OCS STUDY
MMS 86-0073

PROCEEDINGS

Sixth Annual Gulf of Mexico Information Transfer Meeting

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

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PROCEEDINGS
SIXTH ANNUAL GULF OF MEXICO
INFORMATION TRANSFER MEETING

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New Orleans, Louisiana
22-24 October 1985

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PREFACE

The purpose of these Proceedings is to present an overview of major Gulf of Mexico environmental studies programs as presented in the MMS Sixth Annual Information Transfer Meeting held October 22-24, 1985. In order to keep this document to a manageable size, technical description and study results were edited to provide only the briefest description of program objectives. As a result, the Proceedings should be viewed as a reference to studies programs rather than a presentation on their technical content. Further explanations of study objectives and findings should be obtained from either the individual investigator or the responsible government agency. It should be noted that under the presentation titles are the names of the speakers and their respective affiliations. A complete address for all speakers and participants is included in the List of Attendees.

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

Copies of this document may be obtained from the National Technical Information Service (NTIS).

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Introduction

Dr. Richard Defenbaugh
Minerals Management Service

I would like to say good morning and welcome you to the Sixth Annual Information Transfer Meeting, a meeting we put on annually through the Gulf of Mexico OCS Office. We're pleased you can be here with us this morning and hope you can stay with us for the next couple of days. I hope that you find the sessions informative and thought-provoking.

The ITM is a major event in our annual cycle. We see it as a major opportunity for our staff to present to the general public our thoughts on certain issues, our plans for future actions, and to showcase some of our recent accomplishments. It's also an opportunity for you to meet us and to become aware of the issues that confront us each day and to become familiar with the programs that we support as a matter of routine, such as our Environmental Studies Program, our Environmental Assessment and Operations Program, and our Public Affairs and Public Information Programs. And last and perhaps most importantly, it's an opportunity for all of us to meet each other to share information, to share opinions, and to develop friendships and professional peer contacts.

The ITM this year has been developed, as usual, around three standard themes. The first and major theme is the issues of current interest to the Regional Office. You'll see these sorts of issues addressed at the various sessions on biological protection of offshore resources, air and water quality in the Gulf of Mexico, oil spill control and cleanup and use of dispersants, wetlands loss, the use of abandoned platforms for fisheries purposes (what we call rigs-to-reefs), deep water technology and the economics associated with deep water operations, impact of barrier islands, and so on.

Our Plenary Session this morning is organized around such a theme: The future for the Gulf of Mexico in terms of resource developments and activity trends.

The second of the basic themes around which we plan the ITM is the accomplishments of our various programs or our staffs. You'll see some sessions in which the products of the Environmental Studies Program are presented to you, including wetlands loss studies; studies on the marine ecology of the Gulf of Mexico in general and especially the Southwest Florida Shelf area, an area of industry interest; our Physical Oceanography Program, which has a major role in the meetings; and presentations on modeling of drilling dispersants effects. Also, the MMS Headquarters Office's Technology Assessment and Research Program participates in the ITM to showcase its programs and accomplishments.

And, last, the third theme is regional information exchange, in support of the other two themes. An example is the session on physical oceanography programs supported by other agencies. I think we have an excellent meeting planned; let's begin. . .

Dr. Richard Defenbaugh is Chief of the Environmental Studies Section of the Minerals Management Service's Gulf of Mexico OCS Regional Office. His graduate work (Texas A&M University: MS, 1970; PhD, 1976) addressed natural history and marine ecology of northern Gulf of Mexico invertebrates. He has been involved with the Bureau of Land Management/Minerals Management Service Environmental Studies Program and Environmental Assessment Program since 1975.

Biographical Sketch of Mr. John Rankin

John L. Rankin is known nationally and internationally as a pioneer in the development of effective environmental stewardship of lands and resources associated with the Outer Continental Shelf's productive Gulf of Mexico.

For more than 31 years, he exemplified the highest standards of responsibility in federal service. His background in the OCS program has earned him the title of "Mr. OCS"; however, the scope of his background is not limited to the OCS.

Mr. Rankin was born, raised, and educated in Russellville, Arkansas. He received his law degree in 1940 from the University of Arkansas. For the next two years he practiced law and served as budget manager of a chain service store.

He enlisted in the U.S. Navy in 1942 and served until 1945. He then spent the next ten years practicing law, managing a service store, and farming in Russellville. He was elected and served as mayor of Russellville and served on occasion as municipal judge.

In 1955, he entered government service as a law examiner in Russellville. He was transferred to Washington, DC, in 1957 to the Division of Hearings and Appeals. In 1957, he was made manager of the Colorado Land Office.

In January 1959, John Rankin was promoted to manager of the New Orleans OCS Office. Entering the OCS program in its beginning, he found no guidelines. He played a large role in developing the leasing procedures still being followed today in the OCS program nationwide. Mr. Rankin's first lease sale was May 26, 1959, offshore Florida. Since that time, he has leased 5,427 tracts, totaling 26,798,772 acres offshore. Total monies collected from those leases exceed $39 billion. It is this accomplishment that has earned him the title of "Mr. OCS." His dedication and service to the program have been officially recognized by his receiving the Department of the Interior's Distinguished Service Award.

On December 13, 1985, Mr. Rankin hung up his familiar red jacket and retired from federal service.

Keynote Address

Mr. William Bettenberg
Minerals Management Service

The OCS Leasing Program is a most important program. I'm constantly reminded when I talk to people about either how little they know about it or -- if they're working in it -- how frequently they forget the broad perspective. But basically one-eighth of our domestic production of oil comes from the OCS; one-quarter of our domestic consumption of natural gas comes from the OCS. Important, indeed. This involves nearly 1500 producing leases, about 7500 wells, some 3300 platforms, and something in the neighborhood of 15-16,000 miles of pipelines to make what is, in effect, a colossal enterprise actually work. Economically this program brings in something in the range of $20 billion a year to the national economy. Of that, roughly one-sixth of it, plus substantial amounts of bonuses, typically counted in the billions of dollars, comes into the federal treasury. The statistics I've seen indicate that there are probably 130,000 or more jobs dependent on the OCS Leasing Program. So, it is, indeed, a vast enterprise.

While it's a vast enterprise, it's also an environmentally-sound enterprise. We keep statistics on a variety of things. One of them is oil spillage from blowouts, which is one of the primary things that people worry about in any offshore oil development. Total losses in the last decade and a half are about 840 barrels. Last year, from all sources -- and typically this involves fuel oil or something like that --the total losses in the Gulf of Mexico, from drilling operations in Alaska, and from operations in California, totalled less than 700 barrels. These are truly trivial contributions to pollution in the environment compared to events that get headlines for a few days and then completely disapppear from the radar screen and you never read about again. For instance, the Delaware River Spill of a few weeks ago, the *Alvenus*, the Puerto Rican, and so forth.

Again, we think that we run an extremely clean program. We have the statistics to show that and we've not ever been able to find evidence to the contrary. We think that the program is, in fact, run with minimal adverse impact on the environment when that environment is measured in terms of fish or commercial fishing, marine mammals, and other wildlife. We see some positive effects in terms of the artifical reef effects of platforms.

We at the Minerals Management Service and the Department of Interior work hard to be conscientious lessors and neighbors. We have tight operating rules. We revise those as we gain even more and more experience, and as we see problems cropping up. We have a re-write of those operating rules underway right now. We are consolidating in one place all the rules and regulations that operators are subject to and we're tightening up a number of miscellaneous areas. By themselves they are not all that important, but we're concerned that we are very careful in the future, and wherever we see some possible weakness we move in quickly and resolve it.

We also have a major inspection program where we monitor drilling and activities on platforms to make sure that operators are planning their operations appropriately and that they're conducting them appropriately. We also enter into each lease sale with not only our regulations in place but appropriate environmental stipulations to assure that each operation will in fact be conducted in a safe manner based upon the latest in scientific information of which we are aware. That's also why we conduct the Environmental Studies Program and hold these Information Transfer Meetings.

Nationwide, this Environmental Studies Program has been operating for about thirteen years, and it is a major repository, perhaps the major repository, of information on the environment of the Outer Continental Shelf as it relates in any manner at all to oil and gas leasing. Over this thirteen-year period we've spent some $400 million trying to understand every aspect of the environment that is related to oil and gas leasing, trying to run down every problem or perceived problem that anybody might dream up as a potential bottleneck. Let me give you an example of that. A few years ago there were concerns that we might not know everything that was needed to be known about drilling muds and cuttings. So, we immediately went to work on sudies of that. All of those studies have turned out to be positive. And discussions with people at Woods Hole indicated they wished that we would have some more drilling in the North Atlantic so they could continue to see if they could detect any adverse effects. But they had not been able to detect any so far.

In the Gulf of Mexico this is translated into some 94 projects, many of them lasting for a number of years, ranging from physical oceanography to ecological effects, with the heaviest concentration on studies of the marine ecosystem.

We developed a studies plan, a multi-year plan -- I think that's probably in your information packet. We do this in conjunction with the Regional Technical Working Group that operates here in the Gulf of Mexico. We have similar groups on all the other coasts. We also review that Studies Program and our scientific work with our Scientific Advisory Panel consisting of eminent scientists from around the country who have experience in marine topics.

We're currently in the Gulf working on such diverse matters as the ecological characteristics of the deep water area where a substantial amount of leasing has occurred in the recent past and where development is beginning to occur and on the seagrass beds off of Florida so that we can refine our understanding of those. We're also refining our understanding of the physicial oceanography of the Gulf of Mexico.

Turning back to the national picture, it's difficult to overemphasize the role of the Gulf of Mexico. There's an old story I'm sure many of you have heard about the two petroleum geologists, executives in their firms, who die and think they're headed for Heaven. In fact, they're up there standing outside of the pearly gates, and there's a long line getting into Heaven. And being somewhat impatient men and anxious to get on with the next stage of life or whatever, they decide that they'd like that line to disappear, or at least go down. So one of them says: "Let's start a rumor that they've discovered oil down in Hell." So they start this rumor and it starts building and there's a buzz going up and down the line, and people start thinking about that and begin to drift away on their way down to Hell. The next thing you know, the oil men are right up at the pearly gates. And then, one of them turns to the other and says, "Maybe there's something to that rumor." And they depart also.

Well, we've tried to provide opportunities for people who have that kind of optimism to lease and explore around all of the coasts of the country. I sometimes hear the charge that we have focused too much on the Gulf of Mexico. We've actually offered many, many more acres in other areas. The problem is that nobody's finding anything in most of them. If you look over the Atlantic area -- we've leased in the north, the mid and the south Atlantic; in Alaska -- we've leased off basically all of the shores in Alaska at this point; and add to that the eastern Gulf of Mexico as well; we find areas where industry has bid $10.7 billion in bonuses. And at this point we have one possible commercial well that's been discovered in the Beaufort Sea, for all the effort that's gone into that. It's no wonder then that both we and industry keep coming back to the Gulf where substantial discoveries are continously made. People move into different zones like the deeper area, the Norphlet Trend off Alabama.

Probably the one exception to that is offshore California. And if you have been following the press, that's an area that gives us a particular problem. We think, according to our best estimates, that there are probably something like one to three billion barrels that are yet to be discovered off California currently in moratoria zones; and, yet, Congress has placed all of that off limits to the federal government from a leasing standpoint. The area in moratorium off of California at this point hasn't been leased in two decades. Effectively, it probably hasn't been able to be leased in a decade and a half, and it's been downright illegal to lease it in the last five years. That's one of the reasons why the Secretary has taken on the difficult task in a very political world of negotiating an end to the current moratorium and trying to open up at least a part of the area to fashion some sort of a compromise that will give the nation an opportunity to begin to lease, to inventory, and to try to understand the potential of the California areas.

I assure you that is an exceedingly difficult chore. You have to keep your eye on not only the resource potential and the environmental problems, but also on Congress -- who sits where, who has what kind of power -- and recognize how effective they've been over the past five years in stymieing any exploration that might take place there.

Let me cover a couple of other topics that we're dealing with in the Minerals Management Service right now. Many of you are aware that we're in the process of developing a new five-year program. We have, according to the laws, to operate according to a five-year program. Unfortunately, it takes two to three years to develop a five-year program, so we're in the process of developing it most of the time. I sometimes have the feeling that whole forests have had to be felled to produce the paper we use in developing a five-year program. And it's sometimes disconcerting to visualize that we start out the process of developing a five-year program and doing all of this work knowing for a practical certainty that we will be sued by a variety of parties claiming a variety of things. So, when we start developing the five-year program we not only have to worry about what seems right for the country, but how we bulletproof things like environmental impact statements, like the analysis according to Section 18 of the OCS Lands Act, and so forth.

One other issue that has occasionally had a bit of attention here in Louisiana, particularly, and in the Gulf, is the 8(g) issue. I hope that we're seeing the final act of that issue played out in Congress, and I hope that it is resolved by Congress. As the district judge in Texas said, and these are not his words, but convey the sense of what he said, "Why, oh why, have you visited this kind of a problem on me and the courts?" It's one that's very difficult to resolve. I think that we have a solution coming out of Congress. The administration and at least some congressmen are on opposite sides of portions of those arguments. Basically we, in the Interior Department, are trying to assure a fair settlement, but one in which the taxpayer isn't treated as "Uncle Sugar."

Turning from the OCS Leasing Program, one other program that the Minerals Management Service runs, which many of you may not be aware of, is the Royalty Management Program. This program collects something in the neighborhood of $4.5 billion a year in royalties from both offshore leases, for which Minerals Management Service is responsible, as well as for onshore and Indian leases, which involve the Bureau of Land Management, the Bureau of Indian Affairs, individual Indian allotees, tribes, the Forest Service, and a variety of other federal agencies. Also, we're charged with accounting for bonuses that come in from offshore lease sales as well as onshore lease sales -- oil, gas, coal, phosphate, a variety of things.

We've made substantial strides in the last few years to assure that the federal government is collecting all of the money that it's due. We're not there, yet. We are still combing through land records and all sorts of things discovering that there are occasional leases that people can turn up for which we're not yet collecting the funds.

I have an announcement in regard to the Royalty Management Program that is close to home in Louisiana. That is that we've hired ourselves an associate director to take charge of that program, which is headquartered in Lakewood, Colorado. That person is Jerry Hill, who is familiar to many of you from Louisiana. He's previously been undersecretary of the Department of Natural Resources in the state. Also he was called in to help assemble the Department of Environmental Quality. I think he will bring a new dimension to the program.

I would be remiss if I didn't wrap up these comments by also paying tribute to John Rankin, well known by the Rankin Bank designated out in the Gulf of Mexico. Over the past 26 years John has, in a very professional manner and with great good humor, managed the leasing program in the Gulf of Mexico. By my count, he has leased something in the range of about six thousand tracts, 30 million acres. The dollars in the treasury as a result of that to date are about $64 billion, and if you project out to the end of the century the royalties that will accrue from those, that makes John about a hundred billion dollar man. You can think about that a lot of ways. The way, I guess, I like to think about it is as a taxpayer. That's about a hundred billion dollars worth of federal programs that have been paid for from offshore oil and gas rather than out of our pockets or programs that otherwise could not have been carried off. That's a tremendous accomplishment. John is, as I said, a true professional, a real gentleman, and it's been a pleasure to work with him. I wish him well as he moves on at the end of next month to retirement.

Finally, in parting, I would pass on to you Mark Twain's words: "It's a terrible death to be talked to death," and so it is. So, I will turn you over to the other speakers who can finish the job.

William D. Bettenberg was appointed in 1981 by Interior Secretary William P. Clark to be Director of the Minerals Management Service, where he had direct oversight over the offshore program. He has been with the Interior Department since 1964. His background in budget and planning gave him a knowledge of the programs over which he now has jurisdiction. He earned bachelor's and master's degrees in political science from the University of Washington and did additional graduate work there in economics and public administration.

The Exclusive Economic Zone: Status and Anticipated Developments

Mr. Jack Rigg
Minerals Management Service

I'm going to talk a little bit about a program that we started a couple of years ago, our program in the Exclusive Economic Zone (EEZ) on Strategic and Critical Minerals.

We established an office in Long Beach, CA, to take a look at everything other than oil and gas on the OCS EEZ. And the area is a rather large area. We're organized there to have about 15 professional geologists and engineers and environmentalists doing this work. Several executive actions have aided in the implementation of our plans. The first was the National Materials and Minerals Program Plan issued by President Reagan in April 1982, in which he stated that we're going to decrease America's vulnerability on minerals and we're going to try to reduce U.S. import dependence on minerals, and one of the ways to do that is to eliminate barriers to the development of mineral resources on the seabed. That formed the basis for a second point, which was the President's EEZ Proclamation of March 1983, which confirmed the U.S. sovereign jurisdiction 200 miles off our coast. This was preceded by about four months by the development of the Office of Strategic and International Minerals. And, an additional action the President accomplished in 1984 was in his State of the Union message to direct the Department of the Interior to "Encourage careful selective exploration and production of our vital resources in the EEZ, but with strict adherence to environmental laws and the fuller state and public participation."

The legal authority that allows Interior to lease minerals is in Section 8(k). If you read the OCS Lands Act, Section Eight has everything else in it. It has the 8(g), our argument with the states over those lands, and it has 8(k), the other minerals. It says you will use competitive bidding. The authority of this was confirmed in a 75-page legal opinion by the solicitor in 1985, in which the solicitor ruled, "The OCS Lands Act provides authority for Interior to lease seabed lands off the coastal states over which the federal government has jurisdiction. The President's EEZ Proclamation extends U.S. sovereign jurisdiction and MMS leasing authority to at least 200 miles offshore or as far as the geologic OCS may extend." Now, we go beyond 200 miles in some areas already. We have the old Submerged Lands Act which lets us go out to "the extent practicable."

But this ruling upheld our authority and allows us to proceed. We believe that state cooperation in our programs is the key to it. So, we're offering leases for the exploration and possible development of cobalt-rich manganese crust in the Hawaiian Archipelago and polymetallic sulfides off the coast of Oregon and northern California. And, to provide for state consultation we have two federal/state task forces formed to consider the economic and environmental impacts associated with leasing these marine mineral resources. We have cooperative agreements with the affected states that support these task forces as provided for in the announcements by the Secretary of the Interior and respective governors. The initial step, in each case, is to prepare a statement on the economic and environmental impacts of exploration and development in these areas, including any avoidable adverse effects for alternatives and other factors. No decision on future leasing in either case. The decision to lease will be a matter that will be decided later by the Secretary after he consults with the states.

The Hawaiian Task Force was formed in February of 1984 by Governor Ariyoshi and former Secretary Clark. It has twelve members and is co-chaired by an MMS staff scientist and a representative of the Hawaiian Department of Planning and Economic Development. Task Force members are shown to include the technical expertise needed to evaluate the programs. The advisors are all from what we think are the federal and state agencies that need to be involved in the preparation of an EIS for a proposed lease sale. They are familiar with technical, legal, environmental, and regulatory issues. We have a cooperative agreement with the State of Hawaii.

During 1984 and 1985 we sponsored cruises by the University of Hawaii to study the crusts north of Midway Island, the area of the Gardner Pinnacles, at Necker Island, and at Cross seamount. One of the prime targets for these cobalt crusts in the EEZ is in the area surrounding Johnston Island, which is about 700 miles southwest of Hawaii. The major resource data in this area have been provided by an international consortium composed of corporate entities from the U.S., West Germany, and Japan.

Our schedule in Hawaii called for the publication of a draft EIS in March 1986. Public hearings will be held during the comment period, with the final EIS to be published in November 1986. The lease offering, if the Secretary decides to do so, would occur in 1987, with leases issued before the end of the year.

The other major leasing proposal we are now considering is for the polymetallic sulfides in the Gorda Ridge area about 150 miles off the coast of Oregon and California. This leasing proposal is being investigated by the Gorda Ridge Task Force, which was established by former Secretary Clark and Governor Atiyeh of Oregon. This is made up of fifteen members and is co-chaired by the Oregon State Geologist, the California State Geologist, and an MMS staff scientist. Again, we have an advisory group of representatives from various state and federal agencies with an interest in the proposal. This task force made a recommendation and we entered into a cooperative agreement in 1984 with Oregon and California to conduct resource and environmental studies of the Gorda Ridge area. This summer NOAA, Oregon State University, and the U.S.G.S. conducted cruises. Each of the cruises included a scientist from Oregon State University who conducted G and G studies under our sponsorship.

At the Gorda Ridge study area, during NOAA's surveyor cruise in May, scientists reported the discovery of metal-rich seawater at two locations near the Blanco Fracture Zone at the northern end of the Gorda Ridge. This discovery provides a strong indication that active hydrothermal venting is taking place and increases the likelihood that polymetallic sulfide deposits will be found in that area. These fracture zones are placed where the earth's crust pulled apart in the fundamental plate tectonic process and a new ocean crust formed.

Of greater significance probably was the U.S.G.S.'s September 20th announcement that it had discovered metallic sulfide deposits in the Esconaba Trough on the Gorda Ridge., 170 miles off the coast of northern California. Although much more work needs to be done before leasing can be considered, these are positive signs that Gorda Ridge may hold a significant resource potential. So a task force is going to meet in Monterey, CA, on November 6-8, 1985, to review the results of our summer's research activities. They will then develop recommendations for the Secretary of the Interior on the lease proposals, and we'll decide how to proceed. If the proposal is to proceed further, we'll probably have to have more studies, prepare another EIS for leasing, or suspend action and do more research. We don't know.

We have other program activities. One of the things government is good for is to write up the rules on how you work. You can go offshore now and prospect under our 250 regulations to do your G and G work. And we put out a notice in the FEDERAL REGISTER and industry basically said: "We don't want to use the oil and gas regulations; we'd like to have new regulations for these other minerals." So, we're hoping to have these advance notices of proposed rulemaking in the FEDERAL REGISTER in December. We put one out on exploration. We're going to have one out on leasing. We've got an inter-agency working group consisting of agencies with a common interest in federal leases: MMS, Geological Survey, NOAA, BLM, and the Bureau of Mines. And so we've completed a draft of the prospecting regulations and now we're trying to get them over to the Office of Management and Budget so we can put them out to the public for futher comments. We hope to have all of these regulations in-place pretty well by the time we have any leases issued in 1987 or 1988.

Here's the area we're looking at. It's about three billion acres compared to 2.7 onshore. Under the OCS Lands Act, Section 8(k), we can vary lease sizes much more than we do in the oil and gas program. We can vary lease terms, we can vary bonuses, we can also allow bonuses to be paid over a period of years, and we can allow deferral of payments for unplanned or unavoidable interruptions in exploration programs. We can allow expenditures for work on leases to be applied against the bonus rental or royalty payments. We're working on these and we're trying to get something going that will bring this new pioneer area into the interest of people.

We've had more than fifty different industrial groups who have expressed interest in our offshore non-energy minerals. These interests -- you can go around the place up in Alaska -- you have placers, gold and silver and platinum. You have the same off Washington and Oregon. You always have sand and gravel out there. You have phosphorites down off San Diego. In the Gulf area there's a need for sand and gravel in some of the parishes for erosion use. On the East Coast, in the Blake Plateau there are phosphorites, there are manganese nodules, there are ilmenite and rutile and, again, the sand and gravel up into the New England area. There's a great challenge here on these minerals. And the thing we want to emphasize is that we're doing this in the preliminary stages outside of the oil and gas program, but we're using the oil and gas environmental information as well as the leasing procedures to assist us. And when we get ready to issue the leases, we will turn the enforcement of those leases over to the regional managers. If there are any leases for sand and gravel in the Gulf, they'll be run out of the Metairie Office. They will be blended back into our regulatory program after we get the leases issued.

John B. Rigg is Associate Director for Offshore Minerals Managment of the Minerals Management Service, Department of the Interior. From his office in Washington, DC, Mr. Rigg directs the four regional OCS offices, a deputy for leasing and for operations, and a program director for the Office of Strategic and International Minerals.

Anticipated Texas Coastal and Marine Resource Development and Activity Trends

Dr. E.G. Wermund
University of Texas

I was invited to discuss not only the economy and leasing of oil and gas in the Texas area, but also to give an overall view of 1985 activities in the coastal zone. I will (1) highlight representative geographic areas, (2) comment on local economics, (3) briefly describe aspects of the recent state leasing for oil and gas on state-submerged lands, and (4) explain principal issues in the coastal area that are of interest to Texans today.

I come to you from a meeting that occurred in Austin last week and reflects the climate for the oil and gas industry in the coastal zone. Each of the many of the larger communities in the Gulf Coast has geological societies, and they meet once a year as a group called the Gulf Coast Association of Geological Societies. An indicator of economics in the oil and gas industry is attendance at that meeting. Attendance had been on on the rise until two years ago. The attendance this year was 2000, the lowest in 10 years. At that meeting, the major topics of conversation among people, separate from the technical sessions, was the low price of gas, the difficulty in financing exploration, and the difficulty in selling a prospect. In fact, many explorationists admitted that they now twisted facts a little when selling prospects in the Gulf Coast area by emphasizing oil and diminishing the prospects of finding gas, although the Gulf Coast is very strongly a gas province. An excellent reflector of the Texas coastal zone economy is related to the acceptability of prospects.

Houston, which is a signature of oil and gas activities in the Texas coastal zone, has two major problems today. It presently has the largest number of homeowner foreclosures of any city in the nation. It also has the largest amount of unrented office space anywhere in the country. That is especially indicative of the oil and gas sector, but it also represents other portions of the economy as well.

There have been major cuts in production streams and employment of oil and gas refineries and also at chemical processing plants throughout the Gulf Coast area of Texas. Port Arthur/Beaumont has suffered particularly in that loss as have both Baytown/Houston and Texas City. Metal fabrication in Beaumont has decreased dramatically. There, Dresser Atlas is actually leaving and merging operations with Ingersoll on the west Florida coast in order to strengthen economically their fabrication business. The OCS rig count which began to increase in early 1985 has now dipped sharply, as many of you are aware.

The diminished income from oil and gas activity and its peripheral benefits continues to be a serious problem in Texas. Our legislature, in its meeting this spring, was looking at a decrease of 20 to 25% in the overall economy, principally reflecting losses of income from the oil and gas businesses and related areas. We presently need an upswing in all oil and gas businesses for us to grow; the coastal zone is a critical region for that economic activity.

In the coastal agribusiness, most people are holding onto their cattle because there is a depressed price for beef. Texas herds are enlarging and people are not selling unless they must, depending upon the age and size of beef cattle. The Texas rice growers, who grow rice from near Corpus Christi to east of Houston in Chambers County, are having real difficulties competing on the world market. They may be helped in a different kind of way. It was suggested to me by Philip Johnson, who heads the Grey Institute at Lamar University, that a solution may be to establish a futures market for rice that will assist the rice grower to establish better pricing. For feed grains, sorghum, and milo, many of which are grown in the coastal zone, profits are holding, and farmers have done quite well in recent years. Cotton has maintained its economic level.

Probably the strongest resource base, one that is actually gaining strength in the coastal zone of Texas, is the East Texas timber industry. It continues to construct additional papermills and other plants for increased use of timber and lumber in innovative ways.

Recreation and tourism continue to grow. In fact, many crititcal issues in Texas relate to the fact that more and more people want to use the coast for recreational pursuits of different sorts. Texas hosts a large number of tourists, even from out of state, in coastal areas. Galveston had an excellent tourist season this year, up about eight percent, and that is one year after Alicia, the hurricane which caused considerable damage. There was enough publicity of the damage that there had been serious concerns whether fewer tourists would visit and that people would say, "Well, since the hurricane went through there, you know, we can't really go there; it isn't going to be good for while until it builds up." Yet Galveston had a very good year in 1985.

Corpus Christi, the central part of the Texas coastal zone, continues to be very strong in the recreational area. From Port Aransas down the beaches to the Padre Island National Seashore, there is continuing growth in recreation, and the economy is healthy and well. In fact, Corpus Christi represents the high point of the best things that are presently happening in the Texas coastal zone area.

South Padre Island tourism and recreation, on the other hand, are depressed. That may be more nearly related to an international situation rather than a Texas or national impact. The tremendously devalued peso has impacted south Padre Island causing the economy to strongly decline. Many speculative condominiums were built expecting the Mexican recreationists to purchase recreational housing and vacation extensively, but they no longer can afford a recreational retreat at South Padre Island. That market had been very strong until the first devaluation of the peso several years ago.

Texas continues to do quite well in its oil and gas leasing of state lands. Each year we hold two sales, usually April and October. This year April 2 and October 1 sales were scheduled. We leased 78,750 acres in our 1985 April sale; for comparative purposes, in April and October of 1984 we leased 164,000 acres. If we had an equivalent sale in October, then our annual total would be better in 1985 than in 1984. These leases include the submerged lands of Texas; the Gulf of Mexico shelf about eleven miles wide, the estuaries, lagoons, and bays are included in each sale.

In 1985 the most active drilling area is offshore, opposite Calhoun and Matagorda counties. This activity is about halfway between Corpus Christi and Galveston, cities which you may know, generally off an area not far south of Freeport. There a major gas field is being developed in the Texas shelf waters by Conquest Oil Company. Also, off Brazoria County, which is slightly down the coast from Galveston, Tenneco is actively developing a major field. Some drilling of most interest to us includes an AMOCO well which they drilled to 20,000 feet off Kenedy County earlier this year. That is the first really major deep well off coastal Texas in quite some time; unfortunately, it was dry. We have a second chance, though, because just north of there, not far south of Corpus Christi and offshore, ARCO is presently drilling to a project depth of 23,000 feet. They are presently near 12,000 feet. Texas is hopeful that the Corpus Christi area and immediately south, which has generally been dry at shallower depths, may hold better deep possibilities into the future.

There are interesting activities going on at individual Texas ports. I mentioned that metal fabrication in the Port Arthur and Beaumont area had diminished, but there is a new kind of opportunity in Port Arthur which everyone is observing with excitement. The Bethlehem

Steel Company purchased a dry dock at Pearl Harbor from the U.S. Navy, which it moved across the Pacific, through the Panama Canal, and into this area. It will be used prinicipally for the repair of very large rigs. The Navy had used the dry dock for repair of boats, but no longer needed it for that purpose. In all probability, Port Arthur will look at an improved rigs-service type of opportunity that will assist the economy there.

I mentioned earlier that the Corpus Christi area is a real plus in the coastal zone economy. That community was awarded the "home port" for U.S. Navy battleships in the Gulf of Mexico; this will make a strong impact. It means a $100 million investment for the upgrade of the docking facilities at Ingleside near Corpus Christi. It also means about $150 million annually in various kinds of purchases to maintain the facility and further represents a $100 million payroll. There is an environmental concern -- channelization which supplements the present Aransas Pass to Corpus Christi channel. A deep channel will be needed to allow naval battleships to dock in the main harbor area at Ingleside.

Also in the Corpus Christi area, Peter Kewit and a consortium of other companies is building a platform called the Bullwinkle Platform which will weigh 60,000 tons and be approximately 400 feet long.

At one time, a former channel, called Packery Channel, cut through the barrier island and permitted direct access from Corpus Christi Bay to the Gulf of Mexico. There is a study plan and expectation of investment that would reopen the channel again and allow quicker access to the Gulf, particularly for fishing and recreation boats, a major recreational activity.

Brownsville, previously mentioned for recreation in the Brownsville/South Padre area, is not doing very well as a port either. It has a large capacity for use that is not being taken advantage of at the present time. The Marathon Laterno Shipyard, which is mainly a rig maintenance shipyard, is at half strength, half complement of employees, and just barely hanging on. The Union Carbide Chemical Plant has closed opposite the Port of Brownsville. Al Cisnaros, who heads the port authority, states that they try to be optimistic and look at the Union Carbide facility to attract future business. If oil and gas exploration were successful off the Brownsville area, here would be a storage facility essentially in place. Brownsville is hoping also that a water resources bill that is presently in Congress will pass and that will alow them then to channelize to 42 ft; the channel is presently 36 ft. On a 25% cost sharing basis, that would increase the capability of the harbor or port and, perhaps, give them a better economy than they have now.

Some of the issues that continue to concern Texans were mentioned in the Gulf of Mexico Regional Technical Working Group meeting this spring. When the Texas Legislature met, they passed a new litter act because of concerns with trash on the beaches of Texas. But all they could do was increase the fine for littering and recommend further study of the sources for trash. There were no funds for Texas to implement policing offshore in order to contain those who were inclined to trash the waters. Also, because of the *Alvenus* Spill, the Oil Spill Act was reconstituted so that the State has an increased capability to directly seek damages from the owner without necessarily going through the federal government. The legislature also increased the amount of damages that the State could request from anyone that would spill oil from a tanker onto the Texas Coast.

One of the new coastal issues that has arisen is related to older legislation in Congress, the Coastal Barrier Resources Act, Public Law 97:348 of Interior, passed several years ago. Nueces County, the county containing the immediate barrier island area of the Texas Coast near Corpus Christi, looked into the impact of the act in terms of its own economy. They have made our Governor very concerned about its impacts. If the act is enforced as stated, it would reduce island-related developments 60% between now and 2000 on the basis of their study. The cost to the island would be 6,189 new jobs by the year 2000. Further, it would reduce local and state gross tax receipts approaching $269 million. Implementation of the act, in effect, strikes at the economy unfairly in the opinion of community leaders. The balance and concern for development and environment is not just an oil and gas industry problem. It is also a very serious issue in the development of beaches, condominiums, and recreational areas.

Another issue of concern in Texas is a hope that the Texas Water Plan may be passed. Some years ago the legislature requested our Water Department to put together a Texas Water Plan. The plan has gone through several iterations and had real problems. One of the positive elements in the plan for the coastal areas will require releases of freshwater from the dammed reservoirs along our rivers flowing to the coast and freshwater additions to the estuaries, thereby improving our natural fisheries.

Finally, I was asked to look into the future, which I never like to do and would prefer to avoid. I believe that our future in the Gulf Coast is strongly dependent upon the OCS leasing. Very clearly, one Texas concern is that there were a large number of leases purchased between 1980 and 1981; they are approaching a five-year limit. How the industry reacts to those purchases in the present economy -- whether they are aggressive in exploration or whether they back off from commitments and release leases is going to be a real signal -- probably a major signal -- on what is going to happen to our Texas coastal zone economy in the future.

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State of Louisiana Perspective

Dr. Charles Groat
Louisiana Geological Survey
Louisiana State University

Louisiana is in very serious economic trouble. The basic reason for our problem is with the oil and gas industry that we--more than, perhaps, any other state--have been dependent on for revenues to support state government and to support our economy, particularly in the coastal zone. In the days of embarrassing riches, when there were such things as windfall profits, we were as happy with this dependence as we could be. We had more money than we knew what to do with. We were setting up coastal environmental protection trust funds, we were hiring lots of state employees, and we were fat and happy.

The problem with this, of course, is that when times get hard, when the demand for petroleum slackens, when prices drop off, then so does the economy. This all happened and we are in the very unfortunate situation right now of having an economy that is dead in the water. Oil and gas activity is down, and the direct and support industries that are so dependent on petroleum activity are hurting. Our basic chemical industries along the Mississippi River corridor that depended on energy and depended on cheap labor to be competitive are having difficulties and are closing down. State government is having extremely serious problems, both in terms of the number of employees, which they are trying to cut by 4000 this year, and in terms of dollars available to operate state services. We're operating at 86% of last year's budget and have just been told we are going to operate at 22% less next year. That doesn't bode well for either the government employees or the services they offer. We are at present second in the nation in unemployment, and conditions are likely to worsen. Given all those things, the present situation and the near term outlook for Louisiana are not very bright.

What do we do about it? Well, we are doing what everybody else is trying to do: we diversify. We look for other avenues for economic growth. What can Louisiana offer to prospective industries, to its citizens, to better the economic situation and restore us to the lifestyle we would like once again to enjoy?

Much of this future dependence has to be, as it has been in the past, on coastal resources -- those resources found in south Louisiana. Are there other uses that people can make of those resources or expanded uses that would contribute to the economic recovery of the state? Coastal resources are presently a significant element in our economy and in our political fabric. Because of the large concentration of people living in south Louisiana, there is a strong vested interest in what happens to those wetlands, in what happens to those coastal resources, and that interest is reflected by the strong legislative support that fisheries resources and wetlands in general receive at the state level. So, coastal resources are both an economic and a political force in the state.

We are looking, then, for other uses of coastal area resources that would promote economic growth. And this obviously creates conflicts, because historically the things that have provided the most dollars to the economy of Louisiana and the coastal zone have also been the most destructive of those resources that are there. To make big money in the coastal zone, you generally have to alter it, and this results in conflict between the agencies that are required, on the one hand, to develop resources, and on the other those which manage those coastal resources, in part through the Coastal Zone Management Program. How do you preserve and protect at the same time that you're inducing economic development which we so desperately need to bring the economy back to a reasonable shape?

As a result of the interest in economic development, some of the laws and guidelines that intend to protect and preserve coastal resources are being questioned to the degree that they get in the way of the economic development that we so desperately need. This conflict is a very real one and it's increasing in intensity all the time.

You also have to remember, as anybody who's from Louisiana or from near Louisiana knows, that our coastal zone is disappearing. Those resources we're dependent upon are going very fast. We are losing approximately 40 square miles of coastal wetlands a year and our barrier islands are retreating. Thus the wetlands base upon which we depend is in terrible shape, both as a result of natural processes and as a result of man's activities. We have caused our coastal resources to disappear by building levees on streams and channeling sediment over the edge of the continental shelf.

We have a Coastal Protection Program in place, created out of those oil and gas windfall profits that were generated some years ago. This fund was set up to allow us to try to do something to stop or at least slow coastal erosion. The state is spending a significant amount of money to try to do something to preserve and protect coastal resources from the physical processes that are tending to destroy coastal wetlands and barrier islands.

The first five years of that program, focused on trying to slow barrier island erosion, is going to cost about $137 million. We have $43 million. Nevertheless, we're proceeding, with hope eternal, that by some mechanism we'll come up with the additional needed money. Even if we can't, we are confident that with the money at hand we can make significant progress in slowing erosion.

Let's take a look at some of the things that are happening and at some of the trends in resource utilization in the coastal zone, starting with the dominant one, oil and gas. Most of the income that has come out of coastal Louisiana has come from oil and gas and it's been a very intensely developed resource in Louisiana. The fact of the matter is that production is declining. The chances that there will be any significant new large finds in either onshore south Louisiana or in the state coastal waters of Louisiana are not very great. It is a very mature area. Nonetheless, there are both proven reserves and speculative reserves left. And people continue to explore because they can still make money in the oil and gas business, even in these depressed times. That means that some man-induced processes that do affect wetlands in a negative way continue. We have to dredge canals to get at drill sites. The days of 3000-ft canals, when priorities for getting energy resources out were the highest and wetland preservation wasn't a high priority, are gone. Industry realizes this, the State realizes this. We have a pretty cooperative atmosphere between industry and the State in trying to minimize the physical damage that's done in dredging canals and gaining access to oil and gas rights, and I think we've made some real progress in that area. We've shortened canals significantly through the Coastal Zone Management Program. We've used alternate access and directional drilling processes to minimize damage. But the fact of the matter is to get at the reserves that are left, we still have to negatively affect wetland resources, and we have to continue to look for restoration and mitigation techniques to try to minimize those effects.

For the first time, perhaps, there is serious consideration by the State to look at the specific economic benefits that come from oil and gas development in the coastal zone, particularly in these days of declining production and resources. How much does the State and, particularly, the private sector benefit from the dollars we make from producing oil and gas as opposed to the economic disadvantage we incur when wetlands are altered in the process? What are the economic trade-offs? Do we make more from the oil and gas activity or in the long run, do we lose more in dollars because of the damage to coastal environments? We're looking into that. It may be so complicated and with so many unquantifiable variables that we can't get a grasp on it. But the State is interested in trying to find that out, so we're looking at putting a dollar value on both the coastal resources, the renewable resources, and the oil and gas that comes from the coastal area.

In the intent to diversify economically, there's an increased interest in using coastal resources for recreational development and for residential development. While we don't have the barrier islands of the type favored for development in Texas and Mississippi or the recreational beaches that Florida and our neighbors to the east have, we do have wetlands that are appealing for some types of development. And as New Orleans grows, with very little room left to grow other than into the wetlands, and as some of the communities around Lake Pontchartrain and others in the coastal zone grow, it's natural that they would seek to utilize wetlands for commercial facilities, marinas, and residential developments. We have a conflict here in that our Coastal Zone Management Program treats water dependency as a crucial test in making permit decisions involving the alteration of wetlands. Many of the economic development activities that would use the wetlands don't depend on being located in wetlands and therefore don't pass the water-dependency test. Yet there's a strong feeling that we must have the income the development of wetlands would bring. But how do we do that in light of our present Coastal Zone Management Act? It's a very difficult challenge: we have the pressure to grow on the one hand and the pressure to preserve those resources on the other. And if that trend to grow is going to continue, there will have to be some changes in the Coastal Zone Management Act priorities to allow that growth to occur in the pattern that I have mentioned.

Diversification of our economic fare hasn't been significant in Louisiana to this point. Realistically, we're looking at more of the traditional types of development rather than miracle cures. Like Texas, the ports are very active in seeking development. We have a Ports and Waterways Institute at LSU that is growing and is working very actively to assist Louisiana ports in expanding their activities. The Port of New Iberia, for example, has lured Brown and Root and Sohio facilities to build offshore equipment for the Alaskan OCS. That brings us into a land-use conflict. To move that equipment out of the port and into the Gulf requires the dredging of canals and the alteration of hydrologic patterns, which puts us back into facing the same kinds of problems that have caused some of the land loss we have experienced. The Mississippi River Gulf Outlet, dredged for navigation, brought saltwater intrusion which has in a major way adversely affected wetlands. We face more of that if we dredge a long channel through Vermilion Bay into the Gulf of Mexico. Economic development on the one hand, consequences for the wetlands and the coastal zone on the other. The conflict is not resolved yet, but it is there and it's more intense now because our economic needs are so much greater than they were a few years ago. We don't have the slack in the system that would allow us to miss an opportunity for development. So those issues are not being taken lightly in the present atmosphere.

We have to put OCS oil and gas activity in the industrial development category; that is we don't actually produce any OCS oil and gas in Louisiana itself, but we do service the industry. Most of the activities that occur in our coastal zone related to OCS are of an industrial nature. They are service industries, fabrication yards, and transportation industries. Our concerns regarding OCS-related impacts have been expressed in recent years through comments on environmental impact statements and leasing policies. We have maintained that those facilities, canals, and related industrial developments do negatively affect our wetlands. Clearly we benefit from employment; clearly we get taxes from those people that are employed and from property and businesses. We don't dispute that. But in looking out for our own interests and looking at OCS development patterns for the future, we would like to see a reasonable pace. If the action is going to be concentrated in the Gulf, as it clearly looks like it's going to be with frontier areas fading, and with California not wanting to play the game, then we're going to see continued development of existing shallow-water Gulf resources. Developments in deep water will continue the dominance of offshore Louisiana in OCS production. We'd like to see, for our best interest, that development occur at a reasonable rate. And that's one of the reasons why this state has been concerned about accelerated area-wide leasing, about the boom or bust syndrome, and about the environmental consequences of that sort of approach to leasing. Not that we're opposed to oil and gas leasing in the OCS. Clearly we're not, never have been, never will be. But the rate at which development occurs in terms of our economy and our environment is of vital concern. Thus we have been strong in recent years in voicing our concerns, so that we don't induce more conflict in coastal Louisiana as a result of an accelerated activity that we feel would occur at a more reasonable rate than the one the federal government is proposing.

I can sum up by pointing out that the irony of all of this is that the emphasis on increased economic development to help our economy calls for more of those very things that originally caused some of our most severe environmental problems in the coastal zone. In other words, we dredged the canals to access oil and gas. That built the strong oil and gas economy we have in the southern part of the state and it also contributed significantly to wetland loss. We participated with the federal government and supported the Corps of Engineers in dredging major navigation channels like the Mississippi River Gulf Outlet to benefit the economy of the state, to bring about economic development. That brought salt-water intrusion, which is destroying our wetlands. We supported the efforts to build levees on the Mississippi to keep flood waters and sediment out of adjacent areas so we could put people there in a livable environment. The lack of sediment is one of the chief reasons that the barrier islands are disappearing and that our wetlands are shrinking, not growing.

These activities have done great things for the economy of Louisiana on the one hand, but we have suffered in that we have lost renewable coastal resources in the process. Now, as we approach a period with a strong need for economic growth, we are looking to the same kinds of development, port activity, industrial growth, urban expansion, flood control, oil and gas production, and OCS support facilities to help our economy. This will bring more stress, more conflicts, in terms of wetland renewable resource use. So we enter into another very difficult period of trying to reconcile the need for development with the need for preservation of coastal resources. It may become a horse race. It may be a question of whether the efforts we're making through Coastal Zone Management and through our Coastal Protection Program to slow down coastal erosion can keep ahead of the wetland losses that would accompany another round of coastal area development. The real challenge for Louisiana's future is whether or not we can expand our economy without affecting our coastal resources in such a way that they disppear, removing the base we depend on for much of our livelihood.

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Selected Growth and Development Trends in the Coastal Area of Mississippi

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The State of Mississippi addresses coastal and marine resource management through the Mississippi Department of Wildlife Conservation, Bureau of Marine Resources. The Bureau represents the State of Mississippi on the Gulf of Mexico Regional Technical Working Group.

The following brief comments will touch on some of the anticipated growth and development trends, including that for oil and gas activities, which are perceived to be of importance to the state's coastal area. Also, a few words will be offered pertaining to the state's management of coastal wetlands and waters.

TRENDS IN INDUSTRIAL AND ECONOMIC GROWTH

With respect to population, the coastal zone is clearly the fastest growing part of our state. The coastal population, which currently represents 10% of the state's total population, is projected to increase by 30% in the next 25 years. By that time at least one-half million people will be residing in our three coastal counties. The projected growth will be accompanied by significant increases in industrial activities, demands for jobs, goods, and services, and usage of ground water from acquifers which are already in short supply in some areas of the coast. The projected growth requires that special attention be given the coastal area in providing services and in meeting the growing socio-economic and resource usage demands.

Mississippi's coastal economy is largely dependent upon marine-related industry and commerce, as well as tourism. For example, one of the major industries is Ingalls Shipbuilding. Ingalls, the largest single employer in the state with 10,000 employees, has delivered 43 new warships to the U.S. Navy since 1975, and plans are on the drawingboard for new construction projects. Also, Chevron's coastal refinery, the largest petroleum operation in the state and one of the largest in the world, is expanding in order to process over 16 million short tons of heavy crude per year. An oil rig repair facility by next year and a liquified natural gas port and terminal by 1988 are activities included among several planned major industrial activities.

As a result of industrial and port development initiatives, new industries have located in the coastal area, several established industries have expanded, and, in general, long-term industrial growth is contemplated for the years ahead.

Tourism, of course, is a major contributor to the coastal economy with a direct economic impact exceeding $200 million per year. Tourist activities key on recreational fishing and the beach experience. Plans are underway to enhance our sand beach areas in order to attract and accommodate even greater numbers of visitors to our shores.

OIL AND GAS RESOURCE ACTIVITIES IN MISSISSIPPI'S TERRITORIAL COASTAL WATERS

Since 1981, oil companies have shown an interest in leasing Mississippi's coastal waterbottoms. The state's attitude is one of desiring to lease these lands for mineral resource development in hopes that hydrocarbons will be discovered in quantities profitable to develop and produce, and that such production will generate additional revenues for the state. Mississippi held its first offshore lease sale in 1982. Only the southern half of the state's coastal waterbottoms, encompassing some 240,000 acres, were offered in this first lease sale. The state accepted one bonus bid offering for two tracts and awarded a five-year lease.

In February of this year the state awarded to another company a lease for some 20,000 acres of coastal waterbottoms. This particular lease is valid for a period of two years, and drilling efforts will likely begin in early 1986. Also, a negotiated oil and gas lease was recently completed. The area leased includes waters near the upper reaches of tidal influence within the Pascagoula riverine system.

To date, oil and gas drilling activities have not been initiated on any of the state's leased coastal waterbottoms.

The state has formulated a coordinated and systematic approach among appropriate state agencies for oil and gas permitting and development within the state's coastal waters. Also, the Corps of Engineers, Mobile District, recently developed, with cooperative input from Mississippi, a General Permit for hydrocarbon exploration and appraisal within Mississippi's coastal waters.

Mississippi's next coastal oil and gas lease sale (Lease Sale No. 2) is scheduled for December 11, 1985. The area being offered is the same as that offered in the first lease sale, the southern half of the state's coastal waters.

The state is also examining the prospect of offering, at some future date, coastal waterbottoms not previously made available for lease, i.e., those located nearer the mainland.

OIL AND GAS DEVELOPMENTS IN NEARBY FEDERAL OUTER CONTINENTAL SHELF WATERS

During the past four years, companies have acquired leases on 22 Outer Continental Shelf (OCS) tracts which are either adjacent to or in the vicinity of Mississippi's offshore territorial boundary. These leased tracts comprise 60% of the first six tiers of OCS tracts located off the state. Three of these nearshore tracts abut our state waters, two tracts are within one mile of the state boundary, and the remaining 17 tracts lie in the immediate vicinity.

To date, exploratory drilling has taken place on only one of these tracts, a tract adjacent to our territorial waters. Gas was encountered during this drilling. It is anticipated that additional OCS tracts off Mississippi will be leased in future OCS lease sales.

EPA Regions IV and VI are currently working to formulate an NPDES General Permit applicable to OCS oil and gas operational discharges in the Gulf of Mexico. The hope is that recommendations submitted by Mississippi which pertain to drilling fluids discharges will contribute to the development of a General Permit which expedites needed mineral resource development and provides for prudent environmental management.

ONSHORE DEVELOPMENT ASSOCIATED WITH OFFSHORE OIL AND GAS ACTIVITIES

Both state offshore leasing and OCS leasing near the state's territorial waters are relatively new to Mississippi, and a commercially viable hydrocarbon discovery could be a significant asset to the state. Offshore exploration and development must be supported by onshore facilities and associated business activities. Thus, onshore development can prove to be economically beneficial for the state, particularly the coastal area.

Mississippi already has experienced oil and gas resource development benefits in the form of employment of a number of its citizens in offshore oil and gas activities off Louisiana. However, Mississippi has no experience with onshore impacts resulting from offshore oil and gas development within its territorial waters or adjacent OCS waters. Also, the state has no experience with the socio-economic demands and resource utilization conflicts confronted by coastal communities from such development. With proper planning, oil and gas development could complement the traditional economy of our coast and improve the quality of life for coastal residents.

OIL SPILL PLANNING

Mississippi's coastal waters serve as a transportation corridor for crude oil and petroleum products. Certainly, the probability of a spill is low; however, considering the increasing oil transportation activities and the increasing offshore oil and gas activities, prudent environmental management required that pre-planned responses to oil spills be formulated. Therefore, a coastal oil spill contingency guide was developed by the state's Bureau of Marine Resources and made available earlier this year. The hope is that proper planning and the use of the best available technology will minimize the risks and environmental damage in the event of an oil spill occurrence.

COASTAL SEAFOOD INDUSTRY

Harvest of marine fishery resources has contributed significantly to the development of the Mississippi coast for many years. Commerical and recreational marine fishing are considered major industries, contributing several hundred million dollars per year to the state.

Mississippi's reported commercial landings of marine finfish and shellfish over the past ten years show an average annual volume which exceeds 350 million pounds. The 1984 Mississippi commercial marine landings of 477 million pounds established a landings record for the state. In state rankings, these 1984 landings placed Mississippi sixth in the nation in total commercial landings by volume, with one of our ports ranking second in commercial landings among U.S. ports. However, a continuation of increased landings is questionable, and it now appears that some species in the commercial harvest are currently being overfished.

The shrimp fishery, one of our major coastal fisheries, is one of the most economically stressed fisheries. During the past 20 years the shrimp industry has experienced periods of major economic recession, rises in vessel operational costs, and fluctuations in resource availability. In 1984, over 6000 Mississippi shrimping licenses were issued. This represents twice the number of licenses issued a decade earlier. The commercial shrimper's catch per unit of effort has decreased due in part to this tremendous increase in the number of people shrimping. The increased participation can be attributed in part to the demand for shrimp, the influx of Asian-American fishermen, and the growing number of pleasure-boat shrimpers.

Some of our other commercial fisheries are currently in an unfavorable economic condition as well; however, in terms of economics, the coastal recreational fishing industry has grown sharply during the past two decades and an even sharper trend is projected for the future. Increasing conflicts in resource utilization between commercial and recreational fishermen will have to be addressed and resolved.

Seafood processing and marketing contribute significantly to the economic well-being of the coastal region. However, these businesses must cope with increased competition from foreign imports. Growth of the processing and marketing industries will largely depend upon the potential for marketing under-utilized or non-traditional species, improvements in product quality, and the development of marketable new seafood products.

Traditional stocks of marine finfish and shellfish species certainly are not unlimited. Many of the Gulf of Mexico's and Mississippi's traditional fisheries are presently being harvested at or near maximum levels or are actually declining because of over-fishing, domestic and industrial pollution, and habitat disturbance. New and innovative management measures will be called for in an effort to maintain the economic viability of selected fisheries.

