup held on 19 September 1987. During the cleanup we distributed data forms to volunteers at 16 beaches: (Martin, Longview, Little Florida/Oceanview, Chaisson, Constance, Holly, Rutherford, and Dunn beaches in the western part of the state; Isles Dernieres, Timbalier Island, Fourchon, Elmer's Island, Grand Isle and Grand Terre beaches in the eastern part of the state; and North Breton Island in the Chandeleur Island chain. The data form resembled one used by Texas in 1986. It divided the litter into categories according to material (plastic, styrofoam, metal, glass, rubber, paper, and fishing gear). Each piece of litter was recorded under the appropriate category.

SIGNIFICANT FINDINGS

During the statewide beach cleanup, approximately 3,300 volunteers filled about 16,000 bags of litter estimated to weigh about 200 tons. Several large items such as 55-gallon drums, wood pallets, refrigerators, car parts, tires, and 5-gallon buckets also were collected.

Approximately 500 data sheets were returned to us; 400 were used for this analysis. Half of the returned sheets were from two beaches--Grand Isle and Fourchon in the eastern part of the state.

During the statewide beach cleanup 92,653 pieces of litter items were recorded on 412 data sheets. From this information, we estimate that 798,075 items were collected statewide. Our data sheets give a sample of the most commonly found items. Of the recorded data, 40 percent of the litter was made of plastic and 23 percent of styrofoam. Statewide, 36 percent of all the items collected were drink-related.

The five most common items were styrofoam cups followed by pieces of styrofoam, plastic caps and lids, 1-gallon milk or water jugs, and plastic bags. The most common items varied somewhat from beach to beach, but styrofoam cups were always either the first or second most common item. Other very common items were pieces of plastic, glass soft drink bottles, styrofoam food trays, beer and soft drink cans, and rope.

The source of the most common litter, styrofoam cups, cannot be attributed to any single group since everyone drinks fluids. It is reasonable to assume, however, that the cups are probably not coming from day users of the beaches since styrofoam cups also were the most common items on the barrier islands where there are relatively few day users. Styrofoam cups are floating up onto the beaches either from offshore oil rigs, merchant ships, or commercial and recreational fishing boats. Only a small portion of the litter can be traced to a sole source. Some of the litter that can be attributed to a single source are hard hats, write-protect rings, and pipethread protectors from the oil industry; light sticks, crab traps, nets, and salt bags from the fishing industry; and toys, diapers, fishing lures, and beer cans and bottles from recreational users.

Although several countries were represented in the litter (Mexico, Japan, Thailand, Belgium, Greece, Venezuela, and France), overall, a very small portion of the litter originated in foreign countries. Much of this type of litter comes from the maritime shipping industry and has not been disposed of by the country that manufactured the product. In addition, some common canned Oriental drinks can be purchased in Louisiana and are used by fishermen.

RECOMMENDATIONS

Although we have not completed the data analysis for either study, it is obvious from the beach cleanup results that proper disposal of everyday wastes could make a big difference. We could eliminate at least half of the litter found along Louisiana beaches if drink cans, bottles, and cups and food packages were properly disposed of by the industries and individuals who use them along the coast. Public awareness of this fact will be essential if the beaches are to be kept clean.

Ms. Dianne Lindstedt has a master's degree in marine science and has been working on Outer Continental Shelf (OCS) and coastal issues at the Louisiana Geological Survey since 1981.

Mr. Joseph Holmes has a master's degree in physical geography and has been with the Louisiana Geological survey since 1983, working on OCS and coastal issues.

Louisiana Coastal Recreation and Tourism Assessment Team: An Innovative University Approach

Mr. Michael L. Liffmann
Louisiana Sea Grant College Program

In 1986, as part of Louisiana Sea Grant College Program's (Sea Grant) ongoing effort, Sea Grant organized the LSU Ad Hoc Committee on Coastal Recreation and Tourism (Ad Hoc Committee) and the Louisiana Coastal Recreation and Tourism Assessment Team (LCRATAT). This was done to involve the university community in practical, marine-related matters.

The Ad Hoc Committee is composed of 13 faculty, staff, and extension specialists and aspires to (1) foster economic development in the coastal region through the conduct and provision of appropriate research and advisory services; (2) make coastal leaders and residents aware of the economic significance of the industry and the role it can play in stabilizing local economies; and (3) identify the resources, determine the extent of their use, and develop programs to capitalize on their potential.

Limited financial and manpower resources, along with severe data limitations, prompted the Ad Hoc Committee to immediately undertake activities related to the third objective. To this end, it designed a novel approach (LCRATAT) that combines data gathering and analysis techniques, as well as training and technical assistance for parish and community leaders. LCRATAT members are selected from the university and public and private sectors, and are asked to participate in a series of rapid, intensive and low-cost studies designed to provide the local interests with road-maps for the development of recreational and tourism resources. To date, two such studies have been conducted (Cameron and St. Mary parishes) and an additional one is planned for St. Bernard Parish in 1988.

The Cameron and St. Mary studies, along with a project being conducted by the Ad Hoc Committee for the Southern Rural Development Center, and Sea Grant's active involvement in Louisiana's Coastal Cleanup '87, have enabled us to make the following observations regarding Louisiana's beaches. We also have some opinions concerning public perceptions and impediments to the development of beaches and other coastal resources.

STATUS OF INTEREST IN LOUISIANA BEACHES

Louisiana's official shoreline is only 216 miles long, yet the crenulations add 15,000 miles to the total length of the coastline. Despite these figures, beach resort development has been rather limited. Several reasons can be cited: highway access problems and relative remoteness from major population centers; sand-deficient beaches and muddy nearshore water; eroding shorelines; frequent tropical storms and hurricanes, and litter and debris-strewn beaches. The single largest attraction for the visitors to the state's beaches is sport fishing.

Two major beach recreation areas have developed in Louisiana: Grand Isle and Cameron. Some development has also taken place in the vicinity of Cypremort Point. A survey conducted by D.L. Gary and D.W. Davis in 1979 concluded that there are nearly 1,400 recreational camps in Grand Isle, a 7.5 mile long barrier island located 50 miles south of New Orleans. Grand Isle is clearly the premier Gulfside resort in Louisiana.

Data furnished by the Louisiana Office of State Parks (OSP) to the U.S. Army Corps of Engineers indicate that, during the April to September peak season, some 3500 persons visit Grand Isle each week. According to OSP, half of these visitors are day-trippers; they reside in the area motels or camp on the grounds of Grand Isle State Park. The remaining visitors stay in the area's aforementioned recreational camps. It is difficult to establish recent visitation trends to the State Park, as public works projects and several recent storms have shutdown or limited park operations. Calendar year statistics for 1985 show that nearly 52,000 campers and day-users made use of the facilities. According to OSP, 23 percent of these individuals were from out-of-state and a similar percentage represented senior citizens. Total visitations rose to 85,500 in 1986, but indications are that the 1987 figures will decline somewhat.

The Cameron area in southwest Louisiana has approximately a dozen recreational settlements along 30 miles of accessible shoreline. There are some 800 structures, 400 of which are recreational camps. Holly Beach is the only settlement that offers a significant commercial infrastructure, although some service and retail establishments can be found in Rutherford Beach and Constance Beach vicinities. The so-called Cajun Riviera is frequented primarily by regional residents, but visitation statistics are not available. Anecdotal information obtained from local law enforcement agencies indicates that crowds of 10,000 persons on the 4th of July are not uncommon.

Cypremort Point State Park is located on Vermilion and West Cote Blanche bays along the border between Iberia and St. Mary parishes. An artificial, 0.5-mile-long beach was constructed in the mid-1960's, and 221 recreational dwellings are found in the vicinity. Recent statistics point to a steady decline in visitations between 1985 and 1987 to-date. In 1985, over 67,000 persons visited the State Park. In 1986, there were only 51,000 visitations, and the 1987 year-to-date figure is below 44,000. OSP officials attribute this decline to the adverse publicity associated with the closure of other facilities around the state, and the public's erroneous impression that Cypremort Point was also closed. Nearly 75 percent of the beach goers are from the nearby New Iberia/Jeanerette/Lafayette areas.

PERCEPTIONS OF PUBLIC OFFICIALS REGARDING BEACH AND OTHER COASTAL RECREATION AND TOURISM RESOURCES

Louisiana officials have frequently stated a desire to promote the state's coast for tourism and recreation purposes. Leaders agree that if they are to succeed, it is vital that all possible precautions be taken to insure that visitors have favorable experiences. If visitors criticize Louisiana's beaches and marshes as being filthy, other visitors are likely to stay away. Tourism is Louisiana's third largest industry, and travel expenditures reached $3.8 billion in 1986. The state's leaders have recognized the uniqueness and importance of beaches and coastal resources for the generation of tourism activities and have indicated a strong desire to increase the relative significance of this industry in the state's economy.

The same officials concede that the development of beach recreation and tourism is impaired by the marine litter and debris problem. They are of the opinion that it must be dealt with if the state and its subdivisions are to generate additional revenues from beaches and other coastal attractions. The topic has not been a high priority to date, although in the last year, or so, state and local government agencies have been demonstrating a keener interest in resolving the problem. No doubt, unaesthetic beach resources reduce the recreational enjoyment and discourage tourists from visiting the coast. It is a well known fact, that adverse events such as shark sightings, jellyfish, oil spills, foul weather, park closures, litter, nd unsightly conditions adversely affect visitations.

Furthermore, it is the consensus of leaders of coastal parishes and communities that (1) there is an urgent need to diversify the region's economic base by reducing the dependence on the oil and gas and cyclical fisheries industries; (2) their parishes and communities possess the attractions sought by tourists and recreationists; and (3) only a few dollars and technical assistance are needed in order to convert the tourism development opportunities to reality.

IMPEDIMENTS TO DEVELOPMENT OF RECREATIONAL AND TOURISM RESOURCES

Unfortunately, assistance and cleaner beaches and marshes will not, by themselves, overcome the obstacles associated with Louisiana's coastal tourism. Indeed, the obstacles reflect a broader shortcoming which LCRATAT has come to refer to as TOURISM PREPAREDNESS. It is the lack of such preparedness on the part of local, and to a large extent state, agencies that is the single most notorious impediment.

It is quite evident that there is no tourism development strategy for the state and region. This is an unfortunate legacy of the boom times, when the state's private and public leadership did not have to deal with planning for the medium and long-term future. In fact, there has been a myopic outlook toward the future. Planning for development and growth has been largely in anticipation of, or in reaction to, near-term economic circumstances. In order to overcome this impediment, strategies or road-maps need to be formulated and implemented. Only then will opportunities be converted to realities. Broad guidelines for development, as well as goals and objectives, that will serve to shape future tourism development in the region must be prepared. This process, known as strategic planning, concerns itself with how a community/parish/region wishes to relate to its environment and, thus, how its resources are to be developed. This type of planning is a broad-based, community approach from which leaders develop project and business plans. The State, its regions, and most of its communities have confused strategic and project planning and have encouraged or embarked on projects in "anticipation of or in reaction to near-term economic circumstances," rather than trying to shape the future through careful analysis and extensive input.

The same confusion and desperation that led most leaders to rapidly embrace tourism development as a diversification opportunity has led to a serious void in the public-at-large's understanding of how this industry does and does not work, its fundamental differences with the oilfield and fisheries-related industries, and what role it can play in helping stabilize local economies. LCRATAT has identified numerous situations where local businessmen have, or are prepared, to make heavy investments in tourism development projects with little or no knowledge about markets, business plans, competition, etc. The basis for such risk-taking is usually a perception based on little more than gut reactions to what they read or see in the media. Every community is affected by tourism, be it through the purchase of gas, food, lodging, attractions, etc. But whether a community tries to develop tourism as an industry will depend on (1) whether there is a broad-based community interest in it; (2) what community needs would tourism meet; and, finally, (3) whether the benefits of such a program outweigh the costs. Strategic planning can help answer these questions.

Not only is the community's lack of an understanding of the industry manifested in investment practices, but it is also evident on two other fronts: (1) the lack of attention given to the visitor services or hospitality sectors and (2) the appalling litter and debris problem. Tourism development programs in coastal Louisiana have, by and large, been limited to the generation of informational and promotional materials. Very little has been done to acquaint the persons (gas station attendants, restaurant and hotel employees, etc.) that meet the travelling public with the value of tourism, proper behavior, other attractions and amenities in the region, etc. While we have found the visitor services sector eager to learn, it is clear that efforts must be directed at training for preparedness purposes.

Tourists don't like trashy places, and coastal Louisiana, in particular, has a notorious tradition of disposing of litter and debris in its roadways, waterways, marshes, beaches, Gulf of Mexico, and even backyards. The problem has been exacerbated by the fact that nearly 60 percent of the nation's waters drain through the state, the waste disposal practices of the oil and gas industry, commercial and recreational fishermen, and the maritime shipping community. No one is to be singled out for blame. We have all contributed to the problem as we have taken our environmental bounty for granted. Educational programs must accompany the enforcement of litter and waste disposal laws, and there is evidence that Louisiana is making a concerted attempt to shed this lackadaisical attitude. State and federal agencies, our own Sea Grant program, and numerous private organizations and individuals are committed to working together toward the goal of a cleaner state.

CONCLUSION

When Sea Grant, The ad Hoc Committee, and LCRATAT first embarked on this mission of identifying obstacles and opportunities for the orderly development of Louisiana's coastal tourism and recreation resources, we did not realize that this industry was really in its infancy. Data, news accounts, interviews, and anecdotes suggested that we could proceed with identifying public and business opportunities that would attract tourists. It is evident, however, to us that we must return to basics. Leadership and community development training programs must be designed if coastal Louisiana is to realize its full potential. Eagerness and goodwill are no replacements for knowledge and understanding.

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Mr. Michael L. Liffmann is Assistant Director of the Louisiana Sea Grant College Program, a component of Louisiana State University's Center for Wetland Resources. Formally, Mr. Liffmann had been Assistant Director of LSU's Ports and Waterways Institute and worked with Gulf South Research Institute as Manager of Resource Planning and Management Development. Mr. Liffmann is an economist by education and a native of Columbia, South America. He directed and coordinated Sea Grant cooperation and support for the Louisiana Coastal Cleanup, has testified before the U.S. Congress on the Marine debris issue, and formed and coordinates the activities of the Louisiana Coastal Recreation and Tourism Assessment Team.

NOAA's Marine Entanglement Research Program: Goals, Products, Information, and Plans

LCDR Alan R. Bunn
National Oceanic and Atmospheric Administration

PROJECT HISTORY

The introduction of synthetic materials, or "plastics," is considered to be one of the most important technological advancements for modern industry. Fishing gear, cargo nets, lines and ropes, plastic strapping bands and sheeting, and typical domestic galley refuse are increasingly manufactured from plastic. The very qualities of these new synthetic materials that make them an almost universal substitute for natural fiber materials--their lightweight, strength, durability, and low cost--are the basis for the problems they are causing as debris in the marine environment. Refuse from many maritime activities continues to be dumped over the side, much as it was over a century ago. These materials are not only an aesthetic problem, but are known to damage many marine animals, including fish, birds, crabs, lobsters, marine mammals, and others (including some commercially viable target species). Debris can also interfere with vessel operations and ultimately crew safety through propulsion or steering entanglement and engine damage through intakes.

In 1982, the National Marine Fisheries Service (NMFS) review board recommended that a workshop be convened to address the issue of marine debris. Thus, the Workshop on the Fate and Impact of Marine Debris was held November 27-29, 1984, in Honolulu, Hawaii. The Working Groups concluded that a number of studies were needed. They recommended the establishment of an educational initiative and that the NMFS designate a program coordinator for marine debris activities.

Congress, in fiscal year (FY) 1985, appropriated $1,000,000 in funding and directed NMFS to develop a comprehensive research and management program addressing the marine debris issue in consultation with the Marine Mammal Commission. Subsequently, a member of the Northwest and Alaska Fisheries Center Staff, James M. Coe, was designated the program manager for the NMFS Marine Entanglement Research Program (MERP). Congressional appropriations for FY86 and FY87 were for $750,000 each year. The FY88 budget is based on a continuing resolution of $750,000.

A set of project tasks was identified and categorized into three major areas: 1) education and public awareness; 2) research and impacts assessment; and 3) mitigation. These tasks, many in the form of contracts, began in late 1985 and many will continue through 1988.

The education and public awareness component is designed to increase the knowledge of industrial, commercial, and general public contributors about the impacts and control of marine debris. Educational tasks include 1) education program development and implementation for the Gulf of Mexico, Atlantic, and North Pacific regions; 2) beach clean-ups and reports; 3) developing a report of standard methods for assessment of debris in the marine environment; and 4) evaluations of education program effectiveness.

The research and impacts assessment tasks are designed to increase our understanding of the origin, amount, distribution, fate, and effects of plastics and other synthetic debris in the marine environment, as well as how these materials may be removed. A number of research tasks have been undertaken over the course of the program including 1) the role of entanglement in the population dynamics of marine mammals; 2) the sources and dynamics of litter on beaches through surveys; 3) the rate of net discard from fishing vessels; 4) the hazard dynamics of derelict monofilament gill nets; 5) incidental take rates in high seas driftnet fisheries; 6) prevalence and physiological impacts of plastic ingestion by cetaceans, sea turtles, and birds; 7) methods development for assessing density and distribution of marine debris; 8) impacts of floating plastic debris on pelagic ecosystems; and 9) entanglement rates of endangered Hawaiian monk seals and sea turtles.

Mitigation projects are directed toward reducing the amount of non-degradable material that is disposed of directly, or indirectly, in the sea. Tasks have included 1) synthesis of available information on existing, refuse-handling technologies applicable to ships; 2) research on degradable materials and technologies; 3) studies of port reception facilities for marine debris; 4) survey of disposal methods; 5) evaluations of plastic recycling systems; 6) assessment of various shipboard incineration systems; 7) development of guidelines for implementation of international regulations to control vessel sources of marine debris (MARPOL Annex V). NOAA continues to work actively with appropriate international organizations and federal agencies on many aspects of the marine debris issue.

The paper presented at this MMS/ITM is referenced as NWAFC PROCESSED REPORT 87-15, entitled "Description and Status of Tasks in the National Oceanic and Atmospheric Administration's Marine Entanglement Research Program for Fiscal Years 1985-1987" by James M. Coe and Alan R. Bunn. The report gives comprehensive descriptions of the tasks comprising the MERP for each fiscal year since its inception, including a note on the status of each as of July 31, 1987, and a summary table showing the distribution of funds.

ACCOMPLISHMENTS

NOAA's MERP has been recognized as one of the leaders in existing studies and information directed at the problem of synthetic marine debris. It has gained this status through the assistance of a number of contractors and principal investigators working together in an area of study with far more unknowns than knowns. Even so, an ever increasing number of scientists, commercial manufacturers, fishermen, boaters, merchant interests, commercial manufacturers, coastal enthusiasts, and others are becoming increasingly aware of the growing oceanic problems of marine debris. And even more important, these groups are willing to seek means or methods of reducing the problem.

A number of local and federal legislative proposals are a result of a new awareness of the problem. Approximately 13 states are now requiring that plastic beverage yokes, responsible for a number of instances of entanglement, be degradable. Certainly, most states have general littering ordinances, many of which are increasingly enforced on state waterways. There are several national bills being considered to implement legislation that would stop the dumping of persistent plastics within all U.S. waters and even on the high seas by U.S. flagships. Because marine debris on the oceans is an international problem, solving it will ultimately require international legislation such as the Convention for the Prevention of Pollution from

Ships (MARPOL Annex V). Enforcement may prove difficult, but the regulations would, at the least, make the sources aware of the efforts and the rationale for reducing marine debris. Efforts directed at our research fleets have resulted in proposed directives within our own NOAA fleet and the U.S. Coast Guard for increased precautionary measures. Several university fleets appear to be reviewing their own practices of dumping refuse over the side.

Equally important are the number of commercial interests, organizations, and special interest groups that have begun addressing means of policing from within to reduce their own input of debris. Renewed research in a number of alternatives, including recycling, incineration, compaction, recovery, and degradability is a direct result of the new awareness.

The MERP is responsible, both directly and indirectly, for numerous national, regional, state, and local marine debris task force groups. The MERP has also been the impetus for a number of beach cleanups. Most all of these accomplishments are in part due to the new awareness of the problem made possible through the education and public awareness efforts of NOAA, NMFS, MERP, and educational contractors for the program--Natural Resource Consultants of Seattle, and the Centaur/Center for Environmental Education contractors of Washington, D.C. There have been a huge number of other organizations ranging from plastics manufacturers to commercial fishing organizations to environmental groups, all of who have contributed in furthering the goal of reducing the hazard of marine debris in our oceans.

SIGNIFICANT FINDINGS

While further studies are necessary to understand all of the biological impacts of plastics on marine life and seabirds, especially at population levels, the physical effects of plastics are apparent. In the North Pacific, the northern fur seal of the Priobilof Islands has recently been declining at a rate of between 4 to 8 percent annually. Scientists believe that this is primarily the result of entanglement. The Hawaiian monk seal is known to become entangled in derelict fishing gear, and present populations are so small that any additional source of mortality may threaten the continued existence of the species.

Of the 280 worldwide species of seabirds, 50 (18 percent) are known to ingest plastics. In Alaska, 15 to 37 species (40 percent) have been found to have ingested plastics.

Sea turtles, classified as either "threatened" or "endangered" depending on species, have become notorious for ingesting plastic bags which they apparently mistake for jellyfish.

Although amounts of lost and discarded fishing gear is not precisely known, some investigators believe that, worldwide, it may amount to over 100,000 metric tons per year, which can continue to entangle and "ghost fish" a variety of marine species.

Debris sighting surveys from a number of vessels have indicated that the majority of floating items identified are plastic. Major percentages of debris found on remote beaches in Alaska as well as on Sable Island off Canada in the North Atlantic were plastic.

The revolution in consumer product packaging in plastic is increasing drastically. An increase from a current use of 4 billion pounds of composite plastics per year to 16 billion pounds by the year 2000 is anticipated.

RECOMMENDATIONS

The following is a partial list of ways individuals can combat persistent plastic marine debris:

1. Take the minimum amount of nondegradable products on board vessels and to beaches.
2. Use bulk containers for drinks and other products in order to better control and manage their disposal.
3. Make maximum use of disposal technology, including the compaction and incineration of waste aboard vessels large enough to accommodate such facilities.
4. Retain net fragments, fish line, bait bags, plastic convenience products, and other kinds of potentially harmful debris for disposal ashore, preferably at recycling stations. For ports without such facilities, encourage authorities to provide them.
5. Recover and return any derelict fishing gear encountered at sea if possible.
6. Encourage anti-litter efforts, including the placement and use of trash cans on beaches and at marinas.
7. Support volunteer litter cleanups of beaches.

Most all of us should recognize that it is in our own best interest to do something about marine debris in order to have plentiful resources and a clean ocean. If we as a society are going to utilize and benefit from the advanced technology of synthetics, then we must accept the inherent responsibilities of proper disposal.

LCDR Alan R. Bunn has been a commissioned officer of the NOAA Corps for twelve years. He is presently the assistant program manager of NOAA's MERP located at the Northwest and Alaska Fisheries Center, 7600 Sand Point Way, Seattle, Washington, 98115. He received his BS degree from Texas A&M in Marine Science and a master's in marine affairs from the University of Rhode Island. He has served on a number of NOAA's oceanographic and fisheries research vessels including, most recently, a tour as Operations Officer and Acting Executive Officer on the NOAA Ship Miller Freeman which has conducted a variety of studies off Alaska in the Bering Sea. His other assignments within NOAA have included fisheries gear development and technology, as well as a variety of diving operations. Personal field observations of increasing amounts of floating marine debris and incidence of marine life and vessel entanglement and disablement over the years have enhanced his interest in marine debris and marine entanglement studies.

The Offshore Oil and Gas Industry's Campaign to Stop Offshore Littering

Mr. Wayne Kewley
Offshore Operators Committee

The Offshore Operators Committee (OOC) is an organization of approximately 70 companies that conduct essentially all the oil and gas exploration and production activities in the Gulf of Mexico, its adjoining coastal area, and the Atlantic Ocean. The OOC was formed in the early 1950's to provide a mechanism for the offshore industry to interact with the various agencies that regulate it. With passage of several major environmental laws in the 1970's, OOC activities are increasingly related to environmental issues, such as the problem with marine debris impacting Gulf beaches and fish and wildlife resources. The OOC has no paid employees to address the many issues coming before the organization. Rather, professional employees of member companies donate their time to further both the interests of industry as a whole and the private and public groups that are concerned with responsible use of marine resources.

Offshore litter washing up on the Gulf of Mexico beaches has been an especially severe problem in Texas for many years, but environmental and regulatory agencies did not extensively publicize the issue until 1984. In that year, the state of Texas cut beach cleanup funds to coastal counties which then became hard-pressed to raise additional revenue to compensate for lost state funds.

Even with state support, coastal counties had been unable to adequately clean their beaches; without it, they foresaw even more complaints from tourists who were already voicing their disgust with heavily-littered Texas beaches. Recreation and tourism is the third largest industry in Texas, and it was estimated in 1984 that about a third of the tourism expenditures, or $4.5 billion, was spent in coastal counties. While the counties were anxious to bring this debris problem to light, they did not want to have the news media tell the public that Texas beaches are consistently littered.

Later in 1984, however, National Park Service officials at Padre Island National Seashore (PINS) began speaking to the press about the overwhelming litter problem they were experiencing on the 70 miles of the national seashore in South Texas. Currents from the north and south which converge in the area of the national seashore bring marine debris from across the Gulf onto its beaches. Especially troublesome were the large number of 55-gallon drums that were washing ashore. The drums were not only an aesthetic problem, but because many of them contained unknown and potentially toxic chemicals, the Coast Guard's Marine Safety Office had to be summoned to pick up and properly dispose of the drums and their contents at great expense to the public.

In January, 1985, the Texas Coastal Marine Council issued a report that summarized results of a study of the state's beach litter problem. The report stated that 75-90 percent of Texas's beach litter was coming from offshore sources. It also inaccurately implied that offshore production platforms and drilling rigs were allowed to dispose of solid wastes into the Gulf of Mexico. In actuality, regulations already well established in 1984 made it illegal for oil and gas operators to dispose of solid waste into the Gulf. Only food scraps from the galley can legally be discharged from offshore platforms and rigs.

Although solid waste from rigs and platforms cannot legally be disposed in the Gulf, the presence of oilfield-related materials on Gulf beaches initially indicated that the offshore industry was a major contributor to the beach litter problem. As the primary agency regulating the offshore industry, the Minerals Management Service (MMS) urged the OOC to take appropriate action to solve this problem. The OOC decided that producing an educational videotape on the problem would be an effective voluntary action to increase awareness of this problem among offshore oil and gas employees and reduce the industry's contribution to beach litter.

The 13-minute movie, entitled All Washed Up, was completed in May 1986. The basic concept of the movie is that a change is needed in the apparent perception of some workers that offshore litter does not affect anyone. Three fictional offshore workers are shown deliberately, or accidentally, causing solid waste materials to enter the Gulf. These workers later encounter the same type of trash on the beach during their days off and make the connection that their actions offshore can impact coastal areas they enjoy using.

The OOC has received very positive feedback on the quality and usefulness of the movie, particularly from the National Park Service, which has purchased several copies. The movie is being shown to visitors to the national seashore to educate them on the source of litter they see on the beach. In October 1986, the Department of Interior presented the OOC its "Take Pride In America" Award for producing the movie and thereby promoting a sense of stewardship among offshore employees. More than 160 copies have been purchased by 45 member-companies of the OOC.

Since the movie was made available in the summer of 1986, the OOC has continued to keep its member-companies involved with the beach litter issue in a number of ways. At the two general membership meetings held this year, attendees were informed of latest developments and encouraged to continue their efforts to make their employees and contractors aware of the impacts of offshore littering. The attendees were also given advance notice of the 1987 beach cleanups in Texas and Louisiana and urged to support the cleanup day activities. In July 1987, OOC's chairman followed up on this advanced notice by sending each member-company a letter which gave more specific information on the needs of the cleanups's organizers.

Several OOC-member companies responded to the request for help and were among the many volunteers who made this year's Louisiana and Texas beach cleanups so successful. In Texas, Mobil, Tenneco, and ARCO employees helped pick up litter. Mobil also donated all the plastic garbage bags for the entire Texas coast. Twelve other offshore operators helped transport the collected trash off the beach.

In Louisiana, oil and gas companies were key participants in the beach cleanup; particularly important was the role these companies played in transporting volunteers to several outlying islands that were included in this first statewide cleanup. Mobil provided 200 volunteers and the plastic garbage bags for the cleanup in Cameron Parish. At the Grand Isle Zone, more than 60 Conoco volunteers wore especially-made T-shirts with the slogan "A clean beach is within your reach" as they picked up trash. The Grand Isle Zone also received help from Tenneco, which used five helicopters to transport 30 Tenneco employees to Grand Terre Island. Shell also provided food and beverages for the zone's participants. Shell also provided helicopter transportation for volunteers cleaning up the Chandeleur Islands. At the Timbalier Islands, boats and volunteers were provided by Chevron, Texaco, Tenneco, Sun, 2-R Drilling, and Louisiana Land and Exploration. Amoco provided major funding for the cleanup of Lafourche Parish beaches. The OOC hopes that even more companies will participate in the 1988 cleanups to follow up on this year's strong show of interest and support.

While participation in beach cleanups provides a graphic illustration of the problem, the OOC's primary emphasis continues to be educating offshore employees to stop offshore littering at its source. The July

1987, beach litter update sent to all members also included a questionnaire on how they were taking the anti-litter campaign to their employees.

Responses to the questionnaire show that essentially all the major operators in the Gulf are using the OOC-produced movie All Washed Up at regularly-scheduled safety meetings, which often include presentations by company personnel on environmental and regulatory affairs. Several companies are also using it at internally taught environmental or regulatory seminars and orientations of newly hired individuals; it is at forums like these that offshore employees learn about the practices they must follow when working offshore.

Based on information gathered from the responses, an estimated 10,500 employees of the oil and gas industry and their contractors have seen the beach litter movie. Several companies have shown the movie to crews of the workboats and crewboats that support their offshore operations. Only a few companies have shown the movie to crews of seismic vessels.

Many companies are giving hardhat decals to those who see the movie. The six-color decals, with the slogan "Clean Rigs, Clean Water, Clean Beaches," was developed by Conoco and offered to OOC members, who have purchased more than 15,000 of them.

Several operators have also issued statements on company policies regarding proper waste disposal and support for helping to solve the marine debris problem. Others have developed posters for bulletin boards. Conoco has instituted a ban on the use of styrofoam cups at offshore platforms; this suggestion was made to Conoco management by an offshore employee who participated in the Grand Isle beach cleanup and was especially disgusted with the number of styrofoam cups littering the beach.

Feedback on the responses to the questionnaires will be included in another general membership mailing early in 1988. Attendees of the general membership meeting in January 1988, will hear a summary of the responses and a review of developments on the beach litter issue since the last meeting. The OOC hopes that feedback from the questionnaires and regular updates on the issue will spur additional efforts on the part of its members to keep interest and awareness high.

One bit of feedback from the industry's awareness campaign is especially gratifying to the OOC. Superintendent Bill Lukens of Padre Island National Seashore is reporting a significant decrease in the number of 55-gallon drums that have been washing ashore along the national seashore since the OOC began the campaign, as shown in the following table:

Time Period	Drums Picked Up
Jan-Jun 85	150
Jul-Dec 85	87
Jan-Jun 86	82
Jul-Dec 86	28
Jan-Jun 87	23

While there could be several reasons for the noted reduction, the dropoff in the number of drums after the industry's anti-litter campaign began in June 1986. This offers hope that active educational programs can show concrete results. The OOC challenges other industries that operate in the Gulf of Mexico and use products in 55-gallon drums to educate their employees on the problems of improper care and disposal of the drums.

One deficiency noted from the responses to the questionnaires will specifically be brought to the attention of OOC members. As previously noted, only a few companies have educated seismic crews about the beach litter problem. In August 1987, MMS Director William Bettenberg, perhaps anticipating this deficiency, sent letters to members of the International Association of Geophysical Contractors to request its assistance in ensuring that solid waste that is generated during seismic surveys in the Gulf of Mexico is brought ashore for proper disposal. Seismic surveys are the most likely source of the "write-enable" plastic computer rings which are commonly found on Texas beaches. These rings could cause entrapment problems for fish and wildlife resources found in the Gulf and on its adjoining beaches.

Conoco and Mobil have already responded by altering their contracts with seismic survey companies to include the following provision:

> (the company) will not knowingly hire any Contractor who does not comply with the State of Texas General Land Office requirements forbidding the discharge of solid waste and garbage into the Gulf of Mexico. Contractor's vessel while working for (the company) will
>
> 1. Not discharge any solid waste or garbage into State or Federal waters.
> 2. Display a sign stating "Discharge of any solid waste or garbage into Gulf of Mexico from this vessel is strictly prohibited and subject client to a State of Texas lease forfeiture." The sign letters must be at least 1" in size and displayed in a place conspicuous to all personnel on board.

Other companies may be taking similar actions, but because they would have been initiated after the questionnaire was submitted, more details are presently unavailable. The OOC will urge support among its membership for Director Bettenberg's recommendation for onshore disposal of solid wastes from seismic vessels.

The offshore oil and gas industry is also expecting soon to receive education and training materials developed by the National Marine Fisheries Service's Marine Entanglement Program. The OOC provided input to the contractor who is developing these materials so that the materials will be compatible with the industry's current educational campaign.

The OOC is proud to support efforts to stop marine debris from fouling our wildlife and beach resources. When the marine debris problem was first coming to light four years ago, the offshore industry was believed to be one of the primary sources. As more information has become available, it now appears that offshore platforms and rigs operating in U.S. waters are not a major source of the litter found on Gulf beaches. As stated in an article from the Summer 1987 issue of Texas Shores, a Texas A&M Sea Grant publication, the offshore oil and gas industry is often perceived as a primary culprit because "the litter source perceptions imply a visual connection between the sight of the litter." In the same article, Dr. Robert Dittion, a tourism expert in Texas A&M's Department of Recreation and Parks, cautions, however, that the offshore industry must be "sensitive to the fact the people think those platforms are responsible for the litter problem."

Whether a major or minor contributor to the problem, the OOC plans to heed that cautionary remark by continuing an active campaign to eliminate all litter coming from the offshore oil and gas industry.

Mr. Wayne Kewley is employed by Conoco Inc. as the New Orleans Division Coordinator for Environmental Affairs. He serves as Chairman of the Fisheries Advisory Subcommittee of the Offshore Operators Committee. He received a B.S. Degree in Zoology from the University of Illinois and has done graduate work in aquatic sciences at Colorado State University and in public affairs at the University of Houston. Before employment with Conoco, he worked for the U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

Education and Awareness: Keys to Solving the Marine Debris Problems

Ms. Kathryn J. O'Hara
Center for Environmental Education

Marine debris, once considered to be merely an aesthetic problem, is now the focus of national attention. In recent months, the problems caused by marine debris, particularly plastics, have been reported in national publications including U.S. News and World Report, Newsweek, and Businessweek. This problem has also been featured on the front page of the Boston Globe, New York Times, Washington Post, Houston Chronicle, and Los Angeles Times, in addition to extensive coverage in local media, trade journals, brochures, posters, and bumper stickers across the country. This publicity has done much to bring the problems caused by marine debris to the public's attention. Why else would more than 25,000 people in 19 coastal states go to the beach this fall to collect trash? More than 10,000 of them participated in beach cleanups in the Gulf of Mexico.

Congress has also become increasingly aware of the problems caused by marine debris. On April 2, 1987, 30 U.S. Senators sent a letter to the President requesting that action be taken to mitigate problems caused by marine debris. As a result of this initiative, an interagency task force has been established to assess current federal efforts and to provide recommendations for addressing the marine debris problem. During the 100th Session, 10 bills were introduced pertaining to the problems caused by plastic debris in the marine environment and wildlife entanglement. On October 10, the House passed a bill (H.R. 940) that would prohibit the disposal of plastic wastes from ships at sea and require measures to facilitate enforcement. And on November 5, the Senate gave its unanimous consent to ratification of Annex V of the MARPOL Protocol, which will place international regulations on the disposal of garbage from vessels at sea.

Based on this growing public awareness and Congressional action, the process has begun to address the marine debris problem. But what about the groups that have been identified as sources of marine debris? How will they respond to increasing public pressure and new laws that will make the centuries-old practice of tossing trash over the rail illegal? More important, most laws that govern ocean-based activity have major enforcement problems since it is obviously impossible to patrol an area that covers more than two-thirds of the earth's surface. Therefore, solutions to the marine debris problem will largely rely on voluntary compliance among these groups. But how can this be achieved?

In order for those engaged in ocean activities to understand the importance of these new laws, they must become aware of the basis for these actions. They must first understand that plastics are a different kind of trash causing the majority of problems in the marine environment. They must also be informed that the accumulation of plastics in the oceans has negative impacts on ocean industries in terms of economics, safety, and reputation. Moreover, they must accept the fact that while no one group is responsible for all the plastic trash in the ocean, solutions to this problem will require cooperation among all groups that are now dumping plastic trash at sea. Education programs which explain these and other aspects of the marine debris problem to marine industries could lead to solutions.

Recognizing the importance of education and awareness in solving the problems caused by marine debris, the Center for Environmental Education (CEE) has developed an extensive education program for marine industries and other groups. The following section describes the marine debris problem, including its effects on marine industries. Educational materials that have been developed by CEE for marine industries are also listed.

PLASTICS: A DIFFERENT KIND OF TRASH

For years the problem associated with the disposal of garbage in the marine environment was not obvious--metal and glass garbage sank, and paper and cloth wastes decayed. But today more and more manufactured objects are made of plastics. And the increased use and subsequent disposal of plastics now comprise over one-half of all manmade objects sighted at sea and found on coastlines (Dahlberg and Day 1985, CEE 1987). Ironically, the very qualities of plastics that have contributed to their success--light weight, strength, and durability--are also the basis for the problems they are causing in the marine environment.

In February 1987 the CEE released a report commissioned by the U.S. Environmental Protection Agency that identified the problems (types, sources) caused by plastics in the marine and Great Lakes environments of the United States. Investigations clearly indicated that plastic debris is an aesthetic problem nationwide.

But plastic debris causes many other problems in the marine environment. Thousands of marine animals die every year from entanglement in plastic debris including whales, seals, sea turtles, birds and fish. There also has been an increase in reports of marine animals swallowing plastic. Some animals ingest plastics accidentally while feeding, while others actually mistake floating plastic for authentic food items. For example, the ingestion of plastic bags and sheeting by sea turtles has been repeatedly documented and is attributed to sea turtles deliberately seeking out these floating items, mistaking them for jellyfish and other prey. To date, 50 of the world's 280 species of seabirds have also been known to ingest plastic debris, most commonly plastic resin pellets (Day et. al. 1985).

Marine industries should be made aware of the threats posed to marine wildlife by plastics dumped at sea. They should also know that the accumulation of plastic debris in the oceans presents problems for marine industries as well. For instance, lost or discarded fishing gear negatively impacts commercial fishery resources because derelict nets and traps can continue to 'ghost fish' once lost or discarded. Fish and shellfish that become entangled in lost nets or enter traps that are never retrieved die and become bait that attracts others. Losses due to ghost fishing may have significant impacts on fishery resources. Plastic trash can also cost hours of wasted time when it has to be separated from gear. Every additional piece of plastic dumped into the ocean will only compound these problems. The amount of trash dumped into the world's oceans each year is already equal to about three times the weight of the entire 1986 U.S. fish catch.

Floating plastics also pose a navigational menace. Vessel disablement is often caused by plastic nets, rope and fishing line that foul propellers, and from plastic bags or sheeting that clog sea water intakes and evaporators. Besides endangering human safety, such problems cause economic losses in the form of costly tows to port, repairs, and lost time. In a recent assessment of encounters with debris in the Pacific, one out of every five sports fishermen and one of two commercial fishermen surveyed have had problems with plastic garbage. The 58 commercial fishermen who placed estimates on actual costs incurred by plastics put the dollar figure at nearly $112,600 (The Port of Newport 1987).

Increasing public concern over the problems caused by plastic debris is also becoming a major source of bad publicity for many marine industries. Photos of marine wildlife entangled in nets and line, and animals with plastic bags and sheeting in their stomachs, do little to enhance the reputation of various marine industries.

CEE's MARINE DEBRIS AND ENTANGLEMENT EDUCATION PROGRAM

In 1986, CEE was commissioned by the National Oceanic and Atmospheric Administration's (NOAA) Marine Entanglement Research Program to develop and distribute marine debris education materials for areas in the Northwest Atlantic and Gulf of Mexico. Present educational efforts are directed at three primary groups: the commercial fishing industry, the petroleum industry, and the general public. As part of this project, CEE is also working with the Society of the Plastics Industry (SPI) on a national campaign to promote the proper disposal of plastics. Phase I of the CEE/SPI/NOAA campaign focuses on three major industries that are presently contributing to the plastic debris problem: the commercial fishing, merchant shipping, and plastics industries. For each group, a public service advertisement has been developed for industry trade journals with an accompanying brochure explaining the problems caused by dumping plastics at sea. Phase II of this campaign will target additional groups including recreational fishermen and boaters.

In addition, through CEE's Texas Coastal Cleanup Campaign of 1986 and 1987, citizens in the Gulf of Mexico have become increasingly aware of the problems caused by marine debris. The campaign has also helped to initiate efforts on the part of the Texas General Land Office in formulating a statewide "Adopt-a Beach" program. CEE data cards used to record debris items during beach cleanups are also being used by several other states.

The most important elements among the educational materials developed by CEE are recommendations on how each group can minimize its contribution to the problem. Many of the suggestions for marine industries will require simple changes in behavior and shipboard practices. More important, educational materials emphasize that no one group is responsible for all the plastic trash in the oceans and encourages all marine industries to become part of the solution to the marine debris problem.

AVAILABLE MATERIALS

The following educational and awareness materials on marine debris are available from the CEE.

Commercial Fishing

Marine Debris and Commercial Fishermen Slide Show--10-minute slide show details the marine debris problem and how it relates to commercial fishermen, with accompanying written script and audio cassette narrative. Four versions of this program have been produced, each specific to a region of the United states (New England, Mid-Atlantic, Southeast Atlantic and Gulf of Mexico). The program also outlines a set of recommendations of how fishermen can help solve this problem.

Marine Debris PSA and Brochure--Public service advertisement and 8-panel brochure on the marine debris problem as it relates to commercial fishermen and suggestions on ways fishermen can help to reduce this problem.

Merchant Shipping

Marine Debris PSA and Brochure--Public service advertisement and 8-panel brochure on the marine debris problem as it relates to mariners and suggestions on ways to help reduce this problem.

Petroleum Industry

"Plastics are a Different Kind of Trash" education program--designed for offshore oil and gas industry workers in the Gulf of Mexico. Consists of a 6-minute slide video and four briefing sheets (produced by Kearney/Centaur Division of A.T. Kearney, Inc., Washington D.C.).

Plastics Industry

Marine Debris PSA and Brochure--Public service advertisement and 8-panel brochure on the problems caused by plastic resin pellets in the marine environment and suggestions on ways to help reduce this problem.

Recreational Fishing

"Stow it--don't throw it" banner--available on loan to recreational fishing tournaments and other boating events to encourage proper disposal of plastics.

"Stow it--don't throw it" bumper stickers for boat trailers.

General

"Marine Debris and Entanglement"-10-minute slide show program with accompanying script.

<u>Plastics in the Ocean: More Than a Litter Problem</u>--report on a study funded by the EPA on the plastic debris problem in the marine and Great Lakes environments of the U.S. Discusses types of plastic debris, their sources, their impacts on wildlife and coastal economies, and laws and treaties pertaining to ocean debris.

<u>1986 Texas Coastal Cleanup Report</u>--details the 1986 CEE Coastal Cleanup, discusses the findings and recommendations for solving the problems caused by debris.

<u>Entanglement Network Newsletter</u>--current information on legislative developments, research, and other activities pertaining to the problems of marine debris and entanglement.

Citizen's Guide to Marine Debris--informative guide on the marine debris issue for concerned citizens with suggested activities on how to help (available in 1988).

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Texas Adopt-A-Beach Program

Mr. Frank H. Morgan
Texas General Land Office

BEGINNING OF PROGRAM

When Texas Land Commissioner Garry Mauro participated in a statewide beach cleanup in September 1986, he realized that Texas beaches did not have a litter problem, but a garbage problem. In Texas, the General Land Office (GLO) manages and sets leasing policies on 22 million acres of state land, including submerged lands along the Texas coast. Using this authority, Commissioner Mauro put strong new rules in place to prohibit solid waste discharges and to require detailed solid waste management plans from offshore platforms and seismic vessels within state waters. If the operators are caught dumping solid waste in the Gulf, they forfeit their leases or permits.

Since no state, federal, or local agency has overall responsibility for keeping garbage off the Texas beaches, and Texas spent $14 million a year on beach cleaning, the Commissioner organized a Beach Cleanup Task Force within the GLO to coordinate cleaning efforts. Then GLO staff began recruiting an all-volunteer beach cleanup army under the banner of the Adopt-A-Beach Program. The Adopt-A-Beach Program was born.

ADOPT-A-BEACH TASK FORCE

The task force members were chosen from oil and gas industry representatives, geophysical firms, local governments, environmental groups and civic organizations. The task force is split up into four subcommittees: legislation, education, research and prioritization, and finance. All four subcommittees have actively contributed to solving the beach debris problem. The legislative subcommittee supported the local and state legislation that will lead to a long-term waste reduction. The education subcommittee has been promoting a change in attitudes about beach litter within the school systems. The research and prioritization subcommittee helped develop the guidelines for the Adopt-A-Beach program. Since the Adopt-A-Beach Program relies on volunteers and donations from the private sector the finance subcommittee solicits in-kind and monetary donations, and creates ideas for future fund raising. Donations come in many forms, from t-shirts, pencils, and bumper stickers to trash bags and disposal services.

The Task Force developed the Adopt-A-Beach program, in which the adopting groups agree to maintain a designated segment of public beach for one year, conducting three cleanups during that period--two major cleanups scheduled by the GLO, and a third at the adopter's convenience. The cleanups serve as a short-term solution and as a method of focusing public attention on the beach garbage problem. The toll-free 1-800-85-BEACH Adopt-A-Beach hotline makes it easy for volunteers to join the program with a central location giving out "how-to adopt" information. The following are the necessary components of the Texas Adopt-A-Beach Program.

Volunteers

Volunteers are the most vital ingredient of the Texas Adopt-A-Beach Program. All efforts are made to recruit, maintain, and continue to increase the number of volunteers that come out for the cleanups and become adopters. A goal of the Adopt-A-Beach program is to continue increasing the number of volunteers, while the amount of trash dwindles.

County Coordinators

The local volunteer Adopt-A-Beach County Coordinators are the backbone of the program since they direct the volunteers on the beaches during cleanups. They make sure adopting groups know where their section of beach is, supply garbage bags, pencils and data cards, keep track of adopting groups, and round up data after a cleanup. County Coordinators are also responsible for coordinating Adopt-A-Beach activities with appropriate local governments and local cleanup groups, and for seeing that individuals or groups are signed up with the program.

Incentives for Adopters

Adoption certificates and "I Cleaned a Beach" certificates handed out the day of a cleanup provide local and personal rewards for program participants. Incentives such as contests with prizes can be used to promote cleanups, like the Spring Break 1987 Collegiate Challenge beach cleanup, which offered a free campus concert by a popular band to the school that gathered the most garbage.

Accomplishments

In less than a year, the Adopt-A-Beach Program has successfully adopted all Texas's 172 miles of accessible beach to 139 groups. The next step is adopting all of the 111 less accessible miles of beach that can only be reached by boat or four-wheel drive vehicle. Fourteen of those miles have already been adopted. In the two statewide cleanups held in 1987, 10,800 volunteers cleaned up 446.5 tons of garbage from Texas beaches, making the effort the largest ever in the nation.

FUTURE PLANS

With such a rapid fulfillment of the first objective of the Adopt-A-Beach program, that of getting all accessible miles of Texas beach adopted, the program can now focus on increasing public awareness and educating the children of Texas about the beach garbage problem and how they can help with the problem. The program is now developing presentations, videos, and slide shows. In addition, the Adopt-A-Beach program has hired an artist to create a coloring book for children and will be sponsoring a "Name the Dolphin" mascot contest to raise student awareness. Other art and essay contests are also being pursued to guarantee a continued awareness of the necessity of a clean coast.

LOCAL AND STATE EFFORTS

The primary objective of the task force is to promote a comprehensive approach to the solution for the beach garbage problem. The task force has been working with county, city and port authority officials to define local needs and establish a statewide plan of action. Working with government officials in Texas and other states has also helped develop an organized plan for state action and has created support for national action. The task force has also been working with federal officials to coordinate agencies having some jurisdiction over the problem and to identify sources of garbage and seek solutions. State and national media attention is critical in all these areas to continue the public education process.

LEGISLATIVE ACCOMPLISHMENTS

The most important facet of the program's work, however, has been its efforts on the national level in the U.S. House and Senate. The task force has waged a highly successful campaign aimed to ratify MARPOL, Annex V, and to pass implementation legislation for the treaty by the U.S. House of Representatives. On October 13, the House passed the implementation legislation bill, H.R. 940, and on November 5, the Senate ratified Annex V of MARPOL. On November 10 and 19, the Senate Environment and Public Works Committee and the Senate Commerce Committee, respectively, reported favorably on implementation legislation. (On December 30, 1987 President Reagan signed the "Marine Plastic Pollution Research and Control Act of 1987" - Public Law 100-220.)

The next step is to convince the International Maritime Organization to designate the Gulf of Mexico as a "special area," which is defined by MARPOL Annex V as a shallow enclosed body of water where no dumping is allowed. This inclusion is critical to Texas because the Gulf of Mexico is a shallow, enclosed basin with currents that sweep debris dumped in the Gulf onto Texas beaches.

As deputy commissioner for the Land Management Program, **Frank H. Morgan** is responsible for administration and management of the state's surface interests in upland and coastal public school lands. In addition to supervising a staff of 25 professional, technical, and administrative workers, he represents the land commissioner in meetings, negotiations, and cooperative projects with state, federal, and local government officials, industry, environmental and civic organizations, research and educational institutions, and prospective users of state lands. Mr. Morgan came to the GLO in 1985 after ten years with the State Comptroller's Office, where he held a variety of positions, including director of the State Training Center in Kerrville and Assistant Director Field Operations. Mr. Morgan holds a B.S. in history and government from the University of Texas at Austin.

Panel Reports: 1987 Gulf of Mexico Beach Cleanup Highlights (Texas, Louisiana, Mississippi, Florida)

Ms. Linda Maraniss
Center for Environmental Education,
Mr. Calvin Fair
Louisiana Coastal Cleanup,
and
Ms. Gail Bishop
Gulf Islands National Seashore

The Center for Environmental Education (CEE) is a non-profit marine conservation organization based in Washington, D.C., with a Gulf Coast States regional office in Austin, Texas. CEE works on issues relating to the protection of the marine environment and endangered marine animals, including whales, seals and sea turtles. Established in 1972, CEE has over 500,000 members.

CEE has published several reports on plastic in the marine environment and the topic of entanglement. CEE has created educational materials for the general public about marine debris and has created new materials for commercial and recreational fishermen, recreational boaters, the petroleum industry, merchant shippers, and the plastic industry. CEE has created public service announcements, four slide presentations for fishermen, ads for trade journals, a "Citizens Guide to Marine Debris and Entanglement," and several reports on Plastics in the Ocean, and Entanglement of Wildlife. These materials are directed at the users of the Gulf of Mexico, and the Atlantic and Pacific Oceans in an effort to increase awareness of marine debris, and the need to work toward solutions to stop debris at its sources.

CEE has coordinated two state-wide beach cleanups in Texas to focus attention on the increasing problem of marine debris, especially plastic, and its effect on marine animals. Linda Maraniss, CEE's regional director, has served as state coordinator for the 1986 and 1987 Texas Coastal Cleanups. The Texas "BE A BEACH BUDDY" public awareness campaign served as a complimentary program to CEE's entire national program to stop marine debris.

The 1987 Texas Coastal Cleanup was co-sponsored by the Texas General Land Office's (GLO) Adopt-A-Beach program. Over 7,500 volunteer "Beach Buddies" worked along 157 miles of coastline. During the three-hour event, 309 tons of marine debris were removed.

Volunteers are asked not only to collect trash, but to record the kinds and amounts of debris found. CEE designed data cards to include items under the categories of plastic, glass, metal, paper, styrofoam, and wood. Because of this data collection, CEE has, over the past two years, been able to analyze the kinds of debris, and identify sources of marine debris, both offshore, and onshore.

Working with its 1986 Steering Committee, CEE published the 1986 Texas Coastal Report summarizing the results of the cleanup and listing 29 state, national, and international recommendations for stopping marine debris.

The Texas Coastal Cleanup campaign has been supported by many concerned citizens, corporations, state and federal agencies. The oil and gas industry has been a willing and interested participant in CEE's Texas marine debris program. The oil and gas industry has supported CEE's efforts by serving on our 1986 and 1987 steering committee, by encouraging company employees to help during the Saturday morning cleanups, with donations to cover cleanup program expenses, with trucks to haul garbage from beaches to landfills, and with garbage bags for removing trash.

The Offshore Operators Committee has assisted CEE's program with mailings during the summer of 1986 and 1987 to its members, listing suggested ways for them to help--as well as mailing the 1986 Texas Coastal Cleanup Report for their information. Linda Maraniss has been a guest speaker at a major oil company in Houston, and has worked with representatives from the oil industry on CEE's steering committee and Texas GLO's Adopt-A-Beach task force. Twelve oil and gas companies have offered some form of support to CEE's educational programs since 1986.

The 1,580 data cards returned after the cleanup provide useful information on the types of debris found along the Texas coast. CEE will publish a final report on this information early in 1988. Preliminary results will be presented at this MMS meeting. The data collected during two years of beach cleanups will provide unique information on marine debris in the Gulf of Mexico and the beaches of Texas.

In both 1986 and 1987, plastic debris comprised 56 percent of all debris items recorded. Metal comprised 13 percent, glass 11 percent, styrofoam 10 percent, paper 7 percent and wood 3 percent of all debris items recorded.

The most common debris item found was plastic bags, with 31,773 items recorded (14.9 percent). Plastic bottles were the second most frequently recorded item, with 30,295 recorded (14.2 percent). Plastic caps and lids (13.3 percent), plastic pieces (10.1 percent), rope (8.8 percent) and six-pack rings (7.3 percent) ranked third, fourth, fifth and sixth.

New items listed on 1987 data cards included diapers, tampon applicators, syringes, and fluorescent light tubes (Diapers = 1,914; tampon applicators = 1,040; syringes = 930; and fluorescent light tubes = 1,088).

Beverage related items totaled 20.2 percent of all debris recorded. The indicator items for beverage related items included plastic soda bottles, beverage cans, glass bottles six-pack holders, bottle caps, and pull tabs. Along the 157 miles of cleanup, 20,580 beverage cans were recorded.

Selected indicator items were used to study the sources of offshore debris. Four categories were studied, including cargo, galley, operational wastes, and fishing gear. (Indicator items used for galley wastes include egg cartons, milk jugs, and vegetable sacks, for example.) Each category included four or five indicator items. The results for 1987 ranked cargo wastes at 6.4 percent, fishing gear at 4.0 percent, galley wastes at 3.3 percent, and operational at 2.6 percent. The 1987 report on the cleanup will compare these results to the totals found in 1986.

Sources of foreign debris listed on data cards included items from fourteen different countries, including Italy, Thailand, Mexico, France, Germany, Singapore, Japan, England, China, Spain, Scotland, Uruguay, Denmark, Sweden, Venezuela, and Argentina and even a toilet cleaner bottle with an Arabic label.

Volunteers were also asked to list stranded animals found on the beach. From the data cards returned these animals were recorded; two sea turtles, sharks, fish, birds, crabs, dolphin, fish in string, dolphin with tail in large yellow rope, mutilated shark, crab in net, shark head, snake with rope in mouth, stingray in net, seagull in plastic rope, crab with plastic strings around legs, blue herons with fishing line on legs, crabs entangled in debris, crabs entangled in nets, seagull with mouth entangled in fishing line, injured sand piper, bird with oily goop, crab in rope, shot birds. Thirty-four animals were listed as entangled in rope, plastic, or fishing line.

Ms. Linda Maraniss has been the director of the Gulf Coast States Regional Office since it was established in Austin, Texas, in January 1986. Before opening the center's first regional office, Ms. Maraniss was the center's Director of Education for several years. Ms. Maraniss coordinated the Texas Coastal Cleanup in 1986 and 1987, which attracted nearly 10,000 volunteers. As CEE's education director, Ms. Maraniss developed a children's activity book on the marine environment and many other marine educational materials for classroom use. Ms. Maraniss also wrote a teacher's guide to an eight-part PBS mini-series on art and the environment. Ms. Maraniss has a B.S. in elementary education from the University of Maryland. She has taught environmental education classes in Maryland and Texas.

Mr. Calvin Fair of the Louisiana Coastal Cleanup, a private, non-profit educational organization, announced the results of the September 19, "Sweep of the Beach." Over 3,300 volunteers statewide participated in Louisiana's third annual beach cleanup, stuffing nearly 16,000 trash bags with approximately 200 tons of beach litter and debris from 85 miles of Louisiana's beaches. Local authorities also removed additional tons of heavy materials such as wooden pallets, 55-gallon drums, and other large items that volunteers could not lift.

This event, an all volunteer effort with no paid staff, is the third of its kind in Louisiana, but the first statewide effort. Louisiana's three beach cleanups have taken place during Coastweeks '85, '86, and '87--times set aside to draw attention to the problems and benefits of the nation's coastal areas.

Calvin Fair, director of the Louisiana Clean Team, and Margie Schoenfeld, coordinator of the Louisiana Nature & Science Center's Recycle New Orleans program--state coordinators for the cleanup--were pleased with the results. Fair indicated he was overwhelmed with the response. Those who say that Louisianans don't care should take note that we started with 125 participants three years ago and have grown to over 3,300 statewide this year, in the rain...that's fantastic! And with the state's new Adopt-A-Beach program we should be able to show another dramatic increase in participation next year. Those interested in adopting a Louisiana beach should contact Barbara Coltharp at the Litter Control and Recycling Commission in Baton Rouge.

While the first two cleanups were organized by Schoenfeld's and Fair's groups, this year they were joined by the Minerals Management Service (MMS) of the Department of Interior, and the Louisiana Sea Grant College Program in the planning and organization, along with over 75 supporting and cooperating groups, representing business and industry, as well as environmental, conservation, scout, school, university, church, civic, federal, state, and local governments and agencies.

Schoenfeld stressed the unique qualities of the Louisiana celebration. "Louisiana is the only state organizing a cleanup as an all-volunteer activity; as such it has been gratifying to see the response and cooperation of our citizens and the numerous and diverse groups which have made this cleanup such a success." Environmental and Conservation Association volunteers filled trash bags side by side with enthusiastic workers from Louisiana's petroleum industry and blue-shirted Department of Environmental Quality (DEQ) volunteers. Martha Madden, Secretary of the DEQ, stuffed trash bags along with many of her staff at Grand Isle, while representatives from DEQ were present across the state to participate in the cleanup and the removal of possibly hazardous materials.

Members of the Louisiana Geological Survey also worked with the Louisiana Coastal Cleanup to provide forms for statewide data collection; final results of this survey and information on the 1987 cleanup will be available in early 1988.

U.S. Senators J. Bennett Johnston and John Breaux helicoptered to Grand Isle to assist in the cleanup, while Governor-elect Buddy Roemer combed the beaches of Cameron with 1,500 other volunteers.

Organizers point out that while most of the trash and litter on our beaches comes from offshore sources, a percentage comes from beachgoers and onshore activities. It is important to remember that it isn't "those guys" doing it; it is all of us.

Though the beaches are now clean, Louisiana Coastal Cleanup organizers realize that they will remain so only a short time because of the billions of pounds of trash that are dumped in the world's oceans each year. The lasting impact will come through education, legislative controls, and changes in the packaging industry. These measures will provide long term solutions to the trash and litter problems, such as degradable and recyclable materials, which should help reduce the amount of trash dumped into our landfills as well as our oceans.

Mr. Calvin Fair is Executive Director of the Louisiana Clean Team and has been instrumental in organizing cleanup projects throughout the state of Louisiana for the past several years. He and Margie Schoenfeld formed the Louisiana Coastal Cleanup, a private, non-profit organization established solely for the purpose of facilitating Louisiana beach cleanups.

Gulf Island National Seashore (GUIS), one of two national seashores located in the Gulf of Mexico, stretches from West Ship Island in Mississippi, 150 miles east, to the far end of Santa Rosa Island in Florida (none of the park is located in Alabama). Known for its long, beautiful, sugary-white beaches, and blue, clear Gulf waters, GUIS attracts millions of visitors annually.

Unknown, however, to first-time visitors is the unsightly trash that continually washes ashore. The trash presents a health hazard to visitors and wildlife. Concerned with the evergrowing problems, GUIS joined other coastal states to educate seashore visitors and neighbors and to attract community attention to the marine trash issue.

In conjunction with the Department of Interior's take Pride-in-America Program, the Florida and Mississippi Districts of GUIS observed "Coastweeks '87," a 4-week national celebration of the nation's shores. The Mississippi District, which includes a salt marsh in Ocean Springs and four of the five state's barrier islands, joined the Mississippi Department of Wildlife Conservation--Bureau of Marine Resources (BOR) in developing a local marine litter awareness program.

The State of Mississippi adopted the slogan, "Stash Your Trash--Marine Litter is More Than an Eyesore." With funding from NOAA, the Bureau of Marine Resources designed and printed posters and trash bags with information about the marine litter problem. Public service announcements concerning the floating trash problems were borrowed from the Oregon Department of Fish and Wildlife and aired on local Mississippi coastal radio and television stations.

The Mississippi Division of Interpretation at the Seashore produced a 1-hour slide program, "The Plague of Plastics," which was shown weekly from September 19 through October 12 in the William M. Colmer Visitor Center in Ocean Springs, and to different local civic organizations. In addition, during the same time period, a temporary exhibit composed of trash picked up from West Ship Island was displayed in the Visitor Center.

Also included in the marine litter awareness program was a beach cleanup organized by GUIS. Using volunteer assistance, the Mississippi District planned cleanups of the Davis Bayou area, Petit Bois, Horn, and East and West Ship Islands for October 10, 1987. Questionnaires were provided to volunteers to record types and amounts of litter collected during the cleanup.

Because of small craft warnings, only large boats were able to ferry 15 volunteers to Horn Island and 70 volunteers to West Ship Islands. Fifteen volunteers remained on the mainland to pick up trash in the Davis Bayou area. (Additional cleanups occurred on Horn and West Ship Islands.)

Two hundred seventy-five bags of marine litter weighing approximately 9,500 pounds were picked up on October 10, 11, and 31 by 100 volunteers who worked a total of 716 hours and covered approximately 11 miles of beach. Approximately one-quarter of the forms was returned to GUIS. The forms were quickly summarized and mailed to Gulf Coast States Regional Office of the Center for Environmental Education for detailed analysis.

Based on the in-house summary, the top five types of marine litter were:

1. Metal cans (beverage and aluminum)
2. Plastic bottles
3. Glass bottles
4. Plastic bags
5. Plastic lids

Other items collected included plastic milk jugs, rubber gloves, light bulbs, spot lights, five-gallon plastic buckets, tires, ropes, and fluorescent tubes. Unusual items collected were car fuses, one egg carton with 12 uncracked eggs, a freezer, streamers from helium inflated balloons, a rubber raft, and articles of clothing.

POSSIBLE SOURCES OF LITTER

Fisheries

The Mississippi Sound, rich with a variety of fin and shell fish, and an attraction for many fishermen, is part of the "Fertile Fisheries Crescent," an area from Mobile, Alabama, to Port Arthur, Texas. For example, it was estimated in 1986 that there were 175,000 saltwater fishermen in Mississippi. Each year, between six and seven thousand fishermen operate boats trawling for brown and white shrimp. In addition, in 1986, the high tonnage of menhaden landings made the Port of Pascagoula-Moss Point the second highest port in the United States for the volume of landings.

Shipping

Beside the Port of Pascagoula-Moss Point, the Mississippi Gulf Coast, which is 69 miles in length, is home to the Ports of Gulfport and Biloxi. The Port of Gulfport, known as the banana terminal of the country, unloads 25 ships monthly. In addition, ships, boats, and barges pushed by tugboats navigate the Intercoastal Waterway and pass between the barrier islands to the Gulf's waterways.

Oil and Gas

Out of the estimated 244 oil and gas tracts available, approximately 144 are leased in federal waters offshore the Mississippi and Alabama barrier islands. No wells are operational off the Mississippi barrier islands at this time. Three gas pipelines cross the Mississippi Sound.

Drainage Systems

The Pearl, Pascagoula, and Biloxi Rivers flow in to the Mississippi Sound carrying any trash generated on the land.

Recreational Boaters

It is estimated that there are approximately 28,000 registered boats, including small commercial boats and motorized sail boats in the three Mississippi coastal counties.

Gulf Islands National Seashore

The visitation to the National Seashore--Mississippi District continues to increase from approximately 308,000 in 1973 to 1,021,000 in 1986.

MISSISSIPPI SUMMARY

The goals to determine the probable sources of marine litter and to publicize the marine litter were met. Approximately 20 percent of the Mississippi District's coastline was cleaned up for a short period of time, and most of the items collected related to food and beverage consumption. The apparent sources of the majority of marine litter include people involved in commercial fishing and recreational boaters who accidentally or deliberately dump trash overboard.

The results of Mississippi's first effort to bring attention to the marine litter problem through cleanups, printed material, slide programs, public service announcements, and exhibits sparked media coverage. In two-and-a-half month's time, seven newspaper articles, including "Beach Litter Tells Tales of Summer," three editorials, one letter to the editor, and a personal opinion column were printed in three coastal newspapers, and reports were also aired on local radio and television stations.

As a short-term solution to the marine litter problem, GUIS will continue educational programs and beach cleanups.

FLORIDA SUMMARY

Approximately 6,000 pounds of trash and marine litter were collected by approximately fifty volunteers from beach areas within the Fort Pickens and Santa Rosa areas of the National Seashore. Most of the volunteers completed portions of a Coast Cleanup Questionnaire, detailing the types of trash and marine litter they collected during the Coastweeks '87 Cleanup.

Approximately 1,254 plastic trash products were collected; specific plastic items included plastic bags, cups/utensil, caps/lids, milk jugs, six-pack holders, and plastic bottles. More than 300 paper products were removed including paper cartons, newspapers, cigarette wrappers, and disposable diapers. Glass products collected exceeded 500 individual items, ranging from light bulbs to a variety of bottles. Styrofoam products accounted to more than 600 items collected, with the majority classified as cups and pieces such as ice chests and meat cartons. Metal and wood products numbered more than 350 items, most of which were beverage cans and crates and construction materials.

Ms. Gail Bishop has been a National Park Ranger since May 1977. In addition to her assignment at GUIS, she has been assigned to Ford's Theatre N.H.S., Pea Ridge N.M.P., and Big Thicket N.P. Because of the visual impact of marine litter at Gulf Islands National Preserve and the increasing information about the effects of marine litter on marine animals, the interpretive staff at the Seashore has made educating park visitors and neighbors about the marine litter problem one of its main goals.

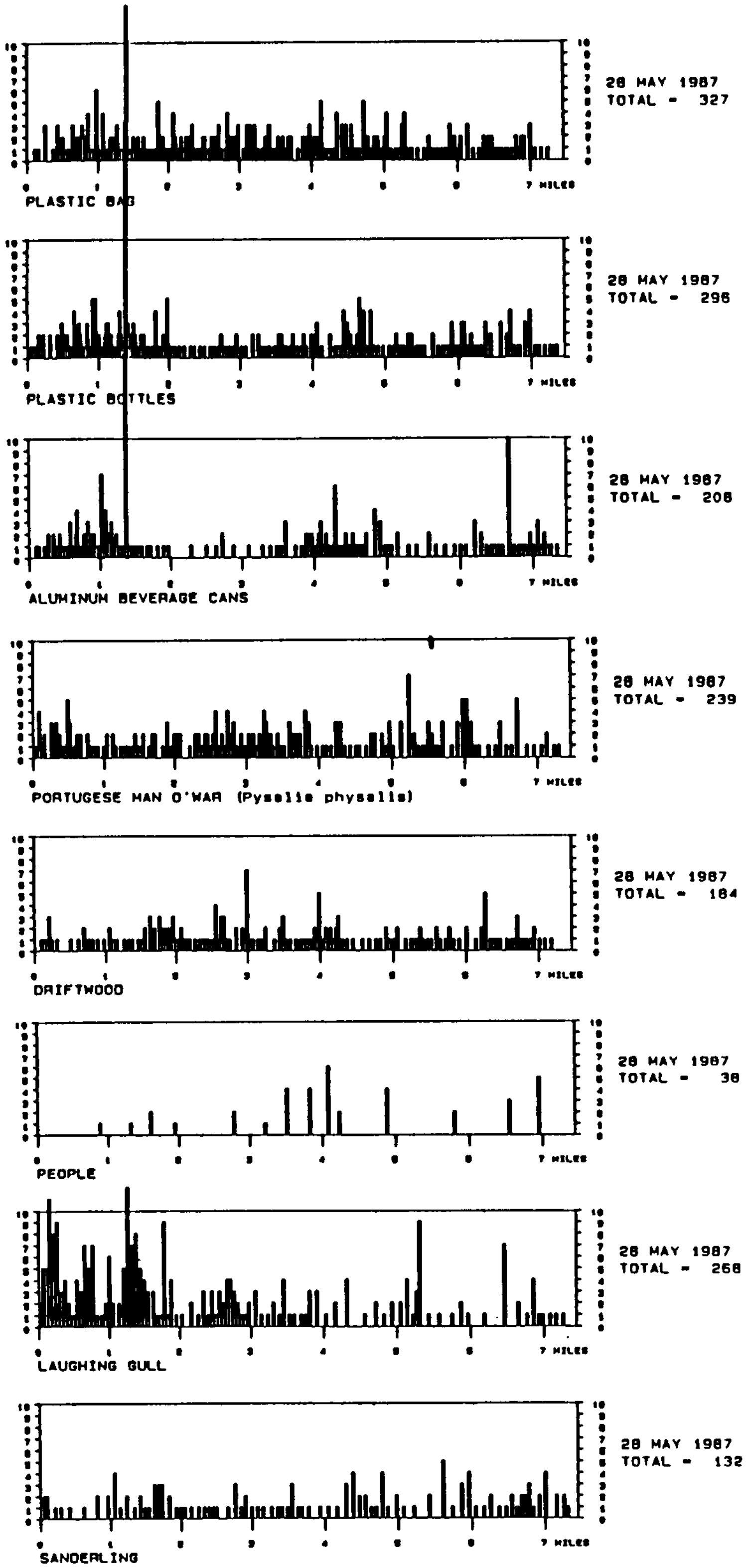

Figure 3.1.--A map of certain categories of litter as they were distributed along the 11.8 km of beach on that same day.

Table 3.1.

Daily and Annual Accumulation Rates

Classification	Daily Rate (lbs/site x day)	Range (lbs/site x day)	Annual Rate (for PINS)
Total Debris	5.51±4.41	0.810-17.96	580.21 tons
Oil and Gas	2.24±1.97	0.108- 7.90	235.87 tons
Domestic	3.26±2.86	0.459-10.06	343.29 tons

Table 3.2

Rates by Season

Season	Mean Total Rate (lbs/site x day)	Mean Oil & Gas Rate (lbs/site x day)	Mean Domestic Rate (lbs/site x day)
Fall-Winter	7.49	2.07	4.49
Spring-Summer	3.25	1.41	1.85

Table 3.3

Rates by Sampling Period

Season	Year	Mean Total Rate (lbs/site x day)	Mean Oil & Gas Rate (lbs/site x day)	Mean Domestic Rate (lbs/site x day)
Fall-Winter	1985	6.70	2.80	3.90
Spring-Summer	1986	1.21	0.43	0.78
Fall-Winter	1986	8.81	3.24	5.48
Spring-Summer	1987	5.98	2.72	3.26

Table 3.4.

Some Factors Affecting the Distribution of Debris and Litter on Mustang Island Beach

Origins	Sources
Offshore	Ships, Rigs, Platforms, Fishing, Recreational, Shrimp, Supply Boats
Bay	Fishing, Shrimping, Recreational Boats, Landfills, Dumping
River	Landfills, Dumping
Beach	Littering, Dumping

Distribution	Factors
Surf Zone	Tides, Waterlogging, Tarring, Turbulence
Shoreline	Tides, Winds, Longshore Drift, Offshore Currents, Windage, Burial, Tarring
Mid-Beach	Tides, Winds, Weather, Burial, Scavenging, Season, Traffic, Cleaning, Vegetation, Morphology
Dunes	Winds, Storm-tides, Dune-building
All-Beach	Camping, Popular Locations, Trash-Barrels, "Partying," Condominiums, Long-Term Beach Residents

Table 3.5.

Countries from Which
Trash has been found on
the Mustang Island Beach Survey

1. ARGENTINA	18. JAPAN
2. AUSTRALIA	19. KOREA
3. BANGLADESH	20. MEXICO
4. BELGIUM	21. MOROCCO
5. BRAZIL	22. NETHERLANDS
6. CHINA	23. NIGERIA
7. CUBA	24. NORWAY
8. CZECHOSLOVAKIA	25. SINGAPORE
9. ECUADOR	26. S. AFRICA
10. FRANCE	27. SPAIN
11. GREECE	28. TAIWAN
12. HONG-KONG	29. TRINIDAD
13. INDONESIA	30. U.K.
14. IRELAND	31. U.S.A.
15. ISRAEL	32. U.S.S.R.
16. ITALY	33. VENEZUELA
17. JAMAICA	34. W. GERMANY

Origins of Man-Made Litter Believed
to Have Drifted Directly to
Mustang Island

1. ALABAMA	6. MEXICO
2. CUBA?	7. MISSISSIPPI
3. JAMAICA?	8. EAST TEXAS
4. FLORIDA?	9. SOUTH TEXAS
5. LOUISIANA	10. TRINIDAD?

Table 3.6.

Debris and Litter Counts on Mustang Island Beach Survey, 28 May 1987

CODE	ITEM	RANK	COUNT	WEIGHT(Kg)
NATURAL DEBRIS:				
CRAB	Dead crabs	0	1	0.355
FISH	Dead fish	0	2	0
CABG	Cabbagehead jellyfish	3	601	0
PMOW	Portuguese Man O'War	2	239	0.593
PENS	Pen shells	0	1	0
DRIFT	Driftwood	4	185	128.296
SARG	Sargassum	3	---	2,174.831
HYAC	Water hyacinth	0	---	9.125
BEAN	Seabeans	-	---	2.923
GORG	Gorgonians	2	---	4.977
PLASTIC DEBRIS:				
PLAS	Plastic sheeting	3	199	0
PBAG	Plastic bags	-	327	0
PMSC	Miscellaneous bits of plastic	-	259	140.699
STYR	Styrofoam	-	122	11.297
FOAM	Other foam	-	10	0
PBOT	Plastic bottles	-	298	0
GBOT	Green bottles (Mexican)	3	57	0
MILK	One-gallon milk jugs	2	32	0
2STR	Two-stroke oil bottles	-	15	0
6PAK	Six-pack holders	-	19	0
CUPS	Plastic cups	-	84	0
LIDS	Plastic lids	-	77	0
EGGC	Egg cartons	-	14	0
PAIL	5-gallon containers	-	16	0
SACK	50-lb produce sacks	-	21	0
GARB	Full garbage bags	-	18	0
ROPE	Polypropylene line	5	131	17.578
FLOT	Fishing floats	3	11	0
NETS	Fishing nets	-	1	0
STIK	Light sticks	-	14	0
RING	Write-protect rings	-	2	0
HARD	Hardhats	-	1	0
BOTL	Bottles of all kinds	4	547	0
HOUS	Household garbage	4	589	0
----	Plastics of all kinds	3	938	151.996
NON-PLASTIC DEBRIS:				
BEVG	Beverage cans	3	209	0
OCAN	Other cans	-	27	0
GLAS	Glass bottles	-	177	0
BULB	Light bulbs	5*	24	1.264
FLOR	Fluorescent tubes	5*	16	0

Table 3.6.

Debris and Litter Counts on Mustang Island Beach Survey, 28 May 1987 (cont'd)

CODE	ITEM	RANK	COUNT	WEIGHT(Kg)
LGHT	Cigarette lighters	-	5	0
METL	Metal	-	5	28.361
PAPR	Paper	-	24	5.096
CART	Cardboard cartons	-	32	0
CRAT	Crates	-	6	0
55GL	55-gallon drums	-	1	0
LUBE	Tubes of grease	-	3	0
APPL	Appliances	-	2	0
REEL	Reels	-	2	0
WIRE	Wire	-	10	0
TIRE	Tires	-	1	0
TOYS	Toys	-	1	0
HAT	Hats	-	1	0
GLOV	Rubber gloves	-	28	0
SHOE	Shoes	-	31	25.636
CLTH	Cloth; clothing	-	4	0
FRUT	Fruit	2*	6	0
VEGS	Vegetables	2*	4	0
CHEM	Chemicals	24	5	0
DEMOGRAPHIC DATA:				
SRMP	Shrimpboats	-	1	-
CARS	Cars and trucks	-	11	-
PEOP	People	-	42	-
DOGS	Dogs	-	1	-
HORS	Horses	-	7	-

ENVIRONMENTAL DATA:

AIRT	Air temperature	26.6 degrees C
HUMI	Humidity	89.5%
SST	Sea-Surface temperature	26.9 degrees C
SSS	Sea-Surface salinity	36.07 ppm
WDIR	Wind direction	130
WSPD	Wind speed	15 kts
STAT	Sea-State	4
HT/L	Shoreline to high-tide line	8 m
D/L	Shoreline to dune-line	22 m
WETH	Weather	Mostly Cloudy windy, rough seas.

BENTHIC ECOLOGY AND LONG-TERM ENVIRONMENTAL MONITORING

Session: BENTHIC ECOLOGY AND LONG-TERM ENVIRONMENTAL MONITORING

Chair: Dr. Robert M. Rogers

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Benthic Ecology and Long-Term Environmental Monitoring: Session Overview

Dr. Robert M. Rogers
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A large portion of the funding for the MMS Environmental Studies Program is allocated to the monitoring of potential and real effects of OCS activities on marine ecosystems, especially in the more stable benthic environment. Such environmental monitoring is by nature a complex and expensive endeavor. In addition to the variability of the physical environment and the biological processes, there are usually questions as to the limits of detection of the sampling methodologies and analytical instrumentation. This is further complicated by the effects of a variety of human activities. The effects of offshore oil and gas activities may easily be obscured by a great deal of other anthropogenic alterations, such as fisheries, transportation, dredging, etc.

To understand more about long-term environmental variability, the MMS is planning such a long-term study to be initiated this fiscal year. Study objectives will be to occupy sampling sites surveyed during previous MMS marine ecosystem and topographic features studies. Sites will be sampled at least on an annual basis, using sampling or observational methods most appropriate for the site, considering topographic relief, water depth, nature of substrate, and biological communities of concern. Sampling sites will be located in the Gulf of Mexico, generally in areas previously studied by MMS, BLM, or other Federal agencies. This will provide a significant data history for comparison with future observations.

The purpose of this session was to emphasize a number of related marine ecosystem studies presently in progress. Most of these studies are sponsored by MMS and have only recently been initiated. With this in mind, presentations were proposed to emphasize program design and sampling methodologies, rather than final results.

The first presentation of the session was given by Dr. Gary Brewer. The MMS Pacific OCS Office is conducting a multiyear, multidisciplinary program designed to monitor oil production platforms off southern California. This California Monitoring Program (CAMP) is the first attempt to measure potentially subtle, long-term changes in biological communities living in the vicinity of oil production platforms.

Phase 1 of the CAMP study began in 1983 with a reconnaissance of the Santa Maria Basin, an area where some exploratory oil drilling has occurred but no previous oil production activity. The overall objectives are to (1) characterize existing sediment hydrocarbons and trace metal concentrations, (2) identify and map benthic biological assemblages, and (3) identify candidate sites and species, and recommend techniques for long-term monitoring during the subsequent Phase 2 period. Phase 2 monitoring will encompass field sampling and analyses for at least five years (1985-1990). The experience gained during Phase 2 should provide the insight for additional studies during the projected Phase 3 period.

The experimental rationale is to sample all regional and site-specific stations during the fall of each year, both before platform drilling begins and after production is established. Studies will be conducted for the characterization of soft bottoms, hard bottoms, chemistry including hydrocarbons and trace metals, sediment, and physical oceanography.

The comprehensive, multidisciplinary design of CAMP reflects the awareness by MMS that the assessment of environmental impacts that may be associated with oil and gas activities or, indeed, any anthropogenic influence, is limited by our poor understanding of fundamental ecosystem processes.

The next three speakers gave an overview of an MMS Gulf of Mexico OCS Regional Office's sponsored study of the Mississippi/Alabama/Louisiana continental shelf. Drs. James Brooks, Rezneat Darnell, and Richard Rezak of Texas A&M University, respectively, discussed the program organization, biological, and geological aspects of the study.

The primary goal of this study is to environmentally characterize this region of petroleum exploration and development interest. This relatively small area is of great importance to the adjacent state because of heavy demands on natural resources from a variety of user groups, including marine transportation, dredge dumping, and commercial and recreational fishing.

Field sampling from the first year field effort will be designed to characterize dominant processes on the OCS and to provide a basis for further investigations into spatial and temporal variations. Included in this concept will be the analysis of trophic relationships among dominant biological components of the ecosystem and a description of current movement within the study area. On the slope, prominent topographic features shall be located and evaluated as to their biological sensitivity and need for further study.

The study is presently in this first phase of field sampling. In October, the first sampling cruise for biological and chemical parameters was initiated. Field sampling activities include benthic grab sampling for infauna, sediment texture, total organic carbon, hydrocarbons, and trace metals. Trawl samples were taken for fishes and invertebrates and for food habit analyses. At each station, a conductivity/temperature/depth transmissivity continuous profile was performed. Discrete water samples of salinity, dissolved oxygen, and nutrients were collected in the water column.

A reconnaissance survey has been conducted of the offshore pinnacle area utilizing side scan sonar and high resolution subbottom profiling. Features observed during a cursory examination of side scan records include pinnacles, banks, patch reefs, sand waves, and ridges.

Field sampling from the second year will consist of two sampling cruises to characterize the OCS, deployment of current meters to characterize current movements, and a biological reconnaissance of continental slope topographic features. Sampling will be based on information needs identified through the first year field effort with an overall emphasis on special communities and ecological processes.

The third phase of this effort will consist of a final cruise(s) for gathering environmental data needed to fill information gaps and a synthesis of information compiled through the previous two years of field effort. The final synthesis will integrate all aspects of the field study, identifying and displaying significant relationships and processes.

Dr. William Schroeder of the Dauphin Island Sea Lab discussed the geological aspects of hardbottom environments of the inner continental shelf off Alabama and northwest Florida. Since 1984, researchers at the Dauphin Island Sea Lab have undertaken 16 reconnaissance surveys at potential hardbottom sites in this area. In the spring and summer of 1987, scientists from the University of Alabama and the Naval Ocean Research and Development Activity (NORDA), under the auspices of the Mississippi/Alabama Sea Grant Consortium and NORDA, conducted five side scan sonar/subbottom profiling cruises and eight underwater TV video and grab/dredge, ground-truthing cruises in three inner shelf study areas.

The hardbottoms observed consisted of loose accumulations of whole and broken shells and of both reworked and in situ carbonate-cemented sandstones and mudstones. Vertical relief of the hardbottom areas is variable, ranging from almost flat to nearly 2.5 m, in water depths ranging from 10 to 35 m. On a region wide scale, these hardbottoms appear to be distributed along several shore-parallel (west to east) isobaths, suggesting an origin related to Quaternary sea-level changes. However, on smaller spatial scales, the orientation of the features are often observed as being oriented northwest to southeast.

Research will continue in 1988 as a major cooperative project. This will include geological work in both the original study areas and in new study areas, as well as biological work dealing with age and growth rates of selected recreationally important fishes. Additional surveillance is proposed from a submersible platform.

The next speaker was Dr. John Cubit of the Smithsonian Tropical Research Institute (STRI) located in Panama. MMS has funded a study through STRI on the effects of an oil spill on mangroves, seagrasses, reef flats, and coral communities on the Caribbean coast of Panama. Such research results should prove very useful in a management decision related to the potential effects of an oil spill in a tropical region of the United States such as south Florida.

In 1986, 240,000 barrels of medium weight crude oil spilled from a ruptured storage tank on the central Caribbean coast of Panama. A significant amount was washed into a sensitive area of coral reefs, seagrass beds, and mangrove forests, including an STRI biological reserve where previous studies provided baseline information.

Dr. Cubit reported on some of the initial findings of the STRI team of investigators. Generally, seagrasses in subtidal beds were not exposed directly to oil slicks and showed little damage. A detailed study of infaunal and epifaunal populations is being carried out on the seagrass communities. Significant effects were noted on the platforms of fringing reefs forming most of the intertidal habitats. Zoanthids, corals, sea urchins, coralline algae, and other reef edge organisms were directly exposed to oiling during each low tide following the spill. Likewise, red mangroves and their associated biological communities directly exposed to oiling were significantly affected.

Mr. Edward Tennyson of the Technology Assessment and Research Branch of MMS gave the concluding presentation concerning preliminary findings from at-sea experiments on two intentional oil spills in Canadian waters. The tests were conducted to evaluate the following: new chemical additives, shipboard radar as an oil-tracking tool, a prospective standardized test offshore boom performance, and existing capabilities to contain and clean up high paraffin-based crude oils. The first exercise evaluated a Canadian emulsion inhibitor, or "demoussifier," and a visco-elastic agent, "Elastol," in a series of ten 5-barrel oil spills off Nova Scotia. The second exercise was a multiphase field trial based on the use of three containment booms and three types of skimmers. A 20,000-gallon oil spill of Brent crude treated with additional paraffin was released off Newfoundland.

Some preliminary analyses indicated the following:

- Existing ship radar can be effective in tracking oil slicks.
- The immediate use of the product Elastol appears to reduce subsequent containment efforts during mechanical recovery.
- When winds exceed 15 knots, downwind towing is preferred in containment efforts.
- The addition of Elastol in dosages estimated to be below 1,000 ppm enabled relatively rapid recovery with olephilic skimmers.
- The oil slicks of Alberta Sweet Blend Mix and Bunker C were totally dispersed within 36 hours in waves approaching 5 to 8 feet.

Dr. Robert M. Rogers is an oceanographer on the Environmental Studies Staff of the MMS Gulf of Mexico OCS Regional Office. He has served as Contracting Officer's Technical Representative on numerous marine ecosystem studies. Dr. Rogers received his B.S. and M.S. degrees in zoology from Louisiana State University and his Ph.D. in marine biology from Texas A&M University in 1977.

Monitoring Changes in Benthic Communities Adjacent to OCS Oil Production Platforms Off California

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INTRODUCTION

The MMS Pacific OCS Region Environmental Studies Program is conducting Phase II of a comprehensive, multiyear monitoring program adjacent to proposed oil production platforms off Southern California. The California Monitoring Program (CAMP) is designed to provide a definitive evaluation of the spatial and temporal impacts of discharges from oil production platforms to Outer Continental Shelf (OCS) soft and hard (rocky) bottom communities.

Previous field studies have evaluated impacts associated with short-term, exploratory drilling activities on benthic communities (i.e., assemblages of animals living on the sea floor), and many laboratory studies have examined the effects of drilling discharges on a broad spectrum of plants and animals. The CAMP project is the first attempt to measure potentially subtle, long-term monitoring during the subsequent Phase II period. Phase II monitoring will encompass field sampling and analyses for at least five years (1985-1990). The experience gained during the Phase II studies should provide the insight for additional innovative studies during a projected Phase III period.

STUDY LOCATION AND OBJECTIVES

The region selected for study (Figure 4.1) encompasses the Santa Maria Basin, an area where some exploratory oil drilling has occurred but with no previous oil production activity. Site-specific stations include the area surrounding Platform Hidalgo (depth 132 m), where drilling is expected to begin during December 1987, and the area surrounding proposed Platform Julius (depth 145 m), where drilling is anticipated during early 1990. Monitoring of hard bottom communities that began in October 1986 is proceeding at the Platform Hidalgo site-specific stations, and monitoring of soft bottom communities that also began in October 1986, is proceeding at the Platform Julius site-specific stations (Figure 4.2) and all regional stations.

The experimental rationale is to sample all regional and site-specific stations (i.e., for biological, chemical, and sediment parameters) during the fall of each year, both before platform drilling begins and after production is established. In addition, seasonal variability in all parameters will be evaluated during at least a 1-year period before and after platform drilling commences. Potential dose-response relationships will be tested by assessing biological changes in the benthic assemblages, together with concurrent physical or chemical changes in the sediments that are specifically linked to platform discharges.

SOFT BOTTOM BIOLOGICAL STUDIES

Triplicate, 0.25 m^2 box cores are being collected at all Platform Julius site-specific stations (Figure 4.2) and all regional stations. Macro-epifauna is photographed via a camera mounted on the corer. Infauna in the upper 10 cm of sediment and retained on both 0.5 and 1.0 mm sorting screens is being identified and enumerated. Sediments below 10 cm are also being (1.0 mm) screened for potential deep burrowers. X-rays are taken of special box core sections to examine the vertical structure of the burrowing organism. Box core collected with a core tube (2.5 cm i.d.) are screened with a 63 micro sieve to collect meiofauna. Major meiofauna taxa are enumerated and all harpacticoid copepods are identified to species. Representative species of infauna and meiofauna are given detailed life-history analysis, including reproductive parameters (i.e. egg production) and growth. Specialists have been subcontracted to ensure taxonomic excellence and provide standardization with previous studies.

HARD BOTTOM BIOLOGICAL STUDIES

Hard Bottom assemblages on rocky features surrounding Platform Hidalgo are sampled by 70 mm photography, and voucher specimens are collected (via a manipulator arm) on a remotely operated vehicle (ROV). Side-scan sonar and a color video camera are used to guide the ROV to each designated feature (Figure 4.3), where at least 70 random photos are taken. The distance between the camera and sea floor is maintained by means of a special laser-ranging device mounted on the camera; photoquadrat size (about 0.5 m^2) is thereby standardized. In the laboratory, species are identified, and density and diversity are estimated by projecting the photographs on a screen and using a point contact methodology.

CHEMISTRY STUDIES

Saturated hydrocarbons, polynuclear aromatic hydrocarbons, and 11 trace metals including arsenic, barium, cadmium, copper, lead, mercury, nickel, silver, vanadium, and zinc are being analyzed from sediments, pore waters, animal tissues, and drilling discharges. Samples from box cores, sediment traps (see below), animal traps, and sources of drilling discharges are included in the chemistry studies. These efforts are designed to quantify the chemical dose of platform-derived hydrocarbons and metals to the soft bottom (Platform Julius) and hard bottom (Platform Hidalgo) site-specific stations against the background of natural chemical variability. Analysis of animal tissues will evaluate potential accumulation of metal and hydrocarbon contaminants.

Laboratory studies are also planned to determine, under different redox conditions, the solubility and partitioning of barium, cadmium, chromium, lead, nickel, and zinc within sediments and sediment pore waters that contain drilling muds. Drilling muds obtained from Platforms Julius and Hidalgo will be mixed with natural marine sediment from the study region. The goal of this special study is to estimate the concentration of metals in pore waters and the flux of soluble metals into the bottom water.

SEDIMENTOLOGICAL STUDIES

Sediment samples from box cores are being monitored for grain size, mineralogy, shear strength, total organic carbon (TOC), carbonate, and redox. Rates of sedimentation are being estimated from analysis of lead/thorium isotope ratios within selected cores. Continuous (one/day) bottom (35 mm) photographs at the Platform Julius site are used to monitor sediment bed forms throughout the study period.

Sediment traps have been placed at selected sites near Platform Hidalgo. The traps are retrieved at six-month intervals throughout the 5-year study period to obtain estimates of sedimentation rates and chemical dose information from the platform.

Two special studies have been funded to evaluate the fate and effects of platform discharged particulate material. The initial deposition of drilling particulates surrounding Platform Julius will be measured during a short term, intensive analysis of a single drilling mud discharge event. Sediment traps will be deployed around the platform to measure the fine-scale deposition of particulates. The results will then be used to attempt to validate the Offshore Operators Committee (OOC) Mud Discharge Model. Hence, field measurements will be compared with results predicted by the OOC Model.

While the validation of the OOC Model concerns the initial deposition of discharged solids, a second special study is designed to evaluate those factors, such as near-bottom flow, bottom stress and sediment characteristics that govern the potential resuspension of particulate matter over the OCS. Special instrumentation placed in the field near the Platform Julius site during 1987 includes two GEOPROBEs and three vector averaging current meter (VACM) arrays. The field measurements lasted three months (May-August) and will be repeated during the winter of 1989.

Complementary laboratory flume experiments are measuring resuspension of natural sediments, sediments that are contaminated with drilling muds, and sediments with and without benthic organisms present. Laboratory experiments are also designed to assess how benthic organisms are affected by the addition of drilling muds, including the initial settlement of larval stages. These efforts may help explain what processes are responsible for any changes in benthic communities that are observed in the field and that are associated with drilling mud contamination.

PHYSICAL OCEANOGRAPHY

In addition to the moored instruments that are being used for the short-term sediment/drilling mud transport and resuspension studies, summarized above, current meters and associated instruments are in place at both platform sites and will provide continuous records for five years. The arrays consist of three current meters with temperature and conductivity sensors suspended at near surface, middle- and near-bottom depths near Platform Julius and Platform Hidalgo and bottom mounted pressure recorders. A surface buoy and antenna relays all data in real-time to an onshore laboratory via the ARGOS satellite. Data from the moored instruments is supplemented with vertical conductivity, temperature, depth (CTD) profiles; pH; oxygen; phosphate; silicate; and nitrate profiles during each cruise. Finally, satellite photographs from AVHRR infrared images are used in conjunction with the current meter data to examine mesoscale transport in the study area.

CONCLUSION

In conclusion, the comprehensive, multidisciplinary design of CAMP reflects the awareness by MMS that the assessment of environmental impacts that may be associated with oil and gas activities, or indeed, any anthropogenic (i.e., man-made) influence, is limited by our poor understanding of fundamental ecosystem processes and natural variability.

Dr. Gary D. Brewer is a marine biologist with the MMS, Pacific OCS Region, Environmental Studies Section. He received the B.S. degree from California State Polytechnic University, San Luis Obispo. His graduate studies and post-doctoral research at the University of Southern California involved the physiological ecology of marine organisms and the ecology of early life history stages of fishes.

Mississippi/Alabama Marine Ecosystem Program

Dr. James M. Brooks,
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and
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The primary goal of the "Mississippi/Alabama Marine Ecosystem Program" is to describe the existing ecosystem and interrelate dominant natural processes in a way that can be used to understand the impacts of man's activities in the area, especially as it relates to petroleum exploration and development.

The first year of the "Mississippi/Alabama Marine Ecosystem Program" (known as the Tuscaloosa Trend Regional Data Search and Synthesis Study) was completed in the summer of 1985 and consisted of identifying all information sources that made reference to this area.

The program phase following the literature search involves this field effort to fill data gaps identified by the Minerals Management Service (MMS). The program phase builds on the information base required by MMS to make petroleum development management decisions. The field effort will be followed by a comprehensive synthesis effort that will integrate both the results of the literature study and field sampling phases of the program. The final outcome of this program will produce the basis for a regional management plan of coastal zone resources for the central Gulf states area.

Field sampling has been designed to characterize dominant physical and chemical processes on the OCS and provide a basis for further investigations of spatial and temporal variations in biologic populations. Included in this study phase are analyses of trophic relationships among dominant biologic components of the ecosystem, descriptions of current movements, and descriptions of geologic features such as hard bottom areas that may be biologically sensitive or unique compared to surrounding habitats. The second year of this field effort consists of field sampling cruises to further characterize the biology and chemistry of the OCS, continued current measurements of the OCS, and biological reconnaissance of continental slope topographic features. The third year of this effort consists of final field work to gather environmental data that may be needed to fill information gaps. More important, it will be a time of synthesis and integration of information compiled during the previous years of field effort and literature review.

The general goals of this study are (1) to biologically characterize the hard banks located on the outer shelf of the study area, (2) to describe the sediments and transition areas of the region, (3) to determine the seafloor topography and how it affects sediment distribution, (4) to evaluate the presence or absence of live bottom areas in the mobile and northern Viosca Knoll leasing area, (5) to study circulation patterns and driving forces, especially due to the loop current, around the DeSoto Canyon, including meteorology, hydrography, currents, sea state, and freshwater discharge, (6) to study the occurrence and extent of the nepheloid layer, (7) to investigate the extent and significance of hypoxia on the shelf, (8) to study the fates of pollutants associated with shelf activities, especially petroleum exploration/production, (9) to define shelf benthic communities with emphasis on habitats not previously described and near-slope environments, and (10) to analyze trophic relationships among biotic components of the shelf ecosystem with emphasis on energy transfer within and between pelagic and benthic components.

The study area occupies the continental shelf from the Chandeleur Islands and Mississippi River delta, on the west, to a line extending from the Alabama/Florida border southeastward intersecting the head of DeSoto Canyon (Figure 4.4). It extends from the shoreline or barrier islands across the shelf to the 200 m isobath. The area extends about 140 miles from east to west, and width of the shelf varies from around 40 miles in the east to about 80 miles in the west. The Mississippi/Alabama shelf is referred to as the Mississippi Bight, although technically it might better be termed the East Mississippi Bight.

Rocky, hard bottom outcrops have been reported to occur in several areas, and the distribution of many of these was mapped in a report of the M/V Oregon for Cruise No. 72 (December 7 1960). Directly south of Mobile Bay, at a depth of about 20 fms, there are extensive areas of low relief calcareous outcrops of unknown origin, labelled locally as "broken bottoms or ragged bottoms." Personnel from the NMFS have indicated that these areas are major spawning grounds for the Atlantic croaker, spot, and other estuary related species. Extremely heavy species concentrations were demonstrated in this area by Darnell (1985). Because of its ecological important, this area represents one of the study sites selected for the present project. Additional rocky outcrops have been reported to occur in depths of 80 to 200 fms in the area from south of Mobil Bay and eastward toward DeSoto Canyon. Another outcrop has been noted at depths of 40 to 50 fms directly south of Biloxi, MS. Others occur in deeper waters of the Mississippi Bight area. From submersible observations, Shipp and Hopkins (1978) reported that the deepwater outcrops around the edges of DeSoto Canyon are flat limestone slabs lying on the surface. This is probably true for many of the other deepwater hard bottoms. Other hard bottom structures have been tentatively identified in our cruises earlier this year.

Biological features of the Mississippi Bight area have been discussed by numerous authors, most prominently by Defenbaugh (1976), Vittor and Associates (1985), and Darnell and Kleypas (1987). The invertebrate and demersal fish fauna are generally typical of the widespread species of the northern Gulf coast. However, detailed analysis shows that there is a considerable admixture of species more typical of the calcareous bottoms of the shelf of the Florida peninsula. Additional faunal elements include slope species that intrude onto the shelf around the Mississippi River delta and around DeSoto Canyon and tropical elements, which are apparently brought in by the Gulf loop current. Many of these are not permanent residents, but Humm and Darnell (1959) reported resident populations of many tropical species of marine algae in the lee of the Chandeleur Islands. Parker (1960) and Defenbaugh (1976) referred to a unique pro-delta environment and fauna near the Mississippi River delta. Reviewing the available faunal information, Darnell and Kleypas (1987) concluded that the fauna of the Mississippi delta is a transitional fauna, representing elements of both the northwestern and eastern Gulf shelf areas. However, it is more than a transition area. It is a unique mix of species, some of which are not found elsewhere along the U.S. Gulf coast, and the delta is characterized by extremely high biological productivity and fisheries yield (Roithmayr 1965). For these reasons, the delta is considered biologically and ecologically unique and a major faunal area in its own right.

The overall responsibility for the program management of this study is assigned to Dr. James Brooks, Director of the Geochemical and Environmental Research Center at Texas A&M University (TAMU) and his Deputy Manager, Dr. Charles Giammona, Associate Professor and Program Manager in the Civil Engineering Department, TAMU. The overall data synthesis and integration is the responsibility of Associate Program Manager, Dr. Rezneat Darnell, Professor of Oceanography, TAMU. A research team composed of scientists from the Department of Oceanography, Wildlife and Fisheries, Civil Engineering, the Geochemical and Environmental Research Center and Texas A&M - Galveston participated in this program.

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Dr. James M. Brooks is a Senior Research Scientist in the Department of Oceanography at Texas A&M University and head of the Geochemical and Environmental Research Group. He has over 80 publications dealing with marine and environmental chemistry. Dr. Brooks is presently Program Manager for the MMS sponsored Mississippi/Alabama Marine Ecosystem Study.

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Dr. Rezneat M. Darnell is Professor of Oceanography at Texas A&M University. He has investigated ecosystem composition and dynamics of streams, estuaries, and continental shelves. Most recently he has studied the distribution of demersal fish and penaeid shrimp populations of the U.S. Gulf of Mexico continental shelf to discern the structure of shelf communities and to develop appropriate management implications. Dr. Darnell received his B.S. in biology from Southwestern College (Memphis, Tennessee), his M.A. in biology from Rice University and his Ph.D. in zoology from the University of Minnesota.

Mississippi/Alabama Marine Ecosystems Study: Biological Aspects

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The objective of the biological component of the Mississippi/Alabama Marine Ecosystems Study is to provide a regional description of the biological communities of the study area, including both the soft bottoms and prominent topographic features. The field studies entail sampling of the macro-infauna, macro-epifauna, and demersal fishes of the soft bottoms. Researchers sampled the environment by using box core and otter trawls, and by means of submersibles, remotely operated vehicles (ROV's), dredges, and hook-and-line. Food analyses will be carried out on important fish species of both soft and hard bottoms to determine trophic relationships among dominant biological components. The combined biological data sets, together with historical information, will be used to characterize the various community types in their spatial and seasonal patterns, as well as the trophodynamics of the systems. Eventually, all the physical, chemical, geological, and biological data from the project will be combined with historical information to provide a coherent synthesis and interpretation of the entire shelf ecosystem.

Although the project officially began in August of 1987, collections and observations from preliminary field studies will be included in the formal project results. Table 4.1 provides an overview of the biological sampling program, as planned, and it also indicates those sampling efforts already completed. Progress to date in the biological laboratory studies is presented in Table 4.2. Although progress in the laboratory has not been great, the project is only a few months old, and all aspects are essentially on schedule.

Biological community delineation and the ecosystem synthesis effort are not scheduled to begin until much later during the study period. Nevertheless, progress has already been made in the review of historical information in order to provide some advanced insight into the types of conclusions which may be reached.

Dr. Rezneat M. Darnell is Professor of Oceanography at Texas A&M University. He has investigated ecosystem composition and dynamics of streams, estuaries, and continental shelves. Most recently, he has studied the distribution of demersal fish and penaeid shrimp populations of the U.S. Gulf of Mexico continental shelf to discern the structure of shelf communities and to develop appropriate management implications. Dr. Darnell received his B.S. in biology from Southwestern College (Memphis, Tennessee), his M.A. in biology from Rice University and his Ph.D. in zoology from the University of Minnesota.

Mississippi/Alabama Marine Ecosystem Study: Geological Characterizations

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Geological studies provide information of value to the biological goals of the program in both soft and hard bottom areas. Hard bottom areas include featureless surfaces as seen on depth recorders and prominent topographic features. A reconnaissance survey utilizing side-scan sonar and a 4 kHz high resolution subbottom profiler is being conducted in an area 35 x 13 natural miles on the outer continental shelf off Mobile Bay. The survey is to provide 100 percent side-scan coverage of the area. The survey was aborted on 8 November 1987 due to weather after completing 60 percent of the total number of lines. Plans call for completing the survey in late February or early March 1988. Based upon the side-scan records, project biologists will select specific local areas to be sites for ROV observations and detailed sampling of the biota. A second mapping effort during the summer of 1988 will result in detailed maps of these local areas for use by the biologists. Side-scan sonar will be used to prepare maps showing the distribution of topographic prominences, hard and soft bottoms, and various surface textural features depicted on the records. The survey effort will provide information that is needed for comparison of the topographic prominences in the present study area with the banks on the outer continental shelf west of the Mississippi River Delta. Features observed during a cursory examination of side-scan records include pinnacles, banks, patch reefs, sand waves, and ridges. The ridges appear to be relict (Pleistocene), truncated coastal dunes. The preservation of the ridges is due to cementation of the sand at, and below, the water table, followed by migration of the overlying uncemented sand out of the area.

The subbottom records provided a penetration of approximately 1 m to 15 m of sediments. Two types of sediments are recognized, and these are separated by an erosional surface. The lower unit is of Pleistocene age and appears to be hard rock. The surface of the unit is frequently irregular due to the incision of stream valleys and channels. In some areas, accretionary bedding and truncated beach deposits are evident. The upper unit has a patchy distribution and does not cover the pinnacles or large areas where the Pleistocene bedrock is exposed at the seafloor. In these areas no subbottom is recorded due to the almost total acoustic reflectivity of the bedrock surface.

Sediment texture is an important variable in the evaluation of benthic organism distributions. This is especially true in determining the population size and dynamics of the infauna community. Sediment texture subsamples are taken from each box core. To date, we have received 155 subsamples for textural analysis. These analyses will also be important in providing ground truth for interpreting the variation in reflectivity of soft bottoms on the side-scan records.

Dr. Richard Rezak is Professor of Oceanography at Texas A&M University, College Station, Texas. He is presently serving as Chairman of the Geological/Geophysical Section of the Department of Oceanography. Dr. Rezak is the geological characterization group leader for the Mississippi/Alabama Marine Ecosystem Study and has served as the Principal Investigator for the MMS-sponsored western Gulf of Mexico Topographic Features Study.

Geological Aspects of Hardbottom Environments on the Inner-Continental Shelf Off Alabama

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Historically, offshore areas along the north-central Gulf of Mexico coast have been typified by expanses of muddy to sand substrates (Curray 1960; Ludwick 1964) with little or no vertical relief (Parker et al. 1983). Parker et al. (1983) state that from Pensacola, Florida, to Pass Cavallo, Texas, reefs of all types make up only 3.2 percent (2,571 acres) of the bottom between depths of 10 and 91 meters, and only 50 percent of the 2,571 acres has relief in excess of 1 m. In the north central Gulf of

Mexico, east of the Mississippi River Delta (Figure 4.5), there is no published evidence that hardbottoms are a conspicuous feature of this continental shelf margin. Moreover, exposed hard substrates were not expected to occur in an area that receives such large amounts of sediment from adjacent river systems and estuaries (Shepard 1956; Ludwick 1964; Ryan 1969; Boone 1973), and that is reported to be covered by sediments with a high percentage of fine grain (silt and clay) material (Shepard 1956; Ludwick 1964; Upshaw et al. 1966; Ryan 1969; USACOE 1982). The one report of hardbottom environments on this shelf is by Ludwick and Walton (1957). They conducted a general survey of topographic high features near the shelf break, between 70-100 m, and their associated sediments and faunas. A detailed study was made of a 13 km^2 section commonly known as the Pinnacles (see Figure 4.5).

Recently, however, hardbottoms* have been observed by Dauphin Island Sea Lab scientists to be present at several locations on the continental shelf, adjacent to Alabama and Florida, in depths of 15-35 m (Figure 4.5). (*The term "hardbottom" is defined here as a generic term that describes any seafloor feature or deposit with a hard or indurated surface. Therefore, there are no qualifications or restrictions placed on the origin (lithogenous, biogenous, or hydrogenous), size (shell hash and gravel to boulders to outcrops and reefs), or morphology (debris fields, platforms, ridges, banks, or pinnacles) of hardbottom substrates.) These areas support organisms, including bryozoans, hard and soft corals, and sponges, as well as snappers, groupers and other fish species, and are well known to local fisherman (although not to scientists). The areal extent of these hardbottoms is unmeasured, and their contribution to the recreational and commercial fishery is unknown. Based on anecdotal information from fishermen, the importance may be substantial, and our preliminary data suggest that the existence of more previously uncharted and essentially unfished hardbottoms is quite likely. It is also quite possible that these hardbottom communities are staging areas for first- or second-year fish that could colonize newly established artificial reef habitats. Thus, siting plans for new artificial reefs should consider placing these structures adjacent to existing hardbottom communities, which contain a ready source of colonists (Stone et al. 1979; Grimes et al 1982; Stone 1986).

Since 1984 researchers at the Dauphin Island Sea Lab (DISL) have undertaken 16 reconnaissance surveys at potential hardbottom sites over the inner-continental shelf offshore of coastal Alabama and northwest Florida. In the spring and summer of 1987 scientists from The University of Alabama (UA) and the Naval Ocean Research and Development Activity (NORDA), under the auspices of the Mississippi-Alabama Sea Grant Consortium (MASGC) and NORDA, conducted five side-scan sonar/3.5 kHz subbottom profiling cruises and eight underwater TV-video and grab/dredge ground-truthing cruises in three study areas on the inner-shelf offshore of Alabama (Figure 4.5: Southeast Banks, Southwest Rock and 17 Fathom Hole). During these cruises a total of approximately 137 km of 150 m range (300 m swath) lines and 32 km of 50 m range (100 m swath) lines of side-scan sonar surveys were successfully completed; over 14 hours of underwater TV-video were produced; and 85 grab, dredge and core samples were collected.

The hardbottom environments consist of loose accumulations of whole and broken shells, and of both reworked and *in situ* carbonate-cemented sandstones and mudstones. Rock rubble and shell hash tend to occupy bathymetric highs of moundlike and ridgelike form, separated by areas of unconsolidated (soft) substrates of mixed sand to clay size material. Vertical relief between "hard" and "soft" bottoms is variable, ranging from almost flat to nearly 2.5 m, in water depths ranging from 15 to 35 m. On a region-wide scale, these hardbottoms appear to be distributed along several shore-parallel (west to east) isobaths, suggesting an origin related to Quaternary sea-level changes. However, on smaller spatial scales, the orientation of the "ridgelike" features is often observed as having pronounced northwest to southeast oriented axes (Schroeder et al. 1987).

Four general types of rock substrate have been identified: (1) sandy sideritic mudstone, (2) sandy aragontic coquina, (3) shelly dolomitic sandstone, and (4) sand calcareous mudstone. Composition of the detrital fraction appears similar to that of the associated unconsolidated sediments of the region. Aragonite, calcite, siderite and protodolomite cements have been identified through use of stained thin sections, optical and scanning electron microscopy and x-ray diffractometry. Stable-isotope ratios are being employed to provide insight into the geochemical environments of cementation (Shultz et al. 1987). Cementation appears to have been controlled primarily by salinity changes and subaerial exposure during Pleistocene lowstands. Burrow-casts and lagoonal lithologies indicate coastal depositional facies. Early cementation resulted in lithification and preservation of crusts and concretions, which were later partially fragmented and reworked by storm waves. Prolonged submarine surficial exposure of these hardbottoms indicates that the recent sediments delivered to this region are not being permanently deposited on the inner-shelf.

Research will continue in 1988 as a major cooperative project consisting of a combined UA/University of South Alabama/DISL team of scientists funded by the MASGC and scientists from NORDA. The 1988 effort will include geological work in both the original study areas and in new study areas, as well as biological work dealing with age and growth rates of selected invertebrates living on the hardbottom substrates, and the censusing of commercially and recreationally important fishes. In addition, submersible platform support is being sought from the NOAA National Underwater Research Program through the University of North Carolina at Wilmington program for the 3-year period (1988-1990), and a final two years (1989-1990) of funding is currently being sought from the MASGC to complete this project.

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Effects of an Oil Spill on Mangrove, Seagrass, Reef Flat, and Coral Communities on the Caribbean Coast of Panama

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In April 1986, 240,000 barrels of medium weight crude oil spilled from a ruptured storage tank at Bahia Las Minas, on the central Caribbean coast of Panama. More than 50,000 barrels of oil immediately washed into an area of coral reefs, seagrass beds, and mangrove forests, including the biological reserve of the Smithsonian Tropical Institute at Punta Galeta. Numerous previous studies of the area provided baseline information for investigating the effects of the oil spill. The following discussion briefly describes some initial effects of the oil on the communities of organisms associated with seagrass beds, reef flats, subtidal corals, and mangroves.

SUBTIDAL SEAGRASS COMMUNITIES

The seagrass Thalassia testudinum forms meadows in the shallow, sandy bottoms of lagoons and embayments in this region of Panama. Seagrasses in subtidal beds were not exposed directly to oil slicks and showed little damage. However, in post-spill sampling, the abundances of infauna in the subtidal beds were much different between unoiled and oiled sites. In clean sites, five months after the spill (September 1986), we obtained the following counts per 95 cm^2 sample (means 32 samples in sets of 8 at four sites): 33.3 amphipods, 9.8 tanaids, 2.1 brachyurans, 1.4 hermit crabs, 2.1 burrowing shrimp, 1.1 bivalves, 0.6 gastropods, and 0.6 ophiuroids. Polychaetes averaged 1.1 gm wet weight per sample. At 3 oiled sites in September, the mean counts in every category were much lower: 0.1 amphipods, 0.2 gastropods, 0.1 brachyurans, 0.6 hermit crabs, and 0.1 burrowing shrimp. Polychaetes weighed an average of 0.3 gm per sample; tanaids, bivalves, and ophiuroids were completely absent. Nine months after the oil spill (January 1987), tanaids were still absent at oiled sites. The counts of amphipods, bivalves, and ophiuroids had increased slightly at oiled sites, but were still significantly lower than at clean sites ($p<0.01$). The abundances of brachyurans, burrowing shrimp, gastropods, and polychaetes were not significantly different between clean and oiled sites ($p>0.05$). Hermit crabs were more than twice as abundant at oiled sites, perhaps a result of an increased supply of shells from dead gastropods.

REEF FLATS

The platforms of fringing reefs form most of the intertidal habitat on this coast. The abundances and distributions of sea urchins and all sessile species (algae, seagrasses, and invertebrates) on the reef flats had been monitored for a number of years before the oil spill. This database was used to compare abundances before and after the spill. Driven by onshore winds, the oil accumulated against the seaward borders of the reef flats during low tides and warm, sunny weather. As a result, the zoanthids, corals, sea urchins, algae, and the other organisms in the reef edge habitat were directly bathed in the crude oil at each low tide for 10 days after the beginning of the spill.

Mortality of organisms on the reef flat was clearly related to the distance from the accumulation of oil at the reef edge. In permanent, 20 m^2 transects, monitored monthly since 1978, populations of the sea urchin Echinometra lucunter in the reef edge zone declined by more than 80 percent immediately after the spill, and the area was littered with the tests of decomposing urchins. This was the largest relative decline seen at this time of year in eight years of monitoring. No such decline was recorded in transects closer to the center of the reef flat.

As part of a larger-scale monitoring program, we surveyed the coverage of organisms at the seaward edge of the reef 16 times between March 1983 and December 1984 and repeated the surveys at 3-month intervals after the spill. The surveys used point-sample methods and consisted of 10 transects, 9 to 22 m long (average length = 15 m), which were perpendicular to the reef edge and spaced randomly within 20 m intervals along the shore. A bloom of microalgae (mainly Cladophora sp., Enteromorpha sp., diatoms (mostly epiphytic), and Centroceras) overgrew both the vacated substrata and sessile organisms that had survived the oil spill. When the transects were resurveyed about 6 weeks after the beginning of the oil spill, the mat of microalgae covered more than 54 percent of the substratum. This was more than 4 times the average abundance and almost twice the maximum abundance of microalgae recorded in pre-spill surveys. The bloom was most pronounced (mean - >76 percent cover) in the seawardmost 6 meters of the transects, where microalgae had been rare before the spill (range - 0.3 - 18.7 percent; mean - 4 percent). Before the spill, most of the reef flat populations of sessile invertebrates and coralline algae had been concentrated in this seaward 6 meters of the transects. Six weeks after the spill, the abundance of the zoanthid Palythoa caribaeorum and the coralline algae had decreased by an order of magnitude. The corals disappeared completely.

In the 1.5 years of surveys after the oil spill, the populations of most sessile invertebrates have not returned to pre-spill levels. However, algae and sea urchins have regained or exceeded pre-spill abundances.

CORALS IN SUBTIDAL HABITATS

Populations of subtidal corals were surveyed on 12 reefs within 4 months after the oil spill using visual estimates of cover in 1 m wide transects traversing the reef slope from the shallowest to the deepest part of the reef. Six of these had been surveyed before the spill, including one heavily oiled reef, one moderately oiled, and four unoiled reefs. At the heavily oiled reef, four months after the spill, the total cover of all corals had decreased to 10-25 percent of pre-spill abundances. In surveys of the moderately oiled and unoiled reefs, no such effects were found.

Partial mortality of corals was also higher in the oiled sites. The percent of S. siderea colonies showing signs of tissue damage was 48 percent of 631 colonies at heavily oiled sites, 34 percent of 495 colonies at moderately oiled sites, and 3 percent of 132 colonies at unoiled sites. The amounts of saturated hydrocarbons in the tissues of this coral five months after the spill were as follows (means of 3 samples): 25.5 $\pm$ 6 ug/mg at heavily oiled sites, 1.3 $\pm$ 0.3 ug/mg at a moderately oiled site, and 0.8 ± 0.8 ug/mg at an unoiled site.

MANGROVE TREES

Dense thickets of the red mangrove Rhizophora mangle form nearly all of the fringing forest on this coast. Driven by winds and currents, oil accumulated mostly at the edge of this forest; within three months, the mangrove trees near the shore began to defoliate. A year later, a band of dead mangroves about 50 m wide paralleled the shoreline and followed channels into the forests. Areas of dead forest were more extensive within Bahia Cativa, where the oil exited the refinery. At places on the outer coasts, red mangroves rooted in subtidal sediments at the seaward edge of the forest suffered less defoliation and formed a green fringe on the ocean side of the dead swath.

EPIBIOTA ON MANGROVE ROOTS

In the area of the oil spill, the prop roots of red mangroves constitute much of the firm substrata supporting benthic algae and sessile invertebrates. These epibiota were censused in 1981-1982 and after the spill (August 1986 to present) in three types of habitats: open coast, channels, and rivers. At each site within these habitats, percent cover was estimated on 25-100 roots that extended at least 20 cm into the water, but were not attached to the bottom.

In two pre-spill censuses on the open coast (1981-1982), space on roots was occupied primarily by foliose algae (mean percent cover = 52 percent, growing mostly in turfs) and sessile animals (mean = 18 percent mainly hydroids, tunicates and sponges). Roots at all these open sites were coated with oil during the spill; the algal turfs became matted with oil, disappeared, and were replaced by loose leafy algae, such as Caulerpa spp., forming 24 percent cover in August 1986 and 14 percent in November 1986. The cover of sessile invertebrates was also much less after the oil spill: 4 percent in August 1986 and 1 percent in November 1986. In unoiled, open shore habitats (~25 km away) in August 1986, the percent cover on roots was similar to oiled sites before the spill: 7 percent cover of animals and 21 percent cover of foliose algae. In August 1987, both foliose algae (5 percent cover) and sessile animals (6 percent cover) were rare at oiled sites while unoiled sites had 28 percent cover of foliose algae and 9 percent cover of animals.

In three pre-spill censuses of roots in channel habitats, an average of 53 percent of the root surface was covered by oysters (mostly Crassostrea rhizophorae) and 13 percent was covered by the barnacle Balanus ?improvisus). Oiling within the channel habitat was patchy, based on measurements of the amount of oil on the roots. After the spill, oysters and barnacles were less abundant in moderately oiled areas: oyster cover was 25 percent in August 1986, decreasing to 7 percent in November 1986; barnacle cover was 2 percent in both August and November. In areas exposed to little to no oil, oyster cover was 36 percent in August 1986 and 27 percent in November 1986, and barnacle cover 6 and 13 percent, respectively, on these dates. The lower coverages in the oiled sites relative to the unoiled sites have persisted through August 1987.

Roots in two riverine sites were censused before the spill; 63 percent of the root surface was covered by the false mussel Mytilopsis domingensis and 7 percent was covered by the barnacle B. ?improvisus. One riverine site escaped the spill; the other was heavily oiled. At the unoiled site in August 1986, the roots remained covered by these animals: 39 percent cover of mussels and 8 percent for barnacles. However, at the oiled site, only the shells of dead animals remained. At the unoiled site a year later (August 1987), 37 percent of the surface was covered by mussels and 3 percent by barnacles. In the oiled site a year later, mussels covered 8 percent of the surface and barnacles covered <0.1 percent.

All of the authors are currently studying the effects of the oil spill at Las Minas Bay in a project funded from the Minerals Management Service of U.S. Department of the Interior (Contract Number 14-12-0001-30393) and grants from the Environmental Sciences Program of the Smithsonian Institution. **Jeremy Jackson** is Chief Scientist. The Project Scientists and their projects are **John Cubit** (reef flats), **Steve Garrity** (mangrove root communities), **Jeremy Jackson** and **Hector Guzman** (corals), **Anthony Knap** and Karen **Burns** (hydrocarbon analysis), and **Mike Marshall** (seagrass bed). **Ricardo Thompson** conducts the long-term monitoring programs for hydrography, meteorology, and echinoid populations. Karl **Kaufmann** is in charge of data management, with consultant assistance from **Sally Levings.**

Preliminary Results of Recent Investigations on Detection, Chemical Treatment, and Recovery of Open Ocean Oil Spills

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Minerals Management Service
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The Minerals Management Service (MMS) participated with Environment Canada and the Canadian Coast Guard (CCG) in two intentional offshore oil spill experiments. These tests were conducted to evaluate the following: new chemical additives, ship board radar as an oil tracking tool, a prospective standardized testing program for offshore boom performance, and existing CCG and Canadian industry capabilities to contain and clean up high paraffin based crude oils.

The first at-sea experiment evaluated a Canadian emulsion inhibitor or "demoussifier" and a visco-elastic agent, "Elastol," in a series of ten 5-barrel oil spills off Nova Scotia on September 9-10, 1987. The oil used in the demoussifier tests was 50 percent Alberta Sweet Blend Mix (ASBM) and 50 percent Light Bunker C. These tests were conducted to evaluate the emulsion inhibiting qualities imparted to the mixed oil by various dosages of the demoussifier. Straight ASBM was used in the evaluation of oil spreading rates and the physical properties of the oil resulting from the addition of differing dosages of "Elastol."

The second at-sea exercise was conducted on September 24, 1987, off Newfoundland, using 20,000 gallons of Brent crude treated with additional paraffin to yield an oil which behaved like Hibernia crude. This multiphase field trial was conducted using three state-of-the-art containment booms and three types of skimmers.

Findings based upon preliminary data analyses showed that

- Existing ships radar proved effective in tracking oil slicks in Sea States 1-5 provided that heavy swells were not also present. Procedures for using this technique include detuning interference filters and observing areas of reduced sea return which indicate slicks.

- When the product Elastol was applied to the ASBM in concentrations of 1000-9000 part per million (PPM), slick spread rates were observed to vary directly with dosages. The slick treated with 9000 ppm was only one-sixth the size of the untreated control slick after 4 hours. Based on preliminary data analyses, it strongly appears that immediate use of this product on a spill could significantly reduce subsequent containment efforts during mechanical recovery. The viscosities of oil treated with various doses of "Elastol" were significantly higher over the 4-hour period than untreated oil.
- Towing of containment booms downwind in winds up to 35 knots was successful in containing the slick of spilled Brent crude oil. These booms towed upwind at the same two speeds leaked significant amounts of oil when the winds were blowing at least 15 knots. Therefore, it is concluded that when winds approach and exceed 15 knots, downwind towing should be the preferred approach. At one point in the experimentation, a boom was able to contain oil at wind speeds reported in excess of 40 knots using downwind towing.
- High paraffin content crude oils do not readily adhere to most oleophilic skimmers. The addition of "Elastol" in dosages estimated to be below 1,000 ppm significantly altered the elastic and adhesive properties of the oil to enable relatively rapid recovery with oleophilic skimmers.
- The slicks of ASBM and a mixture of ASBM and Bunker C were totally dispersed within 36 hours in waves approaching 5 to 8 feet. No oil was detected using one of the most sophisticated airborne remote sensing packages after that period of time. Slicks were observed to materially dissipate within 4 to 5 hours at winds of 25 to 30 knots.

Mr. Tennyson is a senior staff scientist in the Technology Assessment and Research Branch of the MMS. His duties comprise the origination and management of projects pertaining to oil spill mitigation, well control, and well fire suppression. Since 1970, Mr. Tennyson has participated in the evaluation of oil spill response equipment and procedures, in addition to research management. He has served in the U.S. Coast Guard in the capacity now known as On-Scene Coordinator.

Mr. Tennyson received his M.S. in zoology from the George Washington University and has done additional graduate work in oceanography at the University of Virginia.

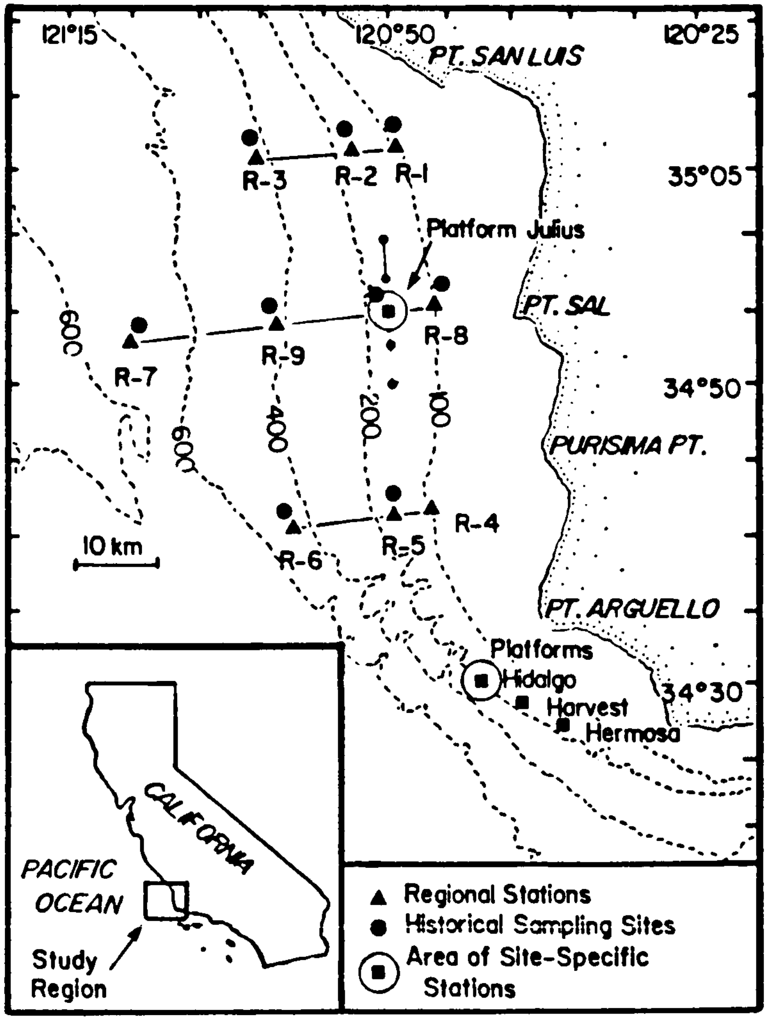

Figure 4.1.--Chart of the Santa Maria Basin Region showing the location of regional stations (R-1 to R-9), the coincidence of several historical (Phase I stations) and site-specific study sites adjacent to Platform Hidalgo and proposed Platform Julius. Depth contours are in meters.

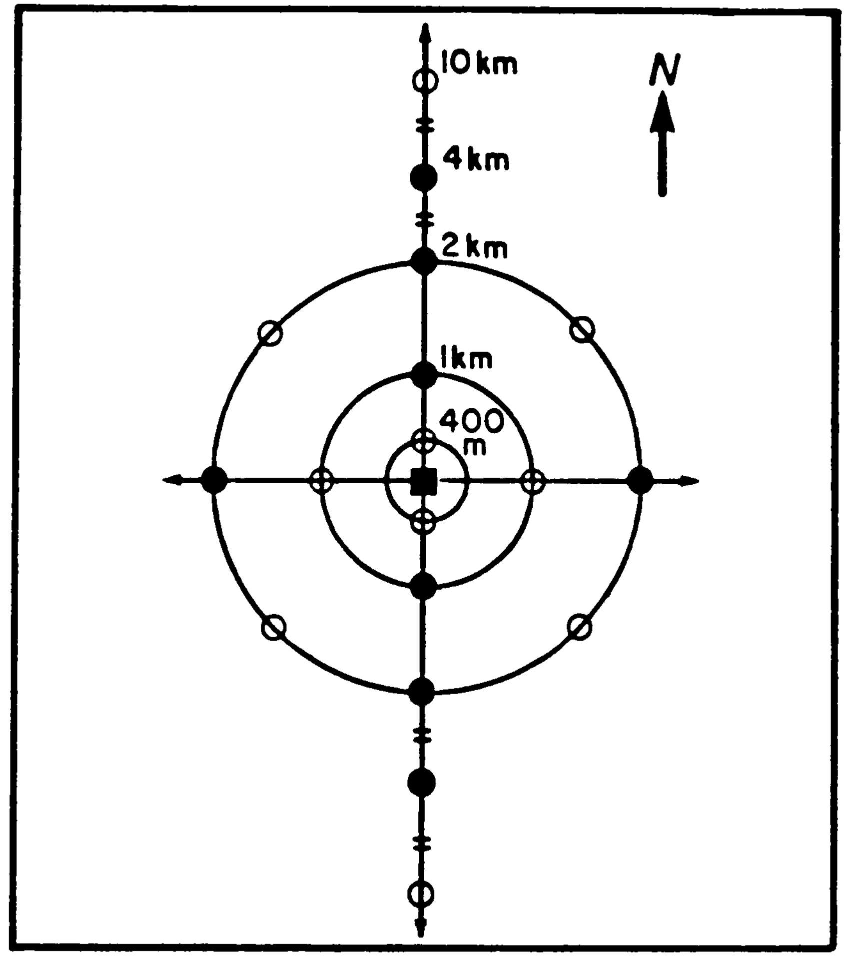

Figure 4.2.--Diagram of the site-specific, soft bottom sampling array around proposed Platform Julius. Primary (dots) and secondary (open circles) stations have been designated to prioritize sample analysis.

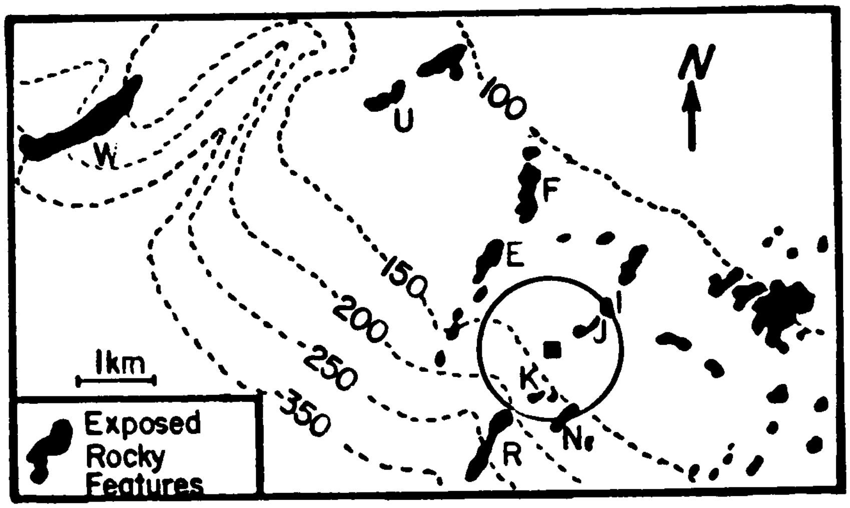

Figure 4.3.--Chart of the area around Platform Hidalgo showing exposed, hard-bottom (rocky) features. Features selected for long-term monitoring are designated as sites W, U, F, E, I, J, K, N and R. The circle encompasses rocky features within 1 km of the platform. Depth contours are in meters.

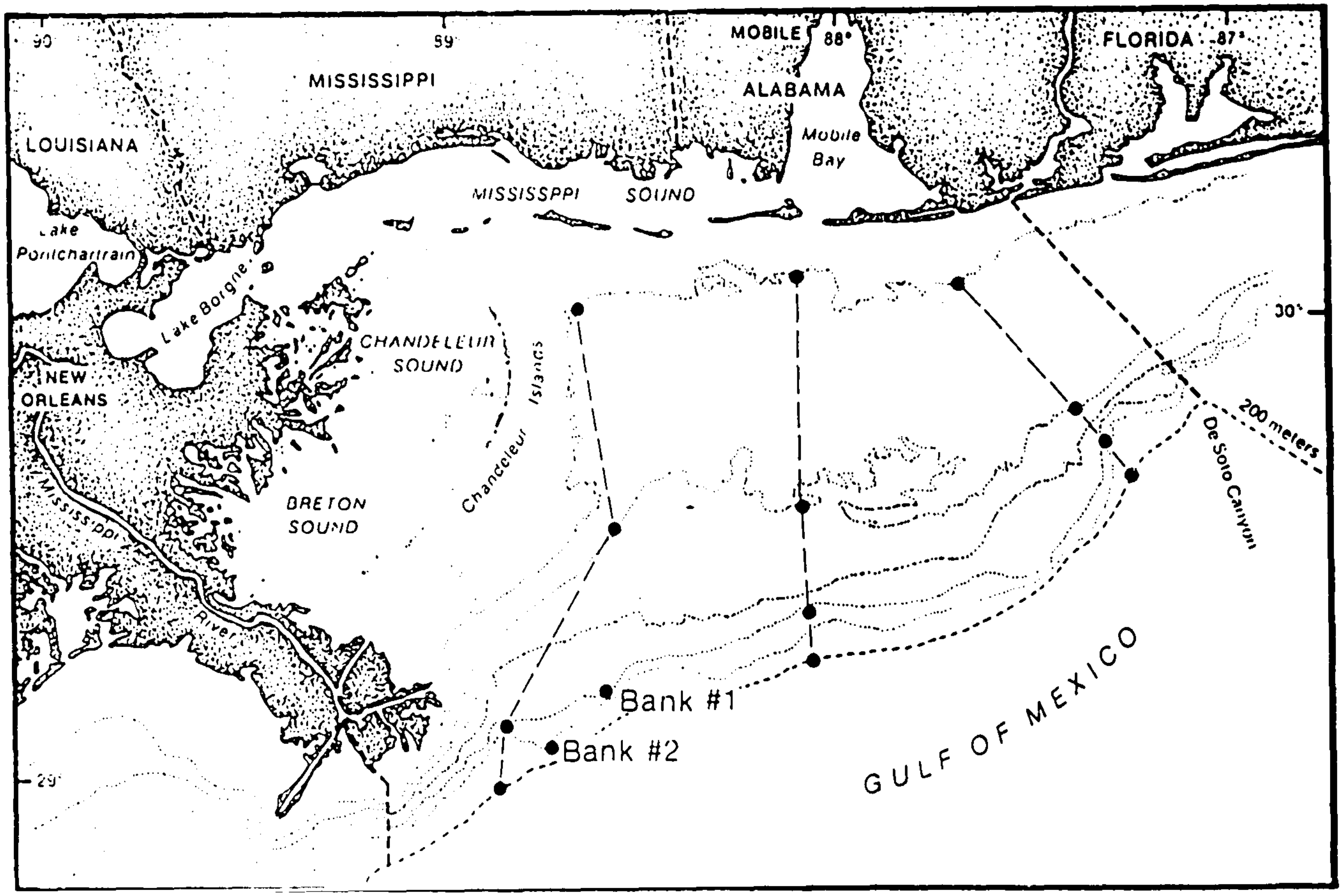

Figure 4.4.--Proposed sample locations for the "Mississippi/Alabama Marine Ecosystem Study."

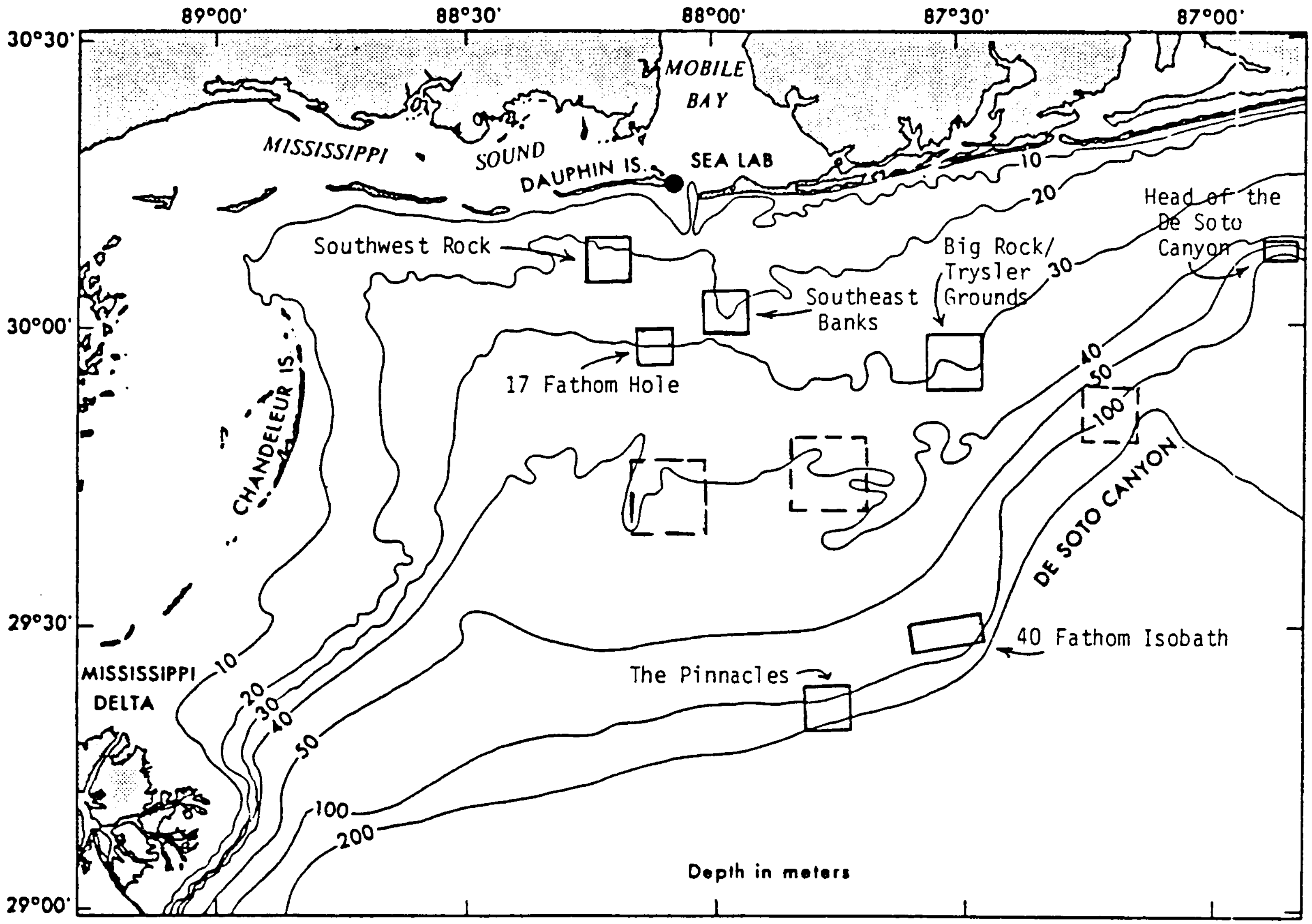

Figure 4.5.--Locations of on-going and proposed study areas (solid lines) and alternative and/or future study areas (dashed lines).

Table 4.1.

Biological Sampling Program

Target/Gear	Preliminary Cr.1	Year I Cr.1	Year I Cr.2	Year II Cr.1	Year II Cr.2	Year III Cr.1
<u>Soft Bottoms</u>						
Macro-infauna (box cores)	X*	X*	X	X	X	
Macro-epifauna (trawls)	X*	X*	X	X	X	
Fish taxonomy (trawls)	X*	X*	X	X	X	
Fish food analysis	X*	X*	X	X	X	?
<u>Hard Bottoms</u>						
Submersible	X*					
ROV				X		X
Rock Dredge			X	X		
Hook and Line			X	X		

*=completed

Table 4.2.

Biological Laboratory Program

Study sub-set	Progress to Date
Soft Bottoms	
Macro-infauna	First cruise samples already sorted to major phyla. Second cruise samples being sorted to major phyla.
Macro-epifauna	First cruise samples already sorted to major phyla. Second cruise samples being sorted to major phyla.
Fish taxonomy	First cruise samples mostly sorted to species. Second cruise samples have begun yet.
Fish food analysis	These studies will begin as soon as first cruise fishes have been sorted to species.
Hard Bottoms	
Submersible	No photos or samples taken. Water too turbid.
ROV	Studies to begin in summer of 1987.
Rock Dredge	No samples taken yet.
Hook and Line	No samples taken yet.

DEEPWATER DEVELOPMENT AND PLATFORM INSPECTIONS

Session:	DEEPWATER DEVELOPMENT AND PLATFORM INSPECTIONS
Chair:	Dr. Maurice I. Stewart, Jr., P.E.
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Deepwater Development and Platform Inspections: Session Overview

Dr. Maurice I. Stewart, Jr., P.E.
Minerals Management Service
Gulf of Mexico OCS Region

Few events have excited the offshore industry interest as have the deepwater oil and gas discoveries recorded recently on Federal OCS tracts in the Gulf of Mexico. Lying underwater from 600 to nearly 7,500 feet (ft) deep, the discoveries are on the slope 30 to 150 miles offshore. Today, operators hold active leases on over five million acres in water depths over 600 ft, and the deep Gulf is considered one of industry's hottest wildcat plays.

There are over 3,600 structures in Federal waters in the Gulf ranging in size and complexity from a simple, single-pile caisson supporting one well to major platforms of considerable structural complexity. Typically, these major platforms are large, multiwell production structures designed for a field life of approximately 20 years.

The offshore engineering session was organized in two distinct parts. In the first part, deepwater drilling and production efforts planned and now underway in the "frontier areas" of the Gulf were summarized. In part two, a summary of current methodologies for inspecting and monitoring the structural integrity of existing platforms was presented.

Since deepwater activity is so widely dispersed throughout the Gulf, Dr. Stewart previewed the session with an extensive overview of both existing and proposed deepwater activities. This set the stage for key deepwater operators to discuss technological and operational challenges that must be overcome to economically develop what may be the most significant U.S. producing area since Prudhoe Bay.

Mr. Antoine Gautreaux, from Placid Oil Company, discussed the development and current status of Placid's 1,500 ft floating production system (FPS) located in Green Canyon Block 29 and its shallow water central processing platform (CPP) in nearby Ship Shoal 207 field in 100 ft of water. The FPS system, designed to support a combination of 24 total template-drilled and satellite wells from surrounding 1,500 to 2,000 ft water, will ultimately establish oil production of 25,000 BOPD (barrels of oil per day) and 120 MMSCFD (million standard cubit feet per day) of natural gas.

The FPS system consists of subsea trees, a subsea template, a production riser, flow lines/pipelines, a semisubmersible drilling/production facility, mooring system, and a shallow water central processing production platform.

To date, one subsea template christmas tree and two satellite well subsea christmas trees have completed factory acceptance testing and are ready for installation. The 24-well subsea template has been fabricated and is installed. A one-mile section of flow line bundle has been constructed, launched, and "bottom towed" to the installation site. One seven-mile section of flow line bundle has been constructed, launched, and "bottom towed" to a temporary "parking" area awaiting final installation.

The Penrod Drilling Company semisubmersible rig 72 is complete with modifications and is moored on location in Green Canyon Block 29, with the production deck section in the field being installed.

Placid's FPS system project clearly demonstrates that major subsea structures can be easily installed with precise positioning in deepwater tracts. Phased installation of the mooring system provided an efficient method of final attachment for permanent installations. Furthermore, the pipeline "bottom tow" procedure provides an effective method of pipeline installation in deepwater applications.

Mr. Cor Langewis, from Conoco, Inc., discussed the development and current status of Conoco's 1,750 ft Green Canyon Block 184 project. Conceptual studies began in 1981 and were refined as exploration and delineation progressed. The concepts studied for field development included conventional fixed jacket platform, guyed tower, tension leg platform (TLP), and a converted semisubmersible with subsea wells.

The tension leg well platform (TLWP) concept was developed and refined in 1984. This concept utilized a small, efficient TLP in the deepwater location to do only those functions that are absolutely required at that site. All other functions would be performed at a second shallow water CPP. Production is scheduled to begin in the last quarter of 1989 at a peak of 35,000 BOPD and 50 MMSCFD.

Detailed design work was initiated in early 1986. The TLWP work was awarded to Lummus Crest/Earl and Wright. The rig design was done by Stress Engineering of Houston. The pipeline work was awarded to Brown and Root. The CPP structure and facilities design is being done by Hudson Engineering (McDermott) of Houston.

The drilling template was installed in June 1987. Batch setting of a 30-inch conductor and a 20-inch surface casing was completed for all 16-inch proposed production wells. Drilling of the first production well started in August 1987, and the third well is currently in progress.

The TLWP will be available for installation in May 1989 when the drilling of production wells is scheduled to be completed. CPP installation and pipeline tie-ins are scheduled to be completed by September 1989 for the start of oil and gas production.

Mr. Gordon Sterling, from Shell Offshore Inc., discussed the status of Shell's 1,353 ft Green Canyon Block 65 "Bullwinkle" project. The 60-slot fixed platform will surpass the height of the tallest existing offshore structure of 1,025 ft. With two drilling rigs operating simultaneously on the platform deck, the entire structure will stand approximately 1,615 ft.

The jacket and deck will be transported and installed by mid-summer 1988. Development drilling will begin in the 1st quarter of 1989 and is scheduled to be completed by the 3rd quarter of 1990. Oil production is expected to peak at 50,000 BOPD in 1991, and natural gas production is expected to peak at 90 MMSCFD in 1992.

Dr. Terry Petty, from Ocean Drilling and Exploration Company (ODECO), discussed the Ocean "El Dorado" FPS. Dr. Petty pointed out that most of the floating production concepts developed thus far rely on the use of subsea systems for production because the large motions of the vessels, principally heave motions, make it impractical to produce conventionally through rigid riser and surface trees.

To overcome this limitation, FPS's with significantly reduced motions such as TLP's and the Ocean El Dorado have been developed. With the reduced motions of these vessels, it becomes feasible to produce conventionally with surface trees on deck, thus avoiding both the capital cost and operating costs of a complex and sometimes inefficient subsea system.

The TLP suppresses heave motion by anchoring the vessel to the seabed with vertical tendons while the El Dorado relies on the hydrodynamic performance of its hull to remain transparent to the seaway.

The Ocean El Dorado design offers the benefit of a semisubmersible hull with significantly reduced motion characteristics, allowing for a more economical and conventional method production. This is combined with a stability/environment criterion consistent with a realistic assessment of the requirements for a deepwater floating production system in the Gulf of Mexico.

Mr. Kevin Bourgeois, from Chevron U.S.A. Inc., discussed Chevron's underwater inspection, maintenances, and repair program. The objectives of Chevron's program are (1) to insure the structural integrity of the platform, (2) to insure the safety of personnel and the environment, (3) to detect and correct detrimental design defects, and (4) to comply with current API/MMS requirements.

To achieve these objectives, Chevron divided its program into two phases. Phase I involves a series of general inspections to determine the present condition of an existing platform and to correct any major defect. Phase II involves a series of detailed and structured inspection tasks to ensure the future structural integrity of the platform.

In order to control a program of this magnitude, automation is essential. Therefore, Chevron developed a computer-aided inspection and reporting system. This system utilizes an inspection database, providing the ability to systematically plan and track the inspection program.

Mr. Pat Dunn, from Shell Oil Company, discussed monitoring the structural integrity of offshore platforms. Mr. Dunn stated that structural monitoring includes any measurement of the behavior, motion, stress, or condition of a platform. He discussed how monitoring is used as an inspection tool in the context of an effective inspection program. Furthermore, he discussed what to do with the results by illustrating a few examples of repair techniques.

Monitoring is also used to gather data about the performance of the platform and about the environment it is in, in order to improve the design of future platforms. Mr. Dunn showed some past measurement programs that have impacted platform design.

Finally, Mr. Dunn expressed that the best defense against future problems is good initial design and construction, along with thorough inspection during construction.

Dr. Stewart is Supervisor of the Technical Assessment Unit for MMS, a Registered Professional Engineer, an author, an inventor, an international lecturer, and an Associate Professor of Petroleum Engineering at Tulane University.

Dr. Stewart's career includes working with a major gas exploration and production company, a marine engineering and construction company, a consulting engineering firm, a university, and a regulatory agency. He has co-authored three engineering textbooks (printed in five languages and used in 183 universities worldwide); he regularly teaches at industry-sponsored short courses and has lectured in 58 countries throughout the world.

Developments in Placid's Green Canyon Block 29 Project

Mr. Antoine Gautreaux, P.E.
Placid Oil Company

In 1983, Placid Oil Company and its partners acquired numerous deepwater tracts including Green Canyon Block 29. Later in that same year, the Placid group's first deepwater discovery was made in what is today known as Green Canyon Block 29 Field. This discovery launched a full-scale internal effort in determining what method would best serve in developing deep water reserves. The system must

- use conventional technology where possible.
- accommodate simultaneous drilling/workover and production and be capable of accommodating 24 wells.
- accommodate surface well flow control devices (chokes) and have individual tubing and annulus lines for each well.
- be capable of gas-lifting any well with surface controls.
- must accommodate production from, or injection to, any well.
- allow for phased expansion.
- include pipelines for transport of production to a sales point.
- work in water depth range of 1,500 to 3,500 feet.

By mid-1985, two additional discoveries were made, one in Ewing Bank Block 999 and one in Green Canyon Block 31. This three-tract field was selected to develop the deepest subsea production system in the world. The Placid group has acquired over 100 deepwater leases. Forty-eight leases are located in the Green Canyon area, an important factor in the final configuration of the first Floating Production System (FPS) in the Gulf of Mexico. The system is scheduled for commissioning in the summer of 1988 by Placid Oil Company.

To generate revenue as quickly as possible, Placid maintained an ambitious project schedule while minimizing project overhead expenses. Experimental technology was considered only when no conventional approach could be found, reducing development engineering expenses. The technical staff and the engineering contractors maintained close communication; many creative ideas and concepts were spawned.

Placid evaluated several drilling template configurations before selecting a structural arrangement having four rows with six slots each. The subsea template was fabricated from standard structural steel shapes rather than tubulars because of the 1,500 ft.-3,000 ft. design depth requirement. The template functions as a foundation for the development wells, the anchor point for the production riser, a pipeline manifold for future pipelines, a connection point for satellite wells, and a landing base for the subsea controls.

All the interior well slots must be template completions. Any of the twelve outside well slots can be used for satellite well connections, with eight capable of template completions. The template was constructed with all production and control piping in place. Production and annulus piping extends from each of the 24 well slots to the production riser base, and ten control lines extend from each well slot to the control system landing bases.

The template is 82 ft. wide, 165 ft. long, and weighs 1,280 tons. The template, lowered to the seafloor in three hours, was set in February 1987, in 1,522 ft. of water. The template is secured to the seafloor using eight piles driven by an underwater hammer.

The subsea tree is a dual bore, 10,000 pounds-per-square-inch maximum working-pressure system consisting of a tree connector, master valve block, tree mandrel, tree cap assembly, flowline loops, and flowline pedestal stabs. The satellite tree differs, in that, the larger bore reduces the flowing pressure loss for distant wells.

The production riser is the more complicated of the components which made up the FPS. The 83-1/2 inch O.D. production riser is rigid and free standing from the production riser base at the subsea template to 150 ft. below the water surface. A combination of syntactic foam and air cans in each riser joint and external air cans on the top 2 riser joints provide the necessary buoyancy to make the production riser free-standing when disconnected from the Penrod 72 floating drilling/production facility (FDPF). The upper riser disconnect allows for a quick separation from the main riser structure. Disconnecting the upper riser, originally intended as "hurricane protection," is not required as revealed in model basin testing. The disconnect does allow for production piping maintenance in the riser which, of course, would include displacement safeguards to prevent pollution prior to disconnect. When disconnected, however, the upper riser disconnect is lifted to below the Rig 72 pontoons using the riser tensioning lines. The riser tensioning system onboard Rig 72, although not required for production riser structural support, is maintained to restrict riser motion during severe sea states.

The Penrod Rig 72 is a large, twin pontoon, six column, semi-submersible drilling vessel. Because of its size (243 ft. long x 196 ft. wide at the superstructure), its conversion was not difficult. Most of the original equipment, quarters, and storage areas are below deck leaving a relatively clear, flush upper deck. The rig's original heliport was removed, and a production deck was fabricated and installed in its place so that production equipment has had minimum impact on drilling space. The production equipment allows for primary liquid separation with gas dehydration.

The facility design is capable of processing 120 million standard-cubic-feet (120 MMSCFD) of natural gas, 45,000 barrels per day (4,500 bpd) of hydrocarbon liquid, and 22,500 barrels per day (bpd) of produced water. Initial equipment allows for one-half treatment capacity. Space is allotted for future separation, compression, dehydration and water treatment.

Additional modifications were a new heliport and sponsons to each corner leg to house the new mooring system components. Modified ballast controls and new production and well control centers were installed.

Station-keeping is required throughout maximum-operating and survival conditions expected during the development life. The entire mooring system was replaced with the newly-designed system capable of maintaining a 150 ft. watch circle during 100-year storm conditions while limiting line tensions to one-half the breaking strength and anchor-holding to two-thirds of the capacity. The mooring system was installed in two phases. This mooring system, employing the spring buoy to straighten mooring line catenaries, is the largest ever installed in the Gulf of Mexico.

Transporting production from deepwater tracts posed a challenge. The "bottom-tow" technique of pipeline installation was chosen to avoid interference with the mooring systems of semi-submersibles working in the area. The integral satellite well flowline bundle design chosen could not be constructed by conventional lay methods. Seafloor, diverless connections of pipelines could easily be accomplished.

Forty-one miles each of 14-inch oil and 16-inch gas pipeline were installed by conventional lay method from the shallow water processing facility to the 550 ft. water depth contour. One 1-mile and two 7-mile flowlines were successfully "bottom-towed," following construction on Matagorda Peninsula, Texas.

The subsea control system incorporates three of the standard control philosophies--direct hydraulic, multiplexed electro-hydraulic, and piloted hydraulic into one hybrid scheme. The entire system is modular, and hardware is installed in stages commensurate with field development.

A computer based electro-pneumatic control system is used in the surface safety system. Analog, pressure, temperature, and flow transmitters will be used to provide the operator with up-to-the-minute information pertaining to the process flow system. The state-of-the-art, computer-based system is supported by a 100 percent online, stand-by system capable of faultless transfer.

The 14-inch oil and 16-inch gas pipelines, originating from the Green Canyon subsea template, terminate at the processing platform located in Ship Shoal Block 207. Conventional processing facilities are used to prepare the gas and liquid hydrocarbon for sale.

In summary, Placid Oil Company's Green Canyon Block 29 development is a milestone achievement in today's FPS technology. The system provides an economic means for development of deepwater production with the ability to generate early cash flow and revenue. The subsea template designed to support the Green Canyon area contains ample pipeline capacity to support transportation of production from other areas as well. Flexibility by design allows for tailoring such a system to closely match field development requirements, thus reducing costs.

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Mr. Antoine Gautreaux received his B.S. in engineering technology from Nicholls State University in 1974. He is now Deepwater Production Superintendent, Placid Oil Company, Green Canyon Block 29 FPS, Deepwater Development Production and Construction Operations.

Jolliet Field Development in Green Canyon Block 184

Mr. Cor Langewis
Conoco Oil Company

INTRODUCTION

Development drilling and construction of major components for the world's second tension leg platform (TLP) are underway for the Jolliet Project located 100 miles offshore in the U.S. Gulf of Mexico (Figure 5.1). At 1,750' water depth, this is the deepest water oil field project with a "fixed" platform in the world.

This is a true "Frontier Area" of the world, in the same league as the North-of-62-degrees-N-Latitude Norwegian Waters approximately 1,000'± deep (but harsh environment) and the deep Campos basin 2,000-3,000' water offshore Brazil. Explorers of the past, such as DeSoto, LaSalle, Marquette, and Jolliet explored and challenged the surface waters of the Gulf of Mexico and Mississippi in the 1600's. It is from this that we have taken the theme of our deepwater developments--Explorers of the Gulf of Mexico--and are naming our projects after them. The first project is GC 184, and it has been named after the French Canadian Louis Jolliet, the man who, with Marquette, was the first to venture down the Mississippi from the Great Lakes and determined that it flowed into the Gulf of Mexico. The development in GC Blocks 52/53, which is a "companion" project to Jolliet, will be called Marquette.

The Jolliet Project will develop and produce oil and natural gas from a medium size field of about 50 MMBOE in 1,750' water depth. Water will be injected in selected sands for pressure maintenance and improved recovery. The important specifics of the development are:

- o Tension Leg Well Platform (TLWP) in 1,750' water depth with primary production and well completion equipment.
- o 16 development wells with dry wellheads in the TLWP.
- o 3 subsea water injection wells.
- o Flexible pipe catenary risers for all pipelines and subsea well flowlines.
- o Conventional production platform in 610' water depth 10 miles north of the TLWP.
- o 75 miles of pipelines for oil, gas, and water.

Total project cost is about $400 MM. Final approval to proceed with construction was given in December 1986, and first production is expected in September of 1989. Peak production is expected by late 1990. The remarkable features of this project, in addition to the water depth, are the speed with which full production is achieved and the overall cost effectiveness and flexibility of the system.

HISTORY

The Green Canyon 184 Block was acquired by Conoco, Getty Oil, and Cities Service Oil and Gas Company in November of 1980. Conoco spudded the first well in the southeastern quarter of the block, in 1,500' of water, in May of 1981 and drilled to 11,300' (Figure 5.2). The well discovered eight oil sands totalling about 175 feet of net pay.

Six additional delineation wells have been drilled from 10,000'-14,500' depth encountering a total of 54 separate productive reservoirs with total pay thicknesses up to 550'. Known recoverable reserves are 40 MMBO and 75 BCFG. Oil is about 33 degrees API.

Green Canyon Block 184, which contains 5,760 acres, is an unconventional, net profits share lease (NSPL), which is no longer offered by the Department of the Interior. The lease term of five years expired in October 1985, but has been extended with a Minerals Management Service (MMS) approved Plan of Development and Suspension of Production (SOP).

The conventional Gulf of Mexico lease has a 1/8 or 1/6 royalty payment to the MMS. The GC 184 NPSL requires payment of a 50 percent net revenue, instead of a royalty payment, after 200 percent cost recovery of the original exploration and development investment.

The intention of the MMS in utilizing the NPSL concept was to encourage more companies to compete for deepwater Gulf of Mexico leases. The NPSL system was designed to enhance upfront cash flow (no royalty) and ensure that investment (exploration and development) is recovered, plus incentive, before "royalty" starts.

Project conceptual development studies were started in 1981 and refined as exploration and delineation progressed. Concepts studied for field development, which was originally located in 1,400' water depth, were conventional fixed jacket, guyed-tower TLP, and converted semi-submersible with subsea wells. Exploration and reservoir evaluation work resulted in the platform location being in about 1,800' water depth with reserves and production rates too low to meet corporate project approval criteria.

The reserves were too big, however, to ignore. The TLWP concept was developed and refined in 1984. This concept utilized a small, efficient, TLP in the deep water location to do only those functions that are absolutely required at that site. All other functions would be performed at a second site that would not be as weight/payload sensitive. The initial configuration was a TLWP with a permanently moored converted VLCC tanker. When other fields were discovered closer to shore, and oil and gas offtake pipelines could be justified, a "fixed" central production platform in shallow water by the new field replaced the tanker (Figure 5.3).

Because of the deepwater aspects of this project, the project is particularly sensitive to the number of wells required for development. The reservoir plan has been prepared in close coordination with the facilities and drilling plans to achieve optimum economic benefit. The program of 16 producers on the TLWP, 13 of which are dual completions and 3 dual completed subsea water injection wells, is optimum based on present mapping. As is the case in most development projects, this plan could change slightly as wells are drilled. The TLWP incorporates a completion rig that will provide future flexibility for recompletions and kick-outs from the producing wellbores when required.

Production is scheduled to begin in September of 1989 and peak at about 25,000 BOPD in late 1990. The economic limit is expected around year 2005.

To summarize, a cost effective solution was found for this "marginal" field development in deepwater by splitting the wells and production facilities to separate platforms and locating the latter at a significantly shallower and, therefore, cheaper, water depth. The key elements of the TLWP concept are

1. In order to limit size and cost, the TLWP will support only those facilities that are absolutely required. All other equipment will be located on the less expensive fixed

platform. Peak production capacity is 35 MBOPD and 50 MMCFGPD.

2. Production wells will be pre-drilled with a semi-submersible rig to save time and minimize load carrying capacity required of the TLWP. Only a "light duty" completion rig will be installed on the TLWP.
3. A two-piece well/foundation template system will allow drilling from a smaller drilling template while the main foundation template is fabricated. The concept will accelerate start of drilling and date of first production.
4. The TLWP tension legs are positioned on the outside of the TLWP hull to simplify hull design and construction.
5. One-piece (1,700' long) neutrally buoyant tension legs with new "side-entry" connectors have been designed to minimize cost, complexity, and offshore installation time.
6. Commercially available standard construction steel will be used wherever possible.
7. Conventional dry surface valve, assemblies ("Christmas trees") will be used on the TLWP wells, reducing cost and operating expense.
8. Dual completion of wells and commingling of zones to minimize the number of wells required to drain the reservoirs.
9. Subsea remote wells will be used for water injection, which could not otherwise be economically drilled from the TLWP location.
10. Use of high pressure flexible pipe for pipeline risers and flowlines to subsea wells (Figure 5.4).

The above elements, along with many detailed refinements, have made the TLWP an efficient concept for deepwater production. The proximity (10 miles away) of significantly shallower water (610') for the placement of the less expensive central production platform has also enhanced the project. This conventional structure will hold the heavy production and processing equipment instead of the TLWP. Pipelines for oil, gas, and injection water will connect the two facilities. After treating, the oil and gas will be piped about 25 miles to existing oil and gas pipelines systems.

Another important aspect of the two platform development for the Jolliet Project is expansion capacity for future developments. The fixed platform will be designed to support additional production facilities and pipelines for future developments where we have already made discoveries. The pipelines between the TLWP and the fixed platform and the oil and gas sales pipelines will have surplus capacity. This initial development will likely be the first of many in the area.

PROJECT STATUS

The project schedule (Figure 5.5) shows how all the pieces of the Jolliet Project will be completed and fit together. Detailed design work was initiated in early 1986 for the TLWP and its facilities, including the completion rig; the design work is now essentially complete. The TLWP work was awarded to Lummus Crest/Earl & Wright and performed in Houston. The rig design was done by Stress Engineering of Houston. Pipeline design work is being done by Brown & Root. The Central Production Platform structure and facilities design is being done by Hudson Engineering (McDermott) in Houston.

Construction of the drilling template by Gulf Island Fabricators of Houma, Louisiana, started in January 1987, and was completed in May. The template was installed in June by the Sonat semisubmersible drilling rig "John Shaw." Upon completion of the template installation, batch setting of 30" conductor and 20" surface casing was completed for all 16 proposed production wells. Drilling of the first production well started in August, and the third well is currently in progress.

The fabrication and installation of the foundation template was awarded to Micoperi/Gulf Island Fabricators in August. Work is well underway, and this template will be installed over and around the drilling template during the summer of 1988. The mooring system installed for the drilling rig will be utilized by the foundation template installation barge as well as the TLWP installation itself.

The fabrication contract for the TLWP has been awarded to Far East Levingston Shipbuilding (FELS) in Singapore. The TLWP will be available for installation in May 1989, when the drilling of production wells is scheduled to be completed. Tie-back of these 16 wells, and their completion and preparation for production, will begin as soon as possible after the TLWP is installed. CPP installation and pipeline tie-ins are scheduled to be completed by September 1989 for start of oil and gas production.

CONCLUSION

The Jolliet Project TLWP concept was developed when oil prices and associated construction and drilling costs were high. By continual striving to keep costs down, the project has remained viable even in the current scenario of partial recovery of oil prices and an uncertain long-term outlook. Conoco, and its joint interest owners in the Jolliet Project, Texaco and Cities Service, feel that a significant new tool is being developed and proven for "marginal" field developments in deep waters, wherever those deep waters may be.

Mr. Cor Langewis is the General Project Manager of Conoco's Jolliet Project. He is responsible for the world's second tension leg platform that will be installed in Green Canyon Block 184.

Shell Green Canyon Block 65 Project "Bullwinkle"

Mr. Gordon H. Sterling, P.E.
Shell Offshore Inc.

GENERAL

The Bullwinkle jacket will be installed in the summer of 1988, in 1,353 feet of water, in the Shell Offshore Incorporated (SOI) Bullwinkle Prospect, Green Canyon Area. SOI acquired Blocks 65 and 109 in OCS sale 72, May 1983; Block 64 was acquired in OCS sale 81, April 1984. The jacket will be placed at a location on Block 65 (see Figure 5.6).

The entire Bullwinkle project will cost about $500 million, excluding lease bonus costs of $34.5MM. About 50 percent of the total costs will be spent to install and equip and platform for drilling. The remaining 50 percent will be spent for development drilling, permanent production facilities, and a pipeline system.

The Bullwinkle platform will surpass the height of the tallest existing offshore structure, SOI's Cognac platform, installed in 1,025 feet of water in the Gulf of Mexico, Mississippi Canyon area, in 1978.

With drilling rigs in place, the entire structure will stand about 1,615 feet high, which is 161 feet taller than the world's tallest building, the Sears Tower in Chicago. The jacket section alone will stand 1,368 feet high and weigh about 50,000 tons (see Figure 5.7).

The installed platform will weigh a record 75,000 tons, with a base dimension of 408 feet x 487 feet. The 60-slot structure will have two drilling rigs operating simultaneously on the platform deck.

SOI projects that development drilling will be completed in the 3rd quarter of 1990. Initial production, while drilling, will begin in the first quarter of 1989, and first production through permanent facilities will occur in 1991. Oil production is expected to peak at 50,000 BOPD in 1991, and natural gas production is expected to peak at 90 MMCFD in 1992.

SOI drilled the discovery well on the Bullwinkle prospect in October 1983, Green Canyon Block 65. A total of 4 wells and four sidetracks were drilled within the three blocks.

FABRICATION

The fabricator (Gulf Marine Fabricators) decided to build this jacket in a most innovative manner. The structure was built in 14 separate segments, which were assembled close to the ground and rolled up into a final assembly in an orderly sequence. Thus four panels were built like a "normal" Gulf of Mexico structure and rolled into place using only cranes; six central "core blocks" were built in panels, stood up, and rolled over into place using large winches with multi-part block and tackles, and with crane assist; and, finally, four very large side panels were built near the ground and rolled into location with cranes and winches.

QUALITY

From materials selection through dimensional control, the jacket has been built to high standards. An example of the quality achieved is in the extremely low welding repair rate throughout the job and, in particular, the downward trend noticed in even that low a rate.

SCHEDULING

The importance of schedule control was recognized from the beginning. The contractor (Gulf Marine Fabricators) developed an impressive CPM system that involved appropriate management people, but, even more important, a system that was integrated down to the yard foreman level. Shell, for its part, developed a scheduling concept that emphasized the monitoring of measurable quantities (i.e. brace ends fit, leg splices, weld volumes, pipe footage, etc.). A logical sequence of work flow was developed on the contractor's overall plan.

The independent scheduling by Shell, and the cooperative approach taken by the contractor, led to an excellent basis for communication. The end result was, and is, a project that is not only ahead of schedule, but is well understood by the people in charge.

CERTIFIED VERIFICATION AGENT (CVA)

This platform is being built and installed under the aegis of the CVA program developed by the MMS. By carefully integrating the efforts of an experienced CVA into the fabrication process, specific benefits in quality, and scheduling have been realized. We have found that the benefits from material traceability, repair records, and frequency data, and material control to be of substantial benefit--in our judgement, far exceeding the nominal cost of the process.

For the design and installation portion of the CVA activity the efforts have been professionally carried out, but the benefits to SOI are less directly observable.

The entire CVA process is simple, and clearly not an administrative burden.

INSTALLATION

The platform jacket will be transported to the site and launched from a specifically built launch barge. This barge has been constructed for Heerema, and is 851 feet long, 207 feet wide, and 49 feet deep (see Figure 5.8). The platform will be transported to location in May 1988, and installation is expected to be completed by mid-summer 1988.

Mr. Gordon H. Sterling is currently Project Manager--Bullwinkle for Shell Offshore, Inc., Offshore East Division. He has a master of science degree from Lehigh University in civil engineering and has spent 19 of his 22 years with Shell in offshore related matters. In addition to Bullwinkle, he has been Project Manager for Boxer, Green Canyon 19, in 750 feet of water installed in 1986; Project Manager of 10 platform projects entitled Mokoko-Abana, offshore Cameroon, West Africa in 50 meters of water, in 1981; and Engineering Supervisor for the Cognac platform installed in 1978 in 1,025 feet of water.

Ocean El Dorado: A Floating Production System

Dr. Terry D. Petty
Ocean Drilling & Exploration Co.

INTRODUCTION

With the expectation of finding significant new reserves in the Gulf of Mexico in water depths exceeding 1,000 ft., there must be new emphasis to flatten the spiraling costs of developing production systems to produce oil and gas in these extreme water depths. In directly addressing this objective, the Ocean El Dorado reverts to simple, state-of-the-art technology by 1) eliminating costly subsea systems, 2) having a complete range of water depths with the same basic vessel, and 3) being reusable to enhance the economy of smaller reservoirs and yet survive the worst environmental conditions known to the Gulf of Mexico--Hurricane Camille.

Most of the floating production concepts developed thus far rely on the use of subsea systems for production because the large motions of the vessels, principally heave motions, make it impractical to produce conventionally through rigid riser and surface trees.

To overcome this limitation, floating production systems with significantly reduced motions, such as tension leg platforms (TLP) and the Ocean El Dorado, have been developed. With the reduced motions of these vessels, it becomes feasible to produce conventionally with surface trees on deck, thus avoiding both the capital cost and operating cost of a complex and sometimes inefficient subsea systems.

The TLP suppresses heave motion by anchoring the vessel to the seabed with vertical tendons while the El Dorado relies on the hydrodynamic performance of its hull to remain transparent to the seaway.

The Ocean El Dorado (Figure 5.9) is a symmetrically shaped six column semi-submersible with a variable deck load of 10,000 L.T. The Ocean El Dorado offers simultaneous full drilling and production capability. The vessel is moored on location with a combination chain/wire system and can operate in 1,000 to 8,000 ft. of water. The number of lines vary from 24 to 36 lines depending on water depth. Oil and gas is produced through rigid 9-5/8" risers with a 7" protective string, sloped at 1 percent of water depth from individual guidebases to the surface. Up to 30 risers are individually tensioned and compensated at the cellar deck. Oil and gas are exported through steel catenary sales lines.

The vessel is designed to ensure, with reasonable margins of safety, survival of the entire production system in an extreme Camille level hurricane.

DESIGN PHILOSOPHY

In developing the general configuration of the El Dorado, a design philosophy emphasizing vessel stability was applied. The principal aspects of this philosophy are

1. On a typical semi of rectangular configuration, the maximum environmental forces act in the diagonal direction, which is also the weakest direction for intact and, in particular, damage stability. However, a symmetrical distribution of the water plane and wind area, as is the case for the El Dorado, provides for a non-preferential alignment to the environment and more uniform stability in all directions (see Figure 5.10).

2. With the total water plane of the vessel distributed evenly between six symmetrically arranged columns, the vessel regardless of heading, always heels on the equivalent of at least two stability columns as opposed to one stability column for some headings on a four, six, or eight column unit. Hence, in the event of loss of buoyancy in one column (damage case), the Ocean El Dorado configuration offers more righting moment and more stability than a typical four, six, or eight column rectangular design.

Consistent with this philosophy and the primary concern of ensuring survival of all the components of the production system, a strict stability criteria was combined with the environmental conditions of a Camille strength hurricane. This criteria is outlined in Table 5.1.

As can be seen, the stability criteria applied to the Ocean El Dorado far exceeds the requirements of the MODU rules, and by letting the damage case during peak storm conditions govern the design, no arbitrary assumptions have to be made as to when damage is allowed to occur.

HEAVE RESPONSE

Since it was not considered practical to bring rigid risers to the surface and produce through surface trees on deck of a typical semi-submersible due to the magnitude of the heave motions, the initial thrust of the Ocean El Dorado project was to develop a hull geometry which significantly reduced the motion response.

This goal was achieved by developing a hull geometry that had a near balance in the hydrodynamic excitation forces acting on it in a seaway. The result is a semi-submersible vessel with very low heave response as shown in Figure 5.11 and optimized for the Gulf of Mexico environment.

Figure 5.11 also compares the Ocean El Dorado heave response with a typical semi (Ocean Odyssey) and the published Trendsetter response curves.

In conclusion, the Ocean El Dorado design offers the benefits of a semi-submersible hull with significantly reduced motion characteristics, allowing for a more economical and conventional method of production, combined with a stability/environmental criteria consistent with a realistic assessment of the requirements for a deepwater floating production system in the Gulf of Mexico.

Mr. Terry D. Petty, is Vice-President, Design and Engineering for Ocean Drilling & Exploration Co. (Odeco), New Orleans. He earned BS, MS, and D. Eng. degrees from the University of Oklahoma. He worked in drilling capacities for Humble Oil and Esso Exploration and was involved in supervision of the first floating drilling operation, offshore Norway (1966).

Petty joined Odeco in 1971 as Manager of New Rig Construction. He is now responsible for the administration of the company's engineering function responsible for design, construction, installation, and major maintenance of rigs, platforms, and production facilities.

Underwater Inspection, Maintenance, and Repair Program of Chevron USA

Mr. Kevin P. Bourgeois, P.E.
Chevron USA

During its life, a platform is subjected to a wide variety of loading patterns, both natural and man made. These events are as mild as a Boston whaler, to as ferocious as a hurricane. To insure these structures can withstand the rigors of the Gulf of Mexico, underwater inspections are conducted. The purpose of this presentation, is to discuss the underwater inspection, maintenance, and repair program of Chevron, USA.

Following its acquisition of Gulf Oil, Chevron operates approximately 1,000 platforms in the Gulf. With such a large number of structures, an organized methodical maintenance program is vital to prudent operations. The annual inspection, maintenance, and repair program consists of the underwater inspections and, if necessary, the underwater repairs.

From an historical perspective, Gulf Oil began an underwater inspection program in 1977. Since that time, 1,000 platform inspections have been conducted at a cost of approximately $3.5MM. This new maintenance program is a refinement of the old Gulf program. The objectives of the program are

1. To insure the structural integrity of the platforms.
2. To insure the safety of our personnel and the environment.
3. To detect and correct detrimental design defects.
4. To comply with current API/MMS requirements.

To achieve these objectives, the program is divided into two phases.

Phase I involves a series of general inspections to determine the present condition of the platforms and to correct any major defects. The second phase involves a series of very detailed and structured inspection tasks to insure the future structural integrity of the platform.

The inspection procedure for Phase I generally follows the following scenario:

1. The dive crew first conducts a general visual inspection of the jacket by swimming down and around, each member looking for gross defects. During this initial series of dives, cathodic potential readings are taken with a diver-held potentiometer at various locations and water depths.
2. Next, all the welds at each joint node on one leg of the jacket are cleaned using a 20,000 PSI water blaster to remove the marine growth. This is probably the most dangerous part of the inspection because of the danger of using such a high pressure tool. A 6-inch section of the welds that were water-blasted are buffed with a hydraulic wire wheel and photographed. These welds are cleaned, buffed, and inspected each time the structure is inspected, thereby yielding a visual corrosion-versus-time comparison of the structure.
3. In a similar manner, all the welds on the nodes of another leg of the jacket are cleaned with the water blaster only. The nodes are inspected, but not photographed. The second leg is rotated each time the structure is inspected, whereas the control leg is always the same.
4. During the cleaning of the legs, several other inspection tasks are being performed:
    a. Debris Survey
    b. Seafloor Survey
    c. Anode Survey
    d. Riser Survey
    e. Marine Growth Survey
    f. Topside Survey
5. The final part of the inspection occurs if any damage is discovered. The divers then do extensive measurements and surveys to determine the extent and severity of the damage. If the damage is a suspected crack, magnetic particle inspection is performed to determine the limits of the crack. Ultrasonic inspection units are used to determine whether a member is flooded, indicating a compromise to the surrounding seawater. The damage is then photographed, using both still photography and video photography. This procedure is followed for all platforms during Phase I of the program. During Phase II, the inspection procedure and the inspection cycle are altered. Whereas the objective of Phase I is to assess and correct defects, the objective of Phase II is to assure the future structural integrity of the members. In other words, in Phase I, we correct gross defects, but in Phase II we try to detect and correct minor defects that develop into gross defects. To accomplish the objectives of Phase II, the inspection techniques are reduced to inspecting hot-spot, stress areas and critical members rather than a global general inspection. Hot-spot, stress areas are those where the highest concentration of stresses occur. The design model of the structure will indicate where the structure should be inspected. Similarly, the inspection cycle may be altered. Depending on

the results of the Phase I inspections, the cycle for Phase II will be adjusted to economically monitor. For instance, we have essentially entered Phase II for the caisson-type structures. Through the inspection of approximately 60 caissons and finding no damage, we have adjusted the inspection to mainly checking the appurtenances to the caissons-such as risers and anodes.

In order to control a program of this magnitude, automation is essential. The focal point of the IMR program is the CAIRS computer program. CAIRS stands for computer aided inspection and reporting system. CAIRS was developed by Ocean Systems Engineering for the reporting and recording of inspection data. Prior to CAIRS, the data was stored in hard copy 3-ring binders making data retrieval difficult, and trend analysis impossible. An additional problem is the physical storage space requirement, an annually increasing problem. Computerization alleviates these problems. CAIRS consists of three integrated modules:

1. Inspection Database
2. Graphic Trends Presentation
3. Inspection Planning System

The inspection database is the heart of the CAIRS system and provides the capability for electronic storage and manipulation of the data. This slide shows the 20 categories of data stored for each platform. Built in to the database are search routines for the 20 categories of data. For instance, this slide shows a search for cracks of lengths greater than 0 inches on this platform, High Island 140 A, and this slide shows the result of this search. The inspection database also allows the user a wide variety of reports, ranging from full reports with photo captions to reports detailing specific damage and anomalies.

The second part of the program is the graphics trend presentation section. A series of modular programs that link directly with the database allow the user to output time and location dependent trends. This can reduce the future cost of inspections by verifying that the trends are being maintained. For instance, this slide shows the growth over time of a theoretical hole.

The third component of the CAIRS program is the inspection planning system. This provides the ability to systematically plan and track the inspection program. The system produces matrices of platforms and specific inspection tasks to be performed. Procedures are first created for the IMR program and numbered into the system. The procedures are linked to the platform by creating inspections as shown on this slide. The matrix is then created by the system, which links procedures, inspections, platforms, and specific locations. The planning system also includes a cost-tracking module that allows the user to control the cost of the IMR program by monitoring the daily costs. The costs can be monitored in the office by transmitting the data with cellular phone hardware.

The latest development of the CAIRS program is the MAIRS program. MAIRS stands for Main Frame Inspection Reporting System. This program was developed jointly by Ocean Systems Engineering and Chevron for the storage of the inspection data. With 1,000 structures, the search capability of the system would be greatly hampered because the capacity of even the largest personal computer hard disks would be exceeded in about 3 years. MAIRS allows the user to store the data on the personal computer. The main frame serves as the library of inspection data. Broad general searches of generic data, such as water depth, location, and inspection year, are manipulated by the mainframe and then downloaded to the personal computer for further refinement of the data. The user can then search for the trends for inclusion in the work package; another step in the maintenance phase is completed, and the cycle continues.

Mr. Kevin P. Bourgeois is a construction engineer with Chevron Eastern Region Design and Construction Group. Since 1982 he has been responsible for the Company's Gulf of Mexico underwater inspection, maintenance, and repair program.

Monitoring the Structural Integrity of Offshore Platforms

Mr. Francis P. Dunn, P.E.
Shell Oil Company

INTRODUCTION

Structural monitoring includes any measurement of the behavior, motion, stress or condition of a platform. In this talk, I'll discuss how monitoring is used as an inspection tool in the context of an effective inspection program. I'll go on to deal with what to do with the results by showing a few examples of repair techniques.

Monitoring is also used to gather data about the performance of the platform and about the environment it's in, in order to improve the design of future platforms. We'll show some past measurement programs that have impacted design.

The bottom line is that the best defense against future problems is good initial design and construction, along with thorough inspection during construction. The ideal is to so design and build a structure that you don't have to count on the use of monitoring to insure platform integrity--maybe unachievable, but a goal worth attaining.

VIBRATION MONITORING FOR INSPECTION

The life cycle of an offshore platform is design, fabrication, transportation, and installation, and maintenance and removal. Structural monitoring impacts the design and the maintenance phases. Maintenance includes painting, cathodic protection, housekeeping, inspection, and repair. Inspection is performed to find inadequate corrosion protection, damaged members, cracks, etc.

In general, "monitoring" is that part of inspection that is non-visual, is done remotely, and involves a quantitative measurement. More specifically, vibration monitoring purports to determine the structural integrity of a platform by measuring its response to some excitation, whether ambient or forced. Vibration monitoring is supposed to reduce the need for underwater inspection or do a more thorough job of inspection.

The first method we attempted employed accelerometers mounted above water to measure the response of the structure under ambient conditions and compared the response to baseline response measurements taken previously. Any change in response would indicate damage somewhere. Unfortunately, this method did not work and, more than likely, will never work. Too many considerations not associated with structural damage will cause changes in response (marine growth, topside load changes, conductors banging around, etc.). Moreover, most structures are so redundant that even removal of a major member will not change response sufficiently, even in higher modes, to detect the change with deck-mounted accelerometers.

A variation of this technique, called flexibility monitoring, has been tested and has shown some promise. In this method, accelerometers are placed on deck and also down through the structure, ideally all the way to the mudline, either in chutes installed during construction or attached to members by divers. Again, the response is measured and compared to baseline responses. Analytical techniques have been devised to determine the significance of changes in response at various levels in the structure, so that conclusions can be made about the integrity of structural members at these levels. This method has the limitation that, at realistic amounts of bracing, the method is less sensitive. In addition, one gains only indirect evidence about conditions below water. If properly organized, flexibility monitoring could help direct an underwater program more efficiently. This is a matter of cost effectiveness.

Another method employs attaching accelerometers to individual members, exiting the members, then comparing the response to baseline measurements. Changes in response would indicate a large crack or flooding (caused by a crack). This technique is now being used in the North Sea, and it will be interesting to see how it works. Our analysis shows that the method is not cost effective in Gulf of Mexico at shallow depths where divers can be used. However, for deeper platforms where access is by ROV only, it may provide an additional and rapid means of checking for flooding and showing that no cracks exceed about 30 percent of circumference. It needs to be compared further to other tools that a ROV can carry for cost effectiveness.

Two other methods of structural monitoring have been proposed: using global acoustic emission techniques to detect cracks and running optical fibers all over the platform (if light transmission through one of the filaments changes, something's wrong). I doubt whether either method will be successful.

We have seen few cracks in members caused by overload in the Gulf of Mexico, primarily, because of the mild environment. Such cracks have been encountered in our older platforms, which were designed for lower environmental criteria than we use now. Moreover, the tubular joint design procedures used at that time certainly caused some of the distress. Again, we have learned.

We have seen even fewer fatigue cracks in our Gulf of Mexico platforms, again because of the relatively mild environment. Fatigue cracks do not seem to be a significant problem in the North Sea either, except for some older platforms in the southern North Sea, and for some braces and well-conductor guides located close to the waterline, which were not designed for wave slamming effects. Most of the Northern Sea platforms are of fairly recent vintage and were designed using more rational tubular joint criteria and better materials.

In my opinion, too much emphasis has been placed on the need to find fatigue cracks in offshore structures. A large amount of money has been spent in applying sophisticated methods to detect such cracks. Many of the "cracks" found by such methods have either not been cracks at all, after more detailed and expensive examination, or have been determined to be relatively unimportant. I again emphasize the importance of good design. If a structure is endangered by the presence of a few cracks, then the design is faulty. I do not mean to imply that cracks are of no concern. They are, certainly, when they are of sufficient size to jeopardize load-carrying ability. Cracks of this size, however, can be seen on good photographs and on high quality video.

CATHODIC PROTECTION MONITORING

I think the most important thing we've learned over the past 20-30 years is that a working cathodic protection system is absolutely necessary for the continuing integrity of an offshore platform. A poorly designed or poorly maintained cathodic protection system will eventually lead to significant structural deterioration within a few short years, as we'll see shortly. Thus, the importance of an ongoing cathodic protection monitoring system--whether it be use of monitoring cells installed on the platform, use of divers or ROV's equipped with the necessary instruments, or whatever--is mandatory, and must be maintained for the life of the platform.

Now I'd like to discuss some examples where inspection and monitoring led to a repair action. The first was not a repair to the structure, but rather to its cathodic protection system. The structure is the Cognac platform, in 1,025 feet of water. Regular surveys were done of the potential between the steel structure and sacrificial anodes. It was found that after a few years in place, the cathodic protection was inadequate. This was due to two factors. First, it wasn't fully understood at the time of design that the cathodic protection demand is significantly greater at depths below 300 feet. Second, the distribution of the anodes on the structure did not place enough near the 60 conductors, a large and shielded surface area.

The decision in this case was clear: this structure was still near the beginning of this useful life, and excess corrosion could not be tolerated. The solution was to add additional anodes. Near the conductors this was achieved by sliding steel members covered with anodes down the unused conductor slots. In addition, extra anodes were attached to structural members. These were installed by a novel method using a remote-operated vehicle. The anodes were hung on short cables from studs that were fired into secondary members by a gun on the ROV. Laboratory testing has verified that the stud would not cause a fatigue or fracture problem in the member.

The next case study involves corrosion also. This platform was installed in 1969 in 300 feet of water. The impressed current, cathodic protection system failed to operate properly. The platform was later retrofitted with clamp-on, sacrificial anodes. These were installed outside the conductor area because of the difficulty divers had getting into that area. Subsequent inspection found several of the conductors partially or fully severed, though the wells were still protected by the casing inside. After some analysis, a plan was devised, tested, and implemented to temporarily abandon the wells, remove the old conductors to the mudline, replace with new 20-inch, and recomplete the wells. In addition, several of the platform members and legs were grouted to improve their load carrying capability and to redistribute loads.

MONITORING FOR DESIGN VERIFICATION

The other side of monitoring is design verification. Structures are monitored so we can learn how they perform compared to the design assumptions. The Cognac instrumentation program is used as an example.

Cognac

Several objectives were to be achieved with one set of instrumentation. Wave staff and current meters measure the directional wave spectrum. Strain gauges measure the internal force in a member and, indirectly, the total load on the structure. Accelerometers measure platform displacements and, indirectly, platform mass and stiffness.

Data were gathered nearly continuously over a three-year period. The program was terminated in 1982 because it had satisfied its original objectives, and it was not cost effective to operate as an inspection tool.

Wind and wave data were collected--useful for fatigue analyses.

Stress cycles in the strain gauged braces were collected. These were compared to design. The design was conservative, due to intentional pessimistic assumptions regarding the natural period.

Cognac also collected data during some hurricanes. This objective was part of a larger program to improve predictions of response to waves.

Since we cannot hope to measure waves and currents as large as the design requirements, the methods of prediction must be built up from several pieces. These include:

- Predicting Waves and Currents
- Predicting Wave Kinematics
- Predicting Forces on Members
- Predicting Response

Each one of these items is studied separately, using field measurements to calibrate theoretical models.

Eureka

Similar data gathering programs have been implemented to verify design to earthquake loads. Several platforms, offshore southern California, carry accelerometers that begin recording when triggered by an earthquake. Our Eureka, a 700-foot platform, is controlled by earthquake loads in most members. Accelerometers placed at both the mudline and the deck, as well as an independent, free-field undersea sensor, will allow predicted response to be compared to measured. Successful measurements were made in July 1986, and then again this year (October 1987). Both recorded events are small compared to design, and would not test some of the engineering assumptions.

Instrumentation for Bullwinkle

Instrumentation to measure the response of Bullwinkle to waves and current is being planned. This is a continuation of previous programs. This program will focus on how the platform blocks the flow of current and changes the way waves and currents combine to load a platform. Another goal is to have sensors in place to record any large hurricane that may occur during the program. This work will have applications to any tubular, framed platform--compliant or fixed.

We also plan to install a fairly sophisticated cathodic protection monitoring system on this platform--not only to insure its integrity, but also to enable us to do a better design job on other platforms.

SUMMARY

We've discussed two aspects of platform monitoring: one, to verify design criteria, loads and techniques; and the second, to determine platform condition. The former has proved to be quite productive. The latter, other than cathodic protection monitoring, has a rather spotty track record, and in many (most?) cases, is simply not cost effective. The most cost effective means of ensuring platform integrity is, by far, to demand proper design and construction, along with first-class quality control procedures during construction.

Mr. Francis Patrick Dunn, Manager, Civil Engineering, Shell Oil Company, received a B.A. at Xavier University, Cincinnati, Ohio, and bachelor's and M.S degrees in civil engineering at Ohio State University. Mr. Dunn worked as project engineer in an offshore production division for four years designing and installing small platforms and production facilities. He was assigned to the Offshore Construction and Design Group in 1968 and became Manager in 1969. The group designs all of Shell Oil Company's offshore structures and has also designed North Sea platforms for an affiliate company, Shell United Kingdom.

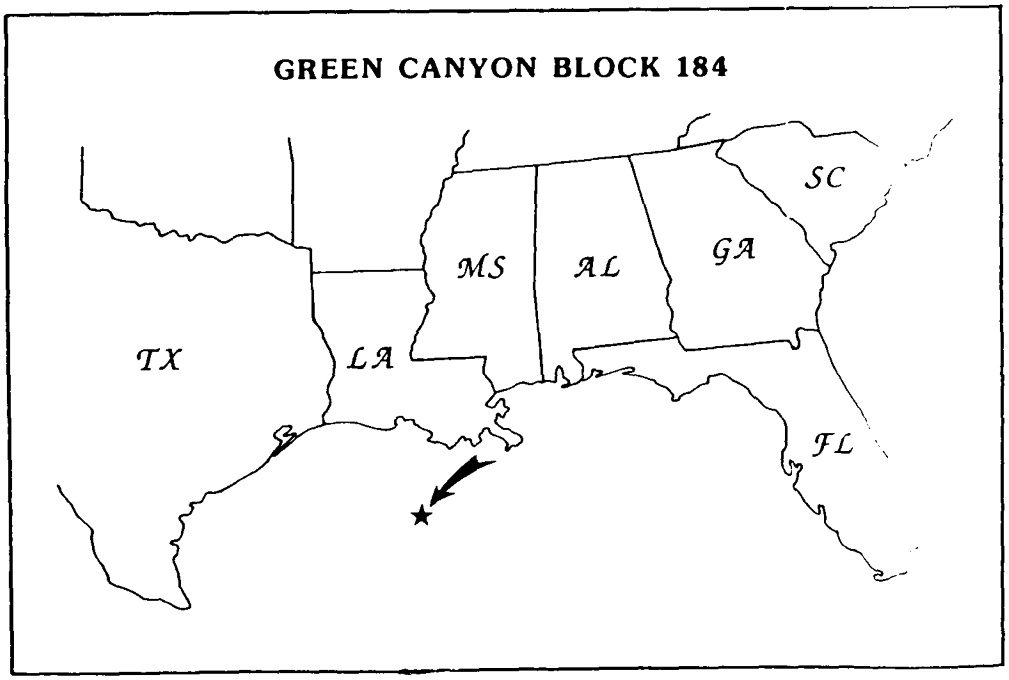

Figure 5.1.--Jolliet Project.

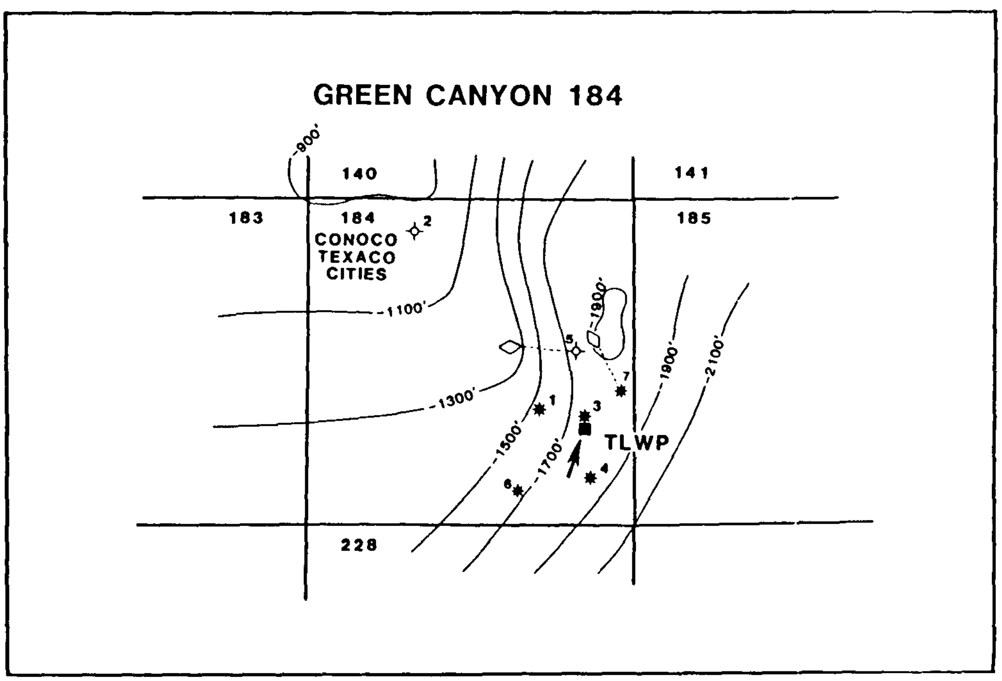

Figure 5.2.--Green Canyon Block 184 development.

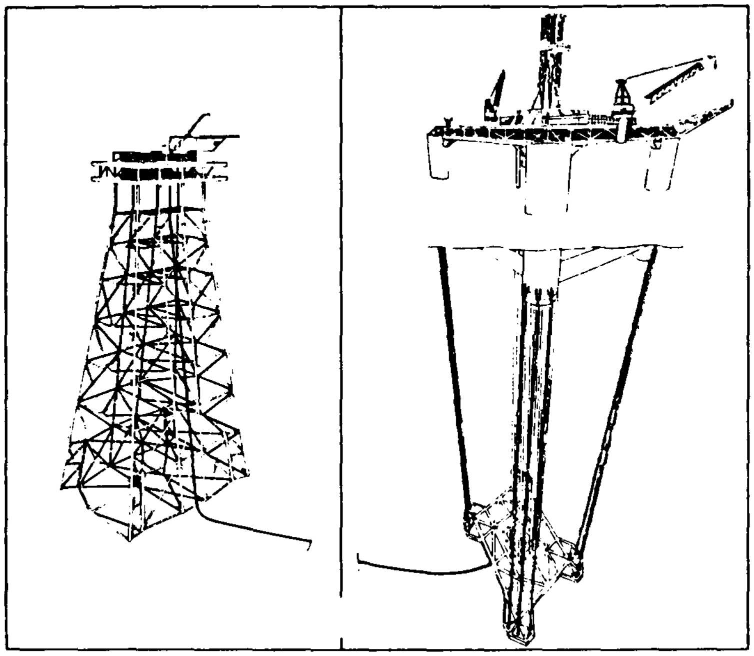

Figure 5.3.--Green Canyon Block 184 development plan.

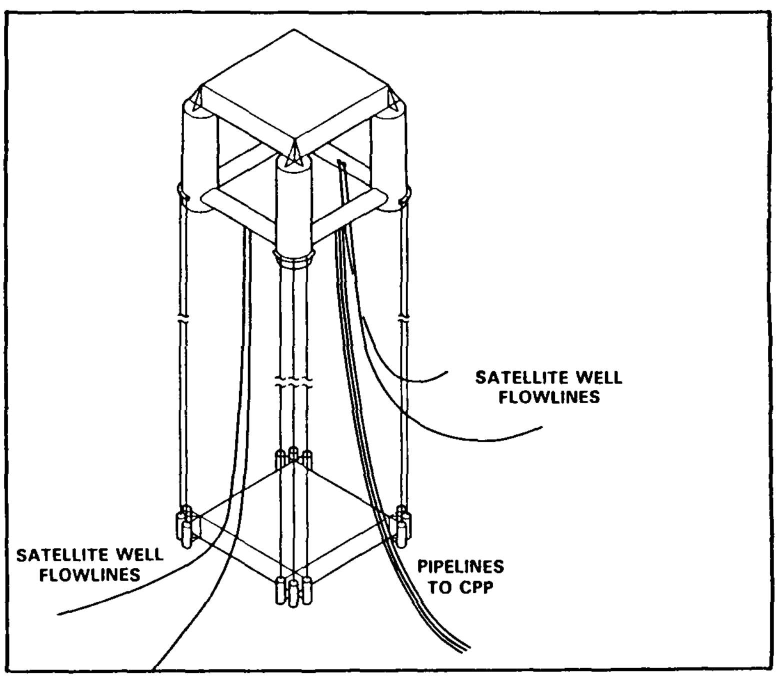

Figure 5.4.--Green Canyon Block 184 TLWP risers.

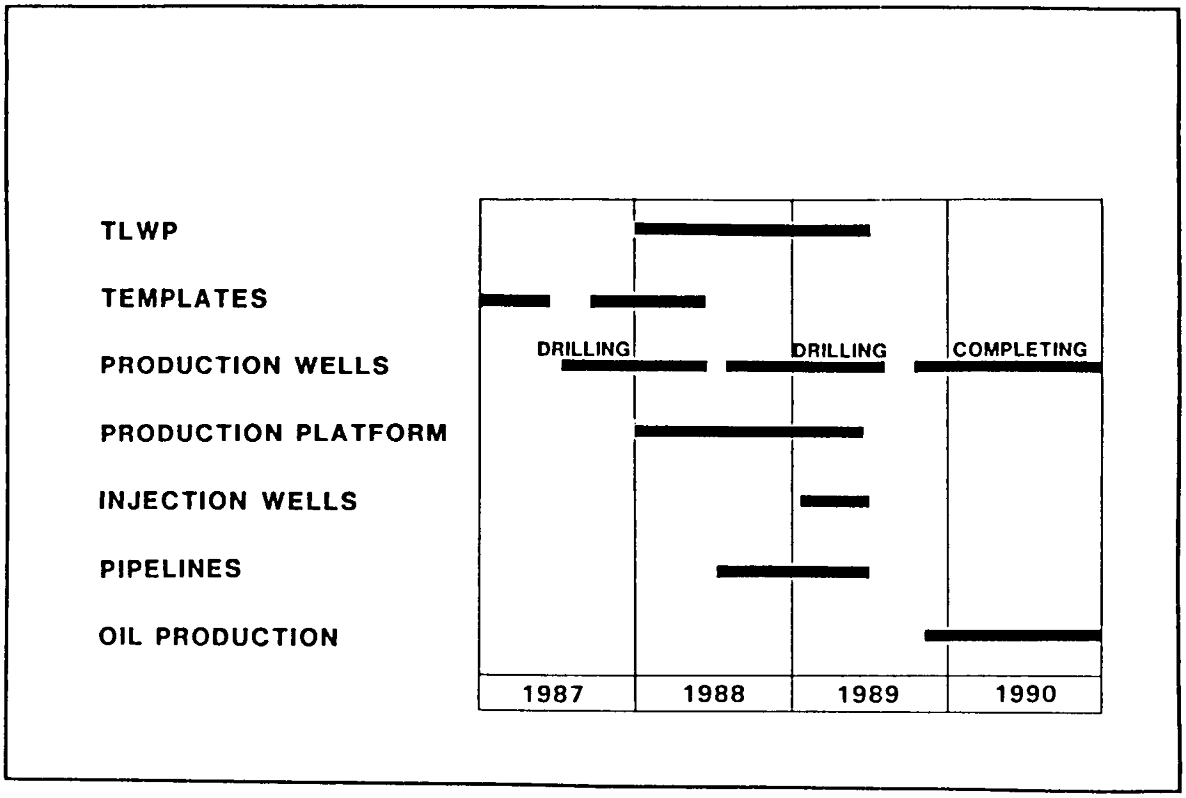

Figure 5.5.--Green Canyon Block 184 construction schedule.

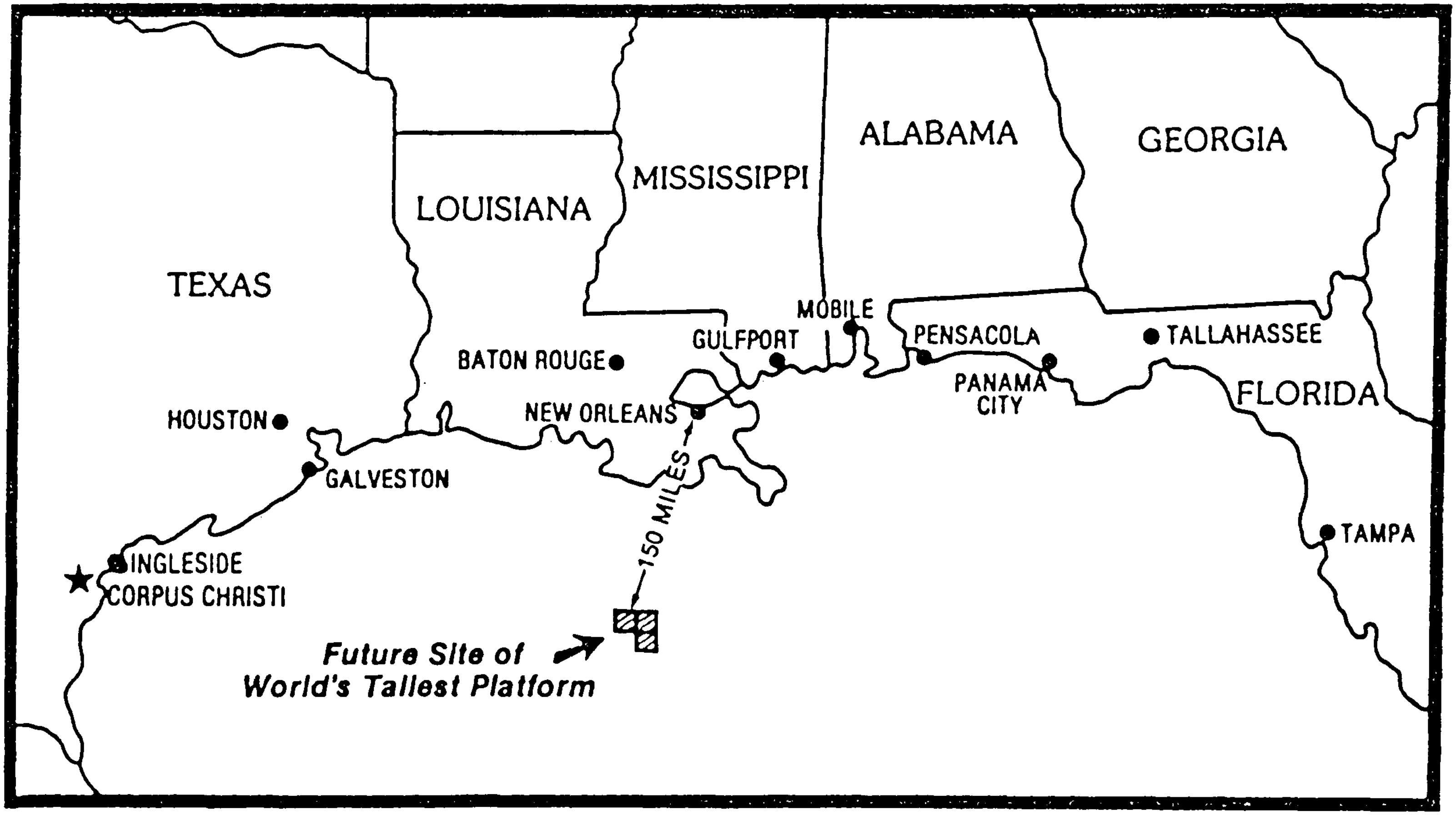

Figure 5.6.-- Bullwinkle Prospect, Green Canyon Block 65 Field.

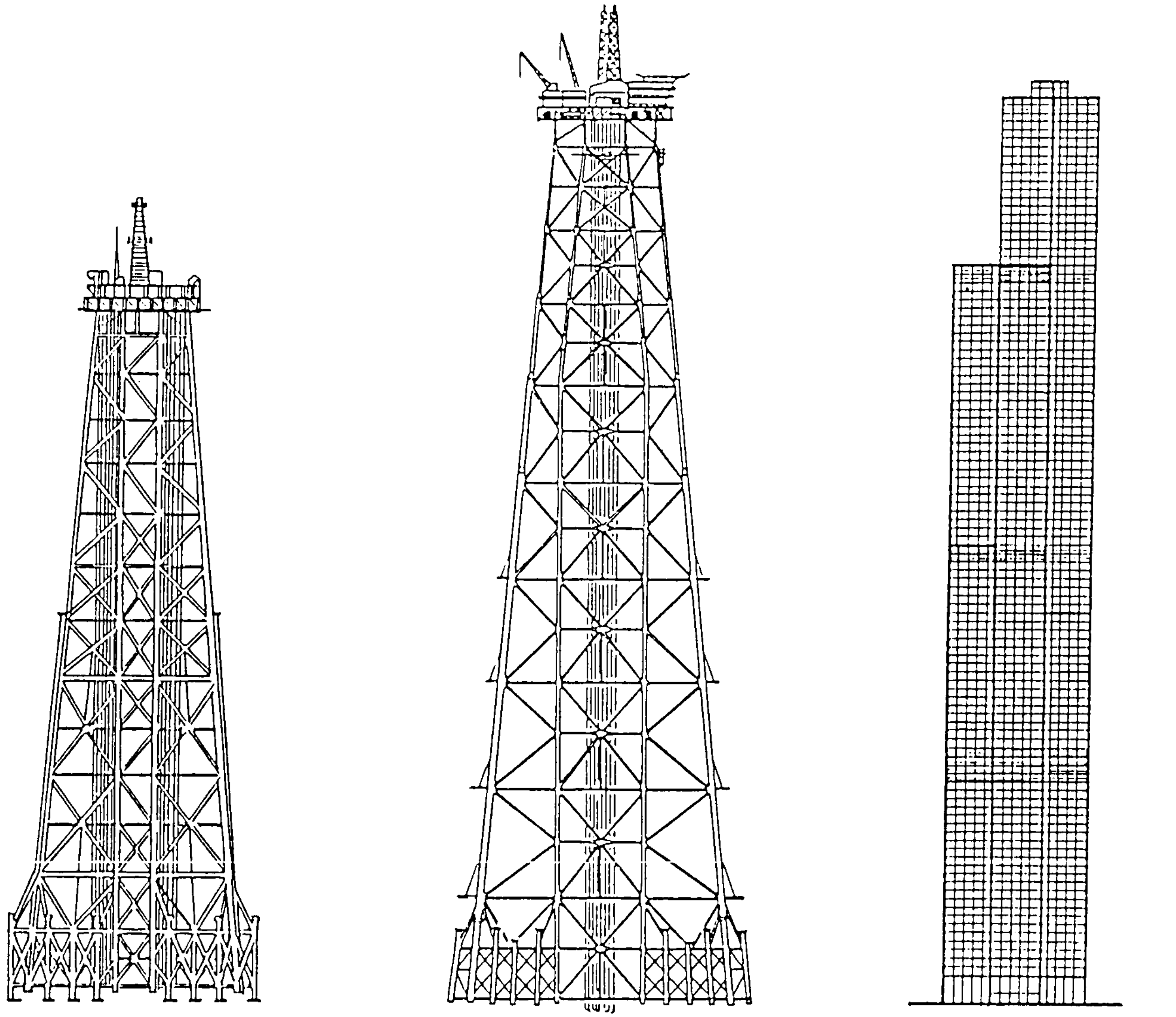

Figure 5.7.--Height comparisons.