AQUACULTURE OPPORTUNITIES

Against the background of economic stress in some commercial fisheries, the world demand for quality fish and other aquatic products is increasing. During this year, world aquaculture output will amount to about 10 million metric tons -- representing more than 10% of the total world harvest of fishery products. This share will increase steadily because aquacultural opportunities are often the only means available for providing and significantly increasing the supply of high quality fishery products for which there is a demand.

In the coastal counties of Mississippi, aquacultural operations have the potential of emerging alongside traditional fisheries. Aquaculture would complement and supplement supplies to the marketplace with non-traditional species and with traditional species which have been over-fished and are on a harvest decline. Our coastal area has the natural resource base, a relatively long growing season and a supporting infrastructure upon which premium value aquaculture products can be produced and marketed. Mississippi should be in a position to take full advantage of its coastal aquaculture potential and thus accrue the associated benefits for its people and economy.

COASTAL WETLANDS MANAGEMENT

Mississippi's coastal wetlands, which include the valuable saltmarshes, undeniably provide significant economic benefits to the state while performing a variety of ecologically and physically important functions. However, not many years ago many acres of our coastal wetlands were susceptible to destruction and some were actually lost through dredging for channels, marinas, and ports, or were filled to create new land. With an increasing population and an ever increasing number of permit requests to conduct activities which influence our wetlands, wetlands management continues to be paramount to maintaining the desired natural productivity upon which a significant segment of the coastal economy depends.

The Mississippi Coastal Wetlands Protection Law was passed in 1973 to prevent future coastal development from adversely affecting the public interest in the wetlands. This law protects and enchances coastal biological resources and environmental quality. It was recognized that the Coastal Wetlands Protection Law should be accompanied by additional affirmative and coordinated efforts to fully encourage sound development practices in the coastal area. These additional efforts would be aimed at protecting wetlands while providing for industrial activities, promoting economic diversity and growth, and maintaining maximum productivity of the coastal fisheries industries. Therefore, in 1980, the Mississippi Coastal Program was implemented to supplement existing regulations with affirmative and coordinated coastal and marine resource management efforts.

As growth and development, including oil and gas activities, increase, there are demanding questions to be addressed and issues to be resolved. This may require the application of techniques to examine our coastal development in new and innovative ways. Coastal Mississippi faces the remaining 15 years of the 20th century bolstered by the fact that, throughout the coastal community, the technical and scientific competency exists to increase our understanding of complex coastal and marine issues. With advancements in understanding, facilitated through research, analysis, and planning, management can be improved. Improved management will provide for economic development and the resolution of critical issues, while protecting the quality and maintaining the natural productivity of Mississippi's valuable coastal wetlands and waters.

Mr. James Franks is on the staff of the Bureau of Marine Resources of the Mississippi Department of Wildlife Conservation. Working within the Bureau's Scientific-Statistical Division, Mr. Franks is involved in environmental management aspects of oil and gas development within the state's coastal waters and the OCS waters of the Gulf of Mexico. He holds a master's degree in zoology and has worked as a marine biologist for the past 19 years.

Dr. Cornell Ladner is Chief of the Scientific-Statistical Division within the Bureau of Marine Resources in the Mississippi Department of Wildlife Conservation. As Division Chief, Dr. Ladner directs activities pertaining to environmental aspects of oil and gas development in Mississippi coastal waters, coordinates the Bureau's involvement in the OCS oil and gas program, and directs the Bureau's activities pertaining to aquaculture enhancement and development and utilization of renewable coastal and marine resources in the coastal area of Mississippi. Dr. Ladner has degrees in microbiology and chemistry and has been involved in environmental research and management for the past 20 years.

State of Alabama Perspective

Mr. Douglas R. Hall
State Oil and Gas Board, Alabama

I'm going to be speaking primarily on the past and present leasing and drilling activities in Alabama coastal waters and adjacent federal waters.

Hydrocarbons were first discovered in Alabama's coastal waters in 1979. Since that time, exploration activities have continued at a lively pace until offshore Alabama has become an area of intense exploration activity with a phenomenal success ratio.

Mobil Oil Exploration and Producing Southeast, Inc., (MOEPSI) made the first discovery of hydrocarbons in 1979. This discovery occurred in State Block 76 with the drilling of the State Lease 347, Number 1. The 347 No. 1 well was drilled to a total depth of 21,113 feet and encountered pay in the Jurassic Norphlet Formation. The initial test for the well was 12.2 million cubic ft of gas per day on a 28/64th-in choke with a tubing pressure of 2996 psig. This was through a perforated interval of 20,634 - 20,883 ft. Hydrogen sulfide content of gas was 9%.

With this discovery by MOEPSI on Alabama Block 76, considerable interest was generated on the hydrocarbon potential of coastal and offshore Alabama.

In March 1981, the State of Alabama, through the Department of Conservation, held a lease sale of state-owned acreage in the state's coastal waters. Bids were accepted on thirteen blocks owned by the state. Bonus money received from the leasing of the state-owned tracts amounted to approximately $449 million. Terms of the leases included a five-year primary term and delay rentals of $5 per acre with royalties of between 25 and 28%. Bonus payments ranged from $1765 to $31,516 per acre with an average of $8160 per acre. Alabama Block 112 received the highest bonus payment of over $137 million.

In September 1982, an oil and gas lease was awarded on State Block 110. During the September lease sale, nine bids were submitted on six blocks. The bid on Block 110 was the highest bid in the sale and the only bid accepted. The bonus accepted on the Block 110 acreage was approximately $3 million. The lease awarded on 110 was for a five-year term and a royalty of 25%. The bonus per acre for this lease was $2407.

As a result of Federal OCS Lease Sale No. 67 in February 1982, the federal government leased the oil and gas rights to 17 blocks in the Mobile area near Alabama state waters. Bonus money totaled approximately $218 million for five-year leases.

In the March 1983 Federal OCS Lease Sale No. 69, Part II, the federal government leased the oil and gas rights to Mobile Block 905. This block was leased to Union Oil for $880,000.

In the May 1983 Federal OCS Lease Sale No. 72, thirteen blocks were leased in the Mobile Area. Bonus monies received from these blocks totaled over $40 million.

In the April 1984 Federal OCS Lease Sale No. 81, the oil and gas rights to 20 federal blocks near Alabama state waters were leased. These were, again, in the Mobile area. Bonus money for these blocks totaled $104 million.

In the August 1984 State Lease Sale, bids on 25 blocks were submitted to the State of Alabama. Bids on 19 of the blocks were accepted, but the bids on the remaining six blocks were rejected. Alabama Block 114 received the highest bonus payment of over $52 million. Bonus money received from the leasing of the 19 state blocks amounted to over $347 million and averaged $4630 per acre.

In the May 1985 OCS Lease Sale No. 98, there were approximately 19 blocks leased in the Mobile area which were in the vicinity of Alabama's coastal waters. Over $140 million was received from the leasing of these tracts.

The State of Alabama plans to hold another lease sale on March 18, 1986. Twenty-four tracts constituting approximately 100,000 acres are available for lease. Leases will have a primary term of five years, delay rentals of $5 per acre, and varying royalty obligations.

As stated earlier, the Lower Mobile Bay - Mary Ann Field was discovered in 1979 with the drilling of State Lease 347, No. 1 in Tract 76. The field was formally established in 1980 by the Alabama Oil and Gas Board and includes State Blocks 76, 77, 94 and 95. Five appraisal wells were then drilled to define more accurately the limits of the reservoir. Three of these appraisal wells were tested and flow rates ranged from 10.5 to 19.4 million cubic ft of gas per day.

In December 1982, public hearings were held to unitize the Lower Mobile Bay - Mary Ann Field. All four state-owned blocks as well as the landed area included within those blocks were included within the field unit.

Production from the Lower Mobile Bay - Mary Ann Field is expected to begin in late 1986 or early 1987. Four production platforms and an auxiliary platform will be constructed. A 14-mile pipeline system will be constructed to transport the gas from the production platforms to the gas treatment plant which will be located in the south Mobile County, 20 miles south of the City of Mobile. The processing plant will have a capacity of 80 million cubic ft of gas per day.

Reserves of the Lower Mobile Bay - Mary Ann Field have been estimated to be in excess of 500 BCF, and the anticipated life of the field has been estimated to be approximately 42 years.

In addition to the deep Jurassic gas which has been discovered in the Lower Mobile Bay - Mary Ann Field area, Mobil has also tested sweet gas from Miocene age sediments. In 1982, MOEPSI's State Lease 350, No. 2, which is located on State Block 95, was drilled to a true vertical depth of 2750 ft and tested four million cubic ft of gas per day.

In addition to the drilling activity in the Lower Mobile Bay - Mary Ann Field, MOEPSI also made a second discovery in February 1984, twelve miles west of the Lower Mobile Bay - Mary Ann Field near the western tip of Dauphin Island. The well, which is located in Block 72, was also completed in the Jurassic Norphlet. The well was drilled to a total depth of 21,315 ft and tested at a rate of 21.2 million cubic ft of gas per day.

MOEPSI presently has a formal petition on the Alabama Oil and Gas Board docket requesting the Board to establish a new field around the Block 72 discovery. MOEPSI is requesting that the new field be named "West Dauphin Island Field," and that the field be composed of Blocks 71 and 72 in the north half of Blocks 89 and 90. Additional drilling activity is expected to commence soon within the proposed new field.

MOEPSI also made a significant Norphlet discovery in 1983 in Federal OCS waters on Mobile Block 823, which is adjacent to Alabama state waters. The 823, No. 1 Well, tested at a rate of 26 million cubic ft of gas per day.

In addition to the drilling activity being conducted by MOEPSI, Exxon, which has become the major lease-holder in Alabama state waters, has been extremely active.

On August 29, 1984, Exxon tested natural gas from the Norphlet Formation north of the Lower Mobile Bay - Mary Ann Field in Block 63. Exxon's Alabama Block 63 Well tested 28.1 million cubic ft of gas per day. This is the highest natural gas test in Alabama's history.

In October 1984, Exxon tested significant quantities of natural gas in Federal OCS waters on Mobile Block 867. The well was completed in the Norphlet Formation and flowed at 24 million cubic ft of gas per day. In November of the same year, a re-test of the 867 Well was reported to have flowed at a rate of 32.9 million cubic ft of gas per day.

Exxon has also made a significant discovery southwest of the Lower Mobile Bay - Mary Ann Field in Block 112. On December the 25th, the Alabama Block 112, No. 1, tested 21.7 million cubic ft of gas per day from the Norphlet Formation.

Exxon's Block 115 Well was tested in April 1985. The well was also completed in the Norphlet Formation and flowed at a rate of 9045 MCF of gas per day.

In May 1985, Exxon returned to the State Lease No. 534, No. 1 Well, which is located in Block 62 so as to run a production test on the well. The Block 62 well was drilled in 1983 and then temporarily abandoned. It tested gas from the Norphlet at a rate of 20.5 million cubic ft of gas per day.

There are presently five wells being drilled in Alabama's coastal waters and one permitted location. Four of these wells are being drilled by Exxon and the fifth is being drilled by Shell Offshore, Inc. Shell's well is located in Block 113.

The wells being drilled by Exxon are located in State Blocks 114, 91, 64, and 97. Exxon also has a permitted location on Block 116, but they have not yet moved a rig into that location.

The outlook for the future development of the hydrocarbon resources in the state's coastal waters would have to be considered excellent. The amount of drilling activity presently being seen in the state's coastal waters should continue for several years. Although the deep Jurassic Norphlet Formation should remain the primary objective, exploratory drilling for shallow Miocene reservoirs is also likely. There are presently 37 state-owned blocks under lease to oil companies for the right to explore for oil and gas. The leasing of these blocks has netted the State of Alabama total bonuses of nearly $800 million.

Sixteen wells have been completed or are presently drilling in the state's coastal waters with the Norphlet Formation as their objective. Of the eleven Jurassic tests that have been completed in Alabama waters, none has been completed as a dry hole.

Douglas R. Hall is Chief Geologist of the Drilling and Permitting Section of the State of Alabama Oil and Gas Board. His responsibilities include permitting of oil and gas wells statewide but with primary emphasis in southwest and offshore Alabama. Mr. Hall received a BS in Geology in 1980 from the University of Alabama and is presently fulfilling requirements for an MS in Geology.

State of Florida Perspective

Mr. Paul Johnson
Executive Office of the Governor, Florida

Today I'd like to talk mainly about the history of OCS activities offshore Florida and how it relates to our future there.

But first I'd like to relate two current events of economic impact to our state. One was Hurricane Elena which sat off our coast for about two days churning up the offshore area between Panama City and Tarpon Springs. This storm had a major impact on our shellfish beds in the Apalachicola Bay area and nearshore fisheries in general. Another natural resource of major economic interest in Florida is the citrus industry. This has recently been severely impacted by the citrus canker.

Here is a story concerning the citrus problem that was passed around the Governor's office recently. Allegedly the Commissioner of Agriculture sent a letter to the Governor requesting he seriously consider having a benefit concert for the citrus industry because it was having such a hard time with the citrus canker. They recommended calling it "The Lemon-Aid Concert," and bringing in Anita Bryant to headline the show. If the oil industry is suffering such economic depression you all might get together and think of having a benefit concert yourself.

Anyway, Florida is a frontier area in the Gulf of Mexico concerning oil and gas. It's like the old West: it has both the vigor and the hardship for development.

The first test well drilled in Florida was in 1948 off the Marquesas Keys. Since then there's been a slow, steady level of activity and exploration; however, we have found no oil and gas to bring ashore.

In the last 20 years, Minerals Management Service has held eight lease sales in the eastern Gulf of Mexico. Thirty-seven wells have been drilled on the OCS with no reported finds.

In our own waters we don't have an active leasing program, but we have an historic one. In that leasing program, 29 wells were drilled, again producing no marketable finds of oil. So it seems the only oil we can find off Florida beaches is suntan oil.

The last federal lease sale held in the eastern Gulf was in January 1984. This was the first lease sale in Florida under the Area-wide Leasing Program. During that lease sale, 8868 blocks were offered, about 50.6 million acres. Only 156 blocks were purchased under that program, producing a net total of $310 million for the federal government. Florida has received no monetary share from that sale.

Major areas of interest in that lease sale are historic areas of interest off the Florida shelf. One is the Destin Dome area, a geological formation between Panama City and Pensacola off the northwest Florida coast, and another the area south of 26°N latitude, off the southwest Florida coast.

There's quite a bit of difficulty exploring the eastern Gulf of Mexico. As I said, like the old west there's a lot of hardship involved. We've been keeping industry out of many areas for a number of years for military reasons. The eastern Gulf is an area of extensive training and testing for military bases in Florida. It turned out that oil and gas operations were not completely compatible with many of these uses. For example, it seems the new pilots training in the eastern Gulf may be having difficulty recognizing the lights of the aircraft carrier versus the lights of the rigs. This could cause some obvious problems. Also, there seems to be a conflict in testing sidewinder missiles, which may seek the heat of flares off the side of rigs. In order to avoid these use conflicts, MMS has worked out agreements with the military to allow certain "windows," or areas, to be open for exploratory drilling during certain times. Five wells have been drilled in the first of six windows identified in the eastern Gulf. Of these, one well is still actively being drilled off the northwest coast. The other four have been plugged and abandoned. That seems to be a common trend there.

The other area of interest is off the southwest coast of Florida between Naples and the Florida Keys. This area has historically been explored and, again, no finds have been made. There are a number of leases that were made available in the last lease sale. However, because of a Congressionally mandated moratorium, no drilling will occur here until three years of environmental data have been collected. As of April 1986, MMS will have collected that information through the Environmental Studies Program, and this area then may be opened for exploration.

Recognizing a national need for energy, the State's position since the 1970's has been that we do not object to oil and gas exploration and development off our coast as long as they will not jeopardize our unique and often sensitive offshore environments and the land-based economies that they support. Two major industries in Florida where this is a concern are coastal tourism and marine fisheries, both recreational and commercial. As oil and gas activities increase off the Coast, they will have to be shown to be completely compatible with these present uses.

However, in the event oil and gas is found, we have pursued the various scenarios developed by MMS through our Regional Planning Offices. Through federal funding, these planning groups have developed seven Facility Siting Studies, locating the best approach to bring oil and gas ashore if it should be found. The two most likely places from the major areas of interest right now would be the Panama City area in the northwest panhandle and Port Manatee in south Florida on the west coast.

Areas of major environmental interest are the seagrass beds, sponge and algae beds, and coral reefs that are found off our coast. These biological assemblages attract a lot of fish and people. They are renewable resources that have been there a long time, and it doesn't take much to change them. And, once that change is made, it has not been demonstrated that they will ever come back.

Although we have spent over $5 million on studies to open the eastern Gulf for exploration, we still have a way to go in understanding the shelf environment. We're finding what lives where on the shelf and what environmental parameters may be most important in controlling their distribution and survival.

Areas of further research and discussion during these meetings should center on (1) some fate and effect studies on oil and gas operations in a fairly pristine carbonate environment, (2) better predictive models for oil spill trajectory so that we can better predict where the material may go and better respond to it, and (3) more secure and safe transportation systems so that if the oil and gas is found on the Outer Continental Shelf it can be brought ashore in an economic and environmentally safe manner.

Thank you very much for the opportunity to speak.

Mr. Paul Johnson is a governmental analyst in the Natural Resources Policy Unit, in the office of Florida Governor Bob Graham. Johnson's background is in environmental studies and research relating to oil and gas exploration. He holds the MS degree in Marine Sciences from the University of Alabama. One of Johnson's principal responsibilities is coordination with the federal offshore minerals leasing program in the Gulf of Mexico.

MMS TECHNOLOGY ASSESSMENT AND RESEARCH PROGRAM FOR OFFSHORE OPERATION

Session: TECHNOLOGY ASSESSMENT AND RESEARCH PROGRAM FOR OFFSHORE MINERALS OPERATIONS, MMS

Chairman: Mr. John Gregory

Date: October 22, 1985

Presentation Title	Speaker/Affiliation
Introduction to the MMS Technology Program	Mr. John Gregory Technology Assessment and Research Branch, MMS
Undersea Inspection of Subsea Production Systems	Mr. R. Frank Busby Busby Associates, Inc.
Improved Gas Diverter System	Dr. A. Ted Bourgoyne Louisiana State University
Extinguishment of Blowout Fires with Water Spray	Dr. David Evans National Bureau of Standards
Overview of MMS Structure Research	Mr. Charles E. Smith Minerals Management Service
Metallurgical Considerations for the Use of High Strength Steel Tension Members in Sea Water	Mr. Joseph A. Hauser, II Naval Research Laboratory
Inspection of Tension Leg Platform Tendons	Dr. John Halkyard

Introduction: MMS Technology Assessment and Research Program for Offshore Minerals Operations

Mr. John Gregory
Technology Assessment and Research Branch
Minerals Management Service

This Sixth Annual Information Transfer Meeting (ITM) is the second such meeting in which projects from the Minerals Management Service (MMS) Technology Assessment and Research Program have been presented. A year ago we discussed deep ocean well control, the collection of oil from flowing wells, and the structures projects directly pertaining to tension Leg Platforms (TLP). Recent leasing of deepwater tracts in the Gulf of Mexico and the Conoco TLP planned for the Green Canyon Area, have offered assurances that the new technologies needed for the deep slope waters are going to be developed. In this vein, we continue at this year's ITM.

Frank Busby tells about his recent survey of Subsea Production System (SPS) activities. Many sizes, shapes, and combinations are noted, and though not presently installed, deepwater (i.e. below diver depth) SPS's are planned. Mr. Busby strongly recommends that the proper inspecting and servicing of these systems will require cooperation among designers, operators, and inspection contractors.

Next, Dr. Ted Bourgoyne discusses his research on improving gas diverter systems which are used to direct shallow gas blowouts away from a drill rig. He outlines the problems with existing diverters, and the research which is being undertaken at the Louisiana State University Blowout Prevention Research Facility.

The suppression of blowout fires, which is important to the safe abandonment of a drill rig, has been under investigation at the National Bureau of Standards. Dr. David Evans describes his studies to attenuate and extinguish blowout flames by use of water sprays.

With regard to structures research, Charles Smith, MMS Research Program Manager, points out the variety of projects which range from seismic concerns to withstanding the forces of the Arctic Ice Pack.

Mr. Joseph Hauser then discusses his research on the testing of high-strength steels for stress-corrosion cracking, a malady which affects certain alloys placed in a corrosive environment under high tensile loading.

Lastly, Dr. John Halkyard describes what might be typical TLP leg configurations and his investigations into proper inservice inspection programs for them.

These are some of the projects of the Technology Assessment and Research Program of MMS, a program which provides a formal technology support base for MMS's offshore operations as the industry moves into the deep open oceans and ice-infested Arctic. The Program provides an independent assessment of the status of the offshore technologies. Where deemed necessary, further analyses are undertaken to assure that OCS operations are safe and pollution free. Projects address the day-to-day needs of our operations personnel, specifically: safety and pollution inspections, enforcement actions, accident investigations, operational permits and plan approvals, and well control training requirements. Studies are conducted at universities, private companies, and government laboratories--wherever there are promising ideas and capabilities for advancing the "regulatory" technologies. Project investigators provide a necessary and all-important dialog or forum at the engineering level between the industry and MMS personnel. These investigators serve as staff adjuncts to MMS personnel by briefing them through a network of working groups known as Operations Technology Assessment Committees (OTACS). The OTACS are located in headquarters and the regional offices; they discuss operational problems and technologies and make recommendations to mangement which are intended to improve MMS procedures and regulations.

The TA&R Program, together with the technology transfer network, is a primary means by which MMS assures the use of the "Best Available and Safest Technologies. . .which are economically feasible" (paragraph 21b BAST), which is a requirement of the OCS Lands Act as amended in 1978.

If you would like a copy of our report, *Technology Assessment and Research Program for Offshore Minerals Operation*, OCS Report MMS 84-001, 1984, please write to the Technology Assessment and Research Branch, 647 National Center, Reston, Virginia 22071. Or telephone us at 703-860-7865. We solicit your comments or questions, and hope you enjoy this session.

Mr. John Gregory is Chief, Branch of Technology Assessment and Research, MMS. He received the Degree of Mechanical Engineer from Stevens Institute of Technology and the Master of Engineering Administration from George Washington University.

Undersea Inspection of Subsea Production Systems

Frank Busby
Busby Associates, Inc.

Since 1960 a total of 292 Subsea Production System (SPS) wells have been installed, and an additional 77 wellheads are assembled and/or on order. (For comparative purposes, there are some 3600 fixed offshore production platforms worldwide, some drawing from dozens of wells.) The SPS units installed consist of wet (274) and dry, 1-ATA (18) structures. Some of the wet structures are single satellite wellheads while others are multi-wellheads grouped within a template. The functions of SPS's are to collect gas and oil or to inject water. A number have been installed for test purposes and are now abandoned. The growth of subsea productions has been slow, but steady. The most optimistic projection puts the number at 1000 by 1990. This pace will be governed by the price of oil, not by technological constraints.

The greatest water depth of SPS installation to date is 293 m. The average depth of SPS installations worldwide is 88 m. These are within the 300 m depth range generally accepted as the present limits for diver intervention. Two single SPS's are scheduled for installation in depths beyond diver intervention: the Montanazo field (762 m) and the Casablanca field (488 m), both in the Mediterranean.

PERFORMANCE

Published reports of SPS performance and reliability show percentage "up" time figures ranging from as low as 51% annually to as high as 96 to 99%. The majority of reports quote the latter percentages. Ten wellheads in the Molino field, offshore California, were retrieved after 20 years' service with no reported breakdowns. A detailed inspection of one of the wellheads showed that it could have gone on producing for, perhaps, several more years.

Problems encountered with SPS's are ascribed to unreliable control systems, downhole electronics, unsatisfactory data handling techniques, manifolds not designed with maintenance in mind, inadequate sensors, unreliable electrical connectors, and sticking subsea valves.

The most severe damage, and of greatest concern to the operators, is that which would be imposed by contact with trawls, dragging anchors, and/or dropped objects. The solution to this latter problem has been to enclose the SPS within a protective framework, to install it within a hole excavated deep enough to avoid impact (i.e., icebergs or ice islands), or to design it so that it can withstand any forces likely to be encountered other than impact by a submarine.

INSPECTION PROGRAMS

The Norwegian classification society, Det norske Veritas, is the only organization that offers a formal post-installation inspection program for SPS's. The manufacturers of SPS's also recommend inspection/maintenance programs for their particular systems, but these are at the option of the operator to pursue or ignore. The operators the writer has interviewed see little or no need for inspection since wellhead pressures, product flow, and temperatures are continuously monitored. Further, short of a major impact, the past history of SPS's shows more than adequate structural integrity as long as a proper corrosion protection system is employed. The results of marine fouling have shown to be more cosmetically unpleasing than damaging.

The greatest inspection effort on the part of the operators is performed before the SPS is installed. These programs can, and many do, begin at the component level and cover the entire system before it is placed in the water. In many instances the system is operated ashore to identify deficiencies. Other operator requirements call for quality asssurance monitoring at all phases of manufacture and assembly for a system configuration based on proven hardware and concepts; and for components that have a proven record of tolerance to rough handling, contaminated hydraulic fluid, and other adverse conditions which commonly occur in practice.

INSPECTION AND MAINTENANCE INTERVENTION TECHNIQUES

There are three primary underwater intervention techniques in use and available for SPS inspection and maintenance: the diver, the manned submersible, and the remotely operated vehicle or ROV. The premier intervention technique is the diver, mainly because few of the early SPS's were designed for other than human intervention, but also because the diver can respond to unforeseen maintenance more adroitly and more quickly than diverless techniques. Because there is no standardization in wellhead design, nor any compelling reason to recommend such, there are no standard maintenance tools that can be applied across the board from one wellhead to another. Field experience and testing and evaluation with diverless techniques demonstrate that a wellhead which is designed for diverless intervention, coupled with a vehicle modified to intervene on that particular wellhead, can be provided with adequate diverless inspection and maintenance. These are the procedures being followed on the two SPS's planned for installation beyond the depth of diver intervention.

RECOMMENDATIONS

The wide variation in configurations and capabilities of present subsea production systems precludes recommendations for research and development in the areas of inspection and maintenance. What might enhance the conduct of these operations on one SPS may not have application to any other. The strongest recommendation is that SPS's that will be deployed beyond or at the margins of diver intervention be designed with the designer, the operator, and the intervention contractor working together. In essence, it is critical that the structure be designed for the vehicle and the vehicle be designed or modified for the structure and the environment. The absence of this practice has been the chief reason for inadequate performance of diverless techniques.

A technical area that shows some promise for overall inspection of large and small subsea production systems is large area television coverage. Field demonstrations have produced images encompassing areas of the bottom averaging 2000 m^2. Research in this area is seeking to expand this to 500 m^2. Large scale imaging of this type may provide a diverless technique capable of externally examining an entire satellite wellhead or template for impact damage, scouring, or debris accumulation rapidly and comprehensively.

Mr. Frank Busby is Director of Busby Associates, Inc., a firm devoted to the design and study of underwater vehicles and work techniques. Mr. Busby received a BS in Geology from the American University and MS in Oceanography from Texas A&M University.

Improved Gas Diverter Systems

Ted Bourgoyne
Louisiana State University

Some of the most costly events that have occurred in the history of the oil industry have been caused by "blowouts." When a well threatens to blowout, quick and informed action by a well-trained crew in the proper use of blowout prevention equipment is often required to avoid harm to personnel, equipment, and the environment and to avoid loss of valuable natural resources.

Well control is especially difficult when a threatened blowout situation unexpectedly occurs at a shallow depth, prior to setting surface casing. This situation is illustrated by the example shown in Figure IIA.1. In this example, a well was being drilled at a depth of 3500 ft just prior to setting the next casing string. Conductor casing was set at only 300 ft. Thus, the well could not withstand any significant pressure without exceeding the fracture pressure of the shallow sediments exposed below the conductor casing. In this type of situation, if formation fracture occurs, there is a high probability that formation fractures may broach to the surface. When the flow through the fractures is severe, a crater may develop and destroy the foundations of the drilling platforms.

The example described above is the situation just prior to the infamous blowout which occurred in the Santa Barbara Channel in 1968. Just prior to the blowout, the drill pipe was being raised in the well to remove the bit. The well started to flow, and the crew dropped the drill pipe into the well and closed the blind rams of the blowout preventer stack. Soon after, a fracture broached to the surface, releasing oil to the sea at a high rate, and the platform was evacuated. Control of the well was greatly complicated and delayed once the integrity of the well was lost.

The best available procedure for handling a threatened blowout situation caused by a shallow hydrocarbon deposit involves the use of a diverter system. Basically, a diverter system is a large vent line which conducts flow away from the rig and rig personnel in a downwind direction. More than one vent line must be available to assure that a downwind diversion is possible. The vent line must be large enough to prevent a significant pressure build-up in the well. Proper flow diversion can maintain the integrity of the borehold and permit a dynamic well kill procedure to be quickly employed, thus minimizing any environmental damage. After the Santa Barbara Channel Blowout, the use of diverters on all offshore wells was required by the Minerals Management Service (formerly the conservation Division of the U.S. Geological Survey).

Although conceptually simple, the design, maintenance, and operation of an effective diverter system for the various types of drilling vessels is a deceptively difficult problem. On the great majority of wells, the diverter system is never needed. This makes the maintenance of effective equipment and crew training psychologically more difficult. On most rigs, the diverter system is designed and added to the rig after the rig is built, complicating the routing of the vent lines. History has shown that average current industry practice is not adequate. Over the past 20 years, the diverter failure rate has been in excess of 50%.

The Petroleum Engineering Department of Louisiana State University, under the sponsorship of the MMS, and with the support of several companies in the oil and gas producing industry, has initiated a multiyear research effort directed at the development of improved diverter systems and operating procedures. The research is being conducted at the LSU Blowout Prevention Research Facility located near the Mississippi River on the edge of the Baton Rouge Campus. The research team is using both a theoretical and experimental approach.

A study of past diverter failures has indicated that major problems include improper diverter sizing and diverter erosion. The initial work focused primarily on these two areas.

One difficulty leading to undersizing of diverters is the poor quality of the available mathematical models for describing multiphase flow through a pipe at sonic exit velocities. Some initial experimental work has been done in highly instrumented 1-in. and 2-in. model diverter systems at sonic flow conditions using natural gas/water mixtures and natural gas/mud mixtures. These data have permitted significantly improved computer models of the reservoir/well/diverter system to be developed.

Erosion tests have also been conducted in a 2-in. model diverter system using mud/sand slurries. Erosion characteristics have been studied for various types of fittings used to change the direction of a vent line. These fittings included short radius bends, long radius bends, plugged tees, and vortice ells. The vortice ell is a relatively new type of fitting which has shown good erosion resistance in pneumatic systems for conveying solids. Unfortunately, data gathered in this study have shown that the vortice ell is not superior to the more conventional fittings for the test conditions used. Shown in Figure IIA.2 is an example wear pattern observed in a horizontal plane on the outside radius of the wall of the fitting. This wear pattern was observed after 90 hours of flow of a mud slurry containing 15% sand at a flow rate of 15,400 barrels per day.

The experimental work done in 1-in. and 2-in. systems will soon be expanded to include nearly full-scale tests after the completion of a 5-in. diverter system tied to a 7-in. wellbore. It was necessary to drill two wells in order to achieve sonic flow in the 5-in. system. (The minimum size diverter system now used in the field has a diameter of 6-in. as required by the MMS.) The wells have been drilled and completed, and the surface diverter lines are being installed. Initial testing is expected in the next few weeks. Gas flow rates in excess of 30 MMSCF/D will be achieved. Further improvements in the computer model are anticipated as a result of these tests.

The current computer model has been used for many typical field situations in order to determine the effect of diverter size on the surface and downhole pressures and on the flow rates experienced during a diverter operation. Typical results predicted after the well has unloaded are shown in Figure IIA.3. In this example, the liquid content of the gas is 100 barrels per MMSCF. Note that significant improvements in diverter performance could be achieved by increasing the current minimum diverter size from 6 in. to 10 in.

Future work calls for additional erosion and pressure loss determinations in the near full scale models. The erosion characteristics of sand/gas mixtures will be included in these tests. Also, a special advanced well control school on diverter operations is being planned.

Dr. A. Ted Bourgoyne is Professor of Petroleum Engineering at Louisiana State University. He received his BS and MS in Petroleum Engineering at Louisiana State University and PhD at the University of Texas.

Extinguishment of Blowout Fires with Water Sprays

David D. Evans
National Bureau of Standards

The Center for Fire Research (CFR) of the National Bureau of Standards (NBS) is investigating the feasibility of controlling radiation from blowout fires and extinguishing these fires using a water-based fire suppression system. It is known that when water is added to hydrocarbon flames, even in small amounts, radiation from the flames is greatly reduced. When larger quantities of water are added, the flames can be extinguished. The major problem to be overcome in the development of blowout fire protection systems is to determine methods for delivering the desired quantity of water and mixing it with the burning hydrocarbons to either control or extinguish fires.

A series of large scale tests was conducted in Norman, OK, to evaluate the performance of a four nozzle water spray system. These nozzles were arranged symmetrically about a 4-in. diameter gas outlet to spray water vertically into and around the flame produced by burning methane gas. It was found that an unobstructed nominally 200 NW (17 MMSCF/D) methane jet-flame could be extinguished under no wind conditions with a water flow rate of 129 GPM, but would continue to burn with a lower water injection rate of 86 GPM. For scaling purposes, extinguishing conditions are specified in terms of the ratio of mass flow rate of water to mass flow rate of gas burning. For the test results given above, the fire was extinguished at a mass flow rate ratio of 2.17 and failed to be extinguished using a flow rate of 1.56.

Small scale testing performed at NBS has been used to establish the nominal mass flow rate ratio of water to gas needed to extinguish methane gas fires for four nozzle water spray systems placed at various distances from the gas outlet.

Figure IIA.4 shows results from both large and small scale fires. For the large scale test geometry in which the ratio of the diameter of the ring of four nozzles to the diameter of the gas outlet was 4.5, the flame was extinguished at a water to gas mass flow rate ratio of 2.17. Small scale tests performed with methane flows of 9.86 MMSCF/D and a 1.75-in. diameter gas outlet show that the minimum water to gas mass flow rate ratio for extinguishment is 2.15.

As shown in Figure IIA.4, other small scale tests at increasing nozzle ring diameters show a general increase in water flow rate required for fire extinguishment. Generally a 75% increase in nozzle ring diameter requires a 25% increase in water flow rate for extinguishment. Other factors, such as spacing between water nozzles along the rings, may be a factor at large ring diameters. It is probable that using more than four nozzles at larger ring diameters may produce extinguishment of a given fire at lower total water flow rates.

Small scale tests are being conducted to examine the effects of obstructions on the water flow required to extinguish gas jet flames. It is expected that flames stabilized by obstructions will require larger water to gas mass flow rate ratios to produce extinguishment than that found in testing unobstructed flames to date. Large scale tests of water spray extinguishment systems will be conducted at Louisiana State University in fall 1985. Obstruction stabilized fires resulting from methane gas flows of approximately 35 MMSCF/D will be used as a basis for evaluation of water based blowout fire suppression systems.

Dr. David Evans is Acting Head, Fire Growth and Extinction Group, Center for Fire Research--National Bureau of Standards. Dr. Evans received his BS in Fluid and Thermal Sciences from Case Western Reserve, and his MS and PhD in Engineering from Harvard University.

Overview of MMS Structures Research

Charles E. Smith
Minerals Management Service

As in the other areas of the Technology Assessment and Research (TA&R) Program, current structure projects reflect industry's move into the frontier areas of the deep oceans and the ice-infested Arctic. During the early days of the Program, structures projects were concerned more with the inspection technologies which could be used to assess the integrity of older platforms in the Gulf of Mexico (GOM). This may be attributed to the fact that platform inspections are required only during construction and installation, there being no regulatory requirements for subsequent periodic inspections. Yet, due to the aging condition of many of these platforms, some form of mandatory underwater inspection was considered quite likely to occur. Even without these requirements, the MMS needs an understanding of the latest technologies for such factors as design, inspection, remote monitoring, and the use of risk and reliability methodologies. This is just as true now as operations are confronted by more severe environmental loads as it was when initially considering the integrity of older structures.

A cumulative index of all TA&R projects is presented in the TA&R Technical Report referenced in the Introduction. For use here, the Structures Category has been defined to include both structural and geotechnical projects. The category does not include such subjects as fracture mechanics, wave forces, or the mechanical properties of sea ice. These subjects definitely have structural significance as forcing or resisting functions but were considered too generic for this presentation. Approximately 16 TA&R projects can be listed within the structural category. It may prove more worthwhile to see how certain research is directed at specific interests in the frontier areas than to discuss each project in detail. As industry moves into deeper and more hostile waters, conventional structural concepts, such as those used in the GOM and Pacific OCS, become prohibitive in cost. To combat these increased costs, a new breed of less redundant, more compliant structures has been developed. Typical of these new concepts are the tension-leg platform and the guyed tower. Special problems, however, are associated with the long-term maintenance and reliability of these pioneering efforts.

Large diameter cables, high-strength steels, and tension piles are being used or are being proposed for these newer concepts. The use of high-strength steels in sea water is of a major concern because of their susceptibility to stress-corrosion cracking. Thus, new guidelines for design and inspection must be developed for components using these steels to determine their fatigue behavior and reliability under operational conditions. Another substantial problem is the inability to predict the capacity of tension piles. Pilings for conventional platforms are usually compressively loaded, but concepts such as the TLP place the pile totally in tension. Such pile loading is not well understood for purposes of design, and to complicate matters, the installation techniques, i.e., driven versus drilled and grouted, is a major consideration. The TA&R Program is sponsoring independently or jointly with industry studies to determine the capacity of tension piles, the methologies for TLP tendon inspection, the effects of riser strumming, and the dynamic behavior of fixed and compliant production facilities.

The Arctic has special problems of its own associated with ice, extreme temperatures, and difficult logistics. The most predominant engineering problem in the northern Arctic concerns the forces exerted on structures by the pack ice. Field studies are being conducted to measure the global load that builds up in the ice pack as it is driven against the structures by wind and currents. Emphasis is also being placed not only on ice-structure interaction problems but also on problems associated with structural deterioration due to large concentrated ice forces. Punching shear tests are being conducted on model and full-scale sections, in conjunction with analytical studies to establish more effective design criteria for Arctic concrete structures. In addition to ice, permafrost is a problem which occurs not only on land but also underneath the water. Studies are being conducted to investigate problems associated with foundation and pipeline which must be placed in the permafrost.

The mid and southern Arctic present their own set of problems. The remoteness of the Navarin Basin brings forth all types of logistic problems. The TA&R program has participated in joint industry projects to investigate structural concepts for production as well as on-site storage of crude. Lease sales in the southern Arctic are in very seismically active areas. Presently, the TA&R Program is focusing its efforts on the use of an instrumentation system known as the Seafloor Earthquake Measurement Systems (SEMS) to collect and store seafloor seismic events. The results will be used to evaluate the earthquake hazards and to provide firm data on the design parameters required. It is interesting to note that this technique is being used in the Pacific OCS area as well.

The above information relates to specific areas, i.e., deep ocean or the ice-infested Arctic. In addition, several structures projects are concerned with techniques to determine the integrity of platforms. The system identification technique is one such method being investigated for this purpose. In this method, the dynamic equations of motion are deduced from experimental data and by observing changes in certain parameters such as the stiffness, mass, and damping matrices; the technique offers the potential of being able to detect not only damage but also its location.

This has been a brief account of several structural-related projects sponsored by the TA&R Program. However, no paper would be complete without at least a few comments on needed research. Areas of future interest to the TA&R Program are in the use of risk and reliability methods as they pertain to offshore structures' design and operation, development of methodologies for reverification of old platforms, investigation of methods to ensure the integrity of existing platforms, and techniques for assessing the reliability of new exploration and production facilities.

Mr. Charles Smith is Research Program Manager for the Technology Assessment and Research Program, Minerals Management Service. Mr. Smith has received a BS in Structural and Applied Mechanics from Virginia Military Institute, an MS in Structural and Applied Mechanics from Georgia Institute of Technology, and a Master of Engineering and Applied Mechanics from the University of Virginia.

Metallurgical Considerations for the Use of High Strength Steel Tension Members in Sea Water

J. A. Hauser
and
T. W. Crooker
Naval Research Laboratory

Presently, the Tension Leg Platform (TLP) is being considered for deep water drilling. The present conceptual designs for TLP's call for the use of high-strength steels (yield strength > 80 ksi) for use in the tendons which will be under tension at all times. This concept contrasts with conventional designs where the major members are constructed of low to moderate strength steel and subjected to compressive loads. The proposed use of high-strength steel introduces new areas of concern, especially that of stress corrosion cracking (SCC).

SCC occurs in susceptible materials subjected to static tensile loading under certain environmental conditions. Most low to moderate strength steels are considered to be immune to SCC in seawater, whereas most high-strength steels are susceptible. Therefore, TLP designs contemplating the use of high-strength steel in the tendons must consider the possibility of SCC.

In the past two decades linear elastic fracture mechanics has become an accepted method for characterizing the SCC susceptibility of a material. The SCC process consists of two distinct phases: incubation, where chemical and mechanical interactions occur to form a crack, and propagation, where the crack grows. Linear elastic fracture mechanics allow the use of precracked specimens in SCC testing, which considerably shortens the incubation period and, therefore, the test time. The unit of measure is K, the crack-tip stress-intensity factor, whose value is directly proportional to the product of nominal stress and the square root of crack length. Conventional materials testing for SCC seeks to determine the relative susceptibility of different materials under specific environmental conditions as measured by the stress-intensity factor, K. For each material/environment combination there is a value of K below which SCC does not occur. This threshold value is defined as the $K_{1}SCC$ value for that material under those environmental conditions.

There are five primary factors which affect $K_{1}SCC$: (1) alloy composition and microstructure: some materials are more susceptible than others; (2) strength level: an increase in yield strength increases susceptibility; (3) environment, especially the type and level of cathodic protection: an increase in cathodic protection level increases susceptibility; (4) fabrication: welding increases susceptibility; and (5) exposure time.

Standard SCC tests were conducted by the Naval Research Laboratory to determine SCC susceptibility of candidate tendon materials provided by two oil companies. Constant displacement tests were run in natural seawater for a duration of approximately 10,000 hours. The materials ranged in yield strength from 80 to 125 ksi and were coupled to zinc. No evidence of SCC was detected in any of the tests. This is a favorable result for the proposed use of high-strength steels in TLP tendons.

Recently, research has revealed a surprising phenomenon involving the interaction of very small cyclic loads superimposed on the static SCC load. This topic has been referred to as "ripple loading." It has been demonstrated that in certain cases a small ripple load can cause a significant reduction in the apparent SCC threshold. This phenomenon is of practical significance because actual structures seldom undergo purely static loads; normally some type of cyclic loads are also present. In the case of the TLP tendons, there are secondary cyclic loads superimposed on the large primary tension load. Therefore, it is possible that SCC tests conducted under static loads give nonconservative threshold values. The accompanying figure of preliminary work at NRL depicts the effect on a 5% Ni steel of adding a 2.5% and a 5% amplitude cyclic load on top of the static mean load in a SCC test. The 5% cyclic load substantially reduces the threshold value and the 2.5% cyclic load reduces it somewhat less. This topic will be further investigated with regard to the use of high-strength steels in offshore applications.

J. A. Hauser and T. W. Crooker, "Influence of Small-Amplitude Cyclic Loading on Stress-Corrosion Cracking of High-Strength Steels in Salt Water," Symposium on Predictive Capabilities in Environmentally Assisted Cracking, ASME Winter Annual Meeting, Miami, Florida, November 17-20, 1985.

Mr. Joseph A. Hauser is a research engineer in the Material Science and Technology Division of the Naval Research Laboratory. Mr. Hauser received a BS and MS degree in Mechanical Engineering from North Carolina State University.

Mr. Thomas W. Crooker is Head, Environmental Effects Branch, Material Science and Technology Division, Naval Research Laboratory. Mr. Crooker received a BS and MS in Mechanical Engineering from the University of Wisconsin.

Inspectibility of Tension Leg Platform Tendons

John E. Halkyard
Ocean Engineering Consultants, Inc.

The objective of Phase I of this study, concluded in May, was to analyze possible in-place inspection requirements for likely TLP tendon designs and appropriate inspection methodologies. The focus of the effort was on tendons consisting of tubular steel elements joined by threaded couplings.

The Phase I study concentrated on modeling the performance of an internal ultrasonic device. The methodology is equally applicable, however, to an external device which might be required for buoyant tendons (i.e., with the tendon I.D. sealed).

Generic "thick-walled" and "thin-walled" connector designs have been considered. The thick-walled connector corresponds to the Hutton TLP tendon design, while the thin-walled connector is more representative of those currently under consideration for U.S. waters.

ULTRASONIC INSPECTION MODEL

A theoretical model of detection limits for ultrasonic inspection from the inner diameter has been developed. Figure IIA.5 illustrates the acoustic beam angles proposed for the inspection of critical areas of the thin-walled connector. Ultrasonic detection limits have been analyzed using assumed conditions for attenuation, reflectivity from boundaries, transmissivity, and crack geometry. The model results in an estimate for ultrasonic echo response given as::

$$\frac{P}{P_o} = C_1 R^2 e^{-\alpha 2d} \frac{S_s S_f}{d^2 \lambda^2}$$

where

C_1 = transmittance coefficient
P = pulse echo sound pressure amplitude
P_o = initial sound pressure

R = reflection coefficient at steel/water interface
α = attenuation coefficient
S_s = acoustic source area
f = area of crack reflecting the acoustic pulse
d = distance travelled by beam in material between source and reflector crack
λ = acoustic wavelength

Values of attentuation coefficients, reflection coefficients, and transmissivity are dependent on material properties and surface finish. Values for smooth, fine-grained low-alloy steel were used in the Phase I analysis, resulting in theoretical detection limits of from less than 2 mm (0.08 in.) in critical areas of the thin-walled connector, to over 4 mm (0.16 in.) in the thick walled connector.

ANALYSIS OF INSPECTION REQUIREMENTS

Inspection requirements were determined by carrying out loads analysis, fatigue, and fracture mechanics analysis for four likely deep water environments:

- Gulf of Mexico (Green Canyon)
- Atlantic
- Pacific (Central California)
- North Sea

Fatigue (crack initiation) and crack growth times depend most critically on load amplitudes, environment, and material properties.

Loads are very platform specific. In particular, tendon fatigue loads arise primarily from wave inertial forces on platform columns and pontoons. These loads vary directly with platform displacement and are dependent on a number of factors such as column spacing, ratio of column to pontoon volume, and total waterplane area.

Figure IIA.6 shows the predicted tendon life as a function of initial crack depth for thin-walled connectors under various environmental conditions. The loading for these cases was derived for "worst case" response functions corresponding to a large production platform with a large column-to-pontoon volume ratio.

A probabilistic crack growth analysis was carried out using Monte Carlo techniques and assumed distributions for probability of crack detection platform responses and material properties. The results for the last pin thread, freely corroding with a presumed inspection to 2mm flaw size, are shown in Figure IIA.7. The results are shown for a single component and a number of components in series representing the reliability of a tension leg taken as a whole.

The above "worst case" assessment suggests that inspection sensitivities in the range of 2 mm for the pipe and/or connector are more than sufficient for an inspection system. In fact, even under these assumptions, and inspection system with a 6-8 mm detection limit would be adequate, although under the worst conditions an inspection to this level might be desirable every 10 years. These results would need to be re-evaluated, of course, for any specific tendon and platform design.

PHASE II PROGRAM

Our Phase II program, which is just now underway, has as its main objective the verification of detection limits for ultrasonic inspection under various conditions. We will be testing several material blocks made up of different materials and geometries to determine acoustic properties and crack detection ability. We will also be "blind" testing precracked connector and weld specimens to estimate the probabilistic detection limits for a realistic mechanical ultrasonic scanning system.

Dr. John E. Halkyard is President of Ocean Engineering Consultants Inc., a company engaged in ocean engineering research and analysis. Dr. Halkyard received a BS in Engineering Science from Purdue University and an MS and DSc in Ocean Engineering from Massachusetts Institute of Technology..