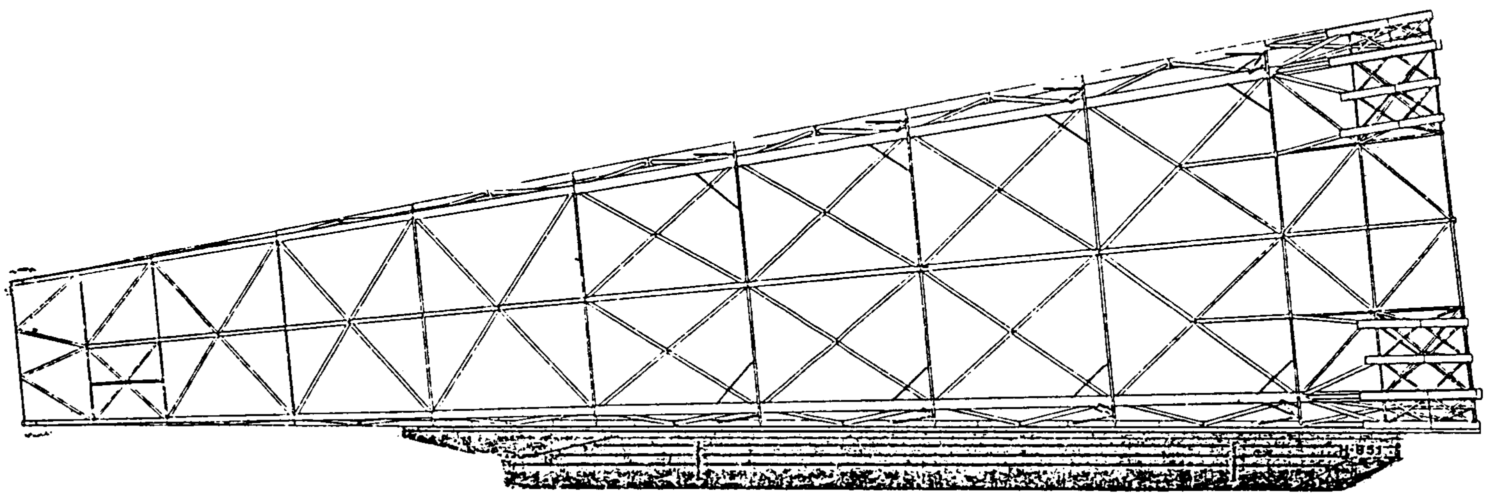

Figure 5.8.--Jacket on launch barge.

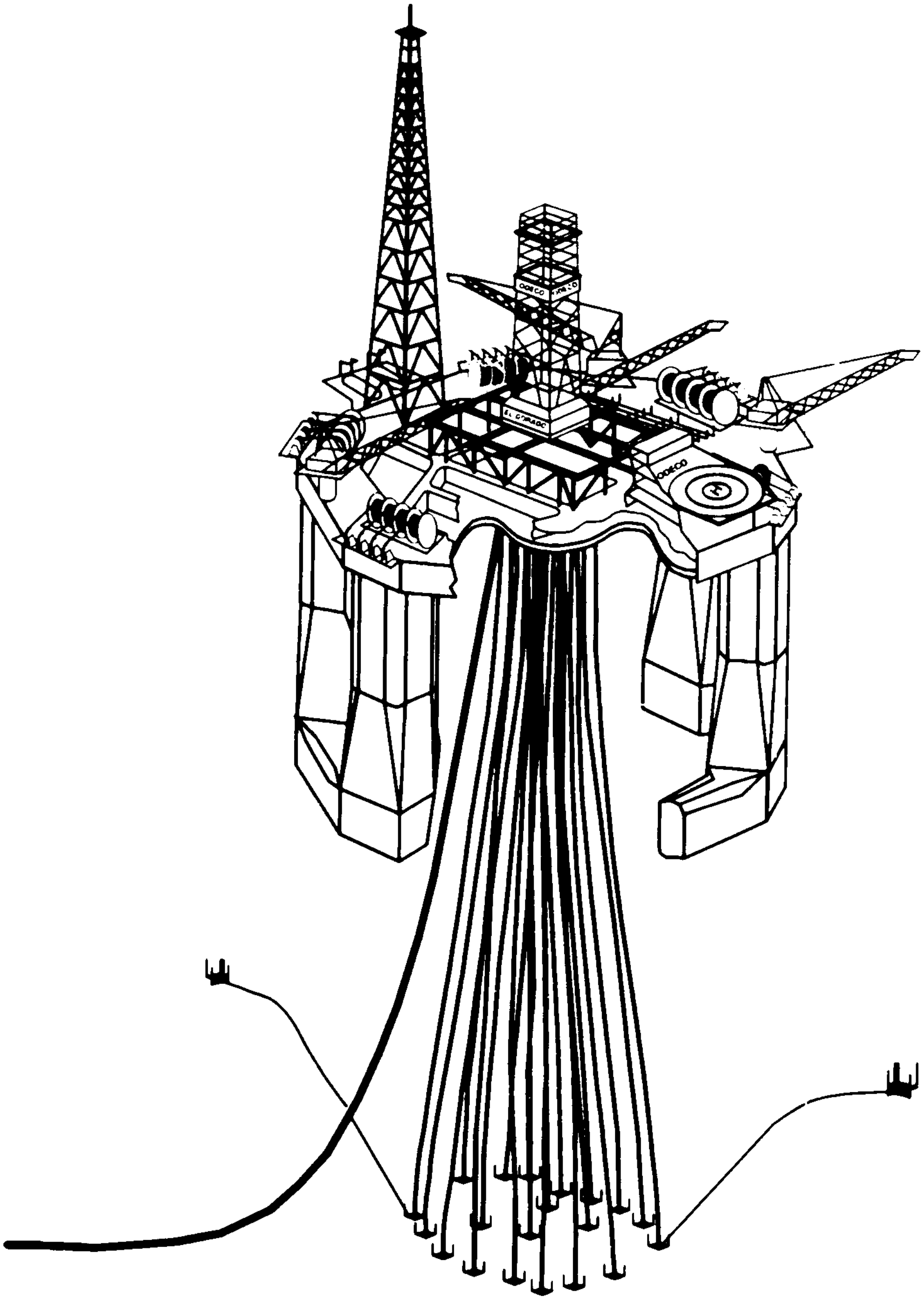

Figure 5.9.--Ocean El Dorado.

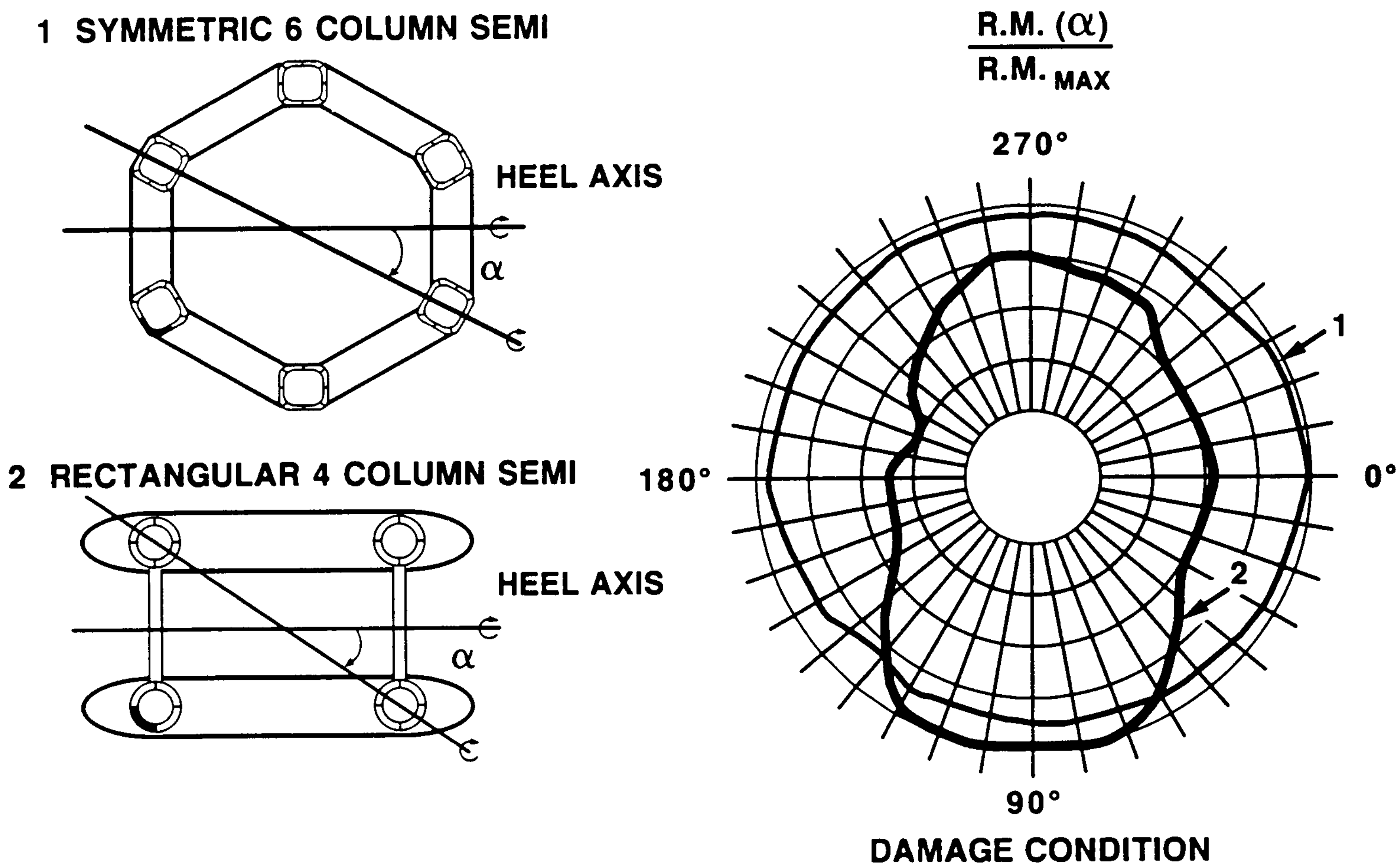

Figure 5.10.--Restoring moment vs. rig heading.

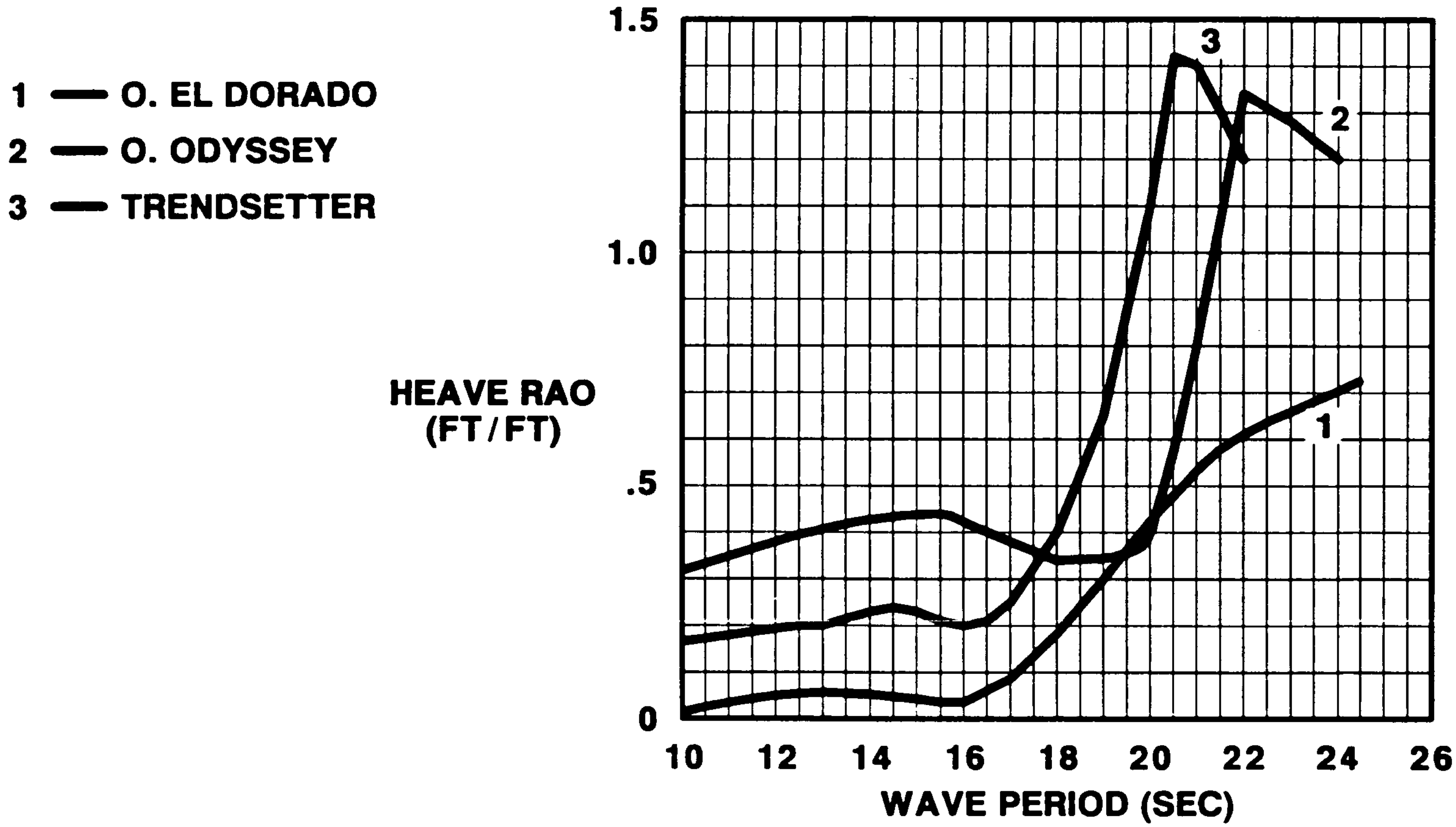

Figure 5.11.--Heave response.

Table 5.1.

FLOATING STABILITY CRITERIA

	OCEAN EL DORADO MOORED	OCEAN EL DORADO W/O MOORING	ABS MODU RULES W/O MOORING	API TLP DESIGN 2T (RP2T)
INTACT	DOES NOT GOVERN	WIND: 162 Kn STATIC HEEL ANGLE < 15°	WIND: 70 Kn OPERATING 100 Kn SURVIVAL AREA RATIO ≥ 1.3	WIND: 100 YEAR STORM* WAVE: 100 YEAR STORM* CURRENT: 100 YEAR STORM* MAINTAIN (+) TENDON TENSION
- - DAMAGED - -	FLOODING: 2 COMPARTMENTS AT W.L. OR 1 PUMP ROOM	FLOODING: 2 COMPARTMENTS AT W.L. OR 1 PUMP ROOM	FLOODING: 1 COMPARTMENT	FLOODING: 1 COMPARTMENT FLOODING
	<u>AT TIME OF FLOODING</u> WIND: 162 Kn WAVE: 90 FT CURRENT: 2.0 Kn Δ HEEL ANGLE < 1° Δ DRAFT < 1 FT	<u>AT TIME OF FLOODING</u> WIND: 130 Kn CALM WATER CONDITION HEEL ANGLE ≤ 15°	<u>AT TIME OF FLOODING</u> WIND: 50 Kn CALM WATER CONDITION HEEL ANGLE UP TO DOWNFLOODING (APP. 25°)	<u>AT TIME OF FLOODING</u> WIND: "NORMAL"* WAVE: "NORMAL"* CURRENT: "NORMAL"* MAINTAIN (+) TENDON TENSION <u>WITHIN 3 HOURS AFTER FLOODING</u> WIND: REDUCED EXTREME* WAVE: REDUCED EXTREME* CURRENT: REDUCED EXTREME* MAINTAIN (+) TENDON TENSION

*ENVIRONMENT DETERMINED BY OPERATOR

WETLANDS LOSS

Session: WETLANDS LOSS

Chair: Dr. Robert M. Rogers

Date: December 2, 1987

Presentation	Author/Affiliation
Wetlands Loss: Session Overview	Dr. Robert M. Rogers Minerals Management Service Gulf of Mexico OCS Region
OCS Development and Potential Coastal Habitat Alteration: Project Design and Management Overview	Dr. R. Eugene Turner and Dr. Donald R. Cahoon Louisiana State University Center for Wetland Resources
Analysis of Direct Impacts of OCS Pipeline and Navigation Channels on Central Gulf Wetlands	Mr. Robert H. Baumann Louisiana State University Center for Energy Studies and Mr. Andrew R. Reed Louisiana State University Ports and Waterways Institute
Long-Term Salinity Trends in Louisiana Estuaries	Dr. William J. Wiseman, Jr. and Mr. Erick M. Swenson Louisiana State University Center for Wetland Resources
Saltwater Intrusion in Louisiana Coastal Channels	Dr. Flora Chu Wang Louisiana State University Center for Wetland Resources
Saltwater Movement between the Marsh and Adjacent Bayous	Mr. Erick M. Swenson and Dr. William J. Wiseman, Jr. Louisiana State University Center for Wetland Resources
Experimental Field and Greenhouse Verification of the Influence of Salinity Intrusion and Submergence on Marsh Deterioration	Dr. Irving A. Mendelssohn and Ms. Karen L. McKee Louisiana State University Center for Wetland Resources
Inventory of Historical Sediment: Load Records of the Mississippi River	Dr. Richard H. Kesel Louisiana State University Department of Geography and Anthropology

Session: WETLANDS LOSS (cont'd)

Presentation	Author/Affiliation
Sea Level and Long-Term Subsidence Rates	Dr. Joseph N. Suhayda Louisiana State University Department of Civil Engineering and Dr. R. Eugene Turner Louisiana State University Center for Wetland Resources
Marsh Sediment Accretion Rates in Vicinity of Manmade Canals and Natural Waterways	Dr. Donald R. Cahoon, Dr. Ronald D. DeLaune Louisiana State University Center for Wetland Resources, Dr. Ronald M. Knaus Louisiana State University Nuclear Science Center, and Dr. R. Eugene Turner Louisiana State University Center for Wetland Resources
Results of Landloss Study Based on High Resolution Digital Habitat Data	Mr. Scott Leibowitz Louisiana State University Center for Wetland Resources and Dr. John M. Hill Louisiana State University Department of Civil Engineering
Modeling Wetland Loss in Coastal Louisiana: Geology, Geography, and Human Modifications	Dr. James H. Cowan, Jr. and Dr. R. Eugene Turner Louisiana State University Center for Wetland Resources
Aerial Imagery Interpretation of Relationship between Canal Area and Number of New Ponds	Dr. R. Eugene Turner Louisiana State University Center for Wetland Resources
Studies of Impacts of OCS Activities on Sensitive Coastal Habitats (Barrier Beaches and Non-Louisiana Wetlands)	Dr. Karen M. Wicker Coastal Environments, Inc. and Dr. Donald F. Boesch Louisiana Universities Marine Consortium
Wetlands Mitigation: A Study of Marsh Management	Dr. Chip G. Groat Louisiana Department of Natural Resources

Wetlands Loss: Session Overview

Dr. Robert M. Rogers
Minerals Management Service
Gulf of Mexico OCS Region

The impacts of OCS oil and gas activities related to onshore alterations in the coastal central Gulf of Mexico have been a concern of MMS for a number of years. Study planning was initiated in 1985 to investigate what factors contribute to wetlands loss and specifically what percentage of this loss is due to pipelines, navigation canals, and support facilities located in wetland areas. This "Wetlands Loss" session was organized to provide a forum for the discussion of the most recent findings from these MMS-sponsored investigations.

In September 1985, MMS contracted with the Center for Wetland Resources of Louisiana State University (LSU) to conduct a comprehensive study entitled "OCS Development and Potential Coastal Habitat Alteration." This study has recently been completed with the technical narrative scheduled for distribution in January 1988. Principal investigators from this project reported on significant findings from their individual areas of research and how this related to the overall issue of wetland loss.

Another related project sponsored by MMS is "Impacts of OCS Activities on Sensitive Coastal Habitats." This 2-year contract was awarded to Coastal Environments, Inc. in September 1986. Addressed during this session was progress on the two study aspects: impacts of Federal OCS pipelines on barrier beaches and barrier islands and a reconnaissance level assessment of the impacts of OCS-produced water discharges in coastal wetlands.

A third related wetland project sponsored by MMS is "Wetlands Mitigation: A Study of Marsh Management." This contract was recently awarded as a cooperative agreement to the Louisiana Department of Natural Resources. The study term is two years, beginning in December 1987 and ending in December 1989. An overview of the project was given, stressing the study objective to assess the suitability and feasibility of using marsh management techniques to protect and enhance coastal wetlands and their related resources.

The first speaker was Dr. R. Eugene Turner, who described the structures and goals of the Center for Wetland Resources' (LSU) Wetlands Loss Study. Realizing the different nature of the Louisiana wetlands, the study region was divided into three areas: (1) the Lafourche study area located to the east of Bayou Lafourche, a distributary abandoned by the Mississippi River about 400 years ago; (2) the Terrebonne study area adjacent to the Atchafalaya River, the most recent Mississippi River distributary that today captures 30 percent of the system's flow; and (3) the Cameron study area located in the western part of the state outside of the direct influence of the Mississippi River.

The project was subdivided into two broad analyses: direct impacts and indirect impacts. Direct impacts of OCS-related activities were assessed and compared with the direct impacts of other oil and gas and miscellaneous wetland use activities on coastal wetlands in the study area. Indirect impacts were assessed by investigating how oil- and gas-related activities affect the natural processes controlling wetland loss and by quantifying wetland loss that is indirectly the result of these activities.

The indirect impacts analysis was divided into the following working groups: saltwater intrusion, sedimentation/subsidence, and landscape patterns. The Saltwater Working Group research goals were to identify and quantify the degree and extent of saltwater intrusion with and without canals that contribute indirectly to wetlands loss. The Sedimentation/Subsidence Working Group was to examine accretion processes (e.g., sediment accumulation, peat formation, oxidation, and submergence) as affected by man's alterations. The Landscape Patterns Working Group used remotely sensed data to conduct computer analyses of landloss patterns. These analyses were coupled with statistical analyses to determine relationships between wetland loss and manmade and geomorphic features across the whole coastal zone.

Mr. Robert Baumann discussed the investigation of the Direct Impacts Working Group. Total direct impacts accounted for an estimated 25.6 percent of the total net wetland loss within the Louisiana study area from 1956 to 1978. OCS direct impacts accounted for 4.0 to 4.7 percent of the total Louisiana wetland loss. An important finding was that direct impacts from OCS pipelines averaged 2.49 ha/km and totaled 12,012 ha. Direct impacts are variable and are related to construction technique, geologic region, habitat type, age and diameter of pipeline, and other factors that were not examined.

Navigation channels accounted for a minimum of 16,902 ha of habitat change. Of this total change, 13,615 ha resulted from the loss of wetland and beach habitat. Only a maximum of 17 percent of this change was attributable to OCS activities. OCS traffic appears to comprise a relatively small percentage of the total commercial traffic using navigation channels; thus, the allocation of navigation channel impacts due to OCS activities is small. Direct impacts per unit length of navigation channel averaged 20 times greater than pipelines. The dominant factor controlling the impacts per unit length is the project design.

The Saltwater Working Group presented its findings on the effects of salinity encroachment and its relation to coastal wetland loss. Dr. William Wiseman spoke first on salinity trends in Louisiana estuaries. The database was composed of long-term (up to 44 years) records of salinity collected by the Louisiana Department of Wildlife and Fisheries and the U.S. Army Corps of Engineers (COE). Generally, conclusions were that there were significant trends in salinity statistics over the time period. There was no spatial pattern to the trends. The total change in any salinity statistic was generally small, so small that it was probably not significant to affect local marsh plants; however, in specific locations, the salinity statistic variability was large, and marsh species were indeed affected. The large natural variability observed could have hidden weak trends.

Dr. Flora Wang discussed saltwater intrusion in Louisiana coastal channels. A computer model was developed to describe the movement of salinity related to physical factors. Each of the physical forcing functions--freshwater discharge, tidal exchange, and surface wind stress--played an interactive role on velocity and salinity profiles in coastal channels. Under similar environmental conditions, the saltwater front intruded farther inland for larger and deeper channels than the one in smaller and shallower channels. Dr. Wang also concluded that deepening and widening of a channel does change the nonlinear behavior of saltwater intrusion and patterns of salinity distribution in the channel.

Dr. Erick Swenson discussed the question of how salt migrates to the interior of the marsh--by overland flooding or migration through interstitial waters. To look at this question, intensive sampling of free water salinities in groundwater was conducted over a 3-day period, coupled with subsequent deployment of recording water level and salinity meters.

Based on these data, it appears that the major mechanism for salt transfer into the marsh is occasional overbank flooding with slow return flow. Water in the marsh is also strongly influenced by the precipitation and evapotranspiration. The system is further complicated by the presence of multiple pathways. Variations in wind strength, direction, and spatial scale, as well as stream discharge, may generate small-scale gradients within the open water. These variations are added to the larger scale, predictable gradients associated with tidal flooding. The water level changes of small spatial scale potentially are able to interact with the marsh topography to allow water to enter and flow within marsh channels by a variety of different paths. This means that the source of overbank flooding that drives an observed salinity signal within the marsh may be locally or far-field driven.

Dr. Irving Mendelssohn addressed the question of how, and to what extent, increases in salinity would affect the vegetation of the various marsh types. The major goal of this project was to investigate the effect of increased salinity and submergence on the dominant plant species in each of three marsh types by the simulation of saltwater intrusion and increased inundation under field and greenhouse conditions. Plant species from each of three major habitats were chosen for investigations: Spartina alterniflora, salt marsh; Spartina patens, brackish marsh; Panicum hemitomon, Sagittaria lancifolia, and Leersia oryzoides, fresh marsh.

Study results showed that the response of marsh vegetation to increases in salinity is influenced by a number of factors, including vegetation type; level, duration, and abruptness of exposure to salinity; and level of inundation. Spartina alterniflora was essentially unaffected by increased salinity and slightly affected by waterlogging. S. patens was more sensitive to waterlogging and increased salinity. Although fresh marsh plant species were adversely affected by waterlogging and increased salinities, their response may vary according to species. Thus, fresh marshes composed of more tolerant species might be able to survive salinity increases for short periods, but would probably quickly succumb to sudden increased salinities above 10 ppt.

Since the vertical accretion of marshes is dependent on the accumulation of organic matter produced by marsh plants, any reduction in this source will slow the aggradation process. A sudden change, that leads to a rapid biomass reduction or an elimination, would reduce the potential for marsh accretion to keep up with subsidence and/or sea level rise. The stresses associated with increase in flooding depth and duration could ultimately cause plant demise in areas where marsh accretion lags behind increasing water level. Saltwater intrusion, whether natural or man-induced, may accelerate this process in fresh, intermediate, and brackish marshes.

The next presentations were from the Sediment and Subsidence Working Group. Dr. Richard Kesel has looked at the role of sediment contribution from the Mississippi River in maintaining coastal wetlands. Using available databases from the COE and the Mississippi River Commission, he documented historic trends in bed- and suspended-load discharges of the lower River. Data indicate that the suspended load transported to the Gulf of Mexico has decreased since 1850 by approximately 60 percent. Changes in the quantity of bed load transported by the River were difficult to establish. There has been a decided shift in bed sediment storage from point bars to the channel floor, and this shift may allow this material to be more readily transported. Sediment accumulation above New Orleans appears to represent a wedge of sediment that is or will migrate downstream to the delta possibly without being stored. Grain size data indicate that there has been a fining of sediments within both the suspended- and bed-load fractions of the lower River. The loss of this coarse material may be important in maintaining subaerial land surrounding the delta front.

Dr. Joseph Suhayda reported on his work estimating changes in the absolute land and sea levels in coastal Louisiana during the past 50 years. Sea level change data measured by coastal tide gauges were examined to separate absolute sea level rise from subsidence. The rate of absolute sea level rise and the contribution of freshwater runoff were used to adjust tide gauge records. Subsidence rates for the locations studied were Cameron, 6.1 mm/yr; Hackberry, 4.5 mm/yr; Morgan City, 8.5 mm/yr; Eugene Island, 9.4 mm/yr; and Grand Isle, 7.0 mm/yr.

Another way of looking at subsidence was the resurvey of benchmarks made by the National Geodetic Survey in Louisiana. The subsidence rate on the Chenier Plain was about 3 mm/yr since 1955 and about 6 mm/yr on the Lafourche Delta. A line from Raceland to Grand Isle showed an increasing rate from 0 mm/yr at Raceland to 8.8 mm/yr at Grand Isle. The effect of the withdrawal of fluids from petroleum reservoirs on subsidence was determined using a prediction model and oil/gas production data. Fluids withdrawn include crude oil, condensate, casinghead gas, natural gas, and water. The largest subsidence potential was estimated for the Lake Washington Field at 86.1 cm. There were 19 fields with a subsidence potential greater than 10 cm, considered to be a cutoff value for the model being used.

Because field specific data were not available for each site, a second approach to determining subsidence was to consider field production. Using this method for four fields, the volume of crude oil only, per unit area, was computed and subsidence calculated as follows: Lake Pelto, 130 cm; Leeville, 91 cm; Bay St. Elaine, 89 cm; and Golden Meadow, 59 cm. These values do not reflect the withdrawal of gas or formation water, nor do they reflect seepage or pumping of water into the formation.

Dr. Don Cahoon discussed marsh sediment accretion rates in the vicinity of manmade canals versus natural waterways. Both recent and long-term accretion rates were analyzed by three techniques. Recent accretion rates were evaluated by two marker techniques, using inert clay and inert rare earth stable isotopes. Long-term vertical accretion rates were determined by 137 Cs (25 years) and 210 Pb (100 years) analysis of soil cores. Sediment markers were placed in the marsh 50 m behind the natural or manmade levees and along

50 m transects perpendicular to the waterway. Vertical accretion rates obtained by the three-marker techniques were similar. Accretion rates obtained from 210 Pb techniques were, in all cases, less than 137 Cs, indicating either oxidation and compaction of peats or more rapid accretion in recent years.

Results of the field effort indicated that manmade canals sometimes, but not always, influence the distribution of sediment across the marsh surface. For example, at the Lafourche Parish saltmarsh, long canals bisecting the region on an east-west plane appear to have an important impact on sediment deposition and marsh surface stability; however, there was no effect of distance on vertical accretion and density of mineral and organic matter at either the bayou or canal sites in the salt, brackish, and fresh marsh. The natural site in the fresh marsh, however, exhibited the typical "edge effect" by having significantly higher bulk densities at the streamside plots. This effect was not apparent at the pipeline site.

Another finding was that continuity of spoil banks had no apparent influence on sediment deposition in the saline marsh at Lafourche Parish. Also, organic matter accumulation rates (0.02 and 0.05 g/cm/yr) estimated from recent and 25- to 100-year cores were essentially the same for the canal and bayou sites studied. Mineral sediment deposition varied, depending on marsh site and presence of any streamside effect. It equaled or exceeded organic matter accumulation at most sites. Mineral sediment constitutes an increasing fraction of marsh solids nearer the coast where there is greater tidal exchange.

The Landscape Working Group emphasized computer analyses of spatial and temporal wetland loss patterns using remotely sensed data. It also looked at statistical relationships between wetland loss and the manmade and geomorphic features of the whole coastal zone. Mr. Scott Leibowitz discussed his part of the project using a geographic information system (GIS) to define landloss areas; comparing landloss rates by site, habitat type, and change in salinity; and determining whether specific spatial features, e.g., canals and affected landloss rates.

A number of important findings related to specific spatial trends in wetland loss were noted from the GIS analyses. Rates of landloss were consistent with the geology of the site. The lowest rate of loss was at the Terrebonne site, which currently contains an active sediment source (the Atchafalaya River). The Lafourche site, which is bordered by a recently abandoned distributary (Bayou Lafourche), had the highest rate. The Cameron site, in the Chenier Plain, had an intermediate loss rate.

Many of the relationships noted should be subjected to statistical testing due to the complex landscape and the multiple effects obscuring causative factors. For example, it has long been assumed that oil and gas canals could cause landloss by introducing saline water into freshwater regions and, thus, killing the vegetation. Evidence suggests this is not so, at least for the Terrebonne site. Managing this area for saltwater intrusion (e.g., constructing impoundments or emplacing weirs) could actually exacerbate landloss by reducing sediment input. By combining a GIS with spatial statistics, the analyst can test assumptions such as this before a plan is implemented.

Dr. James Cowan discussed the modeling of wetland loss. Interpreting the results of three quantitative analyses (principal component analysis, multiple regression, and cluster analysis), he suggested the following three conclusions:

1. The complex and regional differences in landloss reflect variations in geology and the delta cycles, man-induced changes in hydrology, and land-use changes. Analyses suggest that the most important factors (determined here as canal density, development, and sediment age), correlated with landloss rate changes, vary depending on location and geologic history, and that the coastal zone is not homogeneous with respect to causal factors or their magnitude. These analyses also indicate that each of the causal factors probably contributes to land-loss in the whole coastal zone to some degree. However, the data also indicate that the interaction between these factors is locally variable and complex.
2. The relationship between landloss, hydrologic changes, and geology can be described with statistically meaningful results, even though these data are insufficient to precisely quantify the relationship. However, these data support the hypothesis that the indirect impacts of man-induced changes may be as influential as the direct impacts of converting wetlands to open water or modified habitat.
3. Three regions within the Louisiana coastal zone can be defined by using cluster analysis. The moderate (mean=22 percent) wetland loss rates in region 1 are a result of relatively high canal density and developed area in marshes that overlay sediments of moderate age and depth. On the other hand, landloss rates in region 2 are high (mean=36 percent) despite fewer man-induced impacts; the potential for increased landloss due to both direct and indirect effects of man's activities in these areas is high. Conversely, landloss in region 3 (mean=20 percent) is apparently least influenced by man's activity in the coastal zone because of sedimentary geology, even though these areas have experienced significant habitat alterations and direct landloss.

Dr. Turner examined the relationship between canal area and the number of new ponds of different sizes formed in the wetlands. At least five qualitative types of wetland changes were evident in the four different map groupings examined.

New small holes are more numerous than water bodies of the same size. If new small ponds form, it is likely that the less numerous larger ponds will also form. These patterns are consistent with the conclusion that the marsh is literally breaking up internally, rather than eroding at the edge. The relationship between small and larger pond number is less clear as pond size increases. These relationships complicate interpretation of wetland changes at the landscape level, and an analysis of the spatial and temporal distribution of the small new ponds is probably more useful than an analysis of the few larger ponds.

Results from these analyses support the hypothesis that the hydrologic impacts of canals and spoil banks affect wetland-to-water conversion on the scale of kilometers. They are directly related to the majority of wetlands losses in the study area, and their impacts vary regionally, e.g., with sediment compaction rates that increase with increasing sediment deposition layering. Local influences complicate the interpretation, and not all areas are equal. General results agree with the modeling effort in that regional differences of geologic substrate are demonstrated influences on overall regional wetland loss rates.

Dr. Karen Wicker discussed progress on an MMS-sponsored study related to the impacts of OCS activities on sensitive coastal habitats. The objectives of this study are to investigate past impacts and to predict potential future activities of Federal OCS pipelines, facilities, and navigation channels on barrier islands and beaches. As a part of this study, the impact of OCS-produced water discharge in the study area is being investigated. To characterize the impacts of OCS infrastructure on coastal islands, Federal OCS pipelines, facilities, and channels are being identified and researched as to past history. It is anticipated that a synthesis of field data and historical photography will permit a summation of impacts that have resulted for any given set of conditions involving pipeline construction techniques, environmental forms and processes, and other activity in the vicinity of pipelines.

Dr. Donald Boesch of the Louisiana Universities Marine Consortium (LUMCON) reported on his portion of the study, which involves the analysis of produced water impacts in coastal areas. Some 17 facilities discharge OCS-produced waters into Louisiana waters, and most of the discharge comes from a few large facilities in the Mississippi River Delta, Grand Isle, Port Fourchon, and East Timbalier Island regions. This study involves the sampling and analysis of hydrocarbons and trace metals in sediments and organisms, and benthic organisms in water bodies and wetlands in the vicinity of the discharges.

An analysis of produced water effluent sites was undertaken at Grand Isle, Pass Fourchon, and East Timbalier Island. Highest concentrations of petroleum hydrocarbons in the fine-grained bottom sites were found approximately 100 m from the discharge site. Although the more volatile components, e.g., benzene and toluene, were in lower concentrations, a clear contamination signal was apparent up to 1 km from the discharge site. The macrobenthos at the sites exhibiting more contaminated sediments were absent or extremely depauperate, showing an increasing gradient in numbers and diversity with distance from the discharge site.

Dr. C.G. Groat of the Louisiana Department of Natural Resources reported on "Wetlands Mitigation: A Study of Marsh Management." This study contract has recently been awarded and will seek to provide information related to the effectiveness of marsh management. Such traditional management approaches as levees and water control structures either impound or partially impound wetlands, allowing control of water levels and salinity. Although this may enhance the wetlands value, especially for waterfowl and furbearers, its value in wetlands conservation has been questioned. The main objective of the wetlands mitigation study will be to provide an objective assessment of the suitability and feasibility of using marsh management to protect and enhance coastal wetlands and their related renewable resources.

Dr. Robert M. Rogers is a marine biologist on the Environmental Studies Staff of the MMS Gulf of Mexico OCS Regional Office. He has served as Contracting Officer's Technical Representative on a number of wetlands-related studies. Dr. Rogers received his B.S. and M.S. degrees in zoology from Louisiana State University and his Ph.D. in marine biology from Texas A&M University.

OCS Development and Potential Coastal Habitat Alteration: Project Design and Management Overview

Dr. R. Eugene Turner
and
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The purpose of this study was to determine how wetland loss results from Outer Continental Shelf (OCS) development of oil and gas resources in the central Gulf of Mexico. The rationale for the study was that wetlands have societal value; that wetland management is possible; and that improved knowledge is useful to understand, predict, mitigate, and avoid undesirable impacts.

Water, plants, sediments, soils, landscapes, history, and industry were studied by experts over a 27-month period to develop a consensus report due December 1987. To effectively assess the effects of OCS-related activities, it was necessary to quantitatively evaluate the contributions of other factors causing habitat alteration. Therefore, the study was extensive.

STATEMENT OF THE PROBLEM

Coastal wetlands in the Louisiana-Mississippi portion of the study area were converted to open water at an average annual rate of 0.86 percent from 1955 to 1978, thereby continuing a geometric increase (Figure 6.1). This rate amounts to 288,686 ha for the entire 23-year period. At that rate, the state of Rhode Island would be lost within 21 years, the District of Columbia within 7 years, or within 55 years the Netherlands would lose to the sea all of the land she has reclaimed over the last 800 years. This is equivalent to the area of a 1,500 ft2 suburban home being lost in one minute.

There is, naturally, concern about these habitat changes because of the enormous economic, social, geopolitical, and environmental values involved in such massive and rapid landscape alterations. Louisiana's coastal wetlands comprise 41 percent of the U.S. coastal wetlands and are a state, national, and international natural resource. These wetlands directly support 28 percent of the national fisheries harvest, the largest fur harvest in the U.S., the largest concentration of overwintering waterfowl in the U.S., a majority of the marine recreational fishing landings, and a variety of wildlife (Table 6.1). More than 70 percent of the oil and 90 percent of the gas will continue to come from offshore of the study area, move through it, and enter the industrial processing plants that support the entire country. Though now large, these natural and renewable resources may not sustain us through the next century because of their rapid reduction.

Wetland gains and losses are the results of many interacting factors. In a natural marsh, mineral matter from rivers, reworked sediments, and plant debris are required to build wetlands. At the same time, wetlands in Louisiana's sedimentary coast are sinking (because of compaction, for example), and absolute sea level is rising. Any factor that significantly alters subsidence, sedimentation, organic deposition or relative sea level could easily determine whether an area gains or loses wetland to the sea. Although geologic factors clearly influence the rates of wetland loss, other factors are also important. The suspended matter concentration in the Mississippi River has apparently declined in the last 30 years, probably caused by land use changes and the trapping of supply but also the interaction of plants and the prevailing hydrologic regime. For example, besides trapping mineral matter at the surface, plants add a substantial amount of organic material to the soil. Fresh marsh soils are mostly composed of organic debris deposited in situ, not brought in by currents. Even salt marsh soils may be composed of up to 50 percent organic matter. Furthermore, as organic material is laid down, the weight per unit volume of soil decreases. Thus, marshes need less mineral matter than bay bottoms to maintain elevation in the face of rising sea level or sinking substrate.

Man has changed the landscape in several notable ways that may have contributed to these large habitat changes. Direct influences by man include those arising from 40 percent of the U.S. refining capacity being located within the coastal zone of the Gulf of Mexico and 8 major fabrication yards in the MMS central Gulf of Mexico planning area. Indirect impacts include canals dredged in wetlands for both OCS and non-OCS related activities. Most canals and their associated spoil banks have been constructed since 1940 to service the oil and gas industry. Each oil and gas field in the coastal wetlands has numerous canals and spoil banks. The canals are dug to bring in drilling equipment, and the spoil banks are the residual dredging materials placed on either side of the canal in a continuous and unbroken line.

Offshore and onshore oil and gas annual production rates peaked about 10 years ago (Figure 6.1) and have since declined in spite of the deregulation of prices in the late 1970s. Consequently, fewer canals have been built in recent years, although the cumulative total canal area continues to climb. The average canal dredged in recent years is smaller than previously, partly because of increased scrutiny by state and federal management, but also because the canal network has grown enough so that new canals can attach to old ones. Currently, the surface area of canals is equivalent to 2.3 percent of the wetland area. Every hydrologic unit has significant area of canals that has increased greatly in the last 25 years. Overall, the total area of spoil bank levees, plus canal surface, is about 6.6 percent of the present wetland area; increases in spoil and canal area equal 16 percent of the net wetland change from 1955/6 to 1978. There is hardly a place in the Louisiana coastal zone where canals and their impacts are absent.

The temporal and spatial concurrence of rapid changes in wetlands, and both on- and offshore oil and gas industry activities, led to this study. On one hand, oil and gas recovery has previously been extensive and will likely continue to be significant in the future. On the other hand, we presumed little would change geologic rates (subsidence, sediments compaction, and sea level) in the near future. We chose and developed hypotheses and questions to understand the causes of wetland loss and what could be done to reduce them.

PROJECT GOALS AND ORGANIZATION

There were three primary project goals for the study:

1. Determine why the coastal marshes are being lost at a rate approaching 1 percent annually. Specifically, determine whether the high rate of coastal submergence is caused by an increase in wetland sinking (subsidence), a decrease in wetland building (sedimentation and organic peat accumulation), or a combination of both.
2. Determine what impact OCS and onshore oil and gas development (particularly canal construction) have on wetland sinking and wetland building processes and, therefore, what the indirect contribution of such development is to the rate of wetland loss.
3. Determine what extent of wetland loss in south Louisiana is caused by the direct conversion of wetlands to open water or upland habitats by the dredge and fill activities of man.

As a means of better focusing project efforts toward these goals, the investigation was organized around five major questions addressing two important means of marsh loss: coastal submergence and direct conversion to open water.

1. If land is sinking more quickly than land is building, and the rates of each process are changing, to what extent is this disparity caused by changes in: (1) sediment supply reaching the marshes; (2) organic matter accumulation; (3) subsidence rates; and, (4) water level?
2. Do levee construction, canal dredging, and oil and gas production influence the rates of sedimentation, organic matter accumulation, and subsidence in coastal Louisiana? If so, do these impacts contribute to the high rate of coastal submergence?
3. Are there spatial patterns of land loss, and if so, can these patterns be interpreted?
4. How long does it take for a change in subsidence, sedimentation, or accumulation, i.e., surface disparity, to be expressed as wetland loss?
5. What are the direct and indirect impacts of OCS activities on wetland losses in coastal Louisiana?

WORKING GROUPS

The project was subdivided into two broad analyses: direct and indirect impacts. The direct impacts of OCS-related activities were assessed and compared with the direct impacts of other oil and gas and miscellaneous wetland-use activities on coastal wetlands in the study area. Indirect impacts were assessed by investigating how OCS activities affect the natural processes controlling wetland loss and by quantifying wetland loss that is indirectly the result of OCS activities.

Individual research tasks were aggregated into "working groups" to prepare the final selection of sampling sites and the final analysis. These groups have a commonality in their basic thrust and subject matter. A definition of each is listed below, along with the principal investigator (PI) directing the project at Louisiana State University.

Program Management: Methodology Development

Develop hypotheses, experimental design, and methodology for other technical approaches; perform data management, archiving, report and budget coordination, and consensus development (PI: R.E. Turner and D.R. Cahoon, Coastal Ecology Institute, Center for Wetland Resources). Establish a Scientific Review Board (SRB) to serve as technical review group and make recommendations to investigators and MMS concerning methodology, hypotheses, and experimental design (PI: R.E. Turner and D.R. Cahoon, Coastal Ecology Institute, Center for Wetland Resources).

Direct Impacts Working Group

Determine the direct impacts of OCS pipelines, navigation canals, and support facilities by quantifying the areal extent of open water areas created, spoil deposits, and support facilities (PI: R.H. Baumann, Center for Energy Studies). Ascertain historical, existing, and projected volumes of waterborne traffic moving through OCS navigation canals in order to identify major navigation channels (PI: A.R. Reed, Ports and Waterways Institute, Center for Wetland Resources). Determine the direct impacts of non-OCS activities on wetland loss by quantifying wetland conversion resulting from a planned non-OCS-activity (PI: R.E. Turner, Coastal Ecology Institute, Center for Wetland Resources).

Saltwater Intrusion Working Group

Identify and quantify the degree and extent of saltwater intrusion with, and without, OCS-related canals that contribute indirectly to wetlands loss (PI: F.C. Wang, Coastal Ecology Institute, enter for Wetland Resources). Analyze the long-term (40 years) salinity records to determine the magnitude of change, relationships with climate, and oceanographic forces, and residuals caused by geologic changes (PI: W.J. Wiseman, Coastal Studies Institute and E.M. Swenson, Coastal Ecology Institute, Center for Wetland Resources). Investigate the effects of increased salinity, increased submergence, and the interaction of salinity and submergence on the dominant plant species in three major marsh types by simulating saltwater intrusion and submergence under field and greenhouse conditions (PI: I.A. Mendelssohn and K.L. McKee, Wetland Soils and Sediments Laboratory, Center for Wetland Resources). Determine how salt migrates to the interior of the marsh, either by overland flooding or by migration through the interstitial water. A combination of field measurements and modeling were used to investigate the question of advection or diffusion through the groundwater (PI: W.J. Wiseman, Coastal Studies Institute and E.M. Swenson, Coastal Ecology Institute, Center for Wetland Resources).

Sedimentation/Subsidence Working Group

Examine accretion processes (e.g., sediment accumulation, peat formation, oxidation, submergence) as affected by man's alterations (PI: W.H. Patrick and R.D. DeLaune, Wetland Soils and Sediments Laboratory, Center for Wetland Resources). Estimate changes in the absolute wetland and sea levels in coastal Louisiana during the past 200 years (PI: J.N. Suhayda, Ports and Waterways Institute, Center for Wetland Resources). Assess the long-term changes in sediment discharge of the Mississippi River (PI: R.H. Kesel, Department of Geography and Anthropology). Determine the effects of spoil banks and canals on natural sedimentation rates by use of a stable tracer technique (PI: R.M. Knaus, Nuclear Science Center). Determine the effects of spoil bank height, continuity, and soil type on vertical accretion in marshes by use of an inert clay marker (PI: D.R. Cahoon and R.E. Turner, Coastal Ecology Institute, Center for Wetland Resources).

Landscape Patterns
Working Group

Conduct computer analyses of the spatial and temporal wetland loss patterns using remotely sensed data (PI: J.M. Hills, S. Leibowitz, Remote Sensing and Image Processing Laboratory). Determine the statistical relationships between wetland loss and the manmade and geomorphic features of the whole coastal zone (PI: R.E. Turner and J.H. Cowan, Jr., Coastal Ecology Institute, Center for Wetland Resources).

Dr. R. Eugene Turner is a Professor of Marine Sciences in the Center for Wetland Resources, Louisiana State University. He is Program Manager for the MMS contract on habitat modification in the coastal zone. His interests include wetland management, mitigation and restoration, biological oceanography and fisheries ecology. Dr. Turner received his Ph.D. from the University of Georgia.

Dr. Donald R. Cahoon is an Assistant Professor of Research at the Coastal Ecology Institute, Center for Wetland Resources, Louisiana State University. He is the Associate Manager for Science for the MMS contract on potential habitat change in the coastal zone. His interests include resource management, wetlands ecology, primary production processes, and education. Dr. Cahoon received his M.S. and Ph.D. degrees from the University of Maryland.

Analysis of Direct Impacts of OCS Pipeline and Navigation Channels on Central Gulf Wetlands

Mr. Robert H. Baumann
Louisiana State University
Center for Energy Studies
and
Mr. Andrew R. Reed
Louisiana State University
Ports and Waterways Institute

The goal of this task was to quantify the direct impacts of OCS activities within the study area and to determine which factors contribute to the variability of direct impacts within the region. Tasks involved within this effort included the identification of OCS pipelines and facilities, the measurement and inventory of direct impacts, the determination of those factors that account for the variability in the degree of direct impacts of OCS activities, and the allocation of all direct impacts to OCS versus non-OCS activities.

This study was designed to assess several questions:

(1) Is total direct impact an important factor in accounting for wetland loss (habitat change)?
(2) Does direct conversion of wetland/habitat to open water and spoil by OCS-related activities account for a substantial part of all direct impact wetland loss?
(3) Is the degree of direct impact by pipeline construction on wetland loss directly related to the construction technique employed, pipeline diameter, age of pipeline, geologic region, and habitat type?
(4) Do direct impacts resulting from the construction of

navigation channels substantially contribute to total direct wetland loss?

(5) Does OCS water-borne traffic comprise a significant portion of the total water-borne traffic in the major man-made navigation channels?

(6) Is the degree of initial direct impact of navigation channels directly related to the construction dimensions?

Our efforts also included investigations into several aspects of canal and navigation channel widening caused by erosion. Specifically, we wanted to determine whether OCS-canal widening was a significant factor in accounting for total wetland loss and whether the rate of canal/channel widening was related to the amount and type of water-borne traffic.

MATERIALS AND METHODS

Total direct impacts resulting in wetland loss from 1955 to 1978 were estimated using 1:24,000 scale wetlands habitat data. Direct impacts were assumed to be caused by agricultural and urban expansion and by canal and spoil bank construction. OCS pipeline and support facilities could not be separated from all other direct impacts because of the way habitat categories were defined during the original mapping effort. Calculations of site-specific conversions could not be made; only the net change in individual quadrangle maps were calculable.

The identification of OCS pipelines and related facilities required review of many information sources, mostly maps and databases. Although no single information source is entirely accurate or complete, by comparing the total information pool and verifying some of the original data sources, most of the missing data were located, and conflicts were resolved. The key data sets and maps used for OCS identification included (1) the MMS database on OCS pipelines; (2) an unpublished map provided by John Chance and Associates of Lafayette, Louisiana, depicting the offshore location of pipelines, operator, and size of line; (3) a series of historical maps of offshore and onshore pipeline system development, including operator, product transported, and pipeline diameter as published by the Louisiana Geological Survey (LGS); (4) a copy of the most recent database used by LGS to publish maps (includes some operator verification); (5) file data from the Louisiana Department of Natural Resources and the Texas General Land Office, which provided information on processing facilities located within the study area as well as the percent OCS versus non-OCS product transported by individual pipelines; (6) maps published individually by various operators; and (7) unpublished proprietary data from several Louisiana researchers that provided detailed impact assessment of several OCS pipelines.

Once identified, pipeline locations were transferred to the latest edition of USGS 1:24,000 quadrangle maps. High altitude, high resolution, color, infrared photography (NASA Missions 86-032 and 86-033, Dec. 6, 14, 1985) was used to determine the exact locations of pipeline routes. Next, 1:24,000-scale mylar habitat maps were overlaid on the pipeline routine maps. This information base was then used to assess the direct habitat changes resulting from pipeline construction and processing facilities.

Lengths of pipeline impacts were planimetered by pipeline and habitat affected. The habitats included beach (including dunes), open water, salt marsh, brackish marsh, intermediate marsh, fresh marsh, forested wetland, spoil, and upland (including natural levees, cheniers, Pleistocene outliers). The area of impacts, in most cases, could not be similarly measured because the error factor for measuring widths of most spill deposits and pipeline canals at 1:24,000 scale is far too large. The widths of 72 pipelines were field-measured using a Leitz automatic level and metric stadia rod. Average widths of the measured pipeline canals and spoil banks were divided into six classes and assigned a width class, based on air photo comparisons of their apparent width in relation to canals of known width. Exceptions to this rule were made for most of the very large pipeline canals (usually a corridor containing multiple lines), and the widths of these canals were based on actual field measurements. Impact areas were then calculated using the planimetered lengths multiplied by the width class assigned. Impact areas and length were recorded by pipeline, habitat, age, parish, geologic region, and pipeline diameter.

Impact length and area for navigation channels and associated spill deposits were directly planimetered from the 1:24,000 topographic maps. Field measurements verified that these impacts were sufficiently large enough to be measured at 1:24,000 scale with an error factor of approximately 6 percent. It should be noted that canal width measurements were generally larger than canal widths reported by the U.S. Army Corps of Engineers (COE).

General linear models were developed to determine the significance of the factors measured in accounting for direct impact variability. Pipelines were treated separately from navigation channels. Analysis of variance was conducted for all categorical factors (e.g., geologic region, habitat type, construction type), including one-, two-, and three-way models. Analysis of covariance was performed for the continuous factors (e.g., age, width, and diameter) and included all possible interactions of the factors.

All the major navigation channels support OCS and non-OCS activities, and at least 44 out of 225 pipelines transport both OCS and non-OCS hydrocarbons. Allocations of impacts for those multiple use channels and pipelines needed to be determined. For pipelines, the percentage of OCS product flow, to total product flow, is reported by operators on a monthly basis. To our knowledge, the data are only available in raw form and are not centralized in any single, easily accessible form. Data for January 1978 are available in summary form within a proprietary report prepared for the State of Louisiana by the Gulf South Research Institute for product being transported for January 1978. For pipelines constructed post-1978, the same method of allocation was used, based on the Operator Production Audit reports file for the same early months of 1984.

Allocation of direct impacts of navigation channels was based on vessel count, size, and destination data provided by the Waterborne Commerce Statistical Center (WCSC) and the Performance Monitoring System (traffic at navigation locks), both of which are part of the COE. These percentages were used as multipliers to determine the OCS allocation of the total direct impacts. Many of the navigation channels used by OCS traffic were not included in the direct impacts. Many of the navigation channels used by OCS traffic were not included in the direct impact analysis because there was either no impact (use of natural channel), or the direct impacts could not be determined accurately.

SIGNIFICANT FINDINGS AND RECOMMENDATIONS

1. Total direct impacts accounted for an estimated 25.6 percent of total net wetland loss within the Louisiana portion of the study area from 1955/56 to 1978. Of the total direct impacts of 73,905 ha, OCS-related activities accounted for 11,589 to 13,631 ha of the wetland loss during the same time interval. Although this is a substantial areal loss, it represents only 4.0 to 4.7 percent of the total Louisiana wetland loss from 1955/56 to 1978, 15.7 to 18.4 percent of direct impacts.
2. Direct impacts from OCS pipelines averaged 2.49 ha/km and totalled 12,012 ha. Direct impacts are variable and are related to construction technique,, geologic region, habitat type, (Figure 6.2) age and diameter of pipeline, and other factors that were not examined. Management for least impacts should include the following principles: (1) the pipeline should be backfilled; and (2) wetland habitats should be avoided in favor of open water bodies and topographic highs (levees, cheniers).
3. Direct impacts from backfilled OCS canals in the Chenier Plain are not significantly related to age of pipeline; therefore, future indirect impact within the pipeline right-of-way for this situation are not expected to result in a significant increase in pipeline impact. Direct impacts from non-backfilled canals in both regions and from backfilled canals in the Mississippi Deltaic Plain are positively related to age of pipeline.
4. There is a significant relationship between impact and pipeline diameter, although the relationship is non-linear, and the effect of diameter appears to be substantially less than that of other factors examined. Therefore, the best strategy is the installation of a larger diameter pipeline to allow for future expansion of product flow rather than a repetitive smaller diameter installation. In other words, reduce the number of pipelines rather than the size of individual lines.
5. The concept of using a corridor approach, containing several pipelines, rather than a random distribution of individual lines to reduce impacts, appears valid for non-backfilled canals. However, no significant difference in direct impacts for corridor versus random distribution was found for backfilled canals. Backfilling reduced direct impacts by 75 percent and, therefore, is the preferred construction technique over corridor construction.
6. The current MMS published guidelines on the impacts of pipelines on Gulf of Mexico coastal marshes estimate that a pipeline will destroy about 16.25 ha/km (25 acres/mi). Our data show that the average impact for all OCS pipelines traversing an average habitat mix within the coastal zone is 2.49 ha/km. Because backfilling is now a standard procedure, a new pipeline will probably result in an average direct impact of 0.68 ha/km in the Chenier Plain and 1.05 ha/km in the Deltaic Plain. Even using a worst case scenario (salt marsh with no open water, non-backfilled canal in the Deltaic Plain), the average direct impact is 4.38 ha/km, a value substantially less than the published guideline.
7. Widening of OCS pipeline canals does not appear to be an important factor for total net wetland loss

in the coastal zone because few pipelines are open to navigation, and, for the examples found, the impact width was not significantly different than for open pipelines closed to navigation. Individual lines, however may widen at locally significant rates.

8. Navigation channels account for a minimum of 16,902 ha of habitat change. Of the total change, 13,615 ha resulted in the loss of wetland and beach habitats. The maximum amount of habitat change attributable to OCS activities was 2,885 ha (17 percent) of which 2,293 ha (16.8 percent) was the loss of wetland and beach habitats. OCS traffic appears to comprise a relatively small percentage of the total commercial traffic using navigation channels; thus, the allocation of navigation channel impacts to OCS activities is small. Of the total habitat change, 13,652 ha (81 percent) are attributable to MRGO, Calcasieu Ship Channel, and Beaumont Channel/Sabine Pass, all of which have very low OCS destination usage.
9. Direct impacts per unit length of navigation channel average 20 times greater than pipelines. The dominant factor controlling the impacts per unit length is the project design. However, surface channel widths are substantially greater than design widths. A detailed long-term field investigation would be required to determine the validity of the commonly-held belief that channel widening is some function of tonnage, speed, and frequency of vessels, as well as edaphic factors.

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Long-term Salinity Trends in Louisiana Estuaries

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We know that dredging can contribute to saltwater intrusion and, consequently, marsh degradation. While much of the land-loss of coastal Louisiana has been attributed by the press to saltwater intrusion, there have been very few direct observations of saltwater intrusion in Louisiana wetlands. We have analyzed 44 long-term (up to 44 years in length) records of salinity collected by the Louisiana Department of Wildlife and Fisheries and the U.S. Army Corps of Engineers from South Louisiana waterways.

The data were converted to time-series of monthly mean salinity, monthly salinity variance about the monthly mean, and monthly maximum observed salinity. A non-parametric test for trend, the seasonal Kendall Tau, was applied to each data set. If a statistically significant (alpha greater than 0.90) trend was noted, an estimate of the liner portion of this trend was used to estimate the total change in the record over the period of observation.

These analyses show:

1. There exist statistically significant trends in the mean salinity, salinity variance, and extreme salinities in Louisiana estuaries over the time period covered by the records analyses.
2. These trends were increasing in some cases and decreasing in others.
3. There was no apparent spatial pattern to the trends.
4. The total change in any salinity statistic over the period of record was generally small. These changes were probably so small that they were not significantly detrimental to the local marsh plants.
5. In specific locations, the change in salinity statistics was large, and the marsh species composition in the region is known to have altered in recent times in a manner consistent with the observed salinity change.
6. Natural variability is large in the long-term salinity records. This variability can often hide weak trends.

As longer data sets become available, these analyses should be redone.

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Saltwater Intrusion in Louisiana Coastal Channels

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INTRODUCTION

The behavior of saltwater intrusion in coastal channels with small tidal ranges is highly influenced by freshwater inflow from upstream drainage basins. Under the moderate flow condition, the salinity distribution in shallow channels is quite uniform. In contrast, the degree of stratification is greatly enhanced for the low flow condition. In Louisiana coastal channels, the salinity is well mixed at the Gulf side; it then gradually changes into partially and highly stratified at 20 to 40 km upstream from the channel entrance.

This paper summarized the results of the 2-year MMS project for the task of the indirect impact of salinity on wetlands loss. The objectives of this study are (1) to identify the behavior of saltwater intrusion in the major navigation channels supporting OCS related and less related activities; (2) to estimate the length of saltwater intrusion under various forces induced by freshwater inflow, tides and winds, and salinity variations; and (3) to simulate the patterns of salinity distribution in channels resulting from the changes in channel dimensions.

STUDY SITES

The two distinct geophysical zones on the Louisiana coast are the Chenier and Deltaic Plains (Coleman, 1981). The coastal plains are formed by riverine sediments, mainly from the Mississippi River over long periods of geological time. These sediments have built a sequence of deltaic lobes and have prograded the Louisiana coastal shoreline seaward to the Gulf.

There are eight major navigation channels in coastal Louisiana (Figure 6.3). The IntraCoastal Waterway (ICWW), about 40 to 60 km inland from the Gulf, runs in an east-west direction, providing the vital water-borne activity with the State of Texas and Mississippi. The other navigation channels run mostly in a south-north orientation, linking the inland water with the Gulf of Mexico. Three coastal channels, Houma Navigation Channel (HNC), Calcasieu Ship Channel (CSC), and Bayou Petit Caillou (BPC) were selected for this study (Figure 6.3). Their selections are based on geographical locations, physical environments, and channel dimensions for comparative purposes.

FIELD MEASUREMENTS

In this task, the field measurement of velocity and salinity profiles is limited to the low and moderate flow periods that occur from late fall to early spring in coastal Louisiana. The measurements were made at selected locations along the channel depending on the salinity distribution during the time of the sampling period. The purpose of field measurements is to provide an adequate database for the development of a mathematical model that simulates realistically the dynamic behavior of salinity distribution in coastal channels.

Houma Navigation Channel, located in southcentral Louisiana (Figure 6.4a), is one of the major channels that supports OCS-related activities. The average channel depth and width are 6.6 m and 100 m, with a typical width-to-depth ratio of 15. Two field trips were made to this site. The first one was conducted on September 20-21, 1986, when the freshwater discharge measured at the upstream reach was relatively low, about 0.5 cms/m. The 5 ppt saltwater locus reached north of Houma City about 40 to 50 km from the channel entrance. Moderate high (18 to 19 ppt) and uniform salinity profiles were observed on the first 10 to 15 km northward from Cocodrie, Louisiana (Figure 6.5a). The second trip was made on October 17-18, 1986. This time, the 1 ppt saltwater front only reached to Celestin, 25 km from the channel entrance (Figure 6.5b) because of the relatively high freshwater discharge, 1.7 cms/m. from the upstream reach of the channel.

The Calcasieu Ship Channel, located on the southwestern coast of Louisiana (Figure 6.4b), plays an important role in the waterborne commerce activity and a relatively minor role in the OCS-related activity. From Cameron to Lake Charles, the channel is well-maintained by dredging for larger and more modern vessels traveling through the ship channel and to the Gulf. The channel has a typical water depth of 12.5 m and a width of 200 to 400 m, representing a width-to-depth ratio of 15 to 20. Two field trips were conducted to this site. The first one was November 15-16, 1986. At this time, the 5 ppt saltwater locus reached Berry Bay, 75 km from the channel entrance (Figure 6.6a). The second trip was made on March 2-3, 1987. This time, the saltwater (less than 1 ppt) was only detectable near Hackberry, 25 km from the channel entrance, because of the large freshwater discharge, 6.7 cms/m, from upstream (Figure 6.6b).

Bayou Petit Caillou, a relatively shallow and narrow channel and a typical natural bayou, is used mainly for recreation activities. It is located 10 km east of Houma Navigation Channel (Figure 6.4a). The water depth for the first 20 km from the channel entrance is only about 3 m, and it becomes shallower farther upstream. The channel width is about 50 m with a typical width-to-depth ratio of 15. Only one field trip was made to this site on October 19, 1986. The salinity distribution was quite uniform at 10 to 14 ppt from the channel entrance to 15 km upstream; it then decreased rapidly to 1 ppt at a distance of 10 km further upstream. (Figure 6.7a).

COMPARISONS OF FIELD RESULTS

Field results obtained from three separate field surveys conducted for Bayou Petit Caillou on October 19, 1986; Houma Navigation Channel on September 20-21, 1986; and Calcasieu Ship Channel on November 15-16, 1986 were compared. During these sampling periods, their freshwater discharges were 0.5, 0.5, and 0.1 cms per unit width, or 25, 50, and 20 cms, respectively. Their tidal amplitudes were 0.1, 0.1 and 0.3 m. And the local winds were relatively calm.

Under these similar physical environments, their salinity distributions are displayed in Figure 6.7. The figure shows that the 5 ppt saltwater locus at three channels is discerned at 20, 45, and 75 km from their respective channel entrances. The field results indicate clearly that there are differences in the length and extent of salinity distribution for various channel types and dimensions at different geologic regions.

The commonly known saline wedge that occurred in the lower Mississippi River (Balloffet and Borah 1985), has not been found in the three selected channels. The Mississippi River has a much larger drainage basin and higher freshwater discharge, and a much deeper channel than our three study sites. These environments are favorable for the formation of an arrested saline wedge.

MATHEMATICAL MODEL

A two-dimensional, and laterally averaged hydrodynamic model, coupling with a salt flux transport model, is developed to quantify the saltwater intrusion problems due to interactions of freshwater discharge, tidal activity, prevailing wind, and density gradient caused by salinity variations. The model is formulated on the basis of the underlying physical principles. The basic governing equations are the momentum equation, the continuity equation, and the advective-diffusion equation with appropriate boundary conditions.

A numerical scheme with a variable grid size in both the vertical and horizontal direction is designed. The semi-implicit (implicit in vertical direction only), finite difference form is used for both the flow equation and the salt transport equation. The functional forms of eddy viscosity and vertical diffusion (Bowden and Hamilton 1975) are formulated in the model. The empirical parameters in these functions are then determined from, and calibrated with, field data. The stability criteria (Blumberg 1977) are set in the numerical computation.

COMPUTER SIMULATION

For each selected channel, two data sets are required. The first one is used for model calibration. The second independent data set, using the calibrated parameters, is then used for model verification. Intensive efforts were spent in the model calibration. From the experience of various simulation runs, it is found that in coastal Louisiana, a simulation period of five tidal cycles is adequate for the tidal regime, velocity field, and salinity distribution in channels to become stable; thus, the model results from the fifth tidal period are being used for comparative purposes. In general, the calibrated results show good agreement with field measurements. The results of model verification are satisfactory.

The computer model, once field calibrated and verified, can be used to simulate the effect of varying channel depth and width on the salinity distribution in channels. Two channels, Houma Navigation Channel and Bayou Petit Caillou, are chosen for this simulation. Their dimensions were doubled (twice the channel depth and width) while all other variables were kept the same as previous runs. The simulated salinity distribution are shown in Figure 6.8.

CONCLUSIONS

The following conclusions are derived from this study:

1. Each physical forcing function, freshwater discharge, tidal exchange, and surface wind stress, plays an interactive role on velocity and salinity profiles in coastal channels (Figures 6.5 and 6.6).
2. Under similar environmental conditions, the saltwater front intrudes farther inland for larger and deeper channels than the one in smaller and shallower channels (Figure 6.7).
3. Deepening and widening the channels do change the nonlinear behavior of saltwater intrusion and the patterns of salinity distribution in channels (Figure 6.8).

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Saltwater Movement between the Marsh and Adjacent Bayous

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INTRODUCTION

The question of how salt migrates to the interior of the marsh--by overland flooding or migration through the interstitial water--is integral to an understanding of the marsh ecosystem. Saltwater intrusion, as a result of man's activities in the coastal zone, has been implicated as one of the causes of marsh deterioration in Louisiana (Craig et al. 1979; Chatry and Chew 1985). However, there are very few field studies on the mechanisms of saltwater migration in the marshes. This field study was undertaken to address the question of advection or diffusion of salt through the groundwater. This was accomplished through the use of intensive sampling of the salinities in the free water in the marsh system over a 3-day period, coupled with the subsequent deployment of recording water-level and salinity meters.

FIELD APPROACH

Intensive Three-Day Sampling

The general location of the study area was in the brackish to intermediate marshes in the Louisiana coastal zone within the south-central portion of Terrebonne Parish. Initial, intensive surveys were made for 2- to 3-days to determine the distance inland from a canal that salinity variations may be expected to propagate. During these studies, sampling wells were placed along three parallel transects extending from the bayou edge to 50 meters into the marsh. Salinity samples were collected from the wells every three to six hours throughout the 3-day study period. In addition to the samples collected in the wells, samples were also collected from the adjacent bayou. The results from this study were used to determine the placement of six recording water-level and salinity gages that were subsequently deployed.

Time Series Data Collection

During these later studies, a series of six recording water-level and salinity recorders were set up along a transect perpendicular to the marsh edge. The six gauges were placed at the following distances along this transect: (1) in the bayou; (2) on the natural berm; (3) 5 meters from the water's edge; (4) 10 meters from the water's edge; (5) 35 meters from the water's edge; and (6) 75 meters from the water's edge. The natural berm at this location was about 20 cm high and 2-3 meters wide. The gauges were deployed in wells, with inlet holes at a depth of 15 cm below the marsh surface. The purpose was to obtain salinities of the free water within the root zone. The gauges were deployed for 6 weeks.

RESULTS AND DISCUSSION

The salinity data from the intensive 3-day sampling trips were consistent at each site for each of the 3-day sampling trips. In general, the data indicated that high salinities occur on the natural berm, then decrease with distance into the marsh.

The time series salinity and water-level data showed a strong diurnal tidal signal present in the bayou that is damped out as one moves into the marsh. Standard time series analysis (spectral densities and coherences) were used to analyze the data. The results indicated strong coherences (~0.8) among the water level signals for all of the field experiments, for all of the gauges. The results for the salinity data were not as clear. In general, the coherences between salinities in the bayou and the marsh were either weak (~0.6) or non-existent. Thus, it seems that the salinity signal at any given point in the marsh cannot be completely explained by the salinity signal in the adjacent bayou or canal. However, the coherences among gauges within the marsh proper (greater than 35 meters inland) were stronger, implying that the inland marsh acts as a unit, which is then weakly coupled to the adjacent bayou.

Hydraulic conductivities measured during the study were used to estimate the expected horizontal flow velocities. The data indicated flow velocities on the order of 10-6 cm/sec for flow through the spoil banks and 10-5 cm/sec for flow within the marsh proper. Clearly, on the time scale of our measurements (6 weeks) salt water will not be advected any appreciable distance into the marsh.

It appears, based upon this data set, that the major mechanism for salt transfer into the marsh is occasional overbank flooding with slow return flow. The water in the marsh is also strongly influenced by precipitation and evapotranspiration. The system is further complicated by the presence of multiple pathways. Variations in wind strength, direction, and spatial scale, as well as stream discharge, may generate small-scale water level gradients within the open water region of the coastal zone (bayous, bays, and canals). These are added to the larger scale predictable gradients associated with tidal forcing. These water level changes of small spatial scale potentially are able to interact with the topographic variations of the marsh surface and its boundaries to allow water to enter the marsh and flow through it by a variety of different paths. This means that the source of overbank flooding that drives an observed salinity signal within the marsh may be locally or far-field driven.

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Experimental Field and Greenhouse Verification of the Influence of Salinity Intrusion and Submergence on Marsh Deterioration

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Despite the popular notion that saltwater intrusion is a major factor causing wetland loss in the coastal zone of Louisiana, data supporting this hypothesis are not comprehensive and, to the best of our knowledge, have never been reported in the referenced literature. The gradual encroachment of saline water is thought to occur in Louisiana as the Mississippi River deltaic plain subsides and sea level rises (Morgan, 1977) and, indeed, vegetation maps indicate a northward movement of saline marsh types in some areas (Chabreck and Linscombe, 1982). If saltwater intrusion occurs, particularly into a fresh marsh, the vegetation would probably be negatively affected. However, the questions of how and to what extent increases in salinity would affect the vegetation of the various marsh types that occur in coastal Louisiana have not been adequately investigated. Although increases in salinity due to saltwater intrusion into fresh marshes could result in vegetative dieback, brackish and salt marshes contain plant species that are adapted to growth in saline water. In these cases, mechanisms other than saltwater intrusion, i.e., subsidence/increased submergence, and sediment and nutrient deprivation, must be considered as potential causes of the extensive dieback and deterioration observed in salt and brackish marshes in Louisiana.

The major goal of this study has been to investigate the effect of increased salinity on the dominant plant species in each of three major marsh types by the simulation of saltwater intrusion under field and greenhouse conditions. The effect of increased submergence or flooding on these same plant species was also determined exclusive of, and in conjunction with, salinity effects. The following null hypotheses were tested in this study:

1. Given that saltwater intrusion occurs in a marsh, the increase in salinity will not cause the death of the dominant plant species.
2. Given that subsidence occurs in a marsh, the increase in submergence or flooding will not cause the death of the dominant plant species.
3. The interaction of increased salinity and submergence in a marsh will not cause a greater reduction in live biomass than either factor alone.

Plant species from each of three major habitats were chosen for investigation: Spartina alterniflora--salt marsh, Spartina patens--brackish marsh, Panicum hemitomon, Sagittaria lancifolia, and Leersia oryzoides--fresh marsh.

The results of this study showed that the response of marsh vegetation to increases in salinity is influenced by a number of factors, including vegetation type; level, duration, and abruptness of exposure to salinity; and level of inundation. Both greenhouse and field investigations showed that S. alterniflora, the dominant salt marsh species was essentially unaffected by increases in salinity to levels present in Louisiana's coastal waters. This result was not surprising since numerous other studies have documented the vigorous growth of this species in Atlantic coast marshes where salinities often equal that of seawater (36 ppt) (Mendelssohn and Marcellus 1976). However, increased soil waterlogging brought about by a 10 cm decline in surface elevation significantly inhibited the growth of this species. These results indicate that the reduced vigor of S. alterniflora-dominated salt marshes in Louisiana may be primarily caused by factors associated with the chronic waterlogging characteristic of specific sites. Salt marshes are deteriorating because (a) subsidence has increased water levels above that which this species can tolerate and (b) there is an absence of another species that is more flood tolerant (but equally salt-tolerant) to replace it.

Spartina patens, a brackish marsh species, was not only sensitive to increased soil waterlogging, but was less tolerant of increases in salinity than S. alterniflora. The results of this study suggest that if the salinity in a S. patens-dominated marsh is increased above 21 ppt, (1) the aboveground biomass would be significantly reduced in a single growing season, and (2) the combined effect of increased water depth and salinity would have a greater potential for causing deterioration of a brackish marsh than either factor acting alone. However, S. patens was capable of adjusting to, and did survive, a salinity level of 28 ppt in the greenhouse when allowed to slowly acclimate (over a period of days) to the increase in salinity. Regrowth of S. patens at similar salinity levels was also observed in the field. The implication is that if S. patens could survive a change in salinity regime, there would be time for its gradual replacement by a more salt-tolerant species, i.e., S. alterniflora (assuming propagules are available).

Although plant species growing in fresh marsh habitats would be affected adversely by increases in salinity, the results of this study have shown that this response may vary depending upon the species. Broad-leaved species such as Sagittaria lancifolia may be relatively more sensitive to increases in salinity than grasses. Panicum hemitomon and Leersia oryzoides were able to survive and grow (although at a reduced rate) for one month at salinities of 8-11 ppt in the greenhouse. Even S. lancifolia survived salinity levels of 4-5 ppt. However, the three species did not survive a sudden increase in salinity to 15 ppt in the field. The denuded plots were quickly invaded by the annuals, Panicum dicotomiflorum and Pluchea camphorata, which were common in this area at this time of the year. Thus, marshes comprised of these species might be able to survive small increases in salinity for short periods of time, but would probably quickly succumb to sudden influxes of saltwater which increased salinities above 10 ppt. Again, if propagules of more salt tolerant species are present and able to establish, saltwater intrusion could result in a change in species composition, rather than complete deterioration. Although P. hemitomon was more sensitive to submergence in the field than the other two species, the relative flood tolerance of the three species could not be completely characterized based on the results of this study and requires further investigation. However, since flood tolerance among fresh marsh plant species can vary, the effect of subsidence and/or water level rise in this type of habitat would likely differ among marshes of different species composition.

In brackish, intermediate, and fresh marshes, deterioration will most likely occur in areas where the existing vegetation is rapidly eliminated, i.e., by an increase in salinity, water level, or other environmental change, and the marsh surface subsides or erodes to the point where recolonization is not possible. Recolonization by the original species or succession to more salt tolerant plant communities (in the case of a permanent change in salinity regime), however, may proceed in areas where propagule establishment can occur. The deterioration of salt marshes is most likely caused by subsidence. Any alteration in hydrology that increases either the duration or depth of flooding beyond normal limits will probably have a deleterious effect on the growth and survival of the dominant plant species in this habitat.

Since the vertical accretion of marshes is dependent upon the accumulation of organic matter produced by marsh macrophytes, any reduction in this source will slow the aggradation process. A sudden change in the environment that leads to a rapid reduction in biomass or even complete elimination of the emergent vegetation in a marsh would reduce the potential for the marsh accretion rate to keep pace with subsidence and/or sea level rise. The loss of below ground plant material, i.e., roots and rhizomes, that binds the sediment and provides stability would accelerate subsidence and break-up of the substrate. The rapid rate of subsidence in Louisiana's coastal zone (Baumann et al., 1984), in combination with the predicted sea level rise of 50 to 200 cm during the next 100 years (Titus, 1986), will lead to increased flooding stresses. The stresses associated with an increase in flooding depth and duration may ultimately result in the demise of emergent macrophytes in areas where vertical marsh accretion lags behind the increasing water level. Saltwater intrusion, whether natural or man-induced, may accelerate this process in fresh, intermediate, and brackish marshes.

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Inventory of Historical Sediment: Load Records of the Mississippi River

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The Mississippi River has provided the sediment discharge responsible for the construction of the active and inactive subdeltas that comprise the Deltaic Plain. The shifting of the deltaic lobes and the varying characteristics of the suspended and bedload portions of the sediment discharge are responsible for differences in the geomorphic forms and sedimentary environments associated with the plain. Bed load, which is composed largely of fine sand, provides much of the sediment that makes up channel, point-bar, levee, distributary mouth bar, crevasse splay, and coastal beach deposits. The fine silts and clays that comprise the suspended load are deposited seaward from the river mouth with some sediment being pushed inshore by marine currents and deposited in interdistributary troughs. During overbank flow that occurs above flood stage, suspended sediments are carried into adjacent marshlands and interdistributary basins. The amount of sediment introduced into coastal wetlands no longer appears sufficient to offset the land loss. The purpose of this study is to examine and analyze the historic evidence that can be used to discover what changes have taken place in the suspended and bedload regimes of the Lower Mississippi River during the last 100 years.

The history of sediment sampling up to 1931 is summarized in two papers published by the U.S. Waterways Experiment Station (USWES, 1930, 1931). Two surveys during this period provide measurements on a yearly basis. Humphreys and Abbot (1861) measured suspended load from 1851 to 1853 at New Orleans, and a survey by Major Quinn (1894) recorded suspended sediment load in South Pass from 1879 to 1893. From 1894 to 1950, no measurements of suspended load were conducted for an entire year at gaging stations from Cairo to the Gulf. Starting in 1950, the suspended load of the Lower Mississippi River below the Old River diversion was measured at Baton Rouge until 1958; at Red River landing from 1959 to 1963; and at Tarbert Landing from 1963 to present. These represent the longest continuous records of suspended load measurements available for a major gaging station on the lower River. The only other suspended sediment record available on an annual basis for a Mississippi River gaging station below the Old River diversion is near New Orleans at Belle Chasse where the U.S. Geological Survey has taken measurements once a month since 1977. The study has expanded the suspended sediment database for the lower River with the acquisition of unofficial measurements taken by the

New Orleans Sewage and Water Board. The measurements have been taken weekly since 1930 and represent the longest continuous record available for the lower River.

There are no direct estimates of bed load volumes transported by the River because of difficulties with measurement. Reviews of bedload studies conducted in 1932/34 and after 1965 are included in the reports by Robbins (1977) and Keown et al. (1981). These studies have been the basis for comparative studies of size, shape, and mineralogy characteristics of the bed sediments. Some indication of changes in the bed load regime were calculated in this study indirectly using historical hydrographic survey maps available in about 20-year intervals from 1880 to 1975. These maps were used to determine changes in sediment stored on point bars and the elevation of the channel floor.

The data compiled above indicate that the suspended load transported by the Mississippi River to the Gulf has decreased since 1900 by approximately 70 percent. Much of this decrease appears to coincide with dam closures on the Missouri and Arkansas rivers. The present volume of sediment that is available for unconfined overbank flow into areas adjacent to the River, if not restricted by artificial levees, represents approximately 3 percent of the total annual suspended load. Since 1950, this would have amounted to 163 x 10^6 tons of sediment. The volume of sediment available during flood stage by confined flows through crevasses may almost equal the quantity available by unconfined overbank. During the 1973 flood, the sediment volume passing through the Bonnet Carre spillway was 90 percent of that available by unconfined overbank flow.

Changes in the quantity of bed load transported by the river are difficult to establish. There has been a decided shift in the volume of bed-sediment storage from point bars to the channel floor, and this shift may allow this material to be more readily transported. One suspects that the major decrease in suspended sediment load would also be reflected by a similar decrease in bed material. Whatever changes have occurred in the upper section of the River, thalweg elevation data indicate that bed sediments have been accumulating in the lower section of the River below Old River diversion and New Orleans. This has resulted in aggradation of the thalweg of over 1.8 m/km of channel since 1880. Only minor aggradation is evident below New Orleans. Thus, the sediment accumulation above New Orleans appears to represent a wedge of sediment that is migrating or will migrate downstream to the delta possibly without any tendency for sediment storage in this lower segment.

Grain size data indicate that there has been a finding of sediments within both the suspended and bedload fractions of the lower River. The loss of this coarse material may play an important role in maintaining subaerial land surrounding the delta front.

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Sea Level and Long-Term Subsidence Rates

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The general purpose of this work was to estimate changes in the absolute land and sea levels in coastal Louisiana during the past 50 years. The approach taken to answer the question was based upon a combination of data acquisition, data analysis, and modeling. Additional data were acquired concerning marsh elevations near spoil banks. The primary database of the study, i.e., tide gauge record and bench mark re-surveys, was already fixed. But there are problems with using historic data. The data sets were incomplete, and the documentation of the data sets was incomplete. Also, previous analysis of much of the data indicated that interpretation of the data was not straightforward; i.e., relative sea level changes resulted from the influence of several physical processes. In order to overcome the limitations of the existing data base, theoretical models were used (in some cases developed) to extend the knowledge of events or processes into areas not measured.

SEA LEVEL

Data on sea level changes, as measured by coastal tide gauges, were examined in order to separate eustatic sea level rise (absolute sea level rise) from subsidence. The data consisted of tide gauge records taken at a number of locations along the coast of the northern Gulf of Mexico by the National Ocean Survey and the Corps of Engineers (COE). The data result from water level readings that were taken either every hour or once each day. The readings were averaged into mean monthly values of sea level, which is the form in which the data were used in this study. The tide gauge readings were analyzed for the effects of fresh water run-off. The reason for considering the effects of fresh water run-off on tide gauge readings is that most of these gauges are located within the coastal marsh complex and are only partially affected by sea levels. Also, records of tide gauge elevations that were corrected for eustatic sea level rise (sea level rise was subtracted from the records) showed curious apparent rises in land elevation (negative subsidence) for many periods in the record. Thus, the monthly tide gauge records were examined in detail as a component of the data analysis.

The first step in analyzing the water level data was to determine the eustatic sea level changes for the period of interest. This information was derived from two sources. In a recent paper (Barnett, 1984), sea level data for several stations in the Gulf of Mexico were analyzed and a "coherent" sea level variation for the Gulf and North Atlantic were presented. The data shows that, Gulf wide, sea level is rising at a rate of about 2.3 mm/yr when averaged over the whole record. There is little change in the underlying rate of rise, although there are periods of several years for which the rate accelerates (e.g., 1960s) and for which the rate is negative. The data set analyzed by Barnett (1984) did not include any tide stations in Louisiana. To provide a second reference for eustatic sea level variations, the tide gauge record shows more year-to-year variation than the Gulf data. Because the Pensacola record is very close to Louisiana and might reflect Gulf water mass and weather influences on sea level, Pensacola was used as the reference station that defines eustatic sea level.

The next step in the analysis was to determine the degree to which fresh-water run-off might be affecting a tide gauge record in Louisiana. The tide gauge readings were adjusted to account for river discharge. The stage-discharge curves for the Calcasieu, Mermentau, and Atchafalaya Rivers, and Bayou Lafourche were obtained. The discharge of the waterway on which the gauge was located was plotted for each year versus the annual average water level. The average water level for each of several ranges in discharge was computed. This exercise resulted in an average stage-discharge value for the location. For example, at the Cameron tide gauge, a change in water level of .1 feet occurred for an increase in discharge in the Calcasieu River of 100 cfs. With this average stage-discharge value for each location, a second adjustment could be made to the tide gauge records.

The subsidence rates for each location are for Cameron--6.1 mm/yr; Hackberry--4.5 mm/yr; Morgan City--8.5 mm/yr; Eugene Island--9.4 mm/yr; and Grand Isle--7.0 mm/yr.

BENCH MARK DATA

Several re-surveys of bench marks in Louisiana have been made by the National Geodetic Survey. These surveys allow another means for determining the subsidence in coastal Louisiana. The surveys provided by NGS included one line from Beaumont, Texas, to New Orleans and a line from Raceland to Grand Isle. The subsidence rate on the Chenier plain was about 3 mm/yr since 1955 and a value of about 6 mm/yr on the Lafourche delta. The line from Raceland to Grand Isle shows an increasing rate from 0 mm/yr at Raceland to 8.8 mm/yr at Grand Isle.

SUBSIDENCE OVER OIL FIELDS

The effect of the withdrawal of fluids from petroleum reservoirs on subsidence was determined using a prediction model and oil/gas production data. The fluids withdrawn from reservoirs includes crude oil, condensate, casinghead gas, natural gas, and water.

The first approach was based upon applying a model developed to estimate reservoir compaction. The model (Geertsma, 1973; Martin and Serdengecti, 1984) is based upon assuming a uniform reservoir having a bulk compressibility, Cm, that undergoes a reservoir pressure change of dP. The maximum compaction is given as

Cr = Cm dP H

where H is the thickness of the reservoir. For a disc-shaped reservoir, the profile of the surface subsidence above the reservoir can be computed. Data were acquired from the Louisiana Department of Conservation, Summary of Field Statistics for 1973. The report contained a listing of the depth to the top of the producing formation, and the areas and thicknesses of oil and gas components of each field in Louisiana. From these data, fields were selected for which the reservoir was less than 1,000 m (3,000 ft) subsurface. The total area of the 32 fields studied is 620,000,000 m2 (166,490 acres) or about 620 square km.

A value of Cm of 10^6 (1/kPa) was used for the one-dimensional compressibility in the calculations of subsidence. This value is given by Martin and Serdengecti (1984) for unconsolidated sandstone at a depth of 1,000 m and is conservative by perhaps a factor of 2. Poisson's ratio was assumed to be 0.3.

In order to compute the subsidence, data were needed concerning the pressure drops for each field. These data were not readily available; certainly they were not available for each field or well in each field. Pressure data were available for a few wells in a few fields. For example, a well in the Leeville oil fields, at a depth of 882 m (2,894 ft), changed from 1,190 kPa (595 psi) in January of 1984 to 210 kPa (105 psi) in January of 1986. A second well in the Leeville field, at a depth of 767 m (2,516 ft), changed in pressure from 1,400 kPa (700 psi) in May of 1984 to 300 kPa (150 psi) in January of 1985. Because pressure data were not available for each field, a pressure drop of 1,000 kPa was used in the subsidence calculation for each field. This value is 1/20th of the value used in Martin and Serdengecti (1984) for maximum reservoir pressure drops in Louisiana. It is about twice the pressure change that was recorded for the above mentioned wells over just a few years.

The largest subsidence potential is estimated for Lake Washington Field at 86.1 cm. There are 19 fields with a subsidence potential greater than 10 cm, considered to be a cut-off value for the model being used. These results should be conservative, since pressure drops larger than assumed in the calculation have been recorded.

Because field specific data were not available for each site, a second approach to determining subsidence was to consider the field production. Data were acquired from the Annual Oil and Gas Report of the Department of Conservation, State of Louisiana concerning production figures for 1954, 1965, and 1984. The data for the largest fields, Bay St. Elaine, Leeville, Lake Pelto, and Golden Meadow were analyzed. The data include the total production of 4 reservoir fluids and does not include water removed. Water removal was found to vary from 10 to as much as 15 times the crude oil removed. The compaction of the oil reservoirs that occurs because a volume of fluid has been removed from the reservoir per unit area would give an estimate of the surface subsidence, assuming the surface moves downward to replace the volume removed. The volume of crude oil only per unit area for the above mentioned fields subsidence was 130 cm, Leeville 91 cm, Bay St. Elaine 89 cm, and Golden Meadow 59 cm. These values do not include the effects of withdrawal of gas or formation water, nor do they reflect seepage or pumping of water into the formation.

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Marsh Sediment Accretion Rates in Vicinity of Manmade Canals and Natural Waterways

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PROJECT HISTORY

Most of the 50 square miles of Louisiana's coastal wetlands that disappeared annually between 1955 and 1978 was caused by the deterioration of interior wetlands (i.e., that portion of the marsh beyond the edge of natural streams). The rate of submergence of these wetland areas is directly linked to the ability of land building processes (organic matter and mineral matter accumulation) to keep pace with the present rate of water level rise (i.e., eustatic sea level rise plus land subsidence). Recent investigations have suggested that deteriorating interior marshes are experiencing an accretion deficit (i.e., sea level is rising faster than the marsh surface is aggrading). It has been suggested that canals may contribute to the aggradation deficit by altering local hydrology and thus affecting the accumulation of organic and mineral matter.

The purpose of this 2-year study was to evaluate canal impacts on sediment accumulation and vertical accretion in Louisiana's coastal marshes. Interpretation of these results was coordinated with those of other investigators studying changes in sea level along the Louisiana coast during this century (Drs. Suhayda and

Turner) and the influence of historic changes in Mississippi River sediment supply to the coastal region (Dr. Kesel).

Rates of sediment accumulation and vertical accretion were measured in back marsh areas, behind OCS pipeline canal spoil banks, oil and gas access canal spoil banks, and natural streambanks. Both recent and long-term accretion rates were analyzed by three techniques. Recent accretion rates ($\leq$ 1 year) were evaluated by two marker techniques, using inert clay and inert rare-earth stable isotopes. The method using clay is best-suited for salt and brackish marshes, and the chemical isotope method is best-suited for fresh marshes. Long-term vertical accretion rates were determined by ^{137}Cs and ^{210}Pb analysis of soil cores, which provide a 25-year and 80-100-year integrated annual accretion estimate, respectively. When feasible, all three techniques were used simultaneously at a site.

The field work was designed to compare sedimentation rates behind canal spoil banks to rates behind natural streambank levees. To do this, sediment markers were placed in the marsh 50 m behind the natural or man-made levee. Whenever feasible, small wooden platforms were constructed (with appropriate controls) to minimize disturbances to the marsh surface during marking and subsequent collecting. Also, the influence of canals on sediment distribution and vertical accretion across the marsh was investigated at selected sites by sampling every 10 m section along a 50-100 m transect, beginning immediately behind the natural or man-made levee. Sedimentation rates were analyzed in impacted salt, brackish, and fresh marshes along the coast, which sites included both the Mississippi River Deltaic and Chenier Plains.

The results of the field investigations were interpreted for the purpose of answering the following questions:

1. Do human-made canals influence the distribution of sediment across the marsh surface?
2. To what extent does continuity of the spoil banks influence vertical accretion rates?
3. What is the relative importance of mineral and organic matter accumulation to the land-building process, and what influence do canals have on this ratio?

ACCOMPLISHMENTS

An 18-month field effort was organized and implemented in order to evaluate canal impacts on marsh vertical accretion and accumulation of mineral and organic matter (by use of the three techniques described above). The rates of vertical accretion and accumulation of mineral and organic matter were measured along twelve, eleven, and six waterways in Lafourche, Terrebonne, and Cameron Parishes, respectively, representing saline, fresh, and brackish marsh environments. Within these regions, a total 112 clay and 51 stable isotope plots were marked and sampled semi-annually for one year to estimate recent ($\leq$ 1 year) accretion and accumulation rates, and also, 22 radioactive isotope plots were cored (44 acres in total) to estimate historic accretion and accumulation (25-100 years). A unique feature of this study is that both recent and longer-term accretion rates were measured simultaneously at the same marsh locations. A summary of the comparisons tested, indicated by marsh type and dating technique, is presented in Table 6.2.

SIGNIFICANT FINDINGS

The results of the three accretion dating studies have been combined in an effort to answer the three questions identified earlier. A summary of the influence of canals on sedimentation processes is presented in Table 6.3. Caution should be used when applying these results beyond the sites investigated because of the small sample sizes employed and the large variances encountered in the data.

1. Do man-made canals influence the distribution of sediment across the marsh surface?

Sometimes, but not always. Evaluation of 1-, 25-, and 80 to 100-year sedimentation events (vertical accretion and densities of mineral matter and organic matter) at selected sites along the coast revealed that the influence of canals on sedimentation across the marsh surface depended on the local environmental setting.

Analysis of the influence of natural streamside and canal spoil bank levees (Comparisons 1 and 2, Table 6.3) on sedimentation processes in the three locales revealed that mean rates of 50 m behind canals were, in most cases, lower, but because of large variances and small sample sizes rarely statistically significantly different from rates behind natural waterways. A major exception to this was found at the distance analysis sites in the Lafourche Parish salt marsh (Comparison 4, Table 6.3). Long canals bisecting the region on an east-west plane (i.e., perpendicular to the basin hydrologic gradient) appear to have an important impact on sediment deposition (OCS pipeline transect site) and marsh surface stability (as related to coring success north and south of Southwestern Louisiana Canal). Consequently, the alignment of the pipeline canal and navigation channel in the Lafourche Parish salt marsh may influence the sediment exchange along a portion of the hydrologic gradient of the lower Barataria estuary.

There was no effect of distance on vertical accretion and density of mineral and organic matter at either the bayou or canal sites in the salt, brackish, and fresh marsh. The natural site in the fresh marsh, however, exhibited the typical "edge effect" by having significantly higher bulk densities at the streamside plots. The edge effect was not apparent at the pipeline site.

2. To what extent does continuity of the spoil banks influence sediment accretion rates?

The canal spoil levees were higher than the natural streamside levees as evidenced by the presence of upland (mesic) vegetation on the spoil levees. The influence of natural versus canal spoil levee on sediment distribution in the back marsh is discussed above.

Continuity of the spoil bank had no apparent influence on sediment deposit in the saline marsh at Lafourche Parish (Comparison 3, Table 6.3, 0.60 and 0.66 cm yr^{-1}, discontinuous and continuous, respectively).

3. What is the relative importance of mineral and organic matter accumulation to the land building process, and what influence do canals have on this ratio?

Organic matter accumulation rates (0.02 and 0.05 g cm^{-2} yr^{-1}) estimated from recent and 25 to 100-year cores were essentially the same for the canal and bayou sites studied.

Mineral sediment deposition varied, depending on marsh site and presence of any streamside effect, and equalled or exceeded organic matter accumulation at most sites. Mineral sediment constitutes an increasing fraction of marsh solids nearer the coast where there is greater tidal exchange.

COMPARISON OF DATING TECHNIQUES

Vertical accretion rates obtained by recent ($\leq$ 1 yr, clay marker and stable isotope), 25 yr (137Cs), and 100 yr (210Pb) dating techniques were similar. The chemical marker method can be used under water and was proven to work in fresh marsh systems. Accretion rates obtained from 210 Pb techniques were, in all cases, less than 137Cs, suggesting either oxidation and compaction of peats or more rapid accretion in recent years. The coherence between techniques indicates that an evaluation of recent impacts to sedimentation processes is possible through the concurrent use of recent ($\leq$ 1 yr) and long-term (25 to 100 yr) sedimentation techniques. For example, comparison of recent with 25 to 100 yr sedimentation rates at the same site can be used to evaluate the impact on sedimentation processes of management efforts implemented during the interim.

RECOMMENDATIONS

1. We strongly recommend the experimental approach used in this study--a coordinated field effort using different techniques with overlapping applications. This provides a broad experimental base for data interpretation and reinforces the value of the data analysis.
2. Because one marsh has a greater accretion rate than another does not mean necessarily that it is keeping pace with water level rise. Water level rise varies locally across the marsh surface depending on marsh surface topography, hydrologic changes, and climatic conditions. Therefore, the effects of alterations on water level should be quantified in order to compare vertical accretion to local water level variations in the study areas.
3. Some of the brackish marshes east of Lake Calcasieu (natural and canal alike) are apparently not receiving an adequate supply of mineral sediment. Management efforts designed to increase the mineral sediment supply to these regions should be implemented.
4. We recommend that investigations of vertical accretion be done to evaluate the impact of other man-made alterations of the coast, such as impoundments, storm protection levees, or river diversions.

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Results of Landloss Study Based on High Resolution Digital Habitat Data

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As part of the overall MMS study on land loss, three areas in coastal Louisiana were analyzed using a geographic information system (GIS), composed of high resolution (10 m x 10 m) digital imagery. Our goals were to (1) develop a methodology for studying landscape level processes; (2) determine the spatial patter of land loss in coastal Louisiana; and (3) assess the relative importance of natural versus cultural processes as causes of land loss. The methodology was to use the GIS to define areas of land loss for three study areas; to compare land loss rates by site, habitat type, and change in salinity; and to determine whether specific spatial features, e.g., canals, affected land loss rates. Descriptions of the three study areas and initial findings were presented in Leibowitz et al. (1987). A complete discussion of the methods and project results is given in Leibowitz and Hill (1987). A summary of these findings follows:

1. Rates of land loss were consistent with the geology of the site. The lowest rate of loss was at the Terrebonne site (14 percent), which currently contains an active sediment source (the Atchafalaya River). The Lafourche site, which is bordered by a recently abandoned distributary (Bayou Lafourche), has the highest rate (21 percent). The Cameron site, in the Chenier Plain, had an intermediate loss rate (17 percent).
2. Marsh habitats accounted for most land loss at all three study areas. Loss of marsh (both fresh and saline) accounted for 85-95 percent of all land loss. Each of the other habitat types contributed less than 5 percent of the loss at a site (except for agriculture at Lafourche, which accounted for 8 percent of the loss there).
3. The major form of land loss is within the marsh interior, and not shoreline loss. Conversion

of land to inland open water accounted for 70-93 percent of all loss. Loss of shoreline (coastal erosion) contributed less than five percent at all three sites. Direct loss from canal construction was low at Cameron (3 percent), but more significant at Terrebonne and Lafourche (14-15 percent).

4. Saltwater intrusion is not thought to be the major cause of land loss at the Terrebonne site, although this could not be ruled out for the Cameron and Lafourche sites. At Cameron and Lafourche, loss was significantly higher in areas of increasing or high salinity than in the areas of low or decreasing salinity (salinity changes were determined from 1956 and 1978 freshwater/saltwater vegetation boundaries). Therefore, land loss was correlated with saltwater intrusion. Thus, it was not possible to disprove this as a causative factor for these two sites. At the Terrebonne site, however, land loss was highest in areas that remained fresh for the 22-year duration, with no significant difference between this category and the areas of increasing or high salinity. Further, these loss rates were all significantly lower than the values for these same categories at Cameron and Lafourche. Therefore, it is concluded that saltwater intrusion is not the major cause of land loss at the Terrebonne site.
5. Land Loss at the Terrebonne site may be the result of a recent process. For the Cameron and Lafourche sites, a large portion of loss is located adjacent to inland open water. Since land loss prior to 1956 would be classified as inland open water, this may represent the expansion of pre-existing land loss areas. At Terrebonne, however, this was not observed, indicating that loss at this site may have only recently been initiated.
6. Nearness to a major sediment source reduces land loss. Plots of cumulative loss versus distance to major channel (Lake Calcascieu/Calcascieu Ship Channel, the Atchafalaya River, and Bayou Lafourche for the Cameron, Terrebonne, and Lafourche study sites, respectively) show that most loss occurs at distances far from these features (Figure 6.9). For an active sediment source such as the Atchafalaya River, loss rates were greatly reduced to a distance of 12 km.
7. A large proportion of the land loss at the three study sites occurs in areas with canal densities near zero. Cumulative curves of percent land loss indicate that 40-80 percent of all loss occurred in areas with nearly zero canal and spoil density (Figure 6.10). Canal and spoil appear to cause the most damage when they are added to areas of solid marsh.
8. Land loss is not a uniform, heterogeneous process; rather, "hot spots" of high loss have been found (Figure 6.11). A statistical model that included site, habitat type, salinity change, distance to coastal shoreline, and the site interactions had an r-square of 0.24; thus, 75 percent of the variation in land loss was not accounted for. The outliers, however, were spatially clumped, and were associated with areas of high loss. These hot spots account for 43 percent of the land loss, although they represent only 12

percent of the study area. Including the hot spots in the statistical model raised the r-square to 0.75. The cause of these hot spots could not be determined.

In a complex landscape such as the Louisiana coast, multiple effects can occur, and causative factors may not be obvious. It is, therefore, extremely important that environmental assumptions be subjected to statistical testing. For example, it has long been assumed that oil and gas canals could cause land loss by introducing saline water into freshwater regions, consequently killing the vegetation. Evidence suggests that this is not so, however, at least for the Terrebonne site. Managing this area for saltwater intrusion (e.g., constructing impoundments or emplacing weirs) could actually exacerbate land loss by reducing sediment input. By combining a GIS with spatial statistics, the analyst can test assumptions such as this before a plan is implemented. This should lead to more effective environmental management.

Leibowitz, S.G., and J.M. Hill. 1987. Spatial analysis of Louisiana coastal land loss. Chapter 20 in "Causes of Wetland Loss in Coastal Central Gulf of Mexico," R.E.Turner and D.R. Cahoon, eds. Final Report to Minerals Management Service (in press).

Leibowitz, S.G., J.M. Hill, and E.E. Parton. 1987. Computerized analysis of spatial trends in wetlands loss in Louisiana. In"Proceedings Seventh Annual Gulf of Mexico Information Transfer Meeting," OCS Study MMS 87-0058, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, La. Pp 48-50.

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Modeling Wetland Loss in Coastal Louisiana: Geology, Geography, and Human Modifications

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and
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Center for Wetland Resources

PROJECT HISTORY

Louisiana's coastal wetland loss rate(> 100 km^2 yr^{-1}; 0.8 percent of total annually) is a chronic state problem; causes for these losses are complex but have been attributed to both natural and man-induced factors. We report here our use of a Louisiana coastal habitat mapping study to quantitatively relate land loss (primarily in the form of coastal marshes) to factors believed to influence (i.e., cause) habitat change. Natural factors include coastal morphology and sediment input and age, compaction, and subsidence; man-induced factors are related to development in the coastal zone—e.g., canal dredging, agriculture, and urbanization. Wetland loss is defined as the difference between marsh area in 1955/56 and 1978. We chose variables to represent both natural and man-induced factors.

ACCOMPLISHMENTS

The percent of marsh loss in a map unit (7.5 min quadrangle) was modeled as a function of the area of agriculture and urban development in 1978, the area of canals and spoil in 1978, the estimated age of sediments underlying the coastal marshes, the depth of sediments that overly the down-warped Pleistocene terrace, and the linear distance to the Louisiana coast. Principal components analysis (PCA) was used to test for multicolinearity among variables (dependent and predictive) and to determine if they accounted for a significant portion of the variability in the original data. Variables identified as significant in the PCA were employed in a general linear procedure to quantitatively model their relationship to the percent of marsh lost in a quadrangle map unit between 1955/56 and 1978. As a final examination, the quadrangle map units were clustered to determine areas of similar landloss rate and its apparent causes.

SIGNIFICANT FINDINGS

Interpretation of the combined results from the three quantitative analyses (PCA, multiple regression,, and cluster analysis) suggests the following conclusions:

1. The complex and regional differences in land loss rates reflect variations in geology and the delta cycles, man-induced changes in hydrology (principally canal dredging and spoil banking), and land-use changes (principally urbanization and agricultural expansion). Interpretation of the results of principal components and regression analyses suggests that the most important factors (determined here as the predictive variables representing canal density, development, and sediment age) that are correlated with changes in land loss rates in the Louisiana coastal zone vary, depending on location and geologic history, and due to the fact that the coastal zone is not homogeneous with respect to causal factors or their magnitude. These analyses also indicate that each of the causal factors represented by variables included in this study probably contributes to land loss in the whole coastal zone to some degree. However, the data also indicate that the interaction between these factors is locally variable and complex.
2. The relationship between land loss, hydrologic changes, and geology can be described with statistical-meaningful results, even though these data are insufficient to precisely quantify the relationship. However, these data support the hypothesis that the indirect impacts of man-induced changes (hydrologic and land use) may be as influential as the direct impacts of converting wetlands to open water(canals) or modified (impounded) habitat. For example, the mean land loss in all quadrangles used in this analysis was 23.5 percent. By interpolating with the regression coefficients obtained from this analysis, a

50 percent reduction in canal density would result in a nearly 10 percent decrease in land loss (mean = 21.5 percent), while the direct impacts of canal and spoil account for only 8.0 percent (~23,000 of 288,414 ha) of the marsh loss. At zero canal density, land loss is reduced by 10.3 percent. If the direct impacts of canal, spoil, and development are eliminated by interpolation, marsh loss is reduced by nearly 20 percent while their direct impacts account for only 15 percent of that loss. These back-calculations are based on interpolation, however, and care must be exercised during interpretation of results.

3. Three regions within the Louisiana coastal zone can be defined by using cluster analysis, based on the potential causal factors first used in the linear regression model (Figure 6.12). The moderate (mean = 22 percent) wetland loss rates in region 1 (cluster 1) are a result of relatively high canal density and developed area in marshes which overly sediments of moderate age and depth; local geology acts, in this case, to lessen indirect impact. On the other hand, land loss rates in region 2 are high (mean = 36 percent) despite fewer man-induced impacts; the potential for increased land loss due to both direct and indirect effects of man's activity in these areas is high. Conversely, land loss (mean = 20 percent) in region 3 is apparently least influenced by man's activity in the coastal zone because of sedimentary geology (old, thin sediments), even though these areas have experienced significant habitat alterations and direct land loss.

Dr. James H. Cowan, Jr. is a Research Associate at the Coastal Ecology Institute, Center for Wetland Resources, Louisiana State University. He has developed a model to quantitatively relate wetland loss to some factors believed to influence land loss rates in the Louisiana coastal zone. His interests include resource management, fisheries ecology, and recruitment dynamics. Dr. Cowan received his Ph.D. from LSU in 1985.

Dr. R. Eugene Turner is a Professor of Marine Sciences in the Center for Wetland Resources, Louisiana State University. He is Program Manager for the MMS contract on habitat modification in the coastal zone. His interests include wetland management, mitigation and restoration, biological oceanography, and fisheries ecology. Dr. Turner received his Ph.D. from the University of Georgia.

Aerial Imagery Interpretation of Relationship between Canal Area and Number of New Ponds

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We examined the relationship between canal area and the number of new ponds of different sizes (formed in wetlands) for four different map groupings: maps in the Chenier Plain, the St. Bernard delta, the Barataria and Terrebonne hydrologic units, and those maps containing the Mississippi River Gulf Outlet. The four areas together includes 38 percent of the Louisiana coastal zone.

At least five qualitative types of wetland changes were evident in these maps: 1) spoilbank-parallels hole formation, 2) pond formation with apparent random distribution, 3) semi- or complete impoundment and resulting open water formation, 4) cutting off of stream channels upstream of where a spoilbank crosses a natural channel, and 5) erosion at the land-water interface. Only ponds <20 ha appear to form and disappear. This might be considered to be due to mapping errors; however, the large number j(10 percent of the total), a different distribution of the transient ones compared to the new ponds, and mapping of smaller features argue against accepting such biases as meaningful complications in the analysis.

New small holes are more numerous than persistent and transient water bodies of the same size. New area and number of small holes are directly related to the area and number of larger holes; if new small ponds form, it is likely that the less numerous larger ponds will also form. These patterns are consistent with the conclusion that the marsh is literally breaking up internally, rather than eroding at the edge. The relationship between small and larger pond number is less clear as pond size increases. This situation probably reflects, in part, the smaller number of the larger ponds, hence the smaller statistical base to work with. But, it also may reflect the regional (outside the quadrangle map) influence of geologic influences, canal and spoil banks, as well as agricultural impoundments, urbanization, navigation channels, and local sediment sources. These relationships complicate interpretation of wetland changes at the landscape level and an analysis of the spatial, and temporal distribution of the small new ponds is probably more useful than an analysis of the few larger ponds. An analysis of areas of particularly high or low wetland loss was also useful to understand regional differences or anomalous conditions (e.g., in the Cutoff quadrangle map).

Given the relationships between net areal change for ponds <20 ha, ponds <60 ha, and all other pond sizes, we conclude that analyzing the pond number and area for net change in ponds <20 ha and <60 ha, respectively, is indicative of the wetland losses in that map. This is a generalization, and local exceptions were revealed. Other, more useful combinations, were also found to warrant further analyses.

Canals and their spoil banks are directly related to wetland water conversion and it is evident about 2 kms away from those canals. This is clear from distance versus frequency plots for two different pond sizes, by visual examination of the many maps of pond formation, and relationship between pond formation and canal density whose intercept is near zero and whose slope is unique.

New ponds between 0-20 ha tend to be no more numerous next to the 1955/6 canals than to 1978 canals, when compared on a number per surface area basis. We cannot yet explain this, but it is apparent that whatever effect the canal and spoil bank have on wetland loss, that for these maps it does to clearly diminish or gain influence with age, to date.

The implication of these relationships is that there is either a common factor relating canal area to the net change inland to open water or that the relationship is spurious. We assume it is not the latter because of the high number of data points (>7,800 new ponds; 72 maps), a good areal coverage, and known mechanisms to explain the apparent coupling.

We suggest, therefore, that these results support the hypothesis that the hydrologic impacts of canals and spoil banks affect wetland to water conversion on the scale of kms, and are directly related (as a causal agent) to the majority of wetland losses in the study area, and their impacts vary regionally, e.g., with sediment compaction rates that increase with increasing sediment deposition layering. Local influences complicate the interpretation, and not all areas are equal. This is a regional study, not a local study, so the results apply only on a broad scale. This study area includes major sections of all the regional groupings described by Cowan and Turner (this report) and does not differ substantially from the general results of that modelling study, in that regional differences are the same influences of geological substrate and demonstrated influences on the overall regional wetland loss rates.

Dr. R. Eugene Turner is a Professor of Marine Sciences in the Center for Wetland Resources, Louisiana State University. He is Program Manager for the MMS contract on habitat modification in the coastal zone. His interests include wetland management, mitigation and restoration, biological oceanography and fisheries ecology. Dr. Turner received his Ph.D. from the University of Georgia.

Studies of Impacts of OCS Activities on Sensitive Coastal Habitats (Barrier Beaches and Non-Louisiana Wetlands)

Dr. Karen M. Wicker
Coastal Environments, Inc.
and
Dr. Donald F. Boesch
Louisiana Universities
Marine Consortium

The objectives of this study are (1) to determine the impacts of federal OCS pipelines, facilities, and navigation channels on barrier islands, beaches and wetlands (except wetlands in Louisiana) along the Gulf Coast from Cameron County, Texas, to Bay County, Florida, (2) to study the impact of the discharge of OCS-produced water in coastal areas and (3) to predict the impact of future OCS activities in this study region. The study of past and prediction of future impacts of OCS pipelines, facilities, and navigation channels is being undertaken as one task by Coastal Environments, Inc. The OCS-produced water research is being conducted by Dr. Donald F. Boesch of the Louisiana Universities Marine Consortium and Dr. Edward Overton of the Institute for Environmental Studies at Louisiana State University.

The first task involved the identification of Federal OCS pipelines, facilities, and navigation channels and the characterization of these features, where appropriate, in terms of owner/operator, location, size, date, and method of construction, line content, and maintenance and mitigation measures. Environmental parameters (i.e., hydrologic, climatic, botanical, geologic, and cultural) that would affect, or that could be affected by, these features were also characterized for each of the major ecological systems (i.e., Texas

Barrier Island, Strand Plain-Chenier Plain, Mississippi Deltaic Plain, and North Central Gulf Coast). These data were tabulated and mapped at a scale of 1:250,000.

Pipeline emplacement techniques have been researched in general and for specific OCS pipelines. All OCS pipelines facilities and channels have been located on large-scale maps and are being viewed on historical aerial photographs to identify temporal and spatial changes that occur in the vicinity of these features. Field studies were conducted at two navigation channels and at two or three pipeline locations in each of the four ecological regions.

It is anticipated that a synthesis of field data and historical photograph analysis will permit a summation of impacts that have resulted for any given set of conditions, involving pipeline construction techniques, environmental forms and processes, and other human activity in the vicinity of pipelines.

To predict impacts of future pipelines, facilities and navigation channels, the above mentioned summations of impacts will be extrapolated to areas where OCS features are not presently located, i.e., north central Gulf Coast. Predicted impacts will also be discussed in terms of existing regulations governing the emplacement of these features in each of the five states within the study area.

The second task concentrates on an evaluation of the impact of OCS-produced water discharged into coastal areas. Produced waters are waters from deep geologic formations that are brought to the surface during oil and gas recovery. After separation of oil, water and gas, the produced waters are either reinjected in deep wells or, as is typical for production in the OCS and coastal zones of the northwestern Gulf of Mexico, discharged into surface waters. Because it is more efficient to effect separation of larger volumes commingled from several wells, some produced waters generated during OCS production are actually discharged into nearshore and estuarine waters from shore-based separation facilities. This constitutes a potential, and heretofore unstudied, onshore impact of OCS oil and gas development. Because of the lack of information on this potential impact, an element of the study on impacts on sensitive coastal habitats is being devoted to a preliminary assessment of impacts of the coastal disposal of produced waters generated from OCS production.

Produced waters generally have total concentrations of dissolved ions two to three times higher than seawater, substantially higher concentrations of certain metals (Ba, Be, Cd, Cr, Cu, Fe, Pb, Ni, Ag, and Zn), and high concentrations of sulfides or elemental sulfur. In addition, because the produced waters come in close contact with petroleum, they contain dissolved and dispersed petroleum hydrocarbons and more soluble organic degradation products of hydrocarbons (e.g., organic acids and phenols). Dissolved hydrocarbons are mainly the more soluble low molecular weight aromatics (e.g., benzene and toluene) and alkanes. These compounds have high relative toxicity to marine organisms, but they are volatile and not expected to persist in the environment.

Based on preliminary analysis of data from the U.S. Environmental Protection Agency, the Texas Railway Commission, and the Louisiana Department of Environmental Quality, an estimated 3.6 million barrels per day of produced waters are discharged into the coastal and offshore waters of the northwestern Gulf of Mexico.

Of this, approximately 0.8 million bbl/day are discharged into Texas coastal and territorial sea waters, 1.8 million bbl/day into Louisiana coastal and territorial sea waters, and 1 million bbl/day into OCS waters. Approximately 0.4 million bbl/day of the amount discharged in Louisiana waters are from the OCS; the amounts for Texas are negligible.

Of the over 600 identified discharges into Louisiana waters, most are in the southeastern Louisiana and considerable volumes are discharged into fresh or brackish marsh environments where there are current controversies concerning the effects of the briny discharges on salt-intolerant wetlands. At least 17 facilities handle OCS produced waters, and most of the discharge comes from a few large volume facilities (20,000 to over 100,000 bbl/day) in the Mississippi River Delta, Grand Isle, Port Fourchon, and East Timbalier Island regions.

Field investigations of the fate and effects of these OCS-related produced water discharges are being conducted at Grand Isle, Pass Fourchon, and East Timbalier Island. These preliminary studies include sampling and analysis of hydrocarbons and trace metals in sediments, organisms, and benthic organisms in the water bodies and wetlands in the vicinity of the discharges.

Analysis of produced water effluent at two facilities on Grand Isle showed that the longer residence time and passage through an open holding pond in the smaller of the facilities resulted in lower concentrations of volatile and medium weight hydrocarbons in the effluent. Benzene concentrations were, for example, 1,700 ng/ml versus 2,900 ng/ml.

Highest concentrations of petroleum hydrocarbons in fine-grained bottom sediments (up to 1,600 ng/mg or 1.6 percent) were found approximately 100 m from the discharge. The petroleum hydrocarbons in these sediments matched well within those in the produced water effluents, except for the low concentrations of the more volatile components. The clear contamination signal was apparent up to 1 km from the discharge at both Grand Isle and Pass Fourchon. Benzene and toluene were detected in bottom water near the two discharge sites in Bayou Rigaud behind Grand Isle.

The macrobenthos at the sites exhibiting more contaminated sediments were absent or extremely depauperate. The density and diversity of macrobenthos generally increased with distance from the discharges. The presence of the polychaete _Capitella capitata_, a classic "pollution indicator," at some of the transitional sites suggests an organic enrichment effect beyond the region in which sediments may be toxic.

Dr. Karen M. Wicker received a B.A. in American Studies from Mary Washington College and an M.S. and Ph.D. in geography from Louisiana State University. She is presently Director of the Applied Science Division of Coastal Environments, Inc. Her research experience includes habitat mapping, air-photo interpretation, and the application of scientific research principals to the solution of environmental and social problems such as land loss, property ownership, property damage, management of wetlands for multiple uses, and mitigation of habitat loss resulting from development.

Dr. Donald F. Boesch received a B.S. in biology from Tulane University and a Ph.D. degree in marine science from the College of William and Mary. He was a Fulbright-Hays postdoctoral fellow at the University of Queensland and was formerly a member of the faculties of the College of William and Mary and the University of Virginia. Since 1980, he has been the Executive Director of the Louisiana Universities Marine Consortium and Professor at Louisiana State University, University of Southwestern Louisiana, and the University of New Orleans. His research interests encompass benthic ecology, sedimentology, shelf oceanography, and research on the effects of human activities on marine ecosystems.

Wetlands Mitigation: A Study of Marsh Management

Dr. Chip G. Groat
Louisiana Department
of Natural Resources

Man has played a significant role in causing shoreline erosion, barrier island destruction, and wetland loss in coastal Louisiana. By leveeing the Mississippi River, causing river sediments to be deposited beyond the continental shelf, dredging canals and constructing various facilities in the wetlands, we have accelerated the conversion of delta plain marshes to open water. Oil and gas activities, both in state and federal waters, have contributed to this loss of wetlands. Various marsh management techniques have been implemented to reduce wetland loss and to protect facilities located in the marshes.

Traditional approaches to marsh management utilize levees and water control structures to impound or partially impound wetlands, allowing control of water levels and salinity. This has made it possible to enhance the productivity of some wetlands, especially for waterfowl and furbearers. These techniques have been criticized by some members of the technical community who argue that they may be ineffective or actually contribute to wetland loss in some cases. There has also been concern regarding interference with the ingress and egress of commercial and recreational fisheries species. The most important objective of the wetlands mitigation study is providing an objective assessment of the suitability and feasibility of using marsh management techniques to protect and enhance coastal wetlands and the renewable resources they produce.

The study will be conducted by the Louisiana Geological Survey and the Coastal Management Division of the Louisiana Department of Natural Resources. A Technical Steering Committee composed of representatives from state and federal agencies, private landowners, and the academic community will guide the study and review findings and draft reports. Some of the tasks will be subcontracted to Louisiana State University and federal agencies.

The data acquisition phase will consist of three tasks. The first will identify the administrative procedures, legislation, and regulations controlling wetland management in Louisiana. The second task will inventory management activities in the wetlands including public interest goals, data sources, engineering and construction techniques, and economic considerations. Data acquisition will also include mapping of the study area and marsh management projects; characterization of environmental conditions including habitats, hydrologic, and geologic conditions; and a review of management plans and information on permitted sites. The third task will involve monitoring habitat changes resulting from marsh management plan implementation. The monitoring program will include field studies of 24 sites.

The second phase, data synthesis, analysis, and interpretation, consists of four tasks, each drawing upon the data derived from the first phase. The first analysis deals with engineering and economic concerns, the second with study area conditions including habitats, hydrologic, and geologic conditions, and management plans. The third task will analyze the monitoring data and ecological factors. The fourth task will assess the feasibility and suitability of marsh management practices and will include maps portraying suitable and unsuitable areas.

The third phase, report preparation, will result in eight reports or chapters:

- Administrative Framework
- Public Interest Goals
- Data Source Bibliography
- General Study Area Conditions
- Engineering and Construction Techniques
- Monitoring and Ecological Analysis
- Feasibility and Suitability
- Executive Summary

Information from this study will also be used by the U.S. Army Corps of Engineers in preparing a programmatic environmental impact statement dealing with marsh management practices. The study term is two years, beginning in December 1987 and ending in December 1989.

Dr. C.G. Groat has been state geologist and Director of the Louisiana Geological Survey for nine years. He is also Assistant to the Secretary, Louisiana Department of Natural Resources with administrative responsibility for the Coastal Management Program. He holds degrees in geology from the University of Rochester (B.A.), University of Massachusetts (M.S.), and University of Texas at Austin (Ph.D.)

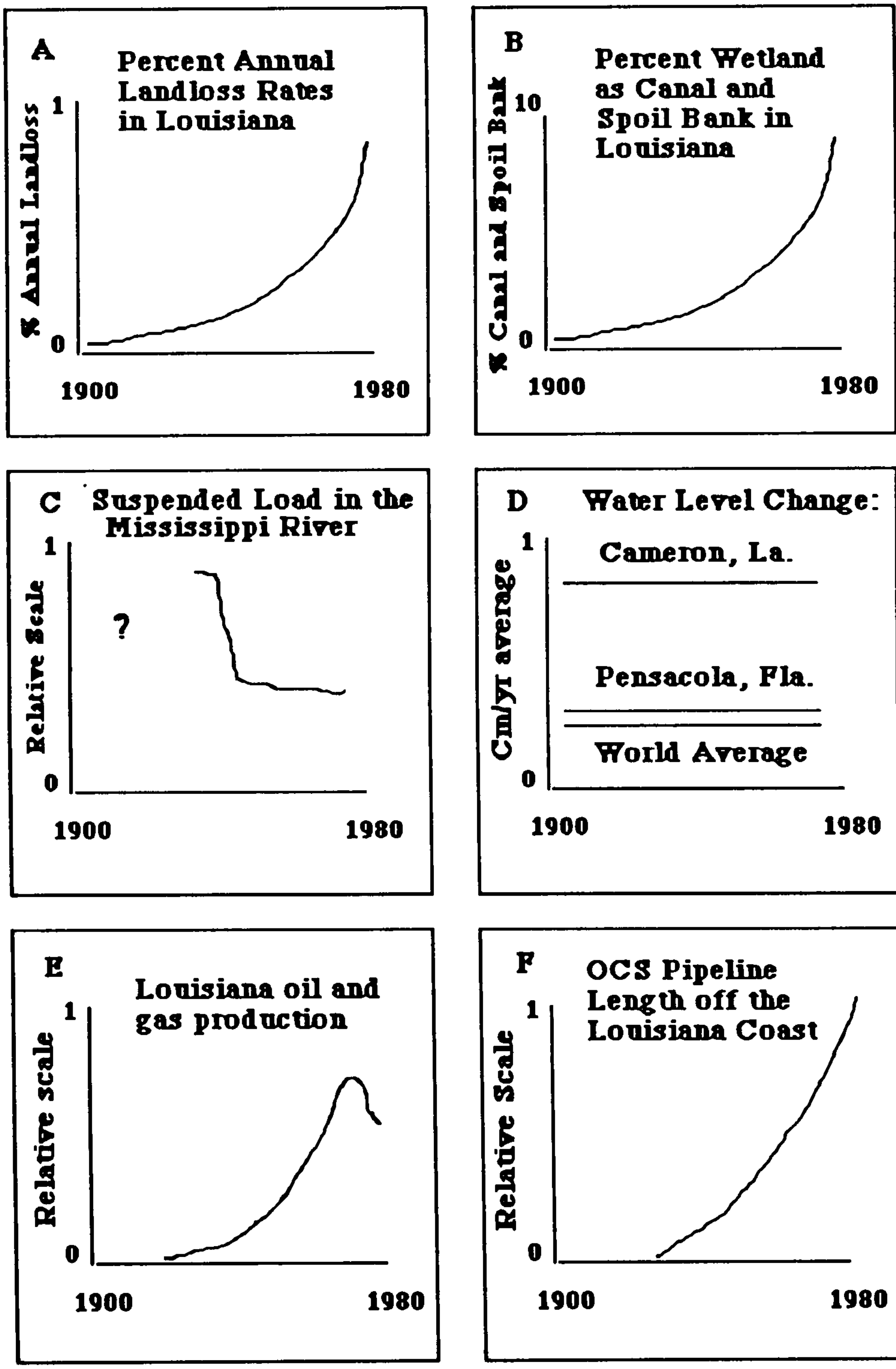


Figure 6.1.--Changes in landscape patterns and use in the study area. A. Land loss rates versus time. B. Canal and spoil bank density since 1900. C. Suspended sediment concentrations in the Mississippi River since 1950. D. Water level record changes for the world oceans; Pensacola, Florida; and Cameron, Louisiana. E. Cumulative oil and gas production for Louisiana. F. Pipeline miles in the Central Gulf of Mexico OCS region since 1950.

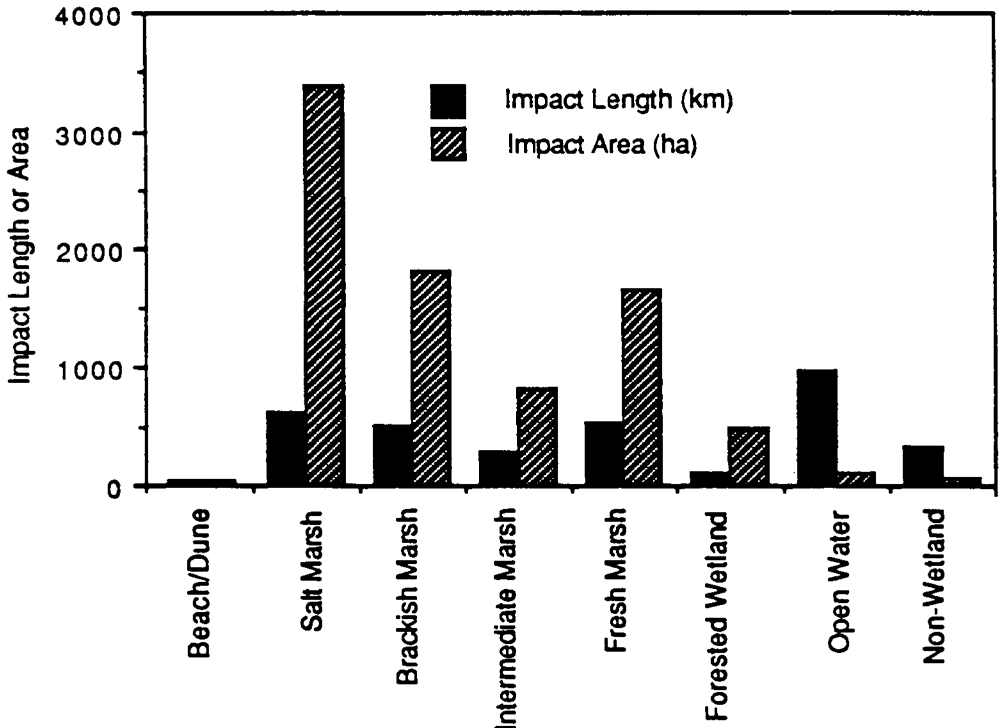


Figure 6.2.--OCS pipeline impacts by habitat (70% sample). The beach/dune category shows only a trace.

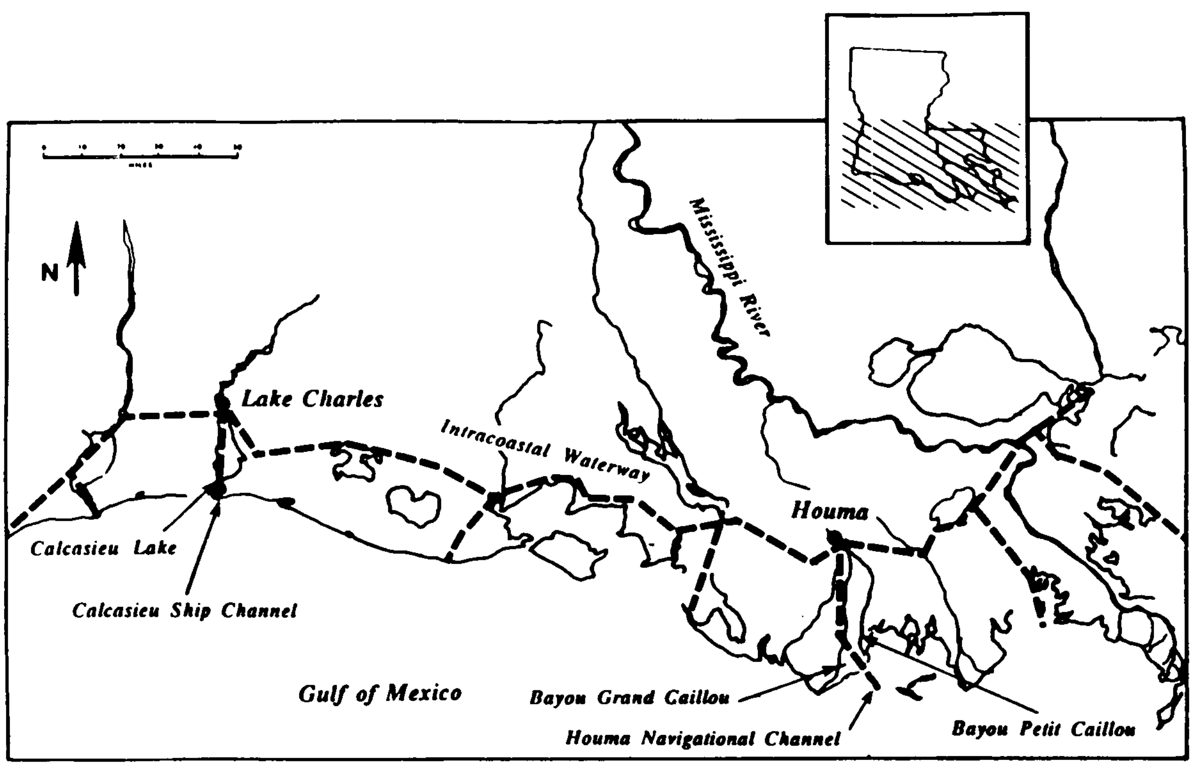


Figure 6.3.--Map showing locations of eight selected channels in coastal Louisiana.

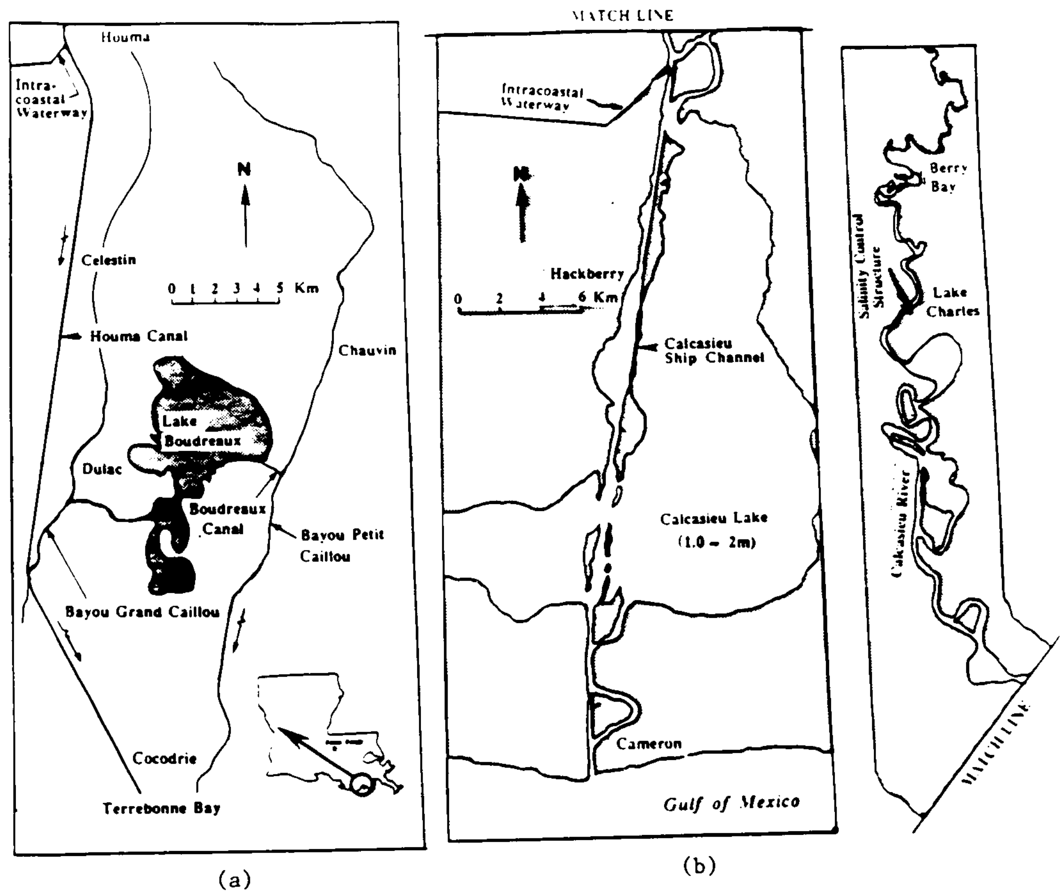
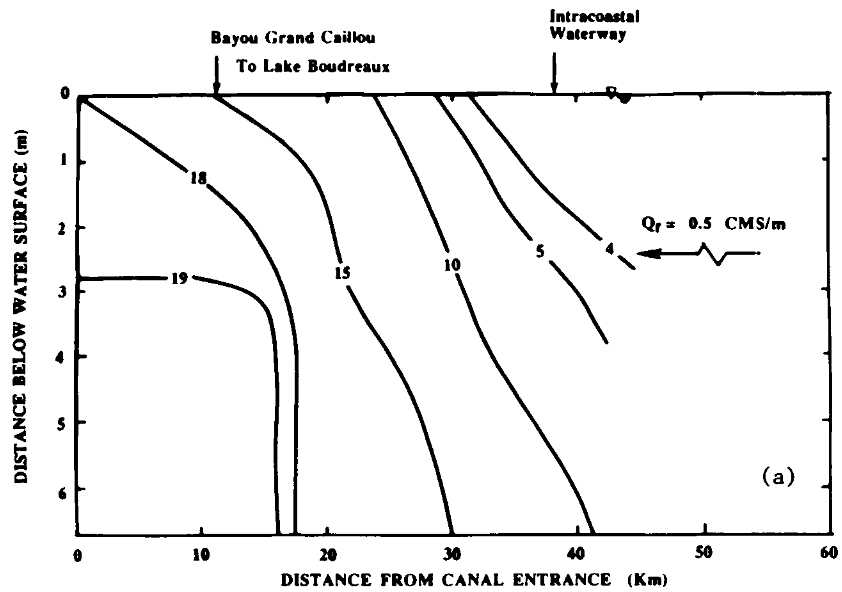


Figure 6.4.--Base maps of selected study sites
(a) Houma Navigation Channel and Bayou Petit Caillou
(b) Calcasieu Ship Channel, Louisiana



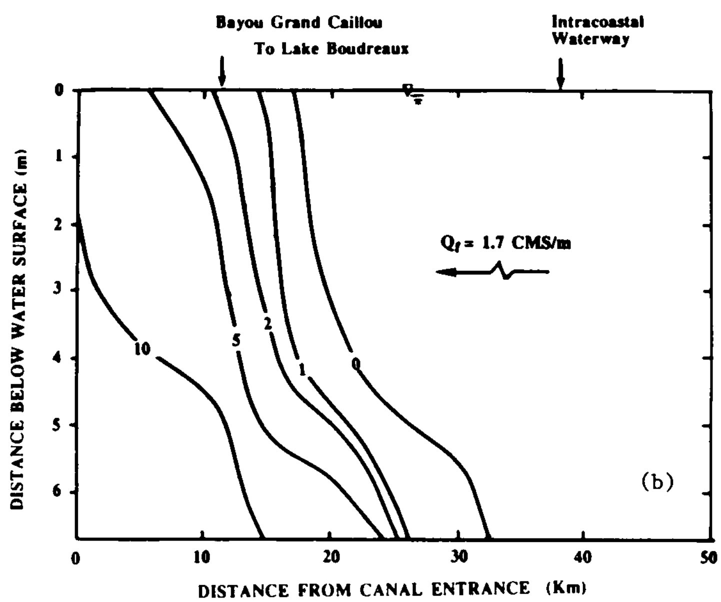
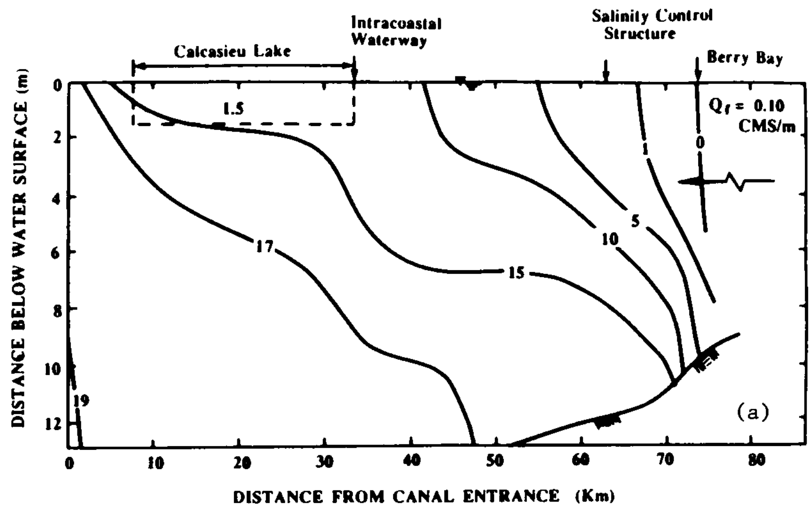


Figure 6.5.--Field measurements of salinity distribution in Houma Navigation Channel, Louisiana
(a) September 20-21, 1986
(b) October 17-18, 1986



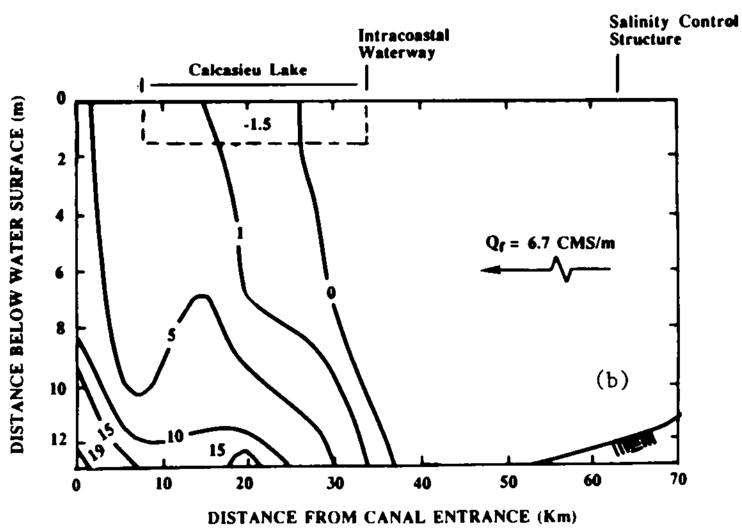


Figure 6.6.--Field measurements of salinity distribution in Calcasieu Ship Channel, Louisiana
(a) November 15-16, 1986
(b) March 2-3, 1987

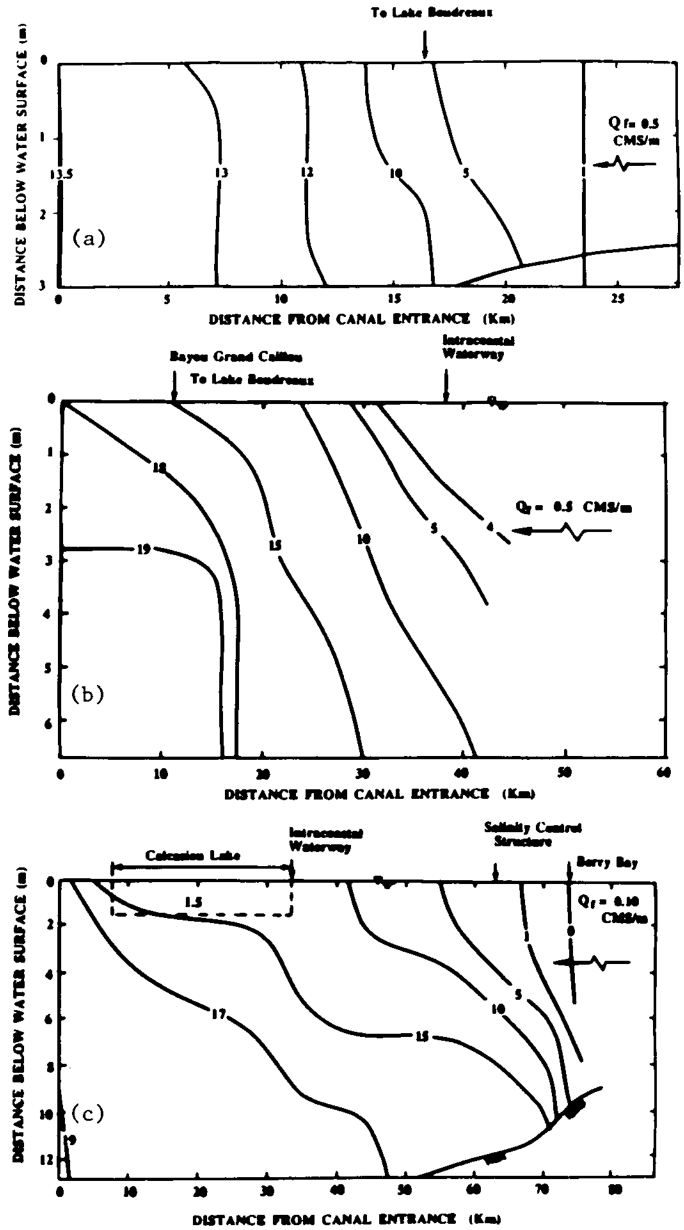


Figure 6.7.--Salinity distribution in three selected channels
(a) Bayou Petit Caillou (depth=3.0m, width=50m)
(b) Houma Navigation Channel (depth=6.6m, width=100m)
(b) Calcasieu Ship Channel (depth=12.5m, width=200m)

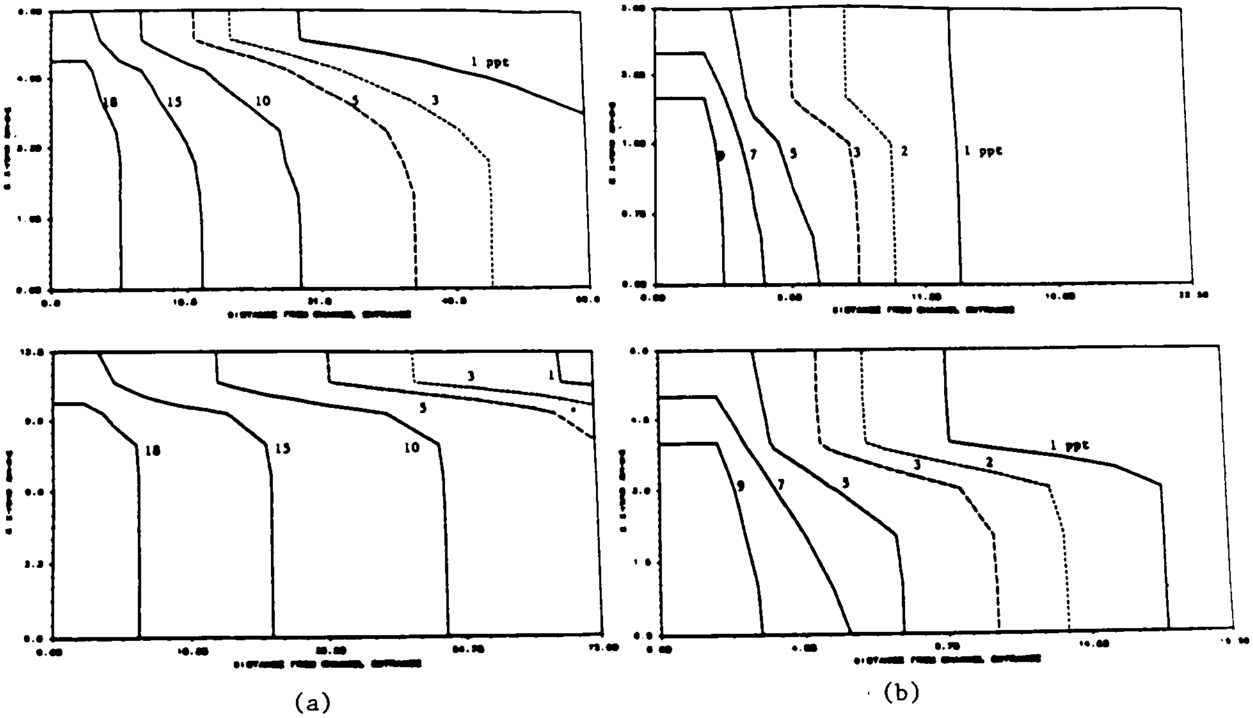


Figure 6.8.--Effects of channel dimensions on salinity distribution
(a) Houma Navigation Channel (depth=13.2m, width=200m)
(b) Bayou Petit Caillou (depth=6.0m, width=100m)

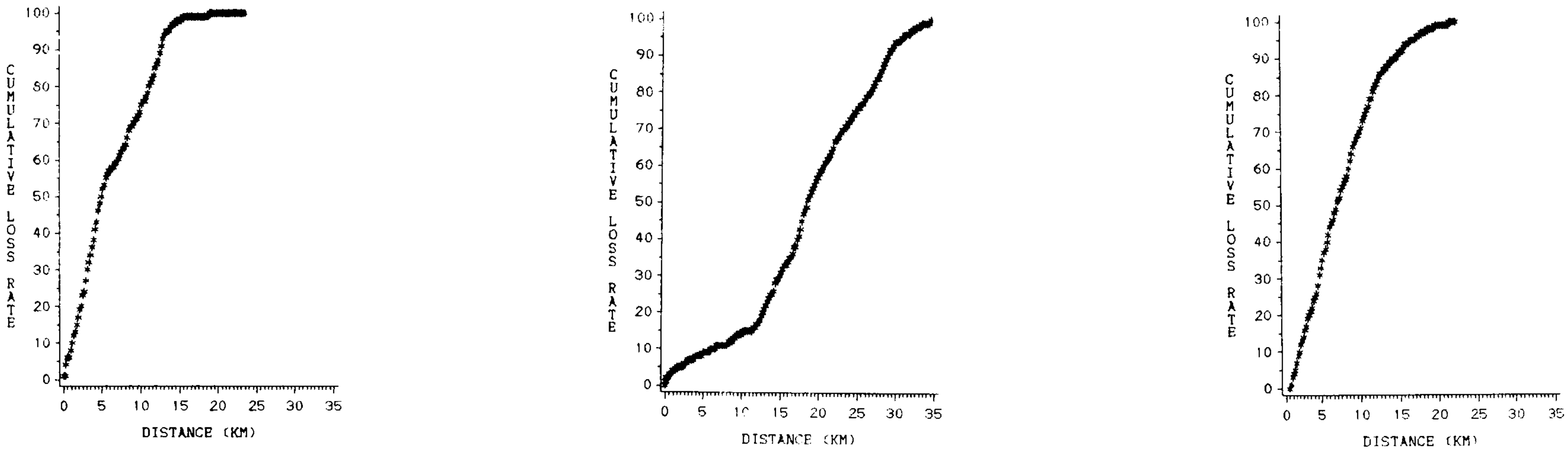


Figure 6.9.--Cumulative land loss versus distance to major channel for Cameron (left), Terrebonne (center), and Lafourche (right) study areas.

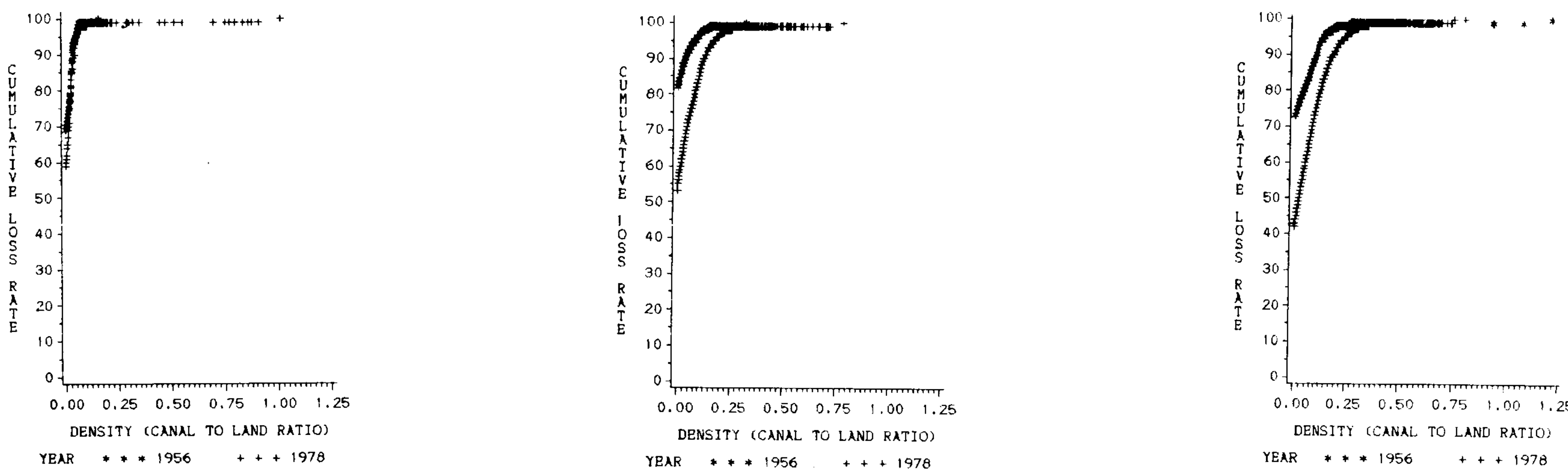


Figure 6.10.--Cumulative land loss versus canal and spoil density for Cameron (left), Terrebonne (center), and Lafourche (right) study areas.

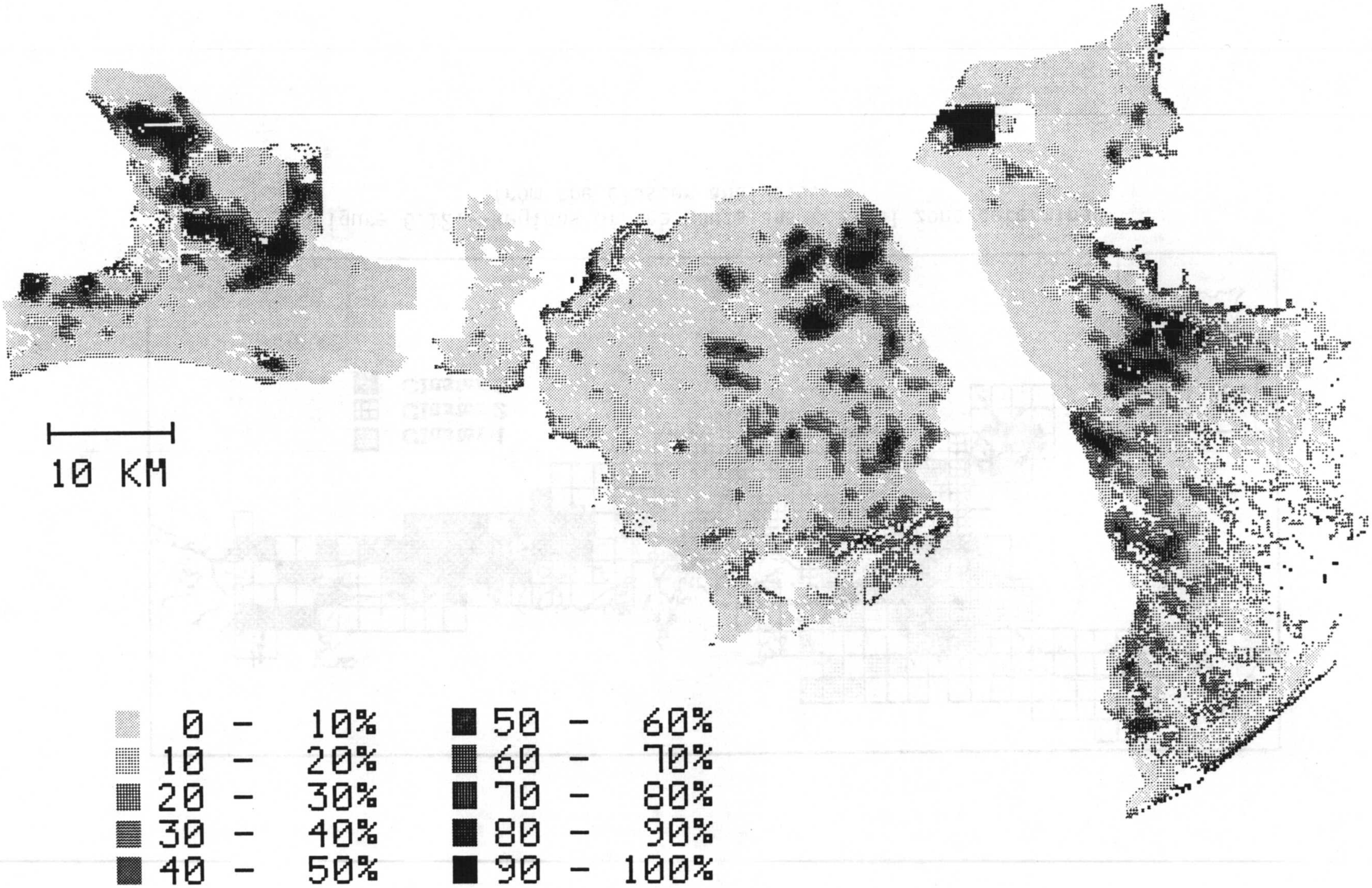


Figure 6.11.--Land loss density trends (percent land loss per square km) for Cameron (left), Terrebonne (center), and Lafourche (right) study areas, showing areas of high land loss (hot spots).

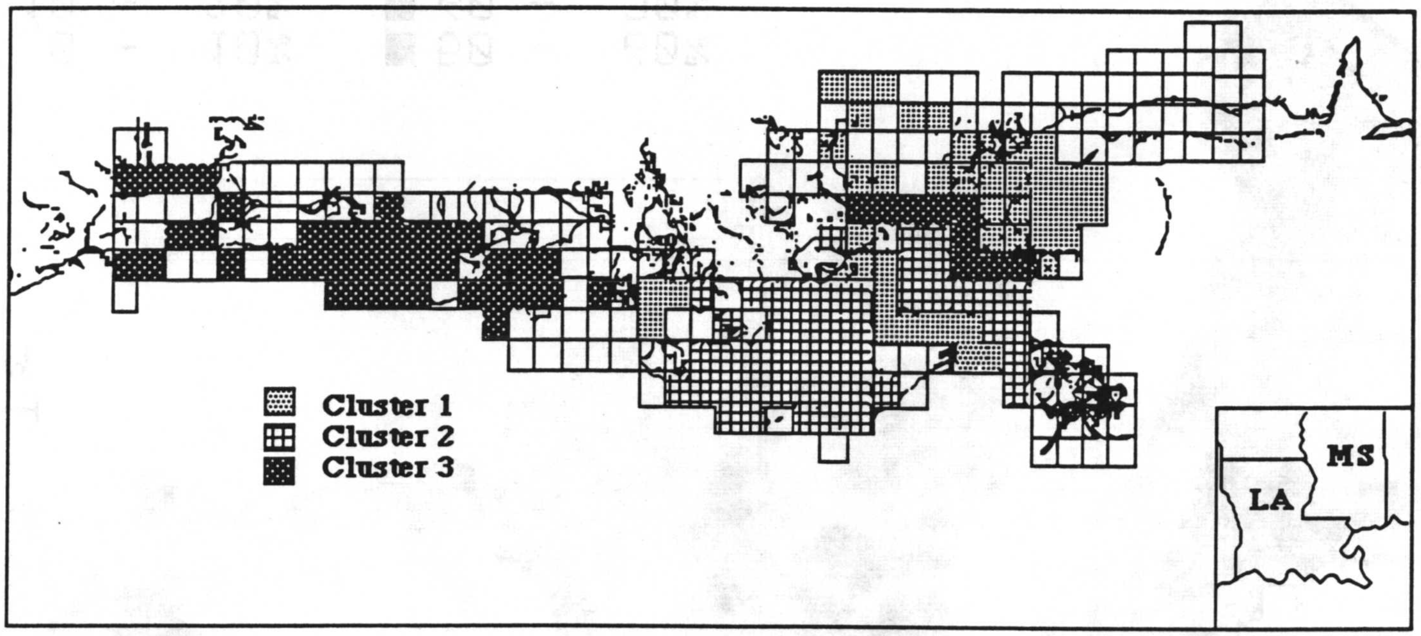


Figure 6.12.--Regions of the Louisiana coastal zone determined from the cluster analysis.

Table 6.1.

Values for Louisiana Wetlands

Fisheries:
- 28% of the total U.S. fisheries in volume in 1986.
- $321,514,000 in dockside value, or 12% of the total dockside value for the U.S.
- 4 of the 10 largest fishing ports are in Louisiana.
- 12,092 fishermen on board and dockside in Louisiana in 1977, or 4.3% of the U.S. total.
- 68,894 commercial fishing applications were filed in 1986.
- 1,000,000 recreational fishermen in Louisiana.

Fur:
- Bobcats, fox, otter, mink, raccoons, muskrats, nutria, and other trapped species provided over $18,000,000 to the state's economy in 1980-81.
- Trapping provided employment for approximately 10,000 people in 1986.

Waterfowl:
- 5,000,000 waterfowl migrate down the central and Mississippi Flyway to winter on Louisiana's 1.5 million ha of coastal marshlands.
- 3,000,000 waterfowl were found in a January, 1986, mid-winter survey of the coastal marsh and inland areas of the Mississippi Delta.
- 102,000 hunters bagged 1.2 million ducks in 1985-86.

People:
- Wetlands provide a buffer from storm..
- Wetlands enhance water quality.
- Wetlands provide homes for 1,000,000 people, including the oldest bilingual population in the U.S.

Table 6.2.

Summary of the Backmarsh Sediment Distribution Comparisons, by Marsh Type and Sediment Marker Technique. The Number of Waterways Compared (Natural vs. Canal) is Presented in Parentheses for Each Marsh Type within Each Comparison

Comparison	Marsh Type	Sediment Marker
Behind Natural Levee vs Continuous Spoil Levee	Salt (n=3)	Clay, Chemical
	Brackish (n=2)	Clay, Chemical, ^{137}Cs
	Fresh (n=3)	Chemical
Transect Analysis Behind Natural Levee vs Pipeline Spoil Levee (0-10-20-30-40-50m)	Salt (n=1)	Clay, Chemical, ^{137}Cs
	Fresh (n=1)	Chemical, ^{137}Cs
Behind Natural Levee vs Discontinuous Spoil Levee	Salt (n=4)	Clay, Chemical
Behind Continuous Spoil vs Discontinuous Spoil Levee	Salt (n=3)	Clay, Chemical
Within Impoundment with Flow vs Impoundment Without Flow	Fresh (n=2)	Chemical
Behind Natural Levee vs Within Impoundment with Flow	Fresh (n=2)	Chemical
Behind Natural Levee vs within Impoundment without Flow	Fresh (n=2)	Chemical

Table 6.3.

The influence of canals on vertical accretion (VA, cm yr^{-1}), bulk density (BD, g cm^{-3}), mineral accumulation (MA, g cm^{-2} yr^{-1}), and organic accumulation (OA, g cm^{-2} yr^{-1}). Data are presented as the difference between means (+ indicates that rates behind the canal were higher than those behind the natural waterway, - indicates they were lower).†

Comparison	Marsh Type	Sediment Marker	Impact of Canal VA	BD	MA	OA
1. Behind Natural Levee *vs* Continuous Spoil Levee (LSN vs LSC, CBN vs CBC, TFN vs TFC)	Salt (n=3)	Recent (C,S)	-0.33	-0.04	-0.07	-0.02
	Brackish (n=2)	Recent (C,S)[f]	-0.2	-0.06	nd	nd
		^{137}Cs	+0.01	-0.05*	0.0	-0.01
	Fresh (n=3)	Recent (S)	-1.37	-0.01	+0.14	-0.04
2. Behind Natural Levee *vs* Discontinuous Spoil Levee (LSN vs LSCd)	Salt (n=4)	Recent (C,S)	-0.4	-0.08	-0.09	-0.03
3. Behind Continuous Spoil *vs* † Discontinuous Spoil Levee (LSC vs LSCd)	Salt (n=3)	Recent (C,S)	+0.06	+0.04	+0.02	+0.01
4. Distance Analysis Behind Natural Levee *vs* Pipeline Spoil Levee (0-10-20-30-40-50m) (LSN vs LSCd Transect, TFN vs TFC Transect)	Salt (n=1)	Recent (C,S)	+0.6*	+0.04*	+0.10*	+0.01
		^{137}Cs	+0.21*	+0.05*	+0.09*	+0.01*
	Fresh (n=1)	Recent (S)	-1.52	-0.06	-0.27	-0.08
		^{137}Cs	+0.09	-0.04	-0.03	0.0

†All values are based on 12 month cores unless otherwise noted. Significant differences (at the 5% level) are indicated by an *. In Comparison 3, the + symbol indicates that the mean rate behind the continuous spoil bank was higher than that behind the discontinuous spoil levee. Under marsh type, n = the number of canal and natural sites compared. Under sediment marker, recent sedimentation estimates were obtained from clay (C) and stable isotope (S) plots.

[f]These rates are based on six and eight month samples. nd means no data available.

NORTHERN GULF OF MEXICO CONTINENTAL SLOPE PROGRAM

Session: NORTHERN GULF OF MEXICO CONTINENTAL SLOPE PROGRAM

Co-Chairs: Dr. Robert M. Avent
Dr. Benny J. Gallaway

Date: December 2, 1987

Presentation Title	Author/Affiliation
Northern Gulf of Mexico Continental Slope Program: Session Overview	Dr. Robert M. Avent Minerals Management Service Gulf of Mexico OCS Region and Dr. Benny J. Gallaway LGL Ecological Research Associates, Inc.
Northern Gulf of Mexico Continental Slope Study - Scope, Objectives and Approach	Dr. Benny J. Gallaway LGL Ecological Research Associates, Inc.
The Slope Environment as Seen from a Biological Perspective	Dr. Benny J. Gallaway LGL Ecological Research Associates, Inc.
Distribution and Abundance: Patterns of Megafauna	Dr. Benny J. Gallaway and Dr. Willis E. Pequegnat LGL Ecological Research Associates, Inc.
Distribution and Abundance: Patterns of Macrofauna	Dr. Benny J. Gallaway and Mr. Randall L. Howard LGL Ecological Research Associates, Inc.
Distribution and Abundance: Patterns of Meiofauna	Mr. Randall L. Howard LGL Ecological Research Associates, Inc.
Distribution and Chemistry of Chemosynthetic Ecosystems	Dr. James M. Brooks, Dr. Mahlon C. Kennicutt II, and Dr. Robert R. Bidigare Texas A&M University
Fine-Scale Distribution Patterns of Chemosynthetic Organisms	Mr. Ian Rosman, Mr. Gregory S. Boland, LGL Ecological Research Associates, Inc. and Dr. Robert S. Carney Louisiana State University

Session: NORTHERN GULF OF MEXICO CONTINENTAL SLOPE PROGRAM (cont'd)

Presentation Title	Author/Affiliation
Physiology of and Death Assemblages Formed by Animals at Petroleum Seeps	Dr. Eric N. Powell, Ms. Audrey Morrill, Ms. Susanne McDonald, Mr. Russell Callender, Dr. George Staff, and Mr. David Davies Texas A&M University
Selected Aspects of Chemosynthetic Community Ecology: Issues in the Making	Dr. Robert S. Carney Louisiana State University

Northern Gulf of Mexico Continental Slope Program: Session Overview

Dr. Robert M. Avent
Minerals Management Service
Gulf of Mexico OCS Region
and
Dr. Benny J. Gallaway
LGL Ecological Research Associates, Inc.

Dr. Avent briefly introduced the program by reiterating the objectives and timing of this four-year study.

In sponsoring this study, the MMS hoped to gain a synoptic, descriptive view of the benthic biota, hydrography, and sediments in the three Gulf of Mexico planning areas. Years 1 and 2 were devoted to five oceanographic cruises and partial analysis of biological, sediment and water samples, and instrumental data. Year 3 was required to complete all sample analyses and produce a quality data set; Year 4, now underway, will produce a final program synthesis report with appropriate statistical analyses, comparisons, and discussions.

The program will give MMS a descriptive overview of the Gulf of Mexico continental slope from 300 to nearly 3,000 m depth at about the time that oil and gas production moves into ever-deeper waters (see the session on Offshore Engineering and Deepwater Production Technology, this volume).

Dr. Benny J. Gallaway next presented a paper on the program's scope, objectives, and approach. His company, LGL Ecological Research Associates, Inc. (LGL), in conjunction with Texas A&M University (TAMU), has conducted the "Northern Gulf of Mexico Continental Slope Study" (NGOMCS) since 1983 to "develop a basic knowledge of the deep Gulf fauna--their environment and ecological processes in advance of extensive petroleum development." The objectives are to

1. provide an environmental and biological background characterization;
2. describe the environment in terms of overlying water masses, bottom water conditions, sedimentary character, and hydrocarbons;
3. describe, over time and space, the composition, distribution and abundance of the benthic biota (meiofauna, macrofauna, and megafauna) and compare the Gulf to other regions;
4. review and synthesize available information on recently discovered chemosynthetic communities;
5. provide a conceptual model of the ecosystems of the continental slope of the northern Gulf of Mexico. This system will be compared to other slope systems; and
6. assess the need for and suggest the types of studies that should be conducted in future program efforts.

Activities during Years 1 and 2 were directed toward field sampling and laboratory sample analysis. Year 3 was dedicated to finishing the sample analysis and compiling data in a usable and interactive format. Work during Year 4 has been dedicated to conducting analyses designed to meet program objectives.

The acquisition of data for meeting the stated objectives occurred over the course of five cruises, all conducted during the first two years of the program.

Dr. Gallaway continued, presenting the program approach and structure to define zonation and habitat variability, with a series of hypotheses to be tested, involving depth, topography, E-W variability, and hydrocarbon contamination. He then described a multistep analytical and statistical program to achieve program goals and presented an overview of "The Slope Environment as Seen from a Biological Perspective."

The Gulf of Mexico is a nearly enclosed basin with moderate depth sills in the Yucatan and Florida Straits, preventing entrance of waters >1,900 m. The physiography of the Gulf was discussed, and major regional features (e.g., canyons, Mississippi cone, Florida escarpment, etc.) were described in turn. Hydrographic data were shown to be remarkably consistent Gulfwide. Sediment distribution showed regional variation, but 55 percent of the stations were silty clay. Sediment hydrocarbon levels were generally low. Of 40 environmental variables, 4 accounted for 61 percent of environmental variability: region/time, depth, altitude, and longitude.

Dr. Gallaway presented a third paper, "Distribution and Abundance: Patterns of Megafauna," coauthored by Dr. Willis E. Pequegnat. Using trawls and benthic photography, LGL described the larger, visible animals--primarily fishes, decapod crustaceans, and echinoderms.

Fish density was markedly higher on the eastern transect and higher in the fall. Abundance peaks appeared at about 600 and 1,200 m, but few were trawled >1,200 m where diversity fell. Invertebrate density was also greater on the eastern transect, but density patterns, unlike those in the fishes, showed some peaks at depth. More species were endemic to the western Gulf than the eastern Gulf as predicted on the basis of circulation patterns.

Mr. Randall L. Howard presented "Distribution and Abundance: Patterns of Macrofauna," coauthored by Dr. Benny J. Gallaway. The macrofauna, here defined as those animals retained on a 0.30 mm sieve, were separated into 1,569 distinguishable taxa representing 18 phyla. Many species were new to science. About 49,000 individuals were collected. Abundance was highest on the central transect, followed by the eastern and western transects. Annual differences were less than regional and seasonal differences. With a few exceptions, macrofaunal abundance declined with increasing depth. Diversity generally decreased from east to west and with increasing depth. Macrofauna density and diversity values show the Gulf to be depauperate compared to the Atlantic Ocean.

Randall L. Howard then described the "Distribution and Abundance: Patterns of Meiofauna." Meiofauna, those forms passing through a 0.30 mm, but retained on 0.063 mm mesh, were generally not identified below major taxon. Nematodes were the most abundant (59 percent of individuals), followed by harpacticoid copepods (18 percent), nauplii (13 percent), polychaete worms (4 percent), ostracods (3 percent), and kinorhynchs (1 percent). But nematodes and harpacticoids each accounted for only 10 percent of the biomass. (Polychaetes made up about half of the total biomass.) Densities ranged from 125 to 1,141 organisms/10 cm^2 with generally higher values on the central transect and decreasing density with increasing depth. Meiofauna were generally about an order of magnitude more numerically abundant than macrofauna, but biomass estimates were similar.

Dr. James M. Brooks presented a paper (coauthored by Drs. Mahlon C.

Kennicutt and Robert R. Bidigare) on the "Distribution and Chemistry of Chemosynthetic Communities." In 1983 in the Green Canyon leasing area, TAMU workers discovered that chemosynthetic animals gain metabolic energy from gasses (mainly H_2S and CH_4) dissolved in aerated seawater. Ten locations between 530 and 2,400 m depth are now known to contain biogenic or thermogenic gas hydrates in sediment cores, and oil and gas seepage is a widespread event in the NGOMCS area. Using both submersibles and surface ships, workers have

1. identified chemosynthetic organisms (tube worms, mussels, and/or clams) at 17 northwestern Gulf of Mexico continental slope sites;
2. discovered that tube worms and clams from these sites do contain chemoautotrophic, bacterial endosymbionts;
3. found a mussel that is the first demonstrated symbiosis between a methanotrophic bacterium and an animal;
4. identified shallow seismic "wipe-out" zones as high probability sites for chemosynthetic ecosystems;
5. shown that oil seepage is associated with all chemosynthetic ecosystems located to date;
6. demonstrated that carbon, nitrogen, and sulphur isotopes can be useful in differentiating heterotrophic, sulfide-based and methane-based ecosystems;
7. identified the transfer of carbon from the chemosynthetic ecosystems to background heterotrophic organisms;
8. discovered 10 gas-hydrate and several active oil seepage locations in the Gulf of Mexico; and
9. determined that shell beds are being produced in and around areas of petroleum seepage.

Dives have been conducted at the hydrocarbon seep communities to refine the description of the distribution and abundance of organisms around the seep sites and to determine the importance of chemosynthesis.

Mr. Ian Rosman presented a paper coauthored by Mr. Greg Boland and Dr. Robert Carney on the "Fine-Scale Distribution Patterns of Chemosynthetic Organisms." Video tape records, sediment cores, and water samples were collected during four dives by the submersible Johnson-Sea-Link from a small diapir located at 560 m depth southwest of Grand Isle, Louisiana (27 degrees 46'N and 91 degrees 30'W). This is the location of a natural oil seep that supports a dense community of chemosynthetic tube worms and mussels.

The percent cover of both tube worm bushes (Lamellibrachia sp.) and mussels (?Bathymodiolus sp.) were estimated along video transects leading to and from stations where water and/or sediment samples were collected at intervals away from the stations (0 to 7.5 m and 7.5 to 15 m). These estimates were then compared to the values for methane and extractable organic material (EOM) obtained at each site. There was a significant correlation between high concentrations of methane in the water column above the sediment and high densities of mussels within the inner sampled interval, but not a significant correlation between higher densities of tube worms in each direction. Percent cover of tube worms and mussels showed a significant correlation between tube worm density and EOM at the inner distance, not the outer. Mussel densities were not correlated with EOM concentrations.

The distribution of tube worms forms a roughly north-south linear pattern with two nodes of high density, but does not conform to the topography of the diapir.

Dr. Eric Powell presented a variety of data gathered by his TAMU team (five coauthors) on the "Physiology of and Death Assemblages formed by Animals at Petroleum Seeps."

Two distinctive groups of sulfide-dependent animals have been described: (1) macrofauna associated with hydrothermal vent/cold sulfur seeps/petroleum seeps and (2) thiobiotic meiofauna associated with the sulfide system of shallow-water marine sands. These two offer an important contrast in adaptations to, and use of, sulfide. Dr. Powell offered biochemical data (metabolic pathways) to illustrate several examples of sulfide dependency. With the exception of a mussel that harbors methane-oxidizing symbionts, seep species generally have low catalase levels, probably because oxygen is below saturation and light (a potent oxygen-radical producer in seawater) is absent.

Seep sites are of great interest to paleontologists because they are locations where shell material accumulates and is potentially preservable in the fossil record. Shells are accumulating today only very nearshore above storm wave base, and even here, shell beds are rare. Petroleum seeps offer the single important exception in the western Gulf of Mexico. Only here are shell beds being formed, and only here are shell beds apparently being formed by accumulation at the sediment surface, which undergoes gradual burial. Clams show low incidences of abrasion and dissolution, but a high breakage frequency. Mussels, in contrast, have both high breakage and dissolution frequencies, observed as a higher live-to-dead ratio.

TAMU is currently developing a taphofacies model for the Texas shelf and estuarine system. The petroleum seep taphofacies is markedly different from others in the western Gulf.

Dr. Robert S. Carney gave the final presentation of the session: "Selected Aspects of Chemosynthetic Community Ecology: Issues in the Making."

The Louisiana continental slope chemosynthetic communities associated with hydrocarbon seeps are one of a series discoveries of functionally- and taxonomically-related assemblages in the deep sea. All are associated with sources of methane or hydrogen sulfide in an oxygenated environment, but the underlying geological processes vary from site to site. These communities are the focus of intense international research, and many of the questions to be asked in the Gulf of Mexico have already been identified in previous efforts elsewhere:

1. What are the processes whereby seeping hydrocarbons support distinct communities in rather restricted locations?
2. How do the communities persist, and do physical-chemical and biological factors interact on spatial and temporal scales?
3. How do the species reproduce, disperse, and then successfully recruit?

Only in the Gulf are we faced with the question of environmental impact upon a fauna that is uniquely associated with exploitable hydrocarbon reserves. While the three basic questions listed above are extremely important, taken alone, they cannot answer the question of potential impact. Dr. Carney addressed potential impact through two scenarios--the "Robust Community" vs. the "Fine-Tuned Community" alternatives. He argued in favor of the latter, which requires a much better understanding of spatial, temporal, life history, and abiotic patterns. The relatively shallow communities in the northern Gulf, an area geochemically well known, are ideal sites for future research.

Dr. Robert M. Avent has been a biological oceanographer with the Environmental Studies Section of the MMS, Gulf of Mexico OCS Regional Office since 1981. He received his M.S. (1970) and Ph.D. (1973) degrees in oceanography from Florida State University. He serves as Contracting Officer's Technical Representative (COTR), developing the content and scope of regional studies and monitoring study contracts. He has held positions in academia, State Government, private industry, and the Federal Government.

Dr. Benny J. Gallaway is president of LGL Ecological Research Associates, Inc. and an adjunct professor at Texas A&M University. His primary research interests lie in the field of population ecology and behavioral responses of fish to environmental gradients. He is a member of the Reef Fish Scientific and Statistical Committee of the Gulf of Mexico Fishery Management Council. Dr. Gallaway holds a Ph.D. degree from Texas A&M University.

Northern Gulf of Mexico Continental Slope Study - Scope, Objectives and Approach

Dr. Benny J. Gallaway
LGL Ecological Research Associates, Inc.

INTRODUCTION

Since 1983, LGL Ecological Research Associates, Inc. (LGL), in conjunction with Texas A&M University (TAMU), has been conducting a study of the continental slope of the northern Gulf of Mexico. The study is being performed for the Gulf of Mexico Regional Office of the Minerals Management Service (MMS). The overall goal of the program is to develop a basic knowledge of the deep Gulf fauna, its environment, and ecological processes in advance of extensive petroleum development.

The objectives of the program are:

1. Provide an environmental and biological background characterization of the continental slope of the northern Gulf of Mexico, based upon pre-study information, with emphasis on how the Gulf might be expected to differ from other temperate and subtropical deep-sea regions.
2. Describe the environment of the continental slope of the northern Gulf of Mexico in terms of overlying water masses, bottom water conditions, sedimentary character, and hydrocarbons with emphasis on identifying spatial (by depth and region) and seasonal discontinuities that might account for observed biological patterns. Compare findings to observations from other deep-sea systems and evaluate results in terms of

environmental assessment implications.

3. Describe, over time and space, the composition, distribution, and abundance of the meiofauna of the continental slope of the northern Gulf of Mexico. Relate any observed trends to environmental features and the macrofauna, comparing results to other deep-sea regions. Identify any unusual or important meiofaunal resources and evaluate the potential for impact on these resources from offshore oil and gas exploration and development.
4. Describe, over time and space, the composition, distribution, and abundance of the macrofauna of the continental slope of the northern Gulf of Mexico. Relate any observed trends to environmental features and compare results to other deep-sea regions. Identify any unusual or important macrofaunal resources and evaluate the potential for impact on these resources from offshore oil and gas exploration and development.
5. Describe, over time and space, the composition, distribution, and abundance of megafauna of the continental slope of the northern Gulf of Mexico. Relate any observed trends in environmental features and compare results to other deep-sea regions. Identify any unusual or important megafaunal resources and evaluate the potential for impact on these resources from offshore oil and gas exploration and development.
6. Describe and synthesize the available information concerning the types of chemosynthetic communities found on the continental slope of the northern Gulf of Mexico, their distribution, and their apparent trophic dependencies.
7. Based upon program data and other published and unpublished data, provide a conceptual model of the ecosystems of the continental slope of the northern Gulf of Mexico, comparing this system to other slope systems.
8. Assess the need for, and determine the types of studies that should be conducted in future program efforts.

Activities during Years 1 and 2 were directed toward field sampling and laboratory sample analysis. Year 3 was dedicated to finishing the sample analysis and compiling data in a usable and interactive format. Work during Year 4 has been dedicated to conducting analyses designed to meet program objectives.

The acquisition of data for meeting the stated objectives occurred over the course of five cruises, all conducted during the first two years of the program. Because of the small size and taxonomic complexity of the macrofauna, all of the contract Years 1-3 (1983-1986), as well as a time extension into 1987, were required to complete the sample analysis. We are presently attempting to complete the data analysis and integration, and we expect the final report to be produced in 1988.

PROGRAM DESIGN AND APPROACH

The program sampling plan was structured to first [based upon sampling conducted on Cruises I, II, III (in part) and IV (in part)] compare environmental and biological attributes of the slope by depth, among planning regions (Eastern, Central and Western Gulf), between seasons (fall versus spring), and between years (1983-84, 1984-85) by season (fall, spring, respectively). Sampling depths were not randomly or evenly spaced down the slope but were the approximate mid-points of previously-defined (Pequegnat, 1983) biological depth assemblages or "zones": (1) the Shelf-Slope Transition Zone (150 to 450 m); (2) Horizon A of the Archibenthal Zone (475-740 m); (3) Horizon B of the Archibenthal Zone (775-950 m); (4) the Upper Abyssal Zone (975-2,250 m); and (5) the Mesoabyssal Zone, Horizon C (2,275-2,700 m). The purpose was not to prove or disprove the concept of zonation versus continuation of change with depth, but rather to evaluate the predictive value of the Pequegnat's zonation scheme.

An information management matrix for the Year 4 Final Report is shown in Figure 7.1. As shown, environmental (hydrography, sediment characterization, hydrocarbon chemistry) and some biological data will be integrated to show how the slope habitat differs among regions, depths, seasons, and years by inspection as well as by more quantitative means such as Principal Components Analyses (PCA). In our project design, we have up to 40 environmental or habitat variables that were measured as potential factors affecting biota. PCA enables one to transform a large original set of variables into a smaller set of combinations that account for most of the variance of the larger set. The purpose is to explain as much of the total variation in the data as possible, with as few of these factors as possible.

The outputs of the PCA enables us to group entities (in our case, stations by depth, seasons and years) in terms of their physical/chemical attributes. This, in effect, provides an environmental classification against which we can compare results of various biological classifications of the same stations. The question being addressed by this approach is "Does the distribution and abundance patterns of biota on the slope correspond to environmental differences?"

The biological analyses will first focus on each of the major taxonomic groups associated with soft bottom habitats, namely, the distribution, abundance, and diversity of meiofauna, macrofauna, and megafauna, the latter of which was sampled using trawls as well as with benthic photography.

The next step in the biological evaluations will be to apply cluster analysis techniques in order to biologically classify stations by region, season, and depth. Results will be compared by inspection to the classification scheme generated from PCA analyses of physical/chemical attributes. Our cluster analysis approach will follow Grassle and Smith (1976), using a Normalized Expected Species Shared (NESS) as the similarity measure.

The findings of the described analyses will be compared to historical analyses of similar nature for other regions: and, in this context, any unusual attributes particular to the Gulf of Mexico will be identified. As part of the overview sections, we will also identify the ecologically important or numerically dominant component groups within each of the macrofaunal and megafaunal designations. These groups will serve as subjects for a series of sections dealing with that group per se.

The same "community-type" analyses described above will be applied to the data for each major component group of the macro- and megafauna. In addition, species abundance data by depth and longitude will be subjected to Chi-square analyses (Backus et al. 1965; Gage 1986) to detect apparent faunal boundaries. By inspection and/or correlation, the findings will be related to distance between sampling sites.

As part of the major group accounts, we will identify the most abundant species within the component groups and compare abundance patterns, over time and space, using ANOVA and orthogonal contrasts as defined above. An appropriate transformation will be applied to the data, if warranted, prior to the analyses. Likewise, correlation analyses will be conducted to determine the apparent associations of species abundance to physical/chemical attributes of the environment, using data provided by the hydrography and sediment investigations (Figure 7.1). These discussions will also include a description of hydrocarbons levels in animal tissue, as provided by the hydrocarbon chemistry studies (Figure 7.1).

Life-history accounts will be provided for numerically dominant or important species of megafauna. These will include discussions of food habits, size distribution, apparent growth patterns, and length-weight relationships. For dominant macrofaunal species groups (e.g., polychaetes) we will attempt to classify populations by feeding type. All of this information is for the purpose of developing an overall conceptual model of the Continental Slope ecosystems based upon the information flow depicted in Figure 7.1.

The Year 4 Final Report will also contain a section dealing with megafauna based upon our benthic photography surveys (Figure 7.1). While these results generally lack the taxonomic resolution required for many analyses, they have enabled an evaluation of overall megafaunal densities based upon trawling. Also, at least one very abundant species was photographed regularly that was never taken by trawling. These topics will be addressed in the Final Report along with habitat observations, making major contributions to the system conceptual model (Figure 7.1).

The concluding section of the Year 4 Final Report will present a conceptual model of the Continental Slope ecosystem of the northern Gulf of Mexico, based upon integration of all the program findings (Figure 7.1). In this section we will define all the various types of assemblages that are represented and identify the energy sources and flows within and among these assemblages. We will also identify areas of major uncertainties about the system and how these might be addressed by future studies.

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Dr. Benny Gallaway is president of LGL Ecological Research Associates, Inc., and an Adjunct Professor at Texas A&M University. Primary research interests lie in the field of population ecology and behavioral responses of fish to environmental gradients. He is a member of the Reef Fish Scientific and Statistical Committee of the Gulf of Mexico Fishery Management Council. Dr. Gallaway holds a Ph.D. from Texas A&M University.

The Slope Environment as Seen from a Biological Perspective

Dr. Benny J. Gallaway
LGL Ecological Research
Associates, Inc.

INTRODUCTION

A primary objective of the northern Gulf of Mexico Continental Slope Study was to describe the slope environment in terms of overlying water masses, bottom water conditions and sedimentary character, including hydrocarbon levels. The purpose of this exercise was not to characterize the oceanography of the slope *per se*, but rather to detect depth, regional, and seasonal discontinuities in habitat that might account for any observed patterns in biological abundance and diversity. In all, some 40 physical/chemical environmental variables were measured for this purpose.

SELECTED ENVIRONMENTAL FEATURES OF IMPORTANCE

The physiography of the Gulf of Mexico has a great bearing on some key environmental features of biota. The first feature is that, although the Gulf has an inlet (Yucatan Strait) and outlet (Florida Straits), they are both located in the southern quadrant and are characterized by relatively shallow sill depths of 1,650 to 1,900 m, respectively. Under normal circumstances, water masses deeper than 1,900 m are prevented from entering the Gulf even though the Gulf Basin is about 3,840 m in depth. At these depths, water temperatures in the Gulf remain at about 4 degrees C, whereas in the Atlantic Ocean or the Caribbean Sea water temperature is on the order of 2 degrees C.

The declivity (Figure 7.2) of the northern Gulf slope also differs by region due to the presence of plateaus, troughs, and escarpments. A prominent feature is the plateau-like nature of the Texas-Louisiana Slope which is bordered on the west by the Alaminos Canyon and on the east by the Mississippi Trough. To the east of the Mississippi Trough lies the Mississippi Fan or Cone, which covers bathyl and abyssal depth zones and dominates the topography of the east-central Gulf.

The Fan is bounded on the east by the Desoto Canyon, with the steep Florida Escarpment being the predominant feature of the eastern Gulf Slope. In our program, sampling emphasis was placed on the Texas-Louisiana Slope and the northern part of the Florida Escarpment. The slope of Texas in the Alaminos Canyon area, the Mississippi Trough and Fan, the Desoto Canyon and the southern Florida Escarpment, thus continue to remain largely unknown from a modern biological perspective.

The general nature of Gulf circulation probably influences the abundance and richness of endemic biota. Based upon circulation, the eastern Gulf might represent a shallow extension of the Atlantic/Caribbean deep sea, whereas the western Gulf might be analogous to the European Mediterranean Sea; i.e., having a single inlet/outlet but receiving discharge from world class rivers.

Hydrographic data collected in this study (eg., temperature, salinity, dissolved oxygen, nutrients) showed great uniformity across the Gulf in terms of depth. From a general biological perspective, as opposed to a detailed physical perspective, results of T/S plots by depth showed three generally uniform T/S environments: a shallow zone (300 to 600 m), an intermediate zone (600 to 1,000-1,200 m), and a deep zone (1,000-1,200 to 3,000 m). Of these, the shallow zone was characterized by the most variation in T/S conditions. Distinct faunal assemblages might be expected to be associated with each T/S environment.

While the photic zone is restricted to shallow surface waters, an extended twilight zone, ever darker with depth, persists down to about 1,000 m. This factor, in conjunction with the T/A patterns by depth, reinforces the concept that a major break in the environment and the biota might be expected at about 1,000 m. Historically, such has been the case with 1,000 m typically being viewed as the start of the deep sea.

Sediment type distribution showed more regional variation than T/S patterns. The most common (over 55 percent of the stations) sediment type was silty-clay found in all areas of the Gulf. There were small amounts of variation within this type depending on the area of the Gulf sampled. In the eastern Gulf, this type had a slightly higher percentage of sand than in the western or central areas. Along the Central Transect, there were slightly higher percentages of silt than clay at the deeper stations C5 and C12.

The second most common sediment type was clay, represented by nine shallow water stations (<1,226 m) in the western and central Gulf. Stations with clay sediments were relatively uniform with little variation in the sand-silt-clay proportions.

Sandy clay was observed in the western Gulf at Stations W1, W2, W5 on Cruise II; at WC5 on Cruise V; and in the eastern Gulf at Station E5 on Cruise II. At Station E5 on Cruise IV, the sediment was predominantly clay with approximately equal mixtures of sand and silt. This is in contrast to the Western Transect station, which had a higher proportion of sand than silt.

The sediment type "sand-silt-clay" has approximately equal proportions of each sediment size fraction. Sand-silt-clay sediment was found only in the eastern Gulf at Stations E1, E1b, E1c, and E2d (at these shallow stations clay was the most abundant of the three parameters and sand was the smallest fraction), and at E4 where clay was the largest fraction but the sand proportion was higher than silt.

Sediment hydrocarbon levels were generally low, but were of interest in terms of their relative concentrations based upon estimated source. In each region, terrestrial-source hydrocarbons had the highest concentrations, increasing from the east to the west to the central transect stations. Correlations were relatively uniform with depth on the Eastern and Western Transects, but increased with depth on the Eastern Transect. The influence of the land- and/or river-derived material was readily apparent in all three regions and accounted for the majority of the 6-C resolvable alkanes.

RESULTS OF PCA ANALYSIS

In our project design, we had up to 40 environmental or habitat variables that were measured as potential factors affecting biota. Principal

Component Analysis (PCA) enables one to transform a large original set of variables into a smaller set of combinations that account for most of the variance of the larger, original set. The purpose is to explain as much of the total variation in the data as possible, with as few factors as possible.

The outputs of the PCA enabled us to group entities (in our case, stations by depth, seasons and years) in terms of their physical and environmental classification against which we can compare results of various biological classifications of the same stations. In each of our four PCA analyses, corresponding to the four experiments, Principal Components 1 and 2 accounted for 45 to 63 percent of the total sample variance:

- PCA(1): Region/Season/Year Comparison - 45 percent
- PCA(2): Depth Comparison - 63 percent
- PCA(3): Latitude by Depth Comparison - 59 percent
- PCA(4): Longitude by Depth Comparison-61 percent

In PCA 1, stations from each region that clustered together were separated on one axis by levels of organic carbon and hydrocarbons versus percent sand and bottom water transparency, and on the other axis by plankton and high molecular weight hydrocarbons versus bottom temperature and surface-water, dissolved, organic carbon. Within region, stations were also grouped by depth, with the shallowest and deeper stations showing the highest levels of organic carbon.

The results of PCA 2, an analysis of variation among eleven central transect stations by depth, yielded three general groupings on the x-axis, separated mainly by hydrocarbon levels. One group included two stations shallower than 500 m and another group that included the three stations greater than 200 m depth. Stations between these depth ranges cluster together with regard to placement on the x-axis (Principal Component 1) but were divided into two groups along the y-axis (Principal Component 2). On the latter axis the separation was mainly attributable to sand content and bottom, dissolved, organic carbon levels.

The results of PCA 3, conducted on eastern transect stations sampled on Cruise IV, yielded six station groupings separated on the x-axis mainly by hydrocarbon levels and clay content and on the y-axis by sand content and bottom water levels of dissolved organic carbon. In general, the groupings reflected four depth related environments: one represented by stations shallower by 500 m; one by stations about 650 m in depth; one by stations about 850 m in depth; and the last by a single station located in 2,900 m of water.

PCA 4 included stations sampled in the west-central Gulf on Cruise V. Analysis yielded three station groupings that reflected station depth even though depth was not an input variable. The depth groups were generally stations in the 300, 500, and 1,200 m depth ranges. Of interest here is that two 500 m depth stations clustered with the 300 m deep stations, mainly due to hydrocarbon content. The two stations in question were located near areas of petroleum seeps.

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Distribution and Abundance: Patterns of Megafauna

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INTRODUCTION

Megafauna sampling was conducted at 59 stations on the continental slope of the northern Gulf of Mexico using trawls and benthic photography. In this paper, we will place emphasis on results of the trawl collections; however, it should be noted that results of benthic photography suggest that density estimates based upon trawling may greatly underestimate actual densities of slope megafauna.

In general, megafaunal invertebrates were four to five times more abundant than fish and exhibited different patterns in abundance and diversity. Below are outlined some of the program findings with regard to overall distribution, abundance, and diversity of fish and invertebrate megafauna.

DISTRIBUTION, ABUNDANCE AND DIVERSITY OF FISHES

Fish density (no./ha.) was markedly higher on the Eastern Transect than on the Central and Western Transects, with density on the Western Transect being slightly higher than that observed on the Central Transect (see Figure 7.2). Based upon data from the Central Transect, fish density appeared higher in fall than during the spring, and there was little difference between collections in Fall 1983 and 1984. On the Western and Central Transects, fish density was highest at the shallowest stations.

Based upon common stations sampled on the Eastern Transect, there was little difference in overall fish density between the 1984 and 1985 spring collections. This was in contrast to the trend of declining abundance with depth on the Western and Central Transects, although an abundance peak was noted at the 1,400 m-deep station on the Eastern Transect.

More intense sampling of the Central Transect during fall 1984 revealed a depth abundance pattern similar to that observed on the Eastern Transect; i.e., two abundance peaks were noted at depths of about 600 and 1,200 m. Relatively few fish were trawled at any of the five stations sampled between 1,200 and 2,500 m in depth.

Sampling along the 350, 650, and 850 m deep isobaths in the eastern Gulf in spring of 1983 confirmed the previously observed depth abundance trends. On each isobath, abundance was higher at stations north of latitude 28 degrees 40' N then in more southerly latitudes. Some of these differences may correspond to differences in sediment type.

The isobathic sampling in the west-central Gulf included a number of specific contrasts as well as horizontal zonations in abundance. Abundance levels at Station WC1 (silty clay) and WC5 (sandy clay) differed little despite the widely separated and differing sediment types. On the 650 m isobath, abundance levels at WC7 and WC8 were higher than at other stations (WC2, WC4 and WC6). On this transect, it had been planned that stations WC6 and WC7 would be at petroleum seeps;

however, this did not turn out to be the case.

Stations WC3, WC9 and WC10 were all on the same sediment type and at approximately the same depth (850 m). Stations WC9 and WC10 were in close physical proximity to one another, compared with Station WC3, which was located farther to the west. Fish abundance was similar at stations WC3 and WC9, but was markedly lower at Station WC10.

Stations WC11 and WC12 were located at the same depth (1,220 m), but WC11 was a topographic high. Abundance was notably higher at WC11 than at WC12.

In contrast to the fish abundance data, diversity levels of fishes differed little among regions, seasons, or years, but declined in depth in each region, season/year sampled.

Comparison of diversity levels by depth on the Central Transect during Fall 1984 showed high and reasonably uniform diversity levels for stations sampled between 350 and 1,200 m. At the five stations sampled below 1,200 m in depth, diversity was uniform at about one-half the level observed at shallower depths. There was virtually no variation in fish diversity along the isobaths in either the eastern or west-central Gulf area.

In 1976, J.A. Musick presented a paper at the joint International Oceanographic Assembly in Scotland in which he described community structure of fish populations along the mid-Atlantic continental slope. A comparison of mid-Atlantic and Gulf slope fish diversity levels shows the two areas to be quite similar.

DISTRIBUTION, ABUNDANCE, AND DIVERSITY OF INVERTEBRATES

Density patterns of megafaunal invertebrates were similar to density patterns observed for fishes in that density levels in the eastern Gulf of Mexico were far greater than those observed for either the Central or Western Transects. In addition, density observed on the Central Transect during fall appeared higher than spring levels, and little difference was detected within seasons or between years.

Density by depth differed markedly from that observed for fish. Density of invertebrates at the deepest stations was often as high as that observed for shallow stations, and the mid-depth stations were usually characterized by the lowest density levels. While this depth trend was not pronounced on the Fall 1984 Central Transect, there was a peak in abundance at shallow depths, low density at intermediate depths, and an increase in density following the mid-depth low.

Invertebrate abundance along isobaths in the eastern Gulf suggested reasonably uniform density along the 350 and 850 m isobaths and at all but one station along the 650 m isobath. The high abundance station was at about 28 degrees 10' N latitude. No explanation is readily apparent. Abundance along the 650 m isobath was higher than along either the 350 or 850 m isobath.

Isobathic sampling in the west-central Gulf along the 550 and 850 m isobaths yielded invertebrate density patterns similar to that previously described for fish. However, in contrast to fish, invertebrate density at WC1 (silty clay) was higher than at WC5 (sandy clay), although both stations were at similar depths. Also, invertebrate density at the topographic high WC11 was higher than density at the same depth at station WC12.

Decapod crustaceans dominated the megafaunal invertebrate collections, and diversity for this group was used for a direct comparison to fish diversity patterns.

As with fish, there were no distinct regional, seasonal, or annual differences in decapod diversity and depth trends, suggesting a decline in abundance with depth. However, maximum diversity was often associated with some of the mid-depth stations, as opposed to the shallower sites. With the exception of two stations (C9 and C10) where diversity was zero (none or only one decapod species collected), intensive depth sampling at the Central Transect showed remarkable homogeneity in diversity. Likewise, there was little variation in decapod diversity along or between isobaths in the eastern Gulf.

Isobathic sampling in the west-central Gulf produced few major differences in decapod diversity except for the shallowest and deepest station pairs. At a depth of 350 m, the station over sandy clay (WC5) had lower diversity than WC1 (silty clay). Station WC11, the topographic high at a depth of 1,220 m, was characterized by low diversity relative to the Station WC12.

Earlier, we implied that based upon circulation characteristics there might be some basis for the eastern and western Gulf slope areas being different. That there were more megafaunal species restricted to the western Gulf than there were species restricted to the eastern Gulf suggests some validity to this hypothesis.

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Distribution and Abundance: Patterns of Macrofauna

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INTRODUCTION

Macrofauna was defined for the purpose of this study as those organisms collected with box corers and retained on a 0.3 mm sieve. The organisms represent much smaller sizes than one typically finds in most other macrofauna samplings that have used 0.5 mm or 0.42 mm sieves. Three general sampling strategies were employed to examine macrofaunal distributions:

1. Cruises I through III sampled down-slope (across isobaths) in three different areas (central, eastern and western transects) and two seasons (see Figure 7.2) in order to study depth-related changes in macrofauna in various parts of the Gulf.
2. Cruise IV sampled parallel to isobaths of the eastern transect, in order to focus upon variability independent of depth; and
3. Cruise V also sampled along isobaths with emphasis placed on areas of special biological interest in the area between the western and central transects.

Samples from the macrofaunal component of the box cores contained on the order of 49,000 individuals representing 18 phyla, which were separated into 1,569 differentiable taxa. From these we were able to identify 1,121 species, many new to science.

MACROFAUNA ABUNDANCE PATTERNS

The overall region, season, year and depth patterns of macrofaunal abundance showed some distinct trends. From inspection, abundance appeared somewhat higher on the Central Transect (mean = 3,156/m^2) than on either the Eastern (mean = 2,695/m^2) or Western Transect (mean = 2,100/m^2). Based upon the data from the Central Transect, spring abundance levels (3,156/m^2) appeared higher than fall abundance levels (mean ranged from 1,657 to 1,987/m^2). The annual difference between the fall collections of 1983 and 1984 on the Central Transect and the spring collection of 1984 and 1985 on the Eastern Transect were 330 and 169/m^2, respectively. This compares to regional differences, ranging between 461 and 1,056/m^2, and seasonal differences, ranging from between 1,169 to 1,499/m^2. Annual differences appear less than regional and seasonal variations in abundance.

On both the Eastern and Western Transects, an overall decline in macrofaunal density with depth was clearly indicated, even though there were some exceptions at the shallower of the sampled depths. On the Central Transect, the observed trend of abundance decrease with depth was interrupted by an apparent abundance peak at the 1,400-m-deep station. Increased sampling intensity on the Central Transect not only validated the 1,400 m peak, but yielded data suggesting the even higher abundance was present at about 1,000 m depths. These apparent differences will be examined in detail in the Year 4 Final Report. Suffice to say now that we believe the "anomalous" abundance peaks are related to physiography and/or proximity to chemosynthetic seep communities.

Results of sampling along the isobaths in both the Eastern and Western Transects yielded consistent results in terms of overall density, except for some of the planned contrasts of sediment type, proximity to seep communities, and topographic features. The exceptions were unexpectedly low densities at Stations E2d and E3 on the Eastern Transect. All of these differences (those accountable by design and those unexpected) will be evaluated in the Year 4 Final Report.

MACROFAUNA DIVERSITY PATTERNS

The diversity evaluations made in this report are based upon comparisons of the H" index applied to data for species only. From review of these data and supporting indices (evenness and richness), it is apparent that most of the difference in the overall index is attributable to the richness aspect, which is greatly influenced by sample size. In the Year 4 Final Report, rarefaction analysis will be used to offset the confounding effects of sample size on the diversity evaluations.

The regional, seasonal, and yearly patterns of macrofaunal diversity by depth also showed distinct trends. Although the trends are not pronounced, diversity appeared to decrease from east to west, and to have been somewhat higher in fall than in spring on the Central Transect. Differences in fall diversity levels between years on the Central Transect were negligible, but spring 1985 diversity levels on the Eastern Transect were marginally higher than spring 1984 levels.

The most consistent depth trend was a marked decrease in diversity between the 1,400 m deep and 2,600 m deep stations on each transect. There also appears to be a tendency of a slight diversity increase between the shallowest station (~350 m) and some of the sequentially deeper stations, which yielded somewhat skewed, dome-shaped diversity curves over the depth range sampled.

The data obtained from sampling a higher density of stations on the Central Transect in Fall 1984 enabled a more detailed examination of macrofauna diversity levels over the sampled depth interval. Diversity appeared to increase slightly from Station 1 (355 m) to Station 3 (850 m), and from there decreased with depth down to Station 9 (1,428 m). A slight peak was observed at Station 4 (1,465 m), after which the diversity level once more declined gradually over depth interval between 1,465 m and 2,945 m.

Macrofauna diversity levels were rather constant along the sampling isobaths in both the eastern and western regions where these studies were conducted. Additionally, there appeared to be very little variation by depth, at least within the intervals sampled.

Diversity indices such as H" often suffer the criticism that they can be biased by sample size. Rarefaction is an approach towards eliminating this bias. In the approach, the sample data are used to estimate the expected number of species represented by a given sample size. Trends in expected number of species, E(S), for a sample of 50 individuals mirrored the findings obtained from use of the H" diversity index.

Comparisons of the overall macrofauna density and diversity levels from the Gulf of Mexico Continental Slope show the Gulf to be rather depauperate as compared to the Atlantic.

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Distribution and Abundance: Patterns of Meiofauna

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INTRODUCTION

Meiofauna was defined as metazoan organisms retained on a 0.063 mm sieve after passing through a 0.3 mm sieve. Sediments were collected using four *in situ* metal tubes (3.1 cm I.D.) installed in a box corer. The upper 5 cm of sediment and overlying water were placed in sample jars and narcotized in an isotonic solution of magnesium sulfate. The sample was then preserved by adding enough neutral buffered formalin (with rose bengal added) to make a 5 percent formalin solution. In the laboratory, two samples from each box core were gently rinsed through nested 0.3 and 0.065 mm sieves. The sediment and organisms retained on the 0.065 mm sieve were carefully placed in sorting dishes containing water. All organisms were removed and sorted into major taxa using a dissecting microscope at about 70X. Meiofaunal biomass was estimated based upon published literature values for the size ranges of organisms found in our samples.

A total of 43 taxonomic groups were identified from the samples collected at 59 stations. Five taxonomic groups, along with nauplii larvae, accounted for 98 percent of the individuals counted. Nematodes were the most abundant, 59 percent of total collection, followed by harpacticoid copepods (18 percent), nauplii (13 percent), polychaetes (4 percent), ostracods (3 percent) and kinorhynchs (1 percent). Although numerically abundant, nematodes and harpacticoids accounted for only 20 percent (10 percent each) of the estimated meiofaunal biomass. From a biomass standpoint, polychaetes were the most important group representing about 46 percent of the meiofaunal wet weight from a typical sample. Ostracods ranked second in biomass and accounted for about 21 percent of the estimated wet weight.

ABUNDANCE PATTERNS

Meiofaunal densities were compared using the design for data analysis described earlier, based on four sets of experimental designs. The first comparison describes region-season-year contrasts by depth. Densities ranged from 125 to 1,141 organisms/10 cm^2 with generally higher densities observed on the Central Transect than on the Eastern and Western Transects. In virtually all cases, meiofauna density decreased with depth, with densities at 2,600 m about one-half the density levels observed at 350 m. Similar declines in meiofaunal abundance with depth were observed in the Central Transect during Cruise III.

Sampling along the isobaths in the eastern Gulf showed that meiofaunal density was slightly higher at 350 m (mean density = 750 organisms/10 cm^2), but not greatly different from density levels observed at the 625 and 850 m deep stations (mean densities were 594 and 671 organisms/10 cm^2, respectively). In the western-central Gulf region, densities varied little with depth or topographic feature. Shallow (325 m) and deeper (1,250 m) stations had similar and lower density than was observed for stations at intermediate depths (550 and 750 m).

TAXONOMIC COMPOSITION

The relative abundance patterns among the major taxonomic groups remained consistent across the stations sampled. Most variation in overall density was explained by changes in all groups rather than changes in one or two groups. The low level of taxonomic resolution, however, did not allow detection of changes in species abundance.

MEIOFAUNA - MACROFAUNA RELATIONSHIPS

Densities of meiofaunal groups such as ostracods and polychaetes showed similar patterns of distribution with depth as did their macrofaunal counterparts, although the meiofaunal group were at least an order of magnitude greater in abundance. Harpacticoids and nematode density relationships were more variable with some instances showing inverse relationships in abundance patterns.

Over the 59 stations sampled, there was a decrease in abundance and biomass of both macrofauna and meiofauna with depth, a pattern that has been noted in other studies of the slope and deep sea fauna. Numerical density of meiofauna was at least an order of magnitude higher than macrofauna density, but biomass estimates were similar.

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Distribution and Chemistry of Chemosynthetic Ecosystems

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The northern Gulf of Mexico continental slope is the site of a number of unique discoveries in the last few years. Active seepage of oil to the sea surface has been observed in the Green Canyon (GC) 184/185 and 190/234 areas. In at least one of these areas, extensive molecular and isotopic analyses have demonstrated that the petroleum in shallow sediments and surface oil slicks is derived from reservoirs more than 6,500 ft. deep in the subsurface. Ten locations on the Louisiana slope (530 to 2,400 m water depth) have currently been identified that contain either biogenic or thermogenic gas hydrates in shallow cores. Analysis of bitumens from several thousand cores on the continental slope suggests that seepage is a widespread phenomena on the Gulf of Mexico continental slope. This seepage drives large populations of chemosynthetic-based organisms. A number of new species of tube worms and bivalves are being described from the trawl and submersible collections at these sites.

Trawling in these areas has identified tube worms and bivalves containing chemosynthetic bacterial endosymbionts (Kennicutt et al., 1985; Childress et al., 1986; Brooks et al., 1986, 1987a,b). These discoveries significantly expand the geographic area of the deep ocean where one might expect to encounter dense populations of vent-type taxa. Subsequent studies on the upper Gulf of Mexico continental slope using submersibles and surface ships have

1. Identified chemosynthetic organisms (either tube worms, mussels and/or clams) at 17 northwestern Gulf of Mexico continental slope sites;
2. Confirmed, based on enzyme activities, elemental sulfur content, and electron microscopy, that tube worms and clams from these sites do contain chemoautotrophic, bacterial endosymbionts;
3. Found a mussel that is potentially capable of utilizing methane as its sole carbon and energy source (the first demonstrated symbiosis between a methanotrophic bacteria and an animal);
4. Identified shallow seismic "wipe-out" zones as high probability sites for chemosynthetic ecosystems;
5. Shown that oil seepage is associated with all chemosynthetic ecosystem located to date;
6. Demonstrated that carbon, nitrogen and sulfur isotopes can be useful in differentiating heterotrophic, sulfur-based and methane-based ecosystems;
7. Identified the transfer of carbon from the chemosynthetic ecosystem to background heterotrophic organisms;
8. Discovered ten gas hydrate and several active oil seepage locations in the Gulf of Mexico; and
9. Determined that shell beds are being produced in, and around, areas of petroleum seepage.

Three series of dives have been conducted at the hydrocarbon seep communities. The first six dives aboard the Johnson-Sea-Link were funded by the Minerals Management Service (MMS) in September 1986. These dives were followed by a large survey using the NR-1 (March 1987). Based on these results, National Undersea Research Program funded a dive series (Dives 2053-2077) in June 1987 aboard Johnson-Sea-Link. The goals of these dives were continued studies to refine the description of the distribution and abundance of organisms around the seep sites; description of the sediment, water and hydrocarbon chemistry around the animals; and documenting the importance of chemosynthesis for these animals using biochemical, physiological and isotopic methods. The ecological components of the proposed series of dives were designed to describe the distribution of organisms within these ecosystems and the factors controlling the observed distributions.

Twelve discrete streams of gas bubbles from the seep sites have been collected and analyzed. As a percent of C_1 to C_5 hydrocarbons, all gases collected were predominantly methane (Table 7.1). Other than the hydrate, methane accounted for more than 94 percent of the C_1 to C_5 hydrocarbon gases. The hydrate gases contained ~30 percent C_1 to C_5 gases. The highest percentage methane gas (99.4 percent) and the second isotopically lightest gas (-52.9 $^{o}/_{oo}$) were collected at GC-272. In general, the isotopically heavier gases were collected GC-184 and GC-234, but a substantial range in values was observed (-37.6 to -53.9 $^{o}/_{oo}$). The gases sampled as discrete streams of gas bubbles were a mixture of thermogenic and biogenic gases. Analyses are not complete enough to evaluate variations in mussel tissue carbon isotopic composition as a function of variations in the source methane carbon isotopic composition.