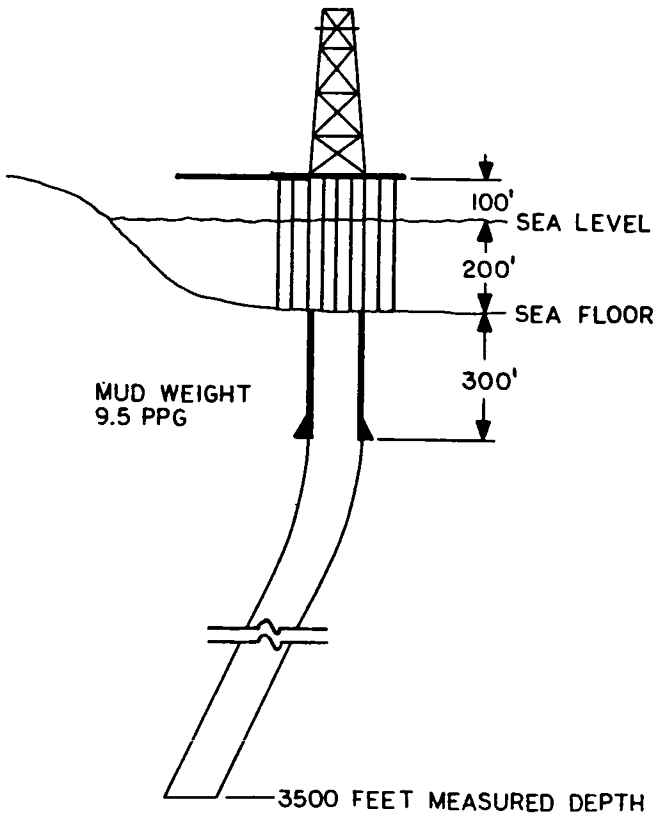


Figure IIA.1 - Drilling Situation on Santa Barbara Channel Blowout

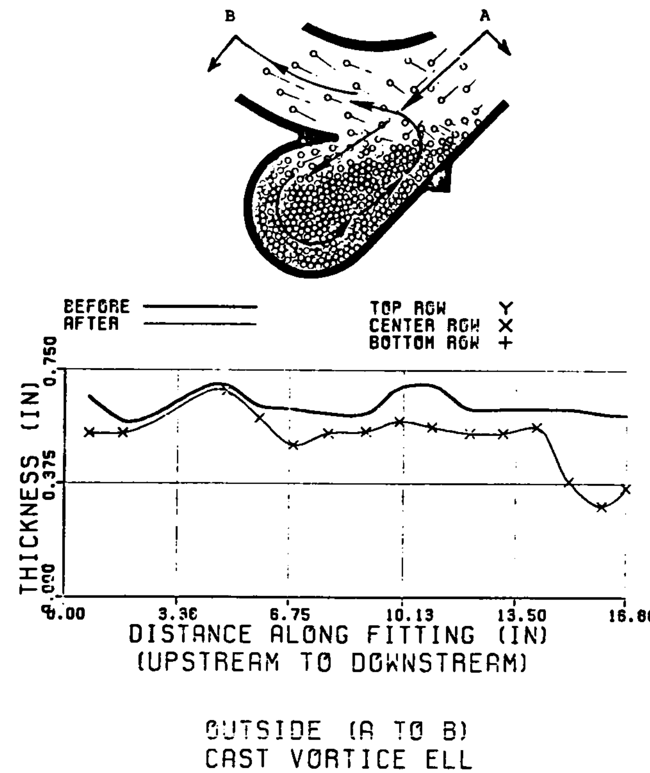


Figure IIA.2 - Example Wear Pattern Observed for Liquid Slurry in Vortice Ell

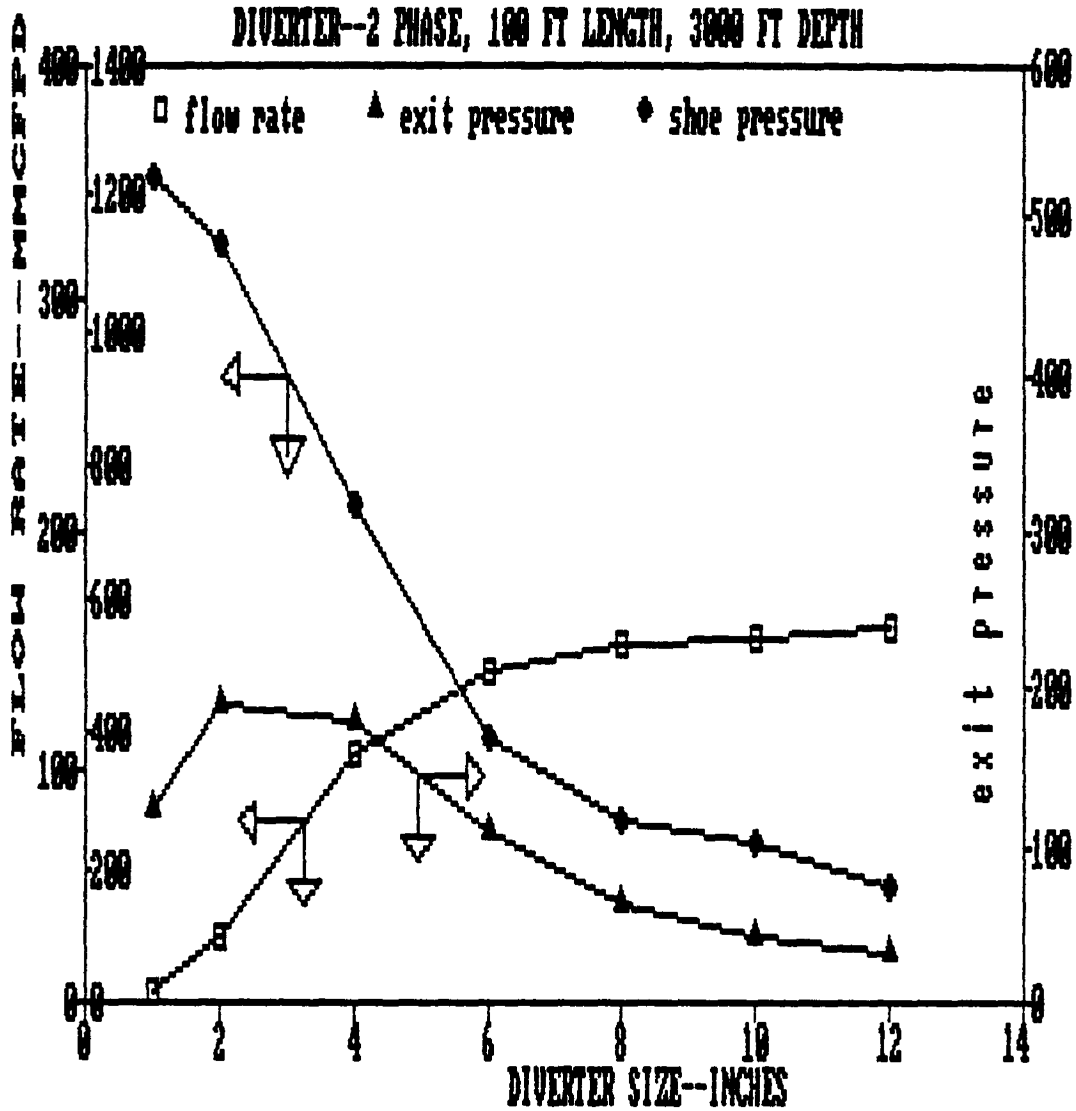


Figure IIA.3 - Example Computer Prediction of Diverter Performance for 8-in. Pilot Hole (Gas Liquid Ratio of 100 BBL/MMSCF)

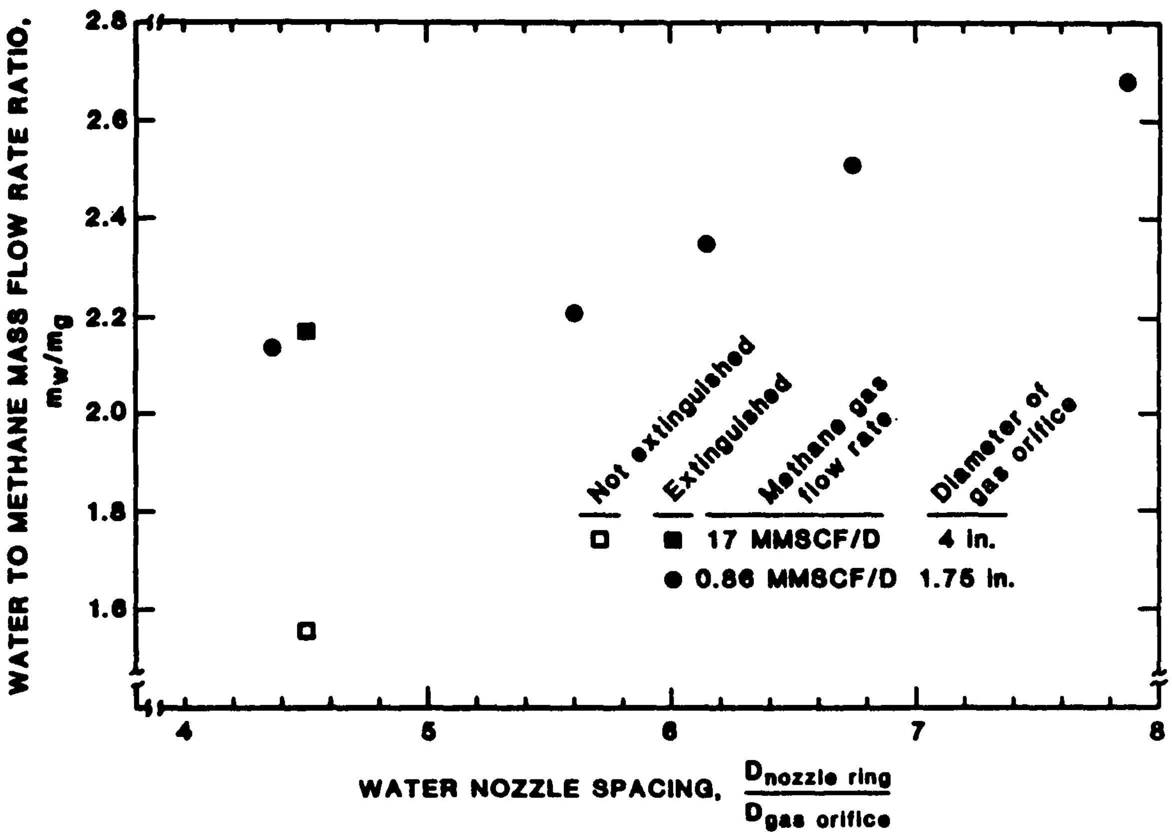


Figure IIA.4 - Sensitivity of Methane Jet-Flame Extinguishment to the Radial Spacing of Four Water Spray Nozzles

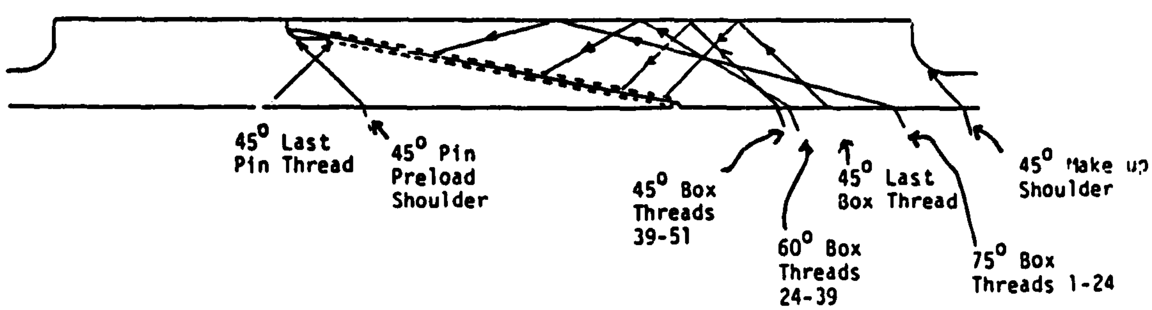


Figure IIA.5 - Ultrasonic Beam Angles for the Thin-Walled Coupling

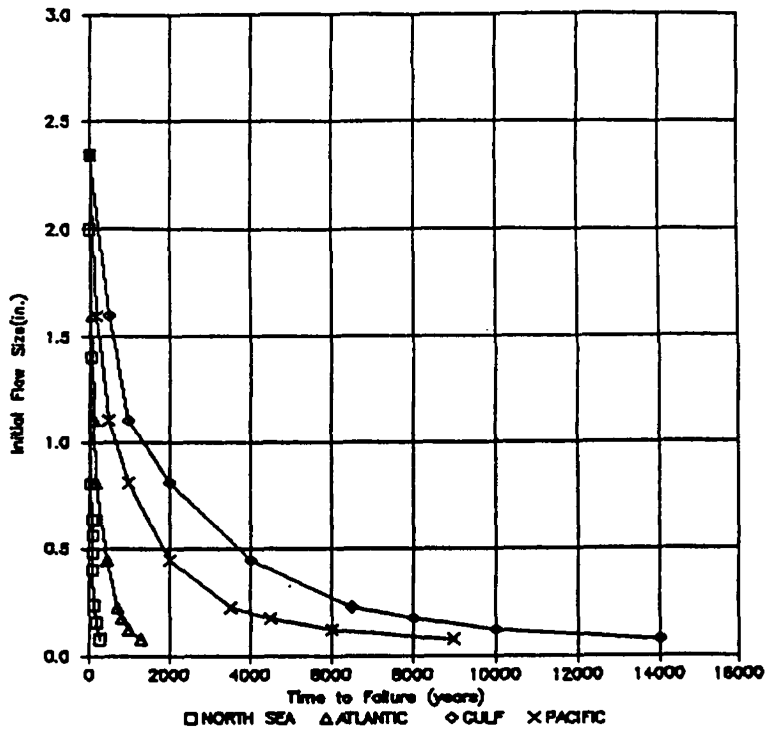


Figure IIA.6 - Initial Flaw Size Versus Time to Failure

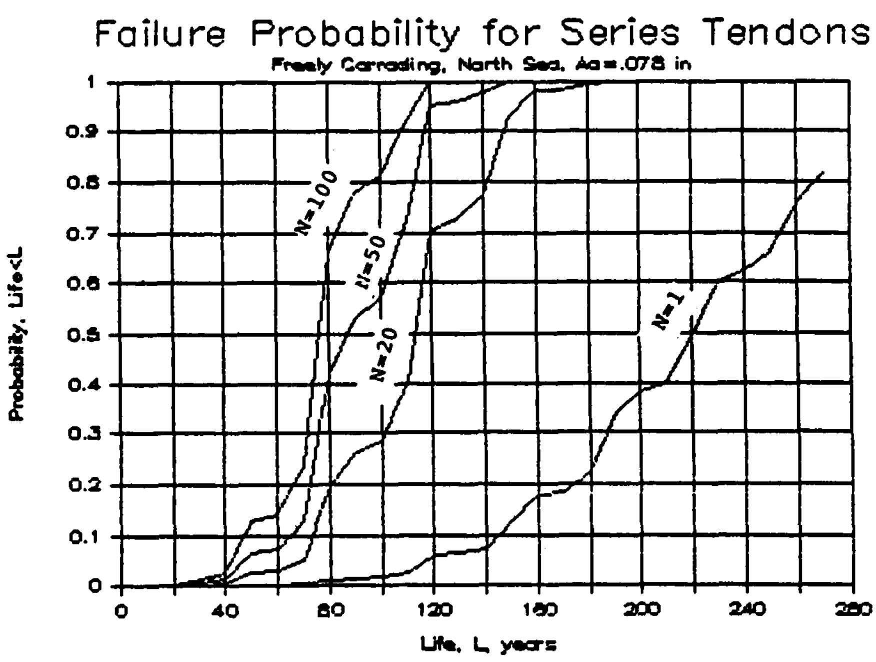


Figure IIA.7 - Last Pin Thread, Thin-Walled Connector

OFFSHORE BIOLOGICAL PROTECTION TOPICS

Session:	OFFSHORE BIOLOGICAL PROTECTION TOPICS
Chairmen:	Mr. Charles Hill Ms. Cheryl Vaughan
Date:	October 22, 1985

Presentation Title	Speaker/Affiliation
Offshore Biological Protection Topics: Session Summary	Mr. Charles W. Hill, Jr. Minerals Management Service
Proposed Revisions to Biological Stipulations in the Gulf of Mexico	Ms. Cheryl Vaughan Minerals Management Service
Mechanical Damage to Reef Communities in the Northwestern Gulf of Mexico	Dr. Thomas Bright Department of Oceanography Texas A&M University
Live Bottom Surveys in the Eastern Gulf of Mexico Findings and Recommendations	Dr. David A. Gettleson Continental Shelf Associates, Inc.
The Offshore Operators Committee Muds Discharge Model as a Tool in the Permitting Process	Dr. Alan D. Hart Continental Shelf Associates, Inc.
The MMS Mud Plume Model: Comparisons with Field Data and the Offshore Operators Committee Model	Dr. Murray L. Brown Minerals Management Service

Offshore Biological Protection Topics: Session Summary

Mr. Charles W. Hill, Jr.
Minerals Management Service

We had, as they say, an honest and frank discussion. Biological stipulations designed to protect biological resources on the OCS have been in use by the Department of the Interior since about 1972. They are stipulations precisely because they can be easily modified as new information comes in from our Studies Program, or from stipulation-required, industry-sponsored monitoring, or from other sources.

Cheryl Vaughan, of our office, described the latest proposed changes to the biological stipulations. I'm not going to go into any detail here. They have been developed by a number of interested parties, and they will be presented as an alternative stipulation in the next Environmental Impact Statement, the draft of which will be available sometime next spring for the 1987 lease sales.

Dr. Tom Bright, of Texas A&M University, described anchor damage at the Flower Garden Banks. The 1983 anchoring incident at the East Flower Garden Bank was fully documented. He showed slides of coral heads that were broken and turned over by the anchor and the anchor chain. Recovery is being observed and documented, but it appears to be very slow. Dr. Bright believes that anchor damage is the only effect on the reef caused by man that can be documented.

Dr. Bright took us through the history of the proposed marine sanctuary at the Flower Gardens. It was first nominated in 1973, and the current nomination is the third reiteration of that nomination. His recommendation, as far as anchoring goes in the sanctuary, would be to prohibit anchoring of vessels greater than one hundred feet, that no more than 15 ft of chain at the anchor be allowed, and that all but the final 15 ft of the anchor line be of some sort of non-metal material such as nylon. And he reiterated the suggestion that the nautical charts be marked with some sort of notice that the topographic features of the west and central Gulf are sensitive areas, requesting mariners not to anchor on them.

Herb Kaufman, the Deputy Chief of the Sanctuaries Program Division, was there to tell us about what NOAA might be able to do about anchoring on these banks, but apparently NOAA either doesn't know or isn't able to do anything, and he didn't say anything.

Dr. Dave Gettleson, of Continental Shelf Associates, described some of the live bottom surveys that are required by lease stipulations in the eastern Gulf of Mexico. He also made a plea for redefining the stipulation, which will certainly give MMS some food for thought over the next few months.

Finally, two mud plume models were described. Dr. Alan Hart, of Continental Shelf, described the model that was developed for the Offshore Operators Committee, a fairly sophisticated model requiring nine inputs. The product is deposition. Verification seems good. He presented some case studies. The model can be used, among other things, to determine the increase in sedimentation in an area owing to the drilling activities.

Dr. Murray Brown, of our office, described a model that was developed for the Minerals Management Service from an existing Corps of Engineers' dredge disposal plume model. Our model is, as Murray said, a "yellow-brown dog" which does not require sophisticated input, but the outputs may be more rough approximations than actual good numbers. He used a number of estimations; this model might be something that's simple, quick, and cheap to do.

The highlight of this meeting may very well be that two of the topographic features of the Gulf now have real names, or soon will. Even as we speak, the Board of Geographic Names is meeting and Eighteen Fathom Bank off Louisiana should very shortly become McGrail Bank, named after the late Dr. Dave McGrail of Texas A&M. And for those of you who went to the party after the RTWG meeting on Monday know, Twenty-eight Fathom Bank is now Rankin Bank.

Charles Hill is with the Environmental Operations Section of the Gulf of Mexico OCS, Regional Office of the MMS. His duties include reviewing industry Plans of Exploration and Development to ensure that activities covered by the plans result in minimum damage to the marine environment, and to ensure that appropriate environmental protection measures, including biological stipulations, are taken by the industry.

Proposed Revisions to Biological Stipulations in the Gulf of Mexico

Ms. Cheryl Vaughan
Minerals Management Service

Biological stipulations are attached to selected leases in the Gulf of Mexico and require the lessee to take specific actions to ensure conservation of the offshore biological resources.

The Gulf of Mexico OCS region of the Minerals Management Service (MMS) is considering a presentation of revised biological stipulations in its next draft Environmental Impact Statement (EIS), for the 1987 series of oil and gas lease sales.

The first biological stipulations tended to be conservative, to over-restrictive protective measures since the scientific knowledge of the effects of oil and gas activities on biological communities did not exist. Since their inception in 1974, the biological stipulations have exhibited minor changes which reflect new information received on the biology of the sensitive offshore habitats. Now, 11 years after the first biological stipulations, a bulk of scientific information has been collected by MMS which was not available during the formation of the first stipulations. Information includes various Bureau of Land Management/MMS-funded studies on the topographic highs in the Western and Central Gulf and on the Southwest Florida shelf biological communities; numerous stipulation-imposed, industry-funded monitoring reports, live bottom surveys, and photodocumentation surveys; and the National Academy of Science (NAS) report entitled *Drilling Discharge In The Marine Environment* (1983).

Based on this collection of information, biologists from the Department of the Interior (MMS and the Fish and Wildlife Service) agreed that the existing stipulation requirements deserved review. A joint effort of these biologists concluded that the present stipulations do not reflect the current body of scientific knowledge and that revisions of the stipulations are in order. Tables IIB.1, IIB.2, and IIB.3 summarize the present stipulation requirements and corresponding alternative requirements which were formulated.

The MMS solicited comments on the alternative stipulations from various federal and state agencies, industry, and individuals who have expressed interest in the protection of offshore biological resources. MMS received comments from two federal agencies, four states, four industry representatives, one environmental group, and one representative of academia. The comments were generally favorable. These comments are being reviewed and may result in modification of the alternative stipulation requirements presented in Tables IIB.1, IIB.2, and IIB.3.

The alternative stipulations for the Central and Western Gulf will be presented for public comment in the next draft EIS to be published May, 1986. (The Eastern Gulf stipulations will not be presented until an EIS is published for a sale in that area.)

Cheryl Vaughan is employed in the Environmental Assessment Section of the Gulf of Mexico OCS Regional Office as a natural resource specialist. Her duties include assessing potential impacts of oil and gas exploration and development activities on the biological resources of the Gulf and developing measures (stipulations) to mitigate any potential adverse impacts.

Mechanical Damage to Reef Communities in the Northwestern Gulf of Mexico

Dr. Thomas Bright
Department of Oceanography
Texas A&M University

Tropical coral reefs are complex biogenic structures on the sea bed which support the most highly diverse communities of organisms in the marine environment. The framework of such reefs is produced primarily by hermatypic (reef-building) corals, which are the dominant components of the reef assemblage. The integrity and nature of the reef communities are dependent on both the continued existence of a substantial cover of living coral to produce new reef rock, and the maintenance of the framework in the configuration in which it was produced. In general, the form and structure of reefs are highly influenced by and adjusted to the physical conditions of their environment. Serious mechanical disruption of reef framework rarely occurs naturally, except during severe tropical storms or hurricanes.

Man has repeatedly caused physical destruction of reef framework. Reef rock is mined for use as building stone in the Indian Ocean, swaths of Red Sea reef flat are blown apart by seismic crews, reefs have been buried beneath causeways, trampled upon, broken piecemeal by tourists, crushed beneath shipwrecks, and subjected to damage by anchors and tackle from ships of all sizes. Although such impacts are most intense on coastal emergent reefs, submerged reefs far offshore are not immune. Recently, a reef at 37 m depth at the edge of the continental shelf in the northwestern Gulf of Mexico was partially blown up by misguided treasure hunters. The nearby East and West Flower Garden reefs, adjacent to commercial shipping lanes, have been used as offshore anchoring sites by large vessels for decades, and it is evident that anchoring on these reefs is increasing with increasing ship traffic. Concern over the fate of the Flower Garden reefs in relation to these impacts has been an important factor leading to their nomination for National Marine Sanctuary status.

ANCHORING AT THE FLOWER GARDEN REEFS

The East and West Flower Garden banks (27°54'32"N, 93°36'W and 27°52'27"N, 93°48'47"W) harbor approximately 500 acres of tropical coral reefs with 18 species of hermatypic corals. These are the northernmost tropical coral reefs on the western Atlantic continental shelf and are therefore of considerable scientific as well as aesthetic interest. They are submerged reefs, cresting at approximately 17 m depth and extending downward to 46 m, where they are replaced by deeper reefal communities dominated by coralline algae. This deeper "algal terrace" covers most of the bank surfaces down to around 79 m depth.

Both the coral reefs and the algal terraces have been subjected to damage by ground tackle (anchors, chains, cables) from vessels for many years, probably starting in the late 1800's with the onset of the commercial snapper/grouper fishery. Obviously, most anchoring instances have gone unobserved. Research groups have reported large tankers anchored on the reefs as early as 1972. Other more recent sightings are listed in Table IIB.4. In their numerous traverses of the Flower Gardens by research submersible, researchers from Texas A&M have often observed evidence of anchor damage in the form of scars or drags on the bottom. Lost anchors, chains, and cable are not uncommon on the banks and have been encountered repeatedly. The largest anchor scar found extended for approximately one mile on the algal terrace at the West Flower Garden and was apparently continuous with a "roadcut-like" gouge into the coral reef.

Anchoring appears to be increasing in frequency at the Flower Gardens. Vessel traffic is certainly increasing, owing in part to development of offshore oil and gas in the area. The anchoring problem at the Flower Gardens has been recognized for at least 13 years (see Table IIB.5). Nevertheless, there is currently no regulation of such activities at the site except in the case of oil and gas lessees, who cannot carry out operations within "no activity zones" corresponding to the hard banks above approximately 100 m depth. This prohibition applies only to the drilling and production operations and does not extend to vessels not associated with the lessees' activity.

A good example of the extent of damage caused by anchoring of one medium-sized vessel is the October 1983 anchoring by the tug *M/V Nick Candies* and tow barge at the East Flower Garden. The impacted area was on the coral reef between 17 m and 27 m depth. Immediately following the incident researchers observed newly broken and overturned coral heads, gouges, and abrasions in a band approximately 3 m wide extending for 61 m or so across the shallower portion of the anchor drag. The band of damage narrowed to about 1.5 m in deeper water, but extended for an additional 122 m length. Damage was considerably less on the deeper part of the drag. Swimming approximately 46 m along the shallow damaged area, the author counted 205 damaged coral heads. The corals of less dense skeletal structure, *Colpophyllia* and *Diploria*, suffered more extensive disruption than did the more solidly built forms such as *Montastrea*.

Anchor damage is the one demonstrable impact of man on the Flower Garden biota. Regulations should be adopted which would (1) prohibit anchoring by vessels greater than 100 ft length within the 50 fathom depth contour, (2) prohibit use of more than 15 ft of chain or wire rope attached to any anchor employed on the bank, and (3) require that the anchor line be of a soft fiber such as nylon or polypropylene or some similar material.

Allowing vessels less than 100 ft length to anchor using a soft fiber anchor line will protect the privileges of virtually all sport divers and fishermen as well as commercial hook-and-line fishermen. Prohibiting larger vessels will protect the reef from the major impacting factors: oil field service vessels, tow boats and barges, tankers and freighters.

Such regulations, if adopted, should be conveyed specifically to the masters of the vessels traversing the area, and not simply to an intermediary in the hope that the ships' masters will somehow find out about the regulations. The only way this can be accomplished effectively is to MARK AND LABEL THE NO-ANCHORING ZONES ON THE U.S. NAUTICAL CHARTS. It has been clearly demonstrated that (1) self-regulation by the ship operators does not work, (2) federal "Notices To Mariners" are ineffective and only temporary at best, (3) MMS lease stipulations pertain only to oil-and-gas operations and are far from foolproof because of communication inadequacies, and (4) the NMFS coral management plan is inadequate because the prohibition of anchoring provision originally proposed was deleted from the plan before its adoption. It seems that the most likely mechanism for implementing some critically needed regulation is through designation of the Flower Gardens as a National Marine Sanctuary. If the sanctuary designation process fails again, it is hoped that the Coral Reef Protection Act proposed by Congressman Solomon P. Ortiz of Texas in 1984, but withdrawn in lieu of the current Flower Garden Sanctuary nomination, will be revived and passed to provide a vehicle for the regulation of destructive anchoring in our valuable reef habitats.

Thomas J. Bright is Professor in the Department of Oceanography at Texas A&M University and Director of the Texas Sea Grant College Program. He has specialized in coral reef ecology for the past 15 years, performing reef studies in Florida, the Bahamas, the Caribbean Sea, the northern Gulf of Mexico, and the Arabian Gulf, and produced numerous papers and reports on reef communities. In 1974, he co-edited the book *Biota of the West Flower Garden Bank* and in 1985 co-authored the book *Reefs and Banks of the Northwestern Gulf of Mexico*. From 1979 to the present, Dr. Bright has served as a member of the Scientific and Statistical Advisory Committee on Corals and Coral Resources for the National Oceanic and Atmospheric Administration, Gulf of Mexico Fishery Management Council. In 1982-83, he was Chairman of the Site Selection and Evaluation Committee for National Marine Sanctuaries in the Gulf of Mexico.

Live Bottom Surveys in the Eastern Gulf of Mexico Findings and Recommendations

Dr. David A. Gettleson
Continental Shelf Associates, Inc.

SURVEY REQUIREMENTS

The Minerals Management Service (MMS) requires photodocumentation surveys (live bottom surveys) around certain potential drillsites in the eastern Gulf of Mexico. Until recently, a live bottom survey was not required unless the presence of hard bottom was indicated in the shallow hazards data. This requirement was based on the assumption that live bottom is invariably associated with hard bottom. Because of the recently documented inability of hazards surveys to detect some types of live bottom not associated with hard bottom, the MMS now requires live bottom surveys for exploratory activities in the eastern Gulf of Mexico in water depths less than 100 m, regardless of hazards survey results. The MMS guidelines for Photodocumentation Surveys specify continuous television observations and color still camera photographs along designated transects to a minimum distance of 1820 m from potential drillsites. The survey transects may radiate from a single drillsite or multiple drillsites, or they may encompass an entire lease block.

RESULTS OF LIVE BOTTOM SURVEYS

The accompanying Figure IIB.1 shows the geographic locations of the 45 lease blocks in the eastern Gulf of Mexico in which live bottom surveys have been performed, relative to the MMS Southwest Florida Shelf Ecosystems Studies transects and other studies. Live bottom was observed in 35 (78%) of the blocks. Six visually-distinct live bottom assemblages were identified. Four of the assemblages were observed and described initially during the Southwest Florida Shelf Ecosystems Studies. The other two assemblages were identified during surveys in the Destin Dome Area. One was associated with shelf-edge rock pinnacles and included visually dominant ahermatypic corals and octocorals. The other occurred on low relief areas and was visually dominated by small sponges, hydroids, and octocorals.

Data available from the live bottom surveys include estimates of percent live bottom incidence along transects (all survey areas), quantitative percent biotic cover within live bottom patches (five survey areas), and number of taxa comprising the live bottom assemblage based on dredge samples (nine survey areas). Percent biotic cover ranged from 4-43%, and number of taxa in dredge samples ranged from 53 to 217. Too few dredge samples were collected to determine the total number of taxa present, making comparisons among surveys difficult. Due to the geographic scatter of survey locations and the variable levels of sampling effort among surveys, it is difficult to draw any conclusions other than those concerning the presence/absence of live bottom and the identity of visually dominant epibiota.

AVAILABLE DATA FOR DECISIONS REGARDING IMPACTS TO LIVE BOTTOM

The terms "significance" and "sensitivity" are often applied to live bottom when making impact-related regulatory decisions. The purpose of the live bottom survey requirement is to determine if significant live bottom resources are present which are deserving of protective measures. The National Research Council's publication "Drilling Discharges in the Marine Environment" suggested that the sensitivity of hard-substrate communities (live bottom) should be evaluated relative to their potential exposure to drilling muds. Although significance and sensitivity are very important considerations, regulators currently do not have adequate information to make decisions regarding these characteristics. Because the current live bottom survey guidelines do not require quantification, regulators must evaluate significance and sensitivity on a case-by-case basis with only live bottom presence/absence data. With such limited data, it is difficult to make decisions.

RECOMMENDATIONS FOR FUTURE LIVE BOTTOM SURVEY GUIDELINES

Live bottom survey guidelines could be strengthened by including a requirement for the collection of sufficient quantitative photographs to estimate percent biotic cover within live bottom areas. A minimum of 100 photographs, each encompassing a standard surface area (e.g. 0.25 m^2), should be analyzed. A standard surface area would allow for direct comparison with data from the Southwest Florida Shelf Ecosystems Studies and other live bottom studies.

The guidelines should specify that visually dominant epibiota be identified during each survey. This may require dredge sampling for identification of specimens. Additional dredge sampling should be required if the assemblage has not previously been characterized in the Southwest Florida Shelf Ecosystems Studies or other live bottom studies so that it can be compared with the other assemblages.

The requirements should state that if live bottom is observed during a survey of drillsite-specific transects, the area between transects where live bottom is observed will also be surveyed. These requirements would simply make explicit that which is in practice normally done in live bottom surveys. Implementing these recommendations would add 10% or less to the cost of what is presently required and not increase the cost of what is actually being performed in most live bottom surveys.

The first decision point in the regulatory framework for protection of live bottom involves a decision on whether the live bottom is significant compared to other live bottom areas. The collection of adequate data to characterize the live bottom is obviously a prerequisite to this decision. If the live bottom is judged to be comparatively significant, then the regulators must evaluate the potential impact associated with oil and gas operations. Additional data are needed for this evaluation. These data include the composition, quantities, and rates of drilling discharges as well as anchor patterns. Discharge data can be incorporated into mathematical models to predict the deposition of drilling muds and cuttings in live bottom areas. Although discharge data are very important in the evaluation of impacts, no direct data on the sensitivity of the live bottom areas to drilling discharges are available. There are no published studies of the effects of drilling discharges on live bottom areas or what the long-term effect may be if damage occurs. Once an evaluation of potential impact is made, the regulators may require certain mitigating measures to lessen the potential impact. These measures include movement of the drillsite location, shunting of the discharges, or no discharge (i.e., barging). Shunting does not appear to be an effective measure owing to the low relief of the majority of the live bottom. In addition to these mitigating measures, regulators may also require monitoring so that data regarding impacts will be available for future decisions.

In summary, information required by regulators for use in decisions regarding the effects of oil and gas operations on live bottom should be formally required. Live bottom survey guidelines should be strengthened to require the collection of quantitative data, dredge sampling in some cases, and additional visual observations to aid in defining such live bottom adjectives as "significant," "important," and "unique." Data on the effects of drilling muds and cuttings discharges should also continue to be collected until an adequate data base for an assessment of live bottom sensitivity is established.

Dr. David Gettleson is Vice-President and Scientific Director at Continental Shelf Associates, Inc. (CSA). He has been involved in the majority of live bottom surveys performed in the eastern Gulf of Mexico. He directed the first three years of a Southwest Florida Shelf Ecosystems Study subcontract on behalf of CSA. He has also been involved in a number of environmental monitoring programs associated with oil and gas activities.

The Offshore Operators Committee Muds Discharge Model as a Tool in the Permitting Process

Alan D. Hart
Continental Shelf Associates, Inc.

Continental Shelf Associates, Inc., has utilized the Offshore Operators Committee (OOC) Muds Discharge Model as a tool for investigating potential effects of drilling muds and cuttings discharges on live bottom areas. The model provides information as to the probable short-term fate of discharged materials from which the effect of deposition on live bottom areas is evaluated. The information gained about probable drilling mud deposition patterns and interpretation with respect to live bottom has been provided to federal regulatory agencies to aid regulators in determining the necessary guidelines and requirements associated with oil and gas activities.

The OOC Model was developed by Exxon Production Research Company (EPR) with partial funding by the OOC. It was developed from the Koh-Chang Model and the Corps of Engineers' Dredged Materials Discharge Model. In its present form, it has been made available to state and federal agencies and to members of the OOC.

The model has been partially validated by tank experiments conducted at Oregon State University. Efforts are presently underway by EPR to evaluate and report data collected during a field validation experiment conducted in California state waters in early 1984.

CONCEPTUAL DESCRIPTION OF THE OOC MODEL

A discharge of drilling mud is taken to originate as a jet from a submerged pipe oriented vertically downward from the drilling rig. The material is discharged into an ocean characterized by stratification and an arbitrary current velocity distribution. After discharge, the material goes through three distinct phases: convective descent, dynamic collapse, and passive diffusion.

During the convective descent phase, the plume of discharged material descends through the water column under the influence of gravity. Receiving water is entrained into the plume, diluting the concentrations of the solids and reducing the density of the plume.

The dynamic collapse phase begins as the plume encounters a level of neutral buoyancy or the ocean floor. The descent of the plume is retarded and horizontal spreading dominates. During the collapse of the plume, the width of the plume increases and the vertical extent of the plume decreases. As the spreading proceeds, the dynamic character of the plume weakens, and the ambient currents become progressively more important in determining the transport of the plume.

Passive diffusion dominates the transport and spreading after the dynamic character of the plume has dissipated. The plume is tracked in this phase via a LaGrangian scheme. Each solid class is tracked individually from the time of release from the dynamic plume to the end of the simulation. The history of the solids from the dynamic phases of the model is used to create many small Gaussian clouds at various positions in space and time. These solids are advected by the ambient currents and settle through the water column according to their settling velocities. Each cloud moves and grows according to local ambient current velocities.

Accumulations of the discharged materials occur as the clouds of solids in the passive diffusion phase of the model impinge on the ocean floor. A grid system is used to accumulate the material as these clouds settle. Each solids class is accumulated on a separate grid, and the grids are overlain to determine the simulated bottom deposition.

CASE STUDIES

Simulations of drilling mud discharges have been performed by Continental Shelf Associates, Inc., in several regulatory process contexts. The purposes of these simulations were (1) to investigate the effect of various scenarios of ambient conditions and discharge schemes on the depositional pattern of drilling muds on the California OCS; (2) to investigate the effect of shunting near a topographically high feature (West Flower Garden Bank) on the northwestern Gulf of Mexico OCS; and (3) to investigate the deposition of discharged materials in the vicinity of live bottom areas on the eastern Gulf of Mexico OCS. In each situation, results and interpretation were provided to federal agencies to aid in the determination of restrictions and requirements regarding the discharge of drilling muds and cuttings.

California

As part of a program to assess the long-term fate and methods of mitigation of discharges on the California OCS, factors affecting the short-term fate of drilling muds and cuttings discharges were investigated using the OOC Model. Scenarios involving various discharge characteristics, ambient current velocities, hydrography, and water depth were simulated. The sensitivity of the results to variations of these parameters was determined. This information was then used as a starting point to evaluate (1) the long-term fate of drilling muds and cuttings and (2) possible mitigation measures.

Northwestern Gulf of Mexico

Simulations of a bulk drilling mud discharge were performed as a part of comments to the Draft General NPDES Permit for Oil and Gas Operations in Portions of the Gulf of Mexico proposed by the U.S. Environmental Protection Agency Regions IV and VI (26 July 1985 FEDERAL REGISTER). An approach has been proposed in this permit which would regulate the rate of discharges near areas of biological concern. The site chosen for the simulations was a proposed exploratory drillsite near the West Flower Garden Bank. The simulated discharges weere performed using various discharge rates and near-bottom current speeds (currents were directed toward the bank as an unrealistically conservative case). Results of the simulations indicated that over 99.9% of the materials from discharges shunted to within 10 m of the ocean floor near the West Flower Garden Bank would be deposited prior to reaching the 100 m isobath.

Eastern Gulf of Mexico

Simulations of high-rate bulk drilling mud and sand trap discharges and continuous low-rate discharges for solids control equipment have been performed using the OOC Model and a trajectory model, respectively. Discharge information from specific operators was combined with likely ambient conditions during the proposed drilling period for the Destin Dome, Gainesville, and Charlotte Harbor areas. In each of these three cases, live bottom areas in the vicinity of the proposed drillsites could be potentially affected by the discharge of drilling muds and cuttings. Results and interpretation of the modeling efforts were provided to the MMS for consideration in the permitting process.

The OOC Model has proved to be a valuable tool for investigating potential impacts of discharged drilling muds and cuttings on live bottom areas. However, a serious gap of knowledge relating short-term fate to effects on different assemblages of live bottom must be closed to provide regulatory agencies more reliable information on potential impacts.

Dr. Alan D. Hart is a biostatistician/data analyst/oceanographer with Continental Shelf Associates, Inc. He received a BS in Zoology from Texas Tech University and PhD in Oceanography from Texas A&M University. Since joining Continental Shelf Associates in 1982, Dr. Hart has been involved in the analysis and interpretation of data collected during several monitoring programs of oil and gas activities in the Gulf of Mexico.

The MMS Mud Plume Model: Comparisons with Field Data and the Offshore Operators Committee Model

Dr. Murray L. Brown
Minerals Management Service

The MMS Mud Plume Model (Multer 1985) presents a simpler approach for assessing mud discharge plume effects on the OCS than the more comprehensive Offshore Operator's Committee (OCC) Model (Brandsma et al. 1983), providing the user accepts severe limitations in its ability to deal with near-field effects. The OOC Model is undoubtedly the state-of-the-art modeling tool for simulating the behavior of mud plumes, but its input requirements and computational costs might limit its utility, particularly in cases where rough -- but reliable -- boundary estimates on physical impacts are acceptable. To provide an elementary code which can easily be used for routine estimates, the MMS contracted with the Army Engineer Corps in 1982 to upgrade and improve the existing model (Wechsler and Cogley 1977) originally written to simulate dredged mud disposal plumes.

The three phases of mud plume development, well characterized by the OOC Model, are convective descent, dynamic collapse, and passive diffusion. Convective descent, commonly characterized as the downward and somewhat downstream movement of a "jet" of suspended material, continues to some point in the water column (or the bottom) where the plume reaches neutral buoyancy, and horizontal spreading exceeds descent rate. After collapse of the plume, passive diffusion of the material predominates. The MMS Model does not include convective descent or dynamic collapse phases, requiring that the user specify the initial condition as a fully-developed, passively diffusing cloud at some location in the water column. Dynamic collapse may realistically be expected to occur anywhere within the upper 100 m or so in the water column, depending on sea conditions; very slow moving currents, say less than 20 cm per second, may retard dynamic collapse to the 100-m level; fast currents, say over 20 cm per second, may cause dynamic collapse close to the surface. Using these rough guidelines, the MMS Model may be used to estimate the expected bottom deposition as follows: maximum deposition thickness occurs when dynamic collapse is achieved at or close to the bottom, and the resulting deposition decreases outward from the point of release; minimum deposition thickness occurs when dynamic collapse is achieved close to the surface, and the resulting deposition is maximum at some distance away from the point of release. An intermediate deposition pattern, peaking closer to the point of release, is expected for releases where dynamic collapse is achieved at depths between the surface and 100 m, for sites deeper than 100 m.

In practice the MMS Model may be run with initial conditions set for dynamic collapse (1) at the surface, and (2) at the bottom depth or 100 m, whichever is shallower, resulting in two curves which are assumed to bracket the actual physical results. The vertical segment over which the passively diffusing cloud is initially found ("window height" in Multer 1985) may be set to variable values, but one-tenth the total water depth has been used with some success. Brandsma et al. (1983) note that a small percentage of total suspended material is lost from the jet prior to dynamic collapse, so a "tall window" extending from the surface down to, say, 100 m for slow current simulations is not recommended.

The MMS Model, in its published form, simulates the spatial characteristics and deposition rates for a simple, lobe-shaped plume oriented downstream in a time-invarient, vertically-integrated current field. It has been found useful to estimate the effects of directionally varying current fields (still vertically integrated) which might direct the lobe in random orientations through a 90° arc, a 180° arc, and throughout an entire circle. In a post-processing step, the MMS staff has used the downstream suspended mass flux values (a standard MMS Model result) to estimate deposition within portions of annular rings. Compared to field data, the deposition rates calculated for simple, lobate plume geometry are quite high. Much better comparisons result from more realistic assumptions, such as

Discharge Period	Geometry	Test Case
Minutes/Hours	90° Arc	Norton Sound
Hours/Days	180° Arc (?)	(None Available)
Days/Weeks	180°Arc/360°Arc	High Island Blowout

The above table has not been rigorously tested, and is offered here only because it fits well with the two sets of deposition data available. No similar post-calculations have been attempted for turbidity (suspended material) since only the maximum values have been used, presumably characterizing the real plume's center line, whatever its orientation. Clearly, the choice of geometries available offers the prospective modeler with another degree of freedom in bracketing the anticipated environmental effects, with the 90° arc and the 360° arc as limiting conditions. The simple, lobate plume may have some validity, however, for situations involving short discharge periods into slow-moving currents.

To test the usefulness of the MMS Model, it has been compared to field data collected at three field test sites and to a recent simulation by the OOC Model prepared for proposed drilling activity. The results are presented below.

1. NORTON SOUND FIELD DATA

Ecomar (ND) reported the results of a monitored release of drilling muds at an Arco platform in Norton Sound, in 12 m of water, where currents ranged up to approximately 150 cm/sec. Their maximum turbidity values and total deposition for the 62-minute test are compared with MMS Model results in Figures IIB.2 and IIB.3. The agreement is good for turbidity at 700-m distance, while possible under-sampling at shorter distances precludes comparison. Agreement is excellent for deposition, utilizing the 90° arc value from the MMS model. Dynamic collapse was presumed to have occurred at the surface in this simulation, due to strong currents.

2. GULF OF MEXICO FIELD DATA

Ayers et al. (1982) reported the results of a monitored release of drilling muds at an Exxon platform in the Gulf of Mexico, in 23 m of water, where the current was approximately 16/cm/sec. Their maximum turbidity values for the 23-minute "high rate" (= 1000 bbl/hr) test are compared with MMS Model results in Figure IIB.4. The model significantly overestimates turbidity at distances greater than about 400 m, although the field data may be low owing to the difficulties in measuring a plume deep in the water column (by helicopter) during a short time period. Dynamic collapse was presumed to have occurred near the bottom in the simulation, due to weak currents.

3. HIGH ISLAND BLOWOUT SITE

In November 1976 a major gas-well blowout occurred at a platform on High Island, South Addition Area, Block 563. Brooks et al. (1978) reported the results of a coring study in the area affected by the deposition of mud from the blow-out plume. The major plume existed for about 100 days, in depths of about 109 m. Currents in the area are about 20 cm/sec, but due to the upward jet created by the gas, dynamic collapse was assumed to occur throughout the water column at the site ("top to bottom"). Their deposition values, some of which are minimum because of incomplete core penetration, are compared with MMS Model results in Figure IIB.5. Agreement, using the 180° and 360° arcs as bracketing conditions, is excellent at distances beyond about 400 m. The unrealistic "collar" predicted by the model close to the plume origin was not actually formed, presumably because of scour and unstable slope.

4. OOC MODEL PREDICTION

Continental Shelf Associates (1984) reported the results of simulating the expected results of cumulative drilling mud releases at a Shell platform at Destin Dome Area, Block 160, in 85.5 m of water, where currents are approximately 18 cm/sec. Their deposition predictions for the 37-day program are compared with the MMS model results in Figure IIB.6. The agreement is excellent. The 360° arc geometry and the assumption of dynamic collapse near the bottom were used in this simulation, in view of expected weak currents and the lengthy period.

Murray Brown earned a BS in Chemistry at Duke in 1970, and a Licentiate (PhD) in Marine Chemistry at the University of Copenhagen in 1975. His original research interests were concerned with marine optics, humus in natural water, and colloid chemistry. He worked in environmental permitting activities for the State of Florida (1976-77) and the Army Engineer Corps (1967-68) before joining the BLM (later MMS) Studies Program. He is project officer for the Physical Oceanography Series, with special interests in information management systems.

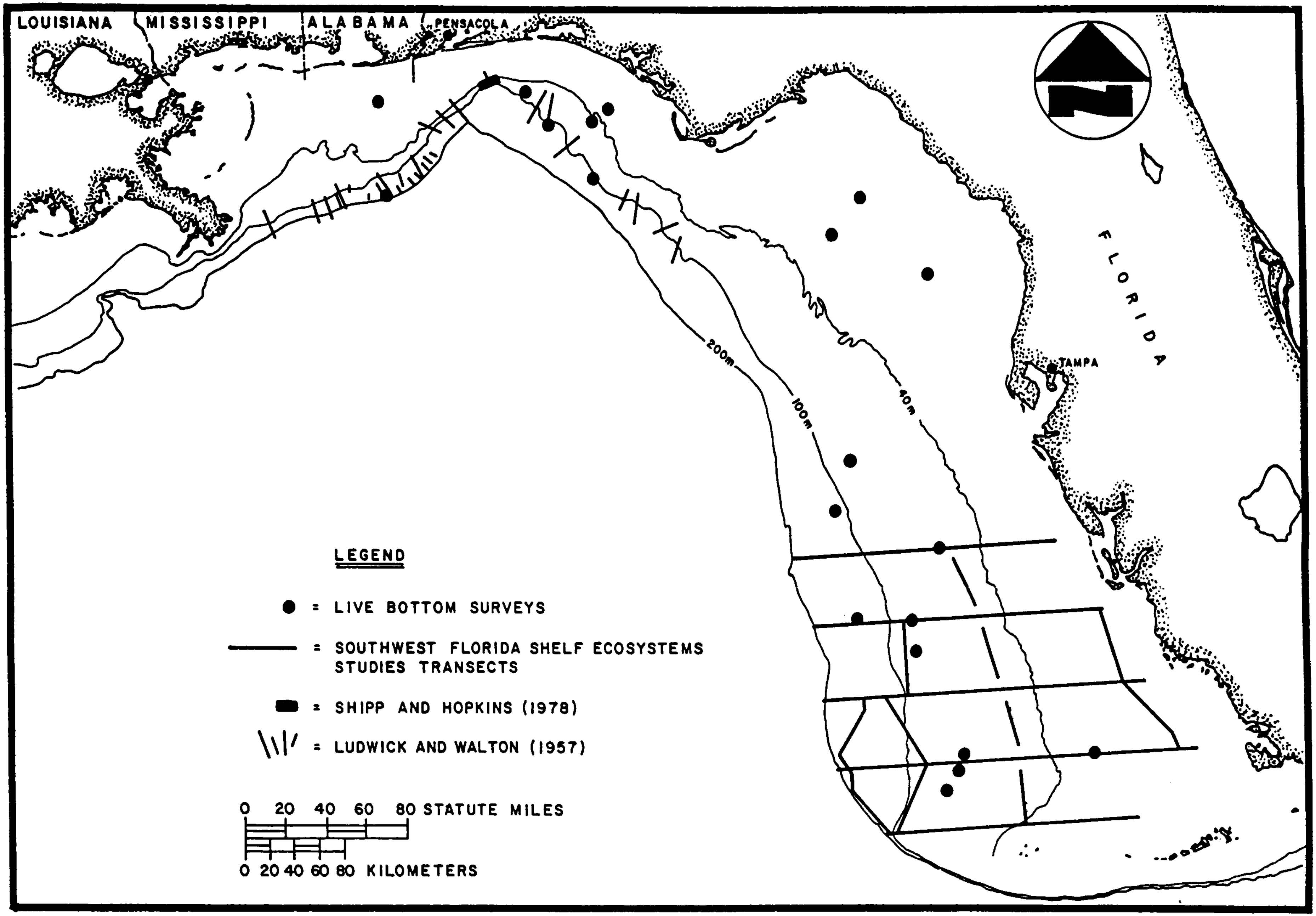


Figure IIB.1 - Geographic Locations of the 45 Lease Blocks in the Eastern Gulf of Mexico in Which Live Bottom Surveys Have Been Performed

Figure IIB.2 - Norton Sound

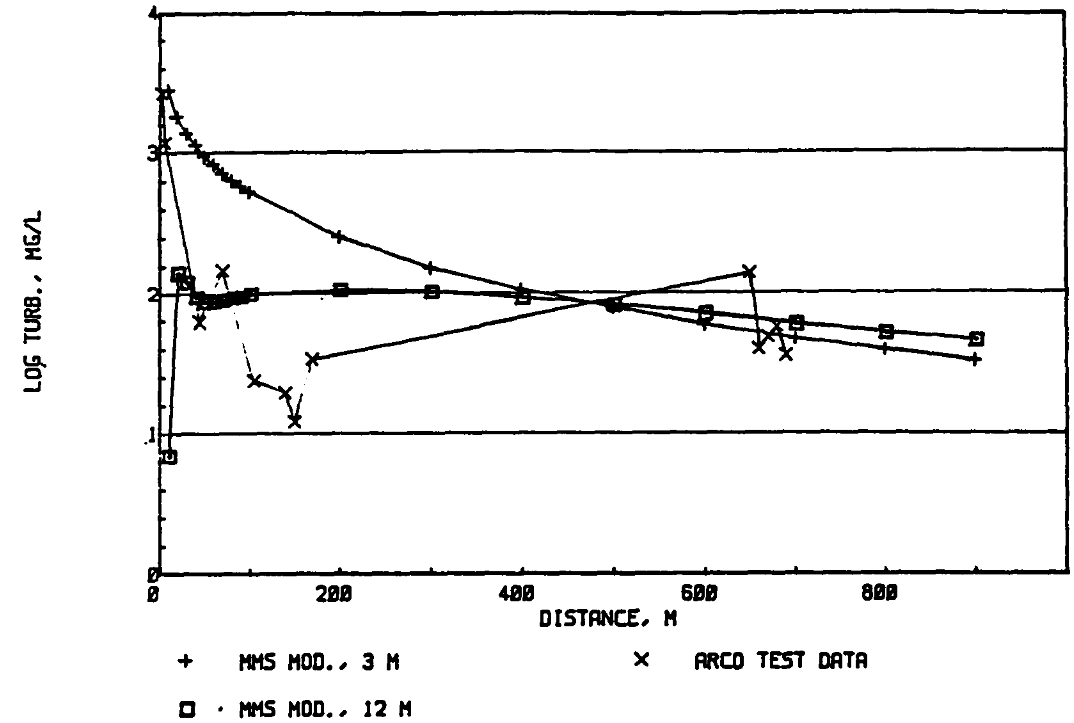


Figure IIB.3 - Norton Sound

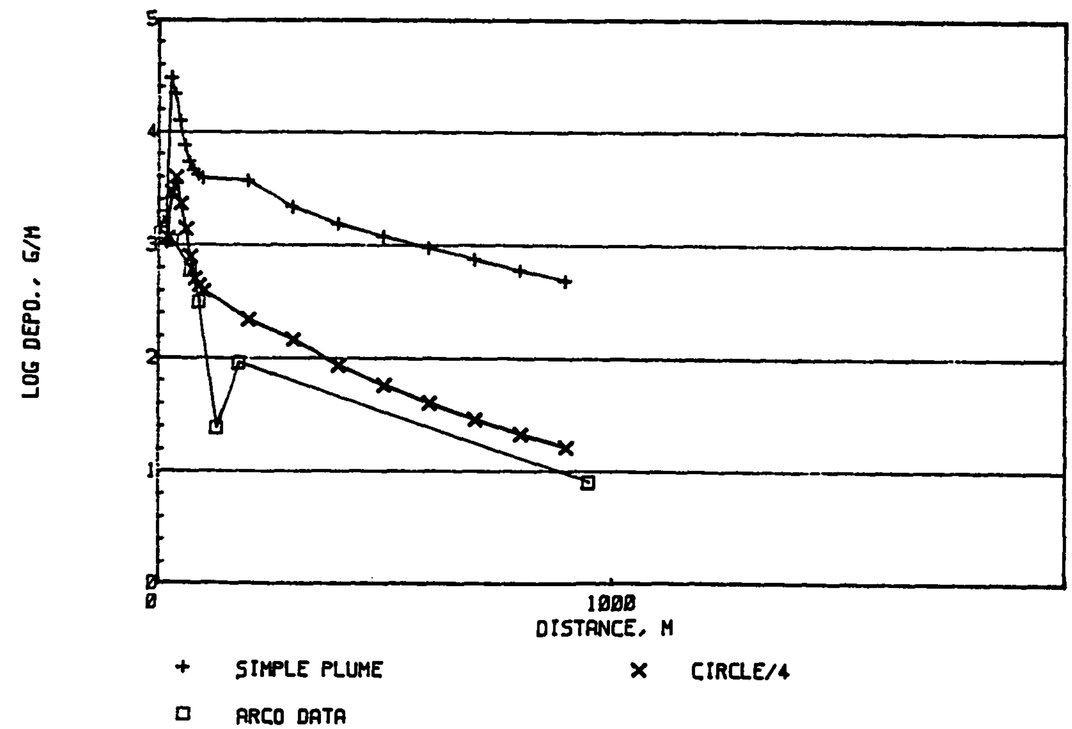


Figure IIB.4 - GOM Field Data

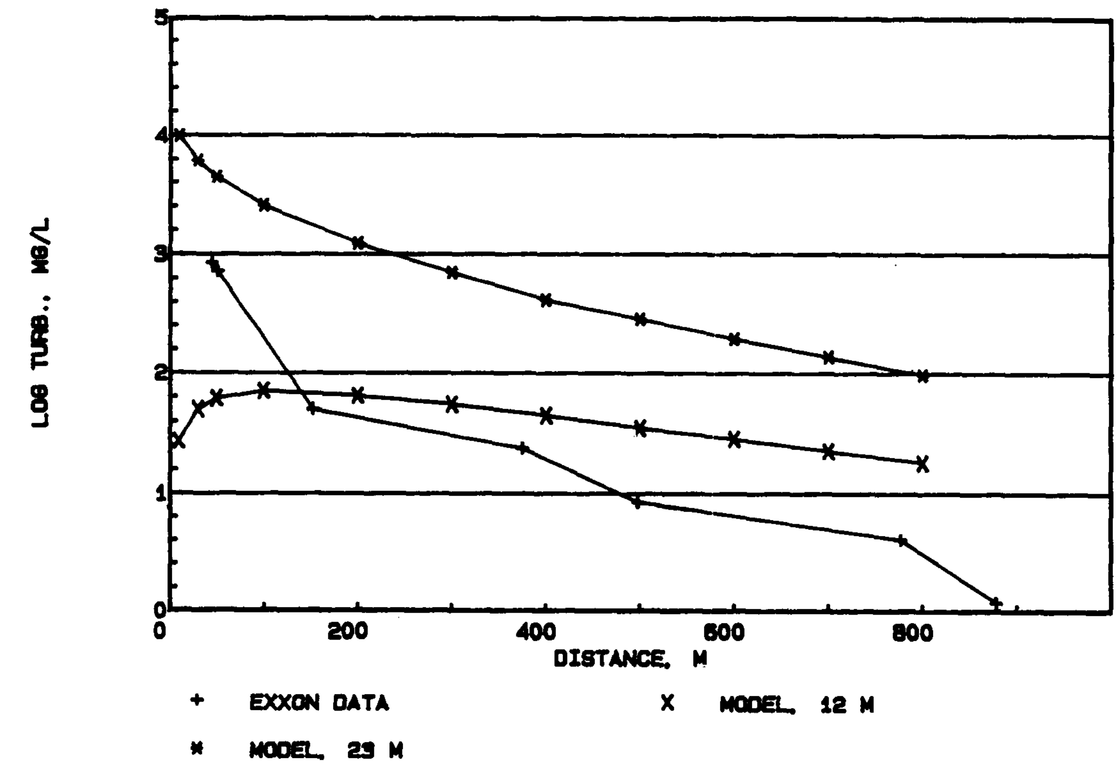
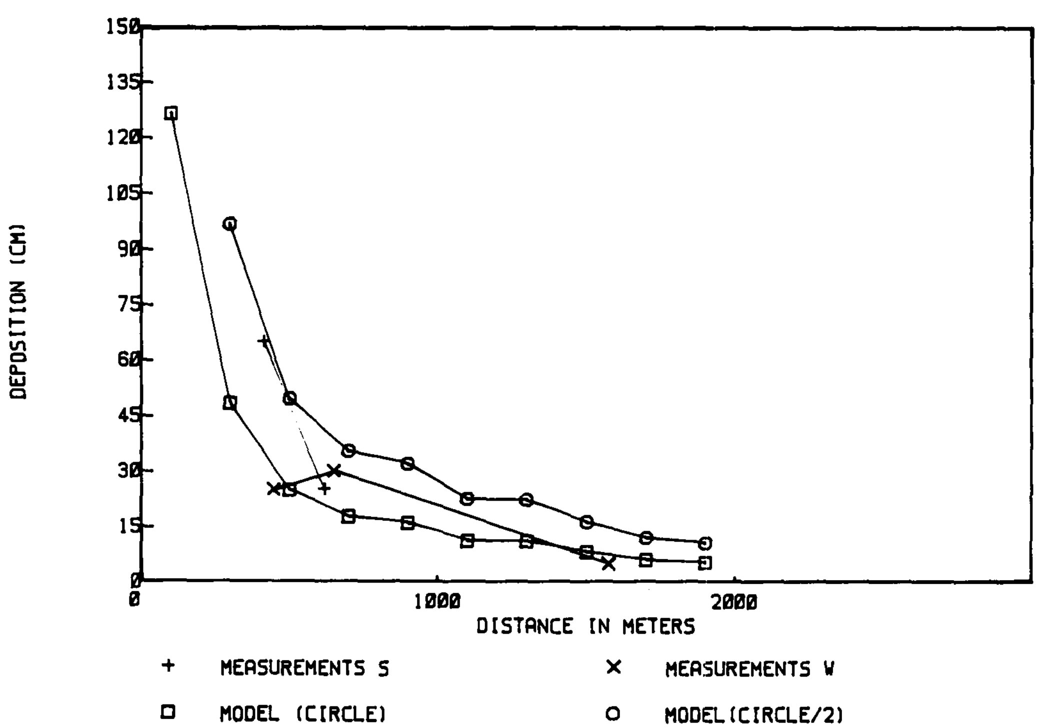