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Fine-Scale Distribution Patterns of Chemosynthetic Organisms

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Video tape records, sediment cores, and water samples were collected during four dives by the submersible Johnson-Sea-Link. The dive site was a small diapir located at 560 m depth southwest of Grand Isle, Louisiana (27 degrees 46'N and 91 degrees 30'W). The diapir is the location of a natural oil seep that supports an abundant community of chemosynthetic tube worms and mussels.

The percent cover of both tube worm bushes (Lamellibrachia sp.) and mussels (?Bathymodiolous sp.) were estimated along video transects leading to, and from, stations where water and/or sediment samples were collected for areas at two radial intervals away from the stations (0 to 7.5 m and 7.5 to 15 m). These estimates were then compared to the values for methane and extractable organic material (EOM) obtained at each site by use of a non-parametric (Spearman's) statistic. The results show a significant correlation (alpha=0.05) between high concentrations of methane in the water column above the sediment and high densities of mussels within the inner sampled interval, but do not show significant correlation between higher densities of tube worms at each direction (Figure 7.3a). When percent cover of tube worms and mussels were compared with concentrations of EOM in the sediments, the situation was reversed; a significant correlation between tube worm density and EOM was seen at the inner distance, not the outer, and mussel densities were not correlated with EOM concentrations (Figure 7.3b).

The percent cover of tube worm bushes was estimated as continuous one-dimensional functions along the video transects by means of an appropriate, non-parametric smoothing technique. These functions were then extrapolated by means of a distance-weighted moving average of the one-dimensional estimates to provide a two-dimensional estimate to tube worm cover throughout the sampled area (Figure 7.4). The results suggest that the distribution of tube worms forms a roughly north-south linear pattern with two nodes of high density. The pattern of distribution does not conform to the topography of the diapir.

Mr. Ian Rosman received a master's in fisheries sciences from Texas A&M University in 1983. He was employed by LGL Ecological Research Associates, Inc., between 1984 and September 1987, at which time he returned to Texas A&M University to pursue a doctorate in biological oceanography. His principal research field is analysis of underwater imagery.

Mr. Gregory S. Boland received the master's of science in biological oceanography from Texas A&M University in 1980. He has extensive experience in scientific diving, underwater photography, and marine electronics. He is presently employed at Texas A&M University as an oceanographic research technician.

Dr. Robert S. Carney is chairman of the department of Ocean Sciences and director of the Coastal Ecology Institute at LSU. He received his B.S. in zoology (1967) at Duke University and oceanography degrees at Texas A&M University (M.S., 1971) and Oregon State University (Ph.D., 1977). As a deep-sea benthic ecologist, his interests include the scientific basis for policies dealing with environmental impact in the deep-sea, the structure of detritus feeding communities, and hydrocarbon seep ecology.

Physiology of and Death Assemblages Formed by Animals at Petroleum Seeps

Dr. Eric N. Powell,
Ms. Audrey Morrill,
Ms. Susanne McDonald,
Mr. Russell Callender,
Dr. George Staff,
and
Mr. David Davies
Texas A&M University

Two distinctive groups of sulfide-dependent animals have been described: macrofauna associated with hydrothermal vent/cold sulfur seeps/petroleum seeps, and thiobiotic meiofauna associated with the sulfide system of shallow-water marine sands. These two groups offer an important contrast in adaptations to, and use of, sulfide. As examples, meiofauna live under anoxia, seep species under oxia. Metabolism is basically aerobic in the macrofauna. It cannot be among the meiofauna. Hence, terminal electron acceptors and many oxido-reductive (e.g., sulfide oxidation) pathways must differ. There are two, not necessarily mutually exclusive, ways to deal with sulfide. (1) It can be sequestered or detoxified. This mechanism is common among the macrofauna and exists as well among the meiofauna. (2) The alternative is a sulfide-insensitive metabolism. Thiobiotic meiofauna have apparently utilized this alternative to a much greater extent than the macrofauna. For example, aerobic metabolism is cyanide- and sulfide-sensitive in the macrofauna. In meiofauna, quite the opposite is true. Hence, the two groups of animals have quite different adaptations to what are substantially different types of extreme environments.

We examined the oxygen detoxificatory enzyme, catalase, in thiobiotic meiofauna, normal oxybiotic macrofauna, and petroleum seep macrofauna. Catalase is present in high activities in thiobiotic meiofauna despite the absence of oxygen where they live. Those species living in the most sulfitic sediments have the highest activities. As far as we know, all known catalases, prokaryotic or eukaryotic, are inhibited by azide and 3-amino-1,2,4-triazole, with one exception. A group of lactobacilli contain a non-heme azide and 3-amino-1,2,4-triazole insensitive pseudocatalase. The group is also sulfide insensitive. Sulfide is a potent inhibitor of true catalases. The catalase of thiobiotic meiofauna is also azide and 3-amino-1,2,4-triazole insensitive. Whether or not it is a true catalase is unclear, but we presume, by analogy with the pseudocatalase of lactobacilli, that it too is sulfide insensitive.

In contrast, with one exception, seep species generally have low catalase levels, probably because oxygen is below saturation and light (a potent oxygen-radical producer in seawater) and is absent. The exception is the mussel that harbors methane-oxidizing symbionts. These mussels exhibit significantly higher catalase activities than clams, gastropods, or tube worms. Methane oxidation probably produces oxygen radicals. All catalases of petroleum seep species were inhibited by 3-amino-1,2,4-triazole, indicating that they are normal catalases. Hence, here too, the tendency exists for thibiotic meiofauna to adopt a sulfide-insensitive metabolism, whereas macrofauna of vents and seeps retain the sulfide-sensitive counterparts.

Seep sites are of great interest to paleontologists because they are locations where shell accumulations are potentially preservable in the fossil record. The continental shelf is generally accepted as an environment in which shell beds accumulate. Many ancient analogues have been studied and a variety of hypotheses have been proposed to explain their formation. Most of these mechanisms either involve low sedimentation rate, high carbonate production and gradual burial, or "events" producing storm deposits (tempestites). However, ongoing investigations of portions of the Texas continental shelf have revealed no such widespread accumulations. In fact, shells are accumulating today only in the very nearshore above storm wave base. And even here, shell beds are rare. Our data indicate that only through storms reworking shell material are any shells preserved in Texas bays, inlets, or on the continental shelf. The simple reason is that acid production in marine sediments is sufficient to dissolve all accumulating carbonate at the sediment surface in most clastic environments. Only by rapid burial well beneath the sediment surface can shells be preserved.

Petroleum seeps offer the single important exception in the western Gulf of Mexico. Only here are shell beds being formed. And only here are shell beds apparently being formed by accumulation at the sediment surface and gradual burial. Two biofacies offer the best chance for preservation: the mussel biofacies and the clam biofacies. A mixed biofacies, clams and mussels, rarely occurs. The clam biofacies is composed primarily of vesicomyid and lucinid clams plus some gastropods. The clams show low incidences of abrasion and dissolution but a high breakage frequency. Mussels, in contrast, have both high breakage and dissolution frequencies, indicating a poorer preservation potential which is, in fact, observed as a much higher live-to-dead ratio in this biofacies.

Taphofacies analysis has become an important paleoecological and paleoenvironmental tool. No taphofacies model exists for recent communities, however. We are currently developing one for the Texas shelf and estuarine system. Taphonomic signature of the seep fauna is considerably different from that of the shallow shelf and bay faunas. Articulated shells are much more numerous than on the continental shelf or inshore in inlet and beach environments. Breakage frequency is also high, probably indicating a greater impact of crab predation in this environment. Dissolution, in contrast, is lower than on the shelf or in inlets, and abrasion frequency is considerably lower than in the beach/inlet taphofacies. Consequently, the petroleum seep taphofacies, formed by gradual accumulation of shell material on and near the sediment surface, is markedly different from other taphofacies of the western Gulf of Mexico, which owe their origin to a much larger extent to storms, sediment reworking, and burial.

Dr. Eric Powell is a professor of oceanography at Texas A&M University. He has conducted research on the effects of drilling muds on corals, metabolic adaptations to sulfide stress in thiobios, death assemblage formation in Texas bays, and the metabolic and ecological effects of parasitism in oysters. Dr. Powell is one of the investigators in the Gulf of Mexico group of NOAA's Status and Trends program and the Texas Sea Grant Program to study parasitism in oyster populations. He is currently conducting research on the ecology and paleoecology of petroleum seeps or the Texas continental shelf.

Ms. Audrey Morrill is a graduate student at the University of Texas Medical Branch in Galveston. She has conducted research on the biochemistry of thiobiotic organisms, emphasizing oxygen detoxification. She is currently working in the Department of Human Cell Genetics at UTMB.

Ms. Susanne McDonald is a graduate student in the Department of Oceanography at Texas A&M University. Her research involves the adaptations of petroleum seep organisms to the high-hydrocarbon environment. She is currently working on the uptake, depuration, and metabolism of polynuclear aromatic hydrocarbons by mussels and clams of petroleum seeps.

Mr. Russell Callender is a graduate student in the Department of Geology at Texas A&M University. He obtained his master's degree at Stephen F. Austin University where he worked on methods for reconstructing the trophic structure of paleocommunities. He is currently studying the taphonomy and ecology of petroleum seep faunas.

Dr. George Staff is a visiting assistant professor in the Department of Geology at Texas A&M University. He has conducted extensive research on the formation of death assemblages in Texas bays. He is currently involved in an NSF-sponsored project to study the formation of death assemblages on the continental shelf off Texas and the development of a taphofacies model for the Texas coastal zone.

Mr. David Davies is a graduate student in the Department of Geology at Texas A&M University. He currently holds a NOAA Sea Grant Marine Fellowship. His research involves the investigation of taphonomic processes and 'event' deposition in the Texas coastal zone. He has developed the analytical technique for taphofacies analysis currently being used in investigations of the petroleum seep taphofacies.

Selected Aspects of Chemosynthetic Community Ecology: Issues in the Making

Dr. Robert S. Carney
Louisiana State University

The Louisiana continental slope chemosynthetic communities associated with hydrocarbon seeps are one of a series of discoveries of functionally and taxonomically related assemblages in the deep-sea. All of these communities share the common feature of being associated with sources of methane or hydrogen sulfide in an oxygenated environment; the underlying geological processes supplying these reduced compounds vary from site to site. These communities are the focus of intense international research, and many of the questions to be asked in the Gulf of Mexico have already been identified in previous efforts elsewhere.

1. What are the detailed geological, chemical, and ecological processes whereby seeping hydrocarbons support distinct communities in rather restricted locations?
2. How do these communities persist, and to what degree do physical-chemical and biological factors interact on spatial and temporal scales?
3. How do the component species reproduce, disperse, and then successfully recruit into new or existing communities?

In the Gulf of Mexico, however, we are faced with the question of environmental impact upon a fauna that is uniquely associated with exploitable hydrocarbon reserves. For the most part, basic deep-sea ecology provides us with little guidance on how to proceed. While the three basic questions listed above are extremely important, taken alone, they can not answer the question of potential impact.

The issue of impact can be approached from one of two opposing views.

1. A Robust Community--Since these communities are associated with petroleum, then they may be uniquely immune from impact by hydrocarbons. In such a case, simple restrictions to prevent mechanical damage might be sufficient.
2. A Fine Tuned Community--Alternately, it can be argued that these communities occupy a very narrow niche associated with different phases of petroleum degradation. Being so very highly specialized, these communities are supported by a narrow range of environmental conditions might be very easily altered by drilling and production activities. Indeed, production may result in a loss of the very energy source required by these communities.

While the Robust Community approach is attractive from the managerial perspective, current evidence suggests that these communities are very fined tuned. This is evidenced by the complex spatial distribution of the communities with respect to geological and chemical factors and the variable species composition of adjacent assemblages.

The highest priority future impact work must develop a detailed understanding of the spatial and temporal pattern of hydrocarbon seepage at the seafloor. Given this knowledge of the pattern of energy supply, ecological investigations must determine how communities are established and persist. When the interplay of geochemical and biological factors is understood, then impact can be predicted, minimized, or avoided.

Rather than make specific recommendations as to how sensitive to impact the chemosynthetic communities might be, it is informative to review the success of basic ecological research on related communities elsewhere. In spite of a decade of well funded research conducted by the best international scientists, we still lack a full understanding of the processes that produce communities at seep sites. While the metabolic systems are increasingly well known, ecological aspects such as recruitment, reproduction, the role of competition and predation, etc., are only sketchily known. When designing work in the Gulf of Mexico, we have to carefully question why progress has been so slow.

The slow rate at which the ecology of seep communities is being understood is a function of several problems. First, the seep systems are so unlike other deep-sea communities that initial research was inappropriately designed. Second, systems in 3,000 m+ water are logistically hard to work with. Third, excitement over geochemical and metabolic discoveries has resulted in assigning a lower priority to ecological questions.

The key to understanding potential impacts lies in understanding how the supplies of chemical energy interact with the biological processes. Whatever approach is taken, it must employ new technologies and employ innovative designs. In the Gulf of Mexico, we enjoy three advantages that can be exploited in future work.

1. These sites are relatively shallow (less than 1,000 m). As a result, a variety of study methods is possible.
2. The processes that supply hydrocarbons are not totally unknown and are the subject of active research.
3. Management needs will result in the appropriate priorities focusing upon the geochemical-ecological link.

Dr. Robert S. Carney is chairman of the department of Ocean Sciences and director of the Coastal Ecology Institute at LSU. He received his B.S. in zoology (1967) at Duke University and oceanography degrees at Texas A&M University (M.S., 1971) and Oregon State University (Ph.D., 1977). As a deep-sea benthic ecologist, his interests include the scientific basis for policies dealing with environmental impact in the deep-sea, the structure of detritus feeding communities, and hydrocarbon seep ecology.

FROM / TO	HYDROGRAPHY	SEDIMENT	HYDROCARBONS	HABITAT	MEIOFAUNA	MACROFAUNA	MEGAFAUNA	BENTHIC PHOTOGRAPHY	CHEMOSYNTHETIC COMMUNITIES	SYSTEMS ECOLOGY
HYDROGRAPHY	Provide hydrographic data for habitat and ecology analyses									
SEDIMENT		Provide sediment data for habitat and ecology analyses								
HYDROCARBONS			Provide hydrocarbon levels in sediments and biota							
HABITAT	Nutrient levels Temperature DO Salinity Depth Distance	Grain size TOC $CaCO_3$ Delta ^{13}C	PL-1 Alkane PL-LO Alkane PE-H Alkane Terrigenous UCM CPI	Define benthic habitats and important factors HC level	Biomass levels			Lebensspuren densities Hard subs. Currents Bottom char.	Petroleum seep description sources	
MEIOFAUNA				Habitat distribution factors for correlation	Define distribution, abundance and relate to environmental factors and macrofauna	Biomass levels				
MACROFAUNA				Habitat distribution factors for correlation		Define distribution, diversity and abundance and relate to environment				
MEGAFAUNA			HC levels in tissues	Habitat distribution factors for correlation		Relative abundance of prey species	Define distribution, diversity and abundance relate to environment, present HC levels, life history			
BENTHIC PHOTOGRAPHY							Megafauna densities	Define distribution and abundance of megafauna, evaluate methods life history		
CHEMOSYNTHETIC COMMUNITIES		Delta ^{13}C	Carbon sources and seep distribution				Observations of chemosynthetic organisms	Observation of chemosynthetic organisms	Provide an overview of chemosynthetic communities in GOM	
SYSTEMS ECOLOGY	Watermass characterization	Delta ^{13}C carbon sources and flows	Carbon sources and flows	Habitat distributions areal extent	Biomass levels	Assemblages Biomass levels feeding types	Assemblages key env. factors biomass estimates	Megafauna density	Community descriptions ecology trophics	Develop conceptual models of the slope ecosystem

Figure 7.1.--Information management matrix for Year 4 Final Report for the MMS Gulf of Mexico Continental Slope Study.

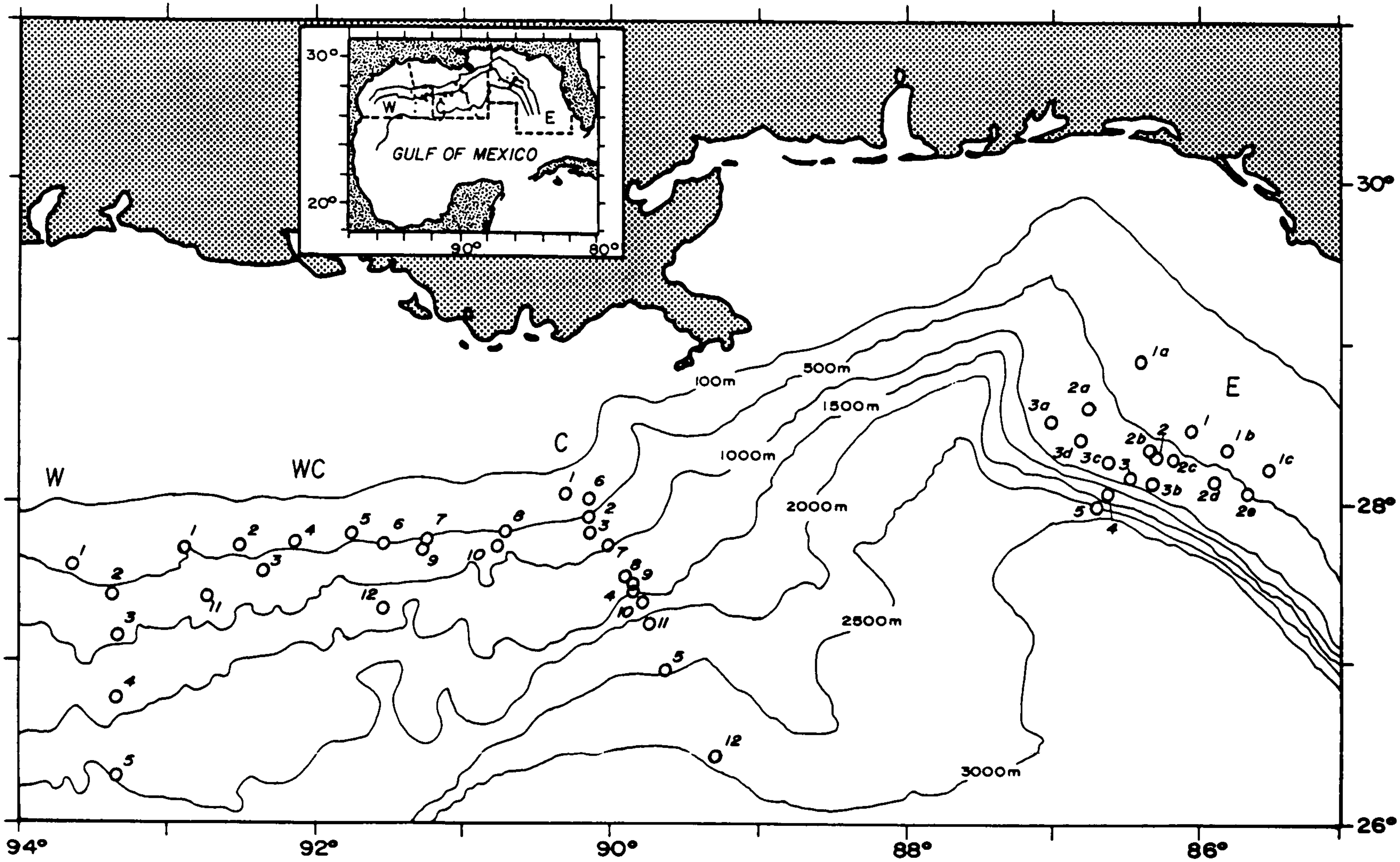

Figure 7.2.--Study area for the Gulf of Mexico Continental Slope Study showing locations of sampling stations.

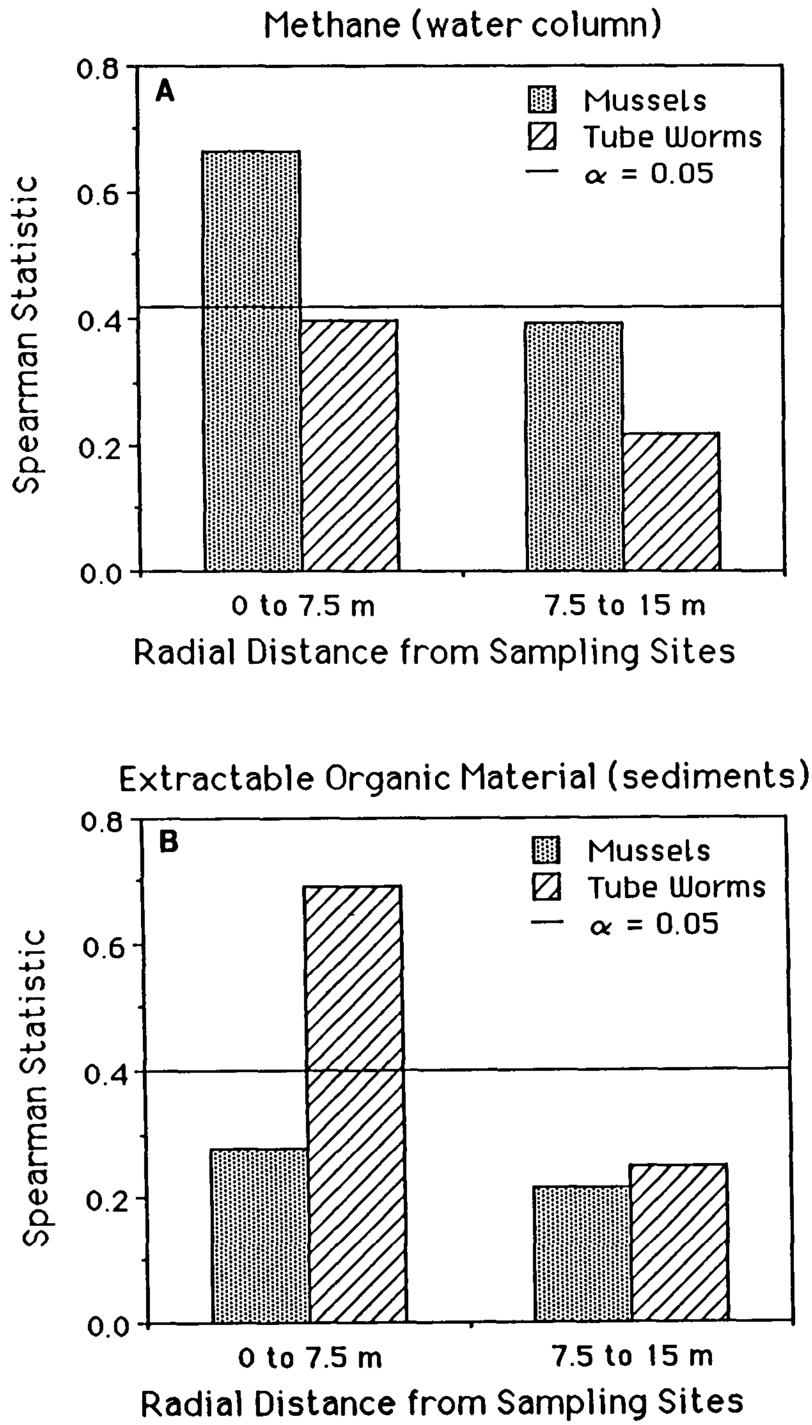

Figure 7.3.--Correlation of percent cover of mussels and tube worms at 12 water sampling stations and 13 sediment sampling stations. The statistic measures the tendency for higher percent cover of the organisms to occur with a) higher concentrations of methane in the water column close to the sediment, and b) higher concentrations of extractable organic material in the sediment samples.

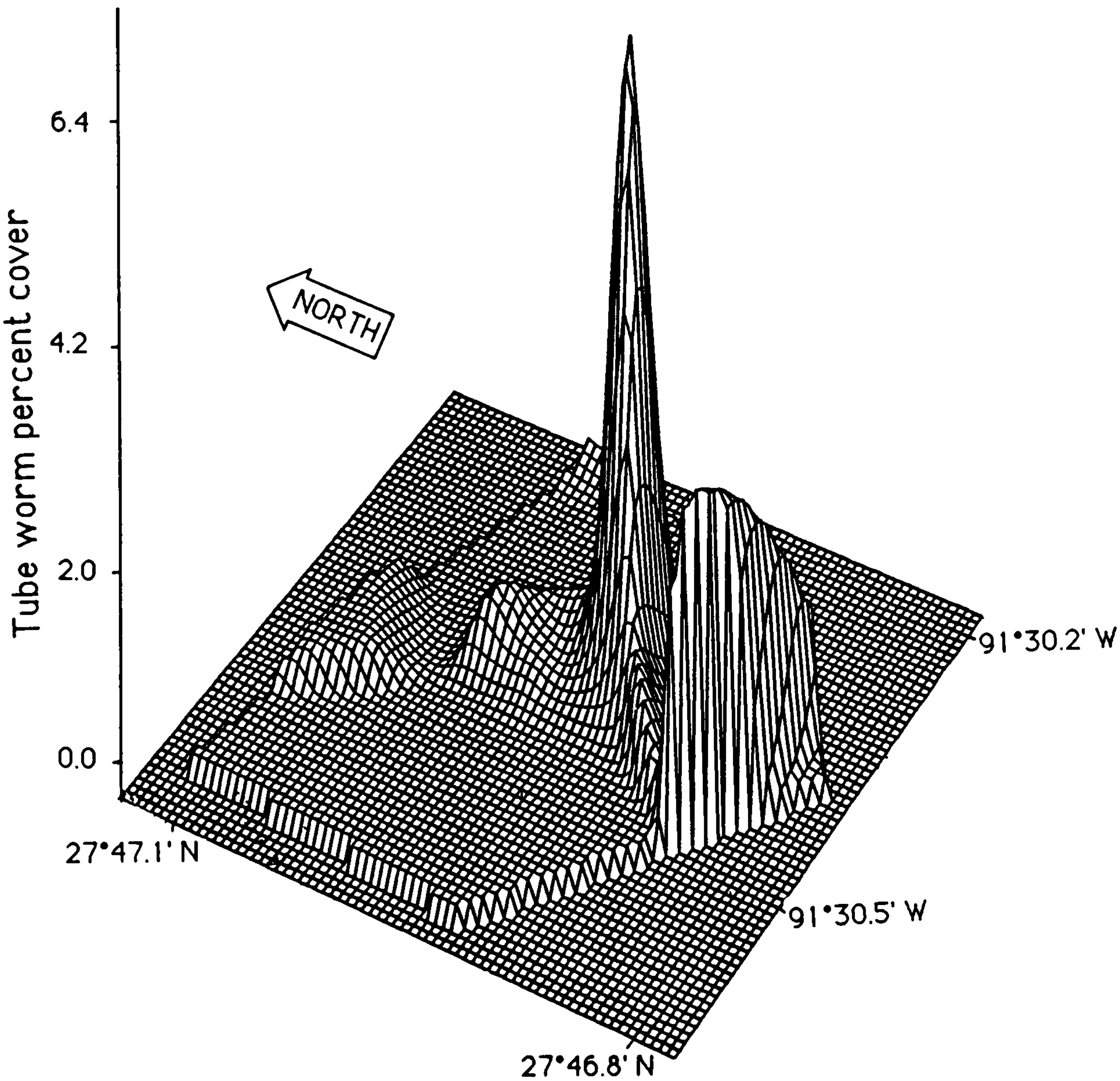

Figure 7.4.--Surface formed by the estimated distribution of tube worm density, measured as percent cover, throughout the area covered by video sampling.

Table 7.1.

Molecular and Isotopic Analysis of Gas Collected
from Bubbling Seeps on the Gulf of Mexico Continental Slope

Sea Link Dive #	Dive Location	Site Description	Methane (%)	Ethane (%)	Propane (%)	C1/(C2+C3)	C-13-CH4 (‰)
2057	GC-234		97.996	1.310	0.540	53.0	-53.9
2061	GC-234	Hydrate	69.342	11.702	12.297	2.9	-44.2,-44.3
2061	GC-234	Mussel & Tubeworms	95.134	3.390	0.881	22.3	-37.6,-37.6
2061	GC-234		95.412	3.252	0.822	23.4	
2062	GC-234		94.595	3.404	1.021	21.4	-51.8,-50.7
2062	GC-234	Mussel site	95.123	3.211	0.906	23.1	-47.0,-46.6
2062	GC-234	Mussel site	94.987	3.270	0.934	22.6	-53.0,-50.8
2063	GC-234	Tubeworm site	95.851	2.985	0.675	26.2	-51.8,-51.8
2063	GC-234	Tubeworm site	95.791	3.031	0.696	25.7	-47.6
2071	GC-272	Clam site	99.446	0.479	0.043	190.6	-52.9,-51.3
2074	GC-184		94.590	3.344	1.435	19.8	-51.3
2074	GC-184	Mussel site	94.452	3.413	1.471	19.3	-46.8,-46.8

SOUTHWEST FLORIDA SHELF ECOSYSTEMS STUDIES

Session: SOUTHWEST FLORIDA SHELF ECOSYSTEMS STUDIES

Co-Chairs: Dr. Robert M. Avent
Dr. Larry J. Danek

Date: December 2, 1987

Presentation	Author/Affiliation
Southwest Florida Shelf Ecosystems Studies: Session Overview	Dr. Robert M. Avent Minerals Management Service Gulf of Mexico OCS Region and Dr. Larry J. Danek Environmental Science and Engineering, Inc.
Program Objectives and Design	Dr. Larry J. Danek Environmental Science and Engineering, Inc.
Live-Bottom and Soft-Bottom Biota of the Southwest Florida Shelf	Dr. Neal W. Phillips Continental Shelf Associates, Inc.
Physical and Chemical Oceanography of the Southwest Florida Shelf	Dr. Larry J. Danek and Mr. Michael S. Tomlinson Environmental Science and Engineering, Inc.
Benthic Habitats of the Southwest Florida Shelf	Dr. Neal W. Phillips Continental Shelf Associates, Inc.
Dynamic and Biotic Processes as Seen with Time-Lapse Photography	Mr. Michael S. Tomlinson Environmental Science and Engineering, Inc.
Ecosystem Models of Valued Ecosystem Components	Dr. Benny J. Gallaway LGL Ecological Research Associates, Inc.

Southwest Florida Shelf Ecosystems Studies: Session Overview

Dr. Robert M. Avent
Minerals Management Service
Gulf of Mexico OCS Region
and
Dr. Larry J. Danek
Environmental Science and Engineering, Inc.

Dr. Avent welcomed the audience and gave a brief introduction. This session was the final series of public addresses describing the results of a six-year research program to understand the habitats, biota, and selected ecological processes on the southwest Florida continental shelf. The program was conducted by three prime contractors: Woodward-Clyde Consultants, Inc. (WCC; Years 1 and 2, Year 2 modification); Continental Shelf Associates, Inc. (CSA; Year 3); and Environmental Science and Engineering, Inc. (ESE; Years 4, 5, and 6). Subcontractors included CSA (Years 1, 2, 6); Mote Marine Laboratory (Years 1, 2, and 3); LGL Ecological Research Associates, Inc. (Years 4, 5, and 6); Skidaway Institute of Oceanography (Year 2 modification); and Florida Institute of Oceanography (Years 1 through 5, ship support). Virtually all reports and other deliverables have been received for all years of the study. The program evolved considerably, following the first year's sampling effort, reflecting the state of knowledge and the need to close information gaps.

Dr. Larry Danek presented the first paper, a "Revision of Program Objectives and Design." The objectives of the six-year program were to

1. determine the location and distribution of benthic habitats and associated communities;
2. determine the seasonal structure and density of selected live- and soft-bottom communities;
3. compare community structure of live and soft-bottom fauna and flora to determine the differences and similarities between them and their dependence on substrate type;
4. determine and compare the hydrographic structure of the water column and bottom conditions at selected sites within the study area;
5. determine and compare sedimentary character at selected sites within the study area, and estimate sediment transport;
6. relate differences in biological communities to hydrographic, sedimentary, and geographic variables; and
7. provide information on dynamics of selected live-bottom communities and determine the major factors that influence their development, maturation, stability, and seasonal variability.

The study area is shown in Figure 8.1.

The program began in 1980 with geophysical characterizations (shallow seismic, side-scan sonar, and bathymetric transects), which were used to identify habitats and community types for future station selection and sampling. Seasonal sampling and additions of transects (as needed) continued into Year 5 but were finished, for the most part, in Year 3. Years 4 and 5 were primarily devoted to the study of benthic processes through the deployment of benthic instrumented arrays to observe and measure biotic change, sediment transport, and current regime in selected "live" bottom community types. Year 6 was a data synthesis effort that included conceptual modeling of the effects on 15 "valued ecosystems components."

Dr. Neal Phillips presented a description of "Live-Bottom and Soft-Bottom Biota of the Southwest Florida Shelf." Over the five field years of this study, 26 live-bottom and 29 soft-bottom stations were sampled using conventional net, dredges, and grabs, and by divers. Depths ranged from 10 m to 159 m and sampled all known habitats in the region. At least 1,497 species were collected in dredges and trawls, and 1,121 in grab samples (with some overlap). Infaunal abundance varied from about 1,000 to 1,400 individuals/m2. Correlations were made between community types and character and environmental conditions (e.g., temperature, light sediment type and thickness, nutrients, and season). Distribution was described for ten community types and six habitats.

Dr. Danek returned to describe the "Physical and Chemical Oceanography of the Southwest Florida Shelf" (co-authored by Mr. Michael S. Tomlinson). In this primarily biological program, all involved recognized the role of abiotic factors that influence the distribution, diversity, and density of biotic communities. The southwest Florida shelf sediments are predominantly calcareous except for a narrow band of quartz sand close to shore. Sand predominates except for a few isolated pockets of carbonate muds to the south. Hard substrate is generally overlaid by a veneer of sand, often quite thin, and exposed rock is uncommon. Sediment resuspension is high during period storms at shallow stations. Little lateral sediment transport was observed. Wave action is variable, with a normal range of 0-5 m. Tides are mixed and weak, usually <0.7 m in height. Currents tend toward the south ~10 to 30 cm/sec, except during Loop Current or eddy intrusion. Energy spectrum and cumulative vector plots were displayed showing current patterns in shallow and moderate depths. Area waters are generally nutrient poor and uncontaminated by man-induced hydrocarbons. Isopleths of nutrients indicate some upwelling at greater depths, which are induced by the Loop Current.

Dr. Neal W. Phillips returned to discuss "Benthic Habitats of the Southwest Florida Shelf." Six major habitats are present on the shelf:

1. High-relief hard bottom.
2. Low-relief exposed or thinly covered hard bottom
3. Thick sand bottom.
4. Coralline algal nodules.
5. Coralline algal pavements.
6. Shell rubble.

Dr. Phillips described the physiography of the area, its ancient reef complexes, and post-pleistocene geological history. He further described the distribution of these habitats, their influence on epifaunal communities, and other controlling factors (light, temperature, and nutrients).

Mr. Michael S. Tomlinson presented a paper, "Dynamic and Biotic Processes as seen with Time-Lapse Photography", which a compilation and interpretation of visual records taken during Years 4 and 5. Time-lapse cameras were affixed upon up to eight instrumental arrays, which were periodically serviced. Eight millimeter film, frames taken one hour apart, recorded numerous biotic and abiotic events over two years. Time-lapse photography provided valuable information on processes that correlated well with current, wave, and sediment resuspension data taken by current meters, wave gages, and sediment collection tubes, respectively. Time-lapse photography also yielded valuable data on fish and turtle abundance, relative abundance, residence times, diel activities, bioturbation, and biofouling rates and succession.

In the final presentation, "Ecosystem Models of Valued Ecosystem Components," Dr. Benny J. Gallaway described activities during the last program year. As a first step, regional-scale community descriptions were developed including evaluation of abiotic factors, biotic associations, and trophic relationships. Key limiting abiotic factors were judged to be light, temperature, and substrate type. Community types were defined in terms of the longer-living sessile organisms and associated fauna. Depth and the four main biological zones were considered.

Community zonation included nearshore ($\leq$ 10 m), inner shelf (10 to 45 m), middle shelf (45 to 100 m), and outer shelf (100 to 200 m). Trophic dynamics were shown for the photic zone (< 45 m) and aphotic zone ($\geq$ 45 m). Impacts of various oil and gas operations were estimated on 15 "valued ecosystem components" (VEC's)--biota of special importance representing protected, economically important, numerous, or especially sensitive species at all trophic levels, and all identified ecosystems across the shelf. This resulted in a summary impact matrix for all VEC's and all effects. Each matrix element estimated impact radius, severity, and likelihood of occurrence.

Dr. Robert M. Avent, has been a biological oceanographer with the Environmental Studies Section of the MMS, Gulf of Mexico OCS Regional Office since 1981. He received his M.S. (1970) and Ph.D. (1973) degrees in oceanography from Florida State University. He serves as Contracting Officer's Technical Representative (COTR), developing the content and scope of regional studies and monitoring study contracts. He has held positions in academia, State Government, private industry, and the Federal government.

Dr. Larry J. Danek received his doctorate in physical oceanography from the University of Michigan. He is currently Vice President in charge of Regional Operations and Senior Oceanographer at Environmental Science and Engineering, Inc. Dr. Danek was Program Manager on the Southwest Florida Shelf Ecosystems Program. He has also served as Program Manager for projects in the Beaufort Sea, U.S. Atlantic coast, Arabian Gulf, and the North Sea.

Program Objectives and Design

Dr. Larry J. Danek
Environmental Science and
Engineering, Inc.

OBJECTIVES

This abstract summarizes the 6-year Southwest Florida Shelf Ecosystems Program environmental study. The objectives defined by MMS for this environmental studies program were to

1. Determine the location and distribution of selected benthic habitats and associated communities;
2. Determine the seasonal structure and density of selected live and soft-bottom communities;
3. Compare community structure of live and soft-bottom fauna and flora to determine the differences and similarities between them and their dependence on substrate type;
4. Determine and compare the hydrographic structure of the water column and bottom

conditions at selected sites within the study area;

5. Determine and compare sedimentary character at selected sites within the study area, and estimate sediment transport;
6. Relate differences in biological communities to hydrographic, sedimentary, and geographic variables; and
7. Provide information on dynamics of selected live-bottom communities and determine the major factors that influence their development, maturation, stability, and seasonal variability.

The ultimate goal of this program was to provide MMS with information essential to determining the potential impact of OCS oil and gas offshore activities on live-bottom habitats and communities. These live-bottom habitats and communities are integral components of the southwest Florida shelf ecosystems.

DESIGN

The study area extends seaward from the west coast of Florida to the 200-m isobath and from 27 degrees N latitude, southward to the Florida Keys and Dry Tortugas (Figure 8.1). This area contains numerous live-bottom areas, which are often separated by wide expanses of sand- or mud-bottom areas.

The 6-year Southwest Florida Shelf Ecosystem Program began in 1980 as an interdisciplinary study designed to meet the objectives previously described. During Year 1 of the program, geophysical (bathymetric, seismic, and side-scan sonar) and underwater television surveys were conducted along Transects A through E (Figure 8.1) from the 40- to 200-m isobath and the 20- to 100-m isobath, respectively. Water column data [salinity, temperature, dissolved oxygen, transmissivity, light penetration, nutrients, chlorophyll, and Gelbstoff (yellow substance)] were collected at 30 cross-shelf stations (Figure 8.1). Benthic data were obtained with underwater television, still photography, and trawls for all 30 stations; in addition, triangular dredges were used to collect benthic data at the 15 live-bottom stations. Infauna data and sediment grain size, carbonate content, hydrocarbons, and trace metals data were collected at the 15 soft-bottom stations.

During Year 2, additional geophysical information was collected along a new north-south transect (Transect F, Figure 8.1), at approximately 100-m water depth, that tied together several of the previously surveyed east-west transects (Transects A through E). Visual data, again including underwater television and still camera photography, were extended along each Transect (A through E) from 100- to 200-m water depths. Twenty-one of the 30 original hydrographic and benthic biological stations occupied during Year 1 were re-sampled twice. For this set of stations, hydrographic and biological data were now available on a seasonal basis. In addition, nine new hydrographic and benthic biological stations (Figure 8.1) were established on Transects A through E, in water depths ranging from 100 to 200 m.

Under a Year 2 contract modification (which was essentially a separate third year of studies), hydrographic cruises were conducted to yield higher resolution analysis of the temporal and spatial distribution of temperature, salinity, transmissivity, phytoplankton, chlorophyll, and nutrients. Primary productivity was measured during both cruises and correlated with nutrient and other physico-chemical data. A simultaneous overflight by the

National Aeronautics and Space Administration (NASA) Ocean Color Scanner during the April cruise was completed to investigate chlorophyll and primary productivity throughout the region during the spring bloom.

The expanded Year 3 program continued the bottom-mapping activities that were begun in Year 1. Bathymetry, side-scan sonar, subbottom profiling, underwater television, still photography, and hydrography studies were conducted along Transects B, C, and D (extended eastward to depths of 10 m) and on new north-south transects (Transects G, H, I;, J, K, and L; Figure 8.1). Biological and hydrographic sampling was conducted at 10 new soft-bottom stations in the 10- to 20-m depth range for infauna and sediment grain size and hydrocarbon content. Five additional live-bottom stations in the same depth range as the soft-bottom stations were surveyed using underwater television, still photography, dredges, trawls, sediment traps, and diver-deployed quadrant bottom sampling. In addition, hydrographic casts were made at the live-bottom stations.

In Year 4 of the program, five soft-bottom and five live-bottom stations (Figure 8.1) were sampled to complete the seasonal baseline descriptive study of the inshore area initiated during Year 3. Hydrographic measurements (salinity, temperature, dissolved oxygen, and transmissivity) were made at all 10 stations. Infauna and sediment samples were collected at the five soft-bottom stations; macroalgae, epifauna, and nekton surveys (using underwater television, still photography, trawling, and dredging) were conducted at the five live-bottom stations. Five additional live-bottom stations (Figure 8.1) were selected for intensive study of physical and biological processes. Sampling at these stations, each representing a separate epifaunal community type, consisted of dredging, trawling, underwater television, still photography, sediments, and hydrography. In addition, in situ instrumented arrays were installed at these stations to study biological and physical processes. Each array was equipped with a current meter that continuously measured current velocity and temperature; three sets of three sediment traps at elevations of 0.5, 1.0, and 1.5 m above the bottom; and ten sets of artificial substrate settling plates that were scheduled to be retrieved at 3-month intervals over 2 years. The arrays at two of the stations also were equipped with a wave and tide gage and a time-lapse camera to document sediment transport and biological recruitment. These arrays were serviced quarterly.

During Year 5, intensive sampling of the five Year 4 live-bottom stations continued, and three other stations were added for intensive study (Figure 8.1). Two of these stations had been surveyed in previous years; the third station, located between the Dry Tortugas and the Marquesas, was a new station established in Year 5. This station was chosen primarily because it was at a key location within the boundary of the shelf and would provide valuable information for subsequent modeling efforts. The other two stations were selected because they were farther north than the original five stations and provided information on latitudinal variation. There was some modification to the sampling program during Year 5. Dredging was discontinued at the five original live-bottom stations and was conducted at only two of the three additional stations. The third station was sampled only with the instrumented array and CTD because sufficient epifaunal information was available for this and similar shallow stations. A second modification was the transfer of a wave and tide gage from a more offshore station to the station located between the Dry Tortugas and the Marquesas because this station was shallower and, therefore, would provide better wave measurements. In addition, tide data from this station would be more valuable in providing boundary conditions for subsequent modeling efforts. Also, seven of the eight arrays were equipped with time-lapse cameras; only the deepest station (125m) was not equipped with a camera because it was too deep for the standard camera cases used for this program. Two new transects were surveyed with underwater television and side-scan sonar. Transect M ran north-south between the Dry Tortugas and the Marquesas at an average water depth of 27 m; Transect N ran from the Tortugas Shoals southwest to a depth of 100 m (Figure 8.1). These transects were added to supplement the habitat-mapping studies completed in previous years. The objectives of the sixth, final year of the program were to

1. Synthesize data collected during the 5-year field study and synthesize data from other sources whether published or unpublished.
2. Produce a concise and coherent description of the biota, conditions, and processes in the study area.
3. Assess potential impacts of oil and gas exploration, development, and production on the southwest Florida soft-bottom and live-bottom shelf communities.

The field data collected during the first five years of the program, data collected from outside sources (e.g., NOAA Data Buoy Center, National Climatic Data Center, University of Florida Coastal Data Network, etc.), and historical data (published and unpublished) were subjected to additional analysis and synthesis during the sixth year of the program. This information was used to provide a comprehensive and coherent description of the physical and biological components of the southwest Florida shelf ecosystems. Following this characterization, a series of valued ecosystem components (VECs) were selected by representatives from the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the Minerals Management Service, the State of Florida (Office of the Governor), and the project team. The following VECs represent producers and consumers at all trophic levels; all ecosystems from nearshore through the continental shelf; benthic and nektonic elements; and species of commercial and recreational interest, ecosystem dominance, environmental sensitivity, and rare and endangered species:

- seagrasses (Halodule, etc.)
- Pink Shrimp (Penaeus duorarum)
- Anadyomene menziesii
- Rock Shrimp (Sicyonia spp.)
- Coralline Algal Nodules
- Spiny Lobster (Panulirus argus)
- Sponges (Ircinia, etc.)
- Stone Crab (Menippe mercenaria)
- Hermatypic Corals (Agaricia, etc.)
- White Grunt (Haemulon pulmieri)
- Snappers and Groupers
- Gorgonians
- Spanish and King Mackerels
- Crinoids (Comactinia, etc.)
- Sea Turtles (loggerhead, etc.)

Conceptual submodels, presented as flow diagrams connecting the initial activities of oil and gas development, through intermediate steps to the final presumed impacts, were then developed for each VEC. The final refinement to the potential impact assessment was the integration of these submodels into a single potential impact matrix. This matrix indicated not only the relative impact level, but the relative probability of occurrence and the probable impact radius. The physical and biological characterizations and impact projections were then presented in the Data Synthesis Report. This synthesis report was designed as a tool to assist MMS personnel in determining environmental impacts resulting from offshore oil and gas development.

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Live-Bottom and Soft-Bottom Biota of the Southwest Florida Shelf

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A major element of the Southwest Florida Shelf Ecosystems Study was biological sampling at live-bottom and soft-bottom stations. Stations were selected after broad-scale habitat mapping with remote photographic and geophysical instrumentation was completed. The live-bottom stations were located in areas of dense sessile epibiota (usually in areas of exposed or thinly covered hard bottom, or where an extensive surface rubble layer was present). The soft-bottom stations were located in areas of sand or mud bottom with a sparse epibiota. Station locations are shown in Figure 8.1 in the preceding abstract by Danek (this session).

LIVE-BOTTOM STATIONS

Twenty-six live-bottom stations were sampled, in water depths ranging from 13 m to 159 m. Generally, each time a station was visited, three dredge samples and one trawl sample were collected, and the seafloor was surveyed with an underwater television/still camera system. Most stations were sampled two or four times, though a few were sampled more intensively. During Year 3, divers also harvested epibiota and measured sediment thickness in 35 or more quadrats at five shallow stations (<20 m depth). Arrays containing time-lapse cameras, colonization plates, sediment traps, current meters, and wave gauges were deployed at selected live-bottom stations during Years 4 and 5, but the results are not included here.

Average coverage of epibiota in the still photographs ranged from 6 percent to 90 percent, and coverage was seasonally variable nearshore due to fluctuating algal abundance. The highest values were at Station 29, which was located at the southwest corner of the study area in a water depth of 62 m. The biological community at this station consisted of flat corals (*Agaricia*), leafy algae (*Anadyomene menziesii*), and crustose red algae (*Peyssonnelia rubra*, *P. simulans*) on a fused coralline algal pavement.

At least 1,497 species were collected in dredges and trawls. Molluscs (291 species) and crustaceans (253 species) were the most speciose groups in the dredge collections, whereas fishes (192 species) and crustaceans (189 species) accounted for most of the species trawled. Over 100 species of sponges and 53 species of scleractinian coral were identified, including many that are also found in the Florida Keys and on Caribbean reefs. Species richness of dredge collections generally declined with increasing water depth. Species composition of dredge and trawl catches varied mainly according to water depth, or related variables such as light, temperature, and nutrients; the major changes in species composition were at depths of about 40 to 50 m and 100 m. The most pronounced north-south gradient in species composition was in the 60 to 80 m depth range; stations toward the south within this depth range had a very well-developed community of crustose and leafy algae, sponges, deep-water scleractinian corals, and a number of tropical reef fishes.

Year 3 quadrant sampling in shallow water (<20 m depth) showed that the thicker the sand veneer overlying hard bottom, the lower the biomass and percent cover of sessile epifauna. The sediment veneer at five nearshore live-bottom stations averaged about 1 to 5 cm in thickness. Biomass of epibiota at the nearshore stations ranged from 600 to 4,300 q wet wt/m2. Sponges were the main biomass contributors (40 to 70 percent).

SOFT-BOTTOM STATIONS

Twenty-nine soft-bottom stations were sampled, in water depths ranging from 10 m to 148 m. Infaunal and sediment samples were collected at each station, remotely, during Years 1 and 2, and by divers during Years 3 and 4. At each Year 1 and 2 station, a trawl sample was also collected, and the seafloor was surveyed with an underwater television/still camera system. During Year 3, additional infaunal and grain size samples were collected at one station along a transect from live bottom to soft.

At least 1,121 infaunal species were identified, with polychaetes and crustaceans each accounting for about 40 percent of the total. Most of the species identified were surface deposit feeders, subsurface deposit feeders, or motile scavenger/carnivores. The latter (for example, syllid polychaetes) were more common near live bottom.

Mean infaunal abundance ranged from about 1,000 to 14,000 individuals/m2 and generally declined with increasing water depth. Polychaetes accounted for 64 percent of the total abundance, with the percentage increasing with water depth.

Species composition of the infauna varied with water depth, sediment grain size composition (silt content), and season. Seasonal variations were most pronounced in shallow water (<30 m), with bivalves and some opportunistic polychaetes (for example, Prionospio cristata, Paraprionospio pinnata) showing dramatic fluctuations in abundance.

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Physical and Chemical Oceanography of the Southwest Florida Shelf

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SEDIMENTS

The southwest Florida continental shelf is a broad (approximately 200 km), flat, limestone platform with relatively few areas of high relief. The shelf slopes gently to the west. In most locations, low-lying, hard substrates either alternate with, or are covered by, a thin veneer of coarse sand. This sand is primarily calcareous, with percentages of calcium carbonate exceeding 90 percent in most locations, indicating that the sand is derived primarily from coral, calcareous shells and algae, and the erosion of bedrock. There is, however, a narrow band of quartz sand parallel to the shoreline that is derived from terrestrial sources. The sediments are generally less than 20 percent silt/clay except in the southwest which is an area of carbonate muds. Sediment resuspension and redeposition, measured with sediment traps on the shelf, was as high as 848 metric tons km^2/day. The material in the traps was 86 percent silt/clay, whereas the ambient sediments were only 3 percent silt/clay. The amount of sediment collected in the traps decreased rapidly with depth of water. Trace metal values on the shelf were very low in the sediments, indicating an uncontaminated environment.

WAVES

Wave action is variable on the shelf; the greatest mean wave height occurs between September and April. Passing tropical storms and fronts during the fall and winter produce the highest waves, usually in conjunction with winds from the west and northwest. Average wave height is less than 1.5 m (monthly means), but much higher waves are produced during storms. Under storm conditions, waves can resuspend and transport sand in shallow water, but during more normal weather and in greater depths, the effect of waves on bottom sediments is negligible. The wind on the shelf usually blows from the east or southeast, producing surface waves propagating toward the west or southwest.

TIDES

The tides in the region are mixed and weakly developed with the observed range usually not exceeding 0.7 m. The semidiurnal component of the tide is a somewhat greater diurnal component in shallow water; however, the diurnal component becomes dominant in depths greater than 30 m.

CURRENTS

Currents along the bottom on the southwest Florida shelf tend toward the south. Bottom currents usually range from 10 to 30 cm/sec. Occasional intrusions of the Loop Current, or eddies generated by the Loop Current, can cause abrupt changes in current direction and speed, especially along the outer portions of the shelf. These intrusions can produce bottom-water velocities in excess of 80 cm/sec. Farther to the east, the average direction of flow of bottom water is more to the southeast, toward Florida Bay.

The near-bottom currents of the shallower nearshore stations of the southwest Florida shelf are dominated by the semidiurnal component of the tides. This is evident from the nearly rectilinear motion of the water with a periodicity in current speed of approximately 6 hours (e.g., Station 52, Figure 8.2). The predominance of the semidiurnal component of the tides also is evident as a pronounced energy peak in the three-dimensional power spectra. The energy spectra also reveal that the semidiurnal component becomes less important farther offshore in deeper waters, and that the diurnal component begins to predominate (at the latitude of the study area, however, the local inertial frequency is at nearly the same frequency as the diurnal component; therefore, it is difficult to separate the two energy bands). In Figure 8.2, the predominance of the diurnal (and inertial) frequencies is demonstrated by the speed-direction plots for Station 7 where the current direction is more evenly distributed (suggesting a more elliptical, rather than rectilinear motion), and the major peaks in current speed occur every 12 hours with only small peaks at the 6-hour interval.

At least two short-term phenomena significantly affect the current regime on the southwest Florida shelf. The first phenomenon involves the intrusion of the Loop Current eddies onto the shelf. These intrusions are characterized by a noticeable increase in the current speed, a tendency for the current direction to become constant, and an increase in the near-bottom water temperature of 2 degrees to 4 degrees C. The effects of an intrusion may extend nearly across the shelf, but generally stay outside of the 20-m isobath. The second phenomenon to affect the current regime is the passage of major storms. The effects of the passage through the study area of Tropical Storm Bob in July 1985 is an example. The most severe effects were at stations nearest the center of the storm. The current speeds increased from an average of less than 10 cm/sec to peak speeds of approximately 60 cm/sec. The effects decreased with distances from the center. Storms such as this also have effects on the waves and tides in the region. The change in water level resulting from a storm, although detectable, was usually less than 0.5 m. The effect of a storm passage on the wave regime was considerably more evident with waves exceeding 5 m.

NUTRIENTS

The upper 100 m of water in the Gulf of Mexico are nutrient poor, with phosphate, nitrate, and silicate values less than 0.4, 2.0, and 2.0 micromoles (uM), respectively. Nitrate-nitrite nitrogen concentrations on the southwest Florida shelf ranged from less than 0.1 to 19 uM; however, the concentrations rarely exceeded 1 uM at depths less than 60 m. There were no obvious seasonal trends. Historically, the total phosphorus concentration ranged from 0.05 to 1.6 uM, with a mean concentration of 0.3 uM for the upper 100 m of water. The mean total phosphorus concentration at depths greater than 100 m was 1.0 uM (ranging from 0.65 to 1.6 uM). There was a 2- to 3-fold near-surface total increase in total phosphorus concentration shoreward of the 20-m isobath. Silicate concentrations on the southwest Florida shelf ranged from less than 1 to 13 uM, with values exceeding 3 uM only at depths greater than approximately 60 m and shoreward of the 20-m isobath.

Generally, nutrient values are higher offshore at water depths greater than 100 m. The higher nutrient concentrations are typical of deeper water; however, the proximity of these offshore locations to the Loop Current probably contributes to higher nutrient values as well. Domed isotherms observed on the shelf suggest that upwelling resulting from Loop Current boundary perturbations brings more nutrient-rich subtropical underwater onto the southwest Florida shelf.

HYDROCARBONS

The distribution of hydrocarbons in surface sediment of the southwest Florida shelf according to source characteristics is as follows: (1) predominantly marine biogenic, found primarily in the mid-shelf to outer continental shelf areas; (2) marine and terrigenous biogenic, found at the deepest stations and those closest to land (<20-m depth); and (3) marine terrigenous biogenic with some petrogenic characteristics, found in a few outer stations influenced by transport from the Loop Current. Hydrocarbon analysis of sediments of the southwest Florida shelf indicates the area is relatively free of petrogenic hydrocarbons. The lack of petrogenic contamination in biota also indicates the absence of petrogenic hydrocarbons in the water column as well as in the sediments.

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Benthic Habitats of the Southwest Florida Shelf

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This abstract summarizes the distribution of habitat types on the southwest Florida shelf, based primarily on visual and geophysical mapping conducted during the Southwest Florida Shelf Ecosystems Study Program. Danek (this volume) describes the methodology and the transects surveyed. For detailed information on habitat mapping, see the Year 3 report from the program (Continental Shelf Associates, Inc., 1987), and the two atlases produced (Woodward-Clyde Consultants and Continental Shelf Associates, Inc., 1983a; Continental Shelf Associates, Inc., 1985).

OVERVIEW OF SUBSTRATUM TYPES

The southwest Florida shelf consists of a broad, gently sloping carbonate platform covered by a veneer of carbonate sand. Two partially buried, ancient reef complexes influence the character of bottom communities on the shelf. The first, a 10-km wide, central reef complex in 70 to 90 m depth, is referred to as Pulley Ridge. This feature probably was formed about 10,000 years ago and provided the environment for the production and impoundment of unconsolidated, biogenic surface sediments on the inner and middle shelves (Holmes, 1981). Due to this impounding effect, the wedge of unconsolidated sediments overlying bedrock increases from about 5 m to 20 m between the 40- and 70-m isobaths (Woodward-Clyde Consultants and Continental Shelf Associates, Inc., 1983b). Seaward of pulley Ridge, the seafloor is covered by a thickening wedge of sediment and marked by wave-cut terraces formed during pauses in sea-level rise (Holmes, 1981). A second, double-reef complex occurs near the modern shelf edge. The inner reef crests at about 130 to 150 m depth and veers landward north of 25 degrees 30' to form the feature known as Howell Hook (Holmes, 1985). This feature was seen during the Southwest Florida Shelf Ecosystems Study surveys of Transect L and the outer end of Transect C. The outer reef forms a steep, west-facing scarp at the modern shelf edge in water depth of 210 to 235 m (Holmes, 1981) and was not surveyed during this study.

Six major substratum types are present on the shelf:

1. high-relief hard bottom
2. low-relief exposed or thinly covered hard bottom
3. thick-sand bottom
4. coralline algal nodules
5. coralline algal pavement
6. shell rubble

Exposed rock or hard bottom is generally rare, widely scattered, and of low relief (<1 m). Thinly covered hard bottom, which is probably alternately exposed and buried due to sand movement, is the most common substratum type for sessile epifauna over much of the shelf. Coralline algal nodules are an important substratum type for sessile epifauna in the 60 to 100 m depth range. The nodules, which range in size from a few millimeters to several centimeters in diameter, are believed to be formed by two genera of coralline algae, Lithothamnium and Lithophyllum. In the southern portion of this depth range, the coralline algae produce a flattened pavement rather than loose nodules. Shell rubble is present in many locations on the shelf, but is particularly important on the outer shelf as a substratum for crinoids.

OVERVIEW OF BENTHIC COMMUNITIES

Most of the inner and middle shelf (to about 70 m) consists of a mosaic of thick-sand bottom and hard bottom covered by a thin-sand veneer, with occasional low-relief rock outcrops. Hard-bottom areas in depths ranging from 10 to 25 m are typified by dense populations of zooxanthellate gorgonians (Pseudopterogorgia, etc.) and large sponges (for example, loggerhead sponge, Speciospongia vesparium, and vase sponge, Ircinia campana). Small scleractinian corals also are present, though not very conspicuous. Sand-bottom areas interspersed with hard bottom in the same depth range are colonized by populations of seagrass (Halophila decipiens) and algae (Halimeda, Caulerpa, Udotea, Penicillus, etc.).

Beyond about 25 m depth and extending to 60 or 70 m depth, the thickness of the sand veneer overlying hard bottom generally increases, and rock outcrops and "live bottom" are encountered less frequently than at shallower depths. Algae (Caulerpa, Halimeda, Udotea, etc.) typically are present in soft-bottom areas to depths of about 70 m. In hard-bottom areas, the dense gorgonian populations are no longer seen beyond depths of about 20 to 25 m; sponges (many of the same species cited above) and algae are the major conspicuous forms of sessile epibiota. Small hard corals (same species cited above, with the addition of some species with affinities for deeper water) are also present to depths of about 40 to 50 m.

Water depths of about 60 to 100 m on the shelf are typified by a mosaic of open, soft-bottom areas and patches of coralline algal nodules. The nodules are sparse and patchy in the northern part of the study area but increase in density southward, culminating in a fused pavement along the southernmost cross-shelf transect. Associated with the nodules are species of calcified algae (*Peyssonnelia rubra*, *P. simulans*, and *Halimeda* sp.) and, in the southern portion of the area, the leafy green alga *Anadyomene menziesii*. Sparse populations of sessile epifauna such as sponges, non-zooxanthellate gorgonians, hard corals, and crinoids are also present in these nodule areas.

The 60 to 80 m depth range on Transect E is characterized by an assemblage of plate corals (*Agaricia* spp.) and dense growths of the green alga *Anadyomene menziesii*, occurring on a fused coralline algal pavement. Biotic coverage in this area ranges from 64 percent to 90 percent, the highest values seen on the shelf. Most of the cover is due to algae (*Anadyomene* and *Peyssonnelia*), which vary little seasonally in their abundance at this depth.

Most of the outer shelf (100 to 200 m) is covered by a thick-sand veneer. Some areas of coarse sand and shell rubble are colonized by comatulid crinoids. Although scattered outcrops occur throughout the area, most are concentrated along the partially buried reef feature known as Howell Hook, in water depths of about 120 to 160 m. At its northern end (Transect C and northern end of Transect L), this feature is seen as isolated, steep-walled outcroppings that protrude up to 3 m above the surrounding thick sand. Farther south, low relief outcroppings and expanses of thinly covered hard bottom are seen. The dominant sessile epibiota are crinoids, antipatharians, non-zooxanthellate gorgonians and hard corals, and hexactinellid (glass) sponges.

CONTROLLING FACTORS

The occurrence of live bottom is strongly influenced by shelf geomorphology. Dense growths of sessile epifauna occur mainly on exposed or thinly covered hard bottom and on coralline algal nodules or other rubble layers. The high incidence of live bottom near shore (<20 m depth) probably reflects the thinness of the sand veneer there. Live bottom on the middle shelf (60 to 100 m) is associated with coralline algal nodules and algal pavements atop the buried central reef feature, Pulley Ridge. Most of the live bottom seen on the outer shelf is associated with outcrops of the other partially buried reef feature, Howell Hook.

Zonation patterns of the sessile epibiota appear related mainly to water depth or correlated environmental variable such as light, temperature, nutrients, and substratum type.

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Dynamic and Biotic Processes as Seen with Time-Lapse Photography

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INTRODUCTION AND METHODS

Time-lapse cameras were installed on two instrumented arrays during Year 4 of the Southwest Florida Shelf Ecosystems Study; during Year 5, eight arrays were equipped with time-lapse cameras. The main objective of the time-lapse cameras was to provide continuous information on sediment transport on the southwest Florida shelf. Several secondary objectives included documentation of sessile community formation and monitoring fish presence around artificial structures.

Each time-lapse camera system (Figure 8.3) consisted of a Minolta Model XL-401 or 601 Super-8 movie camera, an intervalometer (designed by LGL Ecological Research Associates, Inc., to trigger one single-frame exposure every hour), a Vivitar Model 283 strobe, and an external battery pack. The camera and strobe were protected with Ikelite underwater cases tested to 100 m. The optical faces of the cases were coated with a transparent organometallic antifouling compound provided by the U.S. Navy.

The orientation of the time-lapse camera plus the wide angle lens (a zoom f/1.2) set to either 7.5 or 8.5 mm ensured that a graduated sediment rod, two steel biofouling plates (welded to the rod), and the seafloor were in view of the camera at all times. The cameras, although designed to operate for 5 months, optimally were serviced every 3 months. During servicing, the film, batteries, and desiccant were replaced, and all O-rings were cleaned and checked. The time-lapse systems were reassembled and redeployed. The films were developed and then analyzed using a manual film editor and Kodak Moviedeck Model 475 Super-8 movie projector with variable projection speeds (freeze-frame, 3,6, 18 and 54 frames/sec). Films were viewed frame-by frame and at various speeds to detect any sedimentological or biological processes that were occurring too slowly to detect normally. Recorded observations included turbidity, evidence of sediment transport, bioturbation, species identification and counts, and faunal behavior.

SIGNIFICANT FINDINGS

Time-lapse photography provided valuable information regarding sediment transport and biological activity on the southwest Florida shelf. Although some problems were encountered with the time-lapse systems, the utility of time-lapse photography in studying marine benthic ecosystems was firmly established.

The two most common problems encountered were caused by the failure of the Ikelite cases or disturbances caused by large animals. Failure of the cases resulted from corrosion of stainless steel closure fittings or failures in the plastic cases, usually in the form of stress cracks which occasionally caused flooding. Large animals such as jewfish (*Epinephelus itajara*) and sea turtles caused extensive damage or disturbance to the time-lapse cameras (particularly at the shallower stations). Jewfish at the shallowest station were responsible for either moving the entire camera assembly so that the view was blocked or for eventually breaking the power cables that connected the battery supply to the strobe and camera. In spite of these difficulties, many significant observations were made with time-lapse photography.

As stated previously, one of the major objectives of the time-lapse photography was to document sediment transport (in the bed and suspended load). Time-lapse cameras did not detect bedload transport (e.g., in the form of migrating sand waves). Sand waves were occasionally seen with the underwater television; however, no sand waves were ever observed crossing any of the cameras' field of view.

Episodic sediment transport in the form of suspended load, however, was observed. This transport was evidenced by periods of turbidity that, depending on the strength of the storm (and the wave heights associated with the storm), could completely occlude the time-lapse view. These episodes of sediment transport appeared to correlate with the distinct layering that was evident in the sediment traps. The time-lapse cameras provided useful complementary information on the time of occurrence and duration of sediment suspension and, to some degree, the approximate density of suspended particles (expressed as percent transmissivity).

Sediment movement in the form of bioturbation was also observed at some stations where patches of unconsolidated sediment were within the view of the camera. Bioturbation was evident in the form of moving conical or linear mounds of sand. The conical mounds (as high as 10 cm) were observed to grow from the previously flat bottom; the organism responsible for these mounds was never observed. The linear mounds appeared to be caused by echinoids (either sea biscuits or sand dollars). The mounds could be seen to move in various directions, leaving distinctive trails 10 to 15 cm wide. These movements took place almost exclusively at night (between 1700 and 0500). In general, the distance traveled by a single individual did not exceed 4 to 5 m in a single night.

In addition to bioturbation, other faunal activity was observed. Perhaps most significant to this study was the observed attraction of fish to artificial structures (in this case, the instrumented arrays). Many fish arrived at the array within a few days of installation. There was some evidence of succession. For example, at one station, shortly after installation, white grunts (Haemulon plumieri) were most abundant (153 sightings after 3 months), and gray snappers (Lutjanus griseus) were uncommon (16 sightings after 3 months); at the end of 6 months, gray snappers replaced white grunts as the most frequently observed fish (164 sightings versus 1 sighting, respectively).

Most of the sightings of fishes at many of the stations appear to have been repeated observations of the same individual(s) and, therefore, indicate at least semipermanent residency. This is most likely true for snappers and grunts and is known for the jewfish and nurse shark (Ginglymostoma cirratum) which were distinctively marked and could be seen resting in the same locations within an array over a period of days or weeks. Other species, such as the Atlantic spadefish (Chaetodipterus faber), took up temporary residency for a few days and then disappeared from the vicinity. Pronounced diel periodicity was observed (Figure 8.4) for species such as the gray snapper which typically rest near reefs or other benthic relief during part of the day, and forage in sandy areas and seagrass beds during the night. Jewfish attendance decreased near dawn and dusk, perhaps reflecting feeding activities (Randall, 1967).

Fish may also be responsible for a considerable amount of sediment resuspension and bioturbation at selected locations on the shelf. Nurse sharks, jewfish, groupers, and other species that spent a great deal of time at the arrays were the probable cause of the observed removal of sand beneath some of the arrays, as well as the turbidity plumes occasionally observed on the films. For example, spotted goatfish (Mulloidichthys maculatus) were observed feeding in the sand near an array, creating a large plume of suspended sediment.

SUMMARY AND RECOMMENDATIONS

Time-lapse photography can provide valuable information on

- o turbidity,
- o sediment transport,
- o bioturbation
- o fish attraction
- o relative species abundance
- o interspecies associations,
- o residence times,
- o diel activity patterns, and
- o biofouling rates and succession.

Time-lapse cameras are very useful tools for ecosystems studies, and their use should be continued. If, however, time-lapse cameras are used, several precautions must be followed. First, it is essential that the optical surfaces of the cases be coated with an effective, transparent antifouling compound [e.g., the tin-based organometallic polymer (OMP) provided by the U.S. Navy for the study]. Second cameras should either be very rugged or they should be protected by a heavy steel cage to prevent large animals (e.g., jewfish or turtles) from disturbing them.

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Studies in tropical oceanography. Inst. Marine Sci., Univ. Miami Press, No. 5:665-847.

Mr. Michael S. Tomlinson received his bachelor's degree in geological oceanography from the University of Washington. He is currently Staff Oceanographer at Environmental Science and Engineering, Inc. Mr. Tomlinson was Assistant Program Manager on the Southwest Florida Shelf Ecosystems Study. He has conducted, or participated in, multidisciplinary studies along the U.S. Atlantic coast, Pacific Ocean, Arctic Ocean, Puget Sound, Gulf of Alaska, Bering Sea, North Sea, Arabian Gulf, and Gulf of Thailand.

Ecosystem Models of Valued Ecosystem Components

Dr. Benny J. Gallaway
LGL Ecological Research Associates, Inc.

INTRODUCTION

As part of the Southwest Florida Shelf Ecosystems Study, Dr. Rezneat Darnell and I were asked to define and make some rather specific assessments of potential impacts on the ecosystem in the event that oil and gas development of the Southwest Florida Shelf is initiated. From the foregoing talks, one can readily see that the system in question is highly diverse and complex, making the assessment task a difficult matter. In this paper, I will describe how we approached the problem, and the results of our undertaking.

THE COMMUNITIES

As a first step, regional-scale community descriptions were developed including (1) evaluations of important physical/chemical oceanographic factors that likely control community development, (2) the types and structure of the different communities occurring across the shelf, and (3) generalized trophic relationships exhibited by marine communities comprising the regional ecosystem.

Based upon our review, the key oceanographic factors limiting communities were light, substrate, and bottom water temperature. Light penetration sets the maximum limits of depth distribution of the various photosynthetic species. Within a given depth zone, the distribution of hard bottom determines the distribution of attached species (photosynthetic or otherwise). The availability of exposed hard substrate is determined mainly by alternate exposure and coverage of bare areas by moving sediments under the control of bottom currents and wave energy. If the exposure period is sufficient, tall or projecting species such as gorgonians and sponges may survive subsequent coverage of the bottom by thin sand. Particle size and carbonate content of soft sediments determine, to some extent, the distribution and abundance of the infauna. Toward both the outer and inner shelf zones, seasonally low temperatures may play a role in limiting the distribution of tropical species, but salinity appears to be too uniform to be significant. Unanalyzed factors, such as organic content of the sediment, plankton concentrations in the water column, and species interactions, undoubtedly play important roles in determining species distribution.

A biological community consists of a group of species that live together in a common habitat and exhibit various types and degrees of interrelationships. A minor community may consist of a large sponge together will all of its symbionts. A major community may include all the species affiliated with a given depth zone of the sea.

A logical framework for defining the communities of the southwest Florida Shelf seemed to be the depth zonation of the larger sedentary biota. Emphasis was placed on growth forms and higher categories, rather than upon individual species. Within a given depth zone, sub-community types were distinguished as necessary and useful. Attention was given to those larger and more motile species that tend to associate with a given community of sedentary species.

Benthic communities are strongly influenced by light penetration to the bottom. It has been shown that the 1 percent light level intersects the bottom at a depth of about 45 m. The bottom, shoreward of this depth, is considered arbitrarily to lie within the euphotic zone, and all the bottom seaward should be in the aphotic zone. However, biological and sediment data indicate that both areas should be sub-divided into two zones. The four basic zones or benthic communities in the study area are defined

1. Nearshore community (9 to 10 m) -- Euphotic, nearshore zone
2. Inner shelf community (10 to 45 m) -- Euphotic, shelf zone
3. Middle shelf community (45 to 100 m) -- Twilight zone
4. Outer shelf community (100 to 200 m) -- True aphotic zone

Each of these community types was discussed in the final report in terms of physical parameters, biological composition, and ecological dynamics. Schematic diagrams were shown depicting the depth-related distribution of the conspicuous attached biota and major motile species.

The trophic dynamics of the community were shown using two component models, one of the photic zone communities and one for the communities in the aphotic zone. They differ mainly in that the aphotic zone communities contain no producers. Collectively, these models emphasized the importance of light, detritus pathways, and import/export phenomena in the trophic economy of the Florida Shelf communities.

THE NATURE OF IMPACTS

To characterize the nature of the expected impacts, we first defined the specific activities associated with each phase of the development process and identified in tabular form the primary and secondary impact factors associated with those activities. Each factor, so identified, was then evaluated in terms of its potential to affect the ecosystem. The deficiencies of such tables stem from their general nature. It is virtually impossible to list the individual components of an ecosystem and the potential impacts the oil- and gas-related activities may have on each component. A more useful approach, and the one used for this study, is to select a discrete and manageable number of valued ecosystem components (VECs). VECs are those species, groups of species, or other ecosystem features that have been identified as being of special importance for given ecological analysis. Their importance may stem from economic value, rare protected or endangered status, dominance or prominence of ecological role, or sensitivity to environmental disturbance. The VECs for this study were selected by representatives from the Minerals Management Services, U.S. Fish and Wildlife Service, National Marine Fisheries Services, the State of Florida (Office of the Governor), and the project team. The list of VECs (including the reason for their selection) for the southwest Florida Shelf were

1. Seagrass (Halodule, etc.)- Primary producer, provide habitat
2. Anadyomene menziesii - Primary producer, deep and restricted distribution
3. Coralline algal nodules- Primary producer, provide habitat
4. Sponges (Ircinia and others)- Abundant, support dependent communities
5. Hermatypic corals (Agaricia, etc.) - Abundant, support dependent communities, potentially sensitive
6. Gorgonians - Abundant, support dependent communities
7. Crinoids (Comactinia, etc.)- Common form on outer shelf
8. Pink shrimp (Penaeus duorarum) - Commercial and ecosystem importance
9. Rock shrimp (Sicyonia spp.)- Commercial and ecosystem importance
10. Spiny lobster (Panulirus argus) - Commercial and ecosystem importance
11. Stone crab (Menippe mercinaria) - Commercial and ecosystem importance
12. White grunt (Haemulon plumieri) - Most abundant, ubiquitous reef fish, recreational importance
13. Snappers and groupers- Commercial and recreational importance
14. Spanish and king mackerels- Commercial and recreational importance
15. Sea turtles (loggerhead, green, etc.) - Endangered species

This group of VECs represents producers and consumers at all trophic levels, all ecosystems from nearshore through the continental shelf, and benthic and nektonic elements, as well as species of commercial and recreational interest, ecosystems dominance, environmental sensitivity, and representation on the endangered species list.

Analysis of the potential impacts of oil- and gas-related activities were conducted for each VEC. Each analysis was presented as a flow diagram connecting the initial activities of oil and gas development through intermediate steps to the final presumed impacts. All pathways should be carefully considered. Snappers and groupers of the southwest Florida Shelf extend through all depth zones, but the largest concentrations tend to be found in the 20- to 60-m depth zone. Adults are generally associated with reefs, rock outcroppings, and other vertical structures. In this example, the primary expected impact of major concern is that offshore structures would tend to attract and aggregate snappers and groupers where they could be subject to overfishing.

Each of the potential impact factors were then examined to estimate effects on the remainder of the 15 VECs in a manner similar to that for snapper and grouper. A matrix summarizing the potential impacts for all VECs resulting from this analysis was developed. This matrix may be thought of as an integrated conceptual model (consisting of 15 submodels). The summary impact matrix indicates the severity of an impact, the relative probability of occurrence, and the estimated maximum impact radius. The matrix was formed by listing the environmental factors associated with oil and gas structures and activities and their associated potential impacts down one side and the VECs across the top. Each cell was divided into two sectors by a diagonal. The upper left portion of the cell denotes the probability of occurrence of the impact, coded as high, medium, or low. The lower right cell shows impact level. A high impact is virtually certain (e.g., mechanical bottom damage associated with installing a platform). A low impact means that there is at least a probabilistic chance that the impact would occur, but it is not very likely. A medium impacts encompasses everything in between the two maximum extremes. The number in the center of the scale is coded to an estimated impact radius.

Dr. Benny Gallaway is president of LGL Ecological Research Associates, Inc. and an Adjunct Professor at Texas A&M University. His primary research interests lie in the field of population ecology and behavioral responses of fish to environmental gradients. He is a member of the Reef Fish Scientific and Statistical Committee of the Gulf of Mexico Fishery Management Council. Dr. Gallaway holds a Ph.D. from Texas A&M University.

STATION	YEAR 1	2	3	4	5	STATION	YEAR 1	2	3	4	5
1	●	●				29	●	●		●	●
2	●					30	●				
3	●	●				31		●			
4	●	●				32		●			
5	●	●				33		●			
6	●	●				34		●			
7	●	●			●	35		●			
8	●					36		●		●	●
9	●	●				37		●			
10	●					38		●			
11	●	●				39		●			
12	●	●				40			●		
13	●	●				41			●		
14	●	●				42			●		
15	●	●				43			●	●	
16	●	●				44			●	●	●
17	●					45			●	●	
18	●					46			●	●	
19	●			●		47			●	●	
20	●	●				48			●	●	
21	●	●		●	●	49			●	●	
22	●	●				50			●	●	
23	●	●		●	●	51			●	●	
24	●	●				52			●	●	●
25	●	●				53			●		
26	●					54			●		
27	●					55					●
28	●	●									

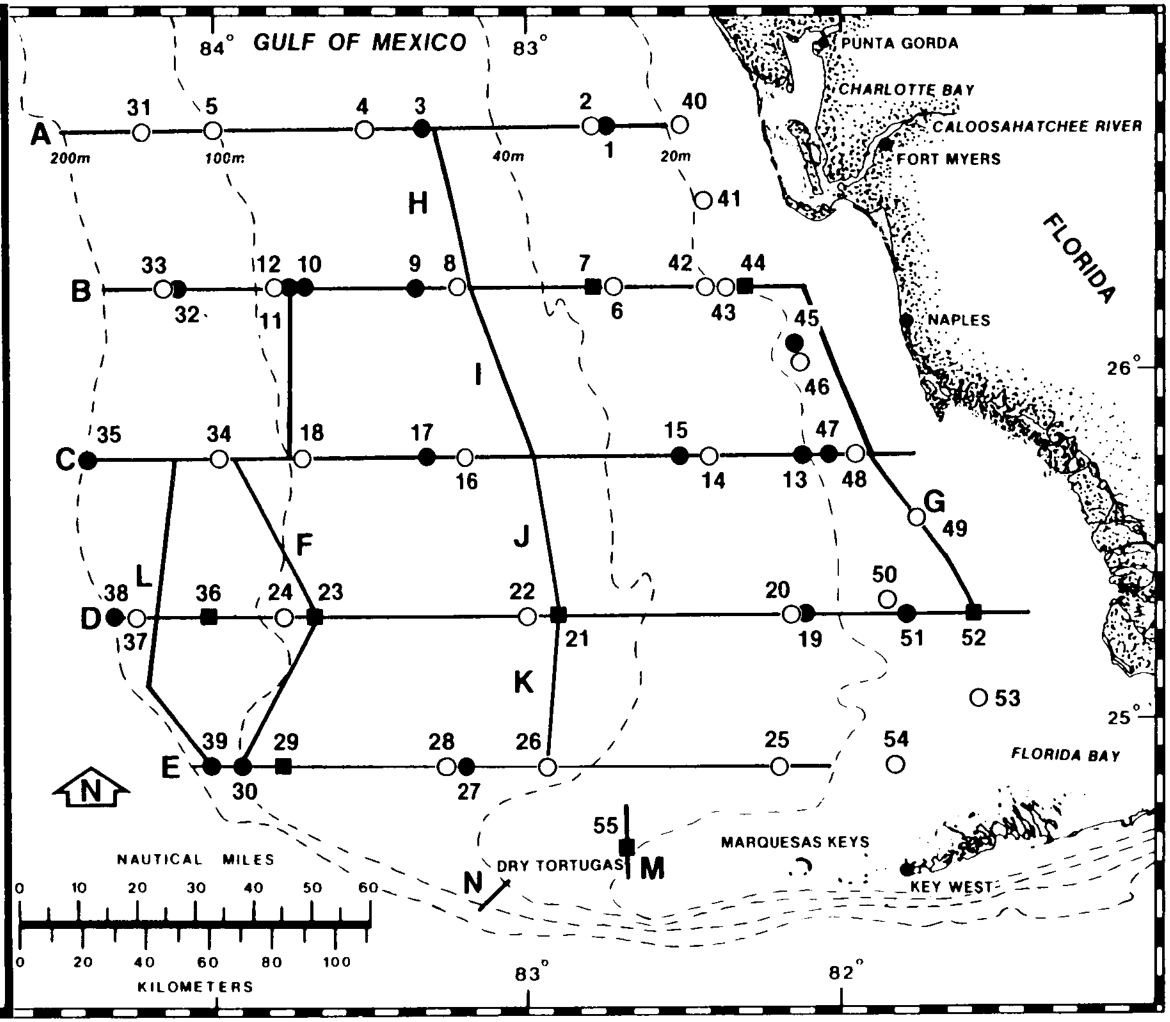

Figure 8.1.--**Southwest Florida Shelf Ecosystems Program study area with Years 1 through 5 geophysical and towed underwater television transects (A-N) and discrete stations (1-55) indicated. Inset indicates years during which stations were sampled; ○ = soft-bottom, ● = live-bottom, and ■ = intensively sampled station.**

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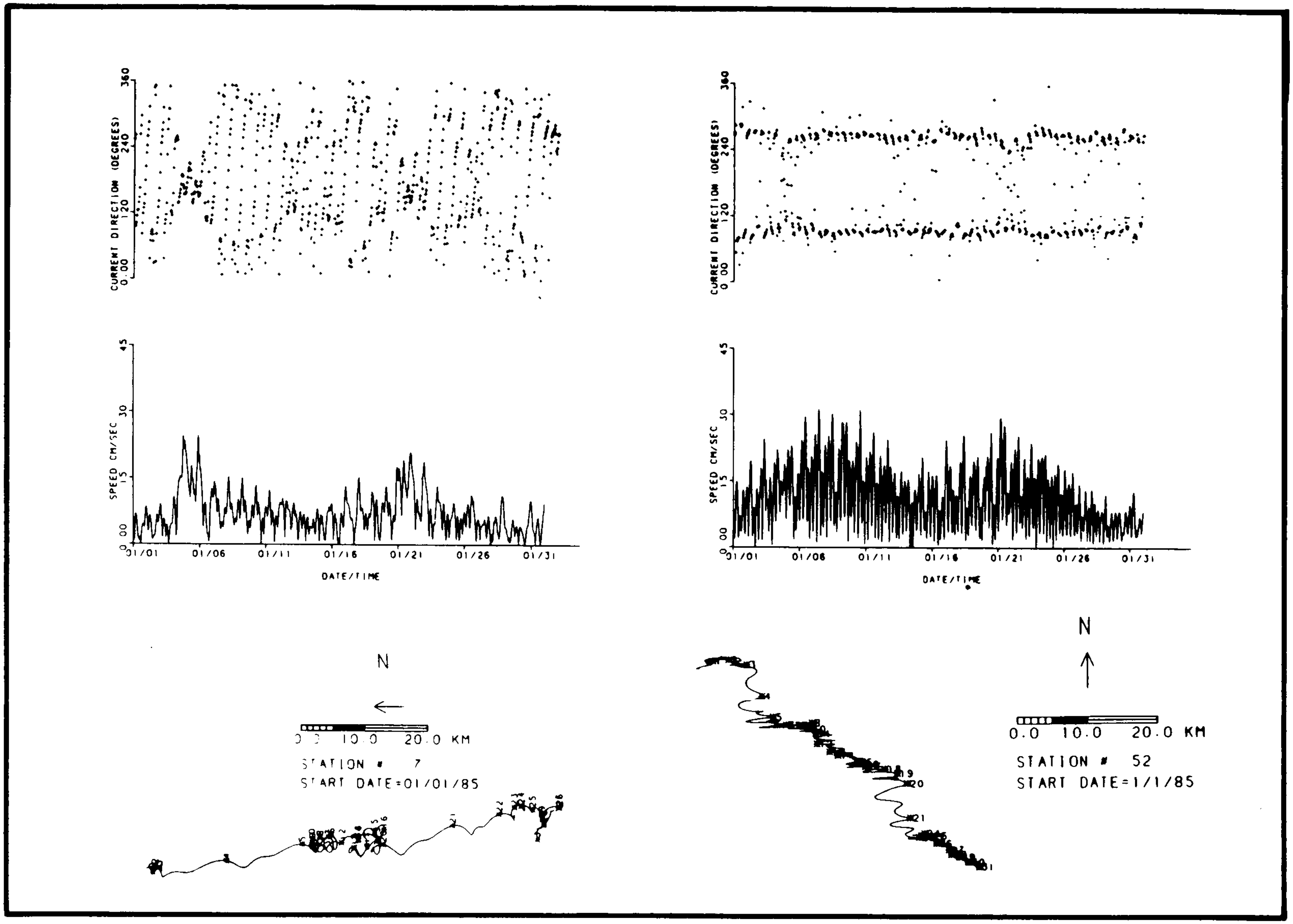


Figure 8.2.--**Example of the change in current velocity characteristics from elliptical to rectilinear motion and diurnal to semidiurnal periodicity as depth decreases from 32m (Station 7) to 13m (Station 52).**

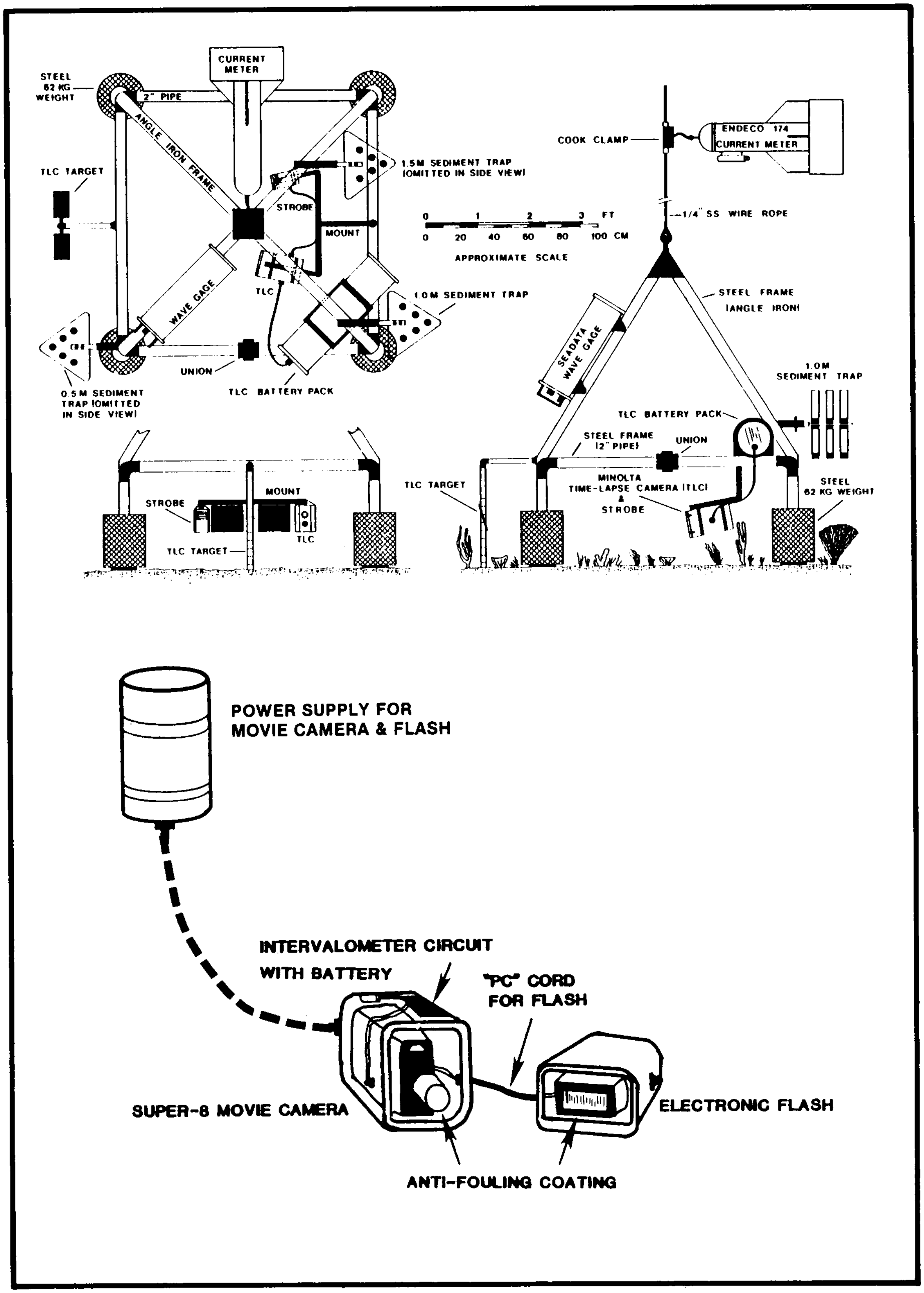
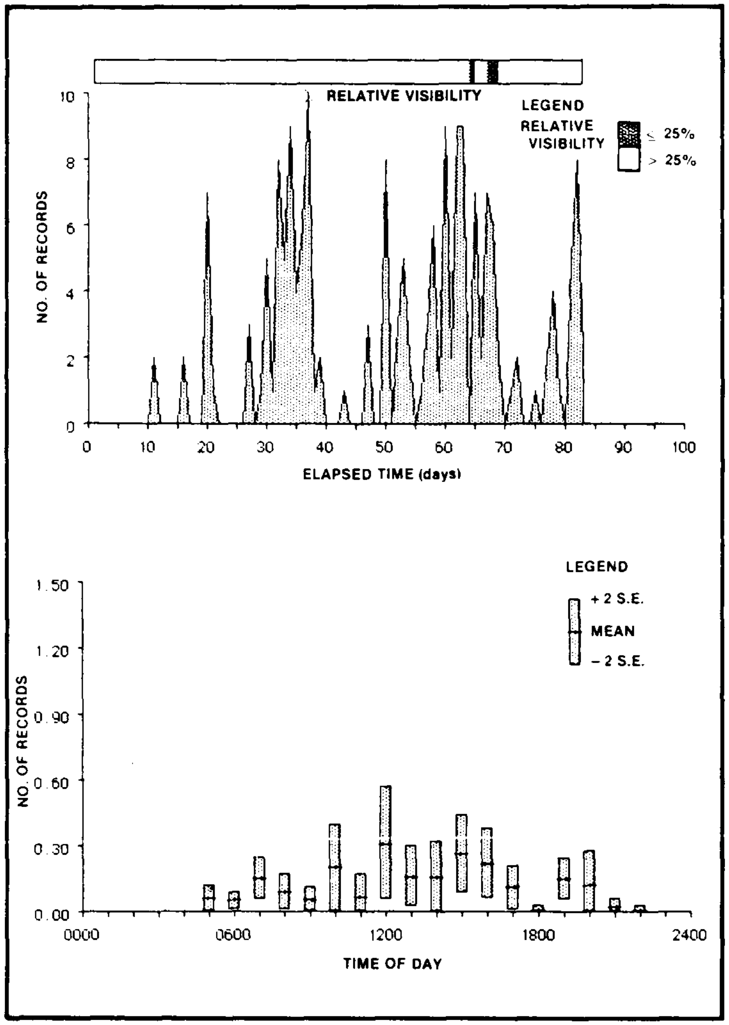
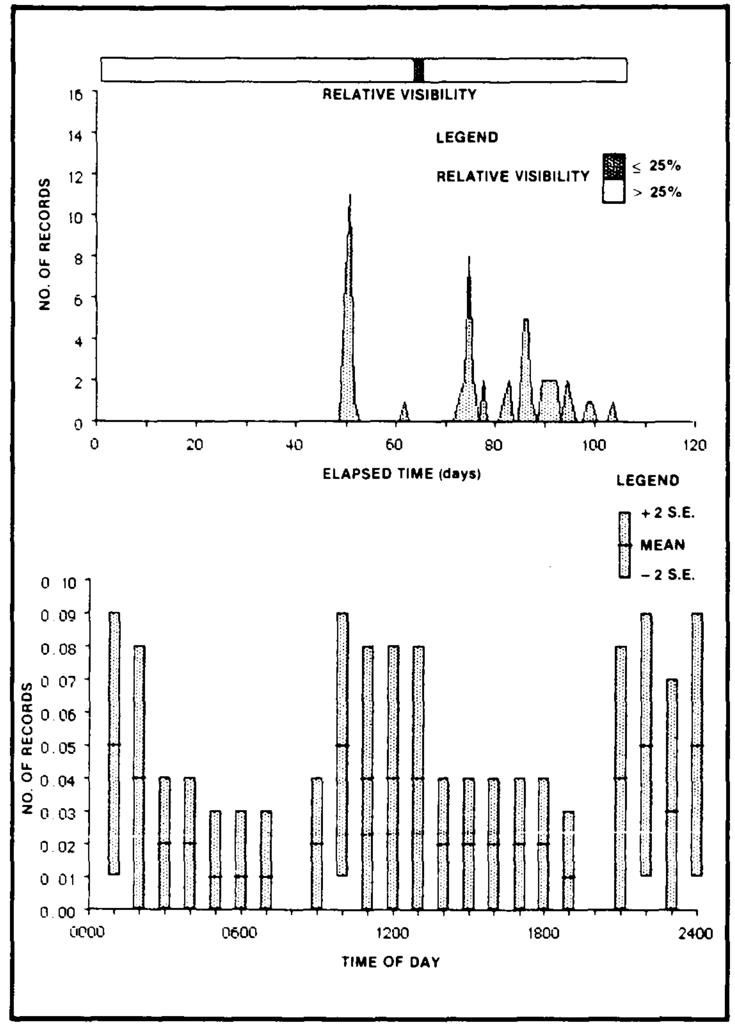


Figure 8.3.-- **Instrumented array and time-lapse camera design.**



TOTAL DAILY ABUNDANCE AND HOURLY ABUNDANCE IN TIME-LAPSE RECORDS FROM STATION 55, JUNE 27 – SEPTEMBER 17, 1985 — *Lutjanus griseus*



TOTAL DAILY ABUNDANCE AND HOURLY ABUNDANCE IN TIME-LAPSE RECORDS FROM STATION 55, DECEMBER 12, 1984 – MARCH 27, 1985 — *Epinephelus itajara*

Figure 8.4.-- **Example of faunal behavior observations from time-lapse camera data.**

MARINE TURTLES AND MAMMALS AND OCS STRUCTURE REMOVALS; OPERATIONAL AND BIOLOGICAL PERSPECTIVES AND STUDIES

Session:	MARINE TURTLES AND MAMMALS AND OCS STRUCTURE REMOVALS; OPERATIONAL AND BIOLOGICAL PERSPECTIVES AND STUDIES
Co-Chairs:	Mr. G. Ed Richardson Mr. Lars T. Herbst
Date:	December 3, 1987

Presentation Title	Author/Affiliation
Marine Turtles and Mammals and OCS Structure Removals; Operational and Biological Perspectives and Studies: Session Overview	Mr. G. Ed Richardson and Mr. Lars T. Herbst Minerals Management Service Gulf of Mexico OCS Region
Structure Removal: Offshore Operators Committee Perspective	Dr. Bruce Cox Marathon Oil Company
Nonexplosive Removal Techniques: An Alternate Method of Structure Removal in Environmentally Sensitive Areas (Abrasive Cutter)	Mr. Jack Fernandez, Jr. Dimensional Oilfield Services
Nonexplosive Removal Techniques: Nonexplosive Platform Removal -- Hydraulic Pile Cutting	Mr. Leon Ortemond Marcon, Inc.
Louisiana Rigs-to-Reefs Update	Ms. Virginia Van Sickle Louisiana Geological Survey
A Case History for Rigs-to-Reefs: A Cost-Effective Alternative for Platform Abandonment	Mr. Win Thornton and Mr. Jim Quigel Cities Service Oil & Gas Corp.
Analysis of Shockwave Signatures Under Controlled Conditions	Dr. Joseph G. Connor, Jr. Naval Surface Warfare Center
Underwater Sightings of Sea Turtles in the Northern Gulf of Mexico	Mr. Ian Rosman, Mr. Gregory S. Boland, Mr. Larry Martin, and Mr. Charlie Chandler LGL Ecological Research Associates, Inc.
National Marine Fisheries Service Perspective on Structure Removals	Dr. Terry Henwood National Marine Fisheries Service
Perspective on Oil and Gas Production Structure Removals and the Permit Process	Mr. Robert Bosenberg U.S. Army Corps of Engineers New Orleans District

Session: MARINE TURTLES AND MAMMALS AND OCS STRUCTURE REMOVALS; OPERATIONAL AND BIOLOGICAL PERSPECTIVES AND STUDIES

Presentation Title	Author/Affiliation
Use of Seismic Air Guns to Produce Avoidance Responses in Loggerhead Turtles	Dr. James O'Hara Environmental & Chemical Sciences, Inc.

Marine Turtles and Mammals and OCS Structure Removals; Operational and Biological Perspectives and Studies: Session Overview

Mr. G. Ed Richardson
and
Mr. Lars T. Herbst
Minerals Management Service
Gulf of Mexico OCS Region

Two sessions on marine turtles and mammals and OCS structure removals were organized to discuss the operational and biological perspectives of this issue. Several objectives were envisioned for these sessions. The Offshore Operators Committee (OOC), National Marine Fisheries Service (NMFS), and Corps of Engineers were invited to present their perspective on structure removals. Several presentations on nonexplosive removal techniques would be offered as alternative methodologies for explosive removals. An update on the rigs-to-reefs program and a case history of the first rig-to-reef conversion in Louisiana offshore waters were provided information regarding this initiative. Reports of studies involving marine turtles and mammals, their sightings, and their behavior and response to noise were scheduled for the sessions. Finally, methods to reduce the number and/or to eliminate the need for Section 7 consultations under the Endangered Species Act (ESA) were to be discussed during the sessions.

Mr. Lars Herbst opened the proceedings and introduced Mr. G. Ed Richardson as co-chair for the morning and afternoon sessions. Mr. Richardson delivered a brief introduction and provided background information regarding the structure removal issue. Mr. Richardson's slides depicted data and statistics from structure-removal applications and observations from structure-removal operations during fiscal year 1987. He also explained requirements under the National Environmental Policy Act for proposed structure removals.

The first presentation of the morning session, "Offshore Operators Committee's Perspective on Structure Removals," was delivered by Dr. Bruce Cox of Marathon Oil Company. The presentation focused on the OOC's position and on recommendations regarding the structure-removal issue. The OOC's position is that, if platform removal by use of explosives poses a threat to the survival of an endangered species or even those that are listed as threatened, the offshore industry is willing to take appropriate steps to mitigate the threat. However, the OOC believes the issue and associated mitigating measures have reached far too high a level of attention without any compelling evidence that structure removals pose a threat to the survival of sea turtle populations. Therefore, the following recommendations were offered in the presentations:

1. encourage a research program that places much greater emphasis on the prevalence of sea turtles at structures. These studies should address sea turtle seasonality and distribution as related to structures located along the OCS.
2. encourage MMS and NMFS to prepare a long-range program that outlines research required to determine whether or not explosive salvage operations indeed jeopardize the continuing existence of sea turtles in the Gulf of Mexico.
3. make modifications to the Section 7 consultation process that would reduce the time

required to review and issue removal permits.

4. establish more realistic guidelines for conducting salvage operations.

The next topic of discussion at the session involved nonexplosive techniques for structure removal. The first of the two techniques discussed, the use of a sand jet cutter, was presented by Mr. Jack Fernandez, Jr., of Dimensional Oilfield. The presentation entitled "An Alternative Method of Structure Removal in Environmentally Sensitive Areas" focused on the equipment required for abrasive cutting. He described the cutter body, which has two tapped side ports that would accept extension arms to size the cutter body to the casing that will be severed. Once the cutter head is made up on the work string and lowered to the cutting depth, the small hydraulic rotary is secured to the work string and to the top of the pipe to be cut. Mr. Fernandez explained that the rotary turns the cutting assembly at about 1 rpm. The cutting time is dependent primarily on the number of casing strings to be cut, the eccentricity of the casing strings, and whether or not the annuli are grouted. The abrasive of choice for Dimensional Oilfield was described as granulated coal slag. Mr. Fernandez mentioned that Dimensional Oilfield has developed a test cell in which particle size, orifice size, and viscosity of the fluid will be examined to produce optimum cutting conditions.

The next presentation was scheduled to discuss the merits of cryogenic fracturing. However, the representative from Offshore Pipeline, Inc., was unable to attend.

The third presentation was delivered by Mr. Leon Ortemond of Marcon, Inc. The presentation included a slide demonstration of equipment utilized in a mechanical cutting operation. The basic equipment list included a pump, a 100-barrel tank, a power unit, a power swivel, and a stabilized work string with the mechanical cutter. The mechanical cutter was described as a multi-blade assembly with carbide tips. The initial rig-up time was stated to be 6 hours, but required only a matter of minutes to move from one pile to the next. A derrick barge or crane would be required to move the assembly from pile to pile. Mr. Ortemond explained that a 16-degree batter pile was successfully cut in Marcon's test facility to demonstrate the ability to centralize the cutter. However, the effectiveness of the cutter to sever well conductors with non-concentric casing strings was not proven.

The fourth presentation, a Louisiana "Rigs-to-Reefs Update," was given by Ms. Virginia Van Sickle of the Louisiana Geological Survey. This presentation was an update to the "Louisiana Artificial Reef Initiative" presentation made by Ms. Van Sickle at the Seventh Annual Gulf of Mexico Information Transfer Meeting (ITM) last year. This year's update focused on the phases of developing the Louisiana Reef Plan. The first phase of the Plan's development was called "exclusion mapping," which eliminated all navigation fairways, military zones, EPA dump sites, live bottoms, and coral reefs. The next phase included the selection of areas that would be considered as high priority for reef development. This selection was accomplished through discussions with the shrimping and fishing industries as well as sport fishing interests. After public hearings were conducted, eight offshore sites were established. The Plan was completed in June 1987, and implementation was initiated when Cities Service Oil and Gas Corporation donated the first reef structure in October 1987.

The morning's final presentation was provided by Cities Service Oil and Gas Corporation and was entitled "A Case History for Rigs-to-Reefs: A Cost Effective Alternative for Platform Abandonment." The presentation was made by Mr. Jim Quigel and Mr. Win Thornton, who discussed both permitting and operational planning for the toppling of the South Marsh Island Block 146 "A" platform. For the permitting procedures, Mr. Quigel explained Cities Services' part in the deed of donation, the site clearance departure, and the endangered species consultation. Next, the actual steps involved in the toppling operation were discussed by Mr. Thornton. The toppling operation closely followed the extensive engineering studies and was deemed a success by Cities Service. The presentation also explained some difficulties Cities Service encountered in following the "Incidental Take Statement" requirements from the endangered species consultation.

The morning session was closed by Mr. Lars Herbst with an explanation of the study to be conducted by the Naval Surface Warfare Center (NSWC) through an Interagency Agreement. The discussion was not presented by the NSWC because of a work conflict. However, an abstract was provided after the ITM that discussed the project. This abstract has been included in the meeting proceedings.

The afternoon session was opened by Mr. Richardson and began with Mr. Ian Rosman's presentation of the underwater sighting of sea turtles in the northern Gulf of Mexico. Data from eight scientific studies in the northern Gulf of Mexico from 1975 to 1985 were reviewed for underwater sightings of sea turtles. This effort yielded 268 verifiable underwater sightings of which 231 came from time-lapse cameras on live-bottom areas off southwest Florida. The majority of sightings were loggerheads. Time-lapse results indicated a distinct diel pattern with more than three times the number of sightings per hour observed during the night. Utilization of underwater structures consisted of brief periods (1 to 5 h) of relative inactivity. Mr. Rosman reached the following conclusions:

1. Underwater sightings of sea turtles by divers were uncommon.
2. Sightings were least frequent during task-oriented dives in turbid water.
3. Time-lapse observations were more effective than dive-observations for determining frequency of occupation at artificial structures.
4. Turtles were repeatedly observed to occupy small artificial structures in southwest Florida waters.
5. Occupation included protracted physical contact with the structure.
6. Occupation occurred more frequently during darkness than daylight.
7. Frequency of occupation possibly increased linearly as a structure remained in place underwater.

Dr. Terry Henwood provided the NMFS perspective on structure removals. He briefly outlined the history of the structure removal and sea turtle issue. Dr. Henwood explained the role of NMFS in ESA consultations. The NMFS is responsible for administering the ESA for all Federal actions that may impact or jeopardize the continued existence of endangered and threatened species at sea. The NMFS performs strictly an advisory function under Section 7 of the ESA.

For all consultations to date regarding structure removals utilizing explosives, the NMFS has concluded that the removals do not constitute a "jeopardy" situation, but may affect listed species. An "Incidental Take Statement" including mitigative measures has accompanied the Biological Opinions for incorporation in the specific removal plans of the applicant.

Dr. Henwood also explained the NMFS responsibilities for administering the Marine Mammal Protection Act (MMPA). The NMFS does not consider injury or death of marine mammals to be likely for explosive structure removals if the operator adheres to the mitigative requirements provided in the ESA "Incidental Take Statement." However, to be in compliance with the MMPA, operators must apply for a permit and be granted a small take Letter of Authorization.

The NMFS offered the following suggestions regarding future structure-removal consultations. Data should be collected to determine when, where, and how many listed species are associated with offshore structures. How many animals are injured or killed as a result of the underwater detonations? Second, he suggested that devices or techniques to "drive" marine turtles and mammals away from structures prior to detonation of explosives should be investigated and developed. Third, the NMFS strongly recommended that industry take an active role in supporting the development of new, nonlethal techniques for structure removals. Industry should also consider data collection to document that some explosive charge techniques presently in use produce minimal blast effects and have little or no impact on marine life in the area of operations.

Mr. Robert Bosenberg presented the New Orleans District (NOD) Corps of Engineers (COE) perspective on structure removals and the permit process. Oil and gas production facilities in tidal bays, estuaries, and within the three-nautical mile zone off the Louisiana coast are under the jurisdiction of the NOD. As those structures cease to be productive, the terms of the State lease agreements, the general conditions of the applicable Section 10 Federal permit (River and Harbor Act) issued by the COE, and economic considerations collectively motivate an operator to remove the obsolete structures as soon as practicable.

When the MMS determined that explosive structure removals constituted a "may effect" situation under Section 7 of the ESA, structures to be removed under the COE's jurisdiction were also affected. The NMFS requested that the NOD of the COE initiate consultations pursuant to Section 7 of the ESA for explosive structure removals. The NOD issued a special public notice directing permit holders to notify the COE before an explosive removal was conducted. The notice further instructed permittees not to proceed until specific notification had been provided. The NOD developed and sent a questionnaire to each of the 15 operators proposing to remove structures. The questionnaire asked precisely why the permittee had to use explosives and what other alternatives were considered. Eleven of the fifteen operators opted for a nonexplosive removal method. The NMFS has concurred with the NOD that nonexplosive removal techniques are not a "may effect" situation and do not require Section 7 consultations. These operators have received permission to conduct their proposed operations.

For explosive removals, the NOD prepares specific biological assessments or, as an alternative, the operator may assemble a specific biological assessment while coordinating with the NOD and NMFS. That assessment could be submitted to the NOD with an explosive removal request and would be subsequently adopted by the COE and submitted to the NMFS for Section 7 consultation.

Mr. Bosenberg also mentioned the need for operators to contact the NMFS and acquire a permit to "take" marine mammals if their proposed activities may involve these animals.

Dr. James O'Hara presented his findings from a study that used seismic air guns to produce avoidance responses in loggerhead turtles. His research was conducted at an electric power plant in Florida utilizing a 300 m dead-end canal from the plant's cooling canal grid. The test canal was isolated by a net at the open end and seismic air guns were arrayed across the canal to establish a sound barrier. A series of subadult turtles were used over several thousand hours of testing in the canal. By using multiple air guns with an air pressure of 2,000 psi firing at a 4/min rate, an effective barrier was established. A statistically significant reduction in occurrence or the movement of turtles into the protected (sound barrier) area of the canal was demonstrated.

Based on the investigations conducted in the canal, Dr. O'Hara believes this technology is transferable to structure-removal operations for offshore platforms in the Gulf of Mexico. He suggests "radio tagging" a sea turtle associated with a structure, monitoring his behavior around the structure for several days, then slowly bringing up the air pressure firing air guns suspended from the structure, and continuing to monitor the movement of the turtle. If the turtle leaves the vicinity of the structure, it would be a clear indication that the methodology is effective.

Dr. O'Hara stated that there is no experimental evidence to indicate that marine mammals would be effectively frightened away from a sound source as the sea turtles had been. However, during the course of the test in the canal with the sea turtles, divers expressed significant discomfort and did not try to approach the sound sources. It is suggested that marine mammals would have a similar response in behavior.

Mr. G. Ed Richardson is a Supervisory Environmental Protection Specialist with the MMS, Gulf of Mexico OCS Regional Office. He has 15 years experience with State and Federal Governments and with the oil and gas industry. Mr. Richardson received his M.S. from Clemson University in microbiology, environmental health, and biochemistry.

Mr. Lars Herbst is employed as a petroleum engineer in the Technical Assessment and Operations Support Section of the MMS. He was previously employed by Flopetrol-Johnston Schlumberger as a field engineer in production testing. He received his B.S. in petroleum engineering from Louisiana State University.

Structure Removal: Offshore Operators Committee Perspective

Dr. Bruce Cox
Marathon Oil Company

HISTORY

Between March and September 1986, a greater than average number of dead sea turtles and dolphins (Tursiops truncatus) washed ashore on the upper Texas and nearby Louisiana coasts. The majority (67 percent) of stranded sea turtles were Kemp's ridley turtles, Lepidochleys kempi. Kemp's ridley turtles are listed as endangered by the Endangered Species Act (ESA). Marine mammals such as dolphins are protected by the Marine Mammal Protection Act (MMPA).

Stranding records have been kept by the National Marine Fisheries Service (NMFS) Sea Turtle Stranding Salvage Network for the past seven years. The natural variability in biological systems and ecosystems, in combination with the probable inconsistencies of the Sea Turtle Stranding and Salvage Network's observer program in the earlier years, makes it difficult to affirm that 1986 strandings were excessive.

Nevertheless, the stranding statistics triggered a "probable cause" investigation by the NMFS, which, in turn, identified an activity of the offshore petroleum industry as a possible contributor to the turtle mortality. The activity is platform and structure removal that utilizes explosives. The Minerals Management Service (MMS) requires all offshore operators to sever platform legs and other structures protruding from the bottom at 16 feet below the bottom mudline. In most instances, explosives are the only reliable and safe method for cutting legs at the required depth.

In August, 1986, an 8-month moratorium on platform removals that employ explosives was proposed by Jack T. Brawner, Regional Director, NMFS, St. Petersburg, Florida, to J. Rogers Pearcy, Regional Director, MMS. The moratorium was to become effective September 1, 1986. Exceptions would be given if a cooperative MMS/NMFS observer program was incorporated to monitor potential effects on listed species and if preliminary studies were initiated to estimate the magnitude of the problem. Additionally, NMFS suggested that mitigating methods to eliminate/minimize any adverse impacts be investigated. Shortly after the NMFS proposal was made, the two agencies (i.e., MMS and NMFS) entered into a "formal" ESA, Section 7 interagency consultation program, which is presently repeated for each structure removal request submitted by industry.

The Section 7 interagency consultation process, coupled with concerns by operators of potentially violating the MMPA, has almost brought structure removals to a standstill. The curtailment of structure removal activities has come to a time when structure abandonment rates in the Gulf of Mexico are on the rise. The increased structure removal rate is due to the growing number of older and now nearly depleted oil and gas fields, which have become uneconomical to produce.

ESA SECTION 7 PROCESS AND MMPA CONSIDERATIONS

Each operator planning to remove a platform or structure with explosives must submit an "application" to the MMS, Gulf of Mexico OCS Regional Office. Information such as platform/structure description, locations, thickness of all casing strings and legs, size of explosive charge, type of charge, how they are to be set, and when the activity is planned are required when submitting an application. The MMS first reviews the application, then submits it to NMFS for review. This review process has ranged in time from seven days to eight months for those applications that have been approved.

From September 1986 to October 13, 1987, 96 applications for removals had been submitted, and 77 approved; however, only 10 structures have been removed during this time span. The low number of removals as compared to approvals reflects, among other things, concerns by operators over a clause contained in the MMS salvage permit approval letter. The clause states that no exemption is granted to operators for protection from provisions of the MMPA. The formal process by which operators can obtain exemptions under the MMPA when structures are removed with explosives is complicated and will likely require one to two years to complete.

Specific guidelines, which are to be followed by the operator at the time of salvage, are developed by the MMS for each salvage job. The guidelines basically address: 1) observer programs; 2) aerial surveys; 3) diver surveys; 4) actions to be taken if and when a turtle is found near a structure; 5) the time when explosive charges can be set; and 6) time intervals for staggering charges.

Research planned by the agencies to facilitate the development of a valid "Biological Opinion" includes observational surveys at the time of salvage, quantification of impulse and pressure zones around salvage blasts, determination of the effects of explosive charges on sea turtles, and a review of dive records from past research conducted around artificial reefs and structures.

OOC PERSPECTIVE AND POSITION

The Offshore Operators Committee (OOC) represents the interest of virtually all domestic companies engaged in petroleum exploration and production in the Gulf of Mexico. Environmental concerns are among those interests that are represented by the OOC. It is the intent of offshore operators to maintain a compatibility between exploration/production activities and the environment. The industries' good record of compliance with environmental regulations and the favorable health of the Gulf of Mexico offshore marine environment speaks strongly of the integrity of the industry.

The OOC recognizes the perils confronting populations of endangered sea turtle species and understands the responsibilities of the NMFS and United States Fish and Wildlife Service to establish programs to protect and propagate these species. If structure removal by use of explosives significantly inhibits the survival of an endangered species such as the Kemp's ridley sea turtle or adversely affects even those populations of sea turtles that are listed as threatened under the ESA, the offshore industry is willing to take appropriate steps to mitigate the threat of its actions.

However, the OOC is concerned that considerable time and money will be spent on establishing and carrying out mitigating measures when it is not clear that the activity of structure removal with explosives has or will significantly jeopardize the continued existence of the Kemp's ridley sea turtle populations. Conversely, it would be grossly unfair to offshore operators if the Kemp's ridley sea turtle population continued to decline after costly mitigating measures were instituted. We believe the issue has reached far too high a level of attention without any compelling evidence that structures are a habitat for turtles and that structure removal poses a threat to the survival of sea turtle populations.

Only the LGL study, sponsored by the MMS, explores this subject. This study involved an analysis of research dive logs accumulated by LGL (a consulting firm in College Station, Texas), while conducting biofouling and fish community studies around oil platforms in the Gulf of Mexico. LGL also analyzed logs from similar studies of artificial and natural reefs in the Eastern Gulf of Mexico. Although the results have not been formally released by the MMS, we understand that most of the turtle sightings recorded were from the Eastern Gulf of Mexico, whereas only a small percentage of the total sightings were from platforms. This study therefore falls short of providing needed answers.

Other studies sponsored or proposed by MMS and NMFS are prematurely directed at mitigation rather than toward the central question of prevalence of turtles at structures. Research on sea turtle abundance, seasonality, water depth limitations, and geographic distribution should take precedence over studies on blast effects and mitigation methods.

RECOMMENDATIONS

The OOC encourages a research program that places much greater emphasis on the prevalence of sea turtles at offshore structures. These studies should also be designed to document sea turtle seasonality and zoogeographical domain as related to structures and platforms located along the Outer Continental Shelf of the northern Gulf of Mexico. The OOC is willing to cooperate in this effort by helping to organize volunteer observer programs using platform operators and professional divers. These programs would supplement observational records currently being made by the MMS and NMFS during actual salvage operations. The OOC does not, however, believe that current observational programs at salvages, even if combined with volunteer platform operator and professional diver observational programs, are rigorous enough to make a valid correlation between platforms/structures and sea turtle presence. Additional study programs would have to be implemented to document this phenomenon.

The OOC encourages the MMS and NMFS to prepare a long range program that outlines research required to develop a sound biological opinion on whether or not salvage operations indeed jeopardize the continuing existence of sea turtles in the Gulf of Mexico. The program outlined should include clearly stated research objectives and define how each study will support a valid assessment of whether or not a problem exists. Methods by which the petroleum industry can cooperate should be addressed in the long-range program outline.

The current MMS/NMFS Section 7 interagency consultation process for each platform/structure removal is cumbersome and time consuming. Any modifications to the Section 7 interagency consultation procedure, that would reduce the time required to review and issue removal authorizations would be endorsed by the OOC.

The OOC feels that present guidelines for conducting salvage operations place an onerous and expensive burden on operators. This is particularly true of the requirement that salvage operations be conducted only during daylight hours. We would hope that more realistic guidelines could be established.

Finally, the OOC strongly encourages the NMFS to find some other funding method to defray the expense of its observer program. The present practice of charging operators for the cost of these observers gives the appearance of "conflict of interest."

These OOC recommendations address the Section 7 process under which our industry is currently operating. An important part of Section 7 interagency consultation process is the development of mitigating measures to protect endangered sea turtle species if they are found to be in jeopardy.

Industry is conducting research in an effort to find alternate and environmentally safe methods to sever platform legs at the required 16 foot distance below the mudline. These programs and methods are the topic of other papers that are to be presented at this year's MMS Information Transfer Meeting.

Dr. Bruce Cox is currently stationed at Marathon Oil Company's Exploration and Production Technology Center in Littleton, Colorado. Since 1980, he has been providing counsel on environmental matters to Marathon Oil Company operations throughout the world. Dr. Cox holds a bachelor of science in biology (1967) from Southeast Missouri State College and a master of science in biology (1970) from Texas A&M University. He has obtained his Ph.D. from Texas A&M in marine biology (1974).

Nonexplosive Removal Techniques: An Alternate Method of Structure Removal in Environmentally Sensitive Areas (Abrasive Cutter)

Mr. Jack Fernandez, Jr.
Dimensional Oilfield Services

The cutting of materials with abrasive particulates has been in existence for thousands of years. In the early years of the oil and gas industry, oil and gas wells were perforated with an abrasive hydraulic stream. We have refined the process of cutting with an abrasive stream into a very viable operation.

In the past, if a structure was to be removed from a marine location, an explosive charge was employed to sever the structure below the natural bottom. Until recently, this method of removal had been an accepted procedure in the oil industry. With the advent of environmental awareness, there came a need to find a cost-effective alternate method of removal. The hydraulic abrasive cutter offers an alternate method of structure remcval that is safe, cost effective, and efficient.

The equipment necessary to hydraulically cut a marine structure consists of a pump, tank, sand injector, high pressure pump lines, a small rotary, work string, and the cutter. The critical element of the equipment list above is the pump. The amount of hydraulic horsepower required to efficiently cut marine structures demands the use of a large pump. In a typical cutting operation, a 4,000 psig pump and 2 BPM flow rate are required (approximately 200 hydraulic horsepower). We employ a 310 HP pump to supply the necessary hydraulic pressure.

The hydraulic cutter head is the only non-standard piece of oilfield equipment used in the cutting operation. The cutter head consists of a main body, which makes up on the work string. The cutter body has two tapped side ports into which extension arms are screwed. At the end of the extension arms sized orifice tips are attached. All screwed connections are O-ring sealed. The length of the extension arms is governed by the inside diameter of the pipe to be cut. We have found, empirically, that a standoff of 0.5 inches (1.27 cm) gives a satisfactory cut without causing undue erosion of the orifice tips. A centralizing ring is installed above the cutting body to maintain concentricity.

In a typical pipe cutting scenario, the depth of the first cut is determined by the number of concentric strings to be severed. A two-foot (61 cm) increment in succession is typically used with the inner string as the deepest cut and the last string to be cut at the prescribed depth. The depth at which the cut is to be made is measured by use of tubing joints and pipe joints utilized in the work string.

The cutter is lowered into the pipe to be cut and the small hydraulic rotary is secured to the work string at the top of the subject pipe. The work string is rotated at about 1 RPM. The sand injector, filled with abrasive particulates, is opened and the pipe-cutting operation commences.

At present, if a casing string is not tensile loaded, there is no clear indication of a complete cut. We currently rely on experience and monitoring of returns to determine the time at which the cutter is pulled, and an attempt is made to retrieve the severed pipe. If a complete cut has not been made, the cutter can be returned to the exact position of the original cut, and severing operations can resume.

In many cases, cutting times for casings with ungrouted annular areas can be as little as ten minutes. As the casing or piling size increases, the cutting time increases accordingly. If the casing program consists of multi-strings, and one or more is grouted, the cutting time is extended. A major parameter governing cutting time, if grouted casing strings are used, is the eccentricity of the casing strings grouted. As the eccentricity increases, the stand-off distance from the orifice tip to the farthest casing wall increases.

At present, we are experimenting with a combination of particle size, orifice size, and viscosity of water that will give a satisfactory cutting force at extended distances. Our test cell will provide empirical data that will give us a high degree of confidence concerning various casing programs.

Of primary importance to the hydraulic cutting operation is the abrasive particulate used. We have selected granulated coal slag as the abrasive of choice for many reasons. A primary consideration is the safety of using a product both above and below the water. The coal slag is completely non-invasive and passive to the environment. In addition to the safety aspect, the coal slag is approximately 3 times harder than sand.

The hydraulic abrasive cutter, as with other methods of structure removal, has its limitations. It is very important that these limitations be addressed prior to the commencement of a job and that contingency plans be made accordingly.

There are certain cases, as in large diameter pipe, where the abrasive cutter can effect a more cost-effective cut than explosives. If the shaped or bulk charge does not completely sever the pipe, re-entry into the pipe to set another charge can be very costly. As with any endeavor in the oilfield, researching the problem at hand and prudent planning will result in a higher percentage of successful operations.

Table 9.1 lists the structures that have been severed using the abrasive cutter.

Mr. Jack Fernandez, Jr., received a B.S. in engineering sciences from the University of New Orleans in 1971. He is currently pursuing a B.S. in computer science from UNO. He has eight years' experience as a production engineer for an independent producer and is presently Engineering Manager for Dimensional Oilfield Services.

Nonexplosive Removal Techniques: Nonexplosive Platform Removal -- Hydraulic Pile Cutting

Mr. Leon Ortemond
Marcon, Inc.

There are more than 6,000 offshore installations worldwide, with two-thirds situated in U.S. waters. All will have to be removed upon reaching obsolescence.

The estimated costs of removing these structures vary significantly, but have ranged upwards of $30 billion.

The 1958 Geneva Convention of the Continental Shelf, a treaty which the U.S. Senate ratified, states "any installations which are abandoned or disused must be entirely removed."

Even the rigs-to-reef movement requires toppling obsolete platforms before converting them to artificial reefs.

Of 116 offshore structures permitted for removal in the Gulf of Mexico in 1987, 107 were scheduled to be removed by explosives. But this method of removing platforms with explosives has been curtailed by the U.S. Department of Interior's Mineral Management Service (MMS) until a study on the destruction wrought by underwater demolition is completed.

The study was proposed after 124 dead-strandings of sea turtles, 17 pre-born porpoises and other assorted marine life were washed ashore on the upper Texas coastline in 1986. The strandings were reportedly associated with the use of explosives to remove a platform.

What does this mean for operators and the multitude of platforms scheduled for removal in 1987? It means that operators are going to have to find an alternative method to explosives for removing platforms or delay removing the platforms.

At Marcon, we believe that the alternative is hydraulic pile cutting.

Hydraulic pile cutting is not a new method, but a 30 year old tried-and-true method.

Basically, with hydraulic pile cutting, radial-turned abrasive knives are lowered down the jacket legs to cut the piles 16 feet below the mudline.

The number of legs varies from four, in the case of small structures, to six and eight, in the case of major drilling and production platforms, and up to 16, in the case of platforms set in the 1950-60 period.

The structures have been removed historically by removing the deck, and either sectioning the jacket or lifting it out intact with a derrick barge, jack-up barge, or spud barge. In any case, the base of the sectioned jacket or intact jacket can only be removed from the seafloor by cutting the pilings grouted inside the legs.

Since its founding in 1979, Marcon has continually developed unique solutions tc intricate offshore problems. Our solution to platform removal is no different. With our hydraulic pile cutter, we have improved on existing technology tremendously.

Recently, Marcon performed a platform salvage project for Phillips Petroleum on High Island Block 273 off the Louisiana coast in 168 ft of water. We used a derrick barge to remove the 500-ton deck, which exposed the 6-pile jacket. Four of the piles were straight--30 inches x 1 3/4 inches--and two were battered--

36 inches x 1 3/4 inches. On this job, we were able to have two pile-top rigs working simultaneously, saving the operators both time and money. After "prepping" the platform, which includes mounting the crane and pile-top rigs and equipment, we were then ready to lower the cutter assembly. The pile-swivel assembly was lowered into the jacket leg and the cutter assembly positioned down to the sub-mudline cutting depth by a crane that can reach all of the legs on the platform. The crane should be positioned on the deck to avoid the heave of the derrick barge and assure an efficient cut of the pile.

What makes the Marcon pile cutter unique is that there is both a top and bottom stabilizer, which center the cutter.

Radial contact rollers allow the cutter to transit ledges and abutments in the legs and pilings that hinder the in-and-out travels of the cutter. Rotation of the cutter is accomplished with seawater hydraulics, which also control the radial spread of the abrasive knives, as the pile is cut. The cutter rotation and radial force are controlled to provide efficient cutting. We have used the assembly to cut up to four layers of conductors and grouting. A typical cut is clean, and with our large O.D. cutter, we can cut up to 84-inch piles. Our large diameter pile cutter, called QUICK-CUT, has a 19 inch O.D. body, shorter knife length with 6 inch armor plate knife, and 18 inch cutting area.

The benefits of hydraulic pile cutting are many:

- o since there is no underwater demolition, marine life is protected;
- o it's not dangerous;
- o it's a proven method in large diameter pipe;
- o and it's cost-effective because rig-up time, cutting time, and exposure are at a minimum.

The costs for removing a structure in the U.S. range from $50,000 to more than $100 million. The low range is for units in water depths of 0 to 20 ft, while the high figure is for the ultra-deep structures. A typical eight-pile structure in the Gulf of Mexico in more than 300 ft of water would reach $3.9 million, with an additional $1.3 million required for offloading, dismantling, and disposal.

The day-rate cost of Marcon equipment for most removals in water depths under 100 ft ranges up to $15,000--a third less than other methods.

Mr. Leon Ortemond founded his own service company, Marcon, Inc., with his wife. He developed two patent systems dealing with the attachment of portable cranes without welding, and an improved self-lifting crane concept. He also developed a pile-top rig used in conjunction with salvage work using no explosives.

Louisiana Rigs-to-Reefs Update

Ms. Virginia Van Sickle
Louisiana Geological Survey

At the last Information Transfer Meeting, you may recall a presentation describing the Louisiana Artificial Reef Initiative. During this presentation, we documented the importance of offshore petroleum platforms to Louisiana recreational and commercial fishermen and presented the National Marine Board's projected rates of removal of these structures through the year 2000. We described for you a unique situation which exists in Louisiana, where natural reefs are scarce, and petroleum structures provide most of our reef habitat. We then described Louisiana's approach for maintaining as much as possible this habitat and the authority for the state to pursue a "rigs-to-reefs" program under the National and State Fishing Enhancement Acts.

A lot has happened since that presentation twelve months ago. Much of this time was spent developing the Louisiana Artificial Reef Plan under sponsorship of the Louisiana Department of Wildlife and Fisheries. This plan will be used to implement the Louisiana Artificial Reef Program. The plan was developed with the guidance and assistance of the Louisiana Artificial Reef Initiative, which met on a monthly basis at the LSU Center for Wetland Resources. The Louisiana Fishing Enhancement Act specifically required that the following components be included in the Louisiana reef plan:

1. Program guidelines, participant roles, and funding requirements.
2. Criteria for permitting and siting reefs.
3. Mechanisms for managing and monitoring reef sites.
4. Exclusionary maps depicting priority areas for reef development.
5. Provisions for updating the plan.
6. Provisions for managing an Artificial Reef Fund.

The first phase of developing the plan was the process we called "exclusion mapping." We eliminated all navigation fairways from consideration as reef sites, as well as military zones, EPA dump sites, live bottoms, and coral reefs. We identified areas of geologic hazards such as the Mississippi Canyon, the unstable lower Mississippi delta, and the continental slope. On a finer scale, we used geo-technical data to eliminate areas of shallow gas hazards and oil and gas pipelines that must be avoided in the reef siting process.

Following exclusion mapping, we began to select areas that could be assigned a high priority for reef development. We interviewed recreational and commercial fishermen, scuba divers, and charter boat operators. We also examined other available user group information that had been compiled by the MMS, the Sports Fishing Institute, and the Sea Grant College Program. Input from the shrimping and menhaden industry was also important. There was plenty of available water bottom, and we wanted to minimize conflicts with our net fisheries. Concentrating all of the available artificial reef material would not affect an area larger than 6 square miles. Based upon the outcome of exclusion and selection mapping, we selected seven artificial reef planning areas off the Louisiana coastline.

After the initial planning areas were selected, the Louisiana Department of Wildlife and Fisheries held public hearings in Houma, Chalmette, and Lake Charles. The majority of the attendees were recreational and commercial fishermen and petroleum industry representatives. Input was extremely positive.

Based upon the input at public hearings and additional meetings that we held with shrimp industry representatives, we added an eighth site off the Timbalier/Fourchon area and modified the boundaries of four planning areas.

Table 9.2 lists the Loran C and Latitude/Longitude coordinates for the eight artificial reef planning ares. Figure 9.1 is a location plat showing the artificial reef planning areas relative to the Louisiana coast.

The state plan was completed in June of this year (1987) and was approved by the Senate and the House Natural Resources Committees during the regular legislative session. Implementation began when the first reef structure was offered to the state by Cities Service Oil and Gas Corporation. The structure was located in the South Marsh Island planning area. We developed a deed of donation and proceeded to apply for the necessary permits. We also began planning for the necessary buoys, notice to mariners, and surveillance of the reef site. The following presentation will discuss the Cities Service reef project in more detail.

Let me conclude by summarizing the major event of the past few years that has supported the rigs-to-reefs concept, beginning with Congressman John Breaux's National Fishing Enhancement Act in 1984. We've experienced the evolution of a grass-roots idea into a state program with the necessary legislative authority, funding provisions, and staffing to develop a well-planned and responsible artificial reef program for Louisiana.

Ms. Virginia Van Sickle is the Assistant Director of the Louisiana Geological Survey at Louisiana State University. Prior to that, Ms. Van Sickle served as Deputy Secretary of the Louisiana Department of Wildlife and Fisheries. She has been involved in wetland management and research in Louisiana since 1975 and co-chaired the Louisiana Artificial Reef Initiative.

A Case History for Rigs-to-Reefs: A Cost-Effective Alternative for Platform Abandonment

Mr. Win Thornton
and
Mr. Jim Quigel
Cities Service Oil & Gas Corp.

The conversion of obsolete oil and gas platforms into artificial reefs has been done previously, often at considerable incremental costs over the costs required for a traditional salvage with onshore scrapping. The additional salvage expenses are typically a result of the mobilization and transportation costs required to move and place the obsolete oil and gas platform on the permitted reef site. These additional costs have been well documented during the creation of several artificial reefs utilizing obsolete platforms off both coasts of the State of Florida. The obsolete platforms were removed from Gulf of Mexico waters off Louisiana and transported to the Florida reef sites.

Recent efforts by the State of Louisiana have brought potential artificial reef sites closer to the bulk of the Gulf of Mexico platforms. In the summer of 1987, the Louisiana Artificial Reef Program (LARP) became a reality with the approval of eight reef planning areas off of the coast of Louisiana. The establishment of these reef sites near existing concentrations of oil and gas platforms provided opportunities to create artificial reefs without the burden of large mobilization and transportation costs.

On October 29, 1987, at 0235 hours, Cities Service Oil and Gas Corporation successfully "toppled," in place, an 8-pile drilling and production platform located in an approved reef planning area in South Marsh Island Block 146 in 238 ft of water. The "toppling" culminated over eighteen months of engineering and regulatory activities directed at utilizing an obsolete oil and gas platform as an artificial reef.

The South Marsh Island Block 146 reef accomplished four major milestones:

1. It was the first time that utilizing an artificial reef cost less than a traditional salvage.
2. It was the first monetary and material donation to the LARP.
3. It was the first abandonment of a major Gulf of Mexico platform by "toppling" in place.
4. Safe round-the-clock explosives operations were successfully completed under the scrutiny of existing Minerals Management Service (MMS) and National Marine Fisheries Service (NMFS) guidelines, designed to protect sea turtles and marine animals.

Cities Service elected to participate in the LARP because of potential cost savings that could be realized through using the reef sites versus the costs of a traditional abandonment, reasonable technical requirements for utilizing the multiple reef planning areas, benefit to the existing recreational and commercial fishing industry, and adequate liability protection for the donor upon creation of the artificial reef. In order to participate in the LARP, Cities Service had to execute a deed of donation. This document established the transfer of title between Cities Service and the State of Louisiana and established the amount of the monetary donation to LARP to help offset administrative, legal, marking, and maintenance expenses for the reef program.

Extensive engineering studies, on the order of magnitude of those performed for the original design, were undertaken to identify potential removal options. The engineering studies concluded that "toppling" the jacket in place after severing the piles and conductors with explosives was the safest, most reliable and cost-effective option. Upon selection of the removal option, detailed engineering was performed to establish the magnitude of the pulling load for "toppling", establish the effect of leaving the conductors in the jacket during "toppling", establish the structural capacity of the platform to withstand the "toppling" loads at the top of jacket and mudline, and to plan a salvage sequence that could be performed with existing equipment available in the Gulf of Mexico.

Upon completion of the engineering efforts that established that the platform could be "toppled," regulatory activities were initiated to obtain the required permits and variances necessary to implement the use of explosives and to create the artificial reef. LARP obtained the Corps of Engineers permit for the reef site. Cities Service obtained a departure from site clearance requirements from the MMS and an Incidental Take Statement (ITS) from the NMFS for the use of explosives and their effect on the endangered and threatened sea turtles.

Cities Service used the unique circumstances presented by the South Marsh Island Block 146 abandonment to request that round-the-clock explosives operations be allowed. Since the presence of the turtles was unlikely due to the distance from shore and the water depth, the MMS and NMFS consented to round-the-clock explosives operations contingent on a 48-hour survey to determine the presence of "resident" turtles. The ITS included the following wording: "If no turtles or marine mammals (suspected by observers to be resident) are sighted, the daylight detonation requirement is waived." Cities Service also obtained clarification in the ITS on bad weather restrictions on the aerial survey: "If weather conditions (fog, excessive winds, etc.) make it impossible to conduct the aerial survey, the blast may be allowed to proceed if approved by the designated NMFS observer on site."

All salvage operations were successfully completed within the guidelines of the original salvage sequence and the ITS without endangering sea turtles or marine mammals. The salvage sequences included several noteworthy activities:

1. During platform decommissioning operations, prior to the arrival of the derrick barge, two NMFS observers were present and performed the forty-eight hour surveillance for "resident" turtles. No resident turtles were found, and round-the-clock explosives operations were permitted.
2. Continuous visual observations were made by NMFS and MMS personnel during all on site activities with the derrick barge. No sea turtles were observed during abandonment activities.
3. The conductors were severed with explosives while the deck and equipment were still in place. This permitted quick and safe access to the top of the conductor for placement of the charges.
4. The nine (9) conductors were shot one at a time. The cycle time to bring a charge from the derrick barge, place it, and detonate it averaged 17 minutes each. The blast of the "engineered" charge was small enough that construction personnel stayed on the deck during conductor severing operations. Observations for sea turtles and marine mammals were performed continuously throughout explosives operations. Severing of each conductor was verified by a drop of 4-5 feet after detonation.
5. The staggered piling charges detonated without problems. The grouping of piles for row 'B' was detonated first with row 'A' following the first series. This sequence gave the jacket a 2.5 degree lean toward the direction of pull. The severing of the piles was verified by a drop of 2-3 feet of the jacket after detonation.
6. The post-blast diving survey noted no major soil disturbance (craters) around the base of the jacket legs or conductors.
7. The "toppling" load and break-over point were within the expected parameters. Once the mudline suction was broken, the jacket took less than three minutes to fully "topple".
8. The conductors slid free in the guides in accordance with the salvage sequence. However, the conductors were never pulled free of the mud and are in a gentle bend from their original mudline location to the base of the toppled jacket.

During actual salvage operations, several problems arose while trying to implement the "idealized" ITS. These problems arose even with the consent of the MMS and NMFS for round-the-clock explosives operations. The problems included the mobilization of all observers and equipment to the field in bad weather conditions, the coordination of multiple observations (aerial, diving, and visual) while under radio silence for the placement of the charges, the validity of a diving survey prior to detonations in deeper water, and the effect of bad weather on diving operations. The ITS needs to be more generalized to permit "reasonable and prudent" activities to be performed under "real life" salvage operations.

The "toppling" in-place of the South Marsh Island Block 146 jacket to create the first artificial reef in the LARP was a success. The jacket formed a high profile benthic reef with over 3.5 acres of hard substrate surface; it encloses over 3.3 million cubic feet of water, and has a mudline area of 43,000 square feet (over twice the "footprint" of its original configuration). A "post-toppling" underwater inspection, performed two days after the completion of explosives operations, showed a teaming fish population, almost back to the levels seen prior to the initiation of salvage operations.

Mr. Jim Quigel is presently the Regulatory and Environmental Supervisor with the Houston District of Cities Service Oil and Gas Corporation. In over 10 years with Cities, Jim has held numerous Engineering and Environmental positions. Mr. Quigel holds a bachelor of science in biology (1974) from Wheaton College and an MBA in management with a marine resources emphasis (1977) from Texas A&M University.

Mr. W.L. "Win" Thornton is currently Lead Mechanical Engineer with the Houston District of Cities Service Oil and Gas Corporation. His experience includes managing the design, construction, and installation of offshore platforms, pipelines and facilities for the Gulf of Mexico. His current responsibilities cover all construction activities in onshore Gulf coast and offshore Gulf of Mexico. Mr. Thornton holds a bachelor of civil engineering (1975) from Georgia Tech and a master of science in civil engineering (1981) from the University of Houston.

Analysis of Shockwave Signatures Under Controlled Conditions

Dr. Joseph G. Connor, Jr.
Naval Surface Warfare Center

NOTE: This paper was not presented at the Information Transfer Meeting, but was submitted afterwards.

INTRODUCTION

Detonation of an underwater explosive produces sudden changes in ambient conditions as the chemical energy in the energetic material is released to propagate away from the detonation site. The effect of the explosion is measured by the amplitude and duration of over- and under-pressure pulses and the rate at which energy and momentum are transported away from the explosion.

Damage to a neighboring object depends strongly on structural details of the object and its surroundings. Some objects are damaged simply by a sharp increase in pressure beyond a critical threshold level. Others are damaged simply by being pushed on hard enough and long enough by the impulse delivered by the explosion shock front.

If the impulse is delivered in a time approximating the period of a natural resonance of the object, resonance vibrations are observed. Vibration amplitude then increases, usually with consequent severe damage. Such resonances appear to be the dominant damage mechanism for biological specimens containing gas-filled cavities. Particular examples are the swim bladders in certain fish, the lungs in air breathing mammals, and the various tissues that contain small pockets of gas in many other creatures.

BACKGROUND

Oil drilling platforms located in navigable waters that have served their purpose must be removed. Left in place, they present obstructions to general navigation as well as to net-fishing operations. The process of removal is most efficiently begun by explosively severing their pilings some distance beneath the ambient bottom. An explosive charge is detonated inside the hollow members that descend into the bottom material. The explosive severance operation should be carried out with little or no deleterious effect on local marine life.

PROBLEM STATEMENT

This program is a systematic approach to determining stress levels on sea creatures, resulting from underwater detonations. Of special interest is the response of biological organisms found near platform legs. The study has four objectives:

1. Assess the limits of the idealized problem.
2. Determine explosive output levels for half-scale leg/piling severance-type explosions and predict turtle effects.
3. Test predictions on turtle specimens.
4. Monitor full-scale platform leg severance destructions to verify predictions.

PROGRAM OUTLINE

The first of the four objectives is to determine the output of typical explosive charges in free-water—away from any boundary influences. The second will model the situation at a Gulf platform by evaluating the output of charges buried in a mud bottom. The third will assess explosion effects on suitably chosen biological specimens. The fourth and final objective will confirm the observations of the first three by monitoring several platform leg/piling severance operations in the Gulf of Mexico.

1. Free-Water Assessment. Typical piling severance charges will be detonated underwater at 30-foot depths. Similitude equations will be determined from pressure measurements. Analysis of these measurements will present a refined picture of the magnitude of the threat to marine life.
2. Half-Scale Models. Half-size models of typical platform legs/piling will be implanted in the mud bottom of the Potomac River at Dahlgren, Virginia. The pressure field generated by charges detonated inside the leg/piling models will be determined. Similitude equations will be determined and compared to free-field constants determined in the first phase. From the similitude equations and established damage criteria for marine biological specimens, mortality ranges from underwater platform destruction explosions will be determined.
3. Turtle Specimens. Several specimens of a species to be determined by MMS will be placed near explosion in free-water--such as were fired in Objective 1. Exact locations will be determined by environmental scientists in the Explosion Damage Branch at the Naval Surface Warfare Center (NSWC). Any damage to the turtles will be assessed by marine biologists provided by MMS.
4. Full-Scale. Actual leg/piling severance operations in the Gulf of Mexico will be monitored. Recordings of the transient pressure pulses near platforms

being removed will be made by a contractor. The resulting tapes will be analyzed with the system used for this purpose at the NSWC. This effort will determine the validity of the predictions made from the free-water data obtained earlier in the program.

PROGRAM STATUS

1. Free-water Assessment Tests. Eight 50-pound charges have been obtained from a contractor who is used frequently for structure-removal operations. The charges were supplied with the detonators and firing system that are used on such operations. Four of the charges are Composition B and four are Nitromethane; both these explosives are typically used in such operations. Several attempts have been made to fire these charges on the Potomac River test range at Dahlgren, Virginia. All attempts have been cancelled because too many large fish have been observed in the firing area. Current plans are to fire these charges in mid-January 1988, either in a quarry in central Virginia or at sea off Key West, Florida.
2. Half-Scale Leg Models. Tests were to be conducted in the Fall of 1987 on the Potomac River firing range, following the free-water tests. These tests have been delayed, as were the free-water tests, by the excessive number of fish in the water on the range. Three hundred feet of sixteen-inch diameter by half-inch wall thickness steel pipe has been delivered. Six 45- to 50-feet lengths, each closed on one end, will be fashioned from this material. In the late spring of 1988, these will be driven 10 to 20 feet into the mud under 30 feet of water in the Potomac River. The top end of each pipe will be open to the atmosphere. Half-scale charges will be placed inside the pipes, 10 to 15 feet below the mud line and detonated. Shock wave characteristics in the water near the pipes will be monitored with the same system used on the free-water tests.
3. Turtle Specimens. Several turtles were to have been tethered near the site of ongoing platform/leg piling severance operations in the Gulf of Mexico. Ranges for each size and species of turtle were to be determined by extrapolation from the existing swim bladder fish mortality model. Strong ecological objections were raised, and these tests have been cancelled for the foreseeable future.
4. Full-Scale Monitoring. Pressure signatures are currently being recorded during several leg/piling severance operations on the Gulf of Mexico. The tapes are expected to be received at NSWC, White Oak, in January 1988. Analysis will be completed as soon as possible, after receipt of the tapes with appropriate calibration information.

ANALYSIS

1. Free-Water Tests. Similitude equations for the two explosives will be generated from the pressure-time signatures. These equations express peak pressure, specific impulse, and energy flux density in the underwater explosion shock, each as function of distance from the charge and charge weight. The equations can be used to assess the equivalence of these explosives to others commonly used in underwater work. The equations developed on these tests will be unaffected by medium boundaries or charge confinement.
2. Half-Scale Leg Models. Similitude equations will also be developed for the charges confined in steel pipes and submerged in the bottom

mud. Comparison of these equations with those developed for the free-water charges will demonstrate the effect of the confinement provided by the pipe and the bottom mud. It is expected that the comparison of the two sets of similitude equations will obviate the need for extensive underbottom tests; extrapolation from free-water data will be possible.

3. Tethered Turtles. This effort has been cancelled.
4. Full-Scale. Similitude equations will be developed for comparison with the results of Objective 1 and 2.

Dr. Joseph G. Connor, Jr., is currently with the Explosion Dynamics Branch of NSWC. Educational background includes a Ph.D. in physics from The Pennsylvania State University. Work experience includes 25 years in explosion effects analysis, and for the past 10 years, he has specialized in underwater explosion testing.

Underwater Sightings of Sea Turtles in the Northern Gulf of Mexico

Mr. Ian Rosman,
Mr. Gregory S. Boland,
Mr. Larry Martin,
and
Mr. Charlie Chandler
LGL Ecological Research Associates, Inc.

Data from eight scientific studies in the northern Gulf of Mexico conducted between 1975 and 1985 were reviewed for information concerning underwater sightings of sea turtles. Records of 1,024 scuba dives, 909 hrs. of underwater video and submersible observations, and 1,545 days of time-lapse photographic observations were compiled from published reports, data logs, and photographic material. This yielded 268 verifiable underwater sightings of sea turtles, 231 of which came from time-lapse cameras emplaced on live-bottom areas off southwest Florida (Table 9.3). The majority of turtles sighted were loggerheads (*Caretta caretta*), although three Kemp's ridley (*Lepidochelys kempi*), and one leatherback (*Dermochelys coriacea*) were also seen.

Diver sightings documented residency of an individual loggerhead for a period of at least nine months. Time-lapse results indicated a distinct diel pattern in the frequency of sightings. From a total of 211 sightings at one camera array, means of 4.2 sightings per daylight hour and 14.1 sightings per nighttime hour were obtained. A significant increase in the daily occupation rate by turtles was observed at a camera array that remained in place for two years (Figure 9.2). Utilization of underwater structures consisted of brief (1 to 5 hrs.) periods of relative inactivity, but not total dormancy. The mean residency time per day of occupation estimated from the time-lapse data was 1.9 hrs. (s.e. 2.02 hrs.).

Conclusions reached from the above review were the following:

1. Underwater sightings of sea turtles by divers were uncommon.
2. Sightings were least frequent during task-oriented dives in turbid water.
3. Time-lapse observations were more effective than diver observations for determining frequency of occupation at artificial structures.
4. Turtles were repeatedly observed to occupy small artificial structures in southwest Florida waters.

5. Occupation included protracted physical contact with the structures.
6. Occupation occurred more frequently during darkness than daylight.
7. Frequency of occupation increased linearly as a structure remained in place underwater.

Mr. Ian Rosman received a master's in fisheries sciences from Texas A&M University in 1983. He was employed by LGL Ecological Research Associates, Inc., between 1984 and September, 1987, at which time he returned to Texas A&M to pursue a doctorate in biological oceanography. His principal research field is analysis of underwater imagery.

Mr. Gregory S. Boland received his masters in biological oceanography in 1980 at Texas A&M University. He was employed as a marine biologist specializing in underwater imagery at LGL Ecological Research Associates, Inc., between 1977 and 1987. He returned to Texas A&M University in 1987 where he is now working with Dr. Gilbert Rowe on remote vehicle measurements of benthic community metabolism. Current interests include underwater imagery and nutrient exchange and oxygen consumption by benthic communities.

Mr. Charlie R. Chandler received his master's degree in wildlife and fisheries science in 1983 at Texas A&M University. He worked as a research diver for the university until he was employed by LGL Ecological Research Associates, Inc., in late 1984. Between 1984 and early 1987, he served as a research diver for LGL on projects in northern Alaska and the eastern Gulf of Mexico. He was the principal ichthyologist responsible for identifying fishes collected on the Continental Shelf and Slope of the Gulf of Mexico. Mr. Chandler is currently working for the Texas Parks and Wildlife Department as a contaminant biologist assessing damages to natural resources caused by pollution.

Mr. Larry R. Martin received his bachelor's degree in zoology in 1968 at Texas A&M University. He is a fisheries scientist certified by the American Fishery Society. He began working with LGL Ecological Research Associates, Inc., in 1976 as a fishery and marine biologist. Mr. Martin's current research involves the effects of oil field development activities on fisheries and Arctic kelp communities.

National Marine Fisheries Service Perspective on Structure Removals

Dr. Terry Henwood
National Marine Fisheries Service

INTRODUCTION

The Minerals Management Service (MMS) regulates and monitors Outer Continental Shelf oil and gas operations. In addition to regulations for the exploration, development, and production phases of these activities, MMS requires that lessees and operators remove obsolete structures and restore the site within one year after termination of the lease. Historically, the majority of the offshore structures have been removed using the quickest, safest, and most cost-effective methods available, primarily bulk explosives.

In the spring of 1986, the National Marine Fisheries Service (NMFS) Galveston, Texas, Laboratory wrote a letter to the MMS Regional Director, New Orleans, Louisiana, suggesting that the removal of structures using underwater explosives might be correlated with sea turtle and marine mammal strandings. This letter was prompted by two unexplained stranding events, which coincided with structure removals in Texas state waters. In a follow-up letter, the NMFS Southeast Regional Office requested that MMS initiate informal consultation under Section 7 of the Endangered Species Act (ESA) (1973), as amended, 16 U.S.C. 1530 et seq.

As a result of the informal consultation process, MMS determined that platform removals using explosives constituted a "may affect" situation and decided to address future platform removals on a case-by-case basis. The MMS Regional Director formally requested that lessees and operators notify his office 30 days in advance of plans to remove structures, and that they provide specific information on the size of platform; removal techniques; amount and type of explosives per change; and the number, size, and severing technique for well conductors. Procedures were established to effect "expedited" Section 7 consultations for proposed platform removals.

ENDANGERED SPECIES ACT CONSULTATIONS

The NMFS is responsible for administering the ESA for all Federal actions that may impact endangered and threatened species at sea. Section 7 (a) (2) of the ESA requires Federal agencies, in consultation with, and with the assistance of the Secretary, to insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of habitat of such species, which have been designated as critical ("critical habitat"). NMFS performs strictly an advisory function under Section 7 by consulting with other Federal agencies to identify and help resolve conflicts between the actions of Federal agencies and listed species, as well as their critical habitat.

When MMS initiated informal consultations under 50 C.F.R. Section 402.13 (1986), a series of discussions and meetings was held to determine whether formal consultation was required. If it is determined during informal consultation "that the action is not likely to adversely affect listed species or critical habitat, the consultation process is terminated..." 50 C.F.R. Section 402.13 (a) (1986). For platform removals using explosives, MMS was unable to provide evidence that this activity did not impact listed species because virtually no data were available. Therefore, MMS determined that listed species may be impacted by removals and that formal consultation should be initiated.

In formal Section 7 consultations, NMFS must formulate a biological opinion as to whether or not the activity (with it's cumulative effects) "is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat" 50 C.F.R. Section 402.14 (g) (4) (1986); see also, 50 C.F.R. Section 402.14 (h) (3) (1986). If a jeopardy opinion is issued and there are no reasonable and prudent alternatives to the proposed action, and the Federal agency determines that the proposed action cannot comply with Section 7 (a) (2), the action cannot proceed without exemption.

For all consultations to date on rig removals using explosives, NMFS has concluded that the removals do not constitute a "jeopardy" situation, but that the activity may affect listed species. The NMFS has determined that the resultant incidental take to listed species will not violate Section 7 (a) (2), and has provided an "Incidental Take Statement" (ITS) including reasonable and prudent measures intended to minimize the level of incidental taking. These terms and conditions must be incorporated in the removal plans by MMS or the applicant to implement the measures specified.

MARINE MAMMAL PROTECTION ACT

The NMFS is also responsible for administration of the Marine Mammal Protection Act (MMPA) of 1972, as amended, 16 U.S.C. 1631, et seq. The MMPA mandates the protection and conservation of marine mammals and their habitats and specifically prohibits the harassing, hunting, capturing, or killing of any marine mammal unless excepted under its provisions. The NMFS has informed MMS that structure removals using explosives are probably in violation of the MMPA (particularly with regard to "harassment"), and MMS has recommended that operators request a small take exception under Section 101 (a) (5).

The NMFS does not consider injury or death of marine mammals to be a likely consequence of removals using explosives, if the removal companies adhere to the requirements provided in the ESA "ITS." Marine mammals can easily be seen and identified by observers because of their surface breathing requirements, and detonation of explosives can be delayed until animals have left the area. By conducting removals only during daylight hours, the probability of an animal being in proximity to the blast without being sighted is greatly reduced. However, to be in compliance with the MMPA, companies must apply for, and be granted, a small take Letter of Authorization.

STATUS OF STRUCTURE REMOVAL CONSULTATIONS

Since NMFS and MMS agreed to consult on structure removals using explosives, a total of twenty-eight Biological Opinions (BO) have been issued by NMFS. The determination that these removals constitute a "may affect" situation has not changed. However, the reasonable and prudent measures in the NMFS ITS have been modified as problems or inconsistencies were identified.

There continues to be a certain amount of confusion regarding the NMFS requirements, as specified in the BOs. The intent of the ITS measures is to insure that companies take reasonable and prudent steps to minimize the impacts of removals to listed species. The NMFS has attempted to standardize these requirements for removals, but in many instances, NMFS adds or deletes requirements if such changes are deemed appropriate. For this reason, requirements may vary on the basis of size of charge(s), removal technique, location of structure, water depth, or other factors that may reduce or increase the potential impacts of the activity on listed species.

The NMFS measure which has received the greatest opposition from MMS and the removal companies is the requirement that charges be detonated only during daylight hours. NMFS concedes that this requirement may alter the duration and timing of the action, but is faced with a dilemma in that, without this requirement, the remaining measures cannot be implemented. Presently, the only proven method of detecting marine mammals or turtles in the vicinity of structures is by observation during daylight hours. While NMFS will continue to explore alternatives to the daylight requirement, we are unwilling to waive this stipulation at this time.

FUTURE STRUCTURE REMOVAL CONSULTATIONS

A major misconception with regard to the Section 7 consultations is that by implementing the measures of the ITS, significant progress is being made toward reaching a solution to this conflict. This is not the case. The NMFS requirements are strictly conservation measures to reduce the potential impacts of removals. While some information about sea turtle and marine mammal occurrence around the specific structures may be collected by observers during structure removals, these data are not likely to be sufficient to alter our conclusions that the activity constitutes a "may affect" situation.

The NMFS believes that additional data must be collected to allow the agency to adequately evaluate the potential impacts of structure removals on listed species. We have been working closely with MMS Washington and Regional Office staffs to develop a research plan that will provide the needed information. Specifically, we need to know when, where, and how many listed species are associated with offshore structures, and how many of these animals are killed or injured as a result of the underwater detonations. With this information, we should be able to conduct a single "generic" consultation addressing the potential impacts of all structure removals in the Gulf of Mexico.

Another suggested approach to this problem is the development of a device or technique to "drive" turtles and marine mammals away from structures prior to detonation of explosives. If such a device or technique were proven effective, there would no longer be a need to consult because the activity would not affect listed species.

The NMFS believes that the ultimate solution to this problem will be found through research and development of new technologies. The use of explosives in removal of structures will never be acceptable to conservationist groups, and MMS and the oil industry will be faced with a continuing series of battles over the issue. The NMFS strongly recommends that the industry take an active role in supporting the development of new techniques for structure removals. We also recommend that industry collect data on the shock waves produced by some of the explosive charges and techniques presently in use. It is likely that some of these removal techniques produce a minimal shock wave and have little or no impact on marine life in the area.

Dr. Terry Henwood is with the NMFS, Southeast Regional Office, Protected Species Management Branch, located in St. Petersburg, FL. From 1980 through 1986, he worked at the NMFS, Mississippi Laboratories, Pascagoula Facility, where he studied sea turtle populations. He analyzed much of the sea turtle distribution, abundance, and mortality data used in promulgating the controversial Turtle Excluder Device (TED) regulations. He received his doctoral degree from Auburn University in fisheries, specializing in population dynamics and management of fisheries resources.

Perspective on Oil and Gas Production Structure Removals and the Permit Process

Mr. Robert Bosenberg
U.S. Army Corps of Engineers
New Orleans District

Nearshore oil and gas production facilities installed many years ago are beginning to play out. This trend is likely to continue and possibly accelerate throughout the nearshore area in the foreseeable future. There are several hundred oil and gas production facilities within the 3-nautical mile zone off the Louisiana coast where the New Orleans District (NOD), Corps of Engineers (COE) has jurisdiction. As those facilities cease to be productive, the terms of the state lease agreements, a general condition of the applicable Section 10 Federal permits (River and Harbor Act) issued by the NOD and the escalating concern of insurance liability collectively motivate the responsible oil and gas industry interests to remove those no-longer productive facilities as soon as practicable.

The use of explosives to effect those removals is most often looked to first by the industry because of its relatively lower cost and simplicity and because an explosive removal can often be accomplished more quickly than other removal procedures. For these reasons, the explosive removal alternative is often selected even when the facility slated for removal would lend itself to less advantageous but equally effective nonexplosive removal techniques.

The use of explosives to effect structure removals in the Gulf of Mexico has been correlated with the stranding of marine species (turtles) afforded Federal protection by the Endangered Species Act (ESA) and could also impact marine mammals protected by the Federal Marine Mammals Protection Act (MMPA). The relationship between explosive removals of petroleum production facilities in the Gulf of Mexico and strandings of Federally protected marine species may only be coincidental, but it was sufficient cause to move the Minerals Management Service (MMS), essentially the COE's regulatory counterpart beyond the 3-nautical mile limit, to declare that explosive removals constitute a "may effect" situation under Section 7 of the ESA. That declaration precipitated the ESA Section 7 consultation process by the MMS.

By extension, the use of explosives to effect structure removals within the 3-nautical mile zone (the territorial sea) was presumed to be a "may effect" situation as well. Upon learning that a COE Section 10 permit (River and Harbor Act) requires removal of the authorized structures upon abandonment and that explosives were a commonly used method to remove oil and gas production facilities, the National Marine Fisheries Service (NMFS) requested the NOD to initiate consultation pursuant to Section 7 of the ESA for explosive structure removals in nearshore waters in concert with similar efforts already underway with the MMS. That situation caused oil and gas industry interests operating in Louisiana waters to informally ask the NOD what options existed and what would be involved if an explosive removal were selected from among a number of viable removal alternatives.

The NOD moved to meet its legal obligation while striving to achieve as much consistency between the various Federal agencies as possible. Early in our research it was apparent that little was known about the marine species presumed to be at risk, and even less was known about the number, location, and anticipated timing of removals from nearshore waters. To begin to assess these factors, the NOD issued a special public notice. In addition to directing permit holders to notify the NOD before an explosive removal was conducted, it further instructed permit holders not to proceed until they received specific notification to do so. In response, the NOD received fifteen requests to conduct explosive removals. To facilitate the NOD's preferred, case-by-case analysis of each request, a questionnaire was developed and sent to each of the respondents. The questionnaire was an effort, among other things, to establish precisely why the permittee had to use explosives to affect the removal and what other alternatives existed.

In eleven of those fifteen instances, and for various reasons, the explosive option was abandoned in favor of an nonexplosive method. The NMFS has concurred with the NOD's position that nonexplosive removal techniques are not a "may effect" situation. As such, the oil and gas industry interests that hold eleven of the fifteen permits that have contacted the NOD and submitted an nonexplosive removal plan for review have received authorization to proceed with the removal of facilities from nearshore waters.

The two interests (representing four permits) that must use explosives were subsequently advised on how to proceed. Time commitments upon the NOD regulatory staff make it difficult for them to prepare even a few, action-specific biological assessments. Thus, permittees can opt to have the NOD's regulatory staff prepare the required case-by-case Section 7 biological assessments as funds and schedules allow. As an alternative, permittees can assemble a case-specific, biological assessment through their own initiatives while coordinating with NOD and NMFS personnel. That assessment could then be submitted to the NOD as an accompaniment to an explosive removal request. If found to be acceptable, the NOD can then adopt the assessment and, in turn, submit it to the NMFS, thereby complying with consultation provisions of the ESA. Interestingly, although a few requests to conduct explosive removals are still outstanding, no such permittee-prepared assessments have been submitted to date.

What about the several hundred other Corps-permitted oil and gas facilities in the inshore tidal bays and estuaries? Don't protected species use those waters as well? Yes, they do. Accordingly, under the COE's permit procedures and other legal obligations, explosive removals of these facilities would also be subject to the provisions of the ESA as discussed above. The NOD is prepared to discuss this matter with the industry and NMFS.

What comes back from the NMFS when a consultation occurs? Hopefully, NMFS concurs with the evaluation prepared by the submitting agency (that a no jeopardy situation exists) and accepts their recommendations on how to proceed. Thus far, for MMS actions, NMFS has rendered no jeopardy opinions. Those opinions, however, also included recommendations intended to provide more insight into the relevance of the presumed negative association between explosive removals and endangered, threatened, and other protected species. Those recommendations, often referred to collectively as "monitoring," typically entail the use of scare devices, pre- and post-explosion seafloor surveys, and the use of trained observers. It is hoped that as information is acquired, a case can be made to diminish "monitoring" efforts, or that other alternatives can be devised that would be equally effective but less burdensome. Because the NOD's ESA and MMPA resolution procedures and the biology of the NOD's area of responsibility are similar to that of the MMS, the NOD and holders of COE permits should anticipate receiving similar direction for "monitoring" explosive removals in nearshore waters as a result of consultation with the NMFS. The shallower depths and unique circumstances that characterize inshore waters should, however, make it easier to pursue exclusionary efforts to avoid undesirable situations than has been the case in Gulf of Mexico OCS waters. The use of water surface-to-water bottom net curtains as exclusionary devices could be an option considered when explosively removing facilities from inshore waters.

The focus of this presentation thus far has been on endangered and threatened species. A few words about the Marine Mammals Protection Act (MMPA) would also seem appropriate. The COE is also legally obligated to consider potential effects on these protected species (e.g., Atlantic bottle-nose dolphin, short-finned pilot whale) when it evaluates permit applications. However, there is no consultation mechanism under the MMPA, but comments are received from the NMFS in response to public notices. The NMFS does administer a permit process. It is separate and apart from the COE's permit process. Thus, for both inshore and nearshore waters, an applicant for a COE permit (or the holder of a COE permit) whose activity would likely involve protected marine mammals, is well advised to contact the NMFS for more information about acquiring a permit to take marine mammals.

In summary, the NOD COE has established a mechanism to meet its statutory obligations to consult with the NMFS under provisions of Section 7 of the ESA when explosive removals of oil and gas facilities are requested by permittees in the territorial sea and inshore waters. Thus far, that procedure requires a case-by-case analysis. As more requests are received, the magnitude of the situation will increase. Adjustments to field-information gathering efforts and to the consultation protocol can be formulated and implemented as appropriate. The type and rate of adjustments to simplify the process, however, will be driven by how quickly data regarding the issue are revealed. Resolution will likely be achieved more quickly if a comprehensive approach is adopted and initiated early.

Mr. Robert Bosenberg is an Environmental Resource Specialist with the NOD, COE, Regulatory Functions Branch. He has been with the Corps for five years in that position. For four years prior to that, he was a Fish and Wildlife Biologist with the U.S. Fish and Wildlife Service, Ecological Services, in New Jersey. He is a Certified Wildlife Biologist and holds an MS degree in ecology.

Use of Seismic Air Guns to Produce Avoidance Responses in Loggerhead Turtles

Dr. James O'Hara
Environmental & Chemical Sciences, Inc.

PROJECT'S HISTORY

A commercial power plant uses large amounts of water to cool the steam condensers used in generating electricity. At the Florida Power & Light Company's St. Lucie Plant, water is taken in through an offshore intake structure and transported through large pipes beneath the substrate until it emerges in a canal, isolated from the ocean. The offshore habitat is a crushed shell substrate with little to no structure in the area of the power plant. Thus, the intake structure has developed many characteristics of an offshore reef, including cave-like entrance spaces for the water. This habitat is very attractive to sea turtles, and many have entered the intake structure and been transported by the water flow to the intake canal. The turtles emerge in the canal unharmed, but unable to return to the ocean. They must be netted and transported back on a routine basis.

Florida Power & Light determined that screening the intake structure was undesirable and requested Environmental & Chemical Sciences, Inc. (ECS) to conduct research to find a method to deter sea turtles from entering the intake structure. This report is on a successful experiment testing the use of sound as a deterrent and how this technique can be used in other applications.

METHODOLOGY

Florida Power & Light provided the use of 300-m-long dead-end canal off the Turkey Point Plant cooling canal grid for use for these experiments. The canal was isolated from the grid system by netting. The study design was to release a turtle in the canal and determine if the turtle could be prevented access to one end of the canal by establishing a sound barrier. The sound source selected was produced by seismic exploration air guns. These air guns produce a uniform repeatable and reliable sound source.

A series of sub-adult turtles were used over several thousand hours of testing in the canal. By using multiple air guns and an air pressure of 2,000 psi firing at a 4/min rate, an effective barrier was established and demonstrated by a statistically significant reduction in occurrence or the movement of turtles into the protected area of the canal (Figure 9.3).

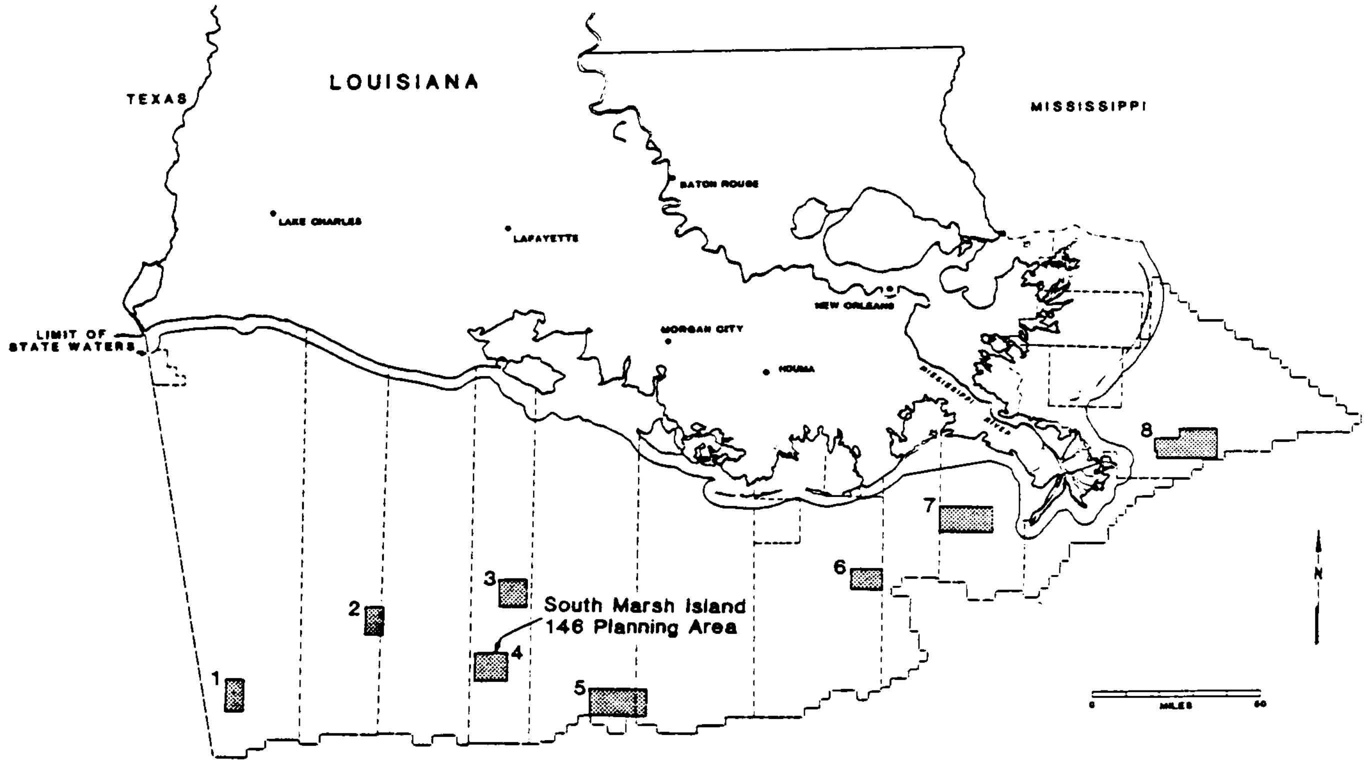
RECOMMENDATIONS

Based on the study done in the canal, we feel that an effective deterrent has been identified, and the technique has practical application in certain situations. The use of this method to scare sea turtles away from offshore oil platforms just prior to platform removal by explosives seems to be such a situation. By suspending one or more air guns from the platform and slowly bringing the pressure level up, a gradient of sound can be established that should frighten the sea turtles from the vicinity of the platform (Figure 9.4). This hypothesis would easily be tested by putting sonar or radio tags on some sea turtles, monitoring their behavior around the platform for several days, and then turning on the air gun deterrent and continuing to monitor the movement of the turtles. If they leave the vicinity of the platform, it would be a clear indication that the methodology is effective.

There is no experimental evidence to indicate that this technique would be effective in frightening marine mammals away from the platforms. However, during the course of the tests on sea turtles, divers expressed discomfort and did not try to approach the sound source. It is anticipated that sea mammals would have the same behavior.

Dr. James O'Hara is Vice President of Environmental & Chemical Sciences, Inc. in Aiken, SC. He earned a Ph.D.

in ecology from the University of Miami, in Florida. He currently works as an ecological consultant to industry and government and is directing a major environmental impact assessment in the Southeast. His recent research has been on responses of sea turtles to environmental stress.



1. West Cameron Planning Area
2. East Cameron Planning Area
3. South Marsh Island (76) Planning Area
4. South Marsh Island (146) Planning Area
5. Eugene Island Planning Area
6. South Timbalier Planning Area
7. West Delta Planning Area
8. Main Pass Planning Area

Reef complexes will be sited within each planning area. Reef complexes will not exceed 3/4 $mi.^2$ in area.

Figure 9.1.--Regional index map, Louisiana artificial reef planning areas.

Multiple Comparison of Turtle Sightings per Day at Station 52

Intervals with overlapping letters are not significantly different (alpha=0.025).

	Number of 24-Hour Days Observed											
	22	19	15	19	33	12	31	31	29	28	23	11
	Observation Interval											
Sightings/Day	10 Dec 83 - 31 Dec	1 Jan - 19 Jan	17 Aug - 31 Aug	1 Sep - 19 Sep	6 Dec - 7 Jan	31 Mar - 30 Jun	1 Jul - 31 Jul	1 Aug - 31 Aug	1 Sep - 30 Sep	1 Oct - 31 Oct	1 Nov - 30 Nov	1 Dec - 11 Dec 85
A. 1.69									A			
B. 1.58						B			A			
C. 1.54						B			A	C		
D. 1.30						B			A	C		D
E. 1.00						B			A	C	E	D
F. 0.74							F				E	D
G. 0.65							F	G			E	D
H. 0.33			H				F	G				
I. 0.27			H		I			G				
J. 0.11		J	H		I							
K. 0.05		J	H	K	I							
L. 0.00	L	J		K								

Figure 9.2.--Pair-ways multiple comparison of observation intervals during a two-year emplacement of a time-lapse camera off the southwest Florida coast. Intervals comprise only complete 24-hr series of hourly photographs. The observation intervals are then considered as a series of binomial trials and differences in the probability of success (photographing a turtle) and are compared by a chi-square test.

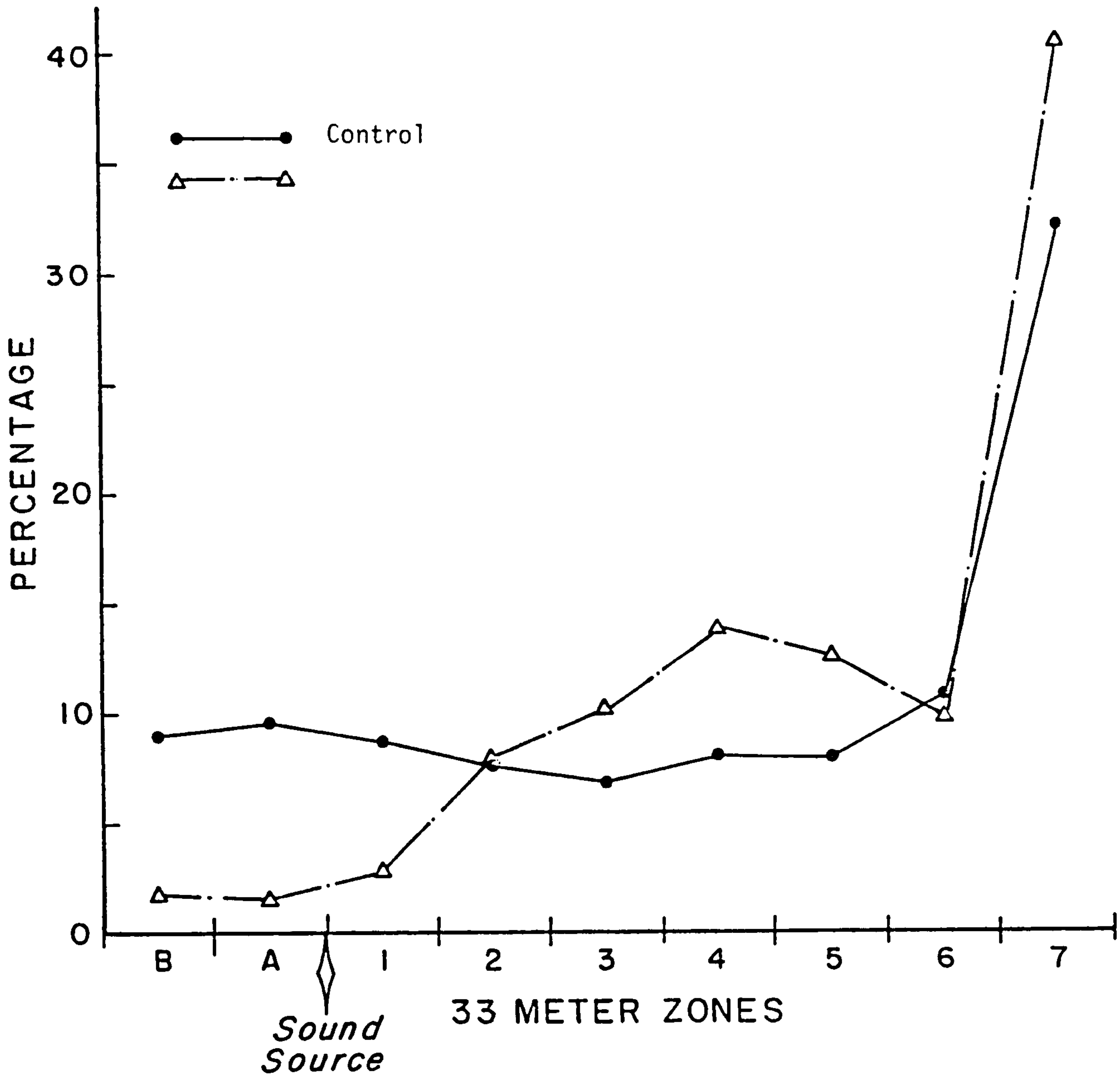


Figure 9.3.--Percentage of time turtles stayed within a zone in the canal.

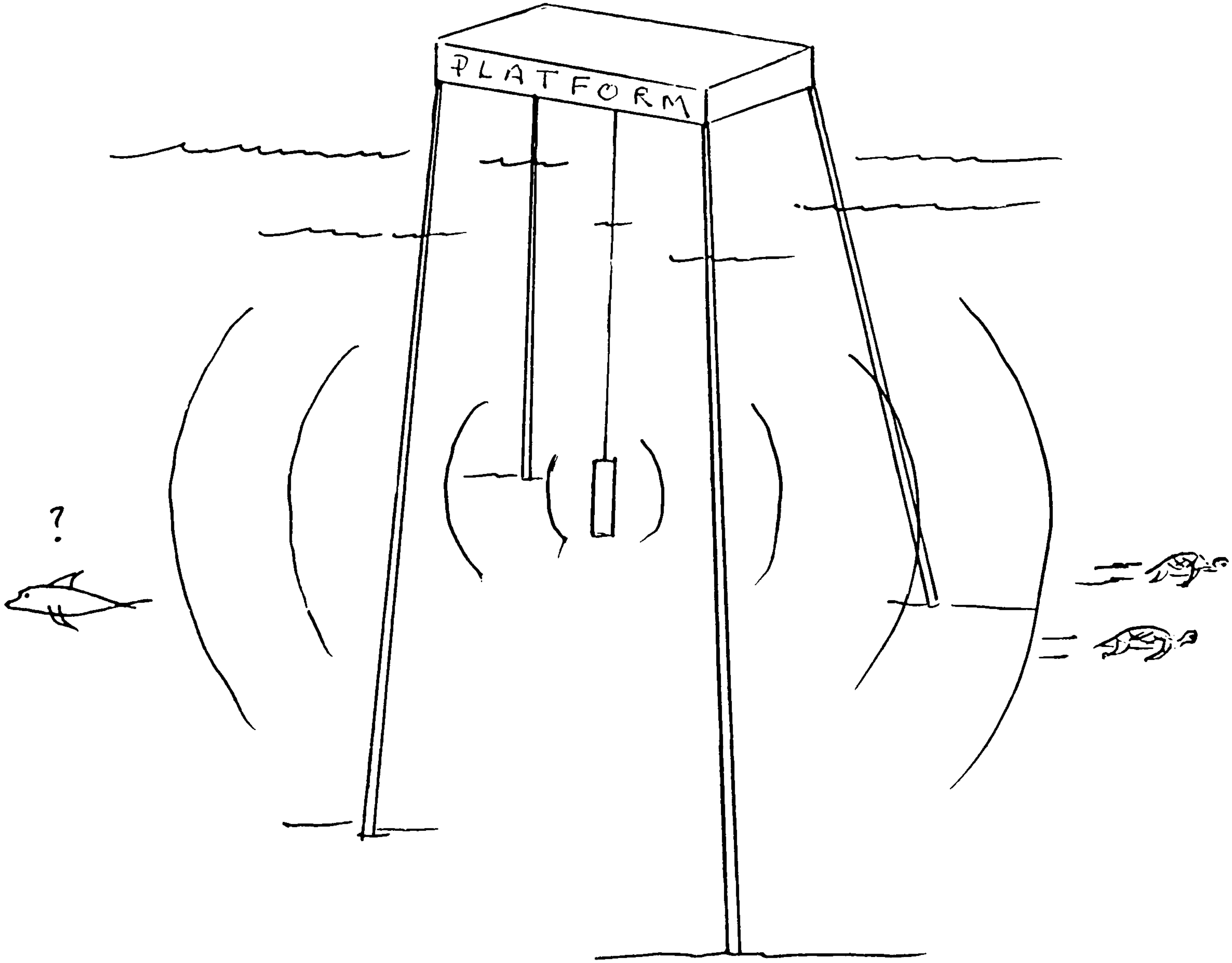


Figure 9.4.--Potential arrangement of air gun(s) to deter turtles around a platform.

Table 9.1.

List of Marine Structures Severed by Dimensional Oilfield Service's Hydraulic Abrasive Cutter

17 - four pile jackets with 16" pilings

26 - wells not grouted with casings ranging from 5-1/2" to 36"

1 - well with 10-3/4", 16", and 30" grouted

1 - 48" caisson with 1" wall thickness

Table 9.2.

Loran C and Latitude/Longitude Coordinates for Artificial Reef Planning Areas, Offshore Louisiana

West Cameron Planning Areas

Loran C	Latitude
W-11210-11242	28°01.3'N-28°11.5'N
X-26152-26250	Longitude
Y-46710-46742	93°16.6'W-93°21.3'W

East Cameron Planning Area

Loran C	Latitude
W-11226-11263	28°23'N-28°30.8'N
X-26640-26770	Longitude
Y-46752-46778	92°34'W-92°43.5'W

South Marsh Island (Block 76) Planning Area

Loran C	Latitude
W-11293-11338	28°31.8'N-28°39.3'N
X-27105-27220	Longitude
Y-46760-46788	91°53.2'W-92°01.2'W

South Marsh Island (Block 146) Planning Area

Loran C	Latitude
W-11335-11383	28°12.4'N-28°19.7'N
X-26945-27080	Longitude
Y-46702-46730	91°58.2'W-92°08'W

Eugene Island Planning Area

Loran C	Latitude
W-11462-11551	28°03.2'N-28°10.3'
X-27237-27455	Longitude
Y-46642-46681	91°17'W-91°33.9'W

South Timbalier Planning Area

Loran C	Latitude
W-11728-11790	28°36.70'N-28°42.2
X-28185-28285	Longitude
Y-46719-46745	90°8.64'W-90°17.5'

West Delta Planning Areas

Loran C	Latitude
W-11842.5-11977	28°53.1'N-29°00'N
X-28510-28705	Longitude
Y-46762.5-46800	89°35.1'W-89°51.2'

Mass Pass Planning Areas

Loran C	Latitude
W-12297-12437	29°14.2'N-29°19.8'
X-29235-29390	Longitude
Y-46826-46879	88°35.7'W-88°50.4'

Table 9.3.

Summary of Results from the Review of Eight Scientific Studies in the Gulf of Mexico that Involved Underwater Observations. Records of Sea Turtle Sightings came from Published Reports, Data Logs, and Photographic Material

A. Limited Studies: approximately two dives per site.

Study Name	Banks	Platforms (< 30 m)	Platforms (> 30 m)	Turtle Sightings
CSA	12	13	7	0
South Texas Platforms and Sebree Bank	1	3	2	0
Central Gulf Platforms	-	20	11	0
Total	13	36	20	0

B. Intensive Studies: repeated sampling at each site

Study Name	Sampling Methods	No. of Stations	Sampling Effort	Turtle Sightings
Southwest Florida	Video Transecting	12	138 h	0
	Diver Observation	4	53 dives	1
	Time-lapse	6	25186 frames	231
Flower Gardens	Video Transecting	2	357 h	2
	Diver Observation	2	178 dives	12
Panama City	Diver Observation	13	194 dives	17
Buccaneer Platforms	Diver Observation	6	599 dives	4
Northwest Gulf Banks	Submersible Obs.	32	374 h	1
	Video Transecting	11	40 h	0
Total		88		268

GULF COAST SOCIO-CULTURAL STUDIES

Session: GULF COAST SOCIO-CULTURAL STUDIES

Co-Chairs: Dr. Brent W. Smith
Mr. William T. Johnstone

Date: December 3, 1987

Presentation Title	Author/Affiliation
Gulf Coast Socio-Cultural Studies: Session Overview	Dr. Brent W. Smith and Mr. William T. Johnstone Minerals Management Service Gulf of Mexico OCS Region
Cultural Conservation on the Gulf Coast	Dr. Nicholas R. Spitzer Smithsonian Institution
National Park Service Ethnographic Studies, An Overview	Mr. C. Ray Brassieur Jean Lafitte National Historical Park
Current Research on Asian-Americans on the Gulf Coast	Dr. Jesse W. Nash Loyola University
Undocumented Central American Project: Houston	Dr. Nestor P. Rodriguez University of Houston
Current Research on Hispanics of the Eastern Gulf Coast	Dr. Miguel A. Bretos Florida International University
Current Research in Ethnic Diversity in Coastal Louisiana	Dr. Donald W. Davis Nicholls State University
Current Research on Gulf Coast Indians	Dr. John H. Peterson Mississippi State University
Current Research on Cajun Culture	Dr. Barry J. Ancelet University of Southwestern Louisiana
Socio-economic Impacts of Offshore Oil and Gas Activities on the Gulf Coast	Dr. Robert Gramling University of Southwestern Louisiana
Adequacy of Available Information on Socio-Cultural Groups and Causes of Recent Socio-Cultural Change in the Gulf Coast	Open Discussion

Gulf Coast Socio-Cultural Studies: Session Overview

Dr. Brent W. Smith
and
Mr. William T. Johnstone
Minerals Management Service
Gulf of Mexico OCS Region

Archaeologists and historic preservationists talk about "cultural resource management." As they define the term, however, almost the entire emphasis is on historic and prehistoric resources, rather than on living people or contemporary cultures and subcultures. The use of the term "socio-cultural" in these sessions relates only to contemporary cultures or those that existed in the recent past.

The Gulf Coast is a region of heterogeneous cultures and subcultures. These groups have been the subject of study by anthropologists, sociologists, folklorists, cultural geographers, historians, and other social scientists. The purpose of these sessions was to characterize the current status of major socio-cultural groups in the Gulf Coast, to discuss current research on these groups and the adequacy of available information, and to identify the causes of recent socio-cultural change, particularly the effects of offshore oil and gas activities.

The first speaker, Dr. Nicholas Spitzer, folklorist with the Smithsonian Institution, discussed the Gulf Coast as a culture region and the role of public agencies in cultural conservation.

The Gulf Coast is a culturally heterogeneous folk region of the United States that has characteristics of both the American South and the Caribbean. Creolization--the interpenetration and syncretism of Afro-European-Native American cultural products, patterns, and processes--is found in Caribbean and Gulf Coast language, architecture, foodways, music/dance, religion, and festival traditions. Thus, it is important to be aware of living cultural resources on the Gulf Coast such as French Creole and Isleno Spanish; shotgun houses and Creole cottages; congri and gumbo; jazz, Cajun music, and zydeco; Spiritualist religion, voodoo, and folk Catholicism; and Mardi Gras, Toussaint, and fleet blessings, among many others.

Material preservation alone, though attractive and consistent with natural science views of cultures as discrete, bounded entities, does not fully address the concerns for culture as a symbolic process where a sense of ethnicity and tradition are continually recreated. This view of culture as a dynamic process and tradition, as being contemporary rather than strictly historical concerns, has profound implications for how we view cultural resource management on the Gulf Coast. We must move beyond viewing cultural resources as exclusively material and historical in nature. Yet, how we deal with the intangible aspects of living culture in a region characterized by such diversity cannot be answered with a simple formula.

Public agencies must work with folklorists and anthropologists to engage in direct dialogues with ethnic/regional community tradition-bearers and folk artists and practitioners on how their resources should be represented. Our efforts at cultural conservation can only be realized through ongoing and multiple cultural conversations with the groups who make the region identifiable on the cultural landscape of North America.

Dr. Spitzer provided the following specific recommendations for cultural conservation work and mitigation policies: (1) redefine "cultural resource" to include the traditional social processes, cultural patterns, and material products of contemporary, tribal, ethnic, regional, and occupational groups; (2) make such living traditional cultural resources a significant part of all major areal studies undertaken by MMS; (3) support ethnographic study and cultural mapping of the entire Gulf Coast (similar to efforts by the State of Louisiana and the National Park Service in Louisiana) to the same degree that the natural resources have been mapped; and (4) base future mitigation and cultural conservation efforts on data provided by ethnographic work at three levels--a broad regional cultural survey, particular ethnic and occupational groups in subregional locations, and selected local, model, cultural ecological situations.

The second speaker was Mr. C. Ray Brassieur, a folklorist with the Jean Lafitte National Historical Park, National Park Service. Mr. Brassieur presented an overview of the ethnographic studies that have been sponsored by the Jean Lafitte National Historical Park.

Jean Lafitte National Historical Park and preserve was established November 10, 1978, by Public Laws 95-625 with the purpose of conserving and publicly presenting the natural and historical resources of the Mississippi Delta region and "to provide for their interpretation in such a manner as to portray the development of cultural diversity." In order to uncover the facts pertaining to "the development of cultural diversity," a baseline research effort, entitled the "Mississippi Delta Ethnographic Overview," was compiled under the editorship of folklorist Nicholas Spitzer. This effort described and interpreted man/land relationships, intra/intercultural relationships, and the historical and contemporary significance of the many cultural groups found within the Mississippi Delta region through the perspective of anthropology, cultural geography, history, folkloristics, linguistics, ecology, ethnic studies, and regional studies.

Since the compilation of the "Mississippi Delta Ethnographic Overview" in 1979, twenty reports containing substantial ethnographic or ethnohistorical data have been submitted to Jean Lafitte National Historical Park. Many of the reports focus upon certain aspects of specific ethnic groups: Louisiana Indian tribes, the Canary Islanders, Filipinos, Creoles, and Cajuns, for example. Several of the reports have primarily historical perspectives such as colonial Caribbean culture exchange or nineteenth century Creole life. Still other reports, such as the ones concerning vernacular architecture and New Orleans gospel quartets, focus upon more specific, yet salient cultural themes.

Mr. Brassieur recommended future ethnographic/ethnohistorical work, including (1) continued focus upon ethnic groups, (2) oral history projects directed toward the collection of folk environmental perspectives gathered from elders of the Delta region, and (3) documentation of a maritime heritage, which continues to recede along with the Louisiana coast. In addition to these recommendations, the author posed the following questions concerning the ethics of cultural resource policies directed toward living groups and extant belief and behavioral systems: (1) How do you mitigate the loss of ethnicity?; (2) How can you advocate cultural conservation without affecting the groups involved?; and (3) What happens when cultural conservation goals contrast with public development goals?

The third paper was prepared by Dr. Jesse Nash, Assistant Professor of Religious Studies at Loyola University and Director of the English Language Program for Vietnamese students at Notre Dame Seminary. The paper was delivered by Dr. Brent Smith. Dr. Nash's paper concerned current research on Asian-Americans on the Gulf Coast, focusing on his own research with the Vietnamese. The Asian-American population is growing in the Gulf Coast region, but the size of the Asian communities does not adequately reflect their contribution or visibility. The Asian communities are involved in the restaurant business, the fishing industry, the growing professional class, and education. The Chinese community has been established for some time, but many of the southeast Asian refugees and the south Asian professionals are relatively recent arrivals.

The Vietnamese are perhaps the most visible and can possibly become a political reality to be reckoned with in the future. They have been the most studied of the Asian ethnic groups. Dr. Nash's own research with the Vietnamese of New Orleans has been of the community study variety and is the result of some four years of field work in the community. Vietnàmese visibility is itself a phenomenon in the region, partly explained by the size of the population but mostly by its "cultural vitality." The Vietnamese have created communities, both in the geographical and symbolic senses. The vitality of the community in New Orleans, in particular, is explained by its communal structures, maintenance of traditional values and attitudes, religiosity, reputation for hard work, and ability to live with creative tension.

Conflicts within the community have not destabilized it so much as made it more vibrant and healthy. Those conflicts center on the relative role of the English and Vietnamese languages in the life of the community, the role of women in terms of education and careers, and ethnic identity. In a real sense, these conflicts face all Asian populations in the Gulf Coast region. They are also united by a common concern for the future of education and employment in the region.

The fourth speaker was Dr. Nestor Rodriguez, Assistant Professor of Sociology at the University of Houston, who discussed current research concerning Hispanics on the western Gulf Coast. Dr. Rodriguez focused on his own research relative to undocumented Central American populations in Houston, Texas, comparing conditions of work and settlement in different parts of the city. Houston ranks second in the United States (Los Angeles is first) in the number of undocumented Hispanics (50,000-100,000).

The study's investigation focused on a variety of social activities, housing, work place and community intergroup interaction, organizational participation in the community, health, employment in the country of origin, reasons for emigrating, experiences with political conflict, conditions during the journey to the United States, and U.S. education of the children.

Completed interviews consist of three major national categories--Salvadorans, Hondurans, and Guatemalans--and also included Nicaraguans, Belizeans, Costa Ricans, and Panamanians. The groups are diverse, reflecting differing racial, ethnic, and linguistic backgrounds. Among these groups are speakers of the Garifuna language, Black Caribs who intermixed with indigenous

Hondurans. Undocumented Central Americans differ from the usual profile of the undocumented Mexican migrant. For example, 45 percent of the sample is older than 29 years of age, and the majority of the sample are, or have been, married. This contrasts with the usual findings of undocumented Mexican migrants as young and single. According to Dr. Rodriguez, further research is needed to understand the incorporation of undocumented Central American immigrants in U.S. society, especially in the context of the new immigration law.

The fifth speaker was Dr. Miguel Bretos, Director of the Cuban Exile History and Archives Project at Florida International University, who spoke on current research on Hispanics on the eastern Gulf Coast. Florida Hispanics are becoming increasingly aware of, and sensitive to, their long history within the region. While Florida had very important connections to Spain during the colonial period, it had even closer connections to Cuba, from where the Spanish adminstration of the Florida colony was exercised for most of the period. This is a matter of some importance, considering that Cubans are, by far, the single largest Hispanic group within the state.

Florida's Hispanics are located primarily in four cities: Saint Augustine, which was the capital of the Spanish colony; Tampa; Key West; and Miami. A very significant influx of Cuban and Spanish immigrants took place in Key West, especially, during the last quarter of the nineteenth century, where their descendants are still to be found. In Miami and Dade County a massive Hispanic, especially Cuban presence, has become one of the fundamental facts of life since 1959. Miami is the "capital" of approximately one million Cuban-Americans dispersed throughout the nation, of whom three-quarters of a million live in Dade County. Other immigrant groups, including Columbians, Venezuelans, Mexicans, and Nicaraguans, live in Dade County.

The demography and socio-cultural dynamics of the Cuban community have received considerable attention. Unlike groups of other recent immigrants, females and the elderly are disproportionately represented among the Cubans, and there is a high proportion of "three-generation" families. It is also known that Cuban women are more likely to be working outside the home than any other Hispanic women.

The Cuban community in South Florida is a true ethnic enclave. In other words, a south Florida Cuban may be born, live, and die entirely within the confines of his culture and language. This has significant economic implications and ensures the continuing vitality of the Spanish language. By the same token, the presence of the enclave may retard the process of assimilation since it is not imperative to learn the language and culture of the dominant society.

The sixth speaker was Dr. Donald Davis, Distinguished Professor of Geography at Nicholls State University, who spoke on current research in ethnic diversity in coastal Louisiana. One impetus for early colonization of Louisiana was its primary base of renewable and nonrenewable resources. Consequently, a range of cultures and settlements is a part of the coastal lowlands, making coastal Louisiana one of the nation's "melting pots."

Dr. Davis identified a heterogeneous ethnic mix in Louisiana, including Spanish, French, Italian, Yugoslavian, Irish, German, Cuban, Greek, Latin American, Islenos (Canary Islanders), Vietnamese, Chinese, English, Filipino, Syrian, Lebanese, and Jewish immigrants. Its biggest and oldest ethnic group is of French descent. Many were Acadians (Cajuns) who adopted a fishing/hunting/trapping/agriculture existence.

Spanish ownership of Louisiana did not lead to adoption of the Spanish language or culture (with the exception of the Islenos). The architecture of the French Quarter is a reminder of the Spanish Period. The French Quarter has been described as discovered by French explorers, built by Spanish pioneers, and owned by Italian businessmen--another indicator of south Louisiana's ethnic diversity.

The historical evolution of ethnic-related studies has been conducted by anthropologists, folklorists, geographers, historians, sociologists, and others. These disciplines prepared the foundation for work in material and nonmaterial culture elements and various socio-economic components of each individual culture group. The French culture hearth was the focus of scholarly interest; research has been conducted in language, folk and vernacular house types, French, German, and plantation settlement patterns, boats, swamp culture, music, folk medicine, cemeteries, and foodways.

According to Dr. Davis, there is a need for contemporary research on French Louisiana, including the province's ethnicity, as it relates to changes in rural-small town businesses, type of employment, farming practices, and urban business activities. Also, no research has been conducted on the ethnology, ethnography, ethnicity, or ethnic geography of the Greeks, Jews, Hungarians, Syrians, Lebanese, or Chinese.

The seventh speaker was Dr. John Peterson, Coordinator of Anthropology and Director of the Cobb Institute of Archaeology at Mississippi State University, who spoke on current research on Gulf Coast Indians. The Indians of the Gulf Coast represent populations remaining behind, after the period of Indian removals from the Southeast in the 1830's and 1840's. According to Dr. Peterson, "Indian" can have at least three different meanings: legally, genetically or biologically, and ethnically or culturally.

The most important factor in the historical experience of the Gulf Coast Indians has been the effort to gain legal status as Indians through the process of being acknowledged by the Federal Government as Indian tribes or communities. Indian groups were investigated and federally acknowledged as Indian tribes. Federal acknowledgement was extended only to the major tribal groups--the Seminoles and Miccosukees of south Florida, the Choctaws of Mississippi, the Chittimachas and Coushattas of Louisiana, and the Alabama-Coushattas of Texas. The history of the remaining nonrecognized tribes centers on their effort to achieve Federal recognition.

Unlike the Northeast, in the Southeast there are relatively few state reservations or sanctioned Indian communities. In the Southeast, one finds a number of non-aggregated, acculturated Indian descendants scattered throughout the region. One-third of all petitions for Federal acknowledgement, or 34 petitions, have been submitted from Indian groups of the Southeast. Of these petitions, only eight have been evaluated, of which two groups have received federally recognized status: the Tunica-Biloxi of Louisiana and the Poarch Band of Creeks of Alabama. Of the remaining 26 petitioning Indian groups in the Southeast, only one has completed the required documentation for evaluation.

Throughout the Gulf Coast area, it is possible to run across previously unorganized and/or unacknowledged Indian descent groups. These include clearly identifiable family groups of Choctaws in the three Mississippi coastal counties and multi-tribal Indian urban communities, such as the one in Pascagoula, Mississippi, which resulted from Ingles Shipping's aggressive minority employment policy.

The federally acknowledged Seminole and Miccosukee Tribes' people and activities are primarily in south-central and east Florida around Hollywood and Ft. Lauderdale. The Poarch Band of Creek Indians is located in west Florida. The Mowa Choctaws located north of Mobile, Alabama, are in the process of documenting their petition for Federal acknowledgement. The federally acknowledged Mississippi Band of Choctaws is the only major Indian group in Mississippi. Louisiana contains three federally acknowledged tribes: Chitimacha in St. Mary Parish, Coushatta in Allen Parish, and the Tunica-Biloxi in Avoyelles Parish. Louisiana also contains five State-recognized Indian groups: the Houma; the Jena Choctaw; the Choctaw-Apache; the Clifton Choctaw; and a suburban agglomerate of Choctaws, the Louisiana Tribe of Choctaws in West Baton Rouge Parish. Texas has only one State-recognized tribe in the Gulf region--the Alabama-Coushatta east of Houston. Also, sizable urban Indian communities exist in Fort Worth and Dallas, representing migrants from Oklahoma and western states.

No assessment of the impact of oil-related activities on Gulf Coast Indians has ever been attempted. Such an assessment must take into account Federal, State, and unacknowledged groups, and must take place within a general framework for assessing human ecological (anthropological), cultural geographical, economic, and demographic change.

Dr. Barry Jean Ancelet, Assistant Professor of French and a Folklorist with the Center for Louisiana Studies at the University of Southwestern Louisiana, was originally scheduled as the eighth speaker, but was unable to attend. Dr. Ancelet's paper concerns research on Cajun culture. He reviewed early work on the history, culture, and language of the Cajuns and Creoles.

In 1968 the Council for the Development of French in Louisiana was created. In 1973, the University of Southwestern Louisiana established the Center for Louisiana History and, in 1974, initiated the Center for Acadian and Creole Folklore. The goal of these centers was to develop and archive information that would serve as the basis for research. The Center for Louisiana Studies developed collections of photographs, manuscripts, maps, and microfilm. The Center for Acadian and Creole Folklore acquired copies of field recordings.

Others have also researched these areas: the Department of Geography and Anthropology at Louisiana State University, which has investigated traditional architecture and material culture; the Acadian Studies Center at Nicholls State University; the National Park Service; Jean Lafitte National Historical Park; and the Louisiana Folklife Program of the State's Department of Culture, Recreation and Tourism. Research has also resulted in the production of films, projects such as an oral history of Terrebonne Parish, and a radio series of Cajun and Creole tales and legends. Still more research projects have involved work on colonial settlement patterns, the development of Acadian and Cajun identities, the Americanization of French Louisiana, the origins and development of Cajun music and zydeco, Louisiana French language and oral tradition, and the impact of the oil industry on Cajun and Creole cultures.

According to Dr. Ancelet, the most undeveloped area of research on the Cajuns and Creoles is linguistics. Progress on this important linguistic front would be an important complement to work in cultural and historical areas.

The ninth paper was given by Dr. Robert Gramling, Professor of Sociology at the University of Southwestern Louisiana, who spoke on socioeconomic impacts of offshore oil and gas activities on the Gulf Coast. This presentation dealt with erroneous assumptions concerning the impacts of offshore energy production.

According to Dr. Gramling, the traditional model for what has come to be called Social Impact Assessment came out of energy development in the western United States and is embodied in the "Boomtown" literature. Gramling argues that this model is not an appropriate one for the analysis of the impacts of offshore oil and gas activities because of the factors of size and mobility. In contrast to the more geographically specific types of development, the mobility associated with offshore energy exploration and development leads to diffused, as opposed to concentrated, social and economic impacts.

This mobility is evidenced in four basic areas. First, the development itself is highly mobile. Second, employees could follow the rig or commute. A third factor in the mobility of the offshore energy production industry is the transportability of many of the products that the industry buys. Finally, the products themselves, oil and gas, are also very mobile. Taken together, what these factors mean is that the positive and negative effects of offshore oil and gas are distributed widely throughout the Gulf Coast, the South, and indeed the continental United States.

To assess the impacts of oil and gas activities in the Gulf Coast, a broad network is required. Studies are needed that emphasize the various associations with the oil and gas industry that have actually changed important human interactions like homes and families, the work place, friendships, and communities. Dr. Gramling suggested that one approach to consider is Bill Freudenburg's Density of Acquaintanceship Model: community interactions should be studied in terms of socialization of youth, deviance, and support systems for the weak (old, infirmed).

Dr. Gramling stated that the concentrated work scheduling in the Gulf of Mexico petroleum industry (7 days on/7 days off, 14 days on/14 days off, 21 days on/21 days off) has to be used in other areas to minimize potential impacts. This concentrated work scheduling has been used for the exploitation of remote resources, for example, in remote mining communities in Newfoundland. The offshore work scheduling model is used to avoid massive "boom" developments. It is not economically feasible to build a new town.

The effects of a concentrated work schedule (in the Gulf Coast) are (1) greater potential to workers (e.g., commuting of north Louisiana offshore workers); (2) participation with the nuclear family is affected (less interaction); (3) families become independent social systems through crisis management; lack of input in decisions can create stress; (4) impacts on employees (it is difficult to unionize, to organize for economic benefit); (5) changes to small coastal communities; and (6) new adaptations and integrations (for example, many get a second job-different time-space management).

Dr. Gramling suggested that we can learn from the results of the MMS Alaska OCS Office, but there are limits to the applicability. We can also learn from studies conducted in Newfoundland, Norway, Indonesia, China, and in other areas of the world. The MMS should consider building a library of worldwide socio-cultural impact studies and other relevant data. Gramling argues that much new data gathered should be microsocial in nature.

After Dr. Gramling's presentation, the assembly discussed the adequacy of currently available Gulf Coast socio-cultural studies. The studies are used to assess the effects of MMS leasing and regulation of operations, and to solicit recommendations as a "scoping" effort for the directions of possible future MMS studies. Dr. Spitzer suggested that MMS might proceed at a variety of levels for future studies. He stated that the international culture of work is something of a constant, although the way a Vietnamese and Cajun family handle the scene are going to be different. Another level is microcultural or ecological; a third level is a broader ethnographic approach in areas where cultures have not been well studied. Dr. Spitzer further suggested that MMS should review the cultural conservation report and should consider the option of completing studies in-house.

Dr. John Peterson suggested that MMS studies should look at the linkage of the human, marine, and coastal environments; the cultural ecology should be studied--the relationship of socio-cultural impacts as related to the broader environment. Dr. Brent Smith stated that the MMS coastal characterization studies have taken this thrust and that a human ecological approach is one being considered for an MMS study--looking at socio-cultural elements relative to the natural and physical environment.

Dr. Smith further stated that there are different levels of effects of offshore oil and gas activities: primary, secondary, and tertiary. For example, employment is a much more direct effect than petrochemical refining and manufacturing. Mr. C. Ray Brassieur stated that an effect assumed to be tertiary might be very significant cumulatively. Dr. Smith responded that the National Environmental Policy Act (NEPA) requires that socio-cultural effects must be tied into the effects on the natural environment to relate to NEPA requirements. Dr. Smith stated that if MMS had never leased and regulated offshore oil and gas activities, Cajuns and other cultures and sub-cultures may have been different from what they are today.

Dr. William Freudenburg, Professor of Sociology at the University of Wisconsin and member of the MMS Scientific Advisory Committee, stated that MMS's duties are to understand what the impacts of its activities are on the human and cultural environment and to mitigate those impacts. MMS has done limited socio-cultural work in the Gulf. Dr. Freudenburg suggested that MMS should start with a range of case studies, carefully selected to give some diversity, balance, and range, in order to develop hypotheses about cause/effect relationships. These case studies should focus on what is happening now, possibly focusing on groups who are the most sensitive to development or to the oil and gas bust; what is happening elsewhere in the world--as mitigation options and lessons to learn; and the historical record, looking at the Gulf Coast and elsewhere in the world, as ways to generate hypotheses. This research effort should be done as a 3- or 4-year study. The first year should involve reviewing available information and developing hypotheses; the second and third years should involve testing hypotheses for individually studied groups.

Dr. Peterson stated that MMS might consider funding a few case studies initially instead of planning a massive study because of the uncertainty of funding.

Dr. Smith stated that one of the alternatives that has been discussed is to gather information (published and unpublished) and, at the same time, do some pilot studies of higher priority areas or situations that might be more sensitive as far as changes, such as the boom/bust cycle. Dr. Smith asked, "If we need to prioritize various areas of study (geographic communities, groups, etc.), do we have any sense of which might be of greatest interest?"

Dr. Peterson responded that he would not take a community or group approach. He would put it in terms of an ecological approach, a topical approach (e.g., family approach). For costs and the massiveness of impacts, Louisiana has to be a high priority.

Dr. Spitzer asked whether it is possible to consider a major, broad survey of the Gulf Coast as a whole. This survey would include microstudies related to cultural ecology, the continuity and discontinuity of culture based on exploitation of resources, rather than basing it on ethnicity.

Dr. Freudenburg stated that ultimately MMS does have to look at the entire Gulf area of responsibility where there is, or will be, oil development. MMS needs to work at developing testable hypotheses based on more than a survey of available information. Dr. Freudenburg suggested that it would be possible to start doing work in Morgan City tomorrow, but MMS should be selective. Dr. Freudenburg stated that it is necessary to know enough about the culture to understand how the people living in the culture are to be affected by OCS oil and gas development.

Dr. Spitzer stated that there are a lot of studies (National Park Service and others) that have already been done. One option is for MMS staff to survey the literature and to develop the hypotheses in-house. The social science discipline can help with microstudies or macrostudies, but ultimately the responsibility for integrating all of that information is MMS's.

Mr. J. Kenneth Adams of MMS asked, "If MMS has a development scenario that consisted of exploration, development, and production off of Tampa, Florida, would it be possible to predict what would happen to the Greek sponge fishers (for example)?" Dr. Gramling and Dr. Peterson responded that it was possible. Dr. Gramling stated that it was possible with a high degree of reliability for sponge fishing, tourism, dock space, and the fishing industry. There are different strategies to mitigate what would happen; for example, one of the strategies is to hire only workers from Louisiana. Dr. Gramling further stated that he was involved in an environmental impact statement for development and production activities off Mobile, Alabama. The total impact to the city of Mobile was water and diesel fuel usage and the employment of two part-time dock workers to lay pipe. Other goods and services were to come from Louisiana.

Dr. Spitzer stated that you cannot isolate just the Greek sponge fisherman. In the real world you cannot convince the Floridians that their unemployed worker should not be working on the rigs. There will be local political questions regarding the unemployed or underemployed people in that area. Inevitably, whether your predictive model says that you can mitigate the problem, there will be things happening as a result: economic, social, cultural, and environmental.

Mr. Brassieur stated that what really happens is that Greek fishermen end up on the bottom of the pile. Dr. Spitzer added that they are told that their problems have been mitigated. Mr. Brassieur asked, "Right now, while we can see it happening, should we try to salvage some of the traditions?" There are cultural conservation ethics to consider. Dr. Peterson responded that the more fundamental question is, "Should people be informed about the potential of cooperative decision making?"

Dr. Spitzer responded that if certain people in the French community and other related communities had known that the boom and bust cycle would have been this way, they might have made some very different strategies related to their culture and cultural ecology. People need to have the ability to choose, and the only way they can choose wisely is to be informed.

Dr. Gramling stated that an isolation and containment model was developed for use in the North Sea, which factored in development over "x" number of years and employment of "x" number of people. The oil and gas industry also knew if they employed local people, the local woolen industry would suffer, so the oil and gas industry isolated it and hired everyone from the outside. Mr. Adams stated that we cannot really have any control over that. Dr. Gramling responded that MMS can make the information available.

Dr. Brent W. Smith is a Social Scientist with the MMS, Gulf of Mexico OCS Regional Office. His responsibilities with MMS include environmental and socio-economic impact assessment for offshore operations. Dr. Smith obtained a B.A. in anthropology from Louisiana State University (1970), an M.A. in social sciences from Northwestern State University of Louisiana (1974), and a Doctorate in Public Administration from Nova University (1986).