Figure IIB.5 - HI A-563 Blowout



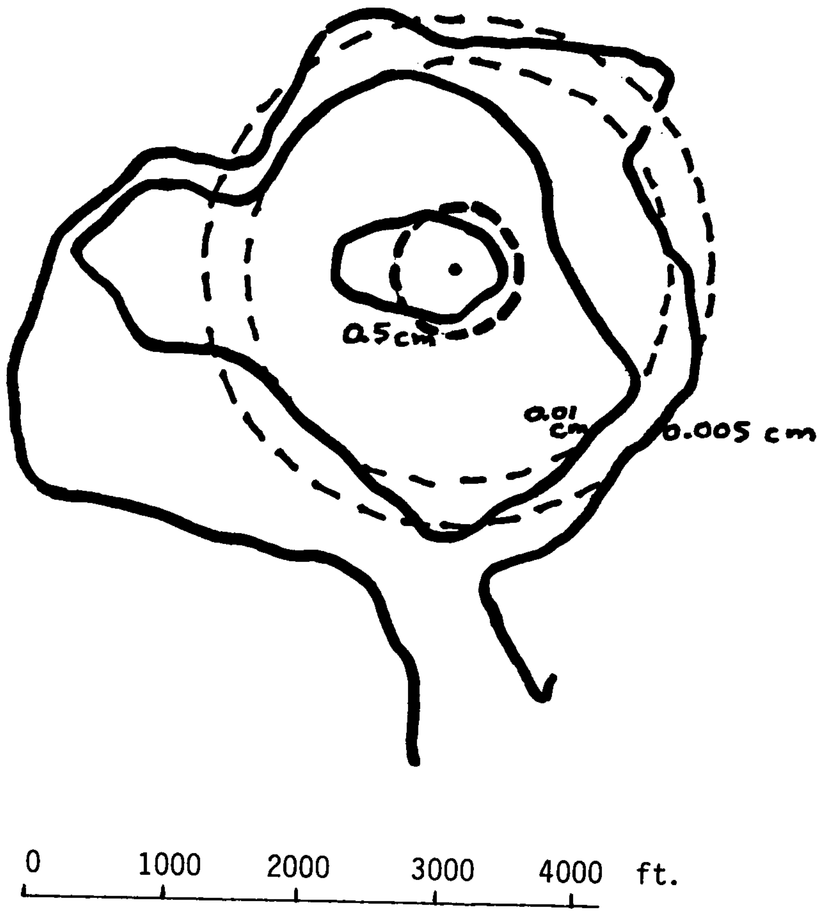


Figure IIB.6 - Destin Dome Area, Block 160

Table IIB.1 - Western and Central Gulf of Mexico Topographic Features Stipulations

Present Stipulation Requirements	Alternative Stipulation Requirements
FLOWER GARDENS	
1) No activity zone	1) Same
2) 1-mile zone requiring shunting and monitoring	2) 1-mile zone requiring shunting
3) 4-mile zone requiring shunting	3) Same
LOW RELIEF BANKS	
1) No activity zone	1) Same
Exception: **Claypile Bank** - (Low relief bank with "Category B" biologic community)	
1) No activity zone	1) Same
	2) 1000 m zone requiring monitoring
SOUTH TEXAS BANKS	
1) No activity zone	1) Same
2) 1-mile zone requiring shunting	2) 1000 m zone requiring shunting
3) 3-mile zone requiring shunting for production only	3) Eliminate
SHELF EDGE BANKS	
1) No activity zone	1) Same
2) 1-mile zone requiring shunting	2) Same
3) 3-mile zone requiring shunting or monitoring	3) Eliminate
Exceptions: **Sweet Bank** - (Deeply cresting deep-water bank)	
1) No activity zone	1) Same
Fishnet and Diaphus Banks - (Shelf edge banks which crest relatively deeply)	
1) No activity zone	1) Same
2) 1-mile zone requiring shunting	2) 1000 m zone requiring shunting
3) 3-mile zone requiring shunting or monitoring	3) Eliminate

Table IIB.2 - Central Gulf of Mexico Live Bottom Stipulation

Present Stipulation Requirement	Alternative Stipulation Requirement *
NORTHERN PART OF VIOSCA KNOLL AREA	
1) Live Bottom survey within 1820 m of activity	1) Live survey within 1000 m of activity
2) Photodocumentation if live bottom survey area indicates presence of suspected live bottom	2) Same
MOBILE AREA	
1) Same stipulation as Viosca Knoll	1) Eliminate

* The specific blocks where the live bottom stipulation would apply are being considered.

Table IIB.3 - Eastern Gulf of Mexico Live Bottom Stipulation

Present Stipulation Requirements	Alternative Stipulation Requirements
AREA NORTH OF LATITUDE 26°N	
1) Stipulation applies to exploration activity in water depths less than 100 m and to production activity in water depths less than 200 m.	1) Stipulation applies to exploration and production activities in water depths less than 100 m.
2) Live bottom survey within 1820 m of activities. Photodocumentation of the surveyed area is triggered by indications of live bottoms in the live bottom survey.	2) Live bottom survey within 1000 m of activities.
3) Photodocumentation out to 1820 m regardless of the live bottom survey results in water depths greater than 70 m.	3) Photodocumentation out to 1000 m in all water depths.
AREA SOUTH OF LATITUDE 26°N	
1) Stipulation applies to activities in all water depths.	1) Stipulation applies to activities in water depths less than 100 m (i.e., the same as recommended north of atitude 26°N).
2) Live bottom survey within 1820 m of activities	2) Same as recommended stipulation north of latitude 26°N.
3) Photodocumentation out to 1820 m of activities.	3) Same as recommended stipulation north of latitude 26°N.
4) Requires monitoring of all live bottom identified.	4) Eliminate.

Table IIB.4 - Recent Incidents of Anchoring at the Flower Garden Banks Witnessed By Researchers

DATE	VESSEL	TYPE	ANCHORING SITE	REMARKS
1978	-----	Liberian tanker	1/2 mi. from reef crest	------
1978	TEXACO FLORIDA	tanker	3/8 mi. from reef crest (27-30m depth)	------
1978	RACHEL SANCHEZ	Liberian tanker	on nodule terrace	left within 45 min. of radio/telephone contact
1979	VENTURE TEXAS	Liberian tanker	East Flower Garden Reef	destroyed monitoring site marker buoy
1979	OGDEN CHAMPION	U.S. tanker	East Flower Garden Reef	very near monitoring site
1980	WILLIAM LAMAR MELLON	tanker	did not anchor (intended to anchor within 100m of research vessel)	left after contact by radio/telephone
1983	NICK CANDIES	tug and tow barge	East Flower Garden Reef crest (24-30m)	reef damage assessment by Continental Shelf Assoc. Inc.
1985		oil field service vessel	East Flower Garden Reef crest	fishing at anchor

Table IIB.5 - Attempts to Regulate Anchoring at the Flower Garden Banks

INITIATOR	DATE	ACTION	REMARKS
NOAA National Marine Sanctuaries Division	1973	Would have regulated anchoring had the Flower Gardens become Marine Sanctuaries	Sanctuary designation process terminated due to oil industry opposition
Bureau of Land Management and U.S. Geological Survey	1974	Prohibited anchoring within "No Activity Zone" (parts of banks less than 100m depth)	Restrictions still in effect but do not apply to operations not involving drilling or productions (e.g. tankers, fishing vessels, service vessels, dive boats, etc.)
Bureau of Land Management	1976	Outer Continental Shelf Lands Act - prohibited operations that damage reef communities without a permit	Authority challenged (U.S. vs Alexander, 1979). Authority of BLM judged to be restricted to those activities related to mineral leases.
Dr. Jim Ray Environmental Div. Shell Oil Co.	1976	Memo to industry requesting voluntary prohibition of anchoring shallower than 49m by offshore service vessels	Possible short term effect but impossible to document.
NOAA National Marine Sanctuaries Division	1977	Flower Gardens again nominated for Marine Sanctuary designation	Nomination withdrawn in 1982 following controversy involving Environmental Protection Agency and Natural Resources Defense Council over boundaries and oil company effluent disposal.
NOAA Office of Coastal Zone Management	1981	Notice to Mariners requesting no anchoring of vessels over 50' length in less than 30 fm	Relatively ineffective method of notifying mariners--no chart amendments.
NOAA Gulf of Mexico Fishery Management Council	1981	Proposed no anchoring of vessels over 100' length in less than 50 fm	Proposal removed from Coral Management Plan (1982) because provision was not related to fishing activity.
Dr. Jim Ray Environmental Div. Shell Oil Co.	1984	Notice to Offshore Operators Committee requesting industry to honor "No-activity Zone" anchoring restrictions	Effect unknown, apparently minimal.
Solomon P. Ortiz Congressman, Texas	1984	"Coral Reef Protection Act" proposed to restrict anchoring in less than 325' depth within 4 nmi of Flower Garden banks	Withdrawn in lieu of proposed NOAA Marine Sanctuary designation
NOAA Gulf of Mexico Fishery Management Council	1984	Prohibited taking of corals on continential shelf without permit and restricted fishing activities in "Habitat Areas of Particular Concern"	Unenforced
Minerals Management Service, Gulf of Mexico Regional Tech. Working Group	1984	Suggested investigation of indicating coral areas on charts with a "Notes to Mariners"	No action apparent
NOAA Marine Sanctuary Division	1984	Flower Gardens renominated for Marine Sanctuary designation	If so designated, anchoring would be regulated by Marine Sanctuary Division of NOAA.

AIR AND WATER QUALITY IN THE GULF OF MEXICO

Session: AIR AND WATER QUALITY IN THE GULF OF MEXICO

Chairman: Mr. Bill Johnstone

Date: October 22, 1985

Presentation Title	Speaker/Affiliation
Gulf of Mexico, Air and Water Quality: Session Summary	Mr. Bill Johnstone Minerals Management Service
National Pollution and Discharge Elimination System Permits for OCS Oil and Gas Facilities in the Gulf of Mexico	Mr. Bob Vickery and Mr. Lloyd Wise U.S. Environmental Protection Agency
Offshore and Coastal Dispersion Model Development for Air Quality Assessment	Dr. Steven R. Hanna Environmental Research and Technology, Inc.
Modeling Ozone Impacts Resulting from Predicted OCS Development	Mr. David Souten System Applications, Inc.
OCS Program Response to the Air Quality Issue in California	Mr. Cary McGregor Minerals Management Service

Gulf of Mexico, Air and Water Quality: Session Summary

Mr. Bill Johnstone
Minerals Management Service

Session II-C consisted of five topics presented by seven articulate speakers. The topics centered around two general components of the natural environments, the air and the water. Those are big subjects and we were unable to explore them entirely, but we did penetrate some of the new technology and some of the modeling techniques that are being used to study and analyze air and water quality in the Gulf of Mexico Region.

Our first speakers were from the U.S. Environmental Protection Agency. One was from the Atlanta Regional Office, Mr. Lloyd Wise, and the other, Bob Vickery, was from the Dallas Regional Office of the U.S. EPA. They talked about the National Pollution and Discharge Elimination System Permits for OCS activities in the Gulf of Mexico. This permit program is undergoing some revision as a result of legislative amendments in 1984. We are currently under a draft guideline regulation for this permit. Under the authority of the Clean Water Act, the EPA issues permits for point source discharges to waters of the United States, including the OCS. These permits are described in Section 402 of the Clean Water Act, and are commonly referred to as the NPDES Permits.

For water quality considerations in the Gulf, the EPA uses the ocean discharge criteria suggested in Section 403-C of the Clean Water Act. For treatment technology, the permit writers use published effluent guidelines.

The draft permit, which we are currently under, was published in the July 26, 1985, issue of the FEDERAL REGISTER and it has effluent limitations that are mostly based on best available technology.

The control discharge rate is based on the requirements that are set forth in the Act. Under the guidelines, the ocean discharge criteria evaluations may allow no permit to be issued unless it can be determined that the action will not cause unreasonable degradation. The term "unreasonable degradation" is a key term in this permit process. It is defined based on three criteria.

> First: Unreasonable degradation is significant adverse changes in ecosystem diversity, productivity, and stability of the biological communities within the area of the discharge and surrounding biological communities.
>
> Second: Is there a threat to human health through direct exposure to pollutants?
>
> Third: Does a loss of esthetic, recreational, scientific, or economic values which is unreasonable in relation to the benefit that will be derived from the discharge occur?

If the Regional Administrator of the EPA determines that the discharge will not cause unreasonable degradation to the marine environment, then a permit is issued. If the Administrator is insufficiently informed and feels that he doesn't have enough information to make a determination, then there will be no permit issued. A permit alternative can be prepared if it meets the following criteria:

> First: That such discharges will not cause irreparable harm to the environment during the period in which the monitoring takes place after the permit is issued.
>
> Second: There is no reasonable alternative to on-site disposal.
>
> Third: The discharges will be in compliance with certain specific specifications and conditions in the permit.

"Irreparable harm" is defined as significant undesirable effects occurring after the date of permit issuance which will not be reversed after cessation or modification of the discharge.

At the current time the regulations and the procedures for the permit, as I've described it, are undergoing an evaluation. There is a comment period which has been extended to November 6, 1985. After that time, work will begin on finalizing the permit guidelines and regulations. It's expected that some time early next year, at least by midyear, the final guidelines will be published for NPDES permits.

Our second session called on two experts to discuss subjects having to do with water. They were Mr. John Klein, of the NOAA Agency, the Office of Oceanography and Marine Studies, and Mr. Marvin Drake, from the New Orleans Corps of Engineers District Office. These two have teamed up to work on a water quality study that is concerned with fresh water diversion into Breton Sound in Louisiana. Their teaming was a result of the ITM meeting last year. John appeared on a session that I chaired, and at the conclusion of his talk struck up a conversation with Marvin. A new study was born.

What they have done is to bring together two modeling techniques, one that the Corps has relied on for sometime and one that John Klein has developed for NOAA. The purpose of this effort was to validate both modeling techniques and to determine what advantage could be gained by combining the two models in one study.

Their talk addressed the application of NOAA's water quality screening model and the regionalize regression equations developed by the Corps of Engineers. A statistical treatment of monthly mean salinity levels and measured hydrometerological parameters, including Mississippi River flow, precipitation, and evaporation rates, were examined. Weather patterns yielding multiple linear regression equations for several station locations within the Sound were also studied.

The same data base was independently analyzed using a two-dimensional steady state screening model which reflected the advective and the fusive characteristics of the circulation within Breton Sound. The result of the two approaches was presented, and spatial and temporal differences were noted. Further calibration of the study is anticipated.

The thrust of the study was to determine if salinity levels could be changed by the diversion of fresh water into Breton Sound using a designed control structure. Generally, both approaches correlated and supported the results of the other.

Our third session initiated the air quality segment of the afternoon session. Dr. Steve Hanna was our first speaker. Dr. Hanna is a principal with the Environmental Research and Technology Corporation of Concord, MA. He talked on the "Offshore Coastal Dispersion Model Development for Air Quality Assessment." The "OCD Model" was developed by Dr. Hanna at the request of MMS. The MMS sponsored the development of the model for use in assessing onshore environmental impacts of air pollutant emissions from offshore sources such as oil platforms and rigs.

The model incorporates over water boundary layer physics, aerodynamic downwash around the platform or rig, fumigation of the plume at the shoreline and impaction of the plume on elevated terrain at the coastline. Offshore observations of winds, turbulence, air/sea temperature differences are preferred by the model, although it can operate with National Weather Service Data. Up to 250 point sources can be handled by the model.

The OCD Model has been evaluated using data from Pismo Beach, Ventura, CA, and also Cameron, LA. The results from the Louisiana application show the importance of accounting for lateral plume meander in stable air conditions.

The model is currently approved for use by MMS. We have applied the model in the Gulf of Mexico region recently in determining what hazard might be involved should a catastrophic blowout occur at a sour gas well near the three mile state line. We were able to determine that virtually no hazard would have resulted had a blowout occurred.

Our next speaker, Mr. David Souten, of Systems Applications, Inc., out of California, talked to us about another modeling technique dealing with ozone. The OCD Model is concerned with the five criteria pollutants that are listed in the Clean Air Act. The Paris Airshed model is concerned with ozone, which is a recognized pollutant caused by a photochemical reaction in the air. It is an elusive and difficult pollutant to study because it occurs, not on a regular basis, but only under certain conditions.

The Clean Air Act requires that each state prepare a State Implementation Plan. This caused the State of California to require MMS to study OCS aspects of air quality. Because of the complexity of accounting for the potential air quality impacts that the OCS activities might generate, a study of ozone formation was undertaken in California. The work resulted in the application of the grid-based photochemical model which treats point source plumes. The proposed project was divided into two phases spanning a two-year period. The first phase, which has to do with acqusition of data, was the more intensive phase. The second phase completed the bulk of the model validation and utilized the model to access air quality consequences in OCS development scenarios. It was determined to set up certain sets of criteria, apply these to the model, and see what happens.

The model predicted coastal concentrations of ozone very well for both episodes that were selected. The model under-predicted second day ozone peaks by about two parts per hundred million at inland stations. Another result dealt with hydrocarbon emissions for underwater seeps. While large in total quantity, these seeps are low in the reactive portion of the model and, therefore, appear to have little effect on ozone prediction. There was some thought that these natural seeps were making a significant contribution to ozone formation. However, it was determined that no significant contribution was made by natural seeps.

The model predicted daily variations in ozone concentrations quite well. The model results appear to be sensitive to initial hydrocarbon concentrations and complex wind patterns in the interior valley areas of coastal California.

The last speaker in our session was Mr. Cary McGregor of the MMS Pacific Regional Office. Mr. McGregor put together an interesting story of the response that has been made by the Pacific Office to a complex political situation. The issue is felt by some to be a very real issue in the Pacific Regions where air quality was poor before OCS activity occurred and continues to be a concern. Mr. McGregor explained the actors in the play, the roles they played, and the interests they represented. The two studies that we heard about are an outgrowth of this conflict between various political interests on the state, local, and federal level to determine whether or not OCS activities were in fact making a significant contribution to the degradation of air quality of coastal California.

Mr. McGregor was dealing in a sensitive area and consequently was careful in the choice of his words. He was able to explain effectively that the MMS and Department of Interior have the same goals and overall mission. The Department is working diligently with the proper authorities in California to make progress in the area of air quality.

Mr. William T. Johnstone has been associated with environmentally related projects while serving in both the private and public sectors of the economy since earning a bachelor's degree from Ohio State University in 1957 and a Master of Regional and City Planning degree from Oklahoma University in 1971. As a practicing planner, Mr. Johnstone has engaged in numerous environmental resource evaluations and has designed plans to facilitate environmentally sound developments. As a senior staff member of the environmental assessment section of the MMS Gulf Region, Mr. Johnstone is currently engaged in air quality, land use, and community infrastructure concerns.

National Pollution and Discharge Elimination System Permits for OCS Oil and Gas Facilities in the Gulf of Mexico

Mr. Bob Vickery
and
Mr. Lloyd Wise
United States Environmental Protection Agency

Under the authority of the Clean Water Act, EPA issues permits for point source discharges to waters of the United States. These permits are described in section 402 of the Act and are commonly identified as NPDES permits, the acronym for National Pollutant Discharge Elimination System.

Because of the large number of oil and gas facilities located in the western Gulf of Mexico, we issued general NPDES permits to authorize most of the Gulf oil and gas discharges in 1981. Several individual permits were issued in the eastern Gulf and the Flower Garden Banks area. Both individual and general permits were issued to lease operators whom we hold responsible for compliance with permit conditions.

Each NPDES permit requirement is based either on treatment technology or effects on the receiving water quality. For water quality considerations in the Gulf, we use the Ocean Discharge Criteria (Section 403(c) of the Clean Water Act). For treatment technology, the permit writer uses published effluent guidelines which define best practical control techology (BPT), best conventional technology (BCT), best available techology (BAT), or new source performance standards.

The draft permit published in the FEDERAL REGISTER on July 26 (1985) has effluent limitations that are mostly based on BAT as determined on a case-by-case basis since effluent guidelines are not published in final form. The controlled discharge rate is based on the requirements of Section 403(c), which is summarized below:

Section 403(c) of the Clean water Act, and subsequent promulgation of the regulations implementing this section, is intended to prevent unreasonable degradation of the marine environment and to authorize imposition of effluent limitations, including a prohibition of discharge, if necessary, to ensure this goal. Under these guidelines, commonly referred to as the Ocean Discharge Criteria Evaluation (ODCE), no NPDES permit may be issued which authorizes a discharge of pollutants to the marine environment except in compliance with these guidelines. They require the Regional Administrator to determine, on the basis of available information, whether or not the discharge will cause unreasonable degradation, defined as:

1. Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities,

2. Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms, or

3. Loss of esthetic, recreational, scientific, or economic values which is unreasonable in relation to the benefit derived from the discharge.

If the Regional Administrator determines that the discharge will not cause unreasonable degradation of the marine environment, an NPDES permit may be issued. If the Regional Administrator has insufficient information to determine, prior to permit issuance, that there will be no unreasonable degradation of the marine environment, there shall be no discharge of pollutants unless the Regional Administrator, on the basis of the best available information, determines that:

1. Such discharge will not cause irreparable harm to the marine environment during the period in which monitoring will take place;

2. There are no reasonable alternatives to the on-site disposal or these materials; and

3. The discharge will be in compliance with certain specified permit conditions.

"Irreparable harm" is defined as significant undesirable effects occurring after the date of permit issuance which will not be reversed after cessation or modification of the discharge.

Since the draft permit was published on July 26, draft BAT effluent guidelines have been published and the permit comment period has been extended to November 6, 1985.

Mr. Bob Vickery is an aquatic biologist in the Industrial Permits Section at EPA Region 6, Dallas, TX. He wrote the previous offshore oil and gas NPDES permits and, in cooperation with Lloyd Wise of EPA Region 4, also wrote the draft permit presented here. Bob Vickery received his BS and MS degrees in Biology from the University of Southern Mississippi.

Mr. Lloyd Wise received his formal education at West Virginia University and Syracuse University, majoring in engineering and the Russian language. He began his career with the U.S. Environmental Protection Agency when they were first organized in 1970. He is presently working on the National Pollutant Discharge Elimination System (NPDES) General Permit for the regulation of Offshore Oil and Gas operational discharges to federal waters of the Gulf of Mexico at EPA's Regional Office in Atlanta.

Offshore and Coastal Dispersion Model Development for Air Quality Assessment

Steven R. Hanna
Environmental Research and Technology, Inc.

The Offshore and Coastal Dispersion (OCD) model was developed by Environmental Research and Technology, Inc., for the Minerals Management Service to simulate plume dispersion and transport from offshore point sources to receptors on land or water. Because the OCD model is intended for routine use as a regulatory model, the approach taken was to retain the basic structure of a standard EPA model, MPTER, but to modify the model components to conform with accepted overwater boundary layer dynamics. The OCD model is, therefore, an hour-by-hour steady state Gaussian model, but with enhancements that consider the differences between overwater and overland dispersion characteristics, the sea-land interface, and platform aerodynamic effects.

Dispersion over land has been successfully parameterized by the EPA as a function of solar radiation and wind speed only. This approach can be used over land without considering surface temperature or humidity because the surface temperature responds rapidly to changes in solar radiation, or air temperature, and sensible head fluxes dominate latent heat fluxes in the boundary layer. This is not the case for the boundary layer over water surfaces where diurnal temperature changes are quite small, response times long, and latent heat fluxes important. Therefore, the traditional methods of determining stability category and thus atmospheric turbulence characteristics are not applicable for overwater sources. Overwater turbulence levels are largely governed by the air-water temperature difference, overwater wind speed, and the specific humidity. If overwater turbulence levels are not measured directly, they must be estimated from boundary layer theory using bulk aerodynamic principles.

The OCD model requires both overwater and overland meteorological data. The overwater data include the following parameters:

- wind direction
- wind speed
- mixing height
- air temperature
- water surface temperature
- relative humidity
- wind direction shear in the vertical
- vertical potential temperature gradient
- turbulence intensities (y and z components).

The overland meteorological data required by the OCD model are identical to those required by the MPTER model. If any or all of the parameters listed above are missing, then replacement values for most parameters are obtained from overland data or from monthly climatological values provided by the user. Missing overwater turbulence intensities, however, are parameterized using bulk aerodynamic wind and temperature profile relationships as well as the overwater stability category (defined in terms of the Monin-Obukhov length). Missing overland turbulence intensity measurements are replaced by the Pasquill-Gifford parameterization for σ_y and σ_z.

Several options available in MPTER have been retained by the OCD model:

- terrain adjustments
- stack-tip downwash
- gradual plume rise
- buoyancy-induced dispersion
- pollutant decay (monthly daytime transsformation rates are user-specified).

The OCD model has incorporated several other features that are not found in MPTER:

- Complex terrain is treated as in COMPLEX II and RTDM.

- Building downwash due to platform influence on the plume is treated as in the BLP model; dispersion coefficients are enhanced and final plume rise is reduced as a result of downwash effectts. Partial penetration of elevated inversions is accounted for.

- Stacks can be oriented at any angle relative to the vertical to accommodate a variety of oil platform sources.

- The land/sea interface need not be a straight line; a rectangular grid system is used to accommodate any complex coastline.

- A virtual source technique is used to change the rate of plume growth as the overwater plume intercepts the overland internal boundary layer.

- Continuous shoreline fumigation (stable overwater and unstable overland conditions) is parameterized using the Deardorff-Willis scheme.

- Hourly source emission rate, exit velocity, and stack gas temperature can be specified.

The OCD model can provide estimates of pollutant concentrations at a maximum of 180 receptors from a maximum of 250 point sources. Summary tables generated by OCD may be used to determine the peak modeled concentrations. Alternatively, modeled concentrations can be written to an output tape or disk file for subsequent postprocessing by the ANALYSIS program. The postprocessor can provide several statistical summaries:

- the top N concentrations for each receptor for averaging periods up to 24 hours in length;

- cumulative frequency distributions of concentrations for each receptor; and

- identification of periods for which threshold concentrations are exceeded at any receptor.

In addition, the ANALYSIS postprocessor can create new concentration files which can be used as input to the processor described above:

- a file of running averages (up to 24 hours in length), and

- a file that is the sum of concentrations from up to five separate files. (Concentrations from each file summed are first multiplied by a user-specified scale factor.)

A performance evaluation of the OCD model along with the MMS model recommended in 1980 for offshore sources (CRSTER with stability classes A and B changed to class C) was conducted with measurements from three different offshore tracer experiments. The three experiments included 37 hours of data from the MMS-sponsored experiment at Ventura, CA, 62 hours from the MMS experiment at Pismo Beach, CA, and 53 hours of data collected at Cameron, LA, in an experiment sponsored by the American Petroleum Institute.

A quantitative scoring scheme was developed for the evaluations, based on the standard Student's t, F and R statistics. These statistics measured the model skill by examining differences in observed and calculated mean concentrations, differences in variances, and correlations. The experimental data were randomly divided into a development data set that was used for improving the model and a test data set that was reserved for final model evaluation.

The OCD model, as a result of the model evaluation procedures, was shown to be a clear improvement over the 1980 MMS model.

Dr. Steven R. Hanna received his PhD in Meteorology from Pennsylvania State University in 1967. He worked as a research meteorologist at NOAA's Atmospheric Turbulence and Diffusion Laboratory in Oak Ridge, TN, from 1967 through 1981. Since 1981 he has been employed as a principal meteorologist at Environmental Research and Technology, Inc., in Concord, MA. He has developed the physical bases for several transport and dispersion models in current use, including the EPA RAM model for urban area sources, the MMS OCD model for offshore sources, the RTDM model for sources in complex terrain, and the EPRI Plume Model for tall stacks.

Modeling Ozone Impacts Resulting from Predicted OCS Development

Mr. David Souten
System Applications, Inc.

Accelerated development of petroleum resources in California has generated concern regarding potential adverse environmental effects from the exploration, development, and production of offshore continental shelf (OCS) hydrocarbon reserves on air quality in the coastal air basins of California. This issue is particularly relevant because most air basins in the affected area have not attained the National Ambient Air Quality Standard (NAAQS) for ozone.

The Clean Air Act requires that each state submit a State Implementation Plan (SIP). Because of the complexities of accounting for the potential, yet uncertain, air quality impacts of continued OCS energy development, the State of California as well as the counties of Santa Barbara and Ventura have been unable to incorporate explicitly this potential source of air pollution into their SIP's.

In response to this need, EPA Region IX and the Minerals Management Service (MMS) initiated a research activity with Systems Application, Inc., of San Rafael, CA, involving the use of a set of state-of-the-art air quality models to assess the impacts of future OCS development, and to incorporate such potential impacts explicitly into the California SIP, especially in regard to attainment and maintenance of the NAAQS for ozone. The work resulted in the application of a grid-based photochemical model which explicitly treats point source plumes.

The proposed project is divided into two phases spanning a period of two years. In Phase I (Data Acquisition and Analysis), we identified the meteorological conditions of greatest interest; delineated the modeling region (spatial extent); generated, collected, and compiled needed meteorological, emission, topographical, and ambient air quality data; and began the model validation (comparison of model results to measured data). In Phase II (Model Application), we completed the bulk of the model validation and utilized the model to assess air quality consequences of alternative OCS development scenarios.

Mr. David R. Souten is the manager of the Advanced Programs Division of Systems Application, Inc., of California. Mr. Souten has bachelor's and master's degrees in mechanical engineering. He has studied various aspects of air quality with SAI and in his previous work assignments with EPA, U.S. Navy, Standard Oil Co. of California, and the National Academy of Sciences.

OCS Program Response to the Air Quality Issue in California

Cary McGregor
Minerals Management Service

Air quality in California is a recognized environmental problem that is a concern of federal, state, and local governmental agencies as well as with private environmental groups. It is a complicated problem that unfortunately does not have easy-to-implement solutions. Technological advancements have received much attention and should continue as a means to reduce air emissions. However, this should not be the only consideration. Decisions have to be made as to when, where, how, and by whom this technology will be implemented. This requires close coordination between appropriate government agencies to achieve understanding of air quality problems and solutions. These solutions must be developed so that responsible companies can reduce their impacts without undue financial hardship. Balancing environment protection against national and local economic considerations adds to the difficulty of these regulatory tasks.

National ambient air quality standards were established as a result of the Clean Air Act to protect the public health and welfare. This act is specific as to how state governments in coordination with the Environmental Protection Agency should achieve and maintain these standards within their jurisdiction. Congress recognized that oil and gas activities in the OCS were not under state jurisdiction and required the Department of the Interior (DOI) through the OCS Lands Act Amendments of 1978 to comply with these national standards.

The DOI promulgated regulations that specify how these national standards are to be protected and has delegated the enforcement responsibility to the Minerals Management Service (MMS). The DOI has taken the position that OCS oil and gas activities must first be shown to cause significant onshore impacts before mitigation is required. This means relating project emissions to onshore pollutant concentrations, which requires knowledge of local meteorology, an understnading of pollutant transport, chemical reactions, and detailed descriptions of future activities of the plan under review. Many onshore state and local agencies have taken an easier approach by using set emission rates to decide when to require mitigation.

California is divided into air basins based on regional meteorology and county boundaries. These air basins are further divided into air pollution control districts to allow for local jurisdiction. There are six coastal air basins, two of which are adjacent to regions with active OCS oil and gas activities. These two air basins unfortunately have most of the air quality problems of California. EPA has classified areas within these basins as being in non-attainment for the federal standards of total suspended particulates, ozone, nitrogen dioxide, and carbon monoxide.

Most Pacific OCS activities have taken place offshore of the South Central Coast Air Basin. To assess the creation of ozone in this area, MMS has been working with the EPA and California state and local agencies in a modeling study called JIMS (Joint Interagency Modeling Study). Unfortunately, the lack of recorded detailed meteorology and background air quality has made this study and other impact analyses very difficult. To reduce these uncertainties, the MMS Pacific OCS Regional Office has conducted studies of its own and with other state and federal agencies. A current example is the South Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP).

Various governmental agencies that have expressed interest in Pacific OCS emissions have different perspectives of assessing impacts. The DOI, to ensure federal consistency, incorporated many EPA guidelines into its OCS air quality regulations (30 CFR 257). However, EPA Region 9 is still concerned that nearby nonattainment areas are not expected to have improvements in the near future and wants all involved jurisdictional agencies to work together to minimize these problems.

California has established a set of air quality standards more stringent than federal standards. Not only do these state standards use lower concentration levels, they also require no exceedences. Federal standards allow one exceedence per year. These differences have caused the California Air Resources Board and local air pollution control districts to adopt more conservative methods. Their emphasis is placed on analysis of worst-case OCS project emission scenarios that may occur infrequently. This has at times lead the MMS and local air pollution control distances to reach differing assessments.

Because of the lack of jurisdiction over oil and gas activities beyond three nautical miles, state and local agencies have interacted with the DOI and the MMS through lawsuits, cooperative modeling studies, formulation of lease sale stipulations, creation of new DOI regulations and joint environmental documents (Federal Environmental Impact Statement and California Environmental Impact Report) for Development and Production Plans. These endeavors have led to varying degrees of success.

The State of California filed a suit against the DOI on July 1, 1981, alleging that the DOI air quality rules are insufficient to protect California's air quality. The DOI and the State of California are currently trying to settle this pending case out of court through the creation of special DOI regulations applicable only to the California OCS. An Advanced Notice of Proposed Rulemaking was issued in the FEDERAL REGISTER to solicit ideas. Unfortunately, there are still major disagreements that have stalled this rulemaking.

As a result of prelease negotiations with the State of California, the MMS attached a special air quality stipulation to Lease Sale 73 tracts. This did not resolve assessment issues but created specific cooperative joint projects wherein the MMS and the CARB are to resolve issues. As a result a list of possible control technologies for exploratory drilling and modeling guidelines was formulated. A similar control technologies list for development and production activities will be completed in the future.

In the Pacific OCS joint federal, state, and county environmental documents (EIS/EIR's and EA/EIR's) are prepared since development and production plans involve offshore and onshore facilities. This process provides a coordinated approach to eliminate differing analyses. This idea has produced both successes and failures of agency cooperation. The Santa Ynez Unit EIS/EIR is an example that had two different air quality analyses in the same document that each satisfied the MMS and Santa Barbara County. Later EIS/EIR documents have had better interagency cooperation with more acceptable analyses.

California's interpretation of the Coastal Zone Management Act (CZMA) has caused interesting and frustrating jurisdictional conflicts with the DOI and MMS. The California Coastal Commission (CCC) is the state agency that was created to determine if any project or action affecting the California coast is consistent with California's Coastal Zone Managment Program required by the CZMA. Any OCS Exploration or Production Plan must have an affirmative consistency ruling before the oil and gas lease operator can proceed. The CCC has interpreted air emission impacts to come under its jurisdiction and is applying California air quality standards. This is counter to the OCS Lands Act and the apparent legal conflict has not yet been resolved.

As a final comment, there must continue to be interaction between MMS regional offices and any state that expresses concern for OCS impacts. This interaction must be perceived by both sides as being constructive in order for both state and federal agencies to carry out effectively their statutory mandates. No state or federal agency can afford to work independently in managing public programs. All parties benefit from improved cooperation and produce greater benefits to public health and welfare.

Mr. Cary McGregor received his BS degree at the University of California at Riverside in Physics. He completed his MS degree in Meteorology at the University of Colorado at Boulder. Mr. McGregor has worked at the National Center for Atmospheric Research in Boulder, CO, and the Chemistry Department at the University of Maryland. Mr. McGregor is presently working for the Minerals Management Service as an air quality meteorologist and monitors emissions from oil and gas facilities in the Pacific OCS.

OIL SPILL CONTROL AND CLEANUP

Session: OIL SPILL CONTROL AND CLEANUP

Chairmen: Ms. Laura Gabanski
Mr. Raymond Churan

Date: October 22, 1985

Presentation Title	Speaker/Affiliation
Oil Spill Control and Cleanup in the Gulf of Mexico: Session Summary	Mr. Raymond P. Churan U. S. Department of the Interior
Federal Response to Oil Spills	Commander Brian Kelly U. S. Coast Guard
Clean Gulf Associates	Mr. Paul Schmidt, Chairman Clean Gulf Associates
MIRG Oil Spill Response	Mr. T. N. Pockman Mobil Oil Corporation
The Gulf Strike Team	Lieutenant Commander Rich Softye USCG Gulf Strike Team
The *Alvenus* Oil Spill	Captain T. G. McKinna U. S. Coast Guard

Oil Spill Control and Cleanup in the Gulf of Mexico: Session Summary

Raymond P. Churan
U. S. Department of the Interior

The session on oil spill control and cleanup was designed to cover contingency planning and the response capabilities in the Gulf of Mexico. The first speaker was Commander Brian Kelly, from the Eighth Coast Guard District, New Orleans, who covered federal response to oil spills. His presentation described the framework of how the oil spill mechanism came about. He discussed, very briefly, the history of the Clean Water Act, the Comprehensive Environmental Response Compensation and Liability Act (Superfund Law), and the Intervention on the High Seas Act, which are the three laws that set the framework for oil spill response activities for the Coast Guard.

Under the Clean Water Act, the planning efforts start with a national contingency plan and the planning efforts from there tier downward from the national, to the regional, to the local, to individual site plans.

He briefly described that at the national scene we have a national response team made up of twelve federal agencies. This is the forum that handles contingency planning at the national level. It's also the forum that develops the guidance for the tiering downward of contingency planning and response activities to the the regional, state and local levels.

The next level that he described was the regional response team, how it operates here in the Gulf of Mexico, how it provides the general planning and guidance for the Gulf, and how it provides assistance to the pre-designated on-scene coordinators. The pre-designated on-scene coordinator is a pre-designated federal employee. Along the coast, it's the Coast Guard; in the upland areas it's the Environmental Protection Agency.

The regional response team and the on-scene coordinator have available to them special expertise. Under the national contingency plan there is a national strike force which is a highly specialized group with special training and equipment. A scientific support coordinator can be available to the on-scene coordinator.

Commander Kelly briefly described the four phases of a spill. The first one is discovery and notification. The notification is normally through the National Response Center. This begins to trigger the tiering effect that I mentioned earlier. It notifies the on-scene coordinator. The on-scene coordinator will move into phase two, which is the preliminary assessment, to see what the spill may be, how severe, what are its characteristics, etc. And then the third phase is containment and cleanup which may or may not require some of the special expertise that is available. The on-scene coordinator may request assistance from the Regional Response Team, the scientific support coordinator, or the Gulf Coast Strike Team.

The last phase is litigation. If there is a federal response to the spill and there are expenditures of funds, then we look at recovering that money from the responsible party.

One of the questions that came up concerned the criteria the Coast Guard uses in taking over a spill when private enterprise will not handle the spill themselves. The answer given was that it's a judgmental call that is handled on a case-by-case basis.

There was a question about the pre-clearance for the use of dispersants for an oil spill. It was mentioned that this planning is being handled at the regional contingency planning level.

The second speaker was Paul W. Schmidt from Conoco, Inc., who spoke on Clean Gulf Associates (CGA). He indicated CGA was founded in 1972 and includes 87 members made up of oil and gas companies in the Gulf of Mexico. He indicated that their purpose is basically to provide state-of-the-art cleanup equipment which they build and maintain. This equipment is available to the 87 members if and when they need it. Their stockpile of equipment has a value right now of about $9.2 million. It's stockpiled around the Gulf of Mexico at key locations: three areas in the State of Texas, five in Louisiana, two locations in Alabama, and one in Florida. And, again, he made the point that CGA is not a cleanup company -- they have no employees -- they are basically an organization that provides equipment. They have a contract with Halliburton, which maintains this equipment. The way that CGA stays current is they're organized with a series of sub-committees made up of representatives from their member companies and these are the people that review the equipment needs and make sure that they are with the state-of-the-art.

Mr. Schmidt showed us a film entitled "On Guard in the Gulf," which provided further details about CGA and the kinds of equipment they have available. They have developed a lot of speciality items for use in the Gulf. The one that they seem to be particularly proud of was a skimmer called the "Hoss-2," a high-volume collection system which is only available here in the Gulf. He also made the point that most of their equipment has been used as standby and in 40% of the cases they have not had to use it.

There were some questions dealing with the equipment and also a question about stockpiling of dispersants, which CGA does stockpile.

The third speaker was Mr. Ted Pockman from the Marine Industry Group (MIRG), who spoke on industry planning efforts in the Gulf. They are made up of nine marine transportation members; and, again are not a spill response group but an information and planning type of organization. Their efforts are basically to enhance oil spill response capability. Their activities are summarized in four areas. The first effort has been to prepare a Resources and Logistics Directory that is an assembly and listing of the manpower and equipment that's available from contractors, cooperatives, industry, and government here in the Gulf. The second effort is an environmental directory which identifies various coastal sensitive areas in case of a spill. The information is specific enough that it can provide meaningful guidance to response personnel, particularly for use by industry. The third effort is to engage an independent contractor who's available to provide guidance in spill control matters and whose responsibility it is to keep the various directories and information sources up to date. The fourth effort is to conduct a resource capability analysis and look at the requirements for additional resources that may be needed for their particular purposes. For example this has led them to lease an aerial dispersant spraying system, which is now available here in the Gulf.

The fourth speaker was Lieutenant Commander Richard Softye, from the U. S. Coast Guard Gulf Coast Strike Team. The Gulf Coast Strike Team is headquartered in Mobile, AL. He gave us a brief rundown of their capabilities and their three major missions. The first one is response. As I mentioned earlier, their capability is available to the pre-designated on-scene coordinator at a spill. They maintain a trained staff and special equipment. The second is to provide training to other federal agencies. They also are now moving into their third and new effort called "Planning Liaison," which is a new federal initiative dealing more closely with the state and local entities in contingency planning and training.

Commander Softye described some of the special equipment that the Gulf Coast Strike Team has available. A lot of it is very specialized. He also indicated that in addition to oil spill activities they are moving into hazardous chemical response activities, also. He also described a couple of the incidents that they have been involved with including the *Alvenus* Oil Spill, the *Puerto Rican*, and also their efforts on Padre Island in relation to removal of drums of hazardous material that have been coming ashore.

The last speaker was Captain Tim McKinna, from the U. S. Coast Guard, Port Arthur, TX. Captain McKenna was the first federal on-scene coordinator for the M/V *Alvenus* Oil Spill response actions. As the on-scene coordinator, he summarized where the pre-planning was successful but also where the problems and unexpected events occurred.

The M/V *Alvenus* Oil Spill was a 65,000 barrel spill. Captain McKinna briefly covered the first notification and response actions that were taken and indicated that everything started off very well. Everyone understood what was happening, and the contingency planning efforts went into action. Then shortly the problems that don't show up in the "textbook" situation started to occur.

The first problem was that the Coast Guard in Lake Charles recognized that containment of the oil would be the first effort. They called on the Gulf Coast Strike Team, which responded with large offshore booms. They also had contracted for a heated ocean-going tank barge to be present to start taking the oil that was spilling into the Gulf and contained by the booms. When the barge arrived, they were told by the barge operator that no contaminated oil would be allowed in the barge and it was not available for use, and it left the scene. A second barge was located and arrived on scene the next day. However, a line got fouled in the tug's propeller, which delayed again the attempt to pick up the oil that was contained at the scene of the spill.

Another area he mentioned was his problems with the press. As the response problems occurred, the reporting by the press was not balanced. He stressed this problem several times.

Another area of criticism that came up was the lack of dispersant use. It was mentioned that the shipowner had assumed responsibility for this spill and had experienced people there who determined right away that the oil was too viscous and that dispersants would probably not work. Also, the early trajectory prediction of the spill indicated that the spill would circle the coast and stay offshore. As a result of some of this early information the determination was made not to use dispersants.

The spill became so large that from a planning effort the Coast Guard designated two on-scene coordinators: one to address the salvage of the ship and the other one to begin to look at the cleanup because they knew that the oil was going to come ashore and, as most of you know, it came ashore mostly in the middle and western portions of Galveston Island.

Captain McKinna covered, in a little more detail, the time it took to complete the lightering of the craft and the cleanup actions along the beach that took several weeks to complete.

One of the questions asked concerned the cause of the crack in the ship. The answer is that they don't really know, neither the Coast Guard nor the National Transportation Safety Board. There was also a question on the use of booms and the problems of trying to use booms in inlet areas with heavy tides.

In summary I think the whole session did a good job of re-addressing the need for contingency planning. I think that it stressed the need to continue looking at ways of improving the response mechanism, improving the communication, and attempting to eliminate some of the overlaps that appear to take place between all of the different jurisdictional interests in the Gulf. I think that the other part of contingency planning is to be able to examine and utilize new techniques that come along, particularly the use of dispersants. You'll hear more about that in these other sessions.

Raymond P. Churan serves as the Department of the Interior's (DOI), Regional Environmental Officer for the Southwest Region which includes the states of New Mexico, Texas, Oklahoma, Arkansas, and Louisiana. Major areas of responsibility include (1) working with federal and state agencies on environmental problems and issues including preparation of environmental documentation, and (2) representing the DOI on the Interagency Regional Response Team, which is responsible for promoting contingency planning and coordinating agency resources related to the emergency response and cleanup of oil and hazardous substance spills. Mr. Churan has been employed by the DOI for over 20 years in a variety of assignments.

Federal Response to Oil Spills

Commander Brian Kelly
United States Coast Guard

Public and scientific interest in ecology focused our attention on oil spills in the 1960's. In the 1970's abandoned hazardous chemical dumpsites and transportation-related accidents involving toxic chemicals grabbed the headlines. Responding to intense public concern, Congress passed three landmark environmental laws.

1. The Federal Water Pollution Control Act created a thirty-five million dollar Coast Guard dministered fund to pay for federal cleanup efforts in 1972. This law was later amended and is now known as the Clean Water Act.

2. The Comprehensive Environmental Response Compensation and Liability Act (CERCLA) established a "Superfund" to pay for hazardous substance cleanup in 1980.

3. The Intervention on the High Seas Actt gives the Coast Guard the authority to take physical control of any non-military vessel which threatens the environment of the United States. It became law in 1974.

Significantly, both the Federal Water Pollution Control Act and CERCLA mandated a National Oil and Hazardous Substance Contigency Plan. Known as the NCP, this plan forms the foundation of the federal response mechanism. The NCP called for regional and local contingency plans and established national and regional response teams. The plans and teams both assist the On-Scene Coordinator (OSC) during a response. On-Scene Coordinators are pre-designated Coast Guard officers or Environmental Protection Agency officials. They take charge of all federally-funded cleanup operations.

The National Response Team (NRT) coordinates spill response at a national level and prepares contingency plans. Monthly NRT meetings in Washington, DC, are chaired by EPA. The Coast Guard representative serves as vice-chairman. Twelve federal agencies work with the NRT. They all have environment jurisdictions and their membership ensures that a broad spectrum of environmental, public safety, natural resource, and welfare issues are considered. The NRT is activated to advise the OSC during cases of national significance. For example, they came on line to assist with a massive spill that threatened the Gulf coast following an oil well blowout in the Gulf of Campeche in 1979.

From the early 1970's, when the Coast Guard was first tasked to provide OSC's, the basic structure of the service helped us meet the challenge.

1. The Commandant, a four-star admiral, is in charge of the Coast Guard. A senior officer from the Environmental Response Division at Coast Guard Headquarters represents the Commandant and the Secretary of Transportation and serves as vice-chairman of the NRT.

2. A flag officer commands each of the 12 Coast Guard Districts and manages resources that include aircraft, ship, and personnel. Coast Guard OSC's can tap these resources when needed.

3. In each Coast Guard District a Marine Safety Division and a Marine Environmental Response Branch manage our response program.

In the civilian sector, 10 Federal regions correspond to the 12 Coast Guard Districts. The Environmental Protection Agency has a Regional Administrator in each region -- each roughly equivalent to a Coast Guard District Commander. The response structure within each region is parallel to that in a Coast Guard District and includes a regional Office of Emergency and Remedial Response and an Emergency Response Branch.

Each federal region is divided into an inland and coastal zone. The boundaries of the zone are predetermined and published in an agreement between the Coast Guard and the EPA. This ensures that both the Coast Guard and EPA understand their areas of responsibility.