Mr. William T. Johnstone is a Community Planner with the MMS, Gulf of Mexico OCS Regional Office. His responsibilities with MMS include extensive coordination of the Environmental Impact Statement required prior to oil and gas lease sales, air quality analysis, and an involvement in several studies concerned with environmental issues. He obtained a bachelor's degree from Ohio State University in 1957 and a Master of Regional and City Planning degree from Oklahoma University in 1971.

Cultural Conservation on the Gulf Coast

Dr. Nicholas R. Spitzer
Smithsonian Institution

The Gulf Coast is a culturally heterogeneous folk region of the United States with characteristics of both the American South and the Caribbean. Caribbean cultural features and cognate populations are most pronounced in communities located on the coast itself. In some areas, such as Gulf Coast Mississippi and Alabama, the Caribbean influences are in a range of two to fifteen miles in depth. In Louisiana, with its strong French presence, Caribbean cultural patterns penetrate as deep as 150 miles. Federal mitigation plans that involve cultural resources should be grounded in ethnographic and cultural ecological research to describe and interpret the continuities and parallels between the Caribbean and the Gulf Coast as socio-cultural areas.

Both zones were shaped by European overseas capitalism in the eighteenth and nineteenth centuries, which meant plantation monocrop agriculture and the importation of slave labor. As such, the zones share a history based on European colonial competition for power and exploitation of Afro- and Native American populations. Both areas have tropical or semi-tropical climates and had insular ecologies (bounded by water or lowland swamp basins and coastal marshes). Creolization--the interpenetration and syncretism of Afro-European-Native American cultural products, patterns, and processes--is central to understanding the Caribbean and the Gulf Coast in such realms* as language (French Creole, Cajun French, Isleno Spanish), architecture (shotgun houses, Creole cottages), foodways (congri, jambalaya, red beans and rice, gumbo), music/dance (jazz, Cajun music, zydeco, second-lining), religion (Spiritual churches, voodoo, folk Catholicism), and festival traditions (Mardi Gras, Toussaint, fleet blessings).

In addition to parallel cultural development in the Gulf Coast and the French/Spanish Caribbean, there are also historical and on-going migrations between these areas that produce direct cultural continuity for some populations. A few of many examples of migrations include Haitian Creoles and slaves arriving in New Orleans at the outset of the nineteenth century, Creoles seeking shelter in Martinique, Cuban cigar makers coming to Ybor City, Florida, in the early 20th century, and contemporary black Caribs arriving in New Orleans from Belize.

The parallels and continuities in the primarily Afro-Mediterranean cultural base of the French/Spanish Caribbean and the Gulf Coast must also take into account such non-colonial refugee and immigrant populations as Sicilian Italians (many of who replaced slaves in the sugar fields during Reconstruction); Greeks in Tarpon Springs, Florida; Dalmatian Coast Yugoslavs in the delta of the Mississippi River; Canary Island Islenos in St. Bernard Parish, Louisiana; and Acadians in Louisiana and Texas.*

Beyond ethnographic description of the Gulf Coast's cultural diversity, its regional traditions, and the creolization process is a concern for how to link all of these domains to cultural conservation. What shape should policies take that address regional, cultural, and ecological concerns for continuity and integrity of nature and culture? The starting point, after a cultural understanding of the Gulf Coast, is recognition that material preservation alone--though attractive and consistent with natural science views of cultures as discrete, bounded entities--does not fully address the concerns for culture as symbolic process where ethnicity and tradition are continually recreated. This view of culture as a dynamic activity, and tradition as a contemporary process, rather than strictly a historical product, has profound implications for how we view cultural resource management on the Gulf Coast. There is no question that we must move beyond viewing cultural resources as exclusively material and historical in nature. Yet how we deal with the intangible aspects of living culture in a region characterized by such diversity cannot be described simply.

Public agencies must work with folklorists and anthropologists to engage in dialogues with ethnic/regional community tradition-bearers and folk artists/practitioners on how their resources should be conserved and represented. Our efforts at cultural conservation can only be realized through ongoing and multiple cultural conversations with the groups who make the region identifiable and significant on the cultural landscape of North America.

Specific recommendations for cultural conservation work and mitigation policies on the Gulf Coast are

1. Redefine "cultural resource" to include the traditional social processes, cultural patterns, and material products of contemporary, tribal, ethnic, regional, and occupational groups.
2. Make such living, traditional, cultural resources a significant part of all major areal studies undertaken by the U.S. Minerals Management Service.
3. Support ethnographic study and cultural mapping of the entire Gulf Coast (similar to efforts by the State of Louisiana and the National Park Service in Louisiana--see map sample Figure 10.1) to the same degree that natural resources have been mapped.
4. Base future mitigation and cultural conservation efforts on data provided by ethnographic work at three levels: a broad regional cultural survey; particular ethnic and occupational groups in sub-regional locations; selected local, model cultural ecological situations.

* The two sets of examples cited are exclusively from the Gulf Coast, but have co-occurrence, continuity, or parallelism with Caribbean examples.

Dr. Nicholas R. Spitzer received his Ph.D. in anthropology from the University of Texas with an areal interest in Gulf South folklife. Spitzer served for 7 years as the Louisiana State Folklorist and was responsible for state laws that recognized traditional cultures and communities as cultural resources. In 1979, he edited and researched the original baseline document for the Jean Lafitte National Park Service's (NPS's) cultural resource planning document, The Mississippi Delta Ethnographic Overview. More recently he completed a study of rural Creole music, dance, and festival in relation to ethnicity for the NPS. Spitzer edited the book Louisiana Folklife: A Guide to the State, and directed the PBS broadcast film ZYDECO. He also curated The Creole State, a permanent exhibit of Louisiana folklife in the State Capitol Building in Baton Rouge. At the Smithsonian's Office of Folklife Programs, he continues work on creolization, Gulf Coast folklife, folk music, media documentation, and cultural conservation.

National Park Service Ethnographic Studies, An Overview

Mr. C. Ray Brassieur
Jean Lafitte National Historical Park

Jean Lafitte National Historical Park (NHP) and Preserve was established November 10, 1978, by Public Law 95-625 with the purpose of conserving and publicly presenting the natural and historical resources of the Mississippi Delta region and "to provide for their interpretation in such a manner as to portray the development of cultural diversity." This legislation further describes the park as consisting of several non-contiguous land holdings, including a 600-acre delta wetland environment area, an historic battlefield, a prehistoric archaeological complex, and an interpretive and administrative facility in the French Quarter section of New Orleans. What's more, the legislation calls for an undetermined number of "cooperative agreement" sites or areas, urban districts, towns, and villages; and natural, cultural, and historical resources located throughout a rather nebulously defined Mississippi Delta region. This legislation marked the beginning of a cultural resources experiment now in progress in south Louisiana.

In order to uncover the facts pertaining to "the development of cultural diversity," a baseline research effort, entitled the Mississippi Delta Ethnographic Overview, was compiled under the editorship of folklorist Nicholas Spitzer. This effort described and interpreted man/land relationships, intra/inter-cultural relationships, and the historical and contemporary significance of the many cultural groups found within the Mississippi Delta region through the perspective of anthropology, cultural geography, history, folkloristics, linguistics, ecology, ethnic studies, and regional studies. This study, despite its preliminary nature, points to a revolutionary change in the field of cultural resources evaluation--a true-paradigm change that refocuses a narrow object-oriented approach to include evaluations of often intangible cultural realities like ethnic value orientations, belief systems, and folkways.

The 1982 General Management Plan (GMP), Development Concept Plan for Jean Lafitte NHP further outlined management objectives to include the public presentation of regional contemporary and traditional cultures, promoting and supporting of cultural heritage programs, assisting cultural groups in maintaining their history, collecting and preserving information on regional cultures and cultural practices, providing for anthropological field study, and special studies on existing material culture and regional folkways. The GMP further directed that these objectives would be accomplished "without affecting cultures or their evolution."

Since the compilation of the Mississippi Delta Ethnographic Overview in 1979, twenty reports containing substantial ethnographic or ethnohistorical data have been submitted to Jean Lafitte NHP. These reports represent a wide range of perspectives and varying levels of quality and scholarship. Many of the reports focus upon certain aspects of specific ethnic groups--Louisiana Indian tribes, the Canary Islanders, Filipinos, Creoles, and Cajuns, for example. Several of the reports have primarily historical perspectives such as colonial Caribbean culture exchange or nineteenth century Creole life but, nevertheless, contain background data essential to the understanding of extant cultural phenomena. Still other reports such as ones concerning vernacular architecture and New Orleans gospel quartets focus upon more specific, yet salient cultural themes. A bibliography of these reports is included below.

This author's recommendations for future ethnographic/ethnohistorical work include 1) continued focus upon ethnic groups, 2) oral history projects directed toward the collection of folk environmental perspectives gathered from elders of the Delta region, and 3) documentation of a maritime heritage, which continues to recede along with the Louisiana coast. In addition to these recommendations, the author poses a number of questions concerning the ethics of culture resource policies directed toward living groups and extant belief and behavioral systems.

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Mr. C. Ray Brassieur holds a B.A. in history from Lamar University and a M.A. in anthropology from Louisiana State University. His initial experience in the field of cultural resource management was from an archaeologist's perspective, but he has since been active in ethnographic, material culture, folk music, and traditional arts documentation, research, and public programming. The author is presently employed by Jean Lafitte NHP as an interpretive specialist/folklorist.

Current Research on Asian-Americans on the Gulf Coast

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The Asian-American population is growing in the Gulf Coast region, but the size of the Asian communities does not adequately reflect their contribution or visibility. The Asian communities are involved in the restaurant business, the fishing industry, the growing professional class, and education. The Chinese community has been established for some time, but many of the southeast Asian refugees and the south Asian professionals are relatively recent arrivals.

Not all of the Asians have achieved the same visibility. The Vietnamese are perhaps the most visible and can possibly become a political reality to be reckoned with in the future. Other Indochinese refugees have failed to create a community; the Chinese are content to stay in the shadows; and other groups simply don't have the numbers to create an ethnic community.

Although the Asian communities and enclaves have been on the coast for at least ten years now, we still do not know a great deal about them. The Vietnamese have been the most studied of the Asian ethnic groups (see e.g., Brown, 1978; Young, 1980; Ward and Gussow, 1979; Urban League of Greater New Orleans, 1978; Sindler, 1980; Starr, 1980; Ragas and Maruggi, 1978), but some of the methods utilized in, and motives underlying, some of the research are questionable (see Skinner, 1980). My own research with the Vietnamese of New Orleans (see Nash, 1986a, 1986b, 1987a, 1987b, 1987c) has been of the community study variety and is the result of some four years of field work in the community. I have also worked with, and studied, the Chinese and Lao populations but in a more limited fashion. The first thing one notices, though, about the Asian populations is that they are quite distinctive, and each population itself is very diverse and resistant to facile generalizations.

Vietnamese visibility is itself a phenomenon in the region partly explained by the size of the population but mostly by its "cultural vitality." The Vietnamese have created communities, both in the geographical and symbolic sense. The vitality of the community in New Orleans, in particular, is explained by its communal structures, maintenance of traditional values and attitudes, religiosity, reputation for hard work, and ability to live with creative tension.

Conflicts within the community have not destabilized it so much as made it more vibrant and healthy. Those conflicts center on the relative role of the English and Vietnamese languages in the life of the community, the role of women in terms of education and careers, and ethnic identity. In a real sense, these conflicts face all Asian populations in the Coast region. They are also united by a common concern for the future of education and employment in the region. The Asians find the Gulf Coast an attractive place to live, but, unless educational and economic conditions improve, the region may lose some of its brightest and hardest working youth to other more promising regions of the country.

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Dr. Jesse W. Nash completed his Ph.D. in Anthropology at Tulane University in 1987. His dissertation was a study of Vietnamese values. He is currently Assistant Professor of Religious Studies at Loyola University and Director of the English Language Program for Vietnamese students at Notre Dame Seminary. He has participated in archaeological field work in the Midwest and sociocultural field work among the Vietnamese, Chinese, Lao, rural Black, and German-American communities, prison populations, and seminaries/monasteries. He is also interested in the relationship between mass media and culture in the United States and Japan.

Undocumented Central American Project: Houston

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THE PROJECT'S INVESTIGATION

The project commenced in the summer of 1985 with the goal of identifying the undocumented Central American populations in Houston and comparing their work conditions and their settlement in different areas of the city. As the study progressed, it evolved a multifaceted methodology of interviewing undocumented immigrants, employers, and organizations; collecting life histories; and observing community life in areas with concentrations of undocumented Central Americans. With a special concern for processes of community development, the study's investigation has focused on a variety of social activities. These included church-sponsored events, community meetings, English classes, fund raisers, household and community fiestas, soccer games, teacher-parent meetings, union organizing activities, and weddings.

Conducted by a crew of eight Hispanics, open-ended interviews constituted the core of the study's information gathering activity. The interview schedule focused on housing, work, workplace, and community intergroup interaction; organizational participation in the community; health; employment in the country of origin; reasons for emigrating; experiences with political conflict; conditions during the journey to the United States; and U.S. education of the children.

Of the 260 interviews completed thus far, 150 have already been analyzed. The completed interviews consist of three major national categories, i.e., 80 Salvadorans (40 males), 31 Hondurans (14 males), and 28 Guatemalans (24 males); and of 8 Nicaraguans, 1 Belizian, 1 Costa Rican, and 1 Panamanian.

FINDINGS

Table 10.1 summarizes the major undocumented Central American groups that have been sampled in the study. As the table demonstrates, the groups are diverse, reflecting different racial, ethnic, and linguistic backgrounds.

Table 10.2 gives a socio-demographic profile of the interviews that have been analyzed. The table indicates that the undocumented Central Americans differ from the usual profile of the undocumented Mexican migrant. For example, 45 percent of the sample is older than 29 years of age, and the majority of the sample are, or have been, married. This contrasts with the usual findings of undocumented Mexican migrants as young and single.

Table 10.3 lists the different reasons given by the undocumented Central Americans for coming to the United States. The tables show that these reasons are varied, and, thus, it is impossible to generalize across the whole undocumented Central American population in Houston.

RECOMMENDATIONS

Further research is needed to understand the incorporation of undocumented Central American immigrants in U.S. society, especially in the context of the new immigration law. The following questions especially need to be addressed: (1) How does interaction with established-residents impact the immigrants' incorporation in U.S. society? (2) How does the development of immigrant communities affect the established-residents' sense of American identity and community? and (3) How does the new immigration law affect the immigrants' community development?

Dr. Nestor P. Rodriguez, Assistant Professor of Sociology at the University of Houston, has been involved in field studies of undocumented Latin migrants in the United States since 1978. His present study focuses on the development of new Central American communities in Houston. This research will evolve in 1988 into a 2-year ethnographic study of social relations between new Latino immigrants and established-residents in Houston.

Current Research on Hispanics of the Eastern Gulf Coast

Dr. Miguel A. Bretos
Florida International University

For the purpose of this discussion, the Eastern Gulf Coast means essentially Florida, especially two areas: the Tampa Bay region and the Palm Beach to Key West corridor where the vast majority of the state's Hispanics live.

This of course is not to deny a more generalized Hispanic presence throughout the state either demographically or historically. Florida was settled and held by Spain for almost three hundred years. Indeed, this simple fact is becoming the mainspring of much of the research, and certainly the interest, about Hispanics in Florida that is likely to occur between now and the Columbus Quincentenary in 1992 and, hopefully, for some time thereafter.

From the spectacular discovery and salvage of the Santo Nino de Atocha in the Florida Keys in 1985 to the no less dramatic identification a few short months ago of the site of Hernando de Soto's 1539 winter camp in downtown Tallahassee, Florida's Hispanic past has become the stuff of headlines. The emergence of Florida archaeology as a growth industry (not only the archaeology of Hispanic, but of pre-Conquest and modern sites as well) raises some fascinating new environmental challenges as well as opportunities.

The case of the Atocha, for example, once again forcefully underlined that the seas surrounding Florida are literally strewn with shipwrecks, some of them of momentous archaeological and historical significance. The excavation of the De Soto site in Tallahassee, not to mention the ambitious scheme to map

De Soto's trail from Tampa Bay to the panhandle and the line of colonial Spanish missions westward and northward from Saint Augustine, will further deepen the general awareness of the state's Hispanic roots. These are also instances where the demands of scientific research and public interest have had, and will have to be, further balanced against the imperatives of economic development in a state where issues relating to environmental integrity and the quality of life acquire critical economic, as well as humane, significance.

An interesting sideline of Florida's unique situation, especially as it pertains to the approaching Columbus Quincentenary, is a noticeable and growing high-level interest in Florida and Florida Hispanics on the part of Spanish governmental and academic institutions. The University of Florida at Gainesville, for example, is embarked on several major collaborative projects with Spain. Of particular interest is the massive data bank on the population of Spanish Florida that has been established between the University of Florida and the University of Seville and which seeks to document every man, woman, and child who lived in Florida under the Spanish colonial regime.

By the same token, Florida Hispanics in general are becoming increasingly aware of, and sensitive to, their long history within the region. From a romantic and largely irrelevant story confined to the shelves of antiquarians, Florida's Hispanic roots are increasingly becoming a source of pride and of strength to the state's diverse Hispanic communities, both old and recent. It is interesting to note in this regard that while Florida had very important connections to Spain during the colonial period, it had even closer connections to Cuba, from where the Spanish administration of the Florida colony was exercised for most of the period. This is a matter of some importance considering that Cubans are the single largest Hispanic group within the state.

This fact leads us to the central question: who and where are Florida's Hispanics? This is really a tale of four cities: Saint Augustine, which was the capital of the Spanish colony; Tampa and Key West, where a very significant influx of Cuban and Spanish immigrants took place especially during the last quarter of the 19th century and where their descendants are still to be found, and Miami and Dade County, where a massive Hispanic, especially Cuban presence, has become one of the fundamental facts of life since 1959.

Because of the central importance of the Miami phenomenon, I would like to dedicate the remainder of this paper to a consideration of its implications regarding Hispanics and Hispanic-related research.

Writer David Rieff in his recent book <u>Miami: Exiles, Refugees, and the New America</u> remarks that, far from your standard urban conglomerate, Miami is "a great capital city." The phrase contains a profound insight and has been consequently widely quoted. But, whose capital is this Miami that some analysts are beginning to single out as the trendsetting American metropolis of the twenty-first century? For one, it is the "capital" of approximately one million Cuban-Americans dispersed throughout the nation, of whom three quarters of a million live in Dade County. And then, it is the mecca for numerous immigrant groups from the Circum-Caribbean region including Colombians, Venezuelans, Mexicans, and Nicaraguans. With the exception of the Cubans, no extensive scholarly studies exist for those groups.

The Cuban exodus to the U.S. took place in a series of episodes. Between 1959 and the 1962 Missile Crisis, when commercial flights between Cuba and the U.S. were suspended, over 200,000 Cubans left Cuba. A hiatus followed until, in 1965, the Castro government allowed the relatives of persons wishing to leave the country to pick them up at the little port of Camarioca.

The disorderly Camarioca boatlift led to the "freedom flights" program whereby 260,500 Cubans arrived in the U.S. between late 1965 and 1973. In 1980, however, after several years without emigration, pent up frustrations within Cuba led the Castro regime to authorize a second boatlift, this time through the port of Mariel. As a result, 125,000 left the island in a chaotic mass migration. It is important to note that between 1959 and the end of the Mariel exodus Cuban "entrants" were granted political asylum, a preferential treatment which sets Cubans apart from other groups such as the Nicaraguans.

The demography and socio-cultural dynamics of the Cuban community have received considerable attention. For example, sociologists Juan M. Clark, Sylvia Pedraza-Bailey, Lisandro Perez, and Alejandro Portes and his associates have made significant contributions. Lisandro Perez has summarized the salient demographic features of the Cuban population. Unlike other groups of recent immigrants, females and the elderly are disproportionately represented among the Cubans. The extended family is alive and well with a high proportion of households being "three-generation" families. The three-generation household, moreover, plays a significant economic role. Household income among Cubans is only slightly below that for mainstream American families; however, several members of the family contribute to the pooled household income. Cuban women are more likely to be working outside the home than any other Hispanic women. Indeed, this holds true in comparison with all women in the Untied States. Consequently, Cuban households have high aspirations and expectations of upward social mobility.

Alejandro Portes has emphasized that the Cuban community in South Florida is a true ethnic enclave. In other words, a South Florida Cuban may be born, live, and die entirely within the confines of his culture and language. This has very significant economic implications. The enclave insulates the new arrival from culture shock and provides employment in enterprises operated by more established Cubans. The vitality of the Cuban economic enclave, moreover, has opened the doors for extensive commercial contacts between Miami and Latin America.

This economic enclave has ensured a continuing viability of the Spanish language in South Florida. By the same token, the presence of the enclave may retard the process of assimilation since it is not imperative to learn the language and culture of the dominant society. This is not to say that English is unknown or eschewed by the younger Cuban generation. Indeed, English is the principal language among Cubans who have been brought up in the U.S.

Dr. Miguel A. Bretos is the creator and director of the Cuban Exile History and Archives Project (CEHAP) and editor of Cuban Heritage. He holds the Ph.D. from Vanderbilt and has taught at Oberlin College and the University of New South Wales In Sydney, Australia. He has held numerous research awards. During 1985, he was Visiting Professor at the Universidad Autonoma de Yucatan, Mexico. He is on the Florida

Steering Committee on the Columbus Quincentenary and the Florida Folklife Council.

Current Research in Ethnic Diversity in Coastal Louisiana

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Nicholls State University

Few regions can compete with coastal Louisiana in production renewable and nonrenewable resources. One impetus for early colonization was this primary resource base. Consequently, a range of cultures and settlements is a part of the coastal lowlands. The region has been transformed into a truly diversified ethnic mosaic, making coastal Louisiana one of the nation's "melting pots." Indeed, the French Quarter has been described as being discovered by French explorers, built by Spanish pioneers, and owned by Italian businessmen--another indicator of south Louisiana's ethnic diversity.

THE FIRST SETTLERS

Prehistoric Indians established their villages on natural levees, exposed salt domes, beach ridges, and other "high ground." Since they had to adapt to a changing environment, their encampments were rarely occupied continuously. In Louisiana, prehistoric man followed the Mississippi River's changing patterns. As new natural levees were built and old ones decayed, Indians moved; their subsistence requirements were no longer available.

Detailed written records are nonexistent, so each group is "finger-printed' by their material culture. Artifacts in or on the ground help anthropologists and archaeologists disentangle settlement succession, as well as document archaic physiographic features present during earlier time.

Swanton (1911, 1946), McIntire (1958) and Gibson (1978) began to unravel the complicated history of these native Americans. This work has been complemented by the State Archeologist and Newman (1977). Since all federal projects now mandate a cultural resource survey, this aspect of Louisiana's ethnic diversity evolves through the research endeavors and interest of a number of consulting firms, plus the University of New Orleans, Louisiana State University, and Catholic Social Services.

THE ETHNIC MIX

Spanish, French, Italian, Yugoslavian, Irish, German, Cuban, Greek, Latin American, Islenos (Canary Islanders), Vietnamese, and Chinese have settled within the coastal borderlands. Louisiana exhibits a distinct ethnic and cultural heterogeneity. Its biggest and oldest ethnic group is of French descent.

These newcomers came directly from France and, indirectly, from French Canada. Many were Acadians, expelled from British-controlled Nova Scotia. After deportation in 1755, nearly 4,000 of these Canadian expatriots located in Louisiana, where they adopted a fishing - hunting-trapping - agriculture existence and came to be known as Cajuns (a corruption of Acadian) (Brown and Spitzer, 1977; Dormon, Griffiths, and Dean, 1983). They arrived in small groups over a 30-year period (1760-1790) (Gibson, 1975). However, as early as 1718 (the year New Orleans was established), Europeans of French descent populated the colony. Unlike the Canadian adventurers de bois, they built homes in New Orleans, ignoring the alluvial wetlands, which were the preferred site for the habitant (peasants).

This rural, ethnic settlement zone represents one of North America's four ethnic provinces. Identified as "French Louisiana," the province has been mapped by Meigs (1941) and Allen (1970) to show its regional boundaries. This province has been well studied; its documentation is a continuous process.

Louisiana rural and urban ethnic islands are much more numerous. They are a product of cluster migration, but not as well studied. These ethnic islands have developed over time. They are, unfortunately, slowly losing their identity and need to be investigated. Louisiana's diverse ethnic landscape, not just its French roots, should be researched. We have a good start, but each group "humanizes" the land differently. These are the elements that should be analyzed systemically.

In 1763, France ceded Louisiana to Spain, which began colonizing the territory in 1766. Spanish ownership did not lead to adoption of the Spanish language or culture, and few Spaniards migrated. Those that came to the colony were soon assimilated into the firmly established French culture. Islenos were the exception. Place names such as New Iberia, Galvez Town, and the Bayou Lafourche settlement Venezuela are current reminders of the Spanish Period.

McDermott's (1974) compendium of articles documents Spanish history within the Mississippi Valley. The Spanish have not been ignored. Din (1976), Hawley (1976), and MacCurdy (1950) provide some insights into this period. Unfortunately, a detailed, focused study of Islenos has not been attempted. Overviews are available, but considerable work remains.

With the conclusion of the Spanish era in 1804, additional ethnic groups migrated into the territory--a process continuing with Latin Americans and Vietnamese immigrants today. In the decades after the Louisiana Purchase, English and talian settlers were absorbed into the French culture. Later waves of migrants from both countries retained their cultural integrity. In the 1700's, Germans colonized a stretch of the River described as the Cote des Allemands (German Coast) where they raised vegetables, an economic imprint that survives. Some surnames remained unaltered; many were Gallicized, as most migrants were acculturated.

With time, these groups were joined by Balkan immigrants from Serbia, Montenegro, Greece, and Albania and other eastern European countries. Irish, Filipinos, Greeks, Syrians, Lebanese, Chinese, and Jews also located within the state's rural and urban confines. Yugoslavian oyster fishermen, for example, settled along the bayous, bays, and lakes southeast of New Orleans. Since the marshes were void of "high" land, narrow riverine strips became the focal point for their settlements (Vujnovich, 1974). Consequently, they built the villages of Olga, Empire, Ostrica, and Oysterville. Currently, the National Park Service is funding a Yugoslavian study.

Contrary to the Yugoslavian practice of settling the "high" ground, Louisiana Land Office records show that, in the early 1880s, Oriental immigrants purchased several small islands in Barataria Bay. These tracts were ideally suited for their shrimp-drying platforms. Settlements at Basa, Bayou Brouilleau, Cabinish, Camp Dewey, Chenier Dufon, Manila Village, and others were established to dehydrate shrimp. In building their isolated platforms, Oriental fisherman established a niche among

Louisiana's ethnic minorities--a niche yet to be investigated in a systematic manner.

Along with these emigrants, a melange of other ethnic groups contribute to Louisiana's "melting pot" image. Yugoslavian, Islenos, French, German, Hungarian, and Chinese moved into predominantly rural parishes; while Italian, Irish, Greek, Syrian, Lebanese, and Jewish immigrants located in towns, villages, and cities.

ETHNIC RESEARCH

As one investigates current research into south Louisiana's ethnic diversity, the available material can be classified as: University sponsored and/or published, thesis/dissertation, popular (frequently published by local historical groups), federally-funded (often through consulting firms), and magazine/newspaper feature stories. The historical evolution of ethnic-related studies has been conducted by anthropologists, folklorists, geographers, historians, sociologists, and others. These disciplines prepared the foundation for work in material and non-material culture elements and various socio-economic components of each individual culture group.

As might be expected, the French culture hearth was the focus of early scholarly interest. In general, university-related research emphasized language (Read, 1931; Breton and Louder, 1979); folk and vernacular house types (Kniffen, 1936, 1965); and French, German and plantation settlement patterns (Deiler, 1909; Post, 1936; Knipmeyer, 1956; Rehder, 1971) and various anthropological issues. Later, material culture within a regional context were added to the list of completed research. Boats (Knipmeyer, 1956), swamp culture (Comeaux, 1972), music (Spitzer, 1986), folk medicine (Landon, 1986), cemeteries (Jeane, 1969), and foodways (Guiterrez, 1983) are some examples.

French Louisiana is experiencing a cultural reawakening or rebound. A need for contemporary research is apparent. The province's ethnicity, as it relates to changes in rural-small town businesses, type of employment, farming practices, and urban business activities should be studied.

Currently, there are three studies worthy of note. The 1987 book The Founding of New Acadia by Carl Brasseaux is an excellent study of the beginning of Acadian life. Federally-funded projects add to the list of new work. Studies supported by the National Park Service, Mississippi Delta Ethnographic Overview (Brassieur, et al, 1979) and The Cajuns: Their History and Culture (Hamilton and Associates, 1987), supply good background information for future research. They are complete and well documented overviews.

Extensive research has been published in the popular and scientific literature related to Acadians. Their material and nonmaterial culture elements are reasonably well documented. There are still "gaps" in our understanding of these "folks." Many other ethnic groups have been largely ignored; many were acculturated, but not fully assimilated. If studied, they are only a chapter or paragraph in a large volume--often the product of a local historical society or feature in the Sunday newspaper. No treatises are available on the ethnology, ethnography, ethnicity, or ethnic geography of the Greeks, Jews, Hungarian, Syrians, Lebanese, or Chinese. Each has contributed to Louisiana's ethnic fabric and should be added to the literature on ethnic diversity. Recently, there have been several works that attempted to capture the totality of the state's ethnic background. As important summaries, they synthesize the available information and are a good first reading of south Louisiana's ethnic mosaic. They are only a beginning. More sponsored research is required to complete the documentation process.

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Coastal Society. He has worked in south Louisiana's alluvial wetlands for nearly 20 years with his research career focusing on man's activities in Louisiana's coastal zone. In this regard, he has presented 35 professional papers (including invited papers in Japan, England, France, Spain, and Wales) and authored or coauthored nearly 70 papers and monographs on a number of coast-related topics. His most recent published work documented the economic consequences of Louisiana's land loss, the canal patterns in "The Lafourche Country," man's response to coastal change in the Northern Gulf of Mexico, and Louisiana's retreating coast.

Current Research on Gulf Coast Indians

Dr. John H. Peterson
Mississippi State University

The Indians of the Gulf Coast represent populations remaining behind, following the period of Indian removals from the Southeast in the 1830s and 1840s. These Indians lived in isolated communities largely ignored by passing events and the non-Indian populations. For the most part, Indian communities were located in less desirable land away from established routes of transportation. Indian communities began to emerge from isolation as modern industrial society began pressing more closely on them and the land they occupied. Since the timing of such impacts and the course of subsequent events varied widely, it is difficult to summarize their recent historical experience. Although research on the Gulf Coast Indians has greatly increased in the past decade, researchers usually focus on an individual tribe, or a group of tribes within a single state. Thus, in addition to describing a scattered and diverse population, I will be summarizing diverse research efforts. My presentation is largely based on papers by these individual researchers, most of who participated in two symposia in recent years, both chaired by Anthony Paredes of Florida State University, and both of which are in preparation as collected volumes edited by him.

It is essential to begin by recognizing that "Indian" can have at least three different meanings. Legally, persons are Indians only if they meet the membership criteria of, and are enrolled in, a federally acknowledged Indian tribe. Indians are the only ethnic/racial group in the U.S. with such clear-cut legal standing. Genetically, or biologically, persons are Indians if they have a high degree of Indian ancestry and a perceptible Indian phenotype relative to the basic criteria of physical anthropology. Ethnically, or culturally, persons are Indians if they were raised in, are part of, and identify with a tribal Indian community. Complicating matters, however, is the existence of individuals and groups who identify themselves as being Indian yet who may not be Indian by any of the above criteria. Such individuals and groups may have ancestry traceable to an established Indian tribe, and may adopt behaviors, dress, and hair style believed characteristic of Indians generally.

The most important factor in the historical experience of the Gulf Coast Indians has been the effort to gain legal status as Indians through the process of being acknowledged by the federal government as Indian tribes or communities. During the early decades of the twentieth century, church and missionary groups became increasingly interested in the unacknowledged Indian groups remaining in the southeast. Missions and schools were established and efforts were made to interest state and federal officials in the remaining Indians whose economic conditions were very poor. As a result, several Indian groups were investigated and granted federal acknowledgement or recognition as Indian tribes. With acknowledgment, the Bureau of Indian Affairs, U.S. Department of Interior, began to acquire lands for the tribes and to extend services in the fields of health, education, and economic assistance. Federal acknowledgment was extended only to the major tribal groups who had the most obvious claim to be "Indians": the Seminoles and Miccosukees of south Florida, the Choctaws of Mississippi, the Chittimachas and Coushattas of Louisiana, and the Alabama-Coushattas of Texas. Numerous other groups failed to be acknowledged as Indian tribes by the federal government, often because of their apparent small population and lack of remaining Indian characteristics. But, since there were now uniform procedures for federal acknowledgement, some groups were rejected through arbitrary decisions. The importance of federal acknowledgement cannot be overemphasized. Through acknowledgement, an Indian tribe acquires a land base for a reservation government. Without membership in a federally recognized Indian tribe, persons may be of Indian descent, but not be legally Indian regardless of the degree to which they are "Indian" in ancestry, appearance, or culture. Further, it is relatively easy to collect data on impacts of developmental projects for federally recognized tribes, since most tribal governments and the Bureau of Indian Affairs maintain reasonable accurate records. The history of the remaining non-recognized tribes centers on their effort to achieve federal recognition.

While recognized Indian tribes enjoyed an increased degree of self-government and practical assistance in the New Deal era, the 1950s brought a significant cutback in programs for American Indians, and two of the acknowledged tribes in the Gulf Coast region lost their federal acknowledgement by Congressional action as part of a wider policy of termination. These two tribes were the Alabama-Coushattas of Texas and the Coushattas of Louisiana.

Conditions for Gulf Coast tribes did not improve until the 1960s and 1970s when community action funds became available to many different groups, including both federally acknowledged tribes and unacknowledged Indian groups. Questions of schools for children of Indian descent in the Civil Rights era, and the potential for community action funds, brought about greater efforts of community organization among the non-acknowledged Indian groups and stimulated group formation among previously unorganized Indian descent groups and groups claiming to be of Indian descent. With a growing list of groups petitioning for federal acknowledgement, it became necessary for the first time to establish specific criteria for such acknowledgement and to establish a Branch of Acknowledgment and Research within the Bureau of Indian Affairs to process petitions. Unlike the Northeast, the Southeast has relatively few state reservations or sanctioned Indian communities. In the Southeast, one finds a number of non-aggregated, acculturated Indian descendants (or those claiming Indian ancestry), scattered throughout the region. One-third of all petitions for federal acknowledgement, or 34 petitions, have been submitted from Indian groups of the Southeast. Of these petitions, only eight have been evaluated, of which two groups have received federally recognized status: the Tunica-Biloxi of Louisiana and the Poarch Band of Creeks of Alabama. Of the remaining 26 petitioning Indian groups in the Southeast, only one has completed the required documentation for evaluation.

Throughout the Gulf Coast area, it is possible to run across previously unorganized and/or unacknowledged Indian descent groups. On the Mississippi Gulf Coast, for example, when the Mississippi Band of Choctaw Indians was acknowledged in 1918, there were still clearly identifiable family groups of Choctaws in the three Mississippi coastal counties. With few exceptions, these families are highly acculturated and have had little contact with Choctaw tribal affairs. Their numbers were too small to warrant extension of services by the Choctaw Agency, and they have become increasingly assimilated with the passage of time. On the other hand, most of these individuals are conscious of their Choctaw descent; at least one individual has claimed such status in securing employment in the Choctaw schools. It is possible that a political issue effecting them as a group might cause the development of a community of interest and formal organization of these people.

A second type of Indian community has formed within the past ten years in Pascagoula, Mississippi. Here Ingles Shipping has carried out aggressive minority employment policy and actively recruited Indian workers from as far away as Arizona. This has resulted in a small multi-tribal Indian urban community which has even operated an Indian center. Most of the individuals involved are members of federally acknowledged tribes, but the Indian community resembles, on a small scale, the urban Indian communities that have been developing nationally since World War Two. It is highly probable that such small urban clustering of Indian people would be found in growing urban areas along the Gulf Coast, especially where industrial employment has been expanding in recent years attracting labor from other areas. There is no systematic research on Indian descent groups or on developing urban Indian groups of the Gulf Coast. Anthropological, sociological, and historical research have focused on federally acknowledged groups and historical Indian communities.

REGIONAL INDIAN ORGANIZATIONS

The United South and Eastern Tribes is an organization composed of the federally acknowledged tribes. It maintains little interest in unacknowledged Indian groups. Three Gulf states maintain a Governor's Council or Commissioner for Indians affairs: Texas, Louisiana, and Florida. Such state government organizations include both federal and state acknowledged Indian groups. The only source of information on groups without federal or state acknowledgement, but seeking federal acknowledgement is the Branch of Indian Affairs. Dr. William Guinn of this organization has an excellent perspective on these groups.

SOUTH FLORIDA

The federally acknowledged Seminole and Miccosukee tribes' people and activities are primarily in south-central and east Florida around Hollywood and Ft. Lauderdale. With the exception of a bingo operation in the Tampa area, they have little population or activities on the Gulf Coast. Dr. Henry Kersey, Department of History, Florida Atlantic University, has worked closely with the Seminoles for many years.

WEST FLORIDA

Dr. Anthony Paredes, Florida State University, contributed to the research leading to the 1984 federal acknowledgement of the Poarch Band of

Creek Indians and is generally knowledgeable of other Indian groups in Florida.

ALABAMA

The Mowa Choctaws located north of Mobile are in the process of documenting their petition for federal acknowledgement assisted by Dr. Susan Greenbaum of the Department of Anthropology, University of South Florida.

MISSISSIPPI

The federally acknowledged Mississippi Band of Choctaw Indians is the only major Indian group. Dr. John Peterson of Mississippi State University has actively worked with the Choctaws for many years.

LOUISIANA

Louisiana contains three federally acknowledged tribes: Chitimacha in St. Mary Parish, Coushatta in Allen Parish, and the Tunica-Biloxi in Avoyelles Parish; and five state recognized Indian groups: the Houma; the Jena Choctaw; the Choctaw-Apache; the Clifton Choctaw; and a suburban agglomerate of Choctaws, the Louisiana Tribe of Choctaws in West Baton Rouge Parish. Dr. Hiram (Pete) Gregory of the Department of History, Social Sciences and Social Work, Northwestern State University of Louisiana, has been working with these groups for many years. He notes that there are scattered Indian populations in all Louisiana urban areas, and several other rural communities with strong Indian identities also exist.

TEXAS

Texas has only one state recognized tribe in the Gulf region, the Alabama-Coushatta east of Houston. This group has been ignored by scholars in recent decades. Dr. Billye Foggleman of the Tennessee Medical School in Memphis has studied the sizable urban Indian communities in Fort Worth and Dallas, representing migrants from Oklahoma and western states. But there have been no attempts to locate or study urban Indian groups along the Gulf Coast.

OIL INDUSTRY IMPACTS

The greatest impact of the oil industry has been on the Indians of Louisiana, with employment being a major factor in improved economic conditions over the past decades. The Chitimacha have income from oil leases and have experienced the greatest employment in the oil industry. All tribes of Louisiana have entered hard times with the current decline in the oil industry. The Mississippi Choctaws own small gas leases. Otherwise, the Indians of the Gulf Coast seem more indirectly than directly impacted by oil-related activities.

RECOMMENDATIONS

No assessment of the impact of oil-related activities on Gulf Coast Indians has ever been attempted. Such an assessment must take into account federal, state, and unacknowledged groups, and must take place within a general framework for assessing human ecological (anthropology), cultural geographical, economic, and demographic change.

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NOTE: Southern Anthropological Society, 1986, refers to papers presented at the Wrightsville Beach meeting of the Society, April 26, 1986, in a Symposium on Contemporary Southeastern Indians organized by Dr. Anthony Paredes, who is editing a volume composed of the papers for the University of Alabama Press.

Native Peoples refers to papers presented at a conference on Native Peoples of the Southeastern United States at Florida State University, March 5 - 7, 1987, organized by Dr. Anthony Paredes and Dr. Leitch Wright of Florida State University. Dr. Paredes is editing these papers for potential publication.

The papers at the first conference focused on the contemporary status of the individual groups, while the later conference focused on the historical experience of southeastern Indians. Collectively, these two volumes, when published, will be the best available summary of the history and contemporary status of southeastern Indians. The above bibliography lists only a portion of the papers presented at these conferences.

Dr. John H. Peterson is Coordinator for Anthropology and Director of the Cobb Institute of Archaeology at Mississippi State University. He received his Ph.D. in 1970 from the University of Georgia based on field work with the Mississippi Choctaws. Since joining nearby Mississippi State University, Peterson has continued to work with the Choctaw tribe including serving as Chief of the Tribal Planning Department in 1972-1973. Peterson has continued to work with the Choctaws, directing a bilingual, teacher-training program in 1974-1975. Since 1983, he has served on the Choctaw Heritage Council.

In addition to research with American Indians, Dr. Peterson has many years of research on the impacts of developmental projects on human populations, including serving as a researcher or consultant for the U.S. Forest Service, the U.S. Army Corps of Engineers, the National Academy of Sciences, and the Library of Congress. Peterson is a coauthor of one of the first studies of Social Impact Assessment for the Institute of Water Resources of the Corps of Engineers. He has also taught methods of Social Impact Assessment to university faculty under a program sponsored by the National Science Foundation.

Current Research on Cajun Culture

Dr. Barry J. Ancelet
University of Southwestern Louisiana

Until recently, research on Cajun culture was sparse, often speculative and lacking in substance. Early works generally depended on Longfellow's Evangeline: A Tale of Acadie, for historical information, pushing the poem beyond its means. At the turn of this century, Felix Voorhies inadvertently produced another red herring. Scholars mistook his fictional Acadian Reminiscences: The True Story of Evangeline for history. Textbooks used to teach Louisiana history in middle schools contain two paragraphs on the Acadians: one on Longfellow and Evangeline; the other on self-styled "Cajun" humorist Justin Wilson.

The bicentennial of the Acadian exile in 1955 breathed new life into the Evangeline cult. Ironically, it also spurred genuine interest in the history, culture, and language of the Cajuns and Creoles, which would eventually help to put the overworked heroine in her place. Oscar Winzerling's Acadian Odyssey (Baton Rouge, 1955), Lauren Post's Cajun Sketches (Baton Rouge, 1962), and Naomi Griffiths' The Acadians: Creation of a People (New York, 1973) were among the first well-documented and carefully researched studies to appear on the subject. The creation in 1968 of the Council for the Development of French Louisiana (CODOFIL) added fuel to the flowing interest in discovering the truth about the state's French heritage.

In 1973, the University of Southwestern Louisiana addressed this issue directly with the creation of its Center for Louisiana History. A year later, the university followed with the creation of the Center for Acadian and Creole Folklore. The goal of these centers was to develop an archive of information, which would serve as the basis for research. The Center for Louisiana Studies developed collections of photographs, manuscripts, maps, and microfilm. Its Colonial Records Collection includes well over a million pages of microfilmed documents from the French and Spanish periods. The Center for Acadian and Creole Folklore acquired copies of field recordings, including the Saucier collection (1920s), the Lomax collection (1930s), the Owens collections (1940s), the Brandon collection (1950s), and the Oster and Rinzler collections (1960s), in addition to the collections generated by staff and students since its creation (1970s and 1980s).

Others also developed research efforts in response to the growing need for information. For example, Louisiana State University's Department of Geography and Anthropology produced landmark research on traditional architecture and material culture. Nicholls State University created an Acadian Studies Center. Glen Pitre's Cote Blanche Production produces not only films such as Fievre Jaune, Huit Piastres et demie, and Belizaire, but also major research projects such as an oral history of Terrebonne Parish and a radio series of Cajun and Creole tales and legends.

For the first time, researchers have available not only a wealth of information, but also a spread of information that reflects developments and changes over a substantial period of time. In addition, historians, sociologists, folklorists, linguists, and ethnomusicologists found themselves working in close quarters, in which an interdisciplinary approach was not only available, but difficult to avoid. The main benefit of this was the addition of a historical perspective to culture and a cultural perspective to history. Research projects that have been made possible by the systematic acquisition of research materials include colonial settlement patterns, the development of Acadian and Cajun identities, the Americanization of French Louisiana, the origins and development of Cajun music and zydeco, Louisiana French language and oral tradition, and the impact of the oil industry on Cajun and Creole cultures, among others. Researchers in these and other areas are giving papers at regional, national, and international meetings, and writing articles and books to fix this information and put it in consumable form. Some have also produced versions for popular consumption to reach beyond the academic community. New courses based on this material are generating even more information by giving students the opportunity to do original research in the area.

Some of the most exciting opportunities for research in this area have recently been provided by the National Park Service through its newly created Jean Lafitte National Historical Park. In addition to preserving natural resources such as alluvial swamps and coastal marshes, Jean Lafitte is intended to address people and their cultural resources in its designated Mississippi Delta Region. The National Park Service worked with the Louisiana Folklife Program of the state's Department of Culture, Recreation and Tourism, to produce an initial ethnographic overview of the region. Under the direct of Nicholas Spitzer, much of this information eventually found its way into Louisiana Folklife: A Guide to the State. Spitzer also produced a substantial report on Louisiana's Black French Creole culture for the National Park Service. Research commissioned for the development of three Acadian culture centers (to be located in Lafayette, Eunice, and Thibodaux) resulted in a five-volume report (totalling more than 2,000 pages) by a team of ten researchers, easily the broadest and largest collection of information the Cajuns assembled.

Ironically, despite the existence since 1968 of a Council for the Development of French in Louisiana, the most underdeveloped area of research on the Cajun and Creoles is still linguistics. During the 1930s, '40s, and into the early '50s, several graduate students produced theses and dissertations on the varieties of Louisiana French. However, no effective effort has yet been made to bring this information together in a systematic research project on the language(s) of the Cajuns and Creoles. Progress on this important linguistic front would be an important complement to work in cultural and historical areas.

In addition to the centralization of research materials, institutional support, systematic efforts, and the publication of information, researchers in Cajun and Creole history and culture have broadened the scope of their work through contacts with interested American institutions such as the Smithsonian Institution's Folklife Program, the National Endowment for the Art's Folk Arts Program, the Library of Congress's American Folklife Center, and the National Council for the Traditional Arts, and especially with other areas of the francophone world in Canada, Europe, Africa, and the Caribbean. Before, for many reasons, outsiders interpreted the Cajuns and Creoles (often erroneously) for themselves and the rest of the world. Now the future holds much opportunity for us to discover and describe our own history and culture. We now have access to many of the pieces, and we have already begun to find where they fit.

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Socio-economic Impacts of Offshore Oil and Gas Activities on the Gulf Coast

Dr. Robert Gramling
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This presentation arises out of information gathered through three major grants, which examined the impacts of offshore energy on the Gulf Coast (Stallings, et al., 1977; Gramling, 1980; Gramling and Brabant, 1984) and subsequent additions to, and further analysis of, that information, which has, to date, appeared in several sources (Gramling and Brabant, 1986; Gramling and Forsyth, 1987). The presentation deals more with the erroneous assumptions concerning the impacts of offshore energy production than it does with the actual impacts.

The traditional model for what has come to be called Social Impact Assessment came out of energy development in the western U.S. and is embodied in the "Boomtown" literature. Because the transportation of electrical power is much cheaper than the transportation of the coal necessary to generate that power, simple economic necessity dictates that coal-fired generated plants be located near supplies of coal. Construction of these plants in the western United States in the 1960s and 1970s involved extensive relocation of individuals (and their families) involved in the construction. The small rural towns in the vicinity of the construction became centers for resettlement, and the extremely rapid population growth quickly became problematic. Schools, housing, medical facilities, social services, police departments, water, and sewage treatment facilities, were soon inadequate (Albrecht, 1978; Bates, 1978; Cortese and Jones, 1977; Gilmore, 1976). Property values and prices rose, negatively affecting those on fixed incomes (Cortese and Jones, 1977). The influx of newcomers with different ideas and lifestyles caused conflict and disrupted community folkways (Bates, et al., 1978; Lillydahl, 1982). The results of this rapid change supposedly were a pathology that evidenced itself in increased crime, mental illness, alcoholism, increased divorce rates, etc. In short, in spite of arguments that the boomtown scenario is simply an adjustment to change and indicative of a healthy economy, boomtown growth generally has a very negative image. In fact, Pribble (1984) has argued that construction of remote communities is a desirable alternative to descending on existing ones, although Storey and Shrimpton (1986) have noted the problems with this option. This image is exacerbated by the fact that about the time adjustments to the new population levels are underway, the construction project is completed, and the newly acquired residents move away, triggering an equally catastrophic bust.

I would argue, and have argued (Gramling and Brabant, 1986), that this model is not an appropriate one for the analysis of the impacts of offshore oil and gas activities. In contrast to the more geographically specific types of development (a generating plant is built, a mine is opened, etc.), the mobility associated with offshore energy exploration and development leads to diffused, as opposed to concentrated, social and economic impacts. This mobility is evidenced in four basic areas. First, the development itself is highly mobile. Offshore drilling rigs can be, and frequently are, moved to virtually any coastal area in the world. It is the drilling and completion of offshore wells that led to growth in employment. Once the wells are tied into pipeline networks, the actual production of petroleum products provides much less employment and only at centrally located refineries. Thus, the basic economic activity upon which development hinges is a highly mobile phenomenon. Additionally, the primary support sectors must also shift the concentration and delivery pattern of their products to follow development. What this means is that employment in the primary sectors of offshore energy production (drilling, drilling supplies, transportation) is not a geographically stable phenomenon. Given this, two solutions to supplying the labor needs of offshore activities emerge: first, new employment could occur as the rig moves to each new location. Second, employees could follow the rig or commute. While both patterns occur, the second is more common both because of the structure of offshore employment and because of employer preferences.

Since offshore workers reside at their place of employment for extended periods of time, as do many primary support employees, particularly those involved in water and air transportation, they can commute infrequently. A 14-day on and 14-day off schedule means that only one round trip between work and home is necessary every 28 days. This allows place of residence and place of employment to be separated by considerable distance. Thus, the second basic way the offshore industry is characterized by mobility is the extreme mobility of its labor force. Gramling (1980:96), in a survey of the labor force of east St. Mary Parish (county), one of the most heavily impacted areas in the world by offshore activities, found that approximately 70 percent of the offshore workers surveyed lived over 100 miles from where they met in East St. Mary Parish to go offshore. By extending the work shifts, these offshore employees can be employed virtually anywhere. Thirty days on and 30 days off was quite common with the development in Alaska, and 90 on and 90 off was common with initial development in the North Sea. Thus, the physical and social factors necessary to support offshore exploration and development have resulted in a system that, if necessary, can operate virtually independently of the geographic area where the activity occurs.

A third factor in the mobility of the offshore energy production industry is the transportability of many of the products that the industry buys. While the transportation of products is characteristic of much industrial development with the exception of the shipping industry, rarely are the construction projects associated with that development transportable.

Three types of construction projects are commonly purchased and transported by sectors associated with offshore energy production: drilling rigs of various types, production facilities (jackets, platforms), and support vessels. Since these products must be constructed on land and transported to a site offshore, they are inherently mobile. This means that they can be produced in any coastal region in the world. Thus, the construction or fabrication associated with offshore development does not necessarily have to occur in the vicinity of that development. While extensive local fabrication has been associated with offshore development in the northern Gulf of Mexico, particularly Louisiana, this occurred because of the history of that development. In the early days of offshore exploration, Louisiana was the primary area of offshore activity in the world. As activities moved farther and farther offshore into new environments, this required modification and redesign of existing equipment. Because the need was local and for local conditions, this allowed the development of a strong fabrication and shipbuilding sector of the economy with little competition from a world market. Recently, however, areas of the world with much lower labor cost have become extremely competitive in the production of offshore drilling rigs, platforms, and vessels, and this trend will undoubtedly continue for the foreseeable future.

Finally, the products themselves, oil and gas, are also very mobile. With rare exceptions, production platforms are tied directly into pipeline networks, and the products are brought ashore via pipeline. As pipelines can be run practically anywhere, secondary treatment, refining, scrubbing, etc., can also take place far from the actual recovery activities. The exception to this, offloading directly to tankers, provides an even more mobile alternative.

Taken all together, what these factors mean is that the effects of offshore oil and gas, both positive and negative, are distributed widely throughout the Gulf Coast, the South, and, indeed, the continental United States, rather than being neatly concentrated for easy analysis. Thus, if we wish to understand the impacts of offshore oil and gas activities, we must focus on a much broader picture than the Boomtown or Community Impact model allows.

In our research for models that allow an analysis of larger geographic units, I would note one particularly tempting (because it is relatively easy) alternative which, although often proposed, I do not believe is appropriate: namely, the input/output model. I believe the input/output model is inappropriate for two reasons. First, although the models have an almost overwhelming impressiveness brought about by their detailed information, the data upon which the models are based (at least at the regional level) are often quite crude. Thus, the models have a deceptive validity. Second, input/output models trace the movement of money. Any attempts to translate purely economic variables into social or cultural ones are based on assumptions that lie outside the input/output model. These detailed, potentially inaccurate, purely economic data have in the past proven to be of little help either to those who must try to assess the social and cultural effects of an activity, or to those who must try to plan for future ones. I would argue for a much more diverse approach (social, cultural, and economic). The U.S. Department of Interior RFP No. 3335 (1986) is a start in this direction.

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Dr. Robert Gramling is a Professor of Sociology at the University of Southwestern Louisiana. Dr. Gramling's principal research interests include socioeconomic impact assessment, microsociology,and the sociology of marriage and the family. His publications include East St. Mary Parish, Economic Growth and Stabilization Strategies (1980), The Role of Outer Continental Shelf Oil and Gas Activities in the Growth and Modification of Louisiana's Central Zone (1984, with Sarah Brabant), Outer Continental Shelf Impacts, Morgan City, Louisiana (1977, with E.F. Stallings, T.F. Reilly, and Dave Manuel), "Boomtowns and Offshore Energy Impact Assessment: The Development of a Comprehensive Model" (1986, with Sarah Brabant), and "Work Scheduling and Family Interaction: A Theoretical Perspective" (1987, with Craig Forsyth). Dr. Gramling holds a B.A., M.A., and Ph.D. degrees from Florida State University.

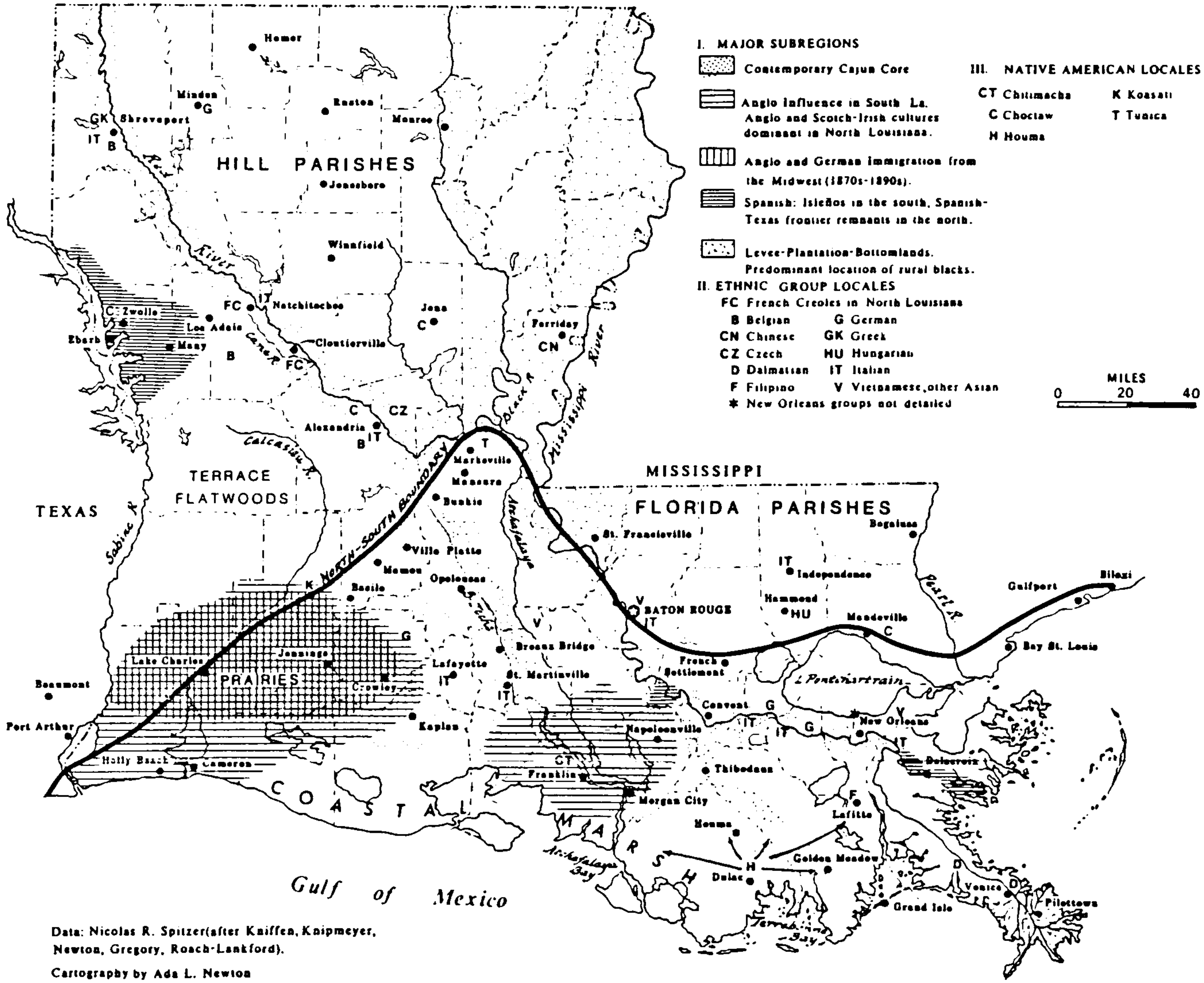

Figure 10.1.--Louisiana folk regions.

Table 10.1.

Undocumented Central American Groups in Houston

GROUP	CHARACTERISTICS
Salvadorans	Urban/rural origin; Spanish language
Guatemalan	
Hispanic	Urban origin; Spanish language
Indigena	Rural origin; Spanish and indigenous languages
Honduran	
Hispanic	Urban origin; Spanish language
Garifuna	Urban/rural origin; Spanish and Garifuna languages

Table 10.2.
Age, Education, and Marital Status

	Guatemalan	Honduran	Salvadoran	Other	TOTAL	%
Age						
18-29	18	14	47	3	82	54.7
30-39	9	14	23	6	52	34.7
40-above	1	3	10	2	16	10.7
					150	100.1
Marital Status						
Single	14	12	32	5	63	42.0
Married	13	17	40	6	76	50.7
Divorced or Widow	1	2	8	-	11	7.3
					150	100.0

Table 10.3.
Reasons for Migrating

	Guatemalan		Honduran		Salvadoran		Other	
	No.	%	No.	%	No.	%	No.	%
Economic	17	60.7	25	80.6	24	30.4	4	36.4
Political Conflict	4	14.3	3	9.7	29	36.7	7	63.6
Economic & Political Conflict	2	7.1	-	-	5	6.3	-	-
Family Unification	4	14.3	1	3.2	13	16.5	-	-
Adventure	-	-	2	6.5	3	3.8	-	-
No Response	1	3.6	-	-	5	6.3	-	-
TOTAL	28	100.0	31	100.0	79	100.0	11	100.0

MARINE MINERAL RESOURCES IN THE GULF OF MEXICO

Session: MARINE MINERAL RESOURCES IN THE GULF OF MEXICO

Co-Chairs: Mr. John B. Smith
Dr. Chacko J. John

Date: December 3, 1987

Presentation	Author/Affiliation
Marine Mineral Resources in the Gulf of Mexico: Session Overview	Mr. John B. Smith Minerals Management Service Office of Strategic and International Minerals and Dr. Chacko J. John Louisiana Geological Survey
Joint Federal/State Task Force Studies of Marine Minerals in the Gulf of Mexico	Mr. John B. Smith Minerals Management Service Office of Strategic and International Minerals
Louisiana Nearshore Sand Resource Inventory	Dr. John R. Suter and Mr. Shea Penland Louisiana Geological Survey Coastal Geology Program
Assessment of Nonenergy Mineral Potential in Offshore Alabama: Phase I, Analysis of Available Geophysical and Bottom Sample Data	Mr. Bennett L. Bearden, Mr. William E. Smith, and Mr. Berry H. Tew Geological Survey of Alabama
Preliminary Assessment of Nonenergy Mineral Resources Offshore Mississippi	Ms. Robin Cranton and Dr. J. Robert Woolsey Mississippi Mineral Resources Institute
Preliminary Assessment of Non-Fuel Mineral Resources of the Texas Continental Shelf	Dr. Robert A. Morton and Mr. William A. White The University of Texas at Austin Bureau of Economic Geology
Outlook for Offshore Shell Dredging	Mr. Robert D. Palmore Dravo Basic Materials Co., Inc.
Incentives for Deep Ocean Mining	Mr. John G. O'Hara Offshore Mining Company

Session: MARINE MINERAL RESOURCES IN THE GULF OF MEXICO (cont'd)

Presentation Title	Author/Affiliation
History of the Beach Nourishment Project, Grand Isle, Louisiana	Mr. Adrian J. Combe, III U.S. Army Corps of Engineers New Orleans District
The Outlook for Offshore Heavy Minerals Resources	Mr. Mark S. Whitney Associated Minerals (USA), Inc.

Marine Mineral Resources in the Gulf of Mexico: Session Overview

Mr. John B. Smith
Minerals Management Service
Office of Strategic and
International Minerals
and
Dr. Chacko J. John
Louisiana Geological Survey

On December 31, 1986, Secretary of the Interior Donald P. Hodel and the Governors of Alabama, Louisiana, Mississippi, and Texas announced an agreement to establish a joint Federal/State task force to study the occurrence, location, and economic feasibility of developing marine mineral resources offshore those states. This Gulf Task Force (GTF) is jointly co-chaired by representatives from the MMS, the Alabama Geological Survey, the Louisiana Geological Survey, the Mississippi Mineral Resources Institute, and the Texas Bureau of Economic Geology.

The GTF is currently conducting an economic reconnaissance study to identify mineral commodities and geographic areas of potential commercial interest. The economic reconnaissance study is scheduled to be completed by October 1988 and its findings presented at the 1988 Gulf of Mexico ITM. The Marine Minerals Session of the 1987 ITM provided an opportunity for GTF members to review the status of the economic reconnaissance study and to disseminate information regarding the preliminary findings of the GTF to the general public, industry representatives, academia, and other interested parties. The agenda for the session included presentations by 10 speakers representing various Federal, State, academic, and private industry groups.

The Marine Minerals Session began with a presentation by Mr. John B. Smith of the MMS's Office of Strategic and International Minerals (OSIM), who, along with Dr. Chacko John of the Louisiana Geological Survey, co-chaired the session. Mr. Smith reviewed the role of OSIM and the purpose of the GTF. He stated that OSIM was established in 1983 to develop a leasing and regulatory program for administering marine minerals exploration and development on the Outer Continental Shelf/Exclusive Economic Zone (OCS/EEZ) under the authority provided by the OCS Lands Act. He emphasized that MMS/OSIM is working closely with the coastal states in developing a marine minerals leasing program for the OCS/EEZ. This is being accomplished through joint Federal/State task forces that have been established to facilitate cooperative investigations of marine minerals located within the territorial sea and on Federal submerged lands.

Mr. Smith reported that the economic reconnaissance study being conducted by the GTF will involve the compilation and synthesis of existing data to make preliminary evaluations of the occurrence, location, and economic feasibility of developing marine mineral resources in the Gulf. Such data will include high resolution seismic reflection profiles, side-scan sonar records, surface sediment samples, gravity cores, vibracores, and soil borings. He stated that the scope of the study is restricted to an assessment of the offshore area, extending from the shoreline to the 200-meter water depth contour level. Resources of interest to the study include sand and gravel, heavy minerals, and shell.

Following Mr. Smith's presentation, Dr. John Suter (Louisiana Geological Survey), Mr. Bennett Bearden (Alabama

Geological Survey), Dr. Robert Morton (Texas Bureau of Economic Geology), Ms. Robin Cranton, and Dr. Robert Woolsey (Mississippi Mineral Resources Institute) presented overviews of relevant technical information currently available in each of their respective states. Dr. Suter discussed the serious coastal erosion and landloss problems being experienced in Louisiana and the State's reconnaissance efforts to investigate the utilization of offshore sand deposits for possible beach nourishment projects. Other speakers focused on information sources on marine minerals located offshore their respective states, the methodology being used to identify minerals of potentially commercial interest, and the quality of the data base.

Speakers from industry included Mr. Don Palmore from Dravo Basic Materials Company, Mr. John O'Hara from Offshore Mining Company, and Mr. Mark Whitney from the Associated Minerals Company. They encouraged federally sponsored mineral investigations and environmental baseline studies of marine minerals, particularly field-oriented studies that involve mapping and sampling programs.

In discussing hurdles to marine mining, Mr. O'Hara expressed the opinion that a legal framework was lacking, both internationally and domestically, that encouraged investment in the development of "deep seabed" mineral resources. Several industry speakers also emphasized that the absence of rules and regulations for marine mining was a major deterrent to exploration and development on Federal submerged lands.

Several industry speakers also stated that environmental problems were a major concern, particularly the permitting requirements of State and Federal regulatory agencies. All of the industry representatives felt that there should be more dialogue, communication, and coordination between Federal and State agencies and industry. They were hopeful that the joint Federal/State task force approach would provide an effective mechanism for such coordination.

Mr. Whitney discussed Associated Minerals' experience in exploring for offshore heavy mineral resources and identified specific topics requiring further research. He concluded by stating that his company was optimistic about offshore minerals, but emphasized that much more work is required to better understand the commercial potential of the resources.

Mr. Adrian Combe of the U.S. Army Corps of Engineers described the history of the beach nourishment project at Grand Isle, Louisiana. This project involved dredging 5.5 million cubic yards of material from two offshore borrow pits during 1983 and 1984. In his presentation, he discussed erosion problems that resulted from several large storms in 1985 and presented recommendations for restoration of the project.

Mr. John B. Smith is a geologist with the MMS, Office of Strategic and International Minerals (OSIM) in Long Beach, California. He holds a B.S. degree in geology and obtained his M.S. degree in mineral economics from Pennsylvania State University. He was employed as a geologist and mineral economist with the Department of the Interior's Bureau of Mines from 1976 to 1984. In 1984, he joined the staff of the newly established OSIM. Mr. Smith presently serves as Department of the Interior Co-chairman of the Joint Federal/State Gorda Ridge Technical Task Force and the Gulf of Mexico Task Force.

Dr. Chacko J. John received his B.Sc. and M.Sc. degrees in geology from the University of Nagpur, India, in 1966 and 1968, respectively. He then worked as an Instructor in Geology at the University of Kerala in Trivandrum, India, and as Geologist-in-charge of English India Clay Mines, also located at Trivandrum, India. He later attended the University of Delaware at Newark, Delaware, and obtained his M.S. and Ph.D. degrees in geology. Prior to joining the Louisiana Geological Survey in April 1987, where he serves as Research Associate and Project Coordinator for the Gulf Coast Task Force on the Exclusive Economic Zone Project, Dr. John worked as advanced geologist with Marathon Oil Company at Lafayette and Houston for six years in development and exploration. He is a member of numerous professional organizations and has a number of publications to his credit.

Joint Federal/State Task Force Studies of Marine Minerals in the Gulf of Mexico

Mr. John B. Smith
Minerals Management Service
Office of Strategic and
International Minerals

The Office of Strategic and International Minerals (OSIM) of the Minerals Management Service (MMS) was established in 1983 to develop a leasing and regulatory program for administering marine mineral exploration and development on the Outer Continental Shelf/Exclusive Economic Zone (OCS/EEZ). The OSIM is working closely with the coastal states in developing a marine minerals leasing program for the OCS/EEZ. This is being accomplished through Federal/State task forces that have been established to facilitate cooperative studies of marine minerals located within the territorial sea and on federal submerged lands.

On December 31, 1986, the Secretary of the Department of the Interior (DOI) and the Governors of Alabama, Louisiana, Mississippi and Texas announced an agreement to form a joint federal/state task force to study potential deposits of marine minerals located offshore those states. This task force, hereafter referred to as the Gulf Task Force (GTF), was charged with the responsibility of studying the occurrence, location, and economic feasibility of developing these resources. The GTF is jointly co-chaired by the MMS, the Alabama Geological Survey, the Louisiana Geological Survey (LGS), Mississippi Mineral Resources Institute, and the Texas Bureau of Economic Geology.

The GTF is currently conducting an economic reconnaissance study to identify mineral commodities and geographic areas of potential commercial interest. The economic reconnaissance study is scheduled to be completed by October of 1988 and its findings presented at the 1988 Gulf of Mexico Information Transfer Meeting (ITM). The study is being primarily funded by the MMS through a cooperative agreement with the LGS. The states are also making significant contributions by providing services, and funding the salaries of technical personnel conducting the investigation.

The tasks to be conducted under the cooperative agreement include the preparation of an economic reconnaissance study of marine minerals in the Gulf, the planning of sessions at the 1987 and 1988 ITM meetings, and the preparation of a letter report containing recommendations for the Secretary of DOI and the governors. This project will be carried out with the LGS as the prime contractor and involve the participation of the Alabama Geological Survey, Mississippi Mineral Resources Institute and Texas Bureau of Economic Geology. Each of these agencies will be subcontractors to LGS and will be responsible for conducting an economic reconnaissance of marine minerals offshore their states. The LGS will be responsible for conducting an economic reconnaissance of marine minerals offshore Louisiana, coordinating the efforts of the other GTF members, planning the ITM sessions, and preparing a final economic reconnaissance study that incorporates the results of studies conducted by other members of the GTF. Recommendations regarding the leasing and development potential of marine mineral resources in the Gulf will be prepared jointly by all members of the GTF and submitted to the Secretary of DOI and the governors by letter report.

The study will begin with an inventory of data on offshore mineral resources. This inventory will involve literature surveys and an examination of existing databases on offshore mineral resources. Such data is expected to include high-resolution, seismic reflection profiles; side-scan sonar records; surface sediment samples; gravity cores; vibracores; and soil borings. Sources of data to be inventoried include those held by federal, state, university, and industrial sources. Based on the results of this inventory, areas perceived to have economically valuable mineral deposits will be selected. Preliminary resource assessment and market analyses are then to be performed on those areas believed to have the greatest potential for near-term development. In those areas where the quality of data is insufficient to conduct resource assessment and market analyses, recommendations are to be made regarding the nature and extent of additional data necessary for an adequate assessment. Additionally, technologies and methodologies necessary for gathering the needed information are to be identified.

The GTF will prepare a letter report to the Secretary of DOI and the governors summarizing the results of the economic reconnaissance study and providing advice regarding the leasing and development potential of the resources, the adequacy of the existing database for conducting economic evaluations, and follow-up studies that may be needed to determine economic potential or support preparation of an environmental document for a potential mineral lease sale. The economic reconnaissance study and letter report are scheduled to be completed by late-fall of 1988.

Mr. John B. Smith is a geologist with the Minerals Management Service's Office of Strategic and International Minerals in Long Beach, California. He holds a B.S. degree in geology and obtained his M.S. degree in Mineral Economics from the Pennsylvania State University. He was employed as a geologist and mineral economist with the Department of Interior's Bureau of Mines from 1976-1984. In 1984 he joined the staff of the newly established Office of Strategic and International Minerals. Mr. Smith presently serves as Department of the Interior Co-chairman of the joint Federal/State Gorda Ridge Technical Task Force and the Gulf of Mexico Task Force.

Louisiana Nearshore Sand Resource Inventory

Dr. John R. Suter
and
Mr. Shea Penland
Louisiana Geological Survey
Coastal Geology Program

The state of Louisiana is currently experiencing the most critical coastal erosion and land loss problem in the United States. Shoreline erosion rates exceed 6 meters per year in more than 80 percent of Louisiana's coastal zone, and can be up to 50 meters per year in areas impacted by hurricanes. Land loss from coastal marshlands and ridgelands, resulting from both natural and human induced processes, is accelerating and now exceeds 100 km^2/year. Louisiana's barrier islands have decreased in area from 105 km^2 (1880) to 64 km^2 (1979), a total reduction of 40 percent in area. Decreased delivery of sediments resulting from stabilization of the Mississippi River and activities related to hydrocarbon exploration, coupled with natural processes such as compactional subsidence and salt water intrusion, have produced the current coastal erosion and land loss problem. In response to this condition, Act 41 of the 1981 Extraordinary Session of the Louisiana Legislature created the Coastal Environment Protection Trust Fund. The Coastal Protection Master Plan, developed by the Louisiana Geological Survey to implement this mandate, was approved in 1985. Phase I of the Master Plan calls for restoration of the eroding barrier shorelines, while Phase II consists of beach nourishments, using sand dredged from the Gulf.

The large sand requirements for these projects can be met cost-effectively only if sand can be found offshore in sufficient quantities. To locate sand for beach nourishment and restoration projects, the Coastal Geology Program of the Louisiana Geological Survey is conducting a statewide nearshore and resource inventory of the Louisiana continental shelf.

Data acquisition for sand body mapping is conducted in two phases. High resolution seismic reflection profiles are collected in grids varying from 6 km by 6 km to 1 km by 1 km. Analysis of reflection character within major units permits the interpretation of lithology and identification of sand resource targets. Coarser grid spacings are suitable for reconnaissance work and regional geologic mapping while more closely spaced data are needed for detailed mapping of potential borrow sites. To date in this ongoing project, approximately 10,000 line km of profiles have been acquired, utilizing both ORE Geopulse and Datasonics 3.5 kHz subbottom profiler systems. These devices provide good resolution and penetration in shallow waters, although seismic response and data quality are primarily dependent upon sea floor geology and sea state conditions.

Interpretations of the seismic lines, coupled with analysis of current and historical shoreline geomorphology, provide the targets for vibracores. Cores are taken to confirm seismic interpretations and provide samples for grain size analysis to determine textural suitability of offshore sands as borrow material. To date, over 300 vibracores exceeding 10 m in length have been taken on the Louisiana continental shelf.

The original Act 41 program called for three pilot beach nourishment projects at sites representing different types of coastal environments: (1) Holly-Peveto Beach (Chenier Plain), (2) eastern Isles

Dernieres (barrier island arc), and (3) Chenier Ronquille (deltaic headland). Preliminary results of investigations indicate that suitable sand is present in each area: buried fluvial channels near Holly-Peveto Beach, submerged beach ridges, distributaries, and tidal deltas near the Isles Dernieres, and buried distributaries and tidal deltas near Chenier Ronquille.

Current statewide reconnaissance efforts indicate that significant quantities of sand are available, primarily in the form of large shoals, such as Ship and Trinity Shoals. These features may each contain as much as one billion m3 of sand. Utilization of these offshore deposits as borrow materials for beach nourishment depends upon the economics of dredging, possible environmental effects of dredging--including alteration of wave refraction and shoreline erosion patterns--and the formulation of leasing guidelines to permit use of sand deposits from Federal waters.

Dr. John R. Suter is a marine geologist and research associate with the Louisiana Geological Survey. He received his B.S. and M.A. degrees in geology from the University of Texas at Austin and the Ph.D. in geology from Louisiana State University. His research concentrates on continental shelf and shoreline deposits in the northern gulf of Mexico. Suter is the author of numerous technical reports and publications and has received several national research awards. He is a member of the American Association of Petroleum Geologists, Geological Society of America, International Association of Sedimentologists, and Society of Economic Paleontologists and Mineralogists.

Mr. Shea Penland is a coastal geologist and research associate with the Louisiana Geological Survey. He received his B.S. in geography from Jacksonville University in Jacksonville, Florida, and M.S. in geography from Louisiana State University. He is currently working on the Ph.D. in geography at Louisiana State University. Penland is the author of numerous publications and technical reports dealing with the geology of the coastline and continental shelf of Louisiana and the Gulf of Mexico and has been the recipient of several national research awards. He is a member of the American Association of Geographers, American Association of Petroleum Geologists, Geological Society of America, International Association of Sedimentologists, and Society of Economic Paleontologists and Mineralogists.

Assessment of Nonenergy Mineral Potential in Offshore Alabama: Phase I, Analysis of Available Geophysical and Bottom Sample Data

Mr. Bennett L. Bearden,
Mr. William E. Smith,
and
Mr. Berry H. Tew
Geological Survey of Alabama

INTRODUCTION

This paper summarizes the progress achieved thus far for an ongoing project supported in part by the U.S. Minerals Management Service (MMS), directed at assessing the occurrence of nonenergy minerals in the offshore area of Alabama. This project consists of separate phases that will address (1) identification and evaluation of available data, (2) collection and evaluation of new data, and (3) study of mining feasibility. The present phase of the study addresses identification and evaluation of available data and preparation of recommendations.

The project is part of a larger program effort sponsored by MMS to assess occurrence, mining feasibility, and economics related to nonenergy minerals in the northern Gulf of Mexico region of Texas, Louisiana, Mississippi, and Alabama.

The study of offshore Alabama will focus attention on areas within state territorial waters and federal waters, including areas out to 200 m depth. Over 9,700 square miles of Gulf bottom and shallow subbottom are subject to investigation, of which about 450 square miles are within Alabama territorial waters. The investigation is directed at assessment of any nonenergy mineral material that may occur in significant quantity and grade (excluding salt and sulfur); anticipated mineral materials are sand, gravel, oyster shell, and heavy mineral sands.

Fine- to medium-grained quartz sand is apparently in good supply in the study area. Thus far, mineral economics have not led to utilization of offshore sand, other than by the U.S. Army Corps of Engineers. Such mining has been done by suction dredge for development and maintenance of the Perdido Pass area near the Alabama-Florida state line.

Oyster shell for use as aggregate and in the preparation of lime and cement has been mined in Alabama water, primarily from Mobile Bay. Evaluation of high resolution seismic data possibly will lead to identification of biostromal and reef deposits in offshore areas.

Heavy mineral sands have not been mined in the Alabama offshore area, but concentrations of heavy minerals including zircon, rutile, ilmenite, hyanite, tourmaline, staurolite, leucoxene, sillimanite, and monazite have been documented along Alabama's barrier shoreline, and limited bottom sampling has suggested occurrence of potential economic deposits of these minerals in the area offshore of Dauphin Island (Drummond, 1976).

EXPLORATION STRATEGY

Although the project allows for collection and compilation of data (such as bottom sampling data) that can lead directly to identification of potential economic grade nonenergy minerals deposits, the preponderance of the data presently available for study consists of geophysical records, which provide indirect evidence of mineral deposits. The primary goal of the current phase of work, therefore, is identification of usable, high-resolution seismic and sidescan sonar data, and a general interpretive study of these records. All this should lead to identification of specific sea bottom and shallow subbottom geomorphic features generally associated with sedimentary depositional environments conducive to accumulation of the previously named minerals.

The currently proposed theory for the development of the offshore Alabama bottom and shallow subbottom terrain suggests late Pleistocene sea level fall ending about 15-18 thousand years BP with concomitant (1) erosion of Mesozoic and Cenozoic Gulf Coastal Plain sediments in continental areas and on the exposed shelf; (2) development of major fluvial systems within incised valleys on the exposed shelf; and (3) progressive seaward (southward) progradation of river delta, estuarine, barrier system, and marine environments across the area extending from the present Alabama coastline to the approximate position of the present continental shelf-slope break. This theory further suggests sea level rise beginning after 15-18 thousand years BP and continuing until the present with concomitant: (4) inundation, partial destruction and modification of previously developed geomorphic features; and (5) progressive landward (northward) retrogradation of fluvial, deltaic, estuarine marine, barrier, and marine shelf environments.

The fluvial systems developed during sea-level fall drained the Alabama and Georgia Appalachian Valley and Ridge, Piedmont, and Coastal Plain areas, and the deposits of these streams consist of sediments derived from erosion of these areas. In general, the Valley and Ridge area is underlain by a sequence of Paleozoic sandstones, shales, and limestones, some of which are chert bearing. The major lithologic contributions from this area to the Pleistocene fluvial deposits include sand, clay, and chert gravel. The Piedmont area consists of metamorphic and igneous rock associations that include many accessory minerals, such as zircon, rutile, ilmenite, monazite, and others, which are common constituents of heavy mineral sands. Additional sediments from this area include sand, clay, and quartzite gravel. The Coastal Plain area consists of poorly consolidated sedimentary rocks which are derived, in part, from the Valley and Ridge and Piedmont terrains. Erosion of this area contributed sand, clay, gravel, and detrital heavy minerals to the Pleistocene fluvial deposits.

Many of the deposits associated with the late Pleistocene sea-level fall have been modified or partially destroyed as a result of subsequent reworking by marine processes associated with the Pleistocene-Holocene sea-level rise. However, preserved, buried, fluvial channels, which potentially contain deposits of sand and gravel, have been identified in the offshore Alabama area. Available data are being evaluated to further delineate these features and identify additional channels.

Subbottom deposits associated with the Pleistocene-Holocene sea-level rise have the potential to contain accumulations of heavy minerals and fossil oyster biostromes or reefs. In addition, the potential exists to identify accumulations of these materials on the present day sea bottom in the Alabama offshore area. The winnowing effect of hydraulic action in higher energy marine environments helps concentrate deposits of heavy minerals reworked from underlying deposits on the seaward sides of barriers, offshore bars, and sand waves. Oyster reefs generally proliferate in sounds, lagoons, and other quiet water environments. Available data are being evaluated to identify these environments and their associated geomorphic features on the sea bottom and in the shallow subbottom of the offshore Alabama area.

IDENTIFIED DATA

Currently identified geophysical data available for analysis include

(1) Fairfield Industries Data Set for OCS Lease Sales 67 and 69 (see (1) on Figure 11.1);
(2) Intersea Research Data Set for OCS Lease Sale 65 (see (2) on Figure 11.1); and
(3) Aquatronics Data Set for OCS Lease Sale 32 (see (3) on Figure 11.1).

Nonproprietary, high-resolution geophysical data identified to date and listed numerically above include numerous line miles of stacked (6-fold or 600 percent), seismic reflection data; sparker sections (12/30 kJ); mini-sleeve, exploder, medial, seismic sections; subbottom profiles (3.5 kHz); fathometer records (41 kHz); relative amplitude sections; velocity plots (RMS and interval); and sidescan sonar records (100 kHz). In general, data quality and line spacing is sufficient for identification of sea bottom and shallow subbottom features that have potential to be associated with accumulations of the previously discussed mineral materials.

The authors make the following recommendations regarding subsequent phases of the offshore Alabama mineral potential assessment project:

1) continued identification, acquisition, and evaluation of available geological and geophysical data for the study area;
2) systematic bottom sampling of selected areas determined by evaluation of geological and geophysical data to have potential for mineral deposits;
3) systematic coring of selected subbottom features determined by evaluation of geological and geophysical data to possess potential for mineral deposits;
4) further sampling and coring of areas and features determined by analyses of data acquired from (2) and (3) above to contain potentially economic mineral deposits for the purpose of delineating areal extent and thickness of the deposits; and
5) study of mining economics and feasibility of identified mineral deposits.

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Mr. Bennett L. Bearden is a geophysicist with the Geological Survey of Alabama. He received his B.S. degree in geology and M.S. degree from the University of Alabama. His research focuses on geophysical mapping of the deep Jurassic strata of offshore Alabama. He is the author of numerous publications and is a member of the Society of Exploration Geophysicists, the American Geophysical Union, Sigma Xi, and the American Association of Petroleum Geologists.

Mr. William E. Smith is a geologist with the Geological Survey of Alabama. He holds B.S. and M.S. degrees in geology from the University of Alabama. Fields of work include mineral resource and mineral deposit assessment, mineral exploration and coastal geology and geomorphology.

Mr. Berry H. Tew is a geologist in the Mineral Resources Division of the geological Survey of Alabama. He holds a B.A. degree and a B.S. degree in geology, both from the University of Alabama. Tew has completed course work for a M.S. degree in geology and is currently completing his thesis toward this degree. Tew is involved in various areas of research at the survey. These include mineral resources assessment of the Appalachian Valley and Ridge and Gulf Coastal Plain areas, Gulf Coastal Plain stratigraphy, and Mesozoic and Cenozoic sea-level changes, and the effects of such changes on stratigraphy and sedimentation in the Gulf area. This research has led to several publications and is ongoing. Tew is a member of the American Association of Petroleum Geologists.

Preliminary Assessment of Nonenergy Mineral Resources Offshore Mississippi

Ms. Robin Cranton
and
Dr. J. Robert Woolsey
Mississippi Mineral
Resources Institute

On November 5, 1987, the Mississippi Mineral Resources Institute (MMRI) entered into a contract with the Louisiana Geological Survey whereby the MMRI was charged with the responsibility of assessing the occurrence and distribution on nonenergy minerals of the Exclusive Economic Zone (EEZ) offshore Mississippi. This work is being done as part of a joint effort by the states of Mississippi, Alabama, Louisiana, and Texas to study potential marine mineral deposits of the northwest Gulf of Mexico. The purpose of the study is to provide the Minerals Management Service (MMS) with data useful in selecting areas for future mineral lease sales. The MMRI contract is restricted to that part of the EEZ extending from the Mississippi shoreline to the 200-meter bathymetric contour and concentrates on nonenergy resources including sand, gravel, shell, and heavy minerals.

The first phase of the study has begun and consists of the compilation of a bibliography of literature and data sets available from various state and federal agencies as well as from private industry. While this phase is currently ongoing, information collected to date has allowed for a preliminary examination of those resources available offshore Mississippi.

A number of general scientific studies have been conducted within the study area, especially within the confines of the Mississippi Sound. In 1980, the Mississippi-Alabama Sea Grant Consortium initiated a program that involved reconnaissance subbottom profiling of Mobile Bay, Alabama; Mississippi Sound; and Lake Borgne, Louisiana. Eighty-five miles of high resolution seismic profiles were obtained through the cooperation of the University of Alabama, Birmingham, and the University of Mississippi. Examination of data led to the subsequent procurement of approximately forty vibracores from within the area. These data have provided the basis for a number of master's degree theses, which include sedimentologic analyses, clay mineral distribution studies, reconstructions of depositional environments, trace metal geochemistry studies, and microfauna studies.

In 1981, this small database was expanded through the efforts of the MMRI, in cooperation with the U.S. Geological Survey (Corpus Christi, Texas) and the Department of Geology, the University of Southern Mississippi. Subbottom profile tracks were run both landward and seaward of the barrier islands. Vibrocores and water-lift samples were also obtained to supplement these seismic profiles. These data have been examined in heavy mineral reconnaissance surveys.

Less information is available concerning resources of the EEZ in front of the barrier islands. While we know some geophysical surveys have been made by the MMS, the National Oceanographic and Atmospheric Administration, Lamont-Doherty Geological Observatory, the U.S. Navy and the U.S. Geological Survey, little has been published concerning the potential for economic mineral deposits.

The MMRI is in the process of locating all available records for use in the evaluation of nonenergy resources offshore Mississippi and has made only a preliminary assessment of the quality of the database and the information it provides. To date, only the following conclusions have been made concerning the occurrence of nonenergy resources offshore Mississippi.

HEAVY MINERALS

Heavy minerals are known to exist in appreciable quantities in the Mississippi Sound and offshore region. At least twenty-six mineral species have been identified, occurring in two distinct suites or provinces. The Eastern Province, as defined by VanAndel (1960), is typically composed of ilmenite, yanite, staurolite, zircon, and tourmaline. These minerals are thought to be derived from the Cretaceous and younger sediments of the Appalachians. The Western Province, composed chiefly of pyroxenes and amphiboles, as well as epidote, ilmenite, and biotite, is believed to be derived from the drainage basin of the Mississippi River. Of these two suites, those minerals containing oxides of titanium, including rutile and ilmenite, zircon, and the rare-earth bearing phosphates of monazite and xenotime, are of interest economically and occur in high concentrations in laminae along the storm berms and dunes of the barrier islands. These deposits, however, are not available for commercial exploitation due to their protection within the Gulf Islands National Seashore. Vibracores obtained from the vicinity of the islands and then analyzed for heavy mineral content suggest that economic deposits may be present farther offshore in ancient fluvial deposits. Analysis of seismic profiles from around the islands also suggests the presence of earlier barrier platforms and cut-and-fill structures, which should be studied for possible heavy mineral accumulation (Simonson and Meyland, 1983). Particular emphasis should be placed on studying the sediments immediately surrounding and seaward of eastern-most Petit Bois Island (as well as Dauphin Island, Alabama), as this area has the greatest potential for accumulation of economically attractive heavy minerals.

SHELL

Commercial shell dredging has been an economically important industry for the state of Mississippi since the early 1950's. Between the years of 1951 and 1973, 4,510,031 cubic yards of reef shell were produced primarily from the western part of Mississippi Sound, providing over $900,000 in revenues for the state (Demoran, 1979). While there is currently no shell being dredged in Mississippi waters or in federal waters off the state of Mississippi, a 1979 study by William Demoran of the Gulf Coast Research Laboratory identified four exploitable reef areas within Mississippi Sound that have the potential of providing 1,870,396 cubic yards of shell. At 1979 prices, this represents a value of $13,092,772 (Demoran, 1979). These potential resources have not been disturbed since the time of that study (Demoran, personal communication, 1987); therefore, these resources are still considered to be a viable commercial resource.

SAND AND GRAVEL

Little information is currently available concerning the presence of economic sand and gravel deposits offshore Mississippi. Simonson and Meylan (1983) recognized several well defined cut-and-fill structures in high resolution seismic records from around the barrier islands. Ground truth data, however, are lacking to substantiate these findings. These authors suggest that a comprehensive coring program would provide the information necessary for assessment of these offshore resources.

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Ms. Robin Cranton is presently employed as an environmental geologist with the Mississippi Mineral Resources Institute. Over the past four years, she has principally been involved with the State's nuclear waste management program, specifically researching geological and environmental concerns related to the development of a high level nuclear waste repository in Mississippi. She has also been involved with MMRI's offshore program, which involves exploration and evaluation of shallow marine mineral deposits as well as the development of technology required for mining these deposits.

Dr. J. Robert Woolsey is a mining geologist with principal experience in the exploration and evaluation of shallow marine mineral deposits. His background includes work with the United Nations and private industry in North and South America, Europe, Africa, and Southeast Asia, involving both industrial and precious minerals. Dr. Woolsey presently serves as Director of the Mississippi Mineral Resources Institute, which devotes a portion of its time to offshore contracts and the development of innovative marine mineral exploration and sampling equipment.

Preliminary Assessment of Non-Fuel Mineral Resources of the Texas Continental Shelf

Dr. Robert A. Morton
and
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Bureau of Economic Geology

Non-fuel mineral resources of the Gulf of Mexico are being investigated to determine their economic value and potential for stimulating leasing of federal tracts as oil and gas reserves are depleted. The Texas part of the study area extends from the Gulf shoreline to the shelf edge (200-m isobath) and focuses on the federal OCS. Mineral resources being evaluated as part of the investigation are sand, gravel, and heavy minerals.

Preliminary evaluation of the resource base includes several phases. The first phase involves a review and inventory of previously published maps and reports that describe the composition, concentration, and areal distribution of the resources. The second phase involves assembling material (cores and sediment samples) and compiling uninterpreted data (textural analyses, geochemical analyses, foundation borings, high resolution seismic profiles) in order to better define the spatial limits of the resources and to provide a basis for delineating areas with the greatest potential for mineral extraction. Specific steps include (1) integrating descriptions of deep cores with seismic characteristics, (2) correlating stratigraphic sections, and (3) mapping lithofacies of depositional sequences identified by steps 1 and 2.

Preliminary results indicate that the thickest and most extensive accumulations of near-surface sand occur at the tops of upward-coarsening sequences. These sequences, which are characterized by clinoform reflections on seismic profiles, represent prodelta, delta front, and delta plain sediments. The nearshore sediments were deposited by late Pleistocene platform deltas that prograded across the continental shelf during falling sea level (Rio Grande) and by shelf-margin deltas (Rio Grande, Brazos-Colorado, Sabine-Calcasieu) constructed during subsequent sea-level lowstands. Other shallow concentrations of sand occur in conjunction with offshore shoals that mark the positions of drowned barrier islands or similar strandline features. These sand bodies formed during brief stillstands of the Holocene transgression and are located on the inner and middle shelf. Gravel-size clasts in surficial sediments generally occur in a matrix of sand mud. Highest concentrations of the coarse fraction are associated with some of the relict bench deposits. They are composed of rock fragments, caliche nodules, and restricted molluscan species (Crassotrea, Rangia) that were eroded from underlying estuarine sediments.

The initial reconnaissance study will (1) evaluate the suitability of existing data for resource assessment and (2) identify areas that warrant more detailed investigations.

Dr. Robert A. Morton is a senior research scientist at the Bureau of Economic Geology, The University of Texas at Austin. There he coordinates projects related to the regional geology of coastal and offshore Texas. His current research focuses on nearshore processes and sediment transport, as well as the genetic stratigraphy and petroleum potential of the western Gulf Coast Basin. Dr. Morton received his B.A. degree from the University of Chattanooga and his M.S. and Ph.D. degrees from West Virginia University.

Mr. William A. White is a research associate with the Bureau of Economic Geology, The University of Texas at Austin. Over the past several years he has coordinated the submerged lands of Texas project, which is a comprehensive inventory of sediment textures, geochemistry, benthic macroinvertebrates, and associated wetlands located in state-owned lands. Recent studies have also included coastal processes and shoreline changes in bay-estuary-lagoon systems. Mr. White received his bachelor's and master's degrees from the University of Texas at Austin.

Outlook for Offshore Shell Dredging

Mr. Robert D. Palmore
Dravo Basic Materials Co., Inc.

NOTE: The following is a summary by Dr. Chacko John of Mr. Don Palmore's talk and is based on the tape recorded record of the session.

In this talk on the above subject Mr. Palmore stated that shell dredging for commercial use was currently being done in Louisiana, Maryland, California, Iceland, and Brazil. He estimated that in the Gulf Coast of the United States, 25 million tons of sand, gravel, crushed stone, and shell were being utilized annually. Louisiana used approximately 6 million cubic yards of shell mostly for road construction. The first commodities that would be mined in the Gulf Coast Exclusive Economic Zone (EEZ) will be sand, gravel and shell. Though there are large reserves of shell available along the Gulf Coast, the present environmental and fisheries conservation regulations made it extremely difficult to utilize this resource. Hence, a viable offshore source of shell and gravel located in close proximity to major Gulf coast markets would greatly benefit the economy of the area. The key factor for a successful offshore mining and production operation was transportation at competitive rates with competing material sources from onshore areas. Limestone from Mexico and the Bahamas is presently being imported into Florida, Alabama, Texas, and Louisiana.

Mr. Palmore was of the opinion that offshore mining of any non-energy seafloor material at present was practically impossible due to the existing policies and regulations set up by the agencies having jurisdiction over offshore mining. He recommended that at future meetings of a similar nature, a legal expert in policy and permitting regulations be invited to attend in order to review what can and cannot be done in the outer continental shelf EEZ regarding offshore mining. He encouraged efforts made towards research and sampling for shell and gravel sources in the EEZ and expressed the need to help develop sampling devices to take representative samples in water depths of 60-100 ft. This would enable material quality testing and help in determining reserves. Offshore mining is an exciting and challenging proposition, but present policies and regulations need to be modified and/or changed for successful development of this industry.

Mr. Robert D. (Don) Palmore received his B.S. and M.S. degrees from the University of Alabama. He is presently the Manager for the Geology and Survey Department of Dravo Basic Materials Company, Inc., Mobile, Alabama. Don Palmore is an licensed land surveyor, State of Alabama, and is a member of the American Institute of Professional Geologists, Association of Engineering Geologists, Alabama Geological Society and the Louisiana Environmental Professionals Association.

Incentives for Deep Ocean Mining

Mr. John G. O'Hara
Offshore Mining Company

INTRODUCTION

This presentation is a survey of current and projected possible incentives for Deep Ocean Mining. A brief summary of historical developments will provide a proper perspective on current developments. Short- and long-term incentives will then be examined in detail.

Historical Perspective

The status of the deep seabed revolves around issues that have been argued since classical times. In ancient Greece and Rome, the status of the deep sea, hence the deep seabed, was governed by the doctrine of Res Nullius (belonging to none)--therefore, open to all claims. Later Roman thinkers, such as Gaius and Justinian advocated Res Communis doctrine, stating that the sea was open for common use, but not for unilateral appropriation.

After the downfall of classical civilization, the Res Nullius doctrine predominated, allowing for wide varieties of claims to be made including the following examples:

- o Byzantium made extensive claims over fishery areas and salt resources;
- o Venice claimed the Adriatic Sea;
- o Many nations laid claims to areas of the Baltic on the basis of local and naval power;
- o Spain and Portugal, in the 1490's, divided the majority of the world's oceans and territories on the basis of a Papal Bull pronounced by Pope Alexander VI.

Current Developments

Closed sea doctrine versus open sea doctrine has been a central issue in the legal distinction between territorial waters and the high seas. In recent times, the debate has continued on a magnified scale.

UNCLOS III

From UNCLOS I in Geneva in 1958 to UNCLOS III at present, no satisfactory regime has been established for mining the deep ocean floor. Rather, intense polarization has occurred in the international arena. The saga of the "have's" and "have not's" continues.

Exclusive Economic Zone (EEZ) Proclamation

President Reagan's EEZ proclamation has served to multiply the area of our nation's coastal jurisdiction; however, a commercially attractive legal framework is still lacking. Present legal framework precludes EEZ mining development in the deep ocean (even on a preliminary geophysical and geological surveying basis). In addition to the necessity of establishing a workable legal framework, extensive second-generation exploration and inventorying programs must be completed in order to identify those areas where commercially attractive mineral occurrences exist.

Recent Incentive Developments

The final stages of the "Decolonization Movement" have resulted in the emergence of several unaligned nations, relatively underdeveloped, yet with great quantities of deep seabed mineral resources and an inclination to develop these resources.

SHORT-TERM INCENTIVE AREAS

The near-term development of deep ocean mining is likely to take place in those areas where there is an atmosphere favorable to economic and industrial development. As a prerequisite, such areas must also be free of legal barriers to such development and sensitive to the requirements of such an enterprise. Obviously, such areas must also be favored with extensive mineral rich waters.

Short-Term Windows of Opportunity

Several emerging nations in the Pacific may be seen as offering short-term windows of opportunity for the development of deep seabed mining. They are classified with the group of nations termed LDC's, yet they are not aligned with this group and remain favorably inclined toward the development of their resources by others.

Emerging Archipelagic Nations

Emerging Pacific Archipelagic Countries (called EPAC's) represent the most attractive areas for offering incentives for developing deep ocean mining within national waters with the blessings of the host nation. Such nations as the Marshall Islands, the Federated States of Micronesia, Fiji, and Kiribati are ideal for such development. The EPAC's possess expansive territorial seas rich with minerals and other resources. They are unencumbered with prohibitive legal frameworks and they are eager to quantitatively identify and develop their internal resources with the help of outside technology and assistance. These nations are open and inclined to cooperate and give large concessions to development groups. This atmosphere is ideal for the formation of consortia without national alignment or prohibition to such enterprises.

Strategic Incentives to U.S. Involvement

The EPAC block previously mentioned extends over a geographic portion of the Pacific Ocean that is not only expansive and rich in undeveloped resources but also strategic in position. The block fans across a broad stretch of the Pacific that is becoming increasing strategic both in economic and military terms as the Pacific rim becomes increasingly powerful in the world arena. These nations are pivotal in the development of the Pacific, and their favor and resources are being sought by many of the developed nations. A strong U.S. involvement in the development of the resources of these nations through U.S. academic, industrial, and governmental input could prove to be of great benefit to all parties. The utilization of U.S. assets and existing facilities and technology would provide strategic benefit to the U.S. and ensure a predominate position of involvement and development in the area.

LONG TERM DOMESTIC INCENTIVES

As the demand for mineral resources continues to grow, and available land based resources dwindle, the need for commercial ocean mining will increase and eventually become a necessity. This development of a safe, responsible, efficient, and commercially feasible industry to call upon our nation's deep ocean mineral resources will eventually become a reality; however, such an industrial capability is currently precluded by lack of incentives.

Domestic Prerequisites to Deep Ocean Mining

The case for deep ocean mining has been made, and many urge the development of a cohesive domestic policy which, in turn, would foster the development of such an industrial capability. Furthermore, the world mineral market's sensitivity to the development of extensive deep ocean mining capabilities and predatory pricing reaction from land based producers must be guarded against if the industry is to survive, once begun. This could be accomplished with the development of a systematic framework of governmental price support to protect the recovered metals from a malevolent marketplace.

In addition to governmental pricing incentives and the removal of legislative barriers, much must be accomplished in the areas of "EEZ and deep seabed 'second-generation' exploration and assessment" prior to the initiation of such a capital intensive industry. It is of great concern to industry that further exploration take place and quantitative inventorying occur to identify those areas where mineral occurrences of commercial interest exist.

CONCLUSION

In sum, mankind has always recognized that incentives do exist for claiming areas of interest on the seas. The deep seabed is no exception to this phenomenon; rather, it presents and renews those areas of conflicting interest that have always prevailed. Insofar as deep ocean mining is concerned, the development of a commercial industry in U.S. EEZ water is at present prohibitive; however, with the removal of barrier disincentives and the enactment of incentive programs, such as cohesive leasing policy and pricing support, such an industry will become a reality.

The same applies to international waters in that any and all leasing activities undertaken in such waters are either questionable at best or spurious at worst, and subject to the ratification of a final UNCLOS III treaty.

Areas where short term possibilities do exist for deep ocean mining include those archipelagic nations in the mineral rich waters of the Pacific that are favorably inclined toward outside development. However, much in the way of scientific exploration, academic evaluation, extensive inventory analysis, and industrial assessment must be undertaken in all areas of the deep ocean--too much is yet unknown.

Mr. John Grady O'Hara was born October 20, 1939, in Campbell County, Tennessee, and raised in the small town of Jellico, Tennessee where he still maintains the traditional family home. He currently resides in Brownsville, Texas. He attended the University of Tennessee at Knoxville, receiving a B.S. in statistics and math in 1962. From 1963 to 1966 he was Air Transport Examiner for the Civil Aeronautics Board and attended graduate school at George Washington University (mathematical statistics, operations research, and economics), Washington, D.C. He was also research scientist and staff fellow of Navy Logistics Research Group, George Washington University. Between 1966 and 1968 Mr. O'Hara was in Corporate Planning, Operations Research, American Airlines, and in graduate studies at Columbia University and New York University.

Currently, Mr. O'Hara is investigating possibilities for the employment of several research and drilling vessels with various academic institutions and numerous governmental agencies.

History of the Beach Nourishment Project, Grand Isle, Louisiana

Mr. Adrian J. Combe, III
U.S. Army Corps of Engineers
New Orleans District

The project--a joint effort of the Corps of Engineers, New Orleans District, the State of Louisiana, and the town of Grand Isle--was built of sand excavated from offshore borrow pits. Dredging began in September 1983 and was completed by September 1984. About five and one-half million cubic yards of material were dredged from two offshore borrow pits to emplace the required two million eight-hundred thousand cubic yards of sand in the beach and dune section on the island. The offshore borrow pits were located about one-half mile from the existing beach. One pit, furnished by the government, was almost two miles long near the middle of the island, and the other, selected by the contractor, was about one-half mile square near the east end of the island. Within one year, the government pit had filled to within ten feet of the natural bottom contour, and the contractor pit could not be differentiated from natural bottom contours.

Meanwhile, in the winter and spring of 1985, erosion of the beach began during strong frontal storms. The eroded length of beach totalled 10,000 feet (in five reaches), and the total sand loss was 230,000 cubic yards. In the lee of the east and west ends of the government borrow pit, where the dredged holes were deepest, and in the lee of the contractor borrow pit, cuspate bars grew from the beach toward the borrow pits.

Then in the summer of 1985, three hurricanes--Danny, Elena, and Juan--struck Louisiana. In mid-August, Danny eroded about 70,000 cubic yards of sand from the beach right up to the toe of the dune in the reaches eroded by winter storms. Elena, at the end of August, further exacerbated those five reaches, removed 40,000 cubic yards of sand, and contributed to an increase in size of the cuspate bars. At the end of September, Hurricane Juan came to the coast of Louisiana and stayed four days, chewing the whole time at the beach and dune on Grand Isle, and eroding an additional 370,000 cubic yards of sand from the beach and dune. Along all areas where the waves from Elena lapped at the toe of the dune, Juan now attacked the dune. About fifteen percent of the dune was leveled, and another twenty-five percent was severely damaged.

ACCOMPLISHMENTS

Despite its damaged condition, the project fulfilled its purpose of protecting structures on Grand Isle from wave action during a hurricane. The estimated value of damages prevented during Juan exceeded the initial cost of the project. Plans to restore and modify the project in two phases are essentially complete, and the first phase is underway.

Phase 1 of the proposed project improvements includes extending the jetties at the east and west ends of the island by 500 feet and excavating the cuspate bar at the east end of the island. Material excavated from the bar will be placed on the beach near the fishing pier in the East End State Park.

Phase 2 of the proposed project improvements includes restoring the damaged beach and dune section by constructing a 10,800-foot long clay core inside the dune sections that were substantially destroyed; raising the crown elevation of the dune along a 7,500-foot reach by 2 feet; raising the crown elevation along a 7,000-foot reach by one-half foot; and by building 1,200 feet of segmented offshore break-water near the center of the island.

SIGNIFICANT FINDINGS

Despite damage to the sand dune and beach by winter storms, the project performed its intended purpose by preventing wave damage to public and private property on the island through a most unusual hurricane season. Losses of sand exceeded pre-construction estimates, but this is often the case during the first years of a beach nourishment project.

The combination of width, depth, and proximity of the offshore borrow pits at Grand Isle contributed to the formation of cuspate bars in the lee of the borrow pits. Once formed, the cuspate bars have become self-feeding features as they modify the nearshore wave climate and continue to grow despite the significant infilling of the borrow pits.

The proposed installation of offshore breakwaters adjacent to the cuspate bars is expected to reduce wave attack on the beach in the lee of the breakwaters, but will not modify the gulfward extent of the cuspate bars. Based on past performance on the sand dune and beach in preventing wave damage to structures on the island, restoration of the project should begin as soon as practicable.

In those reaches of the beach not significantly narrowed by storm-induced erosion in 1985, a second dune is growing on the Gulf side of the man-made dune. Thus we have evidence that the sub-aerial beach width selected for the project is compatible with the environment to maintain a viable dune with wind-blown sand on Grand Isle.

RECOMMENDATIONS

Based on the performance of the sand dune and beach project at Grand Isle, full restoration of the project should be undertaken as soon as practicable.

Based on the response of the shoreline to the offshore borrow pits dredged for the initial construction of the project, offshore borrow pits need to be carefully dimensioned and positioned to minimize their impact on the island. The undredged portion of the offshore government pit can be dredged to restore the project if the depth of cut is limited to ten feet below the natural bottom.

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Mr. Adrian Joseph (Jay) Combe, III, born in 1941 in Humboldt, Tennessee, grew up in the Carrollton section of New Orleans. He graduated from Tulane University with a bachelor of science in civil engineering in 1964. He has worked for the Corps of Engineers since 1967. From 1970 until 1978, he was assigned to the Coastal Engineering Research Center in Washington, D.C., and Fort Belvoir, VA. In March 1978, he returned to the New Orleans District to become Chief, Coastal Engineering Section.

The Outlook for Offshore Heavy Minerals Resources

Mr. Mark S. Whitney
Associated Minerals (USA) Inc.

From the start, I want to be clear that I speak only for my employer, Associated Minerals, and do not pretend to represent other producers in the heavy mineral (HM) placer mining industry. Nevertheless, this is a position paper describing our perception of the current situation for HM placers in the Exclusive Economic zone (EEZ), and our view of the possibility of future development. Although these remarks are not addressed specifically to the Gulf, they are every bit as applicable here as to the Atlantic.

I will address four topics pertinent to both current and future development: geology, economics, regulation, and the environment.

Geologically, heavy minerals were, and are, currently mined from beach and dune placer deposits in the Coastal Plain of the southeastern U.S. The deposits are Pleistocene to recent in age, but similar mineralization is known in Tertiary and Cretaceous sediments. These deposits are long, lensoid bodies 2 to 10 miles in length, 100 feet to 1 mile in width, and 50 to 70 feet in thickness. The deposits may contain as little as 25M tons of mineralized sand, or as much as 500M tons. The concentration of heavy minerals within a deposit is variable, but will average from 2 to 4 percent by weight. The grain size of heavy fraction ranges from less than 50 to 250 macrons, averaging 100 to 150 microns. Processing losses becomes large for sizes smaller than 75 macrons. The mineral assemblage of the heavy fraction varies among deposits. It is dependent on the source areas for the sediment, the conditions of deposition, and the amount of weathering and leaching the assemblage has endured. Our company is interested specifically in the titanium minerals rutile, leucoxene, and ilmenite, and the minerals zircon and monazite.

Researchers have identified several offshore environments as favorable hosts for HM placers. The more prospective ones are drowned barrier systems or strand lines, shoals, and buried channels. In our view, drowned barriers are the only depositional environment worth pursuing. No other, as yet, has provided the mix of factors needed to produce large, high-grade concentrations of valuable, heavy minerals.

But, we are not convinced that drowned barriers occur extensively. We suspect that a transgressing, marine, foreshore zone is an effective and destructive redistribution agent, particularly, on the shallow, flat shelves on the Gulf and Atlantic. Fragile beach and dune environments on currently submerged strand lines would have been easily eroded, and the placers destroyed and redistributed. Segments of the barriers and placers may be preserved, but we believe that they are only basal remnants and are probably small and scattered.

Additionally, mineralogical assemblages in barrier systems on the Coastal Plain of the Southeast show a trend toward less valuable suites in younger concentrations. This likely results, in part, from an increasing content of metastable and unstable minerals that have yet to be weathered from the deposits. Offshore, even if the drowned barriers are older (Pleistocene) in age, they have spent much of their existence submerged are not likely to be as weathered and, hence, as valuable as their age equivalents onshore.

Examples of this are seen in the results of mineralogic studies conducted by several agencies in the Atlantic and Gulf EEZ areas. The studies suggest that valuable heavy minerals in marine suites occur in concentrations only 1/5 to 1/2 those necessary for profitability onshore (Table 11.1). Our own exploration in the EEZ off Georgia confirms those results.

Mineralogy, of course, can have a significant impact on the viability of any single deposit.

Last spring, the U.S. Bureau of Mines published an open-file report, number 4-87, that specifically addressed the mining economics of HM placers in the southern Atlantic EEZ. In its analysis, the bureau concluded that mining could be profitable if the operations could achieve HM grades about twice those of the current onshore mines, assuming similar mineralogy. I will not speculate on the possibility that barrier remnants in the EEZ could meet these requirements. But, I must say that we believe that the parameters for offshore placer mining cannot be adequately defined until a specific discovery is made. We suggest that an economic analysis at this point is premature.

Quite apart from technical aspects, development must contend with regulatory and environmental considerations. In order to allow the development of resources, a regulatory framework must be in place that is not hostile to the developer. Otherwise the developer will go elsewhere--and that may well remain a viable option for miners for the next few decades.

Likewise, environmental constraints can block development and divert it elsewhere. In our own experience, our EEZ exploration program was delayed for several months by the presence of a herd of endangered Atlantic right whales. The delay was required because no one could predict the effect of vibracoring on the whales and on the calving cycle of the cows. What impact could such a delay have on dredging operation? Certainly no miner could afford to shut down for the six months of the year that the whales are in the area.

I do not intend to belittle environmental considerations with this example; rather, I use it to illustrate the need for research into the effects of placer mining on the shallow marine environment. Each dredging operation could disturb several hundreds of acres of seafloor each year for ten to 20 years. It could also impact on other nearshore users, most prominently commercial fishermen and recreational users. We suggest that the effects need to be established, debated, and most important, found acceptable before industry will risk the effort and capital necessary to develop marine resources.

Given these current problems and uncertainties, I believe that future industry interest will continue to be sporadic. This is chiefly because exploration and development of marine placer will have to compete directly with development onshore. We believe that large areas of the Coastal Plain remain unexplored. Despite increasing pressure from other users, primarily from land development, it may be decades before those thousands of square miles onshore are closed to mineral development and the industry is driven to look offshore for its resources. Nor will economics necessarily force industry into the EEZ. For every marginally economic or subeconomic marine placer that is located and banked in anticipation of development at some later time, there are possibly several hundred million tons of onshore material that is of similar commercial status. The onshore resource would not necessarily be developed in preference to that in the EEZ, but it does represent an attractive, well-defined alternative in a familiar setting.

Be aware that the concepts of "defined resource" and "familiar setting" are important to both miners and explorationists. Geologically, the Coastal Plain has been intensely studied compared to the near surface sediments of the EEZ. We can read reports, study maps, stand on the outcrop, and hold the resource in our hands anytime we choose. The miners can easily poke it, prod it, dig holes in it, and run engineering studies on it. The procedures, variables, and answers are all reasonable, well understood, and the industry feels comfortable in predicting the future in this environment.

How different a situation when the resource is under 50 or 100 feet of water! The Bureau of Mines said it well--there are not operating marine HM placer mines from which we can acquire operating data and costs to use in predictive models. The only precedents are tin mining operations, which produce a commodity of far higher unit value. Managers and decision makers have no alternative but to think and act conservatively in that situation.

But, all this must be balanced by an industry concern for all its future options. Lack of foresight, initiative, and innovation will lead to trouble as quickly as lack of prudence. We believe that this is especially true in exploration, and that is why we continue our interest in marine placers.

To keep the industry's interest, or perhaps to generate additional interest in the EEZ, we would suggest a few topics for research:

1) Definition of the shallow geologic framework. This is no small task, but as I am time to time reminded, our company does not run a geological survey. Exploration dollars are always scarce, and basic regional mapping is difficult to justify to management. We cannot do this kind of work.

2) Proof that submerged barriers systems do exist and could be extensive enough or rich enough to support mining operations, or

3) Proof that shoal fields host mineralization with grade and mineralogy that could support development, or

4) Proof that some other environment could support development.

5) Definition of the resource. What is the mineralogy, and what is the chemistry and sizing of the minerals present? How does it change from area to area?

To conclude--I've described my company's perception of the current situations in geology, economics, regulation, and the environment pertaining to marine placer development. I've also described some of the hurdles we see to future development. But, rather than leave you all with the feeling that we are pessimistic about marine placers, I want to stress that we are not. We believe that the reality of today and the near future is that opportunities for reward are greater onshore than offshore. But we also recognize that we know very little of the geology and HM resource potential of the EEZ. So we will maintain an interest unless, and until, the area is proven barren.

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Mr. Mark S. Whitney completed a B.Sc. degree in geological engineering at the University of Missouri-Rolla and an M.Sc. in geology at the Colorado School of Mines. He has participated in exploration programs for uranium, base and precious metals, and is currently Exploration Manager for Associated Minerals (USA) Inc. Associated operates a heavy mineral placer mine in northeastern Florida.

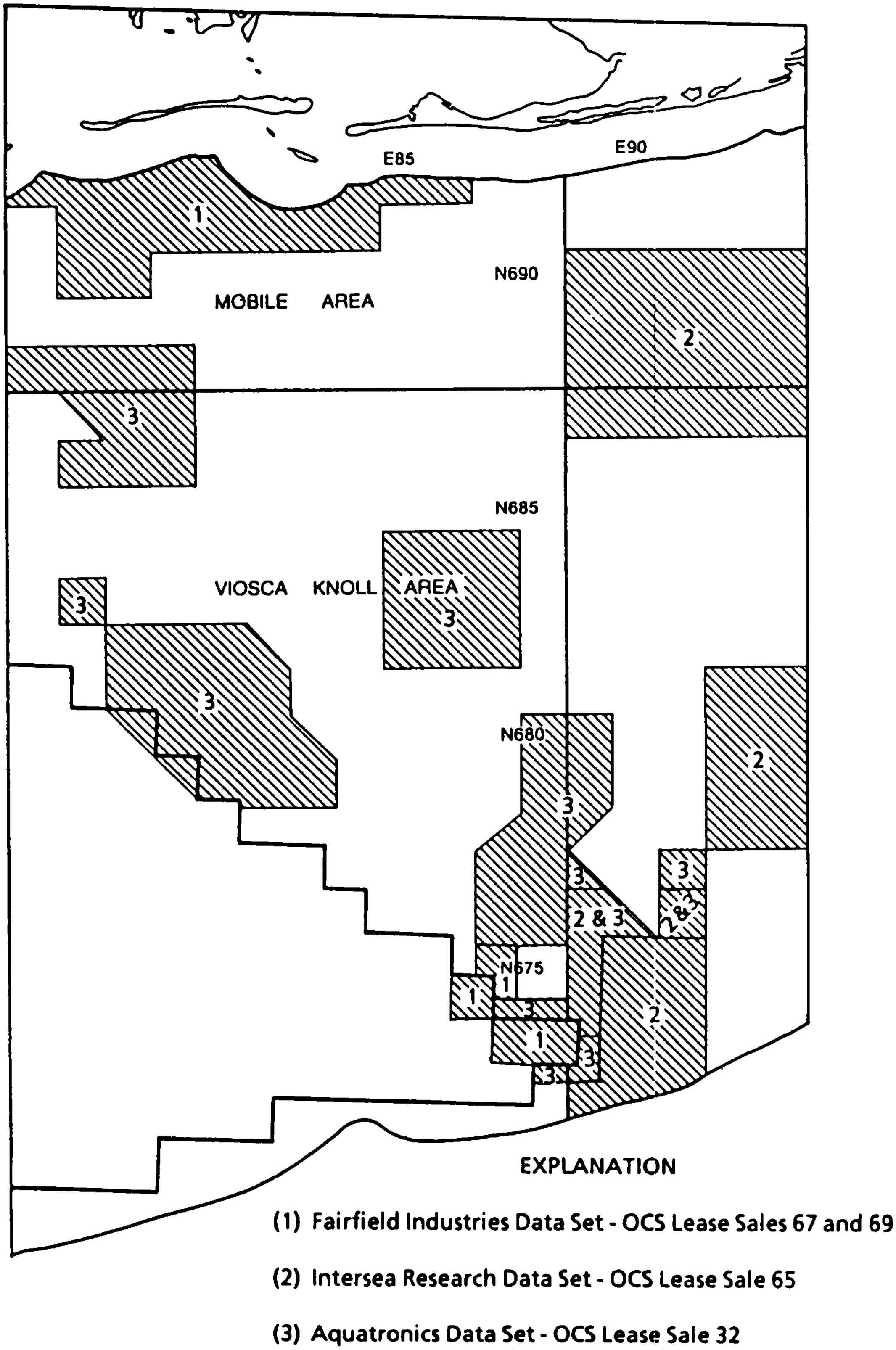

Figure 11.1.--Identified geophysical data sets.

Table 11.1

Percentage of Heavy Mineral Suite

Mineral Species	EEZ	Onshore Mineable Deposits
Rutile	1-3	5-10
Leucoxene	0-1	3-7
Ilmenite	10-20	25-40
Zircon	4-6	10-15
Monazite	0-0.5	Tr-1.5

CURRENT PREHISTORIC ARCHAEOLOGICAL RESEARCH IN THE COASTAL REGIONS OF FLORIDA

Session: CURRENT PREHISTORIC ARCHAEOLOGICAL RESEARCH IN THE COASTAL REGIONS OF FLORIDA

Chair: Mr. Richard J. Anuskiewicz

Date: December 3, 1987

Presentation Title	Author/Affiliation
Current Prehistoric Archaeological Research in the Coastal Regions of Florida: Session Overview	Mr. Richard J. Anuskiewicz Minerals Management Service Gulf of Mexico OCS Region
Inundated Archaeological Sites of the Florida Coastal Region: A Regional Overview	Ms. Melanie J. Stright Minerals Management Service Gulf of Mexico OCS Region
A Consideration of Archaeological Wetsites	Dr. Glen H. Doran Florida State University Department of Anthropology
Results and Implications of the Multidisciplinary Archaeological Research Project At Warm Mineral Springs, Florida	Mr. Wilburn A. Cockrell Florida State University Department of Anthropology
Some Archaeological Sites in the Apalachee Bay of Florida	Mr. Michael Faught University of Arizona Department of Anthropology
Preliminary Archaeological Investigations at Ray Hole Spring	Mr. Richard J. Anuskiewicz Minerals Management Service Gulf of Mexico OCS Region
Archaeological Sites in the Drowned Tertiary Karst Regions of the Eastern Gulf of Mexico	Mr. James S. Dunbar Florida Department of State Bureau of Archaeological Research

Current Prehistoric Archaeological Research in the Coastal Regions of Florida: Session Overview

Mr. Richard J. Anuskiewicz
Minerals Management Service
Gulf of Mexico OCS Region

The MMS of the Department of the Interior is responsible for all OCS minerals activities and their potential for impacting natural and archaeological resources. In order to fulfill its responsibilities for archaeological resources management, MMS has developed a program to inventory, manage, and protect valuable, nonrenewable, prehistoric and historic resources. The MMS meets its goal of archaeological resource protection through a multilevel analysis system. The MMS conducts Regional baseline studies to determine where on the OCS archaeological sites are most likely to occur.

The MMS baseline studies have concentrated on the central and western Gulf of Mexico because most of the oil and gas exploration and production has occurred in this area of the Gulf. However, the recent past has seen the projection of exploration and development of natural resources in the eastern Gulf of Mexico. Regionally-specific archaeological resource management models were originally derived from this baseline data for analysis and management of prehistoric archaeological resources potentially located in the western and central Gulf of Mexico. However, the models are not completely applicable for archaeological analysis in the eastern Gulf of Mexico. In an attempt to resolve this problem, MMS has enlisted the aid of archaeologists conducting current prehistoric research in the coastal regions and offshore Florida. This has been done in order to examine new information from their current research that may be applicable to the MMS cultural resource management program for the eastern Gulf of Mexico.

The focus of this session is to report on the current status of prehistoric archaeological research in the coastal regions of Florida and then to determine if the present analytical models used by MMS, derived from previous baseline studies, are appropriate for performing the requisite MMS cultural resource management analysis.

The first speaker in our session was Ms. Melanie J. Stright of MMS. Ms. Stright began the session by giving an archaeological overview of inundated archaeological sites in the coastal regions of Florida. She reported that 17 inundated archaeological sites have been documented within the coastal area of Florida. These sites became inundated as a result of glacio-eustatic and glacio-isotatic adjustments during the late Wisconsinan glacial epoch and during the Holocene. The distribution of sites should not be considered representative of the true distribution of inundated archaeological sites. There is a strong bias towards shallow water sites since activities such as dredging and sport diving generally concentrate in shallow waters and have led to the discovery of many of the sites.

Diagnostic artifacts recovered include lithics and pottery and span all cultural periods from Paleo-Indian through the Woodland. Human skeletal material from Paleo-Indian and Late Archaic Periods have been recovered, as well as numerous species of late Pleistocene fauna.

The inundated archaeological sites discovered thus far within the coastal areas of Florida suggest that there will be an abundance of archaeological material found off the coast of Florida and that these materials (including organics) will often be well preserved. Sites will probably concentrate in the vicinities of sinkholes, relict fluvial channels, relict estuarine deposits, and outcrops of cryptocrystalline rock. Information contained in these sites may provide important information on prehistoric human migration, settlement patterns, subsistence, and cultural contacts across now submerged landmasses.

The next speaker was Dr. Glen Doran of Florida State University. His paper focused on the preservation potential of organic materials at prehistoric archaeological sites located in wet or saturated environments. He defined these types of archaeological sites, or "wetsites," as locations where remnants of past human activities are preserved in saturated or nearly saturated settings. These types of sites can be found in river channels, coastal marine settings, and within lakes, ponds, and springs. However, there may be some problems in locating wetsites because of their almost invisible nature and the frequent necessity of entering a "hostile" environment to locate them. Wetsites are either underwater, or they are difficult to identify because of water-saturated conditions.

The potential preservation of organic materials is largely due to the presence of moisture, which reduces the physical stress on organic materials by limiting the frequent hydration/dehydration cycle that promotes deterioration of organic remains by expansion and contraction. There are many other factors that contribute to the preservation potential of materials. These factors include the dynamics of water and/or soil chemistry, oxygen levels in the soil and water, temperature, physical stability, and integrity of the soil matrix. When all of the environmental conditions are right, there is also a good potential for preservation of plant material like stems, seeds, leaves, and pollen. Additional soft tissue that can survive includes preserved brain tissue. At the Windover archaeological wetsite, which Dr. Doran has been excavating since 1983, Dr. Doran states that the preliminary analysis of preserved brain tissue indicated a replacement process, that resulted in elevated sulfur levels. Microscopic and macroscopic features of the brains are still preserved, as are some molecular structures. Elemental analysis of bone samples indicates an abnormal absorption of strontium, obviating some studies of dietary composition based on strontium levels. At the same time, some proteins appear well preserved enough for researchers to attempt to develop a biological profile of the 7,000 year old population being studied.

The uniqueness of the preservation of organic materials at wetsites like Windover also presents some unique problems in material preservation. Waterlogged conditions of archaeological material recovered necessitated special conservation techniques. Saturated faunal and human bone was treated with bulking agents which replaced the water. Polyetholglycol (PEG) was initially used, but an acrylic emulsion, Rhoplex, proved more satisfactory. Floral materials (seeds, leaves, wooden artifacts, etc.) involved a variety of conservation procedures including refrigeration, alcohol saturation, treatment with PEG and Damar, and other compounds. Brain tissue was rapidly removed, placed in plastic bags, flooded with nitrogen gas, sealed, refrigerated for transport, and frozen at -70 degrees centigrade within 24 hours to minimize possible degradation and to maximize future analysis possibilities.

Many scientific and archaeological accomplishments were realized at the Windover prehistoric wetsite. The collection, representing a minimum of 155 adults and subadults, is one of the largest samples of human skeletal material and associated cultural materials of this antiquity in the New World. The collection dates between 7,000 and 8,000 years Before the Present (B.P.) and represents an Archaic Period hunting-gathering population. Data on health, diet, disease, demography, etc., in some ways, represent "baseline data," useful in looking not only at human adaptation, but providing an abundance of archaeological, climatological, and environmental data.

Mr. Wilburn A. (Sonny) Cockrell, Director of the Warm Minerals Springs Archaeological Research Project, was the next speaker, and he described his archaeological site as a 70-meter deep spring-fed sinkhole, located 16 kilometers inland from the Gulf of Mexico in Sarasota County, Florida. Saline anaerobic water enters the sinkhole at the 70-meter depth at a temperature of 32-34 degrees centigrade. The source of the springs' water is the Floridian Aquifer some 1,000 meters below the surface. Approximately 19.4 million gallons of natural, hot mineral water flow through the spring each day.

The sinkhole's limestone walls are draped intermittently with dripstone formation zones from 4 to 30 meters below the surface. In addition, some of the underwater sediments are producing a tufa-like formation. This sedimentary rock, composed of calcium carbonate, is formed by evaporation as a thin, surficial, soft, spongy, cellular or porous, semifriable incrustation around the mouth of a hot spring. The limestone matrix of the spring is representative of the Hawthorn Formation, which dates back to the Miocene Period.

Current research is being conducted on a 13-meter ledge, and at the sinkhole's debris cone at a depth of 50 meters. The archaeological diving is being conducted by utilizing both SCUBA and surface supplied air systems. The technology utilized at Warm Mineral Springs reflects both standard underwater excavation methods at the 13-meter ledge and some new and innovative techniques at the 50-meter level where deep diving is required.

There are three archaeological foci at the Warm Mineral Springs archaeological site. They include (1) a terrestrial site located around the rim of the sinkhole, (2) archaeological material at the 13-meter ledge deposited prior to the present level of inundations, and (3) a stratified matrix of undisturbed natural sediments and archaeological materials located in the existing sediment cone at the 50-meter level.

Archaeological material excavated at Warm Mineral Springs ranges from the present to the Formative Period (approximately 2,500 years B.P.), from the Formative to the Archaic Period (approximately 2,500 B.P. to 8,500 B.P.), and from the Archaic Period to the Paleo-Indian Period (approximately 8,500 B.P. to 11,000 B.P.). Archaeological materials excavated from the Paleo-Indian period have been radiocarbon dated to approximately 11,000 B.P. Stratigraphic and chronologic analysis of the archaeological materials excavated indicates that human and other animal faunal remains, such as the ground sloth, saber-tooth tiger, horse and camel, were found to coexist during the same time period. Analysis of preserved botanical remains has provided a continuous paleo-environmental record extending back approximately 30,000 years B.P. In addition, there have been unsubstantiated reports that cave divers in the early 1960's removed a skull from the 13-meter ledge area of the spring and that this skull contained preserved brain material.

Planned future excavations of the anaerobic sediment cone at the 50-meter level may provide a complete time continuum of this archaeological site and, perhaps, provide more preserved faunal material and preserved soft tissue.

The fourth speaker was Mr. Michael Faught, a graduate student from the University of Arizona. His topic involved locating and excavating underwater prehistoric archaeological sites in the Apalachee Bay area of Florida, located in the northeastern area of the Gulf of Mexico. Mr. Faught suggested that anthropologists are somewhat puzzled by the archaeological reconstruction of the cultural transition from the Paleo-Indian Period to the Archaic Period. In the same vein, Quaternary geologists are having similar problems reconstructing the geolomorphical transition from the Pleistocene to the Holocene Period. Both disciplines are acutely aware of the need to study sea level changes and the need to continue to collect paleo-environmental data from the continental shelf. The missing archaeological and geological data includes information about relict geomorphology, prehistoric settlement patterns, and the timing and effects of sea level change on these factors. There has been much written in the archaeological literature about sea level curves; however, very little archaeological research has been conducted on the continental shelf to locate inundated sites to substantiate or dispute existing sea level curves for finding additional prehistoric sites of a terminal Pleistocene age (Paleo-Indian Period).

Mr. Faught further stated that the continental shelves represent a missing and potentially large data set where it is extremely difficult to find either relict topographic and geologic features or submerged archaeological sites. Wave action destruction, subaerial erosion, Holocene alluviation, and neritic sedimentation are significant natural processes that could obscure the Pleistocene geology and continental shelf archaeology.

The search for submerged or drowned prehistoric terrestrial sites by Mr. Faught began after careful examination of onshore settlement pattern models for late Archaic and Paleo-Indian Periods. Research was focused on upland areas of high-density, extinct faunal remains and their associated lithic artifacts and on a potential offshore survey area that exhibited minimal alteration to the natural geology since the Pleistocene. A preliminary predictive model and research design were developed to search for lithic procurement stations, theorizing that lithic cultural material would have the best possibility of surviving natural destructive forces of sea level changes through time. The selected survey area included nearshore regions of the St. Marks, Aucilla, and Econfina Rivers of the Apalachee Bay because the alluvial sedimentation in these rivers is extremely low due to the solutional characteristics of the karst drainage.

The results of the initial survey located four lithic procurement stations in the five areas examined. Three sites were found close to shore in approximately 2 meters of water.

The fourth site was located 4.02 kilometers offshore at a depth of 3.7 meters and produced a large number of modified lithic materials including bifacially trimmed cores and associated flakes. Associated with the lithic debris were pieces of cypress wooden, which radiocarbon dated to 5,160 ± 100 years B.P.

The preliminary results of offshore archaeological surveys in the Apalachee Bay region indicate that by utilizing the developed predictive model, drowned prehistoric archaeological sites can be located. By examining relict features in the inundated karst region and concentrating on surveying the associated rock outcrops, site location is highly predictable.

Mr. Rik Anuskiewicz of MMS was the next speaker, and he reported preliminary archaeological investigations at Ray Hole Spring, a submerged karst feature located on the OCS. The MMS, in cooperation with the Florida Bureau of Archaeological Research, conducted preliminary underwater archaeological investigations at Ray Hole Spring. This submerged karst feature is located approximately 88.5 kilometers southeast of Tallahassee, Florida, and about 38.6 kilometers from the nearest Florida landfall. The Spring is a typical karst feature probably formed during the Pleistocene as a result of the surface limestone collapsing because of either solutional or mechanical action caused by underground drainage.

A 1976 Florida Bureau of Geology bulletin, titled "Springs of Florida," describes Ray Hole Spring as an occasional flowing spring lying in 11.6 meters of water, measuring 7.6 meters in diameter. The north side of the sink slopes southeast with the southeast side of the sink having a nearly vertical limestone wall to a depth of 18 meters. A cave strikes down and southeast from the 18-meter depth to approximately 30 meters.

The October 1986 investigation of the spring revealed a completely different environmental setting at the site. The diving reconnaissance indicated that the spring had almost completely filled in with recent (since 1976) marine shell detritus. Only about 3 meters of relief existed in the southeastern end of the sink. The archaeological investigation of the site included diver swimming reconnaissance, mapping, attempts at coring, and waterjet excavation of selected test units. Coring was discontinued because the coring tool made very little penetration in the shell matrix as a result of the small core diameter and the large size matrix of the marine shell detritus. After negative results from Test Units 1 and 2, and Core Tests 1 and 2, testing was moved to the outer rim of sink. One dive team began excavating with the waterjet at a large crevice. It was theorized that if this were an archaeological site, cultural material may have fallen or have been washed into a crevice and become trapped. The crevice was approximately 15 cms in width and ran in a southwesterly direction towards the rim of the sinkhole. Waterjet excavation approximately 15 to 20 cms into the crevice recovered several poor quality limestone or chert flakes. This material was immediately returned to the surface for examination. Continued waterjet excavation of the crevice yielded a lens of articulated whole oyster shell at the 75 cm level; at the one-meter depth, waterlogged wood was encountered. Samples of the shell and wood were collected, returned to the surface, and stabilized for future analysis. Below where the wood samples were recovered, the crevice narrowed and bottomed out. Excavation was terminated as was the initial archaeological testing.

In April 1987, analysis was conducted on the oyster and wood samples to identify the species and to obtain a radiocarbon date of this organic material. The wood species was identified as live oak, and radiocarbon dates for the oyster shell and wood dated 7,390 ± 60 years B.P. and 8,220 ± 80 years B.P., respectively. The wood sample, dating approximately 800 years older than the oyster shell and being recovered in a lower stratigraphic level than the oyster shell, suggests that these materials were deposited in situ.

Preliminary analysis of the data collected at Ray Hole Spring suggests that this sinkhole may be a prehistoric archaeological site. Several factors (environmental and possibly cultural) tend to support this initial contention. The radiocarbon dates obtained at Ray Hole Spring in combination with the regional sea level curve indicate that for approximately 8,200 years B.P. the sinkhole was a freshwater site supporting freshwater flora. Some time after 8,200 B.P., sea level began to rise, and by 7,400 B.P., the Ray Hole Spring area was supporting a shellfish population in a brackish water environment.

In addition, a cultural manifestation may exist at Ray Hole Spring. The two large limestone/chert flakes collected were examined by five archaeologists. They all seem to agree that the way the flakes were removed from the lithic core suggests that they could have been made by prehistoric man. However, they also agree that two flakes usually do not make an archaeological site.

Obviously, there is more work to be done to fully verify if Ray Hole Spring is an authentic archaeological site. An intensive testing program includes remote sensing studies to determine the true depth and profile of the sink hole, coring of the sediment cone to gather paleo-environmental data, more organic sample collecting for radiocarbon analysis, and the recovery of diagnostic lithic artifacts.

The final speaker of our session was Mr. James Dunbar, archaeological field supervisor with the Florida Bureau of Archaeological Research, Department of State. Mr. Dunbar began his comments by stating that prehistoric archaeological sites inundated by the sea are the most elusive sites to locate. The sites may be deeply buried and inaccessible in some regions of the continental shelf and shallow, but difficult to identify in other areas. The karstic area of the Florida Gulf Coast represents a unique archaeological area where Paleo-Indian remains are highly concentrated and sedimentation has been minimal.

Given the difficulties associated with locating offshore sites, a model based on the type and distribution of sites on the adjacent coast was developed for the Apalachee Bay region of the Gulf of Mexico. Offshore survey work (report by Faught and Anuskiewicz this session) incorporated the assistance of fisherman and sport divers familiar with the project areas. In three days, Mike Faught's survey located four archaeological sites from one to four miles offshore. Rik Anuskiewicz and others surveyed Ray Hole Spring some 24 miles offshore and discovered evidence of what may prove to be a drowned archaeological site.

Mr. Dunbar found from his research that prehistoric site distributions in Florida occurred in changing patterns not only linked to evolving technologies but to fluctuations in the regional surface water systems. The availability of potable water in relation to other needed resources helped dictate possible site locations through time. Ninety percent of the Paleo-Indian sites containing Clovis, Suwannee, or Simpson projectiles are located near karst depressions that penetrate the Tertiary limestones of Florida. Some sites are located around isolated sinkholes and solution depressions, but most occur in areas where multiple karst features occur together and dominate the topography. The largest site clusters are located in and around mature karst river channels with smaller but significant clusters centered around karstified lakes, bays, and prairies.

1. At given points in time, from 15,000 to 5,000 years B.P., can absolute sea level stands be identified to allow chronologically evolving site predictive models?

2. Do archaeological sites exist in the eastern Gulf of Mexico that have stratigraphic integrity despite Holocene sea level transgression and marine erosive conditions?

3. What is the functional variety of archaeological sites encountered?

4. Once prehistoric offshore sites are located, can remote sensing instruments provide diagnostic signatures of the known sites?

Mr. Richard J. Anuskiewicz obtained his B.A. in 1972 and his M.A. in 1974 from California State University at Hayward. He was employed with the U.S. Army Corps of Engineers from 1974 to 1984 as a terrestrial and underwater archaeologist. In 1982 Mr. Anuskiewicz completed all requirements for his Ph.D., except for his dissertation, at the University of Tennessee at Knoxville. In 1984, he accepted a his current position at MMS, Gulf of Mexico OCS Region.

Inundated Archaeological Sites of the Florida Coastal Region: A Regional Overview

Ms. Melanie J. Stright
Minerals Management Service
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At least seventeen archaeological sites, inundated as a result of late Wisconsinan and early Holocene glacio-eustatic and glacio-isostatic adjustments, have been documented within the coastal area of Florida (Figure 12.1). The distribution of reported sites is more reflective of shallow-water activities, such as dredging and sport diving, which have resulted in the discovery of the sites, rather than the true distribution of sites.

Three of the reported sites--the Saxon-Holland Site, Warm Mineral Springs and Little Salt Springs--lie inland of the present coastline within the karst area of central Florida. During periods of lower sea level, the karstic topography was better drained, resulting in lower water levels at these inland lake and sinkhole sites.

SAXON-HOLLAND SITE (SITE NO. 1)

The Saxon-Holland Site is located in Blue Cypress Lake in Indian River County, Florida (see Figure 12.1). Archaeological materials and human remains ranging in age from 11,000 to 500 B.P. occur between 2 and 3 meters below present lake level (W.A. Cockrell, personal communication 1987). There is a direct relationship between the depth of the material and its age, with the oldest material being found in the deeper portions of the lake.

WARM MINERAL SPRINGS
(SITE NO. 2)

Warm Mineral Springs is a sinkhole approximately 19.3 kilometers southeast of Venice, Florida, in Sarasota County. Paleoenvironmental data indicate that the spring would have been an important fresh water source during the late Pleistocene and early Holocene when the climate was more arid and local water tables were lower. The excellent preservation of organic materials in the anaerobic waters of the spring offer a unique opportunity to study the late Pleistocene environment and, also, early man. A detailed discussion of this site is provided in Mr. Wilburn A. Cockrell's paper, included in these proceedings.

LITTLE SALT SPRINGS
(SITE NO. 3)

Little Salt Springs, a water-filled collapse limestone sinkhole, lies 4.8 kilometers northeast of Warm Mineral Springs in Sarasota County, Florida. The site is an Archaic village and cemetery (ca. 7,000 to 5,000 B.P.) which extends into the sinkhole to a depth of 10 meters below the present water level (Cockrell, 1980).

A wooden mortar, two firepits (one near the mortar), food remains, and unidentified carved wooden implements were discovered within the sinkhole at a depth of about 10 meters below present water level. At a depth of 27 meters, the shell of a giant land tortoise with two wooden stakes stuck between the plates of the shell was found. A radiocarbon date of 13,000 B.P. was obtained from one of the stakes (C. Clausen, unpublished report, 1979).

Human remains from a total of 50 individuals, dating approximately 7,000 to 5,000 B.P., have been recovered from the site. Pleistocene faunal remains recovered from the sinkhole include giant ground sloth, giant land tortoise, and bison (C. Clausen, unpublished report, 1979).

A burned log dating 10,000 ± 200 B.P. was located in a cave at the springhead, 24 meters below the present surface of the sinkhole (Lazarus 1965). Although the remains of seven humans also have been found in the cave, direct association with the burned log has not been demonstrated. No artifacts have been removed from the cave.

Like Warm Mineral Springs, Little Salt Springs would have provided an important fresh water source during the late Pleistocene and early Holocene when the climate was more arid and local water tables were lower.

THE DOUGLAS BEACH SITE
(SITE NO. 4)

The Douglas Beach Site extends from the beach to approximately 600 meters offshore in the vicinity of Ft. Pierce, Florida in water depths of 3 to 12 meters. The base of the site is formed by coquina of the Anastasia Formation. Sediment-filled depressions occur within the coquina. Sand forms the lowest sediment layer within these depressions across part of the site. The sand layer, or where it is absent, the coquina rock, is overlain by a dark gray-green clay, which is capped by a dark gray peat. Organics within this peat layer gave an average radiocarbon date of 5,000 B.P. (J. Dunbar, personal communication 1987).

In 1979, a human maxilla with six teeth, a portion of the palate, and part of the sinus cavity was recovered from a pocket of shell hash in the coquina. The find had no provenience. Newnan age projectile points were found out of context, but, due to their known time range, probably came from the clay layer which lies beneath the 5,000 year-old peat layer. Wooden stakes, possibly sharpened at one end, were found within the peat layer. Glades Plain ceramics have been found at the surface of the site. This material is apparently eroding from a nearby land site and being redeposited offshore (J. Dunbar, personal communication 1987).

Although remains of extinct Pleistocene fauna have been found at the site, and artifacts of stone, shell, and bone (bone pins) and human remains have been recovered, direct association between the two components presently cannot be demonstrated. This site is important in demonstrating that intact Pleistocene deposits and associated archaeological deposits can be preserved offshore of high-energy coastline.

THE VENICE BEACH SITE (SITE NO. 5)

This site extends from the present beach at Venice, Florida, out into the Gulf of Mexico. The site consists of a complex of shell middens, with at least two on the beach and one offshore. The top of the offshore midden lies at 2.23 meters below present mean sea level. The offshore midden produced large quantities of shell, Perico Islands Period potsherds, burned and unburned fishbones, land mammal bones, and charcoal. The matrix of the midden was clayey sand. An in-situ sample of charcoal from 20 to 31 cm below the top of the midden gave a radiocarbon date of 1981 ± 85 B.P. (Ruppe', 1980). Approximately 100 meters seaward of the offshore midden, in 5.5m of water, a number of Middle Archaic stone tools have been found lying on the seafloor.

A test pit in one of the beach middens revealed the same types and frequencies of materials as those recovered from the underwater midden; however, the pollen from the beach midden indicated a marsh environment, while the pollen from the offshore midden reflected a predominance of arboreal species such as pine and oak (Ruppe', 1980). It is assumed that some change in eustatic sea level within the last 2,000 years has caused inundation of this site.

TERRA CEIA BAY SITE (SITE NO. 6)

Clay dredge material from Terra Ceia bay in Manatee County, Florida, was used to build a beach on the northeastern side of the bay. Subsequently, archaeological material and Pleistocene faunal material was discovered eroding from the clay beach.

The archaeological material includes projectile points; plano-convex turtle back scrapers; a hammerstone; chert flakes; and plain, sand-tempered, black pot shreds. Six of the ten projectile points recovered represent types similar to an Alabama Dalton Complex dating approximately 9,300 B.P. (Warren and Bullen, 1965). Three of the points are Greenbrier points, a Florida variation of the Dalton point.

The projectile points recovered from this site suggest a late Paleo-Indian to early Archaic site; while the pottery suggests a Woodland component.

Well-mineralized Pleistocene faunal remains recovered from the site include bison horn cores, fragments of mammoth teeth, turtle shell, manatee rigs, fragments of mastadon teeth, and shark teeth (Warren and Bullen, 1965).

No information on the paleogeography or stratigraphy of the bay at the dredge site was provided in the literature.

APOLLO BEACH SITE
(SITE NO. 7)

Dredge material from Tampa Bay, Florida, used as fill for a real estate development at Apollo Beach on the east side of the bay, has produced artifactual and some Pleistocene faunal materials. The dredge material came from a zone ranging between 1 meter below mean high tide (bay bottom), to 5.5 meters below mean high tide (the maximum depth of dredging).

Lithic material recovered from the dredge fill site includes projectile points, scrapers, knives, bifacial core choppers, unifacial core planes, one drill, flakes, worked flakes, and cores. Thirty-four of the 37 projectile points recovered were angle-notched and bifacially worked with little secondary retouching. Pot sherds representing the Orange (fiber-tempered), Transitional, Deptford and Perico Island Periods were also found at the Site (Warren, 1968 (a)). The artifactual material suggests that the original archaeological deposits in the bay is late Archaic to Woodland.

TURTLECRAWL POINT SITE
(SITE NO. 8)

Channel dredging to a depth of approximately 3 meters in Boca Ciega Bay, near St. Petersburg, Florida, produced Early Archaic and Middle to Late Archaic artifacts from apparently in-site archaeological deposits within the bay (Goodyear, et. al., 1980).

The base of the site, at approximately 3 meters below present mean sea level, is marked by the middle Miocene Hawthorn Formation, which locally contains abundant chert. A blue-green clay overlies the Hawthorn Formation and contains residual chert from that formation. Quartz sand overlies the clay layer. The stratigraphy of the dredge spoil pile matches the original geologic stratigraphy, indicating that the dredge first encountered the clay, then the overlying sand. This was explained by the fact that the dredge had intersected the clay deposit in the sloping valley wall of an ancient river channel, then, moving laterally and upward, had contacted the overlying sand deposit.

The Early Archaic material included four Bolen Beveled Point, Two Clear-Fork Gouges, a hafted spokeshave with graver spurs, flake scrapers, and three denticulates. A bifacially flaked adze was found that is similar to Early Archaic Dalton adzes.

The Middle to Late Archaic material included one Marrow Mountain Point, one Newnan Point, and two Florida stemmed Archaic points. Two columella shell gouges and the distal portion of a dagger-shaped tool made from a deer metapodial were also assigned to this late Archaic occupation. The shell gouges were radiocarbon dated to approximately 4,400 B.P. (A.C. Goodyear, personal communication, 1987).

Most of the lithic material is not of the local Hawthorn chert but of a chert foreign to the site. None of the lithics were water-worn, indicating that they had been dredged from in-situ archaeological deposits.

Shell material, mainly mercenaria, was present in the spoil pile. A subbottom profiler run just offshore of the point produced a low-amplitude, domed reflector immediately above the clay reflectors (S.B. Upchurch, personal communication, 1987). This was interpreted as a possible midden deposit and the probable source of the mercenaria found in the spoil pile.

Regional sea level curves indicate that sea level was 12 to 22 meters lower than present during the Early Archaic occupation, making this component an inland site approximately 13 to 28 km east of the coastline. The Early Archaic site is interpreted to have been a lithic procurement and tool manufacture area.

The Middle to Late Archaic component (ca. 7,000 to 4,000 B.P.) was probably coastal. If the domed reflector, observed on the subbottom profiler data, does represent a shell midden, the site function may have been shellfish procurement and processing.

TAMPA BAY SHELL DEPOSITS (SITE NO. 9)

Shell dredging in Tampa Bay has produced Pleistocene vertebrate fossils, artifacts, and one well-mineralized midsection of a human femur (Warren, 1972(b)). A survey of public and private roads constructed from the Tampa Bay shell resulted in an inventory of artifacts including flakes, scrapers, knives, and projectile points. Two of the projectile points, a side-notched Bolen point and a Beveled Bolen point are diagnostic of the Paleo-Indian Period in Florida. The shell itself is probably derived from prehistory shell middens in the bay.

CALADESI CAUSEWAY SITE (SITE NO. 10)

Draglines, dredging to a depth of 5.5 meters below mean high tide in St. Joseph's Sound near Clearwater, Florida, brought up artifactual material suggestive of a Paleo-Indian of Early Archaic lithic workshop. The dredge material was used to construct a causeway.

The ground surface of the causeway was covered with flakes and cores of silicified limestone, and three test pits dug into the fill material showed the lithic debitage to be extremely dense. Artifacts included hammerstones and crude, percussion-flaked knives (Warren 1968(b)). The only diagnostic artifact was the base of a crude, percussion-flaked Suwannee Point. Two other projectile points could not be precisely identified. One was made of mineralized bone, and the other resembled a Bolen Beveled Point, but also had characteristics of a stemmed Archaic point.

The crude percussion flaking of the artifacts and the base of the Suwannee Point suggest that the site represents a Paleo-Indian to Early Archaic Workshop. Like the Turtlecrawl Point Site, with sea level at 12 to 22 meters lower than present, this site would have been well inland of the coast at the time of occupation.

STORM HARBOR MARINA SITE (SITE NO. 11)

Just north of the Caladesi Causeway Site, and approximately 3 miles south of Tarpon Springs, Florida, another channel dredging operation produced artifactual material. The channel was dredged to a depth of 5.5 meters, and the fill was used as land fill adjacent to the dredge site. The surface of the fill material was littered with flakes and artifacts.

Artifacts recovered from the site include small bifacially worked tools (probable scrapers), a small drill, a thin, plano-convex knife or scraper, a high-crowned plano-convex scraper, two non-diagnostic stemmed points, and two small hammerstones. Diagnostic artifacts include Hernando Points, a Clear Fork Gouge, and two non-beveled Bolen Points, or Greenbrier Points (Warren, 1972(a)).

The original stratigraphy of this site has not been studied; therefore, the elevation of the stratum from which the artifactual material was derived is uncertain. The few diagnostic artifacts found in the dredge fill material range from Paleo-Indian to Late Archaic; therefore, the original archaeological deposit may be multicomponent. The debitage suggests a workshop area; however, a broader function of the site is not precluded.

ONE FATHOM SITE
(SITE NO. 12)

The One Fathom Site is a shell midden that lies approximately 0.5 miles seaward of the present beach near New Port Richey, Florida.

Archaic lithic material and Deptform Period shreds have been recovered from the midden deposit. This midden would have been subaerial until approximately 2,600 B.P. A minor sea level reversal would have re-exposed the midden deposit between 2,050 B.P. and 1,650 B.P. (Lazarus, 1965). The dates derived from the sea level curve are completely compatible with the diagnostic artifacts recovered from the midden deposit, and indicate that the site was probably abandoned due to rising sea level at approximately 2,600 B.P.

CHASSAHOWITZKA RIVER SITE
(SITE NO. 13)

This site is situated on the drowned bank of the Chassahowitzka River, Citrus County, Florida, at its confluence with a former tributary. The site has been severely deflated by tidal currents. All that remains are concentrations of archaeological material within pockets in the limestone bedrock at elevations of 0.5 meters to 2.5 meters below present mean sea level (R.J. Ruppe', personal communication, 1987).

Artifacts recovered from the site include Middle Archaic through Late Archaic projectile points, and ceramics dating approximately 1,400 to 1,100 B.P. (R.J. Ruppe', personal communication, 1987)

Results of the research on this site will be published in an upcoming issue of the Florida Anthropologist.

OFFSHORE CHERT OUTCROPS
(SITE NO. 14-17)

Archaeological investigations of chert rock outcrops within the coastal marsh and shallow offshore areas of the Apalachee Bay Region, Florida, identified ten prehistoric quarry sites. Six of the sites occur on the edge of the coastal marsh, but extend below the low tide line. Of the four offshore sites, three are partially exposed at low tide, and the fourth, the Econfina Channel Site (8TA531), occurs 5.5 kilometers offshore in the relict channel of the Econfina River. A detailed discussion of this site is provided in Mr. Michael Faught's paper, included in this proceedings.

Numerous coastal rivers in Florida have produced Pleistocene faunal material and Paleo-Indian artifacts. The best documented of these drowned river sites are the Page-Ladson Site in the Aucilla River whose basal levels are at 8.5 meters below present river level (J. Dunbar, personal communication, 1987); the Piney-Island Site in the Oklawaha River at 0.5 to 1 meter below present river level; and the Tarpon Point Site in the Mayakka River reported to lie at mean sea level, but which is inundated at high tide (L. Murphy, personal communication, 1987).

Like Warm Mineral Springs and Little Salt Springs, many other inundated Florida sinkholes have produced Pleistocene faunal material and archaeological material. Among these are Wakulla Springs, Silver Springs, Hornsby Springs, Devils Den, and Jughole Springs of the Ichetucknee River. With the possible exception of the Silver Springs Site (Hoffman, 1983), the association of faunal and archaeological material has not been demonstrated (Cockrell and Murphy, 1978(b)).

The sites discovered thus far suggest that there will be an abundance of archaeological material found off the coast of Florida and that these materials (including organics) will often be well preserved. The sites will probably concentrate in the vicinities of sinkholes, relict fluvial channels, relict estuarine deposits, and outcrops of cryptocrystalline rock. Information contained in these sites may provide important information on prehistoric human migrations, settlements patterns, subsistence strategies, and cultural contacts across now-submerged landmasses.

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A Consideration of Archaeological Wetsites

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INTRODUCTION

Archaeological "wetsites" are by definition locations where remnants of past human activities are preserved in saturated or nearly saturated settings. The biggest contrast to the typical terrestrial site is in the often excellent preservation of organic materials, difference in excavation techniques, and the necessity of careful conservation (chemical treatment) of virtually all recovered materials.

Archaeological materials can enter saturated settings in several ways. Materials can be intentionally placed in saturated settings such as apparently occurred at Windover, a burial area in east central Florida. Materials can be accidentally discarded or lost in wet settings. In some cases, originally dry sites can be covered with water or organic or other soils that effectively seal the moisture in and limit decay.

PRESERVATION IN WETSITES

Preservation of organic materials, in particular, is what provides much of the scientific potential of many wetsites. The nature of materials recovered in wetsites is dependent upon both what materials are deposited and what materials survive. In many terrestrial sites, organic materials do not survive unless they are carbonized.

Wooden artifacts, stakes, grinding tools, awls, canoes, nets, carvings, baskets, fabrics, etc., appear to be preserved in acidic, basic, and chemically neutral saturated soils (Cushing, 1987; Gilliland, 1975; Beriault et al., 1981; Sears, 1982; Purdy, 1979,1981,1987; MacDonald and Purdy, 1982).

Preservation of soft tissue, in the form of the bog bodies of Europe, is characteristic of acidic bogs where a natural tanning process takes place. Stomach contents, leather, fabric, and other materials may survive (Fischer, 1980; Glob, 1969). Although such acidic bogs exist in the New World, chemical differences, perhaps related to the plants comprising the bog habitat itself, have not produced tanned bodies. Efforts to extract DNA from an English bog body failed and indicate acid bog settings are not conducive to some of the kinds of research that are possible with New World materials (Hughs et al., 1986).

Virtually the only New World parallels in the preservation of soft tissue in wetsites are in the preservation of brain tissue in a number of Florida locations--Windover, with over 90 individuals; Warm Mineral Springs (Royal and Clark, 1960); Bay West (Beriault et al., 1981); Republic Groves (Wharton et al., 1981); and the historic St. Marks Cemetery (Dailey et al., 1972.)

Plant materials (stems, seeds, leaves, pollen, etc.) are common in wetsites and can provide excellent archaeological, climatological, and environmental data (Alexander, 1986; Brooks et al., 1979; DePratter and Howard, 1981; Levathes, 1987; Watts, 1971,1975,1986; Spackman, 1987; Stout, 1986). Preservation of bone, antler, and shell generally requires pH conditions approximating neutrality (Nabergall, 1987).

Stone and ceramic artifacts survive in most wet or dry settings with very little if any deterioration.

WHERE ARE WETSITES FOUND?

Wetsites are more abundant in areas where human activity concentrated, and they can be found in river channels, particularly large, relatively slow moving streams with sand or muddy bottoms that may provide some physical protection to any deposited materials (Cockrell, 1980; Dunbar and Waller, 1983; Waller, 1969). Within the floodplain of water courses, the lower levels of some terrestrial sites may be saturated and can also be classified as wetsites (Purdy, 1987; Jahn and Bullen, 1978).

Some coastal sites are saturated as a result of inundation after deposition (Ruppe', 1980) while others represent events and activities that took place in coastal waters (Cockrell and Murphy, 1978). Shipwrecks are clearly not the only type of coastal wetsites, though they have received the bulk of the attention (Marmelstein, 1975; Marx, 1969).

Wetsites can also be found within lakes, ponds, and springs (Cockrell, 1973; Clausen et al., 1975; Clausen et al., 1979). The Windover materials were approximately 10 ft. below pond bottom in a small 1/4 acre freshwater pond on the east central coast of Florida (Brevard County-Doran, 1986; Doran and Dickel, 1986).

Saturated, but not necessarily submerged, organic soils (peats in particular) are characteristic of wetlands, and the past bogs of Europe are also well known for their archaeological productivity.

At the simplest level, the presence of moisture reduces the physical stress on materials (particularly organic materials) by limiting the frequent hydration/dehydration cycle, which promotes deterioration by expansion and contraction (Stone et al., 1986).

The dynamics of water and/or soil chemistry are also critical in preservation. At Windover and Warm Mineral Springs, Florida, very hard, highly mineralized waters promote preservation. Highly acidic saturated peats have already been mentioned with respect to soft tissue preservation, but at the same time, very acidic conditions can "dissolve" the underlying bone as well as the molecular integrity of some molecules such as DNA (Hughs et al., 1986).

Low oxygen levels (reducing environments) also enhance preservation by limiting the biological activity of decomposing bacterial and fungal organisms.

The physical stability and integrity of the matrix (soil) in which such materials are deposited is also important. Increased movement of materials downslope or across coarse surfaces increases destruction, as will water movement and wave action. At Windover, no fabrics and relatively few articulated skeletal segments were recovered from sloping pond areas. In these locations materials were slowly but inexorably sliding downslope. Where the pond bottom was flatter, approximately 100 articulated burials were recovered, and 37 burials contained had woven fabrics.

Other factors, such as temperature, may also be important. Decay processes of fungi and microbes are reduced at lower temperatures, and this may partially explain the preservation of bog bodies in Europe. Some materials, such as stone artifacts and pottery, are relatively stable, but organic materials are subject to the interplay of changes in moisture levels, temperature, water, and soil chemistry.

Some chemical changes, referred to as digenetic changes, can be precursors to fossilization and involve absorption or depletion of compounds and elements from the soil matrix (Walker and DeNiro, 1986). If the mineralogical component is depleted (demineralization), rapid deterioration can occur. Mineral compounds can also replace organic compounds, and this mineralization, while promoting physical survival, may preclude some chemical and elemental analysis (Buikstra and Mielke, 1985).

At Windover, preliminary analysis of preserved brain tissue indicates a replacement process elevated sulphur levels. Microscopic and macroscopic features are still preserved, as is some molecular structure (Doran et al., 1986). Elemental analysis of bone samples (Hancock, 1987) indicates an abnormal absorption of strontium, obviating some dietary inferences based on trace element analysis (element reference). At the same time, some bone proteins appear well preserved enough for researchers to attempt to develop a biological profile of this 7,000 year old population (Tuross, 1987).

In some wooden artifacts the long fibers providing structural integrity breakdown and conservation becomes difficult. Warping, splitting, checking, and deterioration became problematic. Materials less than 2,000 years old seem to exhibit relative stability while the materials from Windover are more difficult to preserve (Gardner, 1986).

WETSITE DISCOVERY

Archaeological sites (both wet and dry) are often accidentally discovered as a result of construction or other ground disturbing activities. It could be argued that proportionately greater numbers of wetsites escape the attention of archaeologists than dry sites, simply because they are less visible and less accessible.

In addition to accidental discovery, many dry sites are found during archaeological surveys that are designed to identify sites prior to construction or development, as part of cultural resource management programs. Archaeological assessments or surveys are legally required in cases where state or federal property is involved (Tesar, 1986). Survey programs are less effective in wetland and underwater settings.

A large problem in locating wetsites lies in their almost invisible nature and the frequent necessity of entering a "hostile" environment to locate them. Wetsites are either underwater, thus creating problems of simple access, or they are difficult to identify because of the water saturated conditions existing in bog, marsh and lake settings. Literally millions of dryland acres have been surveyed by archaeologists, but only a fraction of the areas with potential wetsites have been effectively studied.

CONSERVATION NECESSITIES OF WETSITE INVESTIGATION

Wetsite investigation is often more difficult and involved than the investigation of a typical terrestrial site. Different excavation strategies may be needed, and the waterlogged condition that preserves materials necessitates special conservation techniques. Some of the Windover procedures will be presented as examples of the conservation requirements necessitated by analytical goals as well as the nature of the materials.

Saturated faunal and human bone was removed from the field in plastic bags and, as rapidly as possible, treated with bulking agents that replaced the water. Initially, polyethylene glycol (PEG) was utilized, but an acrylic emulsion, Rhoplex AC-33 (Conservation Materials, Sparks, Nev.), proved more satisfactory. Small samples of human bone were also removed and frozen for specialized chemical and protein analysis. Concern that molecular changes were continuing to take place even after conservation prompted removal of larger bone samples, which were frozen at -70 centigrade (Tuross, 1987).

Floral materials (seeds, leaves, wooden artifacts, etc.) involved a variety of conservation procedures including refrigeration; alcohol saturation; and treatments with PEG, Damar, and other compounds (Stone et al., 1986). Refrigeration (in sealed containers) reduces the possibility of bacterial or fungi decay and minimizes dehydration. Woven fabrics (made from plant materials) and wooden artifacts undergo a multistep procedure similar to that applied to wooden artifacts. This procedure involves refrigeration, removal of mineral salts by soakings in deionized water, and replacement of water with alcohol/ethulose/PEG solutions. None of the fabric materials has completely passed through the conservation sequence as of December 1987, even though some began treatment over a year ago (Adovasio, 1986).

Brain tissue was rapidly removed, placed in plastic bags, flooded with nitrogen gas, sealed, refrigerated for transport and frozen at -70 centigrade within 24 hours to minimize possible degradation and maximize future analysis possibilities.

Clearly, one of the most profound obligations wetsite investigation entails is a willingness to ensure that the materials recovered are conserved properly, not only for current research needs, but also for future research (Purdy, 1974; Stone et al., 1986).

ACCOMPLISHMENTS OF WET SITE INVESTIGATION--WINDOVER AS AN EXAMPLE

Some have estimated that over 80 percent of most societies' "artifacts" are organic and may not survive in normal archaeological settings. The opportunity to study materials from wetsite settings can provide a much greater understanding of earlier populations and are illustrated by the multidisciplinary research efforts of the Windover Archaeological Research Project.

Excavation at Windover required installation of an extensive wellpoint system (approximately 160 wellpoints between 11-21 ft. in length) which pumped 700 gallons of water per minute 24 hours a day for the first several months of excavation. This demonstrates that dewatering of some wetsites is possible and practical.

The collection, representing a minimum of 155 adults and subadults, is one of the largest samples of human skeletal material of this antiquity in the New World (Taylor et al., 1985; Smith, 1976; Protsch, 1978). The collection dates from between 7,000 and 8,000 years B.P. (before present - A.D. 1950) and represents an Archaic hunting-gathering population (Milanich and Fairbanks, 1980; Smith, 1986; Steponaitis, 1986; Ford, 1985). Data on health, diet, disease, demography, etc., in some ways, represents "base line data" useful in looking not only at human adaptation in this early time, but also as a valuable comparative reference point for understanding later populations' adaptation (Dickel, 1987).

The fabrics from Windover, exhibiting seven different twining and manufacturing techniques, are the oldest fabrics in the southeastern United States and are regarded by some as the largest, most complex set of fabrics of this time period in the New World (Adovasio, 1986). Analysis of the fabrics, bone, antler, stone and wooden artifacts will provide new insights to early craft sophistication.

Plant remains identified as the semidomesticated bottle gourd (Lagenaria siceraria; Newsom, 1987) are the oldest known bottle gourd materials in North America (Smith, 1986; Conrad et al., 1984; Richardson, 1972; Kay et al., 1980). These findings support the proposition that the earliest North American domesticates are tropical plants, and, even at this early date, relations between populations may have been more complex than realized (Ford, 1985).

Identification of preserved human mitochondrial DNA from Windover brain tissue yielded the oldest identified human genetic materials indicating that in some situations molecular analysis of archaeological materials may be possible (Doran et al., 1986).

Study of the preserved bone proteins and amino acids, including (but not limited to), osteonection, transferrin, albumin, IGG, IGN, IGA, methionine, and cystine, provide a unique opportunity to develop a new type of biological profile of an archaeological population. Further studies of these materials should expand our understanding of prehistoric human biology and population relationships (Tuross, 1987).

Detailed analysis of faunal and floral materials are providing data critical to understanding hydrological, climatological, and environmental changes in east central Florida for the last 11,000 years (Newsom, 1987; Nabergall, 1987; Holloway, 1985a, 1985b; Stout, 1986; Spackman, 1987; Flowers, 1985; Frazee, 1986).

THREATS TO WETSITE SURVIVAL

Wetsites, like all archaeological sites, are consistently being destroyed by both natural and human agencies. Natural changes in hydrology and water and matrix chemistry, as well as natural exposure of wetsites by wave action, erosion, etc., can destroy archaeological sites. Some of these destructive agents are beyond normal human control. Some destruction is, however, avoidable, if the importance of the unwritten saga of human experience is recognized, and steps to protect and study such sites are taken.

Urbanization, pipeline construction, dredging, and other coastal and wetland modification are increasingly involving areas containing archaeological materials. If sites can be recognized and activities shifted to avoid sites, such construction may be beneficial in that wetsite locations may be better understood. Furthermore, if such accidentally discovered sites can be investigated, we all benefit.

An invisible threat exists when large scale hydrological patterns are changed for farming, ranching, and other land use needs, and previously saturated areas are dehydrated (Coles, 1984). Archaeological materials below the surface begin to undergo an inexorable dehydration that can eventually lead to total destruction. The loss of these invisible resources is in some ways the most frightening prospect of all. In some areas of the world, such land use changes are associated with peat mining for electrical energy production. Coles has noted that most of the archaeological materials in the Irish National Museum were recovered from wetsite settings (Coles, 1986). As peat is mined without a consideration of the archaeological loss the prospects for understanding many aspects of Ireland's past become increasingly difficult. Coles fears that by the turn of the century the wetsites heritage of Ireland will be irrevocably lost.

Regrettably, intentional relic collecting, without a consideration of the archaeological significance, site integrity, or the potential contribution to our body of knowledge, continues in many areas. In some states, legally sanctioned salvage of archaeologically significant coastal wrecks amounts to little more than pot hunting when insufficient consideration of the scientific importance of the materials exists. This is especially graphic when materials are auctioned off to the highest bidder or the "booty" divided up among investors. Some states, such as Florida, have virtually assured continued pillage by treasure hunters. Other states, like Texas, deem the scientific value of coastal materials sufficiently important to restrict such activities within their coastal waters.

Archaeological sites on state and federal property are protected by state and federal antiquity statutes. Literally millions of dollars are annually spent on seeing that this priceless heritage is not wantonly destroyed. By and large, sites on private property are afforded virtually no protection. Regrettably, even when owners are cooperative, investigations are severely impeded by the lack of funds for proper scientific treatment of these important legacies of human experience.

ARE SOME AREAS MORE LIKELY TO PRODUCE WETSITES THAN OTHERS?

While reliable models capable of predicting wetsite locations are relatively crude, some generalizations about possible locations of wetsites may be helpful.

In North America, wetsites discovery would seem most likely in areas that have been submerged in the last 12,000 years and are, or were, in relatively low energy settings where conditions for preservation may be better. Areas that are rich in organic soils (peats and related soils) may contain significant archaeological materials. When such areas were frequently inhabited or visited by prehistoric and historic peoples, the possibility of wetsite occurrence increases. Submerged peatlands, stream channels, estuary and bay margins would be likely to contain saturated archaeological materials.

During the course of construction, dredging, etc., the following kinds of materials might be discovered:

- large wooden artifacts (stakes, canoes, etc.)
- human skeletal material (bones of the leg and skull are the largest and probably the most noticeable)
- pot sherds, charred bone, fabrics, and small wooden artifacts (these would be very difficult to casually identify in dark peaty soils)
- stone artifacts (although small, if they are a light color they could be distinct against a dark peaty soil)

Any observed materials should be collected and resubmerged in water; further impact to the site should be minimized if at all possible; the location or general area they came from recorded, and an archaeologist contacted as rapidly as possible.

Pragmatic observers have shrewdly noted the media attention that can result from such discoveries and subsequent investigations can create a very positive public image for a company or industry. Local business may also benefit from the increased tourism such sites may generate. Careful planning can also incorporate tours of the site by local dignitaries, school groups, civic organizations enhancing education about archaeological resources. We estimate in the three years of excavation (August - Jan.) between 10,000 and 15,000 people visited Windover. On the Open House Weekend at Windover over 4,000 people visited the site. Needless to say, such public interest requires forethought and planning.

This is almost the exact scenario that began in 1982 when the Windover site was discovered. The accidental discovery, shifts in construction routes, involvement of archaeologists, and the discoveries of the last three years have been reported worldwide. As a result, thousands of central Florida citizens are better informed and more aware of the rich Florida archaeological heritage.

Recognition of the significance of archaeological resources is no guarantee that they will be safe, but it is the first step. Only through enlightened management and understanding of the potential of wetsites to vividly and uniquely reveal the saga of human existence will our prehistoric heritage be safe.

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Results and Implications of the Multidisciplinary Archaeological Research Project at Warm Mineral Springs, Florida

Mr. Wilburn A. Cockrell
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Warm Mineral Springs is a 70-meter-deep, spring-fed sinkhole 16 kilometers inland from the Gulf of Mexico in Sarasota County, Florida. Saline, anerobic water, originating in the Floridian Aquifer some 1,000 meters below surface, enters the cenote at a depth of 70 meters below water surface at a temperature of 32-34 degrees C. The principal hot water spring provides some 19.4 million gallons per day.

The cenote's limestone walls are draped intermittently with dripstone formation zones from 4 to 30 meters below surface; additionally, the underwater sediments have been producing exotic tufa specimens. The limestone matrix is of the Hawthorne Formation of the Miocene.

There are three archaeological components: 1) the remains located on land, 2) dry-laid deposits on the 13-meter-below surface ledge, and 3) deposits in the debris cone on the bottom below 40 meters.

Recovered archaeological deposits range from Formative Stage artifacts (ethnographic present back to approximately 2,500 B.P.) artifacts from the Archaic Stage (2,500 B.P. to approximately 8-9,000 B.P.), and Paleo-Indian Stage materials dating back thus far to 11,000 radiocarbon-years B.P.. The oldest human remains stratigraphically and chronologically coexist with ground sloth, saber cat, horse, camel, and extant species. Well-preserved botanical remains provide a continuous record extending back an estimated 30,000 years from the initial opening of the cavity during a time of lowered sea level.

Current research is principally conducted on the 13-meter ledge and on the debris cone 50 meters below surface. Both SCUBA and surface-supplied air have been used. Technology consists of time-honored archaeological techniques coupled with innovations, when need dictates. Mixed gas diving with surface decompression on oxygen is planned for the upcoming dive season in order to increase bottom time and diver safety.

Warm Mineral Springs and related sites have long been seen by the principal investigator as furnishing primary critical data for predictive modelling for site location on the Outer Continental Shelf. 1 In 1973 the Bureau of Land Management was first informed of the research value of this type site, and subsequent papers have continued to emphasize the technical and scientific applications of the Warm Mineral Springs research.

Phase I of the writer's research as principal investigator was conducted as Florida State Underwater Archaeologist from 1972-1983; Phase II began in 1983 and continues, funded by the Florida State Legislature currently through Florida State University's Department of Anthropology.

Mr. Wilburn A. Cockrell is the Director of the Warm Mineral Springs Archaeological Research Project, Florida State University. He holds a B.A. in anthropology (University of Alabama, 1963), an M.A. in anthropology (Florida State University, 1970) and has completed all but dissertation for his Ph.D. in anthropology at Arizona State University. He began Phase I research at the 12,000-year-old prehistoric site at Warm Mineral Springs as Florida State Underwater Archaeologist in 1972; Phase II of his research began in 1983 and continues, funded by the Florida State Legislature. He has published extensively on early man studies and submerged terrestrial sites, as well as shipwreck archaeology and related legal issues.

Some Archaeological Sites in the Apalachee Bay of Florida

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The results of our survey showed relevant lithic artifactual materials in 4 of 5 outcrops located. Of these, 3 are found close to shore, in more than 6 feet of water (WA 275, 267, JE654). More significantly, a relict channel of the Econfina River was identified in 12 feet of water 2.5 miles offshore, and significant numbers of artifacts, including bifacially trimmed cores and numerous flakes were found at its margins. In no cases were overlying neritic sediments more than 15 cm, and the relict channel was easily identified by its depression and the lack of plant material in it. Associated with the lithic debris were pieces of cypress wood which dated to 5,160 ± 100 bp (A-4696 University of Arizona and NSF grant BNS 8505083).

The results of this survey have substantiated our ideas of the ease of identity of relict features in inundated karst geomorphology, the technique of finding outcrops as lithic procurement areas, and the potential of finding other kinds of prehistoric settlements. The goals of our next season are to continue identification of relict channels, search for sea level standstills, and obtain core samples of river stratigraphies. Two other sites (JE 652, 653) have been added since our initial survey, and we expect to find many more.

Many anthropologists who are concerned with reconstructing the transition from Paleo - Indian to Archaic adaptations are in the same boat with Quaternary geologists who are interested in the transition from Pleistocene to Holocene time: both are acutely aware of the reality of sea level rise and the need for more data from now inundated continental shelves. Missing data include information about relict geomorphology, past human settlement patterns, and the timing and effects of sea level rise on them. While much work has been published about the extent, character, and timing of sea level change (Bloom, 1977, 1983; Morner, 1971; Ruddiman and Duplessey, 1985, for samplers), the archaeological literature is virtually empty of reports of the inundated shelf sites, particularly from late Pleistocene early Holocene context (see Flemming, 1983 for survey). This paper reports the findings of mid-Holocene relict geomorphology and archaeological sites in the Apalachee Bay of Florida, and suggests the high potential of finding many more, including terminal Pleistocene ones.

To suggest that continental shelves represent a missing and potential data set is not to understress the difficulty of finding either relict topographic, geologic features, or archaeological sites. Wave destruction, and Holocene alluvial, and nertic sedimentation are significant processes in the obscuring of Pleistocene details (Flemming, 1983; Emery and Edwards, 1966; Coastal Environments, 1977). These facts, in combination with the logistics of working underwater, can be offset by locating research in areas with minimal alteration since the Pleistocene, by relevant stratigraphic data, and by adequate archaeologic potential (i.e. high density sites of relevant time periods), thus ensuring cost-effective, multidisciplinary research activities. The Apalachee Bay of northwestern Florida is just such an area (Figure 12.2).

A pilot survey by J.S. Dunbar (Florida Department of State), M.K. Faught (University of Arizona), and PART of Florida (a competent amateur organization) was undertaken in July of 1986 to assess the potential of finding offshore archaeology and geomorphology. Our survey area included the nearshore regions of the St. Marks, Aucilla, and Econfina Rivers of the Apalachee Bay. The associated onshore region, the Ocala Uplift, is a raised karst feature with the Floridian aquifer at the surface. High density extinct faunal remains and Paleolithic to Archaic lithic artifacts are well known in the region (Neil, 1964; Dunbar and Waller, 1983), and are currently under professional underwater excavation (Dunbar, et al., In Press). Alluvial sedimentation in these rivers is rare because of the solution characteristics of karst drainage, and sinkholes within the onshore rivers collect quiet water peat and marl sediments, with a high degree of organic preservation. Most terrestrial rock outcrops are the loci of dense chert, and are likely spots for prehistoric lithic procurement. Our survey procedure was to locate inundated wreck outcrops and hand fan the neritic sediments while looking for artifacts. This kind of research was predicted, if not actuated, by the work of Ruppe' (1980), farther south in Venice, Florida.

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Mr. Michael Faught is a graduate student currently pursuing his doctoral degree at the University of Arizona. His research interests include problems of the peopling of the New World, Quaternary geology, and underwater archaeology. He is currently involved in the location and excavation of inundated archaeological sites in the Apalachee Bay area of Florida.

Preliminary Archaeological Investigations at Ray Hole Spring

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In early October 1986, the Minerals Management Service (MMS), in cooperation with the Florida Bureau of Archaeological Research (FBAR), conducted a preliminary underwater archaeological investigation and testing program at Ray Hole Spring. FBAR first became interested in Ray Hole Spring through interactions with the sport diving community from the Tallahassee area. Several sport divers contacted Mr. James Dunbar of FBAR, suggested that the spring may be an archaeological site, and offered to take him to the spring. The MMS was working with the State of Florida and FBAR with mutual research interests in locating the prehistoric archaeological potential of Ray Hole Spring. The two agencies put together a low-budget, cooperative research effort to conduct a preliminary archaeological investigation.

Ray Hole Spring is a submerged karst feature located on the OCS approximately 88.5 kilometers southeast of Tallahassee, Florida, and about 38.6 kilometers from the nearest Florida landfall. The spring is a typical karst feature probably formed during the Pleistocene as a result of the surface limestone collapsing or solutional or mechanical action caused by underground drainage (Glossary of Geology, 1974).

A 1976 Florida Bureau of Geology bulletin titled "Springs of Florida" describes Ray Hole Spring as an occasionally flowing spring lying in 11.6 meters of water and measuring 7.6 meters in diameter. The north side of the sink slopes southeast and the southeast side of the sink has a nearly vertical limestone wall to a depth of 18 meters. A cave strikes down and southeast from the 18 meter depth to approximately 30 meters (Figure 12.3).

The October 1986 investigation of the spring by MMS and FBAR revealed a totally different environmental setting at the site. The diving reconnaissance indicated that the spring has almost completely filled in with recent (since 1976) marine shell detritus. Only about 3 meters of relief exist in the southeastern end of the sink. The archaeological investigation of the site included diver swimming reconnaissance, mapping, attempts at coring, and waterjet excavation of selected test units. Coring was discontinued because the coring tool made very little penetration in the shell matrix as a result of the small core diameter and the large size matrix of the marine shell detritus.

After negative results from Test Units 1 and 2 and Core Tests 1 and 2, testing was moved to the outer rim of the sink. The rim of the sink has a thin layer of carbonate sand underlain by limestone rock. The MMS and FBAR dive team began excavating with the waterjet at a large crevice. Our initial theory was that if this was an archaeological site that some cultural material may have fallen or may have been washed into one of the many crevices around the edge of the sink and become trapped. The crevice we selected measured approximately 15 centimeters in width and was oriented in a southwesterly direction towards the rim of the sinkhole. Waterjet excavation, approximately 15-20 centimeters into the crevice, recovered several probable, culturally-modified limestone or chert flakes. This material was returned to the surface for examination. Continued waterjet excavation of the crevice yielded a lens of articulated whole oyster shell at the 75 centimeters level; at 1-meter depth, waterlogged wood was encountered. Samples of the shell and wood were collected, returned to the surface, and stabilized for future analysis. Below the point where the wood samples were recovered, the crevice narrowed and bottomed out. Excavation was terminated as was the initial archaeological testing.

In April 1987, analysis was conducted on the oyster and wood samples to identify the species and to obtain a radiocarbon date of this organic material. The wood species was identified as live oak, and radiocarbon dates for the oyster shell and wood were dated 7,390 ± 60 years B.P. and 8,220 ± 80 years B.P., respectively. The wood sample dated approximately 1,000 years older than the oyster shell and was recovered in a lower stratigraphic level than the oyster shell, which suggests that these organic materials were deposited *in situ*.

Preliminary analysis of the data collected at Ray Hole Spring suggests that this sinkhole may be a prehistoric archaeological site. Several factors (environmental and possibly cultural) tend to support this initial contention. The radiocarbon dates obtained at Ray Hole Spring in combination with the regional sea level curve (Figure 12.4, CEI, 1983 and 1986) indicate that approximately 8,200 years ago B.P. the sinkhole was a freshwater site supporting freshwater flora. Some time after 8,200 B.P., the sea level began to rise, and by approximately 7,400 B.P., the Ray Hole Spring area was supporting a shellfish population in a brackish water environment.

In addition, a cultural manifestation may exist at Ray Hole Spring. The two large limestone/chert flakes that were collected were examined by five archaeologists. They all seem to agree that the way the flakes were removed from the lithic core suggests that these flakes could have been produced by prehistoric man. However, they also agree that just two flakes alone usually do not constitute an archaeological site (Figure 12.5, depicts one of the potential decortication flakes).

Obviously, there is more work to be done to verify Ray Hole Spring as an authentic archaeological site. This includes a proper level of funding to conduct an intensive testing program, remote sensing studies to determine the true depth and profile of the sinkhole, coring of the sediment cone to gather paleoenvironmental data, more organic sample collecting for radiocarbon analysis, and, hopefully, the recovery of diagnostic lithic artifacts.

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Archaeological Sites in the Drowned Tertiary Karst Regions of the Eastern Gulf of Mexico

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INTRODUCTION

Prehistoric archaeological sites inundated by the sea are the most elusive sites to locate. They may be deeply buried and inaccessible in some regions of the continental shelf and may be shallow but difficult to identify in others. The karstic area of the Florida Gulf Coast represents a unique archaeological area where Paleo Indian remains are highly concentrated and sedimentation has been minimal. The number of Paleo Indian sites located in inland freshwater and terrestrial locations is substantial, but few offshore sites have been located because marine growth and weathering have tended to conceal site locations.

Given the difficulties associated with locating offshore sites, a model based on the type and distribution of sites on the adjacent coast was employed in the Apalachee Bay region of the Gulf of Mexico offshore survey work (reports by Faught and Anuskiewicz this session), incorporating the assistance of fishermen and sport divers familiar with the project area. In three days, Mike Faught's survey located four archaeological sites from one to four miles offshore. Rik Anuskiewicz and Melanie Stright surveyed Ray Hole Spring some 20 miles offshore and discovered evidence of what may prove to be a drowned archaeological site.

ARCHAEOLOGICAL AND GEOHYDROLOGICAL BACKGROUND

As early as the late 1930s, unusual underwater discoveries, including partially articulated mastodon remains associated with stone tools, were being investigated in Florida (Jenks and Simpson, 1941). Almost thirty years later, Wilfred Neill (1964) introduced the "Oasis Hypothesis," proposing that some underwater artifact concentrations represented drowned terrestrial sites. Geologist Kelly Brooks (1973a & b) believed that the availability of surface water for drinking fluctuated so radically over the last 15,000 years that it impacted prehistoric populations. He proposed that potable water existed as climate-dependent, parched systems (intermittent ponds, lakes, etc.) or as exposures of the drought-tolerant Tertiary limestone aquifer system--the Floridian aquifer.

Perched water tables occur as localized systems in some areas of Florida, but quickly shrink if extended droughts starve modern water budgets. In geologic time, long term trends have shifted from arid to wet, and vice versa; thus perched systems have been intermittently turned on and off. When perched water systems existed, the abundance of surface water increased; therefore, settlement options and site distributions became more widespread (Dunbar and Waller, 1983).

Even though the massive Floridian Aquifer is drought tolerant, it has fluctuated with sea level, having low stands during glacial phases and near present or higher stands during the interglacial phases of the Pleistocene (Webb, 1974). Glacial stage water tables as low as 48 meters below present occurred prior to the human habitation of Florida (Brooks, 1967). Investigations of the inundated Devils Den and Little Salt Springs sites revealed that the aquifer was greater than 25 meters below present water level, when human activity was taking place (Webb, 1974 and Clausen et.al., 1979). Parched water systems were greatly reduced during dry climatic phases, and as a result, site distributions were restricted to areas with persistent supplies--mainly aquifer locations (Dunbar and Waller, 1983).

Prehistoric site distributions in Florida occurred in changing patterns not only linked to evolving technologies but to fluctuations in regional surface water systems. The availability of potable water in relation to other needed resources helped dictate possible site locations through time (Dunbar and Waller, 1983). There are three major geohydraulic regions in Florida (Bush, 1982) where potable water supplies varied with climatic changes:

1. The OUTLYING REGION, where the Tertiary limestones are buried by more than 35 meters of younger sediment. A region rarely breached by sinkholes, potable surface water occurs in local, climate dependent, perched systems. Lithic resources for tool production are rare to non-existent.
2. The MARGINAL REGION, where the Tertiary limestones are buried up to 35 meters deep. This region is breached by open sinkholes that penetrate the overlying sediment to expose the limestone. Limestone exposures may occur above but more often below present water tables. Lithic resources

include chert bearing Tertiary limestones and opalized inclusions in the Hawthorne Formation. Lithic resources are not abundant.

3. The TERTIARY KARST REGION, where the limestone occurs near or at the ground surface. The Tertiary limestones of Florida hold one of the nation's largest grown water systems--the Floridian Aquifer. The Tertiary limestones also contain the best and only major chert rock resource in Florida.

Ninety percent of the Paleo Indian sites containing Clovis, Suwannee or Simpson projectiles are located near karst depressions that penetrate the Tertiary limestones of Florida (155 of a total of 172 sites). The Tertiary Karst Region has 71 percent of the sites, the Marginal Region 17 percent of the sites, and the Outlying Region 12 percent of the sites (Figure 12.6). Some sites are located around isolated sinkholes and solution depressions (9 percent), but most occur in areas where multiple karst features occur together and dominate the topography (81 percent). The largest site clusters are located n and around mature karst river channels (60 percent) with smaller but significant clusters centered around karstified lakes, bays, and prairies (23 percent). In Florida, the distribution of Clovis/Suwannee sites indicates settlement patterns were centered where natural resources were most abundant, particularly drinking water and lithic supplies (Dunbar, 1987). For example, natural resource availability in karst river systems has been expressed as a hypothesis for archaeological testing:

> "The river basins in the (two) Tertiary karst regions of Florida have the greatest concentration of Clovis/Suwannee Paleo Indian sites because unique environmental conditions created natural resource accumulations that complemented technology and subsistence behavior. Stable habitats in the karst regions supported grazing animals but drought intervals confined game herds to oasis locals. During droughts, oases in the karst river bottoms offered water, food, bone, and lithic resources for Paleo Indian exploitation. As a result, major site clusters in Florida became centered around rivers like the Santa Fe and Aucilla because multiple resources were available, and repeated exploitation could be supported. During wet periods when intermittent water sources existed above the river valleys, game herds dispersed, and with them mobile hunting groups. Thus a semi-sedentary Paleo Indian life way may have existed with prolonged river camp occupations and less frequent periods of high hunter/gatherer mobility" (Dunbar, 1987).

The geohydraulic history of the Tertiary Karst Region has been dynamic, including the Holocene (ca. 10,000 years ago to present) inundation of many former land areas by transgressing seas or inland water table rises. The Inundation of sites in karstic terrain has promoted good organic preservation and, as a result, promises to yield some of the most informative archaeological remains in the eastern United States. The potential for major archaeological discoveries seems as great offshore as those that have been made inland in sinkholes, springs, and in karst rivers like the Aucilla.

THE AUCILLA RIVER AREA AS A MODEL TO LOCATE OFFSHORE SITES

The Aucilla River is a limestone entrenched river system that flows into the central area of Apalachee Bay. The mouth of the river is located about 50 miles southeast of Tallahassee, Florida. Since 1983, several research expeditions have been conducted in the Aucilla River, including its tributary, the Wacissa River. Numerous land and underwater sites have been recorded. Major research has been conducted on the Page/Ladson site (8Je591) located in the Half Mile Rise section of the Aucilla River. The underwater component of the Page/Ladson site has reveled a stratified sequence some 4 meters thick with in-situ cultural levels 9,500 to 12,000 years old (Dunbar, et.al., In Press).

In the Aucilla River area, Paleo Indian site locations occur in predictable patterns. Large sites are located adjacent to and in river channel segments that are breached by sinkholes. Small or infrequently used sites occur in, around, and away from the river, sometimes around isolated sinkholes. Flint (chert) quarry areas are located in a number of locations, including in the river channel, around sinkholes, and in the surrounding karstic terrain, where erosion resistant chert boulders protrude above the flat coastal terrain.

Prehistoric sites in the flat terrain near the Aucilla River are difficult to locate. Fortunately, any of the most interesting sites are located around obvious features such as chert rock outcrops, sinkholes, and in the river basin.

THE PREDICTABILITY OF OFFSHORE SITES IN APALACHEE BAY

The search for offshore sites becomes much easier if one can locate inundated sinkholes, river channels, and chert rock outcrops as convenient guide posts. The irregular topography associated with these features attracts fish and other marine life which, in turn, attract fishermen and sport divers. Many potential site locations have already been pinpointed. In Apalachee Bay and along the Gulf Coast to Tampa Bay, there are hundreds, probably thousands, of topographic targets to inspect.

The need to conduct offshore archaeological research is overdue. Other than our cursory survey (which did demonstrate numerous sites exist), no meaningful work has been attempted in the Tertiary Karst Region of the Florida shelf. Much of the karst area is environmentally sensitive with numerous sea grass beds and rock outcrops representing breeding areas for marine life. The knowledge we have gained about the marine environment, in all its subtle detail, has been gathered by extensive scientific investigation. Conversely, the archaeological resource has been ignored and is rarely acknowledged and almost never studied.

If we are to fully understand the archaeological potential in the Tertiary Karst Region of the eastern Gulf of Mexico, basic archaeological research questions must be answered. Not only are these research questions important to archaeology in general but also to resource managers who need information to properly manage offshore resources. Therefore, future research on the karstic Florida shelf should consider the following questions:

1. At given points in time from 15,000 to 5,000 years before present, can absolute sea level stands be identified to allow chronologically evolving site predictive models? Coring sinkholes to obtain dateable freshwater and saltwater sediments should provide an absolute sea level curve and

paleo-environmental data to answer this research question.

2. Do archaeological sites exist in the eastern Gulf of Mexico that have stratigraphic integrity despite Holocene sea level transgressions and marine erosive conditions? This question is of particular importance to the limestone sediment starved study area. Conducting limited test excavations to determine site integrity should answer this research question.
3. What is the variety of archaeological sites encountered?--For example, resource procurement vs. habitation sites, coastal oriented vs. inland, major base camp vs. small habitation areas? This questions may also be answered by limited test excavation.
4. Once prehistoric offshore sites are located, can remote sensing instruments provide diagnostic signatures of the known sites? Can prehistoric sites be located with remote sensing equipment once known sites have been scanned? Can it locate several sites in a variety of marine settings and conduct remote sensing surveys to determine if diagnostic signatures are obtainable? If so utilize, this data in an attempt to locate sites with remote sensing equipment.

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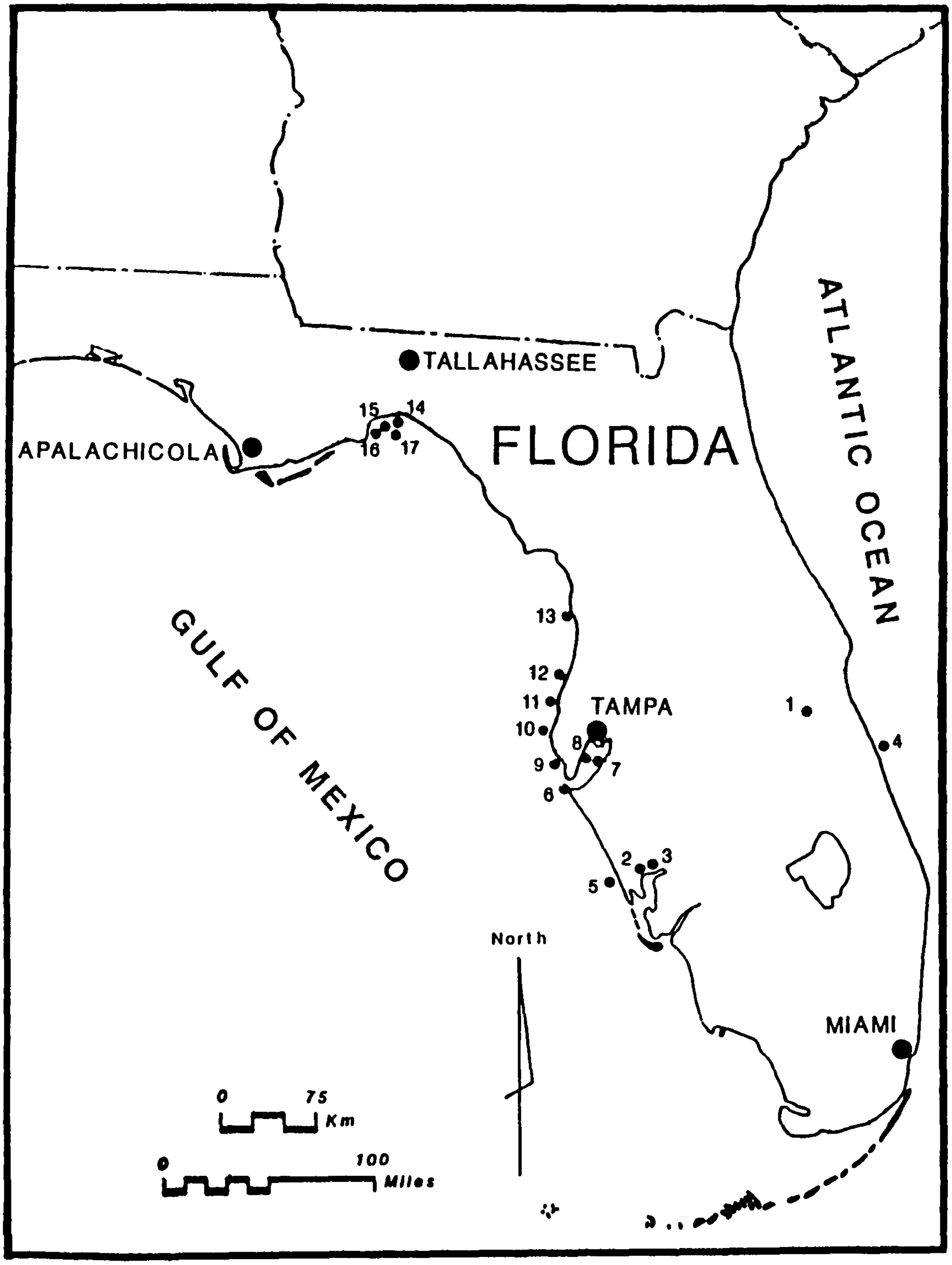

Figure 12.1.--Inundated archaeological sites of coastal Florida.

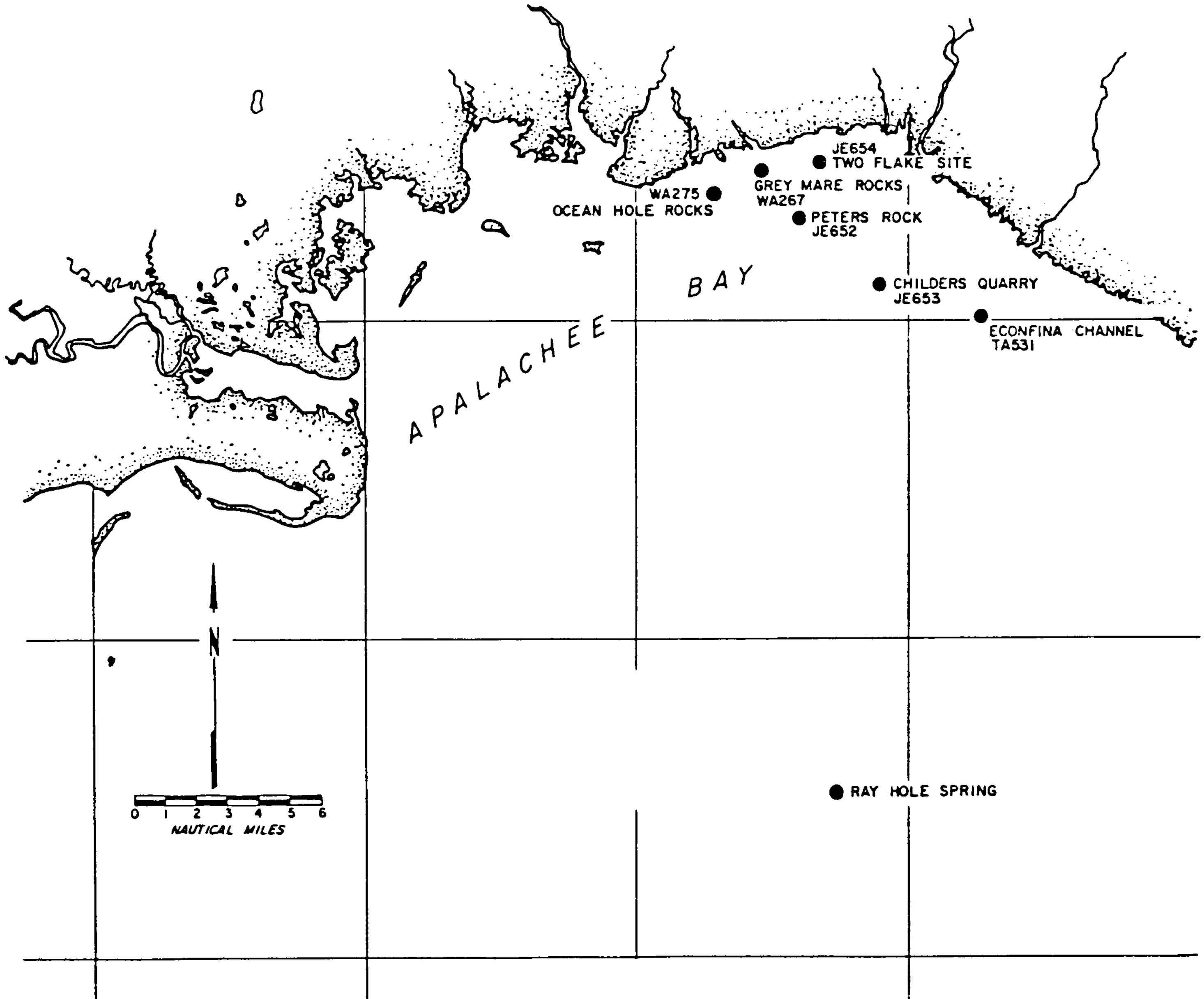

Figure 12.2.--Archaeological sites in Apalachee Bay.

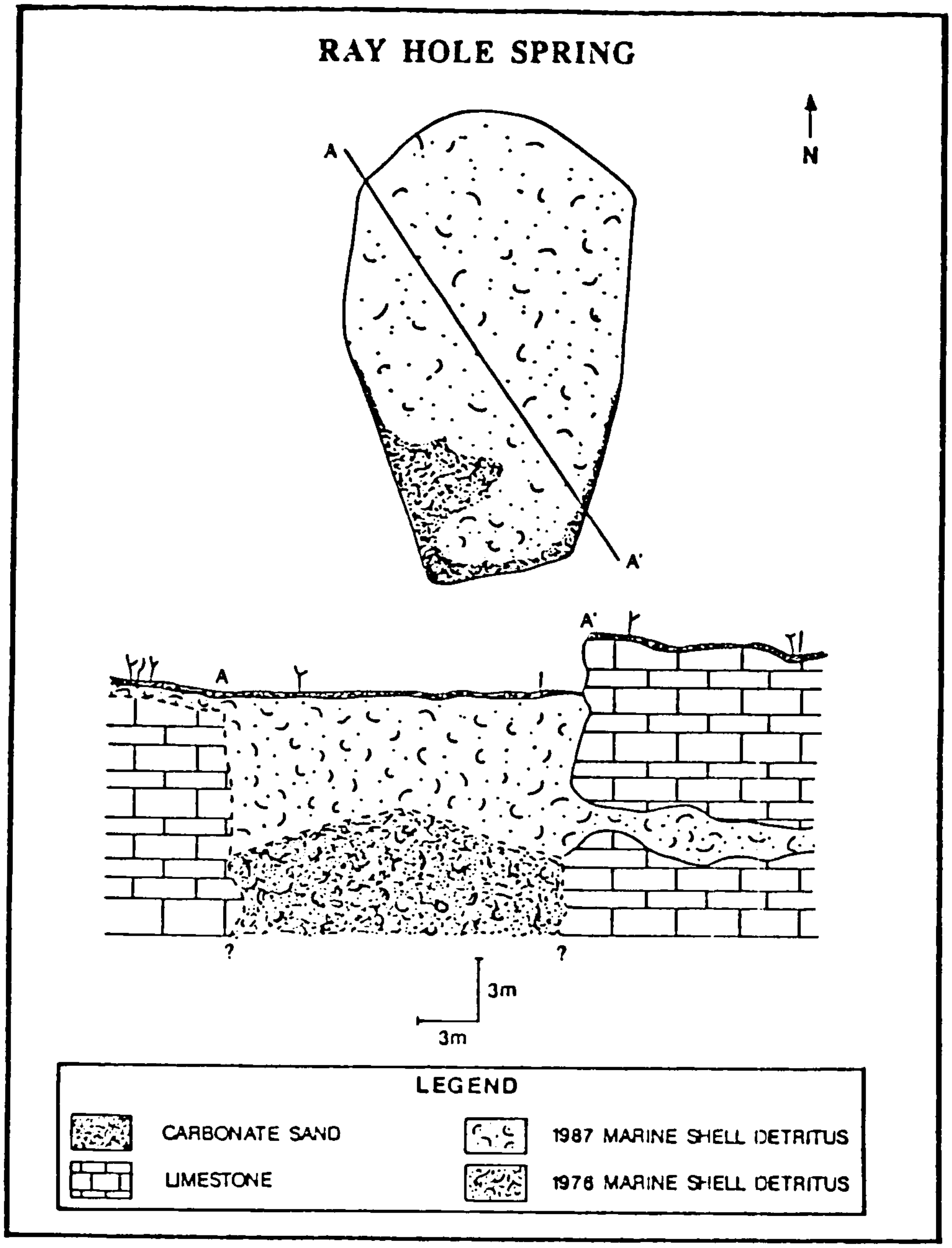

Figure 12.3.--Cross-section drawing of Ray Hole Spring.

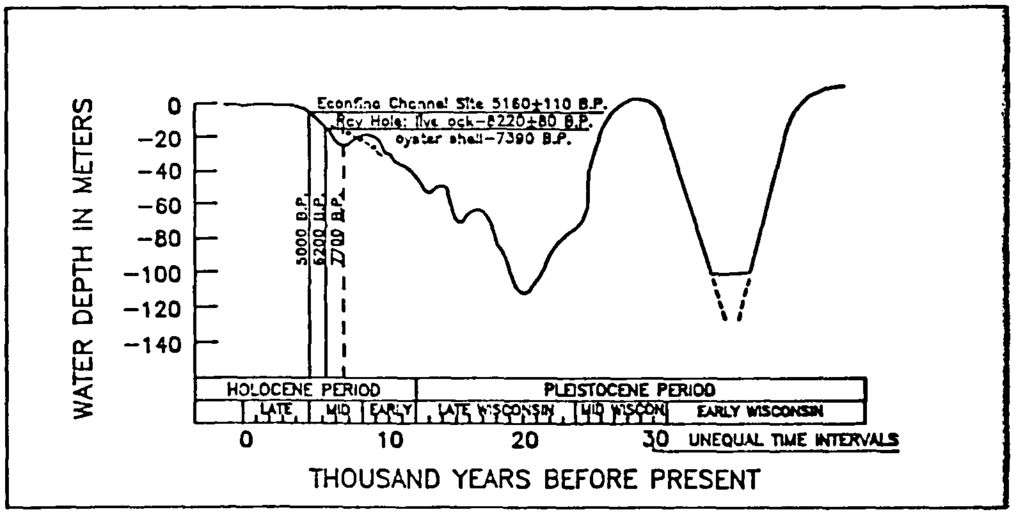

Figure 12.4.--Sea level curve for the Gulf of Mexico.

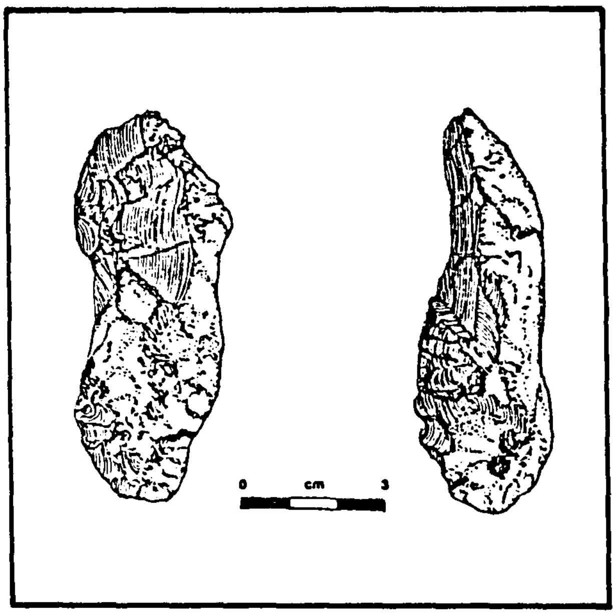

Figure 12.5.--Possible decortication flake associated with Ray Hole Spring.

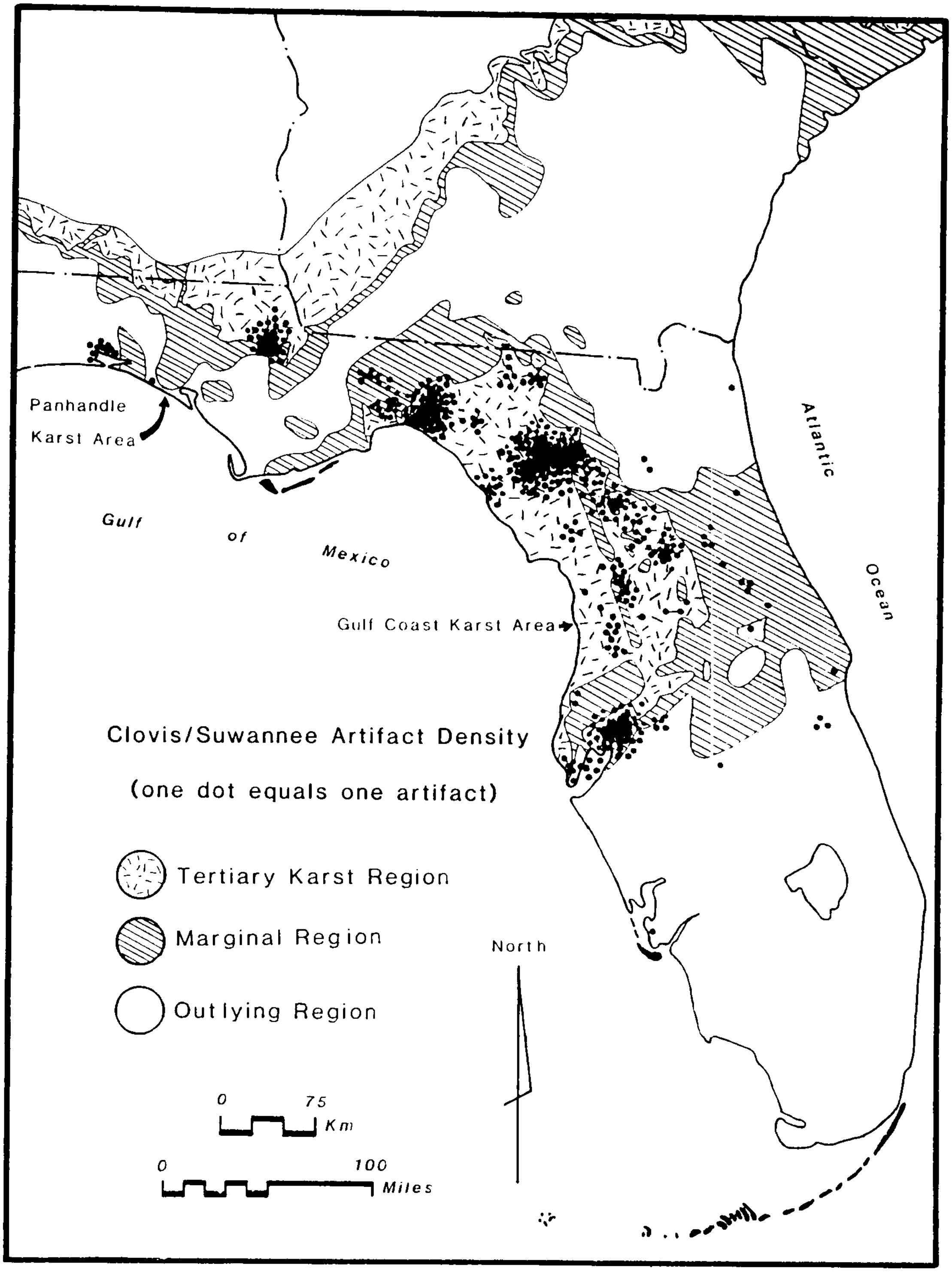

Figure 12.6.--Distribution pattern of diagnostic Clovis, Suwannee, and Simpson artifacts in the Outlying, Marginal, and Tertiary Karst Regions of Florida.

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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.