The OSC is the focal point of both structures during a response. When oil spills or hazardous substance releases occur in the coastal area, the predesignated OSC is a Coast Guard Captain of the Port (COTP). This arrangement benefits the Coast Guard because the COTP is the principal maritime law enforcement agent in their zone with authority from the Port and Tanker Safety Act of 1978. When spills occur inland or when long-term remedial cleanup operations are needed at hazardous waste sites, the EPA provides the predesignated OSC.

The National Contingency Plan created a response structure linked from the national to the local level. Advice and assistance flows through this network to provide an OSC with needed resources. An incident-specific Regional Response Team is activated upon the request of an OSC. It includes officials from those federal and state agencies needed to address specific issues during a response. They advise the OSC and ensure that state, regional, and federal resources are available when needed.

Between spills, a standing Regional Response Team meets semi-annually to review past response activities and update the Regional Contingency Plan. The standing team is made up of an official from each federal agency with environment or health responsibilities.

Local contingency plans identify environmentally sensitive areas, list available response equipment, and detail response procedures for each zone. The federal response mechanism encourages state and local agencies to get actively involved in response efforts. This is reasonable since local police and fire departments are most often the first to respond to an oil or hazardous chemical incident because of their mandate to ensure public safety.

The National Contingency Plan also created a cadre of "special forces" that a Coast Guard or EPA OSC may call upon for specific talents and expertise:

1. The National Strike Force is made up of three Coast Guard Strike Teams located on the Atlantic, Gulf, and Pacific coasts and a Dive Team. All team members are highly trained and experienced in pollution response.

2. Scientific Support Coordinators are predesignated National Oceanic and Atmospheric Administration officers assigned to each federal region. They gather the technical data needed by an OSC and serve as liaison between the scientific community and the OSC.

3. The Emergency Response Team is a group of hazardous substance experts who work for the EPA in Edison, NJ. They are available to help an OSC when response needs exceed available regional resources.

4, The Public Information Assist Team (PIAT) is a cadre of Coast Guard Public Affairs Specialists that can help an OSC maintain a continuous flow of information to the media.
Both Coast Guard and EPA OSC's have requested PIAT assistance.

Each response has four phases:

The first phase is the Discovery and Notification Phase. During this phase, a report is received directly by an OSC, or by a watchstander at the Coast Guard National Response Center, a 24-hour toll-free oil and hazardous chemical hotline. The NRC watchstander immediately relays the information to the proper OSC.

The second phase is the Preliminary Assessment Phase. Once the OSC is notified, he must quickly evaluate the magnitude and severity of the discharge and determine the responsible party. If the spiller assumes responsibility and begins a cleanup, the OSC monitors the cleanup.

When the spiller is unknown or fails to take proper action, the OSC makes sure the federal government has jurisdiction and verifies his legal authority. That authority normally comes from the Clean Water Act or CERCLA. He then determines if the spill occurred within the coastal or inland zone. Once he determines the zone, he notifies the trustee of any natural resources threatened by the spill. He also maintains a list of phone numbers for local, state, and federal officials in the Local Contingency. Plan.

Containment, cleanup, countermeasures, and disposal come center stage during the third phase of a response. As soon as the OSC takes charge of a response, he acts to prevent or minimize damage to the public health and welfare or the environment.

If he needs advice or additional resources, he may request that the Regional Response Team (RRT) be activated. This request brings considerable state and federal response capability to bear on the problem. For example, the Department of Defense RRT member can make arrangements for the U.S. Corps of Engineers to supply heavy equipment to use during the cleanup. At other times, EPA, Coast Guard, and state representatives on the RRT assume their lead roles when the group needs to approve the use of chemical dispersants.

The RRT acts as a communications link between the OSC and the NRT. The NRT and RRT recommend cleanup methods and resolve jurisdictional disputes when asked. They can also recruit equipment and technical support from other regions for the OSC.

Although containment, cleanup, and disposal efforts are controlled by the OSC, commercial cleanup contractors are hired to do the job whenever possible. Local contingency plans almost always include a list of commercial contractors and their equipment.

When an OSC needs additional help or specialized equipment, he can request help from the National Strike Force. Atlantic, Gulf, and Pacific Strike Team members are experts in abating pollution. They also often prevent potential spills by off-loading oil from grounded vessels using specialized pumping equipment. When a spill does occur, they deploy oil recovery equipment such as the offshore skimming barrier, advise the OSC, and monitor the efforts of response forces.

National Strike Force capabilities now also include hazardous substance response. This became necessary in 1980 when the Comprehensive Environmental Response Compensation and Liability Act increased the Coast Guard's role in hazardous chemical response in the coastal zone.

All three Coast Guard Strike Teams receive industry and EPA hazardous chemical response training and maintain entry capability at the highest level. Strike Teams members also have experience preparing site safety plans, documenting response efforts, decontaminating personnel, and using chemical monitoring equipment. When not on a response, they teach these skills to other members of the response community.

OSC's from both agencies also need solid technical advice when they need to make a decision. They get it from Scientific Support Coordinators, who provide all types of technical data about pollutants and the environment. Scientific Support Coordinators, who work for the National Oceanic and Atmospheric Administration, help determine resources at risk, provide hazard data, calculate spill trajectories, and help develop contingency plans.

The Litigation Phase is the fourth and final response phase. When federal funds are used, an attempt must be made to recover all government-incurred costs from the spiller. The recovered money goes directly back to the fund used to finance the response. The success of the U.S. Attorney in court depends upon the complete documentation compiled by Coast Guard or EPA monitors during the cleanup.

SUMMARY

The OSC forms the cornerstone of the entire effort. His authority is based on three recent laws: the Federal Water Pollution Control Act, The Comprehensive Environmental Response Compensation and Liability Act, and the Intervention on the High Seas Act.

These laws provided statutory authority and called for the creation of national, regional, and local contingency plans. A regulatory structure was formed to maintain these contingency plans to ensure they always include any changes in response methods or policy.

The Coast Guard and EPA response structures are parallel organizations that provide strong support to OSC's. They use the local contingency plan, which is a document that contains a listing of response equipment available through contractors and the telephone numbers of various federal, state, and local agencies. It also contains a listing of important operational contacts, environmentally sensitive areas, and response procedures unique to the local area.

Finally, when the OSC needs help during a federally-funded cleanup, four "special forces" are ready to assist.

The federal response mechanism provides a group of professionals working with a set of comprehensive plans at the national, regional, and local levels to protect the public and environment from oil and hazardous substance spills.

Commander Brian Kelly is the Chief of the Marine Environmental Protection Branch at the Eighth Coast Guard District in New Orleans, LA. He is the Executive Secretary for the Federal Region VI Regional Response Team, which plays a significant role in the Federal Response to Oil and Hazardous Chemical Spills in the Gulf of Mexico.

Clean Gulf Associates

Mr. Paul Schmidt, Chairman
Clean Gulf Associates

Clean Gulf Associates is a cooperative of 87 oil and gas producing companies that operate in the Gulf of Mexico between the Rio Grande River and the Florida Keys and was formed in 1972. Its purpose is to procure and maintain a state-of-the-art stockpile of oil spill recovery and cleanup equipment for the use of member companies. Non-member companies can also use the equipment if they make the necessary arrangements. Total expenditures for equipment to date are $9,175,875.13. Clean Gulf Associates locates the equipment in areas where it will be available to the members when needed. There are three equipment stockpiles in Texas, five in Louisiana, one in Alabama, and one in Florida.

Clean Gulf Associates is not an oil spill cleanup company. Oil spills are the responsibility of the operator. He must supply the personnel and the supervision to cleanup the spills. He can use whatever Clean Gulf equipment he needs to clean up his spill, but the spill is most definitely his responsibility. Clean Gulf is not an oil spill cleanup training company. A member company can make use of Clean Gulf facilities and equipment to conduct training for personnel. Halliburton marine supervisors will be present to show the operator personnel how to operate the equipment. The training, however, is very clearly the responsibility of the member company and not Clean Gulf or Halliburton.

Clean Gulf Associates is led by a Board of Directors. Every member company has a representative on the board. The board meets once a year, and voting is weighted by a participation factor. Several committees function. The Executive Committee, appointed by the Board of Directors, conducts overall executive functions. The Operations Subcommittee is concerned with operations matters and the Clean Gulf manual. The Technical Subcommittee investigates new equipment and new technology and recommends new investments. The Legal Subcommittee is concerned with legal matters, and the Accounting Subcommittee with accounting matters. Halliburton procures and maintains new equipment and supplies as directed by the Executive Committee. The Project Coordinator is in Duncan, OK, and the operations personnel include a marine superintendent in Harvey, LA, and seven marine supervisors in various locations.

Mr. P. W. Schmidt is Chairman of Clean Gulf Associates, a member of the Steering Committee and former Chairman of Clean Atlantic Associates (CAA), and a member of the Executive Subcommittee - Offshore Operators' Committee (OOC). He has been employed with Conoco, Inc., for 30 years, where he has worked in various engineering and supervisory positions in Texas, the Middle East, North Sea, Alaska, U.S. Atlantic Coast, and the Gulf of Mexico. Mr. Schmidt has been Manager of Conoco's New Orleans Division since 1979.

MIRG Oil Spill Response

Mr. T. N. Pockman
Mobil Oil Corporation

In 1981 firms involved in the marine transportation of petroleum in the Gulf of Mexico established the Marine Industry Group, which is known by the acronym MIRG. MIRG is not an oil spill response organization nor an oil spill cooperative. Rather it is a group whose primary purpose is enhancing oil spill cleanup capability in the Gulf of Mexico.

The area of interest of MIRG is the entire Gulf of Mexico, including both Mexican and U.S. coastal waters and port accesses from and including the Yucatan Peninsula to the Straits of Florida and up the east coast of Florida.

MIRG now consists of nine participants: Amoco Transport Co., Conoco Shipping Co., Exxon Shipping Co., Cheveron Corp., Mobil Oil Corp., Petro-Canada Products Inc., Phillips Petroleum Co., Shell Oil Co., and SPC Shipping, Inc. (Sohio).

Qualifications for participation in MIRG are very broad. Those eligible include any person, partnership, or corporation, whether private or governmental, operating or owning an interest in petroleum exploration, production, refining, processing, marine/pipeline transportation, or storage.

To satisfy the objectives of MIRG, four major projects or tasks have been undertaken:

RESOURCES AND LOGISTICS DIRECTORY

The first of these was to assemble a resources and logistics directory, a listing of manpower and cleanup equipment resources available from contractors, cooperatives, industry, and government compiled in a workable and usable format, including a time and distance table for movement of these resources to a spill site. For marine transporters reponse plans must cover the entire operating area, not just site-specific locations, because a spill is possible with varying degrees of risk anywhere in the area. The basic concept of the resources and logistics project was to collect information from already prepared contingency plans and other publications and arrange it in a convenient directory for participant use both before and during an oil spill.

As much information as possible was provided by MIRG participants. This included copies of the appropriate sections of the contingency plans of Clean Gulf Associates, Clean Channel Cooperative, the Seventh and Eighth U.S. Coast Guard Districts, and some participants' in-house contingency plans. The contractor, Booz-Allen and Hamilton, obtained a complete printout of the USCG "SKIM" system for the area of interest and sent letters requesting data to cleanup contractors and other organizations in the Gulf of Mexico area. This effort resulted in a significant amount of data which then had to be arranged in a format that would make it workable.

The directory is a four-volume set of looseleaf notebooks divided by state and subdivided by region as follows:

- Volume I: Texas (Brownsville/Corpus Christi; Houston/Galveston; Beaumont/Port Arthur)
- Volume II: Louisiana, Mississippi, Alabama (Lake Charles; New Orleans; Mobile)
- Volume III: Florida (Pensacola; Tampa; Miami; Jacksonville)
- Volume IV: Out of Area

Each region was divided into four sections: Section I, Index; Section II, Equipment Listing; Section III, Distance Tables; and Section IV, Supplier Listing. Section I contains a listing of 47 types of oil spill response resources and under each are listed the suppliers of that resource and their telephone numbers. For certain major oil spill response resources, the index listing refers to a page in Section II which provides detailed information on the amounts and types of equipment available from the listed supplier. Section III of each volume is a quick reference table showing distances between various locations in both road miles and travel time. Section IV provides two lists of all the suppliers identified in the volume, one in alphabetical order and the other by numbers assigned to each supplier and corresponding to Section II page numbers.

The directory has to be updated frequently and information refined to maintain its usefulness. Corrections, additions, deletions, and new information are obtained through review and use of the directory and through a specific program to update the information. The format of the directory allows simple revision by page replacement, and new replacement pages are issued frequently. A priority system of updating ensures that major categories and sources of equipment are maintained more frequently than the lesser priority items.

Complete sets of the resources and logistics directory are kept by the U.S. Coast Guard at the 7th District in Miami, the 8th District in New Orleans, and Headquarters in Washington, DC. As pages are updated, copies are provided to the Coast Guard for inclusion in these sets.

ENVIRONMENTAL SURVEY

The second major project undertaken by MIRG was to assemble concise environmental information for the Gulf of Mexico area, also in a form that can easily be used during an oil spill. The information includes both biologically and socioeconomically sensitive areas, and is specific enough to provide meaningful guidance to spill response personnel.

This environmental survey, for which Research Planning Institute was the contractor, covers both U.S. and Mexican nearshore waters and coastal area, from the Yucatan Peninsula to Florida. It is divided into two volumes. Volume I contains an environmental overview section, cleanup considerations for Gulf of Mexico habitats, and a literature section. Volume II contains sections on Mexico-Yucatan, Mexico-East Coast, Texas, Louisiana, Mississippi/Alabama, and Florida.

Volume I describes the various habitat types found in the Gulf of Mexico and along the east coast of Florida. It describes physical processes likely to influence the movement and fate of spilled oil. Potential impacts of spilled oil as well as various cleanup methods in Gulf of Mexico habitats are also reviewed. Cleanup suggestions are included for each habitat type.

Volume II, which divides the Gulf into six regions arranged by states or groups of states, includes 45 maps which are page sized reductions of 1:250,000 scale that provide overviews of specific regions. Each of these regions is then broken down into several area maps which are page-size reductions of 1:24,000 scale USGS topographic maps. Biological symbols show the seasonality, distribution, nesting, and nursery areas for mammals, birds, reptiles, and invertebrates. Symbols for vegetation (mangrove, marsh, and sea grass) also include approximate area to give an indication of size and importance of each vegetation type.

A detailed description of each area map is given on the page facing it. Information includes habitat types, wildlife uses, seasonality, sensitivity ranking, likelihood of impact, and suggested countermeasures.

Complete sets of the environmental survey have also been placed with the Coast Guard at the same locations where the resources and logistics directories are kept.

OIL SPILL CONSULTANT

The third task undertaken by MIRG to enhance spill response capability was to engage the services of an independent contractor as an oil spill consultant. A contract was entered into between MIRG and O'Brien Oil Pollution Service of Gretna, LA. Services to MIRG under this contract are performed by Jim O'Brien, retired Coast Guard officer and former commanding officer of the Pacific Strike Team. The services performed by the contractor include providing guidance on oil spill response, coordinating the updating of the resources and logistics directory, and staying abreast of Gulf of Mexico response capability. However, the contract expressly provides that anyone, MIRG participant or not, is free to enter into negotiations with the contractor outside of the MIRG contract to act for them on oil spill response matters -- whether it be an actual incident, for training, or for other purposes.

RESOURCE CAPABILITY ANALYSIS

The fourth and final aspect of MIRG's activities has been to survey current resources and assess the means by which oil spill response capabilities and systems might be instituted, modified, or reorganized.

The first result of this analysis is that MIRG has joined with CCC, Clean Caribbean Cooperative, in the lease of an aerial dispersant spraying system manufactured by Biegert Aviation.

The Biegert ADDS Pack, as it is known, represents a substantial forward leap in our ability to apply rapidly and effectively chemical dispersants to offshore oil spills when all necessary permissions have been given. In the past, we had to rely on specially equipped, dedicated spray aircraft. In general they were older propeller planes without modern avionics and navigation equipment that had external hardware which limited their weather handling and airspeed capability.

The ADDS Pack solves that problem by making the spray unit totally self contained and able to be loaded in as little as 30 minutes into any C-130 type jet aircraft, one of the most commonly available cargo airplanes. The plane can then be flown at normal speeds and through marginal weather to the spill site before the spray arms are deployed from the rear door of the aircraft and the pumps activated to spray up to 5500 gallons of dispersant. This system provides speed, range, weather capabilities, and aircraft selection not available to us with dedicated spray aircraft.

Non-participants in MIRG operating in the area of interest may use the system by applying for authorization for dispatch from the MIRG and CCC Chairmen. Such approval is not automatic because participant use has priority. In addition non-participants should know that the lease of the equipment requires payment of a substantial non-participant use fee over and above actual incident deployment costs.

CONCLUSION

As a result of the four major projects which MIRG has undertaken, oil spill response personnel have access to significant new assets that can enhance the quality and speed of their response to oil spills in the Gulf of Mexico.

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T. N. Pockman is Manager, Regulatory and Administrative Compliance for Mobil Oil Corporation. As part of his responsibilities, he coordinates the oil spill contingency planning efforts of Mobil's U.S. Marketing and Refining Division. Currently he is serving as Vice Chairman of the Marine Industry Group. Mr. Pockman received the BS degree in Chemical Engineering from Princeton University.

The Gulf Strike Team

Lieutenant Commander Rich Softye
Commanding Officer
USCG Gulf Strike Team

The U. S. Coast Guard Gulf Strike Team (GST), a component of the National Strike Force (NSF), is a team created by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) to assist in the combatting of oil discharges and chemical releases.

The National Strike Force (NSF) was established as a result of the Federal Water Pollution Control Act (FWPCA) of 1970 as amended by the Clean Water Act (CWA) of 1972. The FWPCA required the Council of Environmental Quality to create a NCP and a further provision required special forces. The NSF is one of those special forces and consists of three teams: the Pacific, Gulf, and Atlantic Strike Teams (PST-San Francisco, CA; GST-Mobile, AL; AST-Elizabeth City, NC). The GST has recently relocated from the National

Space Technology Laboratories site in Bay St. Louis, MS, to the Coast Guard Aviation Training Center in Mobile. The move has improved the response posture of the team in that Coast Guard and commercial aircraft are readily available for rapid deployment of GST equipment and/or personnel. The GST Team consists of five commissioned officers and 25 enlisted members; the former include the Commanding Officer - Lieutenant Commander; Executive Officer - Lieutenant; Chemical Department - Lieutenant(Junior Grade); Engineering Department - Chief Warrant Officer; and Deck Department - Chief Warrant Officer. The enlisted members consist of the following ratings: Marine Science Technician(MST); Damage Controlman(DC); Boatswains Mate(BM); Machinery Technician(MK); Electricians Mate(EM); Storekeeper(SK) and Yeoman(YN). All personnel are cross trained to handle the varied missions of the NSF.

The NSF responds to requests by predesignated On-Scene Coordinators (OSC's) provided for under the Federal Response Mechanism of the NCP. The NSF works for both Coast Guard and Environmental Protection Agency (EPA) OSC's. The GST area of responsibility is defined by Federal Regions IV, VI, and VII including Puerto Rico, South Carolina, Georgia, Florida, Alabama, Tennessee, Kentucky, Iowa, Missouri, Arkansas, Mississippi, Louisiana, Texas, Oklahoma, Kansas, Nebraska, and New Mexico.

The NSF is called to assist foreign nations through the United States State Department when specialized training or equipment is required. The GST has recently traveled to the Middle East, Great Britain, Kenya, Mexico, Venezuela, and Jamaica in various capacities regarding oil or hazardous chemical releases.

The missions of the NSF are response, training, and planning/liaison.

RESPONSE. The Strike Teams are mandated to (a) dispatch at least one person by the fastest means possible to the scene of a pollution incident whenever assistance is requested for a potential or actual pollution incident; (b) dispatch four persons to the scene of a pollution incident within two hours of notification; (c) dispatch up to 12 persons to the scene of a pollution incident within six hours of notification. Response may consist of sending personnel or equipment or both. In many situations the GST may be requested solely for the expertise of the individuals in supervision, documentation, methodology review, site safety, etc. Other emergency responses may need the activation of specialized equipment maintained in the GST inventory. (See Equipment Listing)

TRAINING. The GST is mandated to provide training to all of the Coast Guard Marine Safety Offices and Emergency Port Task Forces on a yearly basis. The training consists of classroom lectures and on-hands simulations tailored to the particular port area. On an as-available basis, the GST will provide training to diverse reponse groups on all aspects of oil and chemical emergency response operations.

Internal training of GST personnel is of utmost importance. GST personnel will attend Coast Guard, EPA, and industry courses as well as meet the qualifications of the GST Qualification/Training Board prior to being assigned a designator as a Response Petty Officer, Response Supervisor, or Response Officer. (Training Courses attended are Coast Guard Marine Safety; Coast Guard Marine Environment and Systems; Coast Guard Hazardous Chemicals; EPA Hazardous Materials Handling; EPA Incident Mitigation and Treatment; EPA Air Surveillance; Industry Respiratory Equipment; Industry Oil Pollution Response). Many of the other courses regarding specialties such as Emergency Medical Technician, Outboard Motor Repair, Tractor-Trailer Driving, etc., are attended by fewer personnel but are also essential to the whole response mechanism.

The GST also hosts foreign delegations that seek training and briefings on the latest state of the art in pollution response. Recently, representatives of Great Britain, the Netherlands, Poland, Hungary, West Germany, Argentina, Boliva, Ecuador, Venezuela, Paraguay, and Mexico have visted the GST for training.

PLANNING/LIAISON. The GST assists the Regional Response Teams (RRT) in developing and maintaining contingency plans consistent with the NCP during annual training trips and scheduled RRT meetings. The GST is present to lend whatever assistance is requested in the way of logistics coordination and planning. As a result of new initiatives by the EPA concerning air toxics contingency planning (as a result of the Bhopal, India, tragedy), the GST will assist local communities and port areas with this planning as requested by the predesignated OSC's.

The GST provides a presence at many trade shows and training conferences to maintain contacts and foster a friendly, healthy and productive relationship among federal, state, local, industrial, and citizen organizations.

POLLUTION RESPONSE EQUIPMENT INVENTORY
(Partial list of equipment maintained by the GST)

1. MOBILE COMMAND POST. The Mobile Command Post can be a valuable asset to the OSC at any time, but particularly when the spill site is located in an isolated area.

a. A self-contained 6 KW generator, which can also be connected to a local power source.
b. Four telephones.
c. UHF, VHF, CB radios.
d. Weather Station

2. ADAPTS (Air Deliverable Anti-Pollution Transfer System)

a. ADAPTS Pallet

(1) Prime Mover - Air Cooled, 40 HP diesel engine that provides hydraulic power for operating the system. Weight = 1100 pounds.

(2) Three different types of submersible pumps: double stage-rated at 1645 GPM; single stage-rated at 1500 GPM and stripper pump rated at 1330 GPM. These pumps range in weight from approximately 850 lbs down to approximately 200 lbs.

(3) Tripod module for raising and lowering the submersible pumps into tanks or compartments.

3. OWOCRS (Open Water Oil Containment and Recovery System)

a. ADC (Air Deployable Container)
b. Skimming Barrier (621' Offshore Devices High Seas Barrier)
c. FSD (Fast Surface Delivery Sled)
d. Pump Float - 3 hydraulically-operated diaphragm pumps powered by the ADAPTS Prime Mover.

4. DRACONE BARGE (Floatable rubber bladder constructed of laminated nylon cord and synthetic rubbers such as neoprene)

The Strike Teams have three types:

a. Type D - Capacity 10,000 gallons, approximately 100 ft in length.
b. Type F - Capacity 40,000 gallons, approximately 150 ft in length.
c. Type O - Capacity 290,000 gallons, approximately 300 ft in length.

5. CHEMICAL RESPONSE VAN (Short Term Response) CHEMICAL RESPONSE TRAILER (Long Term Response)

6. FULLY ENCAPSULATED SUITS (Levels A, B, and C Protection)

a. ILC Dover - Chlorinated polyethylene
b. Eastwind - Neoprene or butyl rubber
c. Splash Gear - PVC and neoprene
d. Coveralls - Polyethylene and worn underneath fully-encapsulated suits for added protection against exposure.
e. Cool Packs - Vest filled with crushed ice (battery operated pump).

7. STAINLESS STEEL SUBMERSIBLE PUMP FOR PUMPING CHEMICALS (Capable of pumping approximately 650 GPM)

a. Stainless Steel Hose (hydraulic and discharge)

Lieutenant Commander Rich Softye, a 1973 graduate of New York Maritime College, entered the Coast Guard on a direct commission program. He has held various positions in Marine Safety, Merchant Vessel Inspection, and Marine Environmental Protection USCG programs. In 1983, he left an assignment as the Senior Instructor for Coast Guard Hazardous Chemical Response Operations and assumed the position as Executive Officer of the GST. In August 1985, he was appointed Commanding Officer of the Gulf Strike Team, Mobile, AL.

The *Alvenus* Oil Spill

Captain T. G. McKinna
U.S. Coast Guard

At 1245 local time on 30 July 1984 Lake City Stevedores, agents for the M/V *Alvenus*, informed the Coast Guard Marine Safety Detachment in Lake Charles, LA, that the British registered tankship *Alvenus*, enroute to Lake Charles was soft aground and leaking crude oil into the Gulf of Mexico. They reported substantial damage in way of No. 2 cargo tanks, and that these tanks contained approximately 40,000 bbls of Venezuelan crude oil. (It was later learned that actually 65,000 bbls of oil vice 40,000 bbls were spilled). The ship was about 11 miles south of the Calcasieu Pass entrance jetties.

The Coast Guard initiated immediate radio contact with *Alvenus*. Our first reponse was for search and rescue, as it was reported that 34 crewmembers were abandoning ship. The fears of fire and sinking calmed, the essential members of the crew stayed aboard the ship, and the remainder were evacuated on boats and taken ashore.

At the time of the incident we had three marine inspectors in a leased helicopter engaged in rig and platform inspections in the vicinity of *Alvenus*. They could see the oil slick from a long distance away and flew over the ship. By 1315 they reported a visible major structural failure across the main deck and down below the waterline on both sides in way of the No. 2 cargo tanks. The vessel was out of the channel and spilling oil, which had already formed a heavy, dark, 1.5-mile long, tear-shaped slick.

The Gulf Strike Team was alerted at 1400.

By 1500 Alvenus Shipping Corp. had assumed financial responsibility for cleanup and had contracted Maritime Loss Control to coordinate the response, lightering, and salvage efforts. Prior to this, Conoco Oil Co., Houston, the owners of the oil, offered assistance should the owners not assume responsibility.

Weather conditions were clear: 15 knots wind from NW and 3-4 foot swells.

A few problems occurred which don't show up in "textbook" situations.

The Gulf Strike Team (GST) has large offshore booms or barriers which they deployed. Lake Charles Coast Guard had early on arranged for a seagoing tankbarge with internal heating coils to be used for spilled oil collection. By 1700 on 31 July, the sea curtain was deployed, positioned, and ready to pump oil. The subject barge was on scene at 1800. At that time, the operator on the tug told the GST that no contaminated oil would be allowed in his barge. Maritime Loss Control had a difficult time finding another inspected offshore heated barge. They found one by 2200 in Port Arthur, ETA on scene 0600, 1 August. It actually arrived by 1100 on 1 August, but got a line fouled in the tug's propeller, delaying pumping even longer. All this time, oil was entraining past the barrier and along the coast. GST collected a mere 200 bbls of spilled oil after all that effort. The Coast Guard received undue criticism for this through the press, giving the appearance that our response was slow and inadequate; not mentioning the refusal of a commercial barge owner to carry contaminated crude oil, or a professional seamanship error.

Another area of criticism came in the lack of dispersant use. Three general criteria were used when the consequences of dispersant use were evaluated:

1. Would it remove a significant amount of the ' slick from the water surface?

2. Could it alter the extent or locations of shoreline impacts?

3. Would damage to habitats and resources be less than those occurring without dispersion?

1. The spilled oil was Venezuelan crude -- two types: Pilon and Merey. They mixed at the spill site and took on the thick viscous characteristics of Pilon (2200 cs viscosity). Dispersants are of very limited effectiveness on oil with viscosity over 2000 cs. A wide variety of experts was contacted to help evaluate dispersant use here, including representatives from the dispersant manufacturer and the cargo owners. We also had response personnel from Europe on scene who had considerable field experience with dispersants. The opinion of all concerned was that COREXIT 9527 (that which was available) was not capable of penetrating the slick and would have little effect on the oil. The magnitude of the spill must be kept in mind.

2. The slick movement and shape was such that, even after dispersant application, the portion which would have been unaffected would still have impacted Galveston Island. The only unknown remains the percentage effectiveness of dispersant.

3. Extensive discussions on environmental consequences of dispersant use were initiated among federal and state resource agencies soon after the initial spill. Reviewing all the environmental information available, there was no clearcut benefit to either using or not using dispersants.

The Scientific Support Coordinator (SSC) from NOAA was contacted immediately after notification of the spill; he gathered initial information to develop a computer trajectory model for the path of the slick. By 1600 on 30 July, the first trajectory prediction indicated that the oil would move west southwest for two days and then south away from the U.S. coast. This forecast obviously influenced the dispersant issue. The SSC continued to update the computer trajectory predictions using real time information. After approximately 48 hours, it became obvious that the Texas coast would be impacted. Again, the news media expected magic tricks and demanded to know why this prediction hadn't been made from the start.

Keeping the news media properly informed is recognized as an extremely important part of this type of disaster. In this area we established a schedule of news briefs which seemed to be adequate. The first 24-48 hours were the most difficult; then the Coast Guard public information specialists from New Orleans and Washington, DC, were deployed to assist.

The *Alvenus* incident became two separate problems after the initial response. One problem was lightering cargo and salvaging the damaged ship. The other problem was beach clean-up. Since the ultimate geographical area covered became huge, the On-Scene Coordinator's (OSC) responsibilities were split: Port Arthur OSC having salvage coverage and cleanup from Cameron, LA, to the North jetties at Galveston entrance; Galveston OSC having responsibilities of Galveston Island and southward.

The salvage operation was conducted slowly, deliberately, without incident. It was slow because of poor weather; thick, cold oil to pump; and to provide maximum safety to personnel and environment. The ship was completely lightered by 18 August and towed to Galveston, where it was drydocked.

Beach cleanup was a major undertaking. On 4 August the main portion of oil came ashore along Boliver Peninsula and Galveston Island. Naturally, of major concern was protection of the sensitive areas of Galveston Bay, East Bay north of Rollover Pass, and San Luis Pass. Deflection and containment booms were deployed in these areas as well as absorbent booms. Oil skimmers were placed on standby in the event the booms failed.

The greatest accumulations of oil occurred on the middle and western portions of Galveston Island, including about 80% of the Galveston Seawall, the rock groins and pilings, and about 90% of the West Beach. Thickness of oil in these areas ranged from 1 to 4 in.

We used road graders to move the beached oil above the high tide zone to prevent oil from washing back into the water and to allow subsequent oil to wash ashore for removal.

Many other methods were tried: vacuum pumps, nets, auger pumps, beach cleaning machines, and even a super sucker on a hydraulic boom. All provided minimal cleanup assistance.

A considerable quantity of oil became submerged in the surf zone and caused new impacts on a daily basis for quite some time. Three weeks after initial impact, approximately 400 bbls of oil beached in the San Luis Pass area, previously unimpacted.

Seawall cleanup presented numerous problems. Several tests on methods of cleaning the seawall were conducted by the cleanup contractor. Hydro-sandblasting was found to be the most efficient. Because dispersant use is of such high public interest, it was tested between two rows of "rip-rap" at the base of the seawall. The dispersants were unable to penetrate the thick oil. No environmental damage was observed as a result of using the dispersant.

Every effort was made to remove a minimum quantity of sand from the beaches. A total of approximately 90,000 cubic yards was removed, roughly equivalent to that removed during a minor storm. The net effect of the sand removal was to change slightly the slope of the beach. This change was undetectable after only a few spring tides. By comparison, Hurricane Alicia in 1983 removed 900,000 cubic yards of sand from this same beach, 10 times the amount removed during cleanup.

Sand and oil disposal sites were a problem, but were taken care of satisfactorily. By the end of August 1984, most of the beach cleanup was completed; seawall cleanup continued until March of this year.

The evaluation of new technologies is a difficult job to accomplish in the field during a response. Concentration on the problem at hand, employing proven methods is always preferred. Marine Safety Office (MSO) Port Arthur and MSO Galveston received countless calls advocating new ideas for easy cleanup of the spill. Local units have neither the resources nor the expertise to deal with the many technologies and issues that may be presented. Predesignated expert R & D task organizations, either at the regional or national level, might be the appropriate groups to conduct evaluations of new systems and methods of cleanup and containment during any major spill response.

Captain Timothy G. McKinna, U. S. Coast Guard, is the Commanding Officer of the Marine Safety Office in Port Arthur, TX, and as such was the On-Scene Coordinator for the *Alvenus* Oil Spill. He is a graduate of the U. S. Coast Guard Academy and has served nearly 24 years on active duty in the Coast Guard distributed between shipboard engineering and Merchant Marine safety assignments. He has served in the Arctic, the Antarctic, Southeast Asia, Alaska, The Great Lakes, and on all three coasts of the U. S.

WETLANDS LOSS

Session: WETLANDS LOSS

Chairman: Dr. Norman Froomer

Date: October 22, 1985

Presentation title	Author/Affiliation
Wetlands Loss Study: Session Summary	Dr. Norman Froomer Minerals Management Service
Coastal Landloss in Louisiana: An Overview	R. Eugene Turner Department of Marine Sciences Louisiana State University
Hydrologic Changes In Louisiana Wetlands	Mr. Erick M. Swenson Center for Wetland Resources Louisiana State University
Marsh Management and Other Wetland Enhancement Programs	Darryl R. Clark Coastal Management Division Louisiana Department of Natural Resources
SCS Soil and Water Conservation District Approach to Wetlands Protection	Bradley E. Spicer State Soil and Water Conservation Committee and U.S. Soil Conservation Service
Politics and Wetlands Management on the Local Front	Mr. Bruce H. Wright, Jr. Environmental Professionals, Ltd.

Wetlands Loss Study: Session Summary

Dr. Norman Froomer
Minerals Management Service

This year's Wetlands Loss Session was divided into two sections. In the first, members of the research team from Louisiana State University that will be working on the MMS-contracted study entitled "OCS Development and Potential Coastal Habitat Alterations" presented an overview of the factors and processes that contribute to wetlands loss in Louisiana, and discussed some of the research techniques and approaches they will use during the project. The goals of the study are to evaluate the relative importance of the causative factors that contribute to wetland loss and to assess the possible involvement of OCS-related activities. In the second part of the session, perspectives on federal, state, and local involvement in wetland management and enhancement programs were presented.

The first speaker was Dr. Eugene Turner, Professor of Marine Sciences at the Center for Wetland Resources at Louisiana State University, who presented an overview of the factors that contribute to wetlands loss in Louisiana, including submergence, sediment deprivation, and canal installations. The data he has collected show more rapid conversions of wetlands to open water in areas where canalization has been extensive and where areas of marshes are partitioned and partially impounded by canal levees. Oftentimes wetlands loss occurs close to the levees, especially in the corners where two or more canals intersect. Dr. Turner believes that a major factor in the wetland changes he has observed is hydrologic changes in the wetlands brought on by extensive canalization.

To discern the pattern of wetland changes in coastal Louisiana and to get some insight into possible cause and effect mechanism, the investigators will have to rely on remote sensing technology. The area is too vast and the impacts are too extensive to observe and analyze them all from the ground. Dr. Jack Hill, the next speaker, will be coordinating the remote sensing aspects of the project.

The facilities and equipment available to Dr. Hill allow him to observe great detail on the ground, and to store and manage great volumes of observations and data. Satellite images now provide ground resolution at about 30 m. LSU owns a plane that is outfitted with remote sensing hardware that can provide even greater detail for areas of special interest. In addition to the hardware to observe ground details, computers and software are available to store and analyze large volumes of data. Software can search through the remote sensing data and look for and compare rates of deterioration in different areas. If the date of canal installation is included in the data base, the lag time for indirect impacts can be determined. The computer can also discriminate patterns of marsh alterations that are associated with natural and human-induced changes.

The next speaker was Eric Swensen, who described some of the results of his studies on the impacts of canal construction and associated levees on marsh surface and subsurface hydrology. His investigations have documented significant differences in the surface and sub-surface hydrologic regimes between marshes that have been semi-impounded by canal levees and undisturbed marshes. Although impounded and undisturbed marshes flood the same, undisturbed marshes drain much more rapidly. Overland flow is also affected by impoundments. Surface water drains from undisturbed and back-filled sites into bayous and canals, but runoff is reduced by as much as half in areas where canal levees exist.

Governmental involvement in marsh management strategies was the theme of the second half of the session. At the federal level, Brad Spicer, with the U.S. Soil Conservation Service, described his agency's involvement with the Coastal Management Division of the Louisiana Department of Natural Resources to implement marsh management plans and projects. Local landowners who are involved in marsh management projects and are interested in conservation planning work with the local soil and water conservation offices. The district people work with the landowner to develop a plan that makes conservation sense and is also suitable to the landowner. The Soil Conservation Service serves as an advisor to the local districts in this process. The SCS has an extensive menu of marsh management techniques to choose from including water control structures, dams, marsh burning, and surface and groundwater conservation to retard saltwater intrusion.

Next, Daryl Clark, of the Coastal Managment Division of the Louisiana Department of Natural Resources, described the State of Louisiana's marsh management plans. The goals of the state's program is to control erosion and to increase the productivity of the coastal environment, not merely improving habitat conditions for one target species. To date fifty marsh managment plans have been developed covering a half million acres.

The last speaker was Bruce Wright, who until recently was an environmental specialist with St. Bernard Parish. He discussed the different orientations toward wetlands policy and management that exist at the national, state, and local levels. Although local involvement usually places greatest emphasis on short-term problem solving projects and displays less technical sophistication, the local programs are usually action oriented and local administrators have a record of actually implementing wetlands management and enhancement projects.

Dr. Norman Froomer is on the Environmental Studies Staff of the MMS Gulf of Mexico Regional Office. He earned a PhD in Geography and Environmental Engineering from Johns Hopkins University and was previously on the faculty at the University of New Orleans.

Coastal Landloss in Louisiana: An Overview

R. Eugene Turner
Department of Marine Sciences
Louisiana State University

Louisiana's oil and gas production is declining and there is a growing interest in maintaining the renewable natural resources that will support and sustain this region when the non-renewable resources decline even further. Louisiana's wetland ecosystems are intimately involved with the social, economic, and ecologic environment of south Louisiana and are a national resource. There is evidence that the current loss rates (0.8% annually in 1982) are having an effect. Impacts include increased saltwater intrusion, loss of the capacity to buffer either storms or high fertilizer loadings to estuaries, fisheries and flood insurance.

Several studies have shown that hydrologic modifications of wetlands contribute to this coastal wetland loss. The local and indirect effects of hydrologic manipulations are modified by the type of deltaic substrate, distance to the coast, and availability of new sediments. The local impacts are similar to those observed for mosquito ditching operations on the Atlantic seaboard during the first half of this century, even though mosquito ditches are relatively much smaller than most hydrologic change in south Louisiana wetlands. These modifications are almost always man-made changes and are therefore manageable and implicitly the responsibility of state and federal agencies since permits are required and a public resource is involved.

The resulting high loss rates are basically the cumulative effect of many small, but numerous, coastal ecosystem changes. Many of these can be traced back to federal, state, and private actions which, by themselves, appear as insignificant, but cumulatively lead to a so-called "death by a thousand cuts" for individual wetlands, oyster reefs, and water quality standards. Reversing or slowing down the high loss rates will involve maintaining natural surface and subsurface hydrology, reducing spoil bank subsurface compaction, backfilling old canals, greater use of existing canal corridors, and a protocol for making strong recommendations until experimental studies in a variety of environments are undertaken.

Dr. R. Eugene Turner is Professor of Marine Science in the Department of Coastal Ecology, Center for Wetland Resources, Louisiana State University. He has conducted extensive research on wetlands change in coastal Louisiana, and specifically on the impacts of canalization and other human alterations on wetlands processes.

Hydrologic Changes in Louisiana Wetlands

Mr. Erick M. Swenson
Center for Wetland Resources
Louisiana State University

This talk is intended to give a broad overview of what are considered to be the major hydrologic changes that have occurred or are occurring in Louisiana wetlands. In the context of this talk, a broad definition of the word *hydrology* has been used, in that I intend to include both actual changes in the water level or flow regimes, as well as other wetland parameters that affect or are affected by the hydrologic regime. These parameters are things such as salinity, eH and pH, sediments, and sedimentation.

The talk is divided into several sections. The first section defines the changes, the next section summarizes research on changes in the water level regime due to canal spoil banks, and the last section discusses ongoing research to investigate the marsh salinity regime, with particular emphasis on the role canals may have in modifying this regime. This investigation is part of a larger scale study, recently funded through the Minerals Management Service, to investigate possible onshore impacts of offshore oil and gas activities.

WHAT ARE THE HYDROLOGIC CHANGES?

In general, the hydrologic changes can be grouped into two broad categories: (1) actual changes in the hydrologic regime, and (2) secondary changes in physical or chemical parameters that are closely coupled to the hydrologic regime. For example, a spoil bank may block the overland water flow in an area, altering the nutrient and sediment supply to the marsh, possibly resulting in reduced vigor in marsh plants, accelerated subsidence rates, marsh breakup and loss, and decreased water quality. The causes of these changes are both natural and man-induced. The natural changes include sea level rise, land subsidence, catastrophic events (hurricanes), wind-induced wave erosion, and tidal scour. The man-induced changes include water (and sediment) diversion in the form of levees, dams, and channelization; canal construction, either navigational or oil access; marsh buggies and other wetland transportation vehicles; and impounding, either incidental or for a management area.

Recently, canals have been cited as being one of the major contributing factors to land loss within the coastal zone. It has been stated that canals are responsible for about 39% of the land loss in the state. Other researchers have placed this figure as high as 69% or even 89%. These figures include both the direct (the canal and its spoil banks) as well as the indirect impacts. It is estimated that the direct impacts are about 8% of the total impact. The remaining impacts, which are referred to as indirect impacts, are assumed to be the result of alterations in the hydrologic regime.

CANAL SPOIL BANK EFFECTS ON THE MARSH WATER LEVEL REGIME

As stated above, changes in the marsh hydrologic regime have been implicated as a major contributing factor to marsh degradation and loss. However, few studies exist which document the effects canals may have on the marsh water level regime. In order to document any hydrologic changes associated with canals, a study was conducted in the brackish marshes near Golden Meadow, LA. A summary of the results is presented here.

In general, the study involved the placement of several recording water level gages on the marsh. Two study sites were used: (1) a control site which had an unaltered edge along the bayou, and (2) a partially-impounded site whose bayou edge was altered by the placement of spoil banks. In addition to the water level gages, overland flow was measured at each station by photographing dye release with a captive balloon system.

The results indicated that in general the water level patterns on the marsh, at both sites, are characterized by a distinct diurnal tidal signal which is superimposed upon larger scale, wind-induced events. The data also indicated that a great deal of fluctuation (40%) occurs below ground. The major impact of the spoil banks was a decrease in the volume exchange between the marsh and the bayou. The above-ground exchange was decreased by about 60%, and the below-ground exchange was decreased by about 55%. The partially-impounded marsh had higher water levels, but with reduced water exchange, implying that water stays on the marsh or becomes stagnant. Indeed, a calculation of the average flooding event lengths indicated that the control site is flooded 23 times a month with each event lasting about 30 hours. In contrast, the partially-impounded site is flooded 4 times a month with each event lasting 150 hours.

INVESTIGATION OF SALINITY CHANGES

The Minerals Management Service recently funded a research project through the Center for Wetland Resources at Louisiana State University to investigate outer continental shelf oil and gas development as it relates to potential coastal habitat alteration. A large, and highly visible, portion of oil and gas activity are canals and their associated spoil banks. As shown above, these canals have significant impacts on the marsh hydrologic regime. It has also been assumed that canals are responsible for many other indirect impacts. One of these indirect impacts is an increase in salt water intrusion. Thus one of the tasks of the research project will be an investigation of the salinity regime of the coastal marshes.

The general questions to be asked by this task are (1) whether there is a statistically significant long-term change in the salinity regimes of the Louisiana estuaries, and (2) if such a change exists, whether it can be explained in terms of climatic variables or anthropologic (particularly canals) activity. The basic approach will be to compile and analyze a long-term (about 30-year) salinity and meteorological data base in order to describe both the short and long term salinity regimes as they relate to climatic and geological changes, and man's activities, particularly oil and gas activities. Data will come from several sources, including Louisiana Department of Wildlife and Fisheries, Army Corps of Engineers, National Oceanographic and Atmospheric Administration, United States Geological Survey, as well as miscellaneous state and local sources.

Mr. Erick M. Swenson is a research associate at the Center for Wetland Resources, Louisiana State University. For the past several years he has been investigating the impacts of canal systems on marsh hydrology.

Marsh Management and Other Wetland Enhancement Programs

Darryl R. Clark
Coastal Management Division
Louisiana Department of Natural Resources

MARSH MANAGEMENT

It is the policy of the Louisiana Coastal Resources Program (LCRP) among others (1) to protect, develop, and where feasible restore or enhance the resources of the state's coastal zone, and (2) to enhance renewable resource management and productivity.

Louisiana's coastal zone is presently experiencing a tremendous rate of land loss (50 mi^2 or 30,000 acres/year). This erosion may be caused by a combination of man made and natural factors such as subsidence, saltwater intrusion, reduced sediment input from rivers, wave action, animal causes (i.e., muskrat eatouts), storms, and man made developments.

The Coastal Management Divison (CMD) and other agencies are encouraging the development of marsh management plans to aid landowners in retarding these staggering erosion rates. The LCRP marsh management goals include the encouragement of management plans which (1) increase overall marsh production, (2) counteract erosion, (3) do not impound tidal marshes, (4) allow aquatic organism movements through water control structures, and (5) encourage the preparation of marsh management plans.

The CMD in the Coastal Use Permitting process requires that marsh management plans contain sections on the following areas: management goals; area history of problems or impacts; vegetational description; water control and other structure design, operation, and location; a policy statement on the control of non-marsh management activities in the area; and a monitoring plan. At present over 10% of the 5.2 M acres in the coastal zone in Louisiana are under some type of marsh or water management. This figure does not include the thousands of acres of federal and state refuges presently under active managment.

Current problems being experienced in coastal Louisiana with some marsh management practices include those that involve one species management (monoculture), total impoundments in tidal areas, retardation of estuarine organism movement, barricades, levees blocking "sheet flow," and improper use of non structural methods of management (i.e., marsh burning or vegetational control) which may increase area erosion if not done properly. There is a current need for research in monitoring management areas and in developing and monitoring new types of water control structures.

The CMD of the Department of Natural Resources, the Louisiana Department of Wildlife and Fisheries, U. S. Soil Conservation Service, U. S. Fish and Wildlife Service, National Marine Fisheries Service, U. S. Army Corps of Engineers, L.S.U., and other state and federal agencies are currently working together and with coastal landowners in marsh management planning and research so that the goals of increased productivity and decreased land loss may be achieved in coastal Louisiana.

COASTAL EROSION PROTECTION TRUST FUND

In 1981, the Louisiana legislature passed the Coastal Erosion Protection Trust Fund (CEPTF, Act 41 of 1981), which initially set aside $35 M for shoreline erosion protection projects. The purpose of this program is for the state to sponsor various projects coastwide which will act as coastal protection demonstration pilot projects. More ambitious projects are to follow the initial demonstrations. Scientific monitoring of all projects is included to measure objectively their individual success or failure.

The projects that were approved in 1982 and their appropriations included the following: (1) Holly Beach-Peveto Beach sand beach nourishment in Cameron Parish ($1.02 M), (2) Isles Dernieres Barrier Island stabilization project in Terrebonne Parish ($4.6 M), (3) Pass Au Loutre Marsh building project in Plaquemines Parish (0.83 M), (4) projection of future coastal conditions ($0.5 M), (5) Caernarvon freshwater diversion project ($0.2 M), and (6) the Teche-Vermilion freshwater diversion project ($0.5 M). This represented a total of $7.7 M for the 1982 approved projects.

Act 669 of 1984 authorized six more coastal protection projects for a total of $5.1 M. These projects included (7) Isles Dernieres beach renourishment project ($0.6 M), (8) St. Bernard Parish Marsh management project ($0.22 M), (9) Lake Pontchartrain dam closure project in St. Charles Parish ($0.4 M), (10) Cameron Parish Hwy 82 revetment and T-groin project ($2.8 M), (11) Terrebonne Parish Montegut Marsh restoration project ($0.6 M), and (12) the Louisiana marine boundaries and tidal datum project ($0.4 M). The twelve projects above total $12.8 M. The Five Year Plan ending in 1989 has a current budget of $132 M. This program is administered by the Coastal Protection Section of the Louisiana Geological Survey.

GEOGRAPHICAL INFORMATION-IMAGE PROCESSING SYSTEM

Another way Louisiana is attempting to measure and curb shoreline erosion is through the Coastal Managment Division's Computerized Geographic Information Image Processing System (GI-IP). This system will enable the state to monitor land loss and other impacts or parameters in the coastal areas. This will be done by storing data with the ability to retrieve it rapidly in a form that can be understood by managers in DNR and other agencies. The system is managed by the CMD Information Section.

The program consists of a Data General MV 10,000 Computer System and interactive AUTOERDAS software package which is composed of AMS, MOSS, MAPS, COS (from Autometrics developed for the US Fish and Wildlife Service), and the ERDAS IP-GIS from ERDAS. The program will assist other regulatory related sections within the Coastal Management Division (i.e., Permits, Enforcement, and Consistency Sections). The data base will include the following: (1) USFWS 1956 and 1978 Ecological Characterization Maps, (2) USFWS 1:100,000 Ecological Atlases, (3) permit sites and ancillary data, (4) water quality and salinity data, (5) shorebird and wading bird rookery sites, and (6) impoundments and marsh management areas.

The initial projects will be focused on (1) special management areas/sensitive area analysis, (2) Landsat Thematic Mapper habitat classification and land loss, (3) aircraft multispectral scanner habitat classification, (4) shell dredge location and monitoring, and (5) the transfer of permit tracking data to the GI-IP System and permit site analysis.

The above programs represent some areas where the Louisiana Department of Natural Resources is encouraging projects which may assist in the reduction of land loss in Louisiana's coastal zone.

Darryl Clark is presently the Marsh Management Coordinator and Chief of the Enforcement Section for the Coastal Management Division of the Louisiana Department of Natural Resources. He is a benthic ecologist with work on estuarine benthic copepods and the effects of thermal pollution on benthic estuarine invertebrates. He participates in marsh management planning and evaluation with other agency personnel and coastal landowners. Mr. Clark received his BS in Zoology and MS in Aquatic Ecology at the University of Southwestern Louisiana.

SCS Soil and Water Conservation District Approach to Wetlands Protection

Bradley E. Spicer
State Soil and Water Conservation Committee
and
U.S. Soil Conservation Service

The management of the wetlands in Louisiana is a cooperative effort. It involves landowners and local, state, and federal agencies working together. Governmental agencies have an important role, but the landowners' cooperation is essential to getting wetland management plans implemented.

Most management plans developed for private lands in Louisiana have been prepared by local soil and water conservation districts (SWCD) with technical assistance provided by the USDA Soil Conservation Service (SCS). Since 1981, all marsh management plans developed in Louisiana by the conservation districts and others have required the approval of the Coastal Management Division (CMD). This agency is a part of the Louisiana Department of Natural Resources and serves as the state's wetland protection regulatory authority. As a result of closer coordination of planning efforts among the agencies, during the last two years a marsh management planning team consisting primarily of representatives of local soil and water conservation districts, the Soil Conservation Service, and the Louisiana Coastal Management Division has evolved. The National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the Louisiana Department of Wildlife and Fisheries frequently participate in the planning efforts if areas under consideration are of particular interest to them. Although many agencies participate in the development of management plans, the local soil and water conservation district makes the initial contact with the landowner and maintains a line of communication during the preparation and implementation of the plan.

Most marsh management systems implemented in Louisiana require the installation of structural measures to control water movement between hydrologic units. Structures are used to stabilize water levels, reduce water salinities and turbidities, or control the rate of tidal exchange. Structural measures used include weirs, culverts, plugs, levees and dikes, and leveed impoundments. Nonstructural measures are used and often in conjunction with structural components in implementing a marsh management plan. Most commonly used practices are prescribed burning, water conservation and management techniques, noxious weed and other undesirable plant control, and vegetative plantings. These structures and practices are the principal measures used to address the more common problems associated with coastal wetland deterioration, mainly marshland erosion, stream bank and shoreline erosion, saltwater intrusion, or critical area protection.

The SCS and districts have acquired considerable expertise in the design and use of structural and nonstructural measures to control wetland problems. These agencies have a technical assistance program which makes planning specialists available to assist landowners in developing and implementing wetland management plans.

To qualify for this assistance, many landowners and operators have entered into cooperative agreements with local soil and water conservation districts. Signing a district agreement is a good indication that the landowner has a strong desire to protect his wetland resources by implementing a comprehensive wetland management plan. The agreement provides that the cooperator can receive technical assistance from the local district and the Soil Conservation Service to design and implement a wetland resource management plan.

The Soil Conservation Service and local soil and water conservation districts have been working with landowners for more than fifty years in efforts to slow or stop wetland loss in coastal Louisiana. The SCS has contributed significantly to the design of water control structures used in the state's wetlands and has played a major role in the development of nonstructure wetland management techniques.

There are presently approximately 1000 landowners in the coastal region of Louisiana that have entered into cooperative agreements with local districts. These landowners control approximately 2.2 million acres of wetlands. Since 1981, through the efforts of local soil and water conservation districts and the Soil Conservation Service, management plans have been developed for nearly 700,000 acres of marshland. Most of this acreage is in private holdings that are under the control of individuals or corporations. In addition there is a significant acreage in wildlife refuges and game preserves that are managed by the state or by the federal government. All district plans developed since 1981 have been approved by the Coastal Management Division.

Most landowners have a serious concern for protecting their wetland resources. Frequently, however, they do not have the resources available to implement a comprehensive wetland protection and management plan.

Mr. Bradley E. Spicer is a liaison officer from the U. S. Soil Conservation Service who works with state agencies to help implement marsh management plans. Mr. Spicer is currently a Ph.D. candidate in the Department of Agronomy at Louisiana State University.

Politics and Wetlands Management on the Local Front

Mr. Bruce H. Wright, Jr.
Environmental Professionals, Ltd.

The politics of wetlands management on any level involves service to a constituency. Elected officials, agency heads, presidents of energy-related companies, and environmental activists all share that common need: to address the interests of their constituents. While the goals set to accomplish that service may vary depending on the group under consideration, there exists a great deal of common ground which might be explored to address the issue of wetlands loss as it impacts each group and management of the wetlands resources for the benefit of each.

Just as ecosystems exhibit gradients in their physical and biological aspects, so do socio-political systems, and, as in natural systems, there is much more interdependence than is evident on the surface. If the constituency gradient is examined for the three basic levels of government involved in wetlands management, some interesting relationships emerge.

The national wetlands constituency is dominated by special interest groups and their lobbyists with appreciable voting and/or financial clout. While they are technically sophisticated, the issues they contend are normally ones of policy or of environmentally unique significance. The administrative system established by the political entities to deal with this constituency is characterized by single-mission agencies with a broad funding base, well-established bureaucracy, and a detailed, comprehensive legislative foundation.

The numbers of votes or dollars are somewhat more moderate on the state level of government, with individuals and small groups being of increasing importance. Technical knowledge is more confined to the state or region in question. Administratively, funding is limited but available, and a rudimentary legislative foundation supports a growing bureaucracy of mixed single and multi-mission agencies.

Locally, individuals dominate the constituency, whether a politically influential landowner or the largest industry in town. They are not technically sophisticated and place greatest importance on short-term problem solving and satisfaction of immediate needs and desires. Funding for wetlands or any other use is severely limited, legislation is limited and frequently mundane, and management responsibility is vested in individuals in a piecemeal fashion.

From the preceding, it would seem that any thought of wetlands resource management on the local level would be ill advised. Its administration is politically fragile in that drainage, public safety, and similar immediate needs readily divert local financial resources from wetlands priorities, and a change in political majority can gut the administrative offices established to oversee wetlands projects by the elimination of one or two positions. It is almost wholly dependent on outside funds and assistance. Yet, it benefits from the pressure of the local constituency to implement rather than study. The administrators involved are in close touch with, if not directing, a variety of diverse projects, and so are more aware of the interrelationships and interdependencies of those projects and wetland management projects. They are in personal contact with the political structure needed to support wetland project implementation, and with the landowners and other constituent groups whose support or resistance mean success or failure. Finally, they have a record of actually implementing wetland projects, within the limits of their resources, which impact a large percentage of their governed area.

Local interest appears to be waning currently owing to the failure of the federal-state-local partnership first envisioned by the coastal zone management program. This lack of support could easily defeat the long-term need for management and preservation of an integral wetlands ecosystem in coastal Louisiana through delays, landowner apathy or resistance, and the inertia of the state and federal agencies themselves. If the constituency groups and agencies on all levels can be reintegrated to utilize the strongest features of each, and to reach compromises which assure the viability of the special interest groups' basic needs, perhaps the bold measures necessary to protect the productivity of our renewable wetland resources will be possible.

Bruce Wright was previously the Environmental Specialist for the St. Bernard Parish Police Jury. He was the Project Director for the implementation of all the Parish's marsh management plans, and the Parish Representative to the Louisiana Coastal Advisory Council. Mr. Wright earned an MS in Physiology from Northeast Louisiana University.

RIGS-TO-REEFS

Session: RIGS-TO-REEFS

Chairmen: Mr. Villere Reggio
Ms. Maureen Fleetwood

Date: October 22, 1985

Presentation Title	Speaker/Affiliation
Rigs-To-Reefs Introduction	Mr. Villere Reggio Minerals Management Service and Ms. Maureen Fleetwood USDI, Office of the Assistant Secretary for Land and Minerals Management
Rig Fishing in the Gulf of Mexico - 1984 Marine Recreational Fishing Results	Mr. John F. Witzig Office of Data and Information Management, National Marine Fisheries Service
The Federal Role in Artificial Reef Development	Mr. Richard B. Stone National Marine Fisheries Service
Preliminary Studies for the Development of Artificial Reef Siting Plans in the Northeastern Gulf of Mexico	Dr. Stan Hecker Mississippi-Alabama Sea Grant Consortium and Dr. E. A. Kennedy Continental Shelf Associates, Inc.
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Resource Planning as Applied to Rig To Reef Siting	Mr. Joseph McGurrin and Mr. Mark Reeff Sport Fishing Institute Artificial Reef Development Center
Federal Focus on Platform Disposition for Artificial Reefs	Mr. Richard B. Krahl Deputy Associate Director for Offshore Operations, MMS
Industry's Prescription on Rigs-to-Reefs	Dr. Michael D. Zagata Gulf of Mexico Offshore Operators Committee
Salvage and Demolition of Two Navy Offshore Platforms	Mr.William N. Seelig, P.E. Naval Facilities Engineering Command,USN
Oil Platforms as Reefs: Oil and Fish Can and Do Mix	Mr. Paul K. Driessen Minerals Management Service

Rigs-To-Reefs

Mr. Villere Reggio
U.S. Minerals Management Service
and
Ms. Maureen Fleetwood
USDI, Office of the Assistant Secretary for Land and Minerals Management

Government reports, private actions, industry deeds, and several planning projects are paving the way to utilize more and more oil and gas structures in the development of permanant artificial reef systems for the Gulf of Mexico. With the impetus of the National Fishing Enhancement Act and the emergence of a National Artificial Reef Plan, all Gulf states are now developing, considering, or reassessing their roles in promoting artificial reefs as a major fisheries management tool. Unless the states accept a pivotol role in artificial reef planning and development in the Gulf of Mexico region, the full fisheries conservation and enhancement potential of Rigs-to-Reefs will never be realized.

During the next 14 years, over 1600 petroleum structures will cease to produce oil, gas, and incidental fishery benefits. It will cost over $1 billion to dispose of these structures on shore. The debate in the Gulf of Mexico no longer centers on whether oil and gas structures are good for fish and fishing but rather how to prolong, expand, and recycle the recognized fishery benefits of these functioning artificial reefs. Although problems remain, we all stand to gain by clarifying issues and finding mutually acceptable remedies to problems. As is exemplified in the presentations at the 1985 Rigs-to-Reefs Session, cooperation and progress are evident, and positive changes leading to further use of petroleum structures as permitted reefs are likely.

The Department of the Interior will continue to encourage federal and industry policy support for multiple use of the Outer Continental Shelf, and with the Minerals Management Service will strive to remove unwarranted regulatory and legal impediments to Rigs-to-Reefs projects, and will make special efforts to encourage the petroleum industry to dispose of structures on permitted artificial reef sites. As noted herein, the Artificial Reef Development Center, the Mississippi/Alabama Sea Grant Program, and the Gulf of Mexico Offshore Operators are prepared to assist and cooperate in the development of good Rigs-to-Reefs projects and programs.

Villere Reggio is an Outdoor Recreation Planner with the Minerals Management Service. 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.

Maureen Fleetwood is a program analyst in the office of the Assistant Secretary for Land and Minerals Management of the U.S. Department of the Interior. She has coordinated departmental Rigs-to-Reefs initiatives and is the principal staff support for the Secretary's REEFS Task Force.

Rig Fishing in the Gulf of Mexico - 1984 Marine Recreational Fishing Survey Results

Mr. John F. Witzig
Office of Data and Information Management
National Marine Fisheries Service

INTRODUCTION

During 1984, as part of the National Marine Fisheries Service (NMFS) marine recreational fisheries statistics survey, data were collected on marine recreational fishing activity associated with oil and gas structures in the Gulf of Mexico. The results presented here are a summary of the 1984 survey as they pertain to rig fishing.

The background of NMFS involvement in this project is described below, followed by a brief description of the methodology used. Results are then presented on a fishing trip and catch rate basis. A final report describing all of these aspects in detail will be available during the first half of 1986.

Background

The NMFS initiated a series of surveys in 1979 to obtain estimates of participation, catch, and effort by recreational fishermen in the marine waters of the United States. The survey was designed to help meet the goals of the Magnuson Fishery Conservation and Management Act of 1976 (MFCMA), and to initiate a reliable data base for estimating the impact of marine recreational fishing by establishing basic performance statistics on these fisheries. The MFCMA mandated a national program for management of fishery resources in the Fishery Conservation Zone (FCZ 3-200 miles), and required that recreational as well as commercial fisheries and their harvest be considered.

The number of oil and gas platforms in the Gulf of Mexico has increased dramatically in recent years. Coincident with the increased drilling activity in the 1970's and 1980's was the recognition by recreational fishermen that offshore structures offered fishing opportunities unequalled by otherwise undeveloped areas.

As a consequence of these circumstances, the Minerals Management Service (MMS) contracted with the NMFS in 1980 to collect data on recreational fishing activity associated with oil and gas structures in the Gulf of Mexico. The purposes of the cooperative arrangement between NMFS and MMS were to estimate: (1) fishing prevalence rates for areas in the FCZ near oil and gas structures; (2) total number of fishing trips taken to areas near rigs; (3) species composition of the catches taken from rig fishing sites; and (4) total catch by species from rigs. In addition the survey was designed to identify primary angler groups using rig fishing sites. Because of unforseen contract difficulties, sufficient data were not collected until the 1984 survey.

METHODS

The data collection methodology used for the survey consisted of two complementary surveys: a telephone survey of households and an intercept survey of fishermen at fishing sites. The telephone survey was used to collect data on certain aspects of recreational fishing, such as number of trips made in the past two months, locations fished, and dates on which those trips were made. Information on the actual catch such as species, number, and weight and length of fish was collected by interviewers at the fishing site. Data from the two independent sources were combined to produce total catch, participation, and fishing effort estimates.

The telephone survey portion of the study was carried out in six periods of interviewing near the end of each two-month period of fishing activity. During the telephone interview anglers were asked a series of questions about each fishing trip taken during the previous two months. Included in the interview were questions regarding the mode of fishing and whether any of the fishing activity occurred within 200 feet of an oil or gas platform.

The intercept portion of the survey consisted of on-site interviews which gathered catch and demographic data from marine anglers in four modes: beach/bank, party/charter boat, private/rental boat, and fishing from man-made structures. In addition, anglers on the Gulf coast fishing from either of the two boat modes were asked whether they were fishing within 200 feet of an oil or gas platform. Sampling was conducted continuously in six two-month sampling periods from January 1984 through December 1984.

RESULTS AND DISCUSSION

Trips

The majority of oil and gas structures in the Gulf of Mexico are located off the coast of Louisiana and Texas with a small proportion off the coast of Mississippi. Owing to the sparsity of rigs in the eastern Gulf, only the results from Louisiana and Texas are considered. Based on the telephone portion of the survey, approximately 37% of all saltwater fishing trips made by Louisiana coastal residents in 1984 were within 200 feet of an oil or gas structure. The Texas results were comparable with 28% of all marine fishing trips being made to sites near oil or gas platforms.

Trips by season -- The popularity of rigs as fishing sites varied by season and state. Eighty-one percent of the marine fishing trips made by coastal county residents in Louisiana during March and April were to areas near oil and gas structures. The prevalence of rig fishing trips in Louisiana declined through the rest of the year. Rig fishing was replaced by fishing activity in shore-based modes and nearshore areas during the warmer months. Conversely, in Texas the highest proportion of rig fishing trips were made in September and October (35% of all saltwater fishing trips) with the lowest prevalence rate being in March and April (12%).

Trips by area/mode -- The telephone survey indicated that in Louisiana the majority of all fishing trips greater than three miles from shore were to areas near oil or gas structures. Results from the intercept portion of the survey in Louisiana independently confirmed the results from the telephone survey and indicated that over 70% of all fishing trips greater than three miles from shore were to areas near oil or gas structures. The prevalence rate for offshore fishing trips near rigs in Louisiana was higher in the party/charter boat mode (72%) than for private/rental boat mode (54%). Less than 20% of all inshore fishing trips were near rigs.

Catch

The affinity of oil and gas structures for popular game fishes directly affected catch rates and catch composition.

Catch rates -- In inshore areas the average catch rate for fishing trips taken to sites near oil and gas rigs (20 fish per trip) was 66% greater than the average catch rate for fishing trips taken to non-rig sites (12 fish per trip). There was no significant difference between rig and non-rig fishing trips in number of fish caught per trip for areas greater than three miles from shore.

Catch disposition -- A significantly greater proportion of the catch was kept by anglers fishing near oil and gas platforms than by anglers fishing in other areas. In areas less than three miles from shore, approximately 60% of the fish caught near rigs were kept compared to less than 10% caught at non-rig fishing sites. The proportion of the catch kept on fishing trips greater than three miles from shore was over 70% for trips to rig sites and approximately 35% for non-rig fishing trips.

Catch composition -- there was a marked difference between rig and non-rig fishing trips in the species composition of the catches. Exclusive of saltwater catfish, red snapper *(Lutjanus campechanus)*, sand seatrout *(Cynoscion arenarius)* and Atlantic croaker *(Micropogonias undulatus)* constituted 80% of the catch near oil and gas platforms. Round scad *(Decapterus punctatus)*, grunts (Haemulidae), and snappers (Lutjanidae) made up over 70% of the catch on non-rig fishing trips.

Size distribution -- The length frequency distribution of some species differed markedly depending on where the fish were caught. For example, red snapper caught near rigs in waters less than three miles from shore showed a bimodal length frequency distribution with modes at 400 mm and over 550 mm; approximately 12% of the catch was greater than 550 mm in length. Red snapper caught at non-rig sites in inshore waters averaged 310 mm in length. The size distributions of red snapper caught at rig and non-rig sites in offshore waters were similar.

SUMMARY

Oil and gas structures have a significant impact on recreational fishing activity in the Gulf of Mexico, particularly off the coast of Louisiana where there is a high density of such structures. The data indicate that rigs concentrate popular food fish such as snappers and seatrout and attract other game fish such as amberjacks and dolphins. This results in a high angler preference for fishing sites near rigs compared to non-rig sites. Preliminary analyses indicate that rigs tend to attract species normally found in deeper offshore waters. An overwhelming majority of fishing trips taken in the FCZ were to areas near oil or gas structures.

Preliminary survey results indicate that oil and gas structures enhance the fishing quality in Louisiana coastal waters. However, the relatively small sample sizes employed in the national survey at the state level cannot be used to produce participation and catch estimates with the precision required for the management of fisheries within small geographic ranges. Additional sampling effort must be undertaken to achieve the precision necessary for the development of sound management plans for the states' territorial waters and for the management of the marine resources confined to limited geographic areas in the FCZ. The economic impact of oil and gas structures on the recreational fishing industry and local support industry has yet to be addressed. The State of Louisiana has made arrangements to augment the number of interviews allocated to the state during the 1986 marine recreational fisheries statistics survey with the purpose of increasing the precision of the participation and catch estimates for the state.

The sixth annual marine recreational fisheries statistics survey was completed in December 1985. Questions pertaining to fishing activity associated with oil and gas structures in the Gulf of Mexico were included in the survey. The results of the survey will be available in the first half of 1986.

John F. Witzig is a statistician with the National Marine Recreational Statistics Survey in Washington, DC. He has worked on the survey since 1984. Previously he was employed as a fishery biologist with the National Marine Fisheries Service in Beaufort, NC.

The Federal Role in Artificial Reef Development

Mr. Richard B. Stone
National Marine Fisheries Service

Although artificial reefs can enhance recreational and commercial fishing opportunities, creating a successful reef entails more than placing miscellaneous materials in ocean, estuarine, and freshwater environments. Planning and management are needed to ensure the benefits of artificial reefs. If reefs are improperly planned, constructed, or managed, they can prove ineffective -- all or part of a reef can disappear or break apart and interfere with commercial fishing operations or damage natural habitat.

In the United States, the federal government is providing technical assistance, guidance, and regulations for the proper use of artificial reefs by local governments and the private sector in a manner compatible with other interests. We have worked with state, university, and private sector scientists to learn how reefs work. While research is continuing, information is being provided to reef builders to help them in their efforts. Federal agencies are working together and with states, the Fishery Management Councils, the Marine Fisheries Commissions, industry, and the public on planning for orderly, effective artificial reef development. This has resulted in a National Artificial Reef Plan which was required by the National Fishing Enhancement Act of 1984.

The National Fishing Enhancement Act (NFEA) of 1984 required the Secretary of Commerce to develop and publish a long-term National Artificial Reef Plan (Plan) to promote and facilitate responsible and effective artificial reef use based on the best scientific information available. This Plan has been developed to provide general criteria or guidance on planning, siting, designing, types of materials, constructing, and managing artificial reefs. It also includes reviews of some of the existing information sources and research needs. Other issues, such as liability and mitigation, are introduced but need to be addressed in more detail by working groups of knowledgeable individuals from the federal, state, university, and private sectors. The Plan is intended to be a dynamic, working document that can change as new information becomes available.

This Plan reflects considerable input from the federal agencies involved in reviewing and approving permits for artificial reefs, the states, Regional Fishery Management Councils, the Marine Fisheries Commissions, industry, recognized artificial reef authorities, and the public. More than 50 individuals have helped prepare this document. While the plan is general in scope, it should provide a framework for regional, state, and local planners to develop more detailed, site-specific artificial reef plans sensitive to highly variable local needs and conditions. These more specific plans should be developed under the cooperative leadership of state agencies and interstate organizations responsible for fisheries management and development, and should focus on specific criteria for reef construction in their geographic areas.

The Plan is intended to address the needs of a wide variety of users, not just reef developers; these other potential users include reef regulators, fishery or environmental managers, prospective donors of reef material, government officials, and the general public. The Plan addresses both criteria specified in the NFEA and unspecified criteria deemed important by the working groups responsible for providing input to this plan. The consideration and use of these guidelines and criteria should assist reef developers, managers, and regulators in focusing or directing their activities on effective artificial reef programs.

I believe the state's role in the artificial reef construction process should be to develop, or participate in developing, site-specific plans and to retain and strengthen regulatory and quality control to ensure that all reef construction (1) has biological justification to meet present and future fishery management needs; (2) minimizes negative effects on, and conflicts with, existing fisheries and uses; (3) minimizes negative impacts on other natural resources and their future use; (4) uses materials that have long-term compatibility with the aquatic environment; and (5) is subsequently monitored to determine if it meets permit terms and conditions and the original enhancement justification. State natural resource agencies should be involved in all artificial reef construction in their waters, and should also have a major role in adjacent federal waters, due to contiguous fishery and resource management concerns. When artificial reef construction projects go beyond state government limitations, state natural resource agencies should provide technical expertise or recommend consultants to assist other responsible organizations undertaking artificial reef projects. This may require money from outside the state budget.

Many artificial reefs would not have been constructed without the donation of reef material. In most cases, the costs to the donor for providing the reef material have been offset by benefits. These benefits have included lower disposal costs at the reef site than at other disposal sites, tax write-offs as charitable donations (to government agencies), and favorable publicity. Recent donations by the gas and oil industry are exceptions -- the costs were considerably higher than disposal costs.

Generally, if there is a cost to the donor beyond normal disposal costs, there has to be an incentive to offset the cost. The future use of materials of opportunity, particularly large items (e.g., ships, gas and oil structures, railroad cars, bridges), will be affected unless some form of incentive is provided.

I believe the public sector and state and federal government in the United States will continue to work together toward solving the problems of financing reef programs, improving the technology level, and communicating to resource managers the economic and environmental benefits that can result from habitat enhancement with artificial reefs. The Plan and site-specific plans may mean fewer reefs but more effective efforts. We will see more state involvement and, for many states, direct supervision of all artificial reef efforts.

Funding is still a question mark. Expanded Wallop-Breaux funds should provide states with some new monies for their reef programs. Salt water licenses also may provide some new money for reef construction. Incentives are needed for more active industry participation. I am encouraged with the prospects for the future -- better planning, better communications, and more effective reefs.

Richard Stone is the Chief Recreational Fisheries Officer for the National Marine Fisheries Service. Most of his career with the Service has been devoted to research, development, and technical assistance on artificial reefs. His advice and congressional testimony have aided in the development of national artificial reef legislation. He is the principal author of the recently-published National Artificial Reef Plan.

Preliminary Studies for the Development of Artificial Reef Siting Plans in the Northeastern Gulf of Mexico

Dr. Stan Hecker
Mississippi-Alabama Sea Grant Consortium
and
Dr. E. A. Kennedy
Continental Shelf Associates, Inc.

Presentor
Dr. Rick Wallace
Alabama Sea Grant Advisory Service

In response to a request for proposals by the National Marine Fisheries Service in early 1983, the Mississippi-Alabama Sea Grant Consortium in cooperation with Continental Shelf Associates, Inc., has been working on a project to develop siting plans for the establishment of artificial reefs in the Gulf of Mexico. The objective of our study is to develop a workable plan for siting artificial reefs in the Gulf of Mexico that would benefit both recreational and commercial fisheries. More specifically, the plan includes investigation of the biological, operational, sociological, economic, and legal aspects of using obsolete oil and gas platforms as fishing reefs. This appears to be a logical approach since about half of the almost 3500 currently active platforms in the Gulf are expected to become obsolete by the turn of the century. Under current regulations, platforms which are taken out of service must be removed by the owner.

The end product envisioned for this project is a detailed set of artificial reef siting plans for three selected areas: Gulfport-Biloxi, Pascagoula-Mobile-Dauphin Island, Pensacola-Ft. Walton Beach-Destin in the northeastern Gulf of Mexico. The work is being carried out by a multi-disciplinary team from academia and industry.

The intent is for the artificial reef siting plans to holistically address biological, operational, sociological, economic, and legal factors related to the three geographic areas. Work undertaken in each of the disciplines is based on reviews of the literature and existing data primarily from the Sport Fishing Institute and other sources such as the affected states.

In addition, an advisory group made up of representatives from public and private organizations comments on the scope of work and more recently heard presentations of and discussed results to date. The advisory group has provided constructive criticism to the researchers that has helped them to focus more directly on some of the issues.

The following will summarize the information as reported by the investigative team. The reports prepared by the investigators are listed in the bibliography.

BIOLOGICAL CONSIDERATIONS

A number of biological parameters were identified to be important to the success of an artificial reef. These include the productivity of existing biota at the site, substrate type, oceanographic conditions and water quality, the shape and profile of the reef structure, and the life histories of the target species.

The reef substrate should be firm enough to keep the structure from sinking into the bottom. Orientation of the structure must be carefully considered based on oceanographic conditions to minimize scour and to permit a flow of nutrients into the area. In this vein, areas of upwelling make good sites for artificial reefs because of the influx of nutrients associated with this phenomenon.

Artificial reef complexes built in groups of units called sets are favored by the Japanese for high productivity. This may conflict with the National Reef Plan, which suggests building new reefs rather than expanding old reefs, and also conflicts with the widely-held view that new reefs should be sited in a manner that disperses fishing effort.

OPERATIONAL CONSIDERATIONS

Operational factors that influence reef siting include environmental conditions at the site, availability and suitability of different reef materials, transportation and logistics requirements, deployment techniques, optimum reef design, and marking requirements.

Numerous types of materials have been used in the past to construct artificial reefs. Based on availability and durability, concrete blocks and rubble, steel ships and barges, obsolete petroleum platforms, and Japanese-designed structures are the most suitable materials for reef construction.

Factors that affect placement of reefs off Mississippi include a broad, shallow shelf; generally soft sediments, except in the eastern portions where sandy sediments exist; an extensive network of navigational channels; and intense utilization by commercial trawlers. Artificial reefs should be sited on available sandy bottoms. A nearshore and intermediate depth zone should be used to expand existing reefs. Low-profile reefs are suggested for the shallow depths. A deepwater zone is also proposed to attract large pelagic game fishes. Obsolete ships and petroleum platforms are suggested for the deepwater zone.

Alabama has an artificial reef program. Most existing reefs are located in a narrow band at water depths between 60 to 100 ft (18 to 31 m). Offshore sediments are primarily sand, providing a large area of suitable substrate. Proposed new reef sites are in an existing nearshore zone and a deepwater zone that extends out from the 80-ft depth contour. Shallow depths in the nearshore zone necessitate construction of low-profile reefs. High profile materials are recommended for use in the deepwater zone.

The area off the Florida Panhandle is characterized by deeper water than off Mississippi and Alabama. Sand bottoms cover a large portion of the area. Most of the existing reefs are located in nearshore waters of 67 ft (20 m) or less. A proposed reef zone extends seaward from the 80-ft depth contour and east of the existing navigational fairway to Pensacola Harbor. This zone includes the site of the existing Tenneco reef at a depth of 175 ft (54 m). Expansion of the reef complex at this site is recommended as a priority.

The U.S. Coast Guard determines the necessity for marking an artificial reef on the basis of (1) physical characteristics of the obstruction; (2) depth of water in which the obstruction is located; (3) proximity of the obstruction to historic or designated vessel routes; and (4) type of vessel traffic at the obstruction site.

Marker buoys are generally not required if there is an 85-ft (26-m) minimum clearance above the reef.

SOCIOLOGICAL CONSIDERATIONS.

A review of the literature indicated that no comprehensive model for the sociological aspects of artificial reef siting was available. Accordingly, the more general Social Impact Assessment (SIA) model was chosen and modified to fit the unique nature of a reef siting plan.

The major impact categories of the SIA model are demographic conditions, fiscal conditions, community services conditions, economic conditions, and social/psychological conditions.

A modification was made for this study to include biological conditions. The standard SIA model considers the temporal dimensions of pre-site characterization, site characterization, construction/operational and post construction.

It was determined that other than demographic data, the wide range of sociological material required for a scientifically grounded siting plan was not readily available. The data are generally fragmented, regionalized, and largely anecdotal. In view of the foregoing, research is proceeding using a skeletal SIA model with the demographic data noted, delphi panels, and community meetings.

ECONOMIC CONSIDERATIONS

The economic aspects explored in this artificial reef siting plan include valuation of recreational fishing, costs of dismantling and transporting platforms, costs of maintaining platforms as artificial reefs, and procedures for estimating the value of an artificial reef to a coastal community. Some of the more significant items determined to date are (1) identifying the means of measuring the value of recreational fishing by either the travel cost method or the contingent valuation method; (2) artificial reefs can provide additional catch for both commercial and recreational fishermen and recreational value for sportsmen; (3) cost components of an artificial reef include a manufacturing or dismantling cost, a transportation and installation cost, a maintenance cost, and a liability insurance cost; (4) individual reefs are established if their expected benefits are greater than their cost of installation; (5) in a simplified manner, the optimal number of reefs can be determined by dividing the dollar value of the maximum possible catch from the unlimited number of artificial reefs by the average cost of establishing artificial reefs and then taking the natural logarithm of the result; (6) a large bank of data has been published in an industry position paper with respect to the removal costs of obsolete oil and gas platforms in the Gulf of Mexico; (7) the decision by oil companies on whether to sell obsolete platforms for scrap or to donate them for use as artificial reefs is one of economics.

On the basis of the economic findings in the available data, an economic model was developed which may be applied to each of the selected reef siting areas.

LEGAL CONSIDERATIONS

Legal considerations for the siting plan development study include permitting, liability, development incentives and international law.

The permitting stage is a highly-structured procedure, but is not as complicated as it might seem because of the use of regional permits in the two U.S. Army Corps of Engineers districts, with federal agencies involved prior to the issuance of the regional permit. In the Jacksonville district, the permit is a joint permit between the applicable state agencies and the Corps.

The required permits are a Section 10, Rivers and Harbors Act, Corps permit, and, within three miles of the coastline, a Corps 404 (Clean Water Act) permit. In Florida, between three and nine miles, the state program still applies, although it is regulated through the same application since the Corps Section 10 permit is still required.

Because the Corps permit is a regional permit, all other federal agencies with a consultation role have had their say about permit conditions. Those agencies, the EPA, FWS and NMFS, still receive copies of applications and have a chance to comment on them.

No other permits appear to be required, although there are state certifications for water quality (§401, Clean Water Act) and coastal zone program consistency that must be obtained. In Florida, these are obtained as part of the joint federal/state permit process.

Liability is a primary concern of many of the parties to reef development, particularly if obsolete oil platforms are used as reef materials. Many of the potential areas of liability are present in the normally-required removal of an obsolete platform, such as injuries to workers of the towing and towed vessels and collisions with other vessels or structures. Negligence in siting and maintaining the reef are discussed, particularly in the light of the National Fishing Enhancement Act (NFEA). Donors of reef materials seem to be held to a strict liability standard regarding the condition of the reef materials when title is transferred, and it is possible that the standard needs to be changed to impose liability only if the donor knew or should have known that the materials were defective at the time title was transferred. The permit should be as explicit and as detailed as possible to protect the permittee since the NFEA states that the permittee will not be liable for actions required to be taken by the permit. This may also cause a problem because it might be interpreted to mean that if those actions are, under certain circumstances, dangerous, the permittee would not be liable if they are undertaken with knowledge of the risk.

The study concludes that there are some questions about the legality of reefs under international law, but that this is not an overriding concern.

REMAINING WORK

With the studies in the five disciplinary fields nearing completion, plans are underway to schedule local meetings at the three demand centers. These meetings will seek local input regarding artificial reef siting alternatives. Information gained at these local meetings will be considered in the drafting of the plans for each of the areas of interest. Upon completion, the draft plans will be presented to and critiqued by the Advisory Group. The comments will then be studied and factored into the plans as appropriate.

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Dr. Rick Wallace is a Specialist (Fishery Management) for the Alabama Sea Grant Advisory Service in Mobile. He works with commercial and sport fishermen to help them better understand and utilize marine resources. Rick serves on the Advisory Committee for the Northeastern Gulf of Mexico Artifical Reef Siting Plans under development by the MS/AL Sea Grant Consortium and Continental Shelf Associates, Inc. Dr. Wallace received his BA in Zoology from Ohio Wesleyan University, his MS in Marine Sciences from the University of Puerto Rico, and his PhD in Fisheries Biology from Auburn University.

Resource Planning as Applied to Rig To Reef Siting

Mr. Joseph McGurrin
and
Mr. Mark Reeff
Sport Fishing Institute
Artificial Reef Development Center

INTRODUCTION

Background

A major tool in enhancing the fisheries for sport fishermen is to construct artificial reefs. The use of obsolete energy production structures as artificial reefs (rigs-to-reefs) holds great potential for fishery development and management. Rig to reef projects may be more successful if the recreational fishing industry and its needs are considered when planning and siting reefs. Careful siting is one of the key management decisions that can maximize the benefits of artificial reefs for both fishermen and coastal communities. By creating effective artificial reef programs, reef developers can initiate positive biological, social, and economic changes for the sport fisherman and his community.

Because the social and economic benefits derived from the marine recreational fishing industry often go beyond the local community and bring prosperity to the region as a whole, it is important that artificial reef siting plans reflect a state-wide (or even coast-wide) approach. The Sport Fishing Institute has developed standardized siting procedures for regional and national application called Resource Planning. The primary goal of this paper is the application of the Resource Planning to rig to reef siting. Resource Planning provides state and local artificial reef coordinators with basic information that they can incorporate into their reef plans. This information can be refined to meet their particular needs and used to identify specific sites that show potential for artificial reef development.

Past artificial reef efforts point to the importance of a good reef location. Some of the early reef construction has been characterized by poor planning, haphazard siting, and limited benefits for the majority of private recreational fishermen. Occasionally, reefs have been located in areas where conflicts arise with traditional commercial fishing activities or with various other user groups, leading to navigational and other safety hazards. In some instances, reefs are sited too far offshore for most private recreational boat fishermen to reach safely. All of these problems highlight the need for Resource Planning.

Project History

The Sport Fishing Institute has undertaken a project to encourage effective use of artificial reefs as fishery management tools. The Institute created the Artificial Reef Development Center (ARDC) to provide a national focus for reefs in sport fishery development and management. One important ARDC product is called Resource Planning.

Resource Planning can be used as a means to determine optimal sites to build artificial reefs. It provides a broad picture of recreational fisheries, and can also be utilized as a guide in other sport fishery projects including development of shore-based facilities (i.e., boat ramps, marinas, tackle shops, hotels, restaurants, etc.) and in fishing area management (fishery management plans, boating safety, multiple use planning).

RESOURCE PLANNING AND RIGS-TO-REEFS SITING

Purpose

The purpose of Resource Planning procedures is to initially focus artificial reef siting efforts where a high probability of recreational fishing use is likely, and where multiple use conflicts can be eliminated or minimized.

Goal and Objectives

Resource Planning extends the Sport Fishing Institute's national level activities to benefit regional and local artificial reef programs by applying a tested methodology to collect needed information.

Resource Planning addresses the following objectives:

1. Characterizing the marine recreational fishing industry on both state and local levels including identification of major coastal population centers and access routes supplying the coastal communities with recreational fishermen and boaters; specific access facilities such as marinas and boat ramps; and the approximate numbers of private boat fishermen making use of local access facilities.

2. Determining priority recreational fishing zones (areas of potentially high recreational fishing use) which are bounded by the average maximum distance traveled by private boaters from the point of entering unprotected waters to the offshore fishing area.

3. Identifying exclusionary areas within these zones including shipping lanes, live bottoms, traditional bottom trawling areas, military warning zones, and marine sanctuaries.

4. Integrating rig structure information with Resource Planning procedures including information on the rig potential as fish habitat, rig active lifespan, and various alternatives of rig dispostion.

PLANNING PROCEDURES

The objectives outlined above may be considered as a series of tasks with specific steps to completion. These steps form the standard procedures of Resource Planning as applied to rig to reef siting.

Task A: Identification of Nature and Extent of the Marine Recreational Fishing Community - The Onshore Facilities

A.1 Identify major population centers, coastal tourism communities and access routes
A.2 Identify specific access facilities
A.3 Estimate number of private marine recreational boat fishermen

Task B: Identification of Recreational Fishing Zones

B.1 Research reef fishermen behavior and activity

B.2 Calibrate the maximum average distance they will travel for fishing to determine priority fishing zones

Task C: Identification of Exclusionary Areas

C.1 Identify the areas to be excluded within each fishing zone (possible user conflict areas)

C.2 Chart the exclusionary areas - exclusion mapping procedures

C.3 Chart known de facto reef structures (active rigs, hangs, and wrecks) and planned artificial reefs within the fishing zones

Task D: Integration of Oil Structure Data with Resource Planning Information - Distribution of Results

D.1 Inventory oil structures on a state or regional level and evaluate their fish habitat potential

D.2 Determine oil rigs coming off line that are suitable for fish habitat

D.3 Analyze rig disposition alternatives, including toppling in place, deployment at another site, or taking to shore for salvage

D.4 Transfer planning information to charts distributed to state fishery managers, local artificial reef planners, and oil industry officials

CONCLUSION

Resource Planning - Uses and Assumptions

Although artificial reefs in some cases have been sited for research and sanctuary purposes, Resource Planning is oriented to locating reefs where they will be used by recreational fishermen. Recreational fishing activity and access facilities are not generally distributed uniformly along a state's coast-line. Access sites located closer to major population areas will be used to a much greater extent than more distant areas. Therefore, recreational fishing reefs should be sited adjacent to major centers of saltwater fishing demand where utilization can be expected to be great. By siting reefs in such a manner, planners can develop reef projects that produce tangible benefits for the sport fishing industry.

Resource Planning is used to narrow the possible locations for artificial reefs in an effort to site reefs in optimal locations. The procedures outlined in this paper are intended to guide decision making and investment where the relationship of benefits to costs are of importance. These procedures are not intended as a substitute for the planning process but rather to guide local planning efforts. A plan that specifies reef objectives, target fisheries, and evaluation of alternative locations must still be completed prior to deployment. Also, the procedures presented here are not intended to substitute for the expertise provided by biologists, geologists, and oceanographers, but rather to guide their efforts to appropriate service regions.

Resource Planning is presented on a series of transparent overlays that correspond to National Ocean Survey (NOS) nautical charts. A narrative accompanies each set of the chart overlays and provides specific keys to chart symbols and information. By using transparent overlays, annual changes made by NOS can be accommodated, and local planners can add or modify data suited to their own goals and needs. Thus, the overlays serve as working documents, and changes over time do not necessitate production of entirely new charts.

PROJECT IMPACT

A prime application of Resource Planning is in providing a standard methodology for rig to reef siting. Although the number of projects are slowly increasing, rig to reef projects continue to be an underutilized fishery development option. Previous work has shown that many oil structures have outstanding fish attraction capabilities. Yet overall, the number of rigs that have been deployed as reefs is small. The reasons for this center about political, social, and economic obstacles. Some of the constraints that have been identified include (1) high costs of rig to reef deployment; (2) national security questions concerning submarine detection around reef structures; (3) liability concerns about possible boating and fishing accidents on reefs: and (4) present legal requirements for removing the structures.

Given these obstacles to rig to reef deployments, some incentive to build artificial reefs must be provided. A prime incentive is the value of rig to reef projects to sport fishermen, divers, and coastal communities. Resource Planning can be used to maximize this value.

The ultimate aim in the application of Resource Planning to rig to reef siting is to maximize recreational benefits for the public and thus provide the economic, social, and political support for effective projects. Using Resource Planning as a guide, proposed projects can be evaluated in terms of the potential costs and benefits of alternative sites. Beyond rigs-to-reefs, Resource Planning can be used for other types of reefs and in coastal areas other than the Gulf of Mexico. By utilizing orderly and systematic procedures like Resource Planning, obsolete and surplus materials can be recycled as effective fish habitat and provide a new source of fishing opportunities for the nation's angling community.

Joseph McGurrin received a BS in Biology from the College of William and Mary and an MS in Fishery Science from the University of Maryland. He is presently Director of the Artificial Reef Development Center. Mark Reeff has a BA in Geology and Environmental Studies and an MS in Natural Resource Management from Central Washington University. He is Assistant Director of the Artificial Reef Development Center. The Center operates under the Sport Fishing Institute in Washington, DC.

Federal Focus on Platform Disposition for Artificial Reefs

Mr. Richard B. Krahl
Deputy Associate Director for Offshore Operations
Minerals Management Service

Good afternoon! I appreciate having this opportunity to participate in this Sixth Annual Information Transfer Meeting. I will address several areas that encompass our involvement in the utilization of platforms as artificial reefs.

As we have heard, the National Fishing Enhancement Act of 1984 requires the development of a National Artificial Reef Plan, the issuance of artificial reef permits by the Corps of Engineers, and presents criteria for this approval. This heightens previously-raised concerns of how applications for departure from the Minerals Management Service (MMS) leasehold clearance requirements should be treated. In 1983, the MMS attempted to clarify its policy by issuing an interpretative rule that provided guidance for handling requests which depart from current regulatory requirements for lease clearance to convert platforms into artificial reefs.

Our interpretation of the rule is that if the structure is permitted within the Corps of Engineers' statutory authorities to be left in place, then we would discharge our responsibility by ensuring that any wells on the platform are properly plugged and abandoned. In addition, we would ensure that the abandonment application presented evidence that the Corps of Engineers' permitting requirements had been followed. When the Memorandum of Understanding (MOU) is signed, the Notice of Interpretation published in July 1983 will be withdrawn as it does not provide for unilateral action by MMS.

The MMS supports the national plan and will fulfill its obligation outlined in the prospective interagency MOU and the Department of the Interior's (DOI) previously-stated policy to encourage the conversion of selected Outer Continental Shelf (OCS) structures to artificial reefs. In the implementation of this policy, any application to convert a structure to a reef or leave a portion of the platform in place will be reviewed on a case-by-case basis with full coordination of the MOU signatory agencies and will be consistent with the national artificial reef policy. I have been designated as the lead staff official for the artificial reef program within the DOI.

At our request, the National Research Council, under its Marine Board, established the committee on Disposition of Offshore Platforms to document and assess alternatives for removing, disposing, or reusing offshore platforms that are beyond their useful production life. Also, the Marine Board was asked to make recommendations concerning government policy on platform disposition.

The report "Disposal of Offshore Platforms" was released yesterday, and I have a few copies for distribution. Essentially, the Marine Board concluded that, to date, removal of platforms has not developed into a major industry. The population of fixed offshore structures that may require disposal in the next 35 years (the timeframe of this study) include 4094 existing in 1983 plus an additional 1461 projected to be installed through 1990. Currently, platforms are removed at a rate of 30 a year, but this should increase to well over 200 a year in the future. More than 95% of these structures are or will be located in the Gulf of Mexico. To date, all structures built can be removed with current technology. Most are not too costly to remove since over 93% are in less than 200 ft of water. The real problem will begin in the 1995-2000 timeframe when platforms in 200 to 400 ft of water have to be removed. Deepwater platform removal will begin to be a problem around the year 2005. Based on 1985 dollars, this removal chore equates to about $2.5 billion in 2005 and $8.5 billion by 2020.

In a December 1984 FEDERAL REGISTER notice, the MMS solicited as a resource for the study of public comments the disposition of offshore platforms. These comments were furnished to the Marine Board, which assessed the issues that were identified and used this in determining policy alternatives and report recommendations. These were:

- The DOI should amend its removal policy to allow determination of the ultimate disposition of offshore platforms on a case-by-case basis in accordance with predetermined standards and criteria.

- The U.S. Coast Guard (USCG) should develop a national position on the disposition of offshore platforms for submission to the International Maritime Organization for international consideration.

- The EPA should establish a limited number of ocean dumpsites for the disposal of offshore platforms to include policy and permitting procedures.

- The DOI should develop a proposal designed to provide relief from liability to former owners of platforms where the means of disposition approved by the government does not do so.

It should be emphasized that the DOI role can only be that of encouraging the use of these structures as reefs. Our only authority that comes into play is in the site clearance requirements when a platform is removed. Dick Stone and the National Marine Fisheries Service should be commended for consulting so extensively with such a broad spectrum of varied interests and expertise during the development of the National Artificial Reef Plan. As a participant in the review of the draft plan, I can tell you that it was a formidable undertaking. Any DOI artificial reefs initiative must now be viewed as a component of the national plan.

During the development of the plan, the DOI expressed its concerns about the format. From our perspective, as one of the regulators of the OCS, the DOI would have preferred a plan written in a format which would be easier for a prospective reef builder to follow.

However, while we have some misgivings about the contents, we consider the plan to be a living document and by its implementation will cause all the players (i.e, federal, state, local, institutional, industry, etc.) to better understand their respective roles. Effective implementation of the plan should be improved.

As the National Fishing Enhancement Act of 1984 is implemented and the National Artificial Reef Plan is modified and refined, we hope that the plan will become more oriented to the information needs of the prospective first-time artificial reef builders.

However, there are still uncertainties involving the creation of artificial reefs from platforms involving such questions as, "Who best could fit the mold as permittee?" "Who or what entity has the attributes of experience, knowledge, jurisdictional, and willingness to manage an artificial reef?" "What entity could best become the local focal point for others in constructing/using an artificial reef?"

We would encourage the applicable coastal states to take the lead in applying to the Corps of Engineers for artificial reef permits. The MMS would suggest that all entities interested in constructing a reef work through the applicable states. In those situations where a platform is to be left in place, we would require that a completely state-sponsored institution be the responsible agency. Of course, this would only be applicable when a platform is left in place and the MMS would waive the complete location clearance requirements.

The MMS believes that the states or state-sponsored organizations are best equipped to site and manage artificial reefs in a manner that maximizes fishing resources as well as minimizing conflicts among competing users -- at the same time protecting the environment, property, and people.

Realizing that many factors must be integrated into a platform disposition plan, and also being aware of the extensive technical, environmental, economic, and legal detail that must be aggregated and evaluated for each and every site abandonment plan; I would add a suggestion before any platform is removed: the operator should have at least considered as a salvage alternative the feasibility of creating an artificial reef either in place or located elsewhere.

By way of summary, the MMS believes that the artificial reef program is worthy of success. We believe that the appropriate state or state-sponsored organization should be the permittee and that every platform salvage plan contain some configuration of an artificial reef as one of many alternatives for abandonment. Recognizing the concerns of other users of the oceans such as the Department of Defense, USCG, Corps of Engineers, and various fishing interests, approval for and recommendation of disposition of the platform as an artificial reef will be on a case-by-case basis.

The MMS will encourage OCS oil and gas lessees to carefully consider the options available to them which could serve to minimize the harm that would be done to fisheries by the total removal of oil and gas structures (de facto artificial reefs) when production ceases and their leases expire. Where an obsolete production facility is to be abandoned in place in accordance with an artificial reef construction permit approved by the Corps of Engineers, the MMS will review and approve-disapprove or require modification of a Well and Platform Abandonment Plan that is designed to permanently plug and abandon all oil and gas wells and also leave the platform and well conductors and casing in a configuration which complies with the provisions of the approved construction permit issued by the Corps of Engineers.

Finally, where do we go from here? As stated earlier, the designation of more areas in the OCS as artificial reef sites under the authority of the 1984 law has the potential for providing other alternatives for platform disposal with resultant benefits both environmentally and economically.

However, MMS site clearance regulations could be in conflict with any permit for an oil and gas facility to function as an artificial reef in its original location. Therefore, we intend to issue an advanced Notice of

Proposed Rulemaking (ANPR) to move toward eliminating this potential conflict.

The ANPR will contain the following:

POLICY

- It will clarify that MMS generally favors the use of obsolete platforms as reefs. It will establish that the MMS position is intended to be consistent with the 1984 Law, the National Artificial Reef Plan, and the Corps of Engineers' permit requirements.

- It will recognize and support the significant financial benefits of alternatives to current platform disposal options and the environmental benefits of the conversion of platforms to artificial reefs when these do not constitute a safety hazard or impede navigation.

- It will suggest artificial reef use as an alternative to platform removal.

REGULATIONS

We will give notice of possible rule changes we are contemplating, such as:

- Modifying the absolute requirement to clear sites when an artificial reef is proposed.

- Requiring lessees to indicate whether they have considered obtaining reef permits.

- MMS for approval to leave platforms on site. for leaving platforms on lease sites by obtaining necessary permits.

QUESTIONS

As we propose these rules, several questions remain on which we will also solicit comments. The provisions of the law absolve persons transferring title to reef materials (donors of reefs) from liability for damages if the materials meet requirements and are not defective when transferred.

The MMS will solicit comments on the following:

- What would make a platform defective for artificial reef purposes?

- Is any equipment on a platform or oil and gas structure unsuitable for a reef?

- How can materials in platforms be shown not to be defective?

- Corps of Engineers in determining whether platform materials are defective or not?

- Has the liability question been answered?

In the final analysis, creating new reef material does not bother me as much as destroying that which is currently in place. I would assume that this is a concern of many here today. We put forth a lot of rhetoric on what should be done, but the bottom line is trying to make multiple use of the OCS lands compatible with the various intent. Rigs-to-Reefs can be great for sport fishing but maybe not for commercial trawling interests. Defense and national security issues play a heavy role. However, I believe there is room to accommodate all these views and in this framework continue to formulate a viable artificial reefs program that can utilize obsolete and outdate structures.

As Deputy Associate Director for Offshore Operations, **Mr. Richard Krahl** is responsible for providing program guidance, oversight, management, and coordination of national programs relating to the regulation and supervision of industry operations involving OCS exploration, development, and production of offshore oil and gas. Mr. Krahl was educated as a petroleum engineer and entered federal service with the U.S. Geological Survey in 1959. He has held numerous positions in support of the OCS petroleum development program at both the field and headquarters levels. Among his many special assignments is the development of an MMS position and program in support of artificial reefs.

Industry's Prescription on Rigs-to-Reefs

Dr. Michael D. Zagata
Gulf Of Mexico Offshore Operators Committee

It is a pleasure to be here on behalf of the Offshore Operators Committee among the proponents of the Rigs-to-Reefs concept. We share a common interest in promoting the concept and in removing the barriers to an expanded use of retired platforms to create artificial reefs. I would like to thank Dick Fitch for his help with the talk.

We at Tenneco have had a very positive, yet somewhat costly, experience with the Rigs-to-Reefs program. The public's acceptance of the program and the positive coverage by the news media have been tremendous. The following brief news clip from Channel 11 in Houston is an example of the positive exposure those of us associated with the oil and gas industry rarely receive. It illustrates the public's enthusiasm for the program, the willingness of the media to cover it, and the need for an incentive to cover the extra cost to the donor. Indeed, according to an October 13, 1985, article in the *Times Picayune*, states are beginning to actively compete for the structures. [Tape shown]

The reef program has the potential to demonstrate that oil and gas operations have the potential not only to be compatible with the marine environment, but enhance it. That story needs to be told to and understood by those who perceive a need to impose leasing moratoria on the OCS. Oil and gas structures have helped to increase commercial and sport fishing catches. Various studies and experts confirm this. A report to the Texas Coastal and Marine Council revealed that in the Houston-Galveston area 87% of all offshore sport fishing boats operate around platforms. Commercial fishing throughout the Gulf has not only coexisted, but flourished, alongside oil and gas operations. Thirty-six percent of the nation's seafood came from the Gulf in 1982 and much of that from around offshore oil structures.

The use of retired offshore platforms to create artificial reefs has the potential to benefit everyone involved. Our industry would like to see more retired offshore platforms utilized as artificial reefs rather than be dismantled and hauled ashore.

However, the existing 4000 offshore oil and gas platforms have acted as artificial reefs ever since they first appeared in the Gulf of Mexico. The Artificial Reef Development Center of the Sport Fishing Institute concludes that offshore oil and gas structures "offer the greatest potential for artificial reefs." Thus we must provide for certain structures, when they meet certain criteria and are requested by the appropriate parties, to be left intact or toppled on-site.

Offshore oil structures used as artificial reefs not only improve catches for the commercial and sport fishermen, but also can add to government revenues. An artificial reef boosts local economies, tourism, fishing, diving, and marina services. These businesses and individuals serving and using the the new reef generate additional tax revenue for state and local governments.

POTENTIAL PROBLEMS

The liability question has been addressed in the National Marine Fisheries Service's "National Artificial Reef Plan" and the oil industry largely concurs with its findings and observations. The plan notes that the liability question for the reef permit holder, the materials donor, and the federal government has been addressed, in part, in the National Fishing Enhancement Act of 1984. The act establishes government coordination in the artificial reef permitting process and delineates donor and permit holder liabilities.

However, the liability question is not totally clear. A critical step in the rigs-to-reefs process -- transporting the structure to a remote artificial reef site -- raises liability issues that are not covered in the National Fishing Enhancement Act. It is this remaining issue of liability during transportation and installation that most concerns the oil industry.

After a site has been designated and a permit issued, an oil structure must be moved to the reef site, accurately and properly located, and properly marked. Potential liability during this stage includes injury to workers or damages to other vessels, platforms, pipelines, etc., during transportation and siting.

Although the National Fishing Enhancement Act provides that the donor is immune from liability once title to the structure has been transferred to the permit holder, the context of this provision really anticipates construction of an artificial reef, rather than transporatation of an obsolete platform. Presumably, liability for transportation accidents would be the same as in any other maritime situation, and liability would be assumed by the permit holder. But this is only a presumption and not specifically covered in the National Fishing Enhancement Act. Potential donors of these reefs want the question of who is liable during transportation to be made clear and explicit. This will be necessary to encourage active participation in a rigs-to-reefs program.

The cost of conversion to a reef and the tax credit possibilities make up another concern of the oil industry. In its draft form, the National Artificial Reef Plan did not address this concern.

Dismantling an offshore oil structure is very costly. Figures from the Oil Industry International Exploration and Production Forum will give you an idea of just how much money is involved. The cost of removing a platform from 40 to 75 m of water in the Gulf of Mexico is estimated to be $1.4 million 1983 dollars. As the water gets deeper and structures much larger, expenses rise quickly. Their estimate to completely remove a platform in 1000 ft of water ranges from $75 million to $90 million.

Removal costs increase when an offshore structure is dismantled and moved to a remote artificial reef site, because the distance to the reef site is generally greater than the distance to shore and the scrap yard. Also, turning a platform into an artificial reef may require modifications to the structures or changes to dismantling procedures, thus also adding to removal expenses. A platform that Tenneco donated to Florida was transported 275 miles from the coast of Louisiana. The incremental cost of creating a reef was just over $300,000. Of this amount, about 46% or $138,000 would normally be recaptured as a tax deduction. This left the donor with an out-of-pocket expense of $162,000.

Oil companies will not be eager to donate their platforms for artificial reefs if it costs more than normal removal operations and/or additional liability is incurred. Unfortunately, most reef permit holders do not have the funds to pay even the incremental costs for moving a rig to a reef site. The Artificial Reef Development Center has prepared a technical report on transportation costs, which points out that, "Funding for reefs is sporadic at best. ."

Therefore, tax incentives for the donor are the most workable and logical solution to the cost problem. In fact, the National Fishing Enhancement Act called for an evaluation of "modified tax obligations" to facilitate the transportation of artificial reefs. Tax incentives could make rigs-to-reefs economically feasible for both donor companies and reef permit holders.

Tax incentives would not necessarily reduce government revenues. To the contrary, federal, state, and local governments have much to gain in terms of taxes from rigs-to-reefs. The Offshore Operators Committee has agreed to help fund a study for the Artificial Reef Development Center to determine a method to define economic benefits from artificial reefs.

The federal government benefits most if a platform is not removed but instead toppled in place. Any removal activity, whether to shore for scrap or to an artificial reef site, creates tax deductible expenses for a donor.

The third concern involves the case of mitigation banking credits produced by artificial reefs to offset impacts on live bottoms in the offshore area. This issue is expected to be addressed in the final artificial reef plan and holds great promise as one form of incentive.

In summary, our industry believes the rigs-to-reefs concept is worthwhile and could be made workable. Therefore we endorse it. It has potential benefits for all participants as it solves some platform disposal problems and creates economic growth opportunities associated with the reef. Yet, the program cannot proceed much further without special attention to and resolution of the questions I raised today, namely, the transportation, liability, and relocation costs. These are not insurmountable problems, but they must be addressed.

Dr. Michael Zagata is Manager of Ecological Sciences at Tenneco, Inc. Dr. Zagata was born and educated in New York with graduate and undergraduate degrees in the biological and physical sciences. He earned a doctorate in Wildlife Ecology from Iowa State University. Dr. Zagata has worked as an educator in academia, as an administrator and public relations director for national conservation organizations, and was formerly associated with the National Academy of Sciences.

Salvage and Demolition of Two Navy Offshore Platforms

William N. Seelig, P. E.
Naval Facilities Engineering Command
United States Navy

This presentation describes the salvage and demolition in 1984 of two medium-sized platforms formerly located offshore of Panama City, FL. Factors influencing the method of disposal are discussed.

BACKGROUND

The U.S. Navy built two offshore platforms off the Panhandle coast of Florida in 1957 at the Naval Coastal Systems Center (NCSC), Panama City, FL. The platforms provided a staging area for a variety of U.S. Navy research projects. The platforms were originally designed to be manned and included large amounts of heavy equipment. The platforms were named "STAGE I," furthest offshore, and "STAGE II," more nearshore. At the time of construction, the platforms represented the state of the art in offshore platform construction with the general overall characteristics shown in Table 1.

TABLE 1. PLATFORM CHARACTERISTICS

	STAGE I	STAGE II
Distance Offshore	12 n.m.	1.75 n.m.
Water Depth	105'	60'
Decks	105'x105'x25'	60'x84'x36'
Jackets	16-30" piles	9 piles (8-24", 1-28")

INSPECTION/STRUCTURAL ANALYSIS

A detailed underwater inspection and structural analysis revealed that major members were in poor condition. It was predicted that a direct hit by a hurricane could cause the structures to topple. The structures had actually completed their useful life, and the cost for rehabilitation proved to be prohibitive. These findings led to the conclusion to dispose of the structures.

ANALYSIS OF DISPOSAL ALTERNATIVES

Allowing the platforms to topple naturally was ruled to be unacceptable because of polluting items on-board the platforms; the presence of extensive recreational beaches nearby; and the high cost of salvaging toppled structures.

An analysis of alternative disposal methods was undertaken to consider such factors as:

- Cost
- Federal, state and local laws
- Impact on the environment
- Benefits that fishing reefs provide
- Navigation
- Benefits provided for Navy demolition training

Groups consulted in the analysis of alternative included:

- State of Florida (Departments of Environmental Regulation & Natural Resources)
- U.S. Coast Guard
- U.S. Army Corps of Engineers
- U.S. Environmental Protection Agency
- Minerals Management Service
- Bay County, Florida
- Representatives of the oil & gas industry
- Local interested parties

SELECTED DEMOLITION/SALVAGE APPROACH

Based on the above considerations it was decided to:

(a) Clean up polluting items (asbestos, oil, etc.)

(b) Cut up the decks and transfer to shore for salvage

(c) Topple supporting piles in place to form submerged artificial reefs

PROJECT COMPLETION

Deck cleanup and salvage was performed by a contractor, and demolition of the supporting piles to make artificial reefs was undertaken by the U.S. Navy Explosive Ordinance Disposal Team located at Panama City. Navy participation provided excellent prototype demolition training.

The total project required six weeks on the site with approximately 30% down time due to the weather. Cost of the salvage/demolition was $1.4 M.

ACKNOWLEDGEMENTS

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LT. J. DeSimone was the Officer-In-Charge of EOD Team
Mr. M. Southall was the NCSC Head, Engineering Branch, Public Works Department
A/E services were provided by Barnett & Casbarian, Metairie, LA
Salvage work was by Sanford Offshore Salvage, Morgan City, LA

Mr. Seelig is a civil engineer with the Naval Facilities Engineering Command, Ocean Engineering & Construction Project Office, Washington Navy Yard, Washington, DC. He has spent the past 15 years in engineering research, design, construction, and demolition of coastal and ocean structures. He is the author of numerous technical papers, computer programs, and design manuals.

Mr. Seelig received his BS in Civil Engineering from Virginia Polytechnic Institute & State University and MS in Coastal/Ocean Engineering at Texas A&M University.

Oil Platforms as Reefs: Oil and Fish Can and Do Mix

Mr. Paul K. Driessen
Minerals Management Service

During 1984, some 4100 oil and gas structures and platform complexes in the Gulf of Mexico -- along with about 30 platforms off the California coast -- produced 370 million barrels of oil and 4.5 trillion cubic feet of natural gas. That's enough oil to run 35 million cars and enough gas to heat 50 million midwestern homes for the entire year. In the process, they also served as artificial reefs.

Most U. S. ocean bottoms are flat, featureless expanses of mud or sand--biological deserts that provide little habitat diversity, have low carrying capacity, and thus support only limited life. Coral reefs and other hard surfaces are rare, so the algae and larvae carried by all ocean currents have few suitable places on which to attach and grow.

By providing an average of 1.5 to 2.0 acres of hard surface, a single platform "jacket" provides an excellent substrate for algae, sponges, hydroids, corals, shellfish, and other marine life. These "encrusting organisms" must attach themselves to a suitable hard surface before they can metamorphose into adult form and begin to grow and reproduce. In fact, production platforms provide an estimated 28% of all the known hard bottom habitat in the central and western Gulf of Mexico.

Within days after a platform is placed on site, the encrusting organisms begin to colonize the jacket. Virtually every square inch is covered, from several inches to several feet thick, creating benthic, midwater, and upper water habitats; providing food and hiding places; and allowing species to expand their normal ranges.

Even the cuttings piles under platforms get colonized by organisms that fall from the jacket above, as well as by those that migrate from elsewhere as larvae, juveniles, or adults. A constant rain of fecal pellets, eggs, sloughed-off organisms, and other nutrients greatly enriches the cuttings pile and area around the platforms, causing the number of tube worms and other benthic animals to increase with closer proximity to a platform.

Swift, algae-laden, pollution-free currents enable mussels, oysters, clams, and scallops to grow rapidly, often to record sizes. Nine-inch mussels have been found under Santa Barbara Channel platforms, as have 30-in. giant starfish, *Pisaster giganteus*. The mussels mature in 12-18 months, compared to 36-48 months in nearshore areas.

Platforms also attract and propagate fish. Their high relief provides reference points and shelter from currents and predators, while their open structure allows nutrients to circulate freely.

Platforms thus raise primary (algal) productivity levels; augment habitats and food supplies; provide breeding grounds and shelter for eggs and fry; increase local carrying capacity and biomass -- and thus expand the numbers, diversity and range of highly desirable fish and shellfish, enabling them to live in areas where they were formerly absent. Moreover, platforms do this without reducing fish populations at other natural or artificial reefs.

In other words, platforms do far more than just concentrate or redistribute fish, though initially they may do that as well. They greatly increase the number and variety of fish and other organisms a given ocean area can support.

In fact, 20 to 50 times more fish can be found under and near California and Gulf platforms than at nearby areas with soft bottoms. Two to five times more fish have been observed around platforms than at nearby natural hard bottom sites. In the Santa Barbara Channel, the large fish populations have caused California sea lions to establish colonies on buoy barges, floating pipelines, and even parts of the platforms themselves.

Obsolete oil production structures have been sunk in several locations off Alabama, Florida, and other states. The Florida Department of Natural Resources has called a sunken Exxon subsea production template the most impressive fish producer in its entire artificial reefs system.

Naturally, the platforms also attract fishermen and sport divers. Some 85% of the sport fishing trips out of Galveston, TX, go to the rigs. In Louisiana, some 75% of the sport fishing trips in federal waters are to platforms; licensed sport anglers fishing the rigs contribute an estimated $190 million per year to the Louisiana economy.

Specially-equipped shrimp boats trawl as closely as possible to pipelines, where the shrimp seem to congregate most heavily. Commercial hook-and-line boats come all the way from Florida in search of snapper, grouper, and mackerel off Louisiana platforms. The fish are sold to some of the finest restaurants in New Orleans, New York, Chicago, and other cities.

Ninety-five percent of all U.S. offshore platforms -- some 4100 in all -- are in the Gulf of Mexico. Yet, commercial fish landings increased five-fold between 1950 and 1983 -- strongly suggesting that, at the very least, platforms and energy production have not adversely affected either fish or commercial fishing.

Using an "auto schlepper," Bob Meek harvests over 6000 pounds of sweet, succulent mussels every week from platforms in the Santa Barbara Channel for sale to restaurants and markets. Tests by the U. S. Food and Drug Administration and California Public Health Department found that their meat had less oil, chemical, bacterial, and sediment contamination than did mussels harvested in pristine Bodega Bay, California's cleanest bay.

One reason fish and shellfish harvested from platforms are safe to eat (and one reason corals and other pollution-intolerant marine life are able to grow under platforms at all) is that, following several bad spills in 1969 and 1970, a number of major technological and regulatory changes were made. The changes included greatly-improved blowout preventers, coupled with automatic shutdown systems and multiple backups; downhole shutoff valves; computerized downhole monitoring equipment; worker training programs; and frequent unannounced drills and inspections. These changes have all but eliminated blowouts and other spills associated with offshore exploration and production.

In fact, since these changes were made in 1970, blowouts have caused a TOTAL loss of fewer than 840 barrels of oil, out of over 5 BILLION barrels produced. In 1984, a TOTAL of only 670 barrels of oil were lost from ALL exploration and production operations on the Outer Continental Shelf.

By comparison, tankers have lost nearly 2 million barrels of crude oil and refined products since 1970. The British tanker *Alvenus* alone lost over 54,000 barrels when it went aground off Louisiana in 1984. According to the California State Lands Commission, natural seeps empty 18,000 to 278,000 barrels of oil into California coastal waters every year. And according to the Rhode Island School of Oceanography, motorists in Providence dump some 300 barrels of oil into alleys and storm sewers -- and thus into the ocean -- every year, when they change their own crankcase oil.

America will need to find 32 billion barrels of new petroleum reserves during the next ten years, just to replace what we will be using up. The enormity of this task is underscored by recent Department of Energy figures indicating that, between 1985 and 2015, the U. S. will spend nearly $3 trillion on imported oil -- enough to buy America's 500 largest industrial corporations not once, but twice, based on the 1984 value of their total assets.

Great public awareness of the benefits of offshore oil production to fish, fishing, and the environment may help reduce the current opposition to many lease sales and keep these depressing predictions about imports from becoming a reality.

Paul K. Driessen is trained in geology, biology, and environmental law and is an attorney-advisor and policy analyst for the Minerals Management Service of the U. S. Department of the Interior. He writes frequently on energy and environmental issues and presented a paper on oil platforms as artificial reefs at Coastal Zone 85. He holds a law degree from the University of Denver and a BA degree from Lawrence University.

DEEPWATER TECHNOLOGY: A CURRENT OVERVIEW

Session: DEEPWATER TECHNOLOGY: A CURRENT OVERVIEW

Chairmen: Mr. Felix Dyhrkopp
Mr. Jess Hunt

Date: October 23, 1985

Presentation Title	Author/Affiliation
Deepwater Technology - A Current Overview: Session Summary	Mr. Jesse Hunt Minerals Management Service
Minerals Management Service: The Role of the Regulatory Agency with Respect to Deepwater Operations	Mr. Richard B. Krahl Deputy Associate Director for Offshore Operations Minerals Management Service
Deepwater Operations: An Overview	Jesse L. Hunt, Jr. Minerals Management Service
Deepwater Drilling Technology	Vernon Grief Rig-Support Engineering Sedco-Forex
Subsea Production Systems: A Current Overview	Mr. R.L. Hansen Exxon Production Research Company
U.S. Geological Survey Mapping Program in the Gulf of Mexico	Dr. Bonnie A. McGregor U.S. Geological Survey

Deepwater Technology, a Current Overview: Session Summary

Mr. Jesse Hunt
Minerals Management Service

First, I wanted to make a couple of brief announcements. The Bouma Bank set of the Berryhill Series of Geologic Maps -- they are one to 250,000 scale geologic maps -- are in. They'll be available around the first of the month for sale at the office in Metairie. Also, the final Environmental Impact Statement for the Western and Central Gulf of Mexico sales 104 and 105 will be available at the first of the month.

We had a good session on deepwater technology yesterday and were privileged to lead off with Mr. Richard Krahl, who is the Deputy Associate Director for Offshore Operations. He spoke on the role of regulatory agencies with respect to deepwater operations.

MMS is currently examining what is considered to be new technology or innovative uses of old technology in trying to determine if existing regulations can be adequately applied or if new regulations need to be promulgated.

With regard to exploratory operations, MMS is looking into the adequacy of station-keeping ability of mobile offshore drilling units, very long mud-risers, diverters, choke and kill lines, and blowout preventers. The reliability of these systems must be maximized for deepwater operations. Also, MMS is assessing procedures for the recontrol of wells blown out in deep water and the necessity for regulations which may be needed for MMS verification of design, manufacture, inspection, and operation of certain drilling equipment.

With regard to production, in 1980 the platform verification program was instituted by MMS under which all platforms in water depths greater than 400 ft must have their design, fabrication, and installation reviewed by an independent third party to verify that the design, fabrication, and installation are in accordance with the MMS requirements for verifying structural integrity of OCS platforms. More than 42 structures have been processed successfully to date and, therefore, no new regulations are anticipated as we move into deeper water. It's possible that new regulations for underwater inspection of production platforms are soon to be proposed.

The MMS in the Gulf of Mexico region currently has a task group formed to determine where new regulations might be needed for subsea completion systems. The MMS will continue to rely on industry standards where possible and also to interface with industry to have a common base of knowledge to formulate any new requirements that might be needed.

I gave the second paper, an overview of current deep water technology. We started by looking at a slide of how deepwater exploratory drilling or how world-wide exploratory drilling has proceeded in the deeper water since the mid-sixties, culminating in the current depth record of 6952 ft off New Jersey drilled by Shell in 1984.

We looked at deep water leasing and drilling activity in the Gulf of Mexico since 1983. Some 961 tracts were leased in over 300 ft of water, and 83 of those were in over 3000 ft of water, the deepest of which is in the southwest corner of the Green Canyon area in about 7400 ft of water. Drilling activity has been in a flurry since the first of the year; 41 exploratory wells have been spudded in more than 1000 ft of water in the Gulf.

We went on to look at types of rigs available for doing exploratory drilling. The jack-up rig, which is limited to about 450-ft water depths by the length of the legs, and then the two floaters, the semisubmersible and drill ships. The semisubmersible offers larger deck space, but it has smaller weight capacity because of a lower wetted surface area and, therefore, it needs more support vessels. However, one other advantage is that it's much more stable than a ship-shaped drill rig. Because the drilling ships have more wetted surface area, they can support more weight, and they are more mobile.

Four technological achievements have allowed drilling to move off into deeper and deeper water. There's dynamic positioning, electro-hydraulic blowout preventer control to reduce reaction time, the marine risers with syntactic foam buoyancy, and improved couplings and guidelineless re-entry with underwater TV and sonar.

For production systems we looked basically at the conventional platforms, compliant structures such as the guyed tower, the tension-leg platform. We looked at floating production systems utilizing converted semisubmersibles and submerged production systems.

Then we went on to look at transportation systems such as pipelines using conventional lay techniques, J-tube or verticle-lay techniques for deeper water, reel methods where it's spooled on to a large reel and spooled off, or where pipelines are made up onshore and dragged to the site and installed. And then shuttle tankering, the other transportation alternative, utilizing catenary anchor leg mooring or single anchor leg moorings.

Our third speaker was Mr. Vernon Greif, the manager of Rig Support Engineering for the Dallas engineering group of Sedco Forex Drilling Contractor. It was an interesting talk on deepwater drilling operations and it was liberally interspersed with colorful ancedotes from his operational background. He went into detail on the four technological achievements I previously mentioned.

On dynamic positioning, he went into the navigation that's utilized, the different systems that are utilized, and the station-keeping. And he wound up with a big advantage in that a dynamically-positioned vessel can arrive on station and literally within 30 minutes be lowering the drill bit to spud the hole in. One of the big disadvantages is that dynamically positioned drill rigs are very thirsty. A drill ship with roughly 20,000 available horsepower would utilize about 6500 U.S. gallons a day of fuel to maintain station and operate all of the drilling equipment; whereas, a large, dynamically-positioned semisubmersible with 25,000 available horsepower would use some 11,000 gallons a day. One drill ship, the *SEDCO 471* has recently been refitted and is participating in the National Science Foundation's deep ocean drilling program. It's equipped to drill in 27,000 ft of water.

Mr. Greif went into blowout preventers, their operating systems, and the multi-plex control systems and backup systems. Then we talked about risers -- how the risers are made up, the problems they had vortex shedding in currents and some of the methodology used to overcome those problems. He also went into the syntactic foam buoyancy modules to help alleviate some of the weight problems in very deep water.

We then talked briefly about guidelineless re-entry. They have developed a sub that goes down -- it's a piece of tubing that goes down the inside of the drill pipe when they get ready to re-enter and it goes out the bottom of the pipe. It has a small television camera with lights at the end of it and on the very tip; on the side, it has a side-looking sonar. To test this they took the*SEDCO 471* out in the Atlantic using navigation from the old *Glomar Challenger*. They went out and found one of the deepsea drilling project sites and actually re-entered a hole in 16,000 ft of water that had been abandoned earlier. He closed with a discussion of design considerations for deep water.

The next speaker was Mr. Bob Hansen, who is Senior Research Supervisor for the Subsea Systems, Exxon Production Research in Houston. He gave an interesting talk on subsea production systems. Most of the systems now working are in the North Sea and Brazil. In Brazil, the oil company Petrobras is the largest user of subsea completions in the world, and they hold the depth record of 1257 ft. They have one well that's been drilled and completed, and the system is designed and under construction for a 3000-ft water depth.

Three hundred and thirty-four subsea production systems have been installed world-wide and of those 83 have been abandoned.

Mr. Hansen went into Exxon's deepwater submerged production system that was tested in the Gulf of Mexico from 1974 to 1979. It was installed, operated, and maintained without diver assistance. And they were able to, during the life of the test, to change out all of the valves and all of the control pods using a maintenance manipulator. He gave examples of active systems such as the Central Cormorant Field in the North Sea. It has nine wells producing 30,000 barrels of oil a day. It's been extremely reliable and they have 98% up-time with that system.

The Northeast Frigg Field, operated by Elf, has six very prolific gas wells producing 50 million cubic ft a day each. And the Argyle Field -- and another example was the Garoupa Field, off Brazil. That has a number of wells all leading back to a central manifold. And the wellheads and the manifold are all located inside of a one-atmosphere chamber.

And then we talked about the Zinc prospect, which is Exxon's prospect in the Mississippi Canyon Area. It's in 1500 ft of water. The wells have been drilled -- or the reservoir has proven out. Gas is to be produced with a submarine production system with four wells and it will be piped to a platform in Mississippi Canyon 268, which is about four miles away. One of the concerns they have is the formation of hydrates in the product line and to counteract that they will be injecting methanol at the wellhead.

Our last speaker was Dr. Bonnie McGregor, who is a marine geologist with the U.S. Geological Survey. She was the chief scientist on the *GLORIA* cruise. The *GLORIA* is a side-scan sonar. GLORIA itself is an acronym for Geological Long Range Inclined Asdic operated by the Institute of Oceanographic Sciences in England. The tow-fish is 25 ft long. It's towed at ten knots, 50 m below the surface and 400 m behind the ship. And it can record up to a 60 km swath width, 30 km to each side. In the Gulf of Mexico this summer, they recorded some 130,000 square nautical miles of sea floor. They formed composites which she had along. And we looked at some selected areas along the Sigsbee Escarpment, the Sigsbee Canyon, and on the Mississippi Fan. The data from that system were digitally recorded and is being set up for satellite imagery processing to enhance the data. That data will be published in one by two degree sheets along with the bathymetry in atlas form by December 1986.

Jesse L. Hunt, Jr., is an environmental protection specialist for MMS. He received a BS degree in Geology in 1969 and an MS in Marine Geology in 1974, both from the University of Georgia. Following a sedimentological study of the Caribbean continental margin of Venezuela, he spent five years with BLM's New Orleans OCS office as an oceanographer/geologist. Mr. Hunt went to Gulf Oil as a geologist involved in exploration offshore Louisiana. He returned to MMS this past August.

Minerals Management Service: The Role of the Regulatory Agency with Respect to Deepwater Operations

Mr. Richard B. Krahl
Deputy Associate Director for Offshore Operations
Minerals Management Service

As recent Gulf of Mexico (GOM) lease sales have indicated, the U.S. offshore oil and gas industry believes they now have the capability to drill and produce wells in greater water depths. These capabilities have been demonstrated by successes such as Shell Oil Company's drilling of an exploratory well in 6952 ft of water in Baltimore Canyon off the U.S. East Coast. Further successes have been enjoyed by Shell, Exxon, and Union Oil Companies in their design, fabrication, and installation of four platforms in approximately 1000-ft water depths in the GOM. Included in this number is Exxon's guyed tower, an innovative new concept in offshore platform technology. Furthermore, Shell is presently constructing a fixed platform for 1350 ft of water in Green Canyon Block 65; Placid Oil Company is converting an existing semisubmersible drilling unit for use as a floating production platform in 1500 ft of water in Green Canyon Block 29, and Conoco is seeking Minerals Management Service (MMS) permits to install a combination tension-leg platform (TLP)/moored tanker production unit in 1720 ft of water in Green Canyon Block 184. Even greater water depths are being challenged overseas where Chevron's Montanazo D2 discovery offshore Spain is planned for production in 2474 ft of water using a subsea completion. Servicing of the well will be primarily by a remotely operated vehicle although vertical entry of the Christmas tree will be provided as an option.

As industry operations move into even deeper waters in the GOM, the development and application of new technologies in drilling and producing hydrocarbons are inevitable. In such depths, even the use of proven technologies and equipment will require innovation in their application and maintenance.

Just as industry must anticipate new problems and strive for their solutions, the regulatory agencies must anticipate the need for regulatory changes brought about by departures from our experience base. A logical first step in this endeavor is to examine what is considered to be new technology, or innovative uses of old technology, and then to determine if existing regulations can be adequately applied or if new regulations must be promulgated. The MMS is at precisely this point with regard to deepwater operations on the GOM Outer Continental Shelf (OCS). Therefore, I will attempt today to point out those areas where we believe an assessment of existing regulations is necessary and, where possible, what our plans and/or throughts are at this time.

Since exploratory drilling activities precede development activities, let me first address those aspects of deepwater drilling where regulatory efforts may be directed. The adequacy of such items as the station-keeping ability of mobile offshore drilling units (MODU), very long mud risers, diverters, choke and kill lines, and blowout preventers (BOP) will be studied since the reliability of such equipment must be maximized for deepwater applications. Other considerations include assessments of the procedures for the recontrol of a well which has blown out in deep waters and the necessity for regulations which may be needed for MMS verification of the design, manufacture, inspection, and operation of certain drilling equipment.

Production activities are moving into deeper waters with unprecedented speed. Increased oil prices have provided the incentive, and innovative platform design concepts have provided the means to produce the large fields being found at those deep locations. This first viewgraph indicates four such concepts which can be used in GOM waters. From this chart, one can notice that beyond approximately 1400 to 1600 ft of water depth, economics narrow the choice of platform types to the TLP and the floating production facility. Other than cost comparisons, the TLP usually has the well-completion equipment located above the waterline and access is relatively easy, whereas the floating production facility normally has the completion equipment located on the seafloor. The subject of subsea completions is not new to the MMS, but their application in deep water beyond the reach of divers has increased our awareness of the possible need for new regulations governing their use. This subject will be discussed later, but first I would like to address regulations governing the platform structures themselves.

In January 1980, the MMS instituted the Platform Verification Program whereby all platforms installed in the GOM in water depths exceeding 400 ft must have their design, fabrication, and installation reviewed by an independent third party. The review must verify that the three phases mentioned above are carried out in accordance with the MMS "Requirements for Verifying the Structural Integrity of OCS Platforms." The stated purpose of the document is the enumeration of requirements that, combined with sound engineering practice and methodology, can achieve an acceptable safety level. That level must be consistent with the overall objectives of minimizing the consequences of failure and of ensuring that the oil and gas resources are produced with the greatest possible regard for human life and the safety of the marine environment.

To date, more than 42 structures from all OCS areas have been successfully processed through the program, and no new regulations are anticipated as production moves into deeper waters. The present program does not address the need for structural inspection of production platforms once they are placed into service. However, minimum requirements for underwater inspection of the structures are being proposed in the soon-to-be published regulatory reform package. For ultradeep water operations, where divers cannot readily inspect or repair structural members, periodic inspection by remotely operated vehicles or some form of flexibility monitoring may be studied as a means of satisfying any needed regulations in this area. In accordance with a Memorandum of Understanding between the U.S. Coast Guard (USCG) and the MMS, structural certification of buoyant production facilities such as TLP's and floating production platforms is the responsibility of the USCG. As such, postinstallation periodic inspections of those structures are required under their present regulations and is, therefore, not a subject for further regulatory consideration by the MMS. However, it is worth mentioning that discussions with the USCG are being planned which may result in the transferral of responsibility for the structural verification of buoyant production facilities to the MMS.

As indicated in the previous viewgraph, floating production facilities present a favorable economic picture to 7000-ft water depth. It is, therefore, reasonable to assume that their use for production of deepwater fields in the GOM will increase with time. Since such facilities usually rely heavily on the use of subsea completions and complicated production risers, the MMS believes that new regulations are needed which address those areas.

As shown on this viewgraph, estimates of subsea completions through the year 2000 indicate a substantial increase in both their number and installation water depth. The chart includes both wet and dry trees and is worldwide in scope. Anticipating increases in their future use, the MMS GOM Region has formed a task group to determine where new regulations for subsea completions may be necessary. This task group, having only recently been organized, has not yet formed any conclusions on this matter. However, areas being explored include:

a. Safety systems.

b. Process components possibly located on the seafloor.

c. Risers and hydraulic/mechanical riser connections - structural integrity and disconnect time.

d. How workover operations will be carried out.

e. Well control - controlling a kick when the wellhead is on the ocean floor.

The process for the development of regulations is dynamic and interactive. We continue to study the need for new requirements looking at the different environmental conditions in which operations are being conducted together with the experiences encountered during these operations. To date, the necessity for establishing additional requirements has not been realized. However, it is anticipated that the regulatory regime will need to be expanded to include more specific provisions dealing with deepwater operations. These will be set forth as performance standards to the greatest extent possible, and where more specific requirements are necessary we will continue to rely on accepted existing industry standards where appropriate. As such, a technical interface with the industry will be maintained to ensure that there is a common base of knowledge from which to formulate any new requirements. Along with this, our Branch of Technology Assessment and Research is funding several contract studies looking at various aspects of deepwater drilling and production activities in order to identify at an early stage potential problems in equipment and operations that might be mitigated through the judicious application of regulatory requirements.

REFER TO FIGURES IIIA.1 - IIIA.2.

Biography: See Session IIF, Paper 5.

Deepwater Operations: An Overview

Jesse L. Hunt, Jr.
Minerals Management Service

Worldwide Exploratory drilling has proceeded into deeper water since the mid 1960's, culminating in the current water depth record of 6952 ft offshore New Jersey by Shell Oil in 1984.

Since 1983 in the Gulf of Mexico, 961 tracts have been leased in water depths exceeding 300 ft, and 83 have been leased in more than 3000 ft of water. The deepest tract leased to present in the Gulf of Mexico is in the southwest corner of Green Canyon Area in more than 7400 ft of water.

Three types of rigs are used for exploration drilling: the jack-up rig, which is limited to about 450 ft by the length of the legs; semisubmersibles; and drillships. Semisubmersibles have larger deck space than drillships but carry less weight capacity. They therefore need more support vessels. They are also more stable. Drillships have a larger wetted-surface area, and therefore are able to carry more weight than semisubmersibles, which makes them more self-sufficient and mobile.

Four technological achievements have allowed drilling in ever-increasing water depth:

- dynamic positioning
- electro-hydraulic blow out preventer control to reduce reaction time
- marine risers with syntactic foam bouyancy and improved couplings
- guidelineless re-entry with TV and sonar.

For production, conventional platforms have long been the standard for the offshore oil and gas industry. The 46,000 ton Cognac Platform Shell Oil installed in the Gulf of Mexico is the deepest conventional platform in the world at 1025 ft. The amount of steel, and thus the cost, for construction of conventional platforms increases exponentially with water depth. Maximum feasible depth is about 1500 to 2000 ft of water.

Compliant structures were developed to reduce the amount of structural steel required for construction. They are designed to move with environmental forces. The guyed tower and tension leg platforms are the compliant structures currently in use. Exxon installed their Lena Platform in the Gulf of Mexico in 1983 in 1000 ft of water. This guyed tower is similar to a conventional platform, but is much smaller, is mounted on a swivel base, and is held upright by guy wires. This design can be used for water as deep as 2000 to 2500 ft.

The tension leg platform is a floating system held in place over the well template by tension members (usually rods connected to a piled foundation). The first tension leg platform was installed in the Hutton Field in the North Sea in 485 ft of water. Conoco also plans to install a similar system in the Gulf of Mexico in 1700 ft of water.

Floating production systems offer another alternative for deepwater production and are usually used with subsea well completions. These systems have generally utilized converted semisubmersible drill rigs. The deepest floating system in use was installed off Tunisia in 1982 in 460 ft of water.

The two categories of subsea completions in use are wet completion and dry completion . The wet system has the wellhead exposed to sea water whereas the wellhead is in a one- atmosphere chamber in the dry system. Both may also use a multiwell template.

Conventional pipeline construction in deepwater faces two major problems: the "S" curve sag bend and over bend stress, and the ability of tensioners to support heavy coated pipe in deeper water. Twenty-inch pipe has been laid in the Mediterranean in 2060 ft of water.

To eliminate the "S" curve, methods have been developed for "J" curve construction. The major obstacle in this method involves the welding process. The industry is now developing electron beam welding to speed up the process.

Pipelines can also be constructed on shore and towed to the site on the surface, at mid-water depths, or on the bottom.

Future deepwater technological advances will be determined by the economic incentives provided by large discoveries and the need to exploit them. Deepwater areas may prove to be a valuable source of hydrocarbon energy as easier sources are depleted.

Biography: See Session IIIA.

Deepwater Drilling Technology

Vernon Grief
Rig-Support Engineering
Sedco-Forex

The types of equipment used for exploratory deepwater drilling include jack ups for 300 to 450 ft, semisubmersibles for depths to 1500 ft, and drillships for 6000 to 8000 ft. The technology is now available to drill in water deeper than 6900 ft. Drillships hold more tonnage and have greater mobility. Semisubmersibles are more stable and have larger deckspace but don't hold as large a deck load.

One consideration in deepwater drilling is station keeping. Modern rigs can drill in about 1200 ft of water with chain mooring. Typically a 3-in. chain mooring with thruster assist can be extended to depths of 1700 ft. Off the Philippines a well was drilled in 2500 ft of water using a combination chain/wire system. The wire provides restoring force and the chain adds weight to the anchor.

Dynamic positioning is one innovation which has allowed drilling in very deep water. Various position-sensing systems feed into a central computer which controls lateral and fore/aft thrusters to maintain the vessel over the well. A big advantage is that a vessel can literally start drilling within about 30 minutes of arrival on station. One big disadvantage is fuel consumption: a typical modern semisubmersible with 20,000 horsepower will consume about 6500 gal. of fuel in a day, and a modern drill ship with 25,000 horsepower can consume some 7000 gal. per day. Under harsh environmental conditions, a vessel may consume as much as 11,000 gal. of fuel in a day. Since there is no contact of a mooring system, dynamically positioned vessels are not limited by water depth as conventional mooring systems are. The drillship *SEDCO 471* is such a vessel, and is equipped to drill in 27,000 ft of water. It is under contract for the Deep Ocean Drilling Project of the National Science Foundation.

The next innovation allowing drilling in deeper water is electro-hydraulic blowout preventers (BOP). The BOP stack is typically mounted at the seafloor, and the well is drilled through it to control the well should high pressure be encountered. Large, high pressure accumulators are mounted on the BOP to provide rapid hydraulic pressure to operate all systems without resupply from the surface. Resupply lines are available, however. Multiplex control cables allow multiple electrical control signals to be sent or received simultaneously to operate the proper valves and rams on the BOP, while keeping the size of the cable as small as possible.

The third innovation mentioned in the previous presentation is in riser design. An attempt is always made to use the smallest riser possible. Risers must be kept in tension to avoid buckling. Tensioners are used on the vessel to allow movement with wave surges and still maintain constant tension. At the same time a riser recoil system must be used to prevent the riser from driving up through the rotary should an accidental or emergency disconnect occur. To alleviate the weight problem with long heavy risers in deep water, syntactic foam buoyancy modules are added to the riser. These units are 90 to 98% bouyant and must go through the rotary table during installation of the riser. Stress levels in the riser are generally kept at around 1/3 yield. Under harsh conditions, stress may approach 50% yield.

The last major innovation of the four is guidelineless re-entry using sonar and underwater TV. The *SEDCO 471* successfully re-entered a hole using such a system in 16000-ft water depth in the Atlantic Ocean which was abandoned by the *Glomar Challenger*.

Prior to any deepwater operation, a number of design considerations must be thoroughly analyzed. These include such factors as formation fracture gradient, disconnect plan (displace riser, etc.), well control techniques, hydrate occurrence, storm contingencies, and proper training for all personnel.

Mr. Vernon Greif is currently Manager of Rig Support Engineering for the Dallas Engineering Group of Sedco-Forex. Mr. Grief has been a petroleum engineer in the industry for 22 years, 20 of which have been with Sedco-Forex.

Subsea Production Systems: A Current Overview

Mr. R. L. Hansen
Exxon Production Research Company

The principal motivations for subsea completions are to extend the reach of platforms, to develop marginal fields, to provide early production, and to develop deepwater locations. Based upon about 25 years of experience, subsea completions have evolved into a technically mature option for offshore oil and gas development. Research, field testing, and commercial development have advanced subsea technology to where it is now ready for water depths up to 5000 ft or more.

Many subsea configuration options are available and have been used commercially, with the processing located on a floating vessel, a nearby platform, or land, and with production from wells manifolded together or produced separately. Most subsea trees are "wet trees," exposed to the marine environment, but some "dry trees" have also been used, where a dry chamber isolates the tree from the marine environment.

Of the 334 subsea wells that have been installed and produced worldwide, most have been in less than 600 ft of water. However, two are in slightly more than 1000 ft, and several others have been drilled and are awaiting production equipment in water depths out to 3000 ft off Brazil. The recent deepwater completions installed off Brazil are designed for installation without diver assist. Many of the subsea completions installed previously off Brazil and elsewhere in the world were also designed for diverless installation to develop the hardware and techniques in shallow water. This wide variety of experience by many operators and suppliers provides a solid basis for extension to deeper water.

WORLDWIDE SUBSEA COMPLETIONS BY WATER DEPTH (Rev. 10/85)

Water Depth (Feet)	Number of Wells	Percentage
0-90	46	14

90-150	46	14
150-300	80	24
300-600	134	40
600-1000	26	7
1000	2	1

Maintenance of trees and related equipment has been done mostly by divers or by retrieving the tree. Diverless, remotely-operated vehicles (ROV's) of various kinds, which have been evolving for over 20 years, are now available for truly diverless maintenance of seafloor hardware. Even many downhole servicing tasks can be done remotely using through flowline (TFL) techniques which have undergone over 20 years of evolution and refinement. About 53 of the wells completed so far are equipped for TFL servicing. This capability may become more important as use of subsea wells expands into deeper water, where conventional servicing becomes more difficult and more expensive.

Worldwide, about 250 subsea wells are still active. Most commercial subsea completions have achieved their goals without major difficulty. Only a few, less than 5%, have been abandoned with downhole or mechanical problems. Many subsea trees have produced over the field life, some up to 20 years, with no maintenance required, and the tree hardware was found to be still functioning within acceptable limits.

WORLDWIDE SUBSEA COMPLETIONS

Active	251
Abandoned	83
Total	334

REASONS FOR ABANDONMENT:

Depleted	45
Downhole or Mechanical Problem	16
Marine Damage	2
Completion of Research Project	9
Field Redeployment	6
Other	2
Unknown	3
	83

Looking toward the future, the use of subsea completions appears to be increasing, especially as the industry develops smaller reserves and deeper water prospects. They will continue to both compete with and supplement surface-based alternatives and will find applications where reservoir and economic conditions make them attractive. Subsea systems are now an established option for development of offshore fields. The API is supporting this technology through the Committee on Standardization of Subsea Systems, which was formed in 1984.

Although subsea completions have a good record for safe, reliable production, more attention will be devoted to improved reliability and reduced installation and maintenance costs, which should enhance the economic viability of some marginal subsea developments. Emphasis on quality assurance will be especially important, and the combined efforts of the API, operators, and vendors will be essential to ensure that reliable subsea equipment is available to the industry.

NEAR TERM CHALLENGES

- SEAFLOOR EQUIPMENT RELIABILITY AND MAINTENANCE
- DIVERLESS INSTALLATION AND MAINTENANCE
- PIPELINE/FLOWLINE INSTALLATION AND MAINTENANCE
- MARINE PRODUCTION RISER
- HYDRATE CONTROL
- WORKOVER REQUIREMENTS AND METHODS
- ARTIFICIAL LIFT
- HIGH PRESSURE CAPABILITY
- COST REDUCTION
- QUALITY ASSURANCE

REFER TO FIGURE IIIA.3.

Mr. R. L. Hansen is Senior Research Supervisor of the Subsea Systems Section, Offshore Systems Division, for Exxon Production Research Company. He holds a BS in Mechanical Engineering from Iowa State University and an MBA degree from Oklahoma City University. He has been with Exxon for 20 years and has been developing subsea production systems since 1972.

U. S. Geological Survey Mapping Program in the Gulf of Mexico

Dr. Bonnie A. McGregor
U. S. Geological Survey

INTRODUCTION

The 1983 presidential proclamation of a U.S. Exclusive Economic Zone (EEZ) established federal jurisdiction over the submerged lands extending 200 nautical miles seaward from the coast of the United States, the Commonwealths of the Northern Mariana Islands and Puerto Rico, the Virgin Islands, and other U.S. territories and possessions. The EEZ encompasses over 3 million square nautical miles of federal lands, many of which contain potential energy and mineral resources. The vast size of the EEZ, which is approximately 30% larger than the subaerial land area of the United States, requires a coordinated national effort to evaluate and develop the potential resources of this area.

As a first step in evaluating the EEZ, the U.S. Geological Survey (USGS) is completing a series of reconnaissance scale maps of the sea-floor morphology of the EEZ using the GLORIA (Geological Long-range Inclined Asdic) system designed, developed, and operated by the Institute of Oceanographic Sciences (IOS), United Kingdom. *GLORIA*, which provides a map view of the sea floor in swaths 30, 45, or 60 km wide, is towed at a speed of 15-18 km/hr, approximately 50 m below the sea surface.

Mapping of the EEZ was initiated off the west coast of the United States during the spring and summer of 1984. The area mapped extended from the continental shelf edge to the seaward boundary of the EEZ between the Mexican and Canadian borders. In 1985 the USGS mapping effort focused on the EEZ in the Gulf of Mexico. Approximately 380,000 square km in the Gulf of Mexico were mapped from about the shelf edge seaward, starting in August and continuing through the middle of October (Figure IIIA.4). In 1982, a portion of the continental slope (approximately 70,000 square km) seaward of Texas and Louisiana was surveyed using the *GLORIA* sidescan-sonar system. The data that were collected in 1985 are being merged with this earlier survey.

A preliminary mosaic of the data was constructed aboard ship at a scale of 1:375,000. The sidescan sonar data, which are recorded digitally, will undergo post cruise processing to remove radiometric and geometric distortions and to enhance the images (Chavez, 1984). Image-enhanced sonographs and geologic interpretations of these data will be published in a USGS atlas series as 22 two-degree sheets at a scale of 1:500,000. Single-channel seismic reflection profile data collected during the survey will be included in the atlas.

GULF OF MEXICO SURVEY

The *GLORIA* survey of the Gulf of Mexico (August 7 to October 22, 1985) was divided into three parts, or legs, each focusing on a different region of the Gulf with different geologic settings. The MV *FARNELLA* departed Miami, FL on August 7, 1985, to begin the survey. On Leg 1 the survey centered on the western Gulf seaward of Texas and Louisiana, abutting the 1982 coverage, terminating in New Orleans. This part of the Gulf is dominated by salt tectonics. The Sigsbee Escarpment, the seaward edge of a salt front, was mapped on the sidescan sonographs from the Western Gulf to just west of the Mississippi Canyon. The Escarpment is marked by piles of debris along its base and several re-entrants formed by submarine channels. One such meandering channel can be traced from the shelf edge through the maze of diapirs on the slope and out across the Sigsbee Abyssal Plain. Numerous bedforms are present seaward of the Sigsbee Escarpment, suggesting that strong bottom currents are present. Leg 2 focused on the Mississippi Canyon and fan system in the central Gulf. Much of the Mississippi Fan and its channel are buried by submarine slides or debris flows. Based on the sonographs, mass wasting appears to be an important process in distributing sediments in the deep water of the central Gulf. Leg 3 concentrated on the West Florida Escarpment, the western edge of the Florida carbonate platform, and also completed the coverage of the lower Mississippi Fan and part of the Florida Abyssal Plain.

Each of these cruise legs has focused on a different area with different geologic problems, processes, and setting. A better understanding of the morphology, surficial geology, and sedimentary processes of the continental slope and rise in the Gulf of Mexico is important for evaluating and developing energy resources. Because of industry's interests in and improvements in deep-water drilling technology, exploration is moving into this deep-water area. Results from the *GLORIA* survey will contribute to a better understanding of the depositional environments of these deep-water areas, which will in turn be valuable in developing depositional models for exploration and in identifying areas that are potentially hazardous for development.

FUTURE PLANS

These USGS reconnaissance scale maps will be used to identify areas of geologic interest for further study. In the future, additional types of data will be collected with tools designed to address specific problems. Deep-towed sidescan systems and video-camera systems will provide information on details of the morphology, the processes responsible for the observed morphology, and textural differences inferred from sonographs. In order to define further the processes associated with a particular geologic phenomenon or setting, an additional suite of data to be collected may include: (1) observations, samples, and measurements using submersibles or deep-towed remote controlled systems; (2) measurements of currents and bottom-sediment transport by tripods; (3) piston cores and dredged samples; (4) measurements of sediment properties using available drillcores; (5) measurement of geotechnical properties of the sediments using in situ probes; and (6) additional seismic reflection profiles. This variety of data is needed to unravel the processes of sedimentation and to aid in the resource evaluation and development seaward of the shelf edge in the deepwater of the Gulf of Mexico.

Chavez, P.S., Jr., 1984, U.S. Geological Survey Mini Image Processing System (MIPS): U.S. Geological Survey Open-File Report 84-353, 12 pp.

Dr. Bonnie McGregor is a marine geologist with U.S.G.S. She holds a BS degree in Geology from Tufts University, an MS degree in Oceanography from University of Rhode Island, and a PhD in Marine Geology from the University of Miami. She was a Marine Geologist for NOAA for 10 years, spent 1 1/2 years as a research associate at Texas A&M University, and has been with USGS for six years. Most recently she was chief scientist for the *GLORIA* cruise in the Gulf of Mexico.

Figure IIIA.1 - Production Activities (Relative Costs to Water Depth)

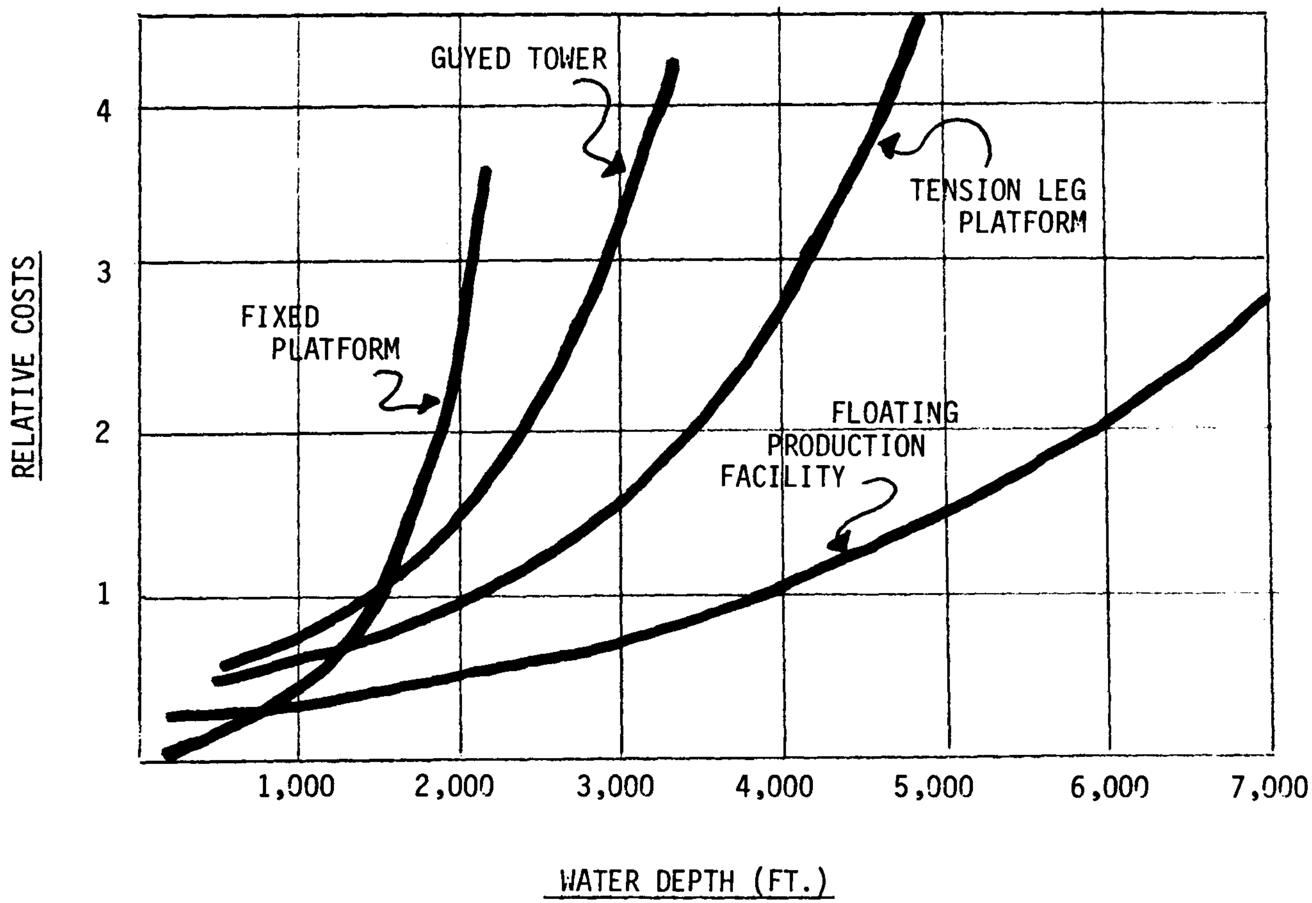
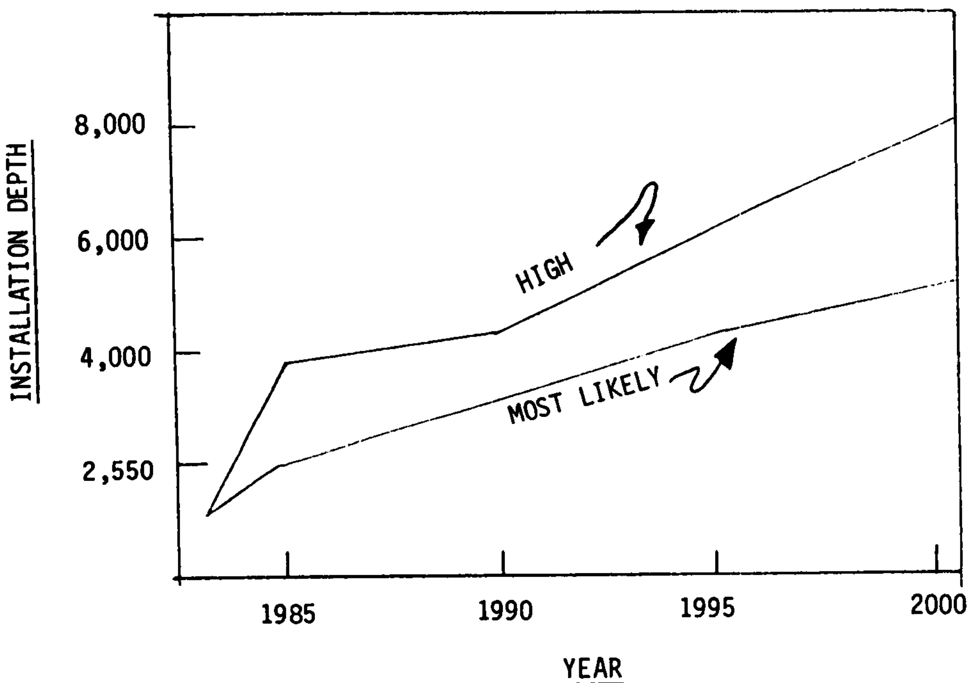


Figure IIIA.2 - Future Estimates - Subsea Completions



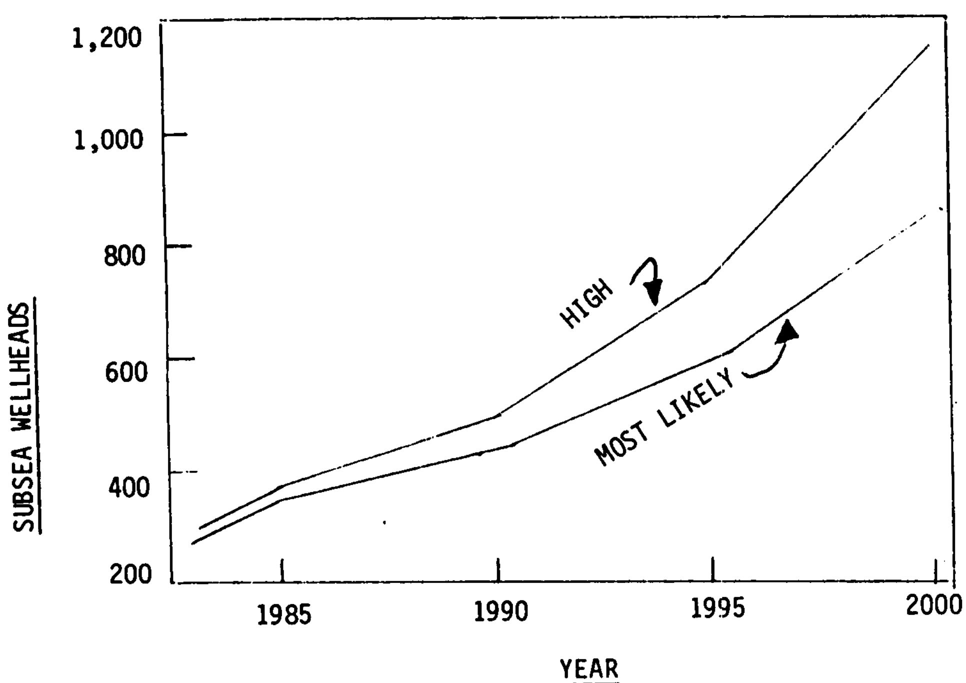
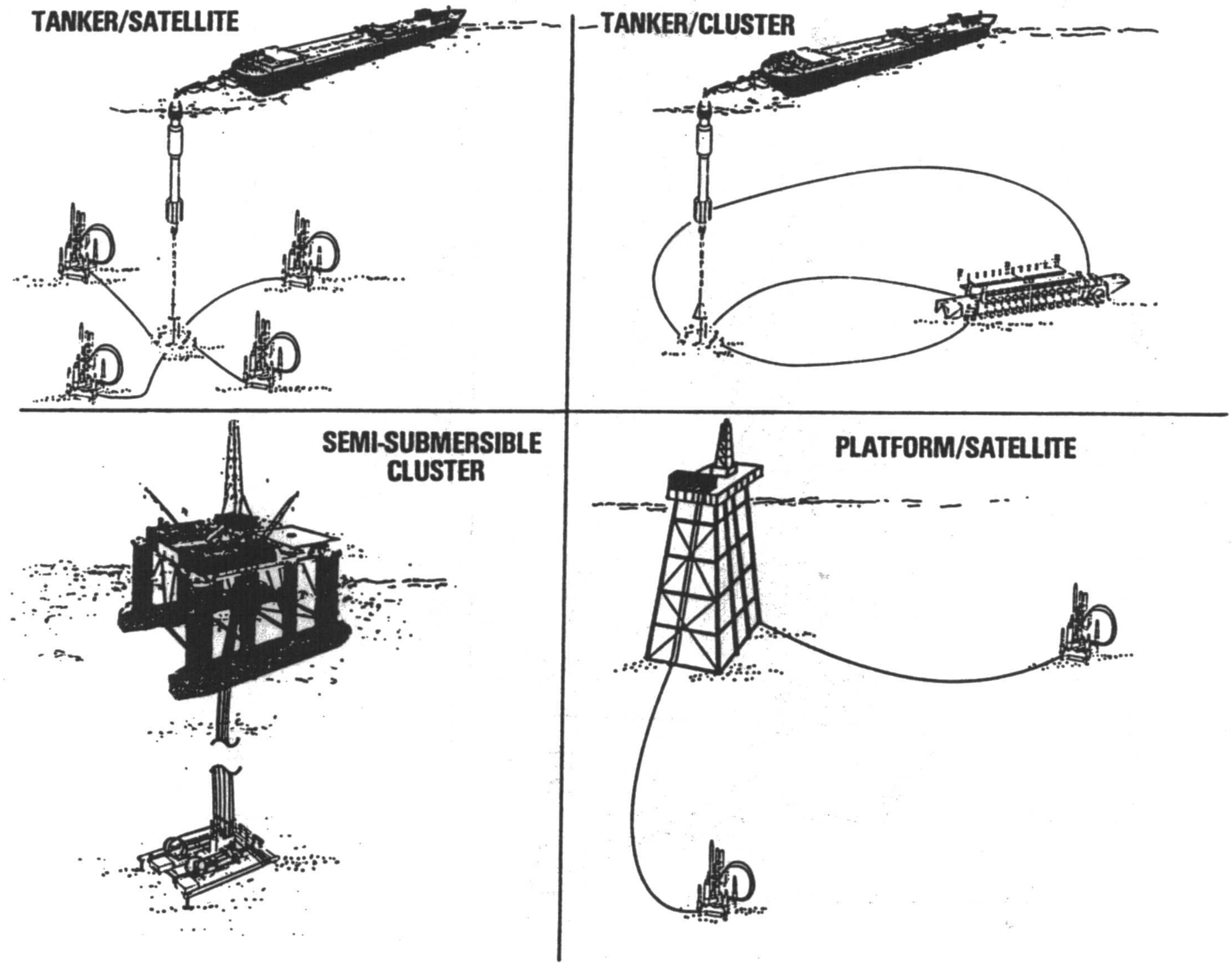


Figure IIIA.3 - Subsea Production Configurations



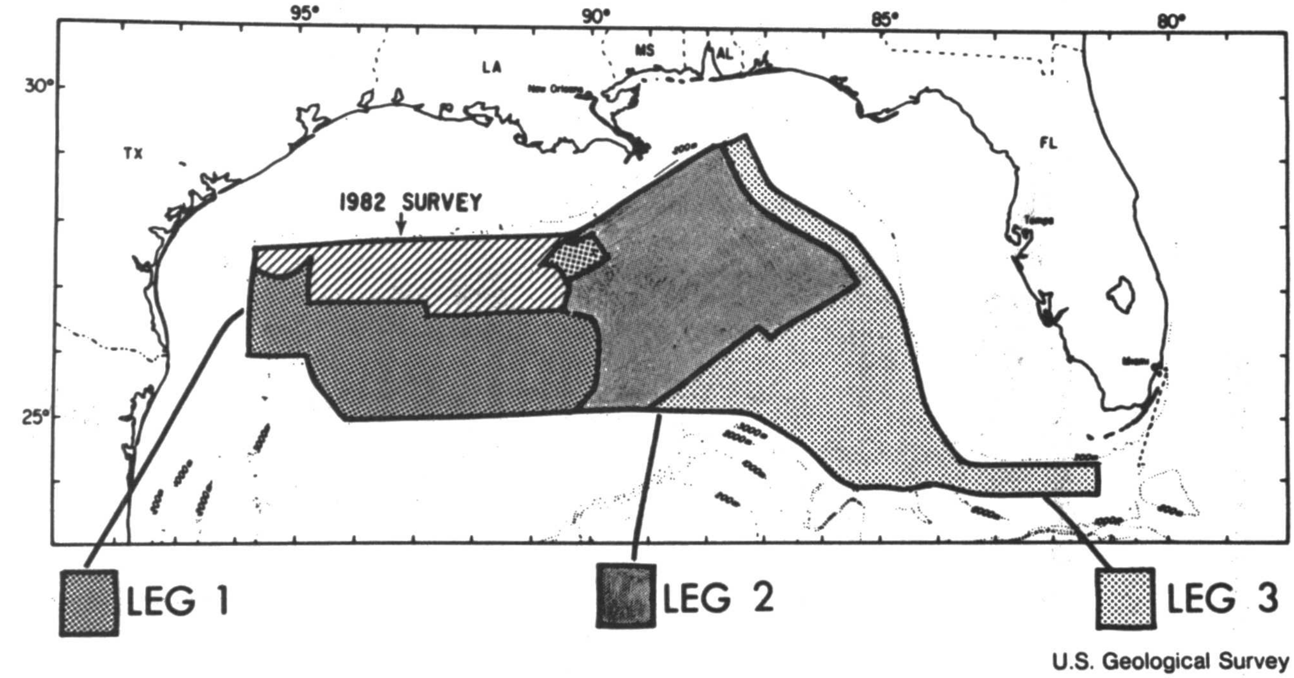


Figure IIIA.4 - GLORIA Sidescan Sonar Survey of the Gulf of Mexico

MMS MARINE ECOLOGICAL STUDIES IN THE GULF OF MEXICO

Session: MMS MARINE ECOLOGICAL STUDIES IN THE GULF OF MEXICO

Chairman: Dr. Robert Rogers

Date: October 23, 1985

Presentation Title	Speaker/Affiliation
MMS Gulf of Mexico Marine Ecological Studies: Session Summary	Dr. Robert Rogers Minerals Management Service
Tuscaloosa Trend Regional Data Search and Synthesis Study	Dr. Barry A. Vittor Barry A. Vittor & Associates, Inc.
Seagrass Habitat Mapping in the Big Bend of Florida	Mr. John Thompson Continental Shelf Associates, Inc.
Biological Resource Mapping in the Northwestern and Eastern Gulf of Mexico	Dr. Rezneat M. Darnell Department of Oceanography Texas A&M University
Recent Discoveries of Deep Water Communities in the Northwestern Gulf of Mexico	Dr. Mahlon C. Kennicutt, II Department of Oceanography Texas A&M University and Dr. Benny Galloway LGL Ecological Research Associates, Inc.

MMS Gulf of Mexico Marine Ecological Studies: Session Summary

Dr. Robert Rogers
Minerals Management Service

A large component of the MMS Environmental Studies Program is the marine ecological studies series. Since the inception of the studies program in 1974, approximately $40 million have been spent in the Gulf of Mexico on marine ecological studies.

As oil and gas development proceeds in the Gulf, particular areas of concern have to be addressed by state and federal agencies, industrial managers, and the environmentally-concerned public. Marine studies have to be designed with these concerns in mind. Recently these studies have centered about such environmental issues as live bottoms and seagrass communities off Florida, the Tuscaloosa Trend off Mississippi, Alabama, Louisiana, and fisheries resources on the western and eastern Gulf OCS, as well as deep-water communities throughout the Gulf of Mexico.

The first speaker in this session was Dr. Barry Vittor of Vittor and Associates, Inc. His organization along with Quantus, Inc., and Science Applications, Inc., have recently completed the Tuscaloosa Trend Data Search and Synthesis study. This study was designed to gather and synthesize environmental information relevant to the Outer Continental Shelf (OCS) and coastal areas of eastern Louisiana, Mississippi, and Alabama. This is an area of active oil and gas exploration and development interest. The potential ecological impacts of this accelerated interest along with the many other socioeconomic activities in this area are of concern to the MMS and to adjoining states.

Dr. Vittor reviewed the five sections of the report including a discussion on geological oceanography, physical oceanography, chemical oceanography, ecosystem structure, and the socioeconomics of the area. As part of the study, such data gaps as the following were identified. In the discipline of physical oceanography, information is needed on the nepheloid layer of the area. Also, as in Louisiana and other areas of the Gulf of Mexico, there seems to be a significant problem with hypoxia (low oxygen) on the Shelf. The highest priority for studies needs in the future should be in the chemical oceanography section. Historically, not a great deal of work has been done on the chemical components of the sediments, as well as the water column. Data gaps regarding the ecosystem function include poor information on plankton and primary production.

This data search and synthesis contract have just been completed, and the very limited number of copies initially available were quickly exhausted. More copies will be available in the near future and can be obtained from our office for those who are interested. In addition, a computer-based literature search was initiated yielding over 2000 reference citations. In the near future, a field effort is planned to further fill the environmental data gaps and investigate areas of concern expressed by federal and state agencies related to the Mississippi/Alabama Shelf.

The second speaker was Mr. John Thompson of Continental Shelf Associates, Inc. Mr. Thompson is the project officer of a seagrass habitat mapping project on the West Florida continental shelf between Ochlockonee Bay in the north and Tarpon Springs in the south, a region known as the Florida Big Bend.

Various methodologies were used in this mapping program, including remote sensing by airplane coupled with groundtruthing by TV tow-transects, diver tow-transects, and quantitative dive stations. The study consisted of three phases: (1) a pre-overflight groundtruthing cruise, (2) remote sensing overflights encompassing the study area, and (3) a post-overflight ground- truthing cruise to verify remote sensing interpretations.

From the mapping effort covering over 2.4 million acres of seafloor, it was found that the inner study area consists of dense seagrass beds, mainly manatee grass, turtle grass, and shoal grass. Farther offshore these beds are superseded by two different species of *Halophila*, a smaller grass. These species extend beyond the limit of the study area.

The report from this study is in draft form and will be finalized within two or three months. A follow-up program assessing the damage of Hurricane Elena in this area is planned for the near future.

The next speaker was Dr. Rezneat Darnell, of Texas A&M University, who discussed his biological resource mapping in the northwestern and northeastern Gulf. He has completed a northwestern Gulf bio-atlas mapping the seasonal distribution of many fish and shrimp species in that area and is now continuing this work into the northeast Gulf. He gave an interesting discussion of the comparisons of the two regions.

The western Gulf is largely a homogeneous soft bottom supporting fish populations of relatively low diversity. A large number of invertebrate and fish species are estuarine-dependent and exhibit a distinct onshore/offshore gradient related to season and life cycle. In the eastern Gulf the continental shelf is characterized by a diversity of habitats, such as live bottoms, seagrasses, coral rubble, and sand. The fauna is related to these habitats, producing a wide diversity and irregular distributions. Needless to say, the analysis of data bases and description of ecological trends is complicated by this diverse ecosystem.

Dr. Darnell expects to analyze these patterns to be presented in the forthcoming EASTERN GULF SHELF BIO-ATLAS. The project is proceeding well. All maps have been drafted; the narrative report is being written; and after proofing, only the final printing will remain.

The next speaker on our program was Dr. Mahlon Kennicutt of Texas A&M University (TAMU). TAMU is a subcontractor to LGL Ecological Research Associates, Inc., for the Northern Gulf of Mexico Continental Slope Study. Dr. Kennicutt discussed the Continental Slope hydrocarbon distributions and vent communities.

Sampling has been carried out for the last two years along three transects in the Western, Central, and Eastern Planning Areas. Sampling depths range from about 350 m to 2800 m. The study design allows for comparisons by depth, between the two seasons, and among the three areas. Unique factors in the study include riverine influence, which tended to decrease from the central Gulf to the western Gulf and to the eastern Gulf.

A comparison of known areas of oil and gas seepage to non-seep areas has become particularly interesting since December 1984 with TAMU's discovery of hydrothermal vent-type taxa at hydrocarbon seep areas. These are unique areas in the Gulf where the hydrocarbons literally seep from the bottom, sometimes producing slicks on the water surface. In the vent communities are a unique aggregation of tube worms, clams, and other characterstic organisms. Analyses on these biological organisms indicated that they are utilizing hydrocarbons as a food source. These communities are much like the Galapagos communities, only they are found in a much shallower area. The studies on these vent communities is just beginning and will be continued in the near future using the Johnson Sea Link Submersible.

Dr. Robert M. Rogers is on the Environmental Studies Staff of the MMS Gulf of Mexico OCS office. He has served as Contracting Officer's Technical Representative (COTR) on numerous marine ecosystem studies. Recently, this has included a study of seagrass distributions off the Florida Big Bend and a synthesis of environmental information on the Mississippi/Alabama OCS.

Dr. Rogers received his BS and MS degrees in Zoology from Louisiana State University and PhD in Marine Biology from Texas A&M University.

Tuscaloosa Trend Regional Data Search and Synthesis Study

Dr. Barry A. Vittor
Barry A. Vittor & Associates, Inc.

PROJECT HISTORY

Of current interest to oil and gas exploration in the northern Gulf of Mexico is the outer continental shelf area off southeastern Louisiana, Mississippi, and Alabama. The geologic feature known as the Tuscaloosa Trend extends from southern Louisiana into the offshore waters of the Chandeleur Islands and eastward to the DeSoto Canyon, and promises to be highly productive in terms of recoverable oil and natural gas reserves (Figure IIIB.1). The waters adjacent to the Chandeleur Islands and within Breton Sound, Mississippi Sound, and Mobile Bay also support a significant recreational and commercial fishery, which is of concern to the adjoining states. Because of industry interest and potential for future ecological impact by accelerated OCS oil and gas activities, the Tuscaloosa Trend region was selected by Minerals Management Service for a thorough environmental characterization and ecosystem modeling effort. This presentation deals with the initial work effort, which consisted of a comprehensive survey of available data and literature for synthesis into a report, identification of information/data gaps, and development of an ecosystems model for management purposes. The Trend program began in October 1983, and the final report was accepted by MMS in July, 1985. The subcontractors were Quantus, Inc., and Science Applications, Inc., Oak Ridge.

INFORMATION COLLECTION AND REVIEW

Information collection involved computer-based literature searches, literature and data collections, and interviews with researchers and managers within academic and governmental agencies within Louisiana, Mississippi, and Alabama. Over two thousand reference citations were retrieved and cross-referenced. All citations were entered in the NEDRES format, while pertinent references were also annotated.

The final report involved literature review and synthesis and was organized into the following topics:

- Physiography
- Geology
- Physical Oceanography
- Chemical Oceanography
- Ecological Resources
- Socioeconomics

Information synthesis was centered on establishing structural and functional relationships between and among coastal marshes, estuarine waters, and continental shelf subsystems based on major sources of inputs and outputs and processes conceptualized within the Tuscaloosa Trend ecosystem model.

The report also presents the results of analysis and interpretation of selected data sets. These supplemental reports include benthic community characterization of the Breton and Chandeleur Sounds, distributions of commercially- and recreationally-important fish and penaeid shrimp, and quantitative demersal finfish and shellfish population/community characterizations.

SIGNIFICANT FINDINGS

Conceptual Ecosystem Model

Conceptual representations of physical, chemical, geological, and ecological processes were developed for the Tuscaloosa Trend ecosystem as part of the data search and synthesis effort (Figure IIIB.2). These representations provide a framework for information search and synthesis activities and for identification of data gaps that could be filled in subsequent research efforts. The conceptual model also provides a means by which such research activities could be directed and communication between researchers enhanced. Finally, the model provides the Minerals Management Service with a management device which clearly identifies the interrelationships and potential multiple use conflicts among the resources of the Trend study area.

The approach to development of the Tuscaloosa Trend conceptual ecosystem model involves: (1) review and evaluation of existing marine ecosystem conceptualizations; (2) selection of an appropriate existing conceptualization; and (3) adaptation of the selected model to the Tuscaloosa Trend study area. The conceptualization of the Tuscaloosa Trend study area is hierarchical and consists of three levels; Level 1 - the whole ecosystem; Level 2 - individual subsystems (e.g., sedimentological, biogeochemical and ecological); and Level 3 - specific ecological applications (e.g., nekton life histories, marsh-estuarine interactions, pelagic and benthic food webs).

The Synthesis Report

Information collected for the Trend area was synthesized to complement the structure of the conceptual ecosystem model. Some of the available data can be identified with particular system inputs/outputs, compartments, processes, and regulators. Inputs include atmosphere, estuarine discharges, transported sediments, wastes, and organic matter, and biological population movements. The available information is generally adequate to characterize these inputs, but additional data are required for quantification. System outputs are defined by water mass circulation, sediment dispersion from the Trend OCS area, wastes, biological production (as migrating populations and fishery harvesting) and mineral resource extraction. The information regarding sediment and waste outputs is considered inadequate to characterize relationships between the OCS and adjoining systems. Additional data are also needed for circulation patterns and biological population movements out of the area.

The final report characterizes system compartments and processes, which include components of physical and biological oceanography, sediments, wastes, mineral resources, navigation, and recreation. While good data exist for socioeconomic resources, only limited information has been obtained for other resource categories. Particularly important components for which limited data exist are chemical composition of the OCS area, waste levels and fates, and biological populations, including phytoplankton and zooplankton.

RECOMMENDATIONS

Information gaps have been identified for each of the principal components of the Tuscaloosa Trend study area. Some are related to basic environmental or socioeconomic characterization of the region, while others pertain to the processes which define the dynamics of the ecosystem.

Geology

(1) The Minerals Management Service's Marine Geologic Atlas Series should be extended to include the remaining area within the Tuscaloosa Trend.

(2) Efforts should be made to define better the hydrodynamic mechanisms within the Tuscaloosa Trend which influence sediment transport both nearshore and in deep water.

(3) Areas where there are potentially hazardous foundations for petroleum exploration and production structures and pipelines need to be well documented. Geologic features which merit special attention include: (1) gas at shallow depth; (2) buried stream channels; (3) active faults; (4) surficial and shallow deformation including slumping and creep; and (5) diapirs and faulting.

(4) Detailed study of the Chandeleur Sound, Breton Sound, and the adjacent continental shelf should be conducted, and should include sediment distribution mapping, bathymetric surveys, and subbottom profiling.

Physical Oceanography

(1) Circulation patterns and driving forces in the DeSoto Canyon should be investigated in order to determine the movement of sediments and chemicals across the Trend shelf and up- and downslope.

(2) Existing Tuscaloosa Trend area data concerning currents, temperature, and salinity should be further analyzed in order to assist in description of shelf processes and to aid in designing and directing future process-oriented investigations.

(3) The occurrence and extent of the nepheloid layer in the Trend shelf area should be thoroughly studied, in support of studies of the fate and effects of hydrocarbon and heavy metal pollutants introduced from coastal, riverine, and shelf sources.

(4) Additional studies of currents and circulation patterns across the shelf should be performed, including meteorology, hydrography, horizontal currents, sea state, bottom pressure, and freshwater discharge.

(5) A model of physical oceanographic properties of the Trend area should be developed as a guide to future studies and to predict dispersion of possible pollutants.

Chemical Oceanography

(1) Nutrient flows and distributions from the tidal passes across the shelf should be characterized in order to complement studies of biological productivity and communities.

(2) Phenomena with significance to the distribution and abundance of biota on the shelf -- i.e., hypoxia and the nepheloid layer -- should be investigated through field sampling.

(3) Processes of transport and dispersion of terrigenous pollutants should be examined in order to distinguish between effects of coastal and upstream activities vs. those which occur on the open shelf.

(4) Fates of pollutants associated with shelf activities -- including petroleum exploration/production, dredged material disposal, and waterborne commerce -- should be studied.

(5) Processes of bioaccumulation and biomagnification of chemicals introduced to the Trend shelf should be defined, in order to provide a means to assess the long-term ecological effects of pollutant influxes.

Ecological Resources

(1) Movements of biota through the tidal passes should be described to determine energy flux between coastal and OCS waters.

(2) Shelf benthic communities should be defined, with emphasis on habitats (sediment types) not previously described, near major points of riverine discharge, and near-slope environments (including the DeSoto Canyon).

(3) Plankton communities should be described for the shelf with emphasis on primary and secondary production, and correlated with physical and chemical processes to assess relationships between shelf/coastal water/riverine discharge and OCS biotic potential.

(4) Further analysis of trophic relationships among the biotic components of the shelf ecosystem should be conducted, with emphasis on energy transfer within the between pelagic and benthic components.

Socioeconomics

(1) Patterns of navigation and vessel casualties should be examined throughout the Trend study area, in order to assess the likelihood of accidents due to increased traffic activity from Tenn-Tom waterway and support vessels for exploration/production rigs.

(2) A model should be formulated for projecting the impacts of major oil spills on travel, tourism, and recreation in the Trend area, based on effects of the Ixtoc spill off Texas

(3) Studies of recreational fishing activities should be standardized among the three states which border the Tuscaloosa Trend area.

(4) Areas of possible submerged prehistoric habitation should be examined through sediment coring and subbottom profiling, in order to determine the likelihood that such sites would be impacted by offshore petroleum exploration/production.

Dr. Barry A. Vittor is Director of Barry A. Vittor & Associates, Inc., a private environmental research and consulting firm based in Mobile, AL. He has been active in several major multidisciplinary studies of the Gulf OCS and coastal waters, with particular emphasis on benthic species and communities and wetland valuation and mitigation.

Dr. Vittor received his BA in Zoology from the University of California, Riverside, his MA in Marine Biology from San Diego State College, and his PhD in Ecology from the University of Oregon.

Seagrass Habitat Mapping in the Big Bend of Florida

Mr. John Thompson
Continental Shelf Associates, Inc.

Recent industry interest in offshore oil and gas exploration in the Florida Big Bend area has generated concerns about possible environmental impact to the extensive seagrass beds found there. These seagrass beds are considered valuable and productive habitats that provide nursery areas for commercially valuable fish and shellfish. The Minerals Management Service, as the federal agency responsible for prediction and management of offshore oil and gas related environmental impacts, initiated the Florida Big Bend Seagrass Habitat Study in September 1984 to provide baseline information about Big Bend area seagrass beds. Study results may be used to formulate buffer zones and develop biological stipulations for upcoming offshore oil and gas lease sales.

Total seagrass acreage in the Big Bend area was poorly known prior to this study. Previous studies used published reports and diver surveys to estimate seagrass coverage and zonation near shore (water depths <10 m). Very little was known of the seagrass and algal assemblages reported to occur farther offshore (water depths of 10 to 20 m).

Specific study objectives were the following:

1) To map and categorize Big Bend area seagrass beds using remote sensing techniqes (aerial photography) and shipboard "ground truth" surveys;
2) To determine the seaward extent of major seagrass beds:
3) To classify and delineate major benthic habitat types in the area.

Twenty-six north-south flight lines covering 2.1 million hectares were flown during late October and early November 1984. Six hundred color aerial photographs were taken. The photographs were analyzed stereoscopically, and the results were used to develop a composite map of seagrass distribution (Figure IIIB.3).

Two "ground truth" cruises were conducted to supplement the remote mapping data. Resolution on the remotely collected imagery allowed delineation of seagrass beds to a depth of 12 m (Figure 1). Shipboard surveys using underwater television and towed divers extended this coverage to a depth of 20 m (Figure IIIB.4) and allowed estimation of the percentage of "live bottom" within mapped seagrass beds. Quantitative seafloor photographs from fifty "signature control" stations were analyzed for species composition and blade densities.

Mapping efforts delineated a total of 232,893 hectares of dense seagrass beds, 279,722 hectares of patchy seagrass beds, and 498,034 hectares of sparse seagrass beds. Within the sparse offshore seagrass beds, algae accounted for 21% of total blade density. Diver and underwater television observations in the deep, offshore seagrass beds indicate that about 44% (342,213 hectares) of the area mapped as sparse or patchy seagrass actually represents sponge/hard-coral/gorgonian "live bottom" assemblages.

Study results indicate two major species associations of seagrasses in the Florida Big Bend area. An association of turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filforme*), and shoal grass (*Halodule wrightii*) occurs in water depths of less than 9 m and forms dense stands that are easily identified on aerial imagery. Farther offshore in water depths of 10 to 20 m, large areas of the continental shelf are covered by a seagrass/macroalgal assemblage in which *Halophila decipiens* and *H. engelmanni* (neither has a universally recognized common name) are the only vascular plants seen. Turtle grass and manatee grass are the largest marine grasses found in the Big Bend area. Shoal grass and both species of *Halophila* are much smaller and generally are considered fringing or pioneer species growing on the fringes of major grass beds.

The unique aspect of seagrass distribution in the Florida Big Bend area is the extended nature of the offshore fringing zone where *H. decipiens* and *H. englemanni* are numerically dominant. These species, along with the associated macroalgae, form a physiographic climax covering most of the offshore portion of the study area.

Environmental factors favorable to development of these extended fringing seagrass beds probably include: (1) the gentle slope of the northwest Florida continental shelf, which provides a large area for seagrass colonization; (2) the lack of coastal turbidity sources, which allows greater offshore light penetration; and (3) the relatively low wave and current energy levels along this coast.

Future studies on the seagrasses of Florida's Big Bend area should be directed toward determining the environmental relationship of this extensive fringing community to the northwest Florida shelf ecosystem as a whole. Specifically, such studies should assess the depth limits, resistance to wave energy, light requirements, seasonality, primary productivity, and associated biota of these deep seagrass and macroalgal assemblages.

Mr. John Thompson received his Master of Science degree in Marine Biology from Florida Atlantic University in 1974 and is presently a senior staff scientist with Continental Shelf Associates, Inc., (CSA) in Jupiter, Florida. Prior to joining CSA in 1980, he was with The Harbor Branch Foundation where he headed their Remote Sensing Services Department. He has been involved in remote sensing and seagrass bed mapping since 1977 and has mapped seagrass distribution along both the east and west Florida coasts.

Biological Resource Mapping in the Northwestern and Eastern Gulf of Mexico

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In May 1980, under an IPA appointment, I began working on a project entitled "Offshore Mapping of the Ecological Zonation of Biological Communities of the Gulf of Mexico Outer Continental Shelf." The original intent was to map the distribution of major benthic and demersal community types of the U.S. Gulf of Mexico outer continental shelf from the Rio Grande to the Florida Keys, based largely upon summary and synthesis of available published literature. Investigation revealed the existence of a number of major unpublished data bases which, if they could be obtained, would provide detailed insight into the seasonal distribution patterns of individual species as well as of community types on the continental shelf off the entire U.S. Gulf coast.

Concentrating first on the shelf west of the Mississippi River delta, I obtained, standardized, and analyzed a major data set covering the trawlable fishes and penaeid shrimp of this area. The resulting publication, coauthored with R.E. Defenbaugh and D. Moore, was entitled *NORTHWESTERN GULF SHELF BIO-ATLAS, A Study of the Distribution of Demersal Fishes and Penaeid Shrimp of Soft Bottoms of the Continental Shelf from the Rio Grande to the Mississippi River Delta,* MMS Open File Report 82-04. 438 pp., 145 Pl.

Subsequently, twelve data sets were obtained covering the continental shelf area from the Mississippi River delta to the Florida Keys. These data have been standardized and analyzed, and distribution maps have been prepared. The narrative is nearing completion. The *EASTERN GULF SHELF BIO-ATLAS* is being coauthored with J. Kleypas, and this volume will be the companion to the volume which has already appeared. Together they will span the entire U.S. Gulf continental shelf. The present article is an interim report on some of the findings of this project.

Of the 18 species of penaeid shrimp encountered during the study, 11 species were common to both the northwestern and eastern Gulf shelf areas. One species appeared only in the northwest, and 6 species were unique to the eastern shelf. Of the 372 species of demersal fishes obtained, 139 species (37.4%) were common to both shelf areas. Twenty-five species appeared only in the northwest, and 208 species were unique to the eastern shelf. Of the 164 species taken from the northwestern shelf, 15.2% were unique, whereas of the 347 species taken from the eastern shelf, 59.9% were unique to that area. Clearly, the eastern Gulf shelf has over twice as many species and over eight times the number of unique species. From the management standpoint it is important to understand the various distribution patterns and the factors which underlie these patterns so that, despite human intrusions into the shelf environment, the genetic and ecological diversity will be maintained.

Estuarine related species make up a large component of the northwestern Gulf shelf demersal fauna. These species are heavily concentrated seasonally on the inner half of the shelf off Louisiana and eastern Texas. These are supplemented by soft bottom species which inhabit primarily the middle or the outer shelf environments. A few scattered hard bottoms and topographic high areas are present, but they contribute little to the fauna of the soft bottoms. A few tropical species from Mexico enter the fauna of south Texas, but this contribution is also relatively insignificant. From the standpoint of numerical abundance, the ichthyofauna of the northwestern Gulf shelf is characterized by a double density gradient, with higher density on the inner half of the shelf and lower offshore, and higher density off Louisiana and east Texas and lower toward south Texas. The higher densities inshore off Louisiana and east Texas reflect the availability of extensively low salinity estuarine nursery areas as well as the muddy shelf bottoms derived from fine Mississippi River sediments.

By contrast, the continental shelf of the eastern Gulf is characterized by a diversity of local habitat types, each of which is inhabited by a characteristic suite of species. Eastern Louisiana, Mississippi, and Alabama have extensive low salinity nursery areas, and the shelf environment off these states is much like that immediately west of the Mississippi River. Peninsula Florida has extensive seagrass beds in the Big Bend region and low salinity areas off the Everglades. At mid-shelf are found living and dead coral reefs, exposed hard bottoms, and soft bottoms with shell hash and coral rubble. Offshore there is the special environment of De Soto Canyon and the soft bottom outer shelf habitat. As a group, estuary-related species are less prominent in the eastern Gulf shelf fauna, and these tend to be concentrated off Mississippi and Alabama and around the mouths of the bays of peninsula Florida. On the middle shelf of peninsula Florida, hard and soft bottoms alternate in a scattered fashion so that the faunas are intimately related. Hard bottoms of this region are structurally complex because of the presence of sponges, calcareous algae, and both soft and hard corals. Structural complexity of this sector engenders species diversity. A significant component of the demersal fauna of peninsula Florida is the Bahamian and West Indian tropical fauna which is represented by permanent and temporary populations, periodically reseeded by the Gulf Loop Current. Along the eastern margin of this current, meanders and gyres bring slope waters across the outer half of the shelf enriching the fauna with deeper water species. Thus, extreme habitat diversity and repeated tropical invasion together explain much of the species diversity observed in the demersal communities of the eastern Gulf continental shelf. In the forthcoming *EASTERN GULF SHELF BIO-ATLAS* these patterns and factors will be analyzed in greater detail, and the management implications will be addressed.

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 in an effort to discern the structure of shelf communities and to develop appropriate management implications.

Dr. Darnell received his BS in Biology from Southwestern College (Memphis, TN), his MA in Biology from Rice University, and his PhD in Zoology from the University of Minnesota.

Recent Discoveries of Deep Water Communities in the Northwestern Gulf of Mexico

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Department of Oceanography Texas A&M University
and
Dr. Benny Galloway
LGL Ecological Research Associates, Inc.

The Northern Gulf of Mexico Continental Slope Study (Contract No. 14-12-0001-30046) is a multi-year program being jointly conducted by LGL Ecological Research Associates, Inc., (LGL) and Texas A&M University (TAMU). During Year I of the Slope Study, sampling to determine water mass characteristics, sediment nature and quality, and biological characteristics in terms of community composition, distribution, and life history patterns was conducted along three transects in the northern Gulf of Mexico. There was one each in the Eastern, Central and Western Lease Planning Areas (Figure IIIB.5). Sampling depths along each transect ranged from about 350 to 2800 m. Specific depths were chosen to correspond to Pequegnat's (1983) hypothesized faunal zones for megafauna, namely the Shelf/Slope Transition (350 m); Archibenthal Horizon A (approximately 850 m); Upper Abyssal (approximately 1440 m); and Mesoabyssal (approximately 2500 m). The Year I study included two cruises: one to the Central Transect in the Fall of 1983; the other to all three transects in the spring of 1984. The sampling design enabled comparisons, by depth, between the two seasons and among the three areas. The annual report has been completed and is available from MMS.

During Year II, the present year, sampling was conducted at 12 stations in Fall 1984 along the Central Transect to better define zonation (Cruise III); at 16 stations in the eastern Gulf to define lateral variation along selected depth contours (Spring/Summer 1985); and at 12 stations in the western Gulf (Spring/Summer 1985) for the same purpose as well as to contrast known areas of oil and gas seepage to non-seep areas and habitats with topographic relief to bottoms with a more uniform relief. The seep comparisons became of more than passing interest because of TAMU's discovery in December 1984 of hydrothermal vent-type taxa at hydrocarbon seep areas.

Temporal and spatial differences were observed in sedimentary characteristics during Year I. These changes were observed in grain size composition, total organic carbon, calcium carbonate, and hydrocarbons. Grain size changes were subtle. Sediment grain size differences between Fall 1983 and Spring 1984 indicated a slight shift from clay to silty clay at water depths of 650 to 850 m. Clay predominated at 350-m depths during both seasons, and silty clays were likewise prevalent during both seasons at the two deeper stations (1400 and 2500 m). The most pronounced difference in sediment grain size among areas was that stations on the Eastern Transect were characterized by nearly equal mixtures of sand-silt-and-clay-sized particles, whereas sediments from the other two transects were predominantly clay. The role of sediment grain size and its relationship to biological distributions will be evaluated in this program.

Sediment samples from stations along all three transectscontained a mixture of thermogenic, terrigenous, and planktonic hydrocrabons. Total hydrocarbon concentrations ranged from 0.5 to 4.5 µg/g (as derived by gas chromatography). Individual hydrocarbon compounds were detected at low concentrations (<0.1 to 0.5 µg/g). These levels are generally lower than previously reported hydrocarbon concentrations in Gulf of Mexico sediments (range: < 0.1 to > 300 µg/g). The dominant n-alkane in the 15 to 22 carbon range was variable while normal alkanes with 23 to 32 carbons were dominated by n-C_{29} and n-C_{31}. The input of planktonic hydrocarbons (n-C_{15}, n-C_{17}, n-C_{19}, pristane) was difficult to discern in the Western and Central Transect, but as readily apparent in the Eastern Transect. The low planktonic hydrocarbon concentrations in the Western and Central Transect may be due to the high sedimentation rate and/or dilution with riverine material.

Hydrocarbons at the Central Transect appeared to be less degraded and more terrigenous in nature during Cruise II than Cruise I.

Hydrocarbon concentrations were not significantly different at two samplings of the Central Transect, but were different during the third sampling. Mean aliphatic hydrocarbon concentrations for stations along the Western and Central Transect did not differ significantly within each transect. Aliphatic concentrations at the deepest stations of the Eastern Transect were significantly higher than those at the shallowest station. A significant spatial variation was detected when the Western, Central, and Eastern Transects were compared. The influence of riverborne material decreased from the Central to the Western to the Eastern Transect. This interpretation was also confirmed by the $S^{13}C$ of the sedimentary organic matter with heavier isotopic values being present at the Eastern Transect. The effect of Mississippi River discharge was most important at the Central Transect, but was also evident to some degree at all stations sampled. In general, the highest aliphatic hydrocarbon concentrations were associated with the more clayish/organic carbon-rich sediments. Aromatic hydrocarbons were below the detection limit (approximately 5 ppb) at all locations sampled. The presence of very low-level aromatic hydrocarbons was inferred at all locations by total scanning fluorescence.

Hydrocarbon levels in organisms were highly variable. The dominant hydrocarbons detected were pristane, n-C_{17}, n-C_{15}, and n-C_{19}, which have a presumed planktonic origin. Demersal fish tissues reflect a predominantly plankton-based diet. This interpretation was confirmed by the $O^{13}C$ composition of organism tissues. Crustaceans, in general, contained little or no hydrocarbons. When hydrocarbons were present they were predominantly planktonic in origin, though in a significant number this planktonic input was overprinted with the hydrocarbon signature of the sediments in which they live. A few demersal fish also contained traces of terrestrial plant biowaxes, possibly suggesting that they sometimes feed on benthic organisms. A preliminary summary of the proposed hydrocarbon sources, pathways, and interactions is presented in Figure IIIB.6.

Kennicutt et al. (1985) recently reported the location of seep communities at two areas in the Green Canyon Lease Area. These sites were subsequently sampled as part of this MMS program (Figure IIIB.7). While no tube worms, clams, or mussels were collected at the one site (Station WC-6, Lease Blocks GC 217 and 272), large collections of deep-water stony corals were retrieved and a photograph of an apparent tube worm was taken in GC Block 184.

A notable finding of the November 1984 Cruise (III) was the photographic observations of a bed of large clams at 940 m in depth in Green Canyon Lease Block 215. These clams exhibited motility and comparisons of the photographs to specimens collected by TAMU at another seep locality indicated that they are representatives of the chemosynthetic *Calyptogena*, probably *Calyptogena ponderosa*. This species is a relative of *Calyptogena magnifica*, a motile giant white clam characteristic of hydrothermal vent communities in the Pacific Ocean. Actual specimens of cold water seep biota, analogous to the Pacific hydrothermal vent biota, had been discovered and collected at the base of the Florida escarpement (3300 m) during a diving expedition with the submersible *Alvin* (Florida Cruise Participants 1984) and further west in the Green Canyon Lease area by Kennicutt et al. (1985).

Ballard (1984) provides a description and history of the discovery of the deep-sea hot spring and cold seep communities, up to and including the Florida cold seep discovery. Both types of communities are characterized by white bacterial mats, large dense beds of clams and mussels, numerous small gastropods, galatheid crabs, and in the Pacific, dense patches of giant tube worms, *Riftia pachytila*. Chemosynthetic tube worms which have been collected from the Gulf of Mexico are closely-related forms, but fall into different families (either the Lamellibrachiidae or a new family presently being described by M. L. Jones of the National Museum of Natural History, Smithsonian Institution).

At Station WC7 (Blocks GC 146, 189, 190, and 191) tube worms were collected (representatives of both Lamellibrachiidae and the new family) and numerous photographs of individual tubes were obtained. These photographs resemble some of those shown at the Florida Escarpment. Based upon TAMU photographs, dense clumps or tangles of worms and discrete assemblages of organisms are represented in these areas.

Cold water seep communities are thought to be associated with seismic wipe-out and hydrocarbon seep areas across the slope of the northwestern Gulf between water depths of 400 and 1000 m. Based on present data (Kennicutt et al., 1985), chemosynthetic organisms characteristic of seep communities have been documented in Green Canyon Blocks 184, 189, 190, 215, 234, 235, and 272 (Figure IIIB.7).

The TAMU collections suggest that most of the organisms which have been collected at the Pacific and Florida sites are also present in the northwestern Gulf site.

Ballard, R. D. 1984. The Exploits of *Alvin* and *Angus*: Exploring the East Pacific Rise.
Oceanus 27(3): 7-14.

Kennicutt II, M. C., J. M. Brooks, R. R. Bidigare, R. R. Fay, T. L. Wade, and T. J. McDonald.

1985. Vent Type Taxa in a Hydrocarbon Seep Region on the Louisiana Slope. *Nature* 317: 351-353.

Dr. Mahlon C. Kennicutt is presently an Associate Research Scientist and member of the Graduate College Faculty, Oceanography Department of Texas A&M University. He received his PhD in Oceanography from Texas A&M University in 1980 and BS in Chemistry from Union College, in 1974. Dr. Kennicutt has a variety of research interests in the field of marine chemistry.

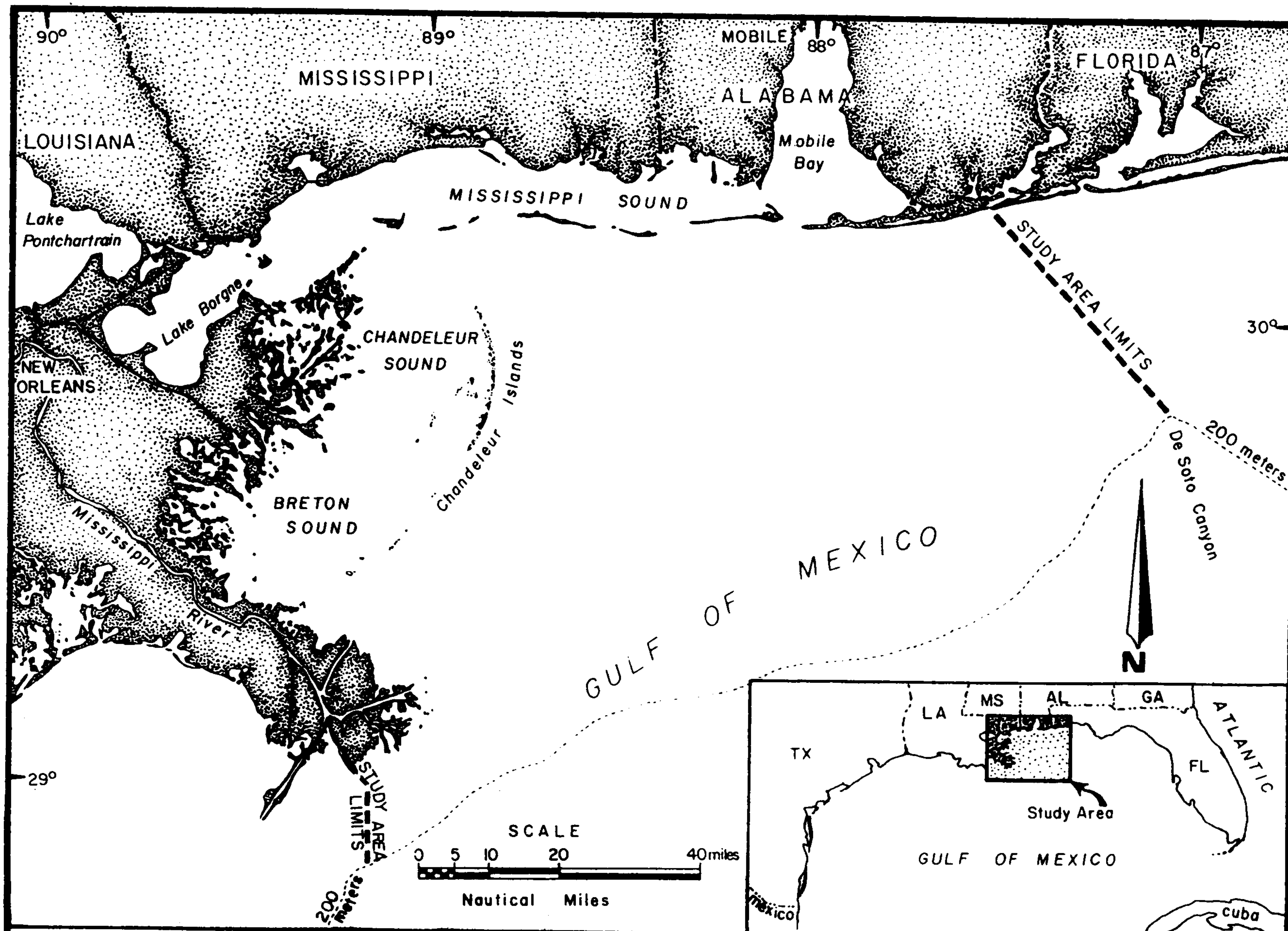

Figure IIIB.1 - The Tuscaloosa Trend Study Area

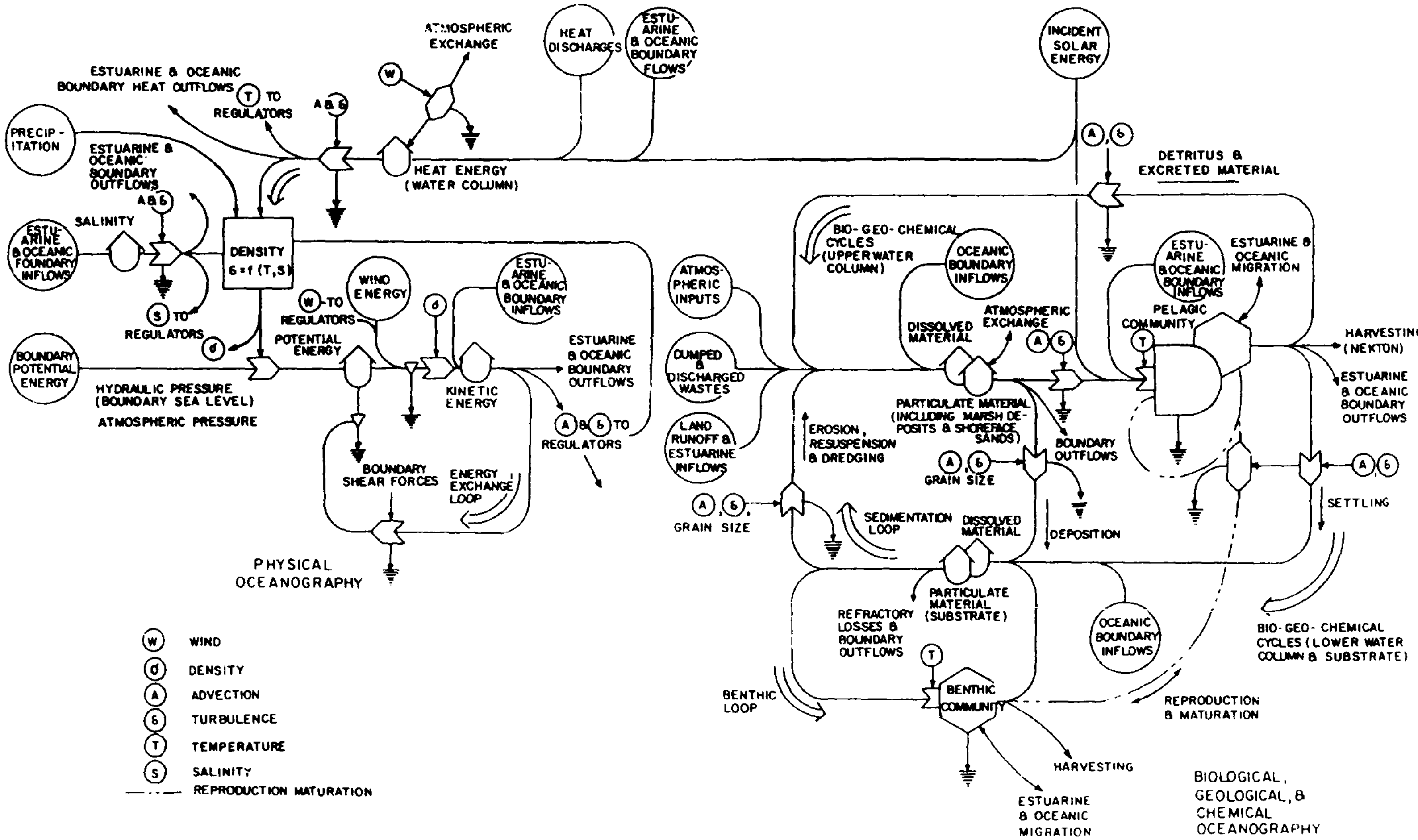

Figure IIIB.2 - A Comprehensive Conceptual Representation of the Tuscaloosa Trend Ecosystem (Modified from McLaughlin et al., 1975)

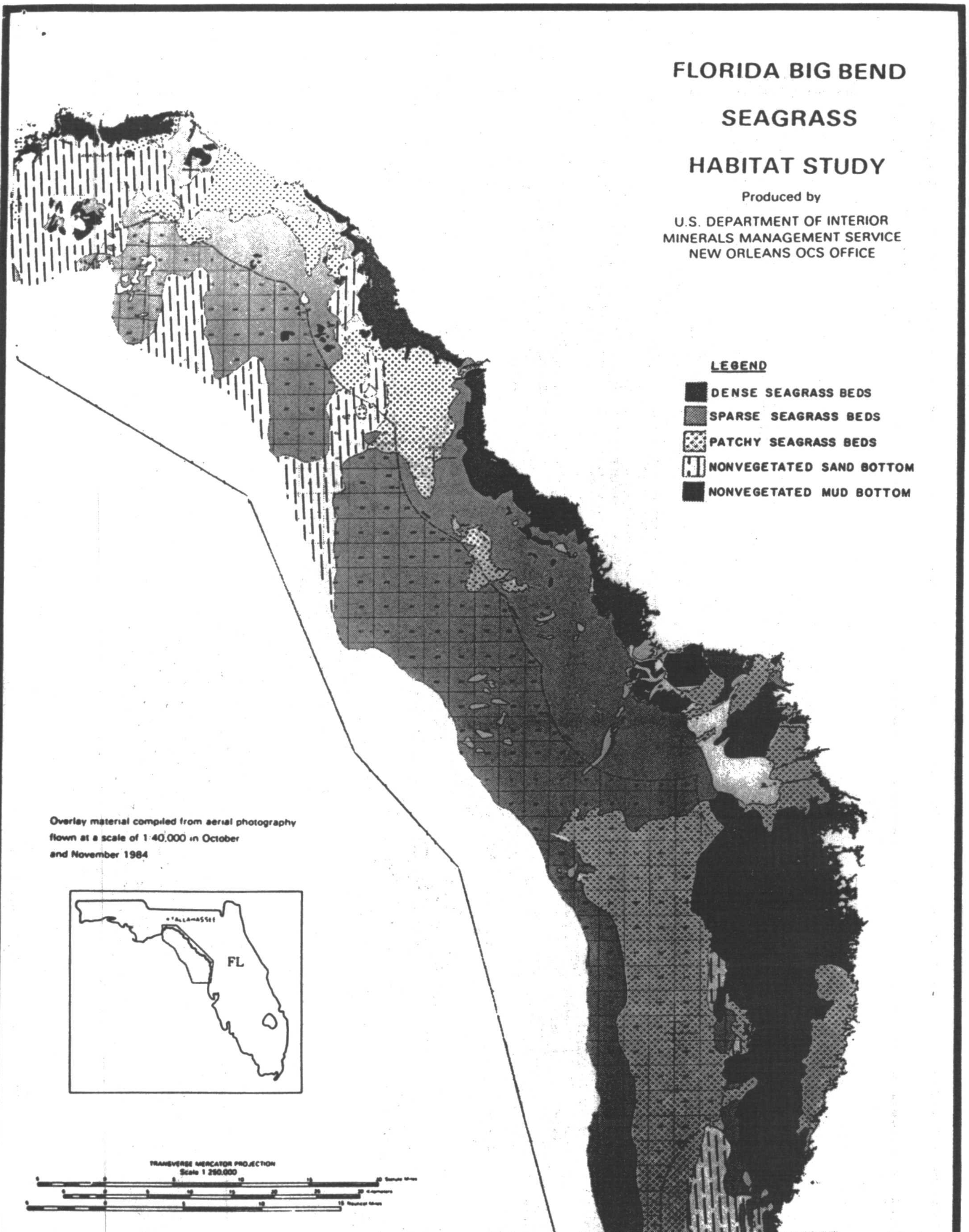

Figure IIIB.3 - Florida Big Bend Seagrass Habitat Study Composite Map Based on Aerial Interpretation Alone (Photographic Reduction)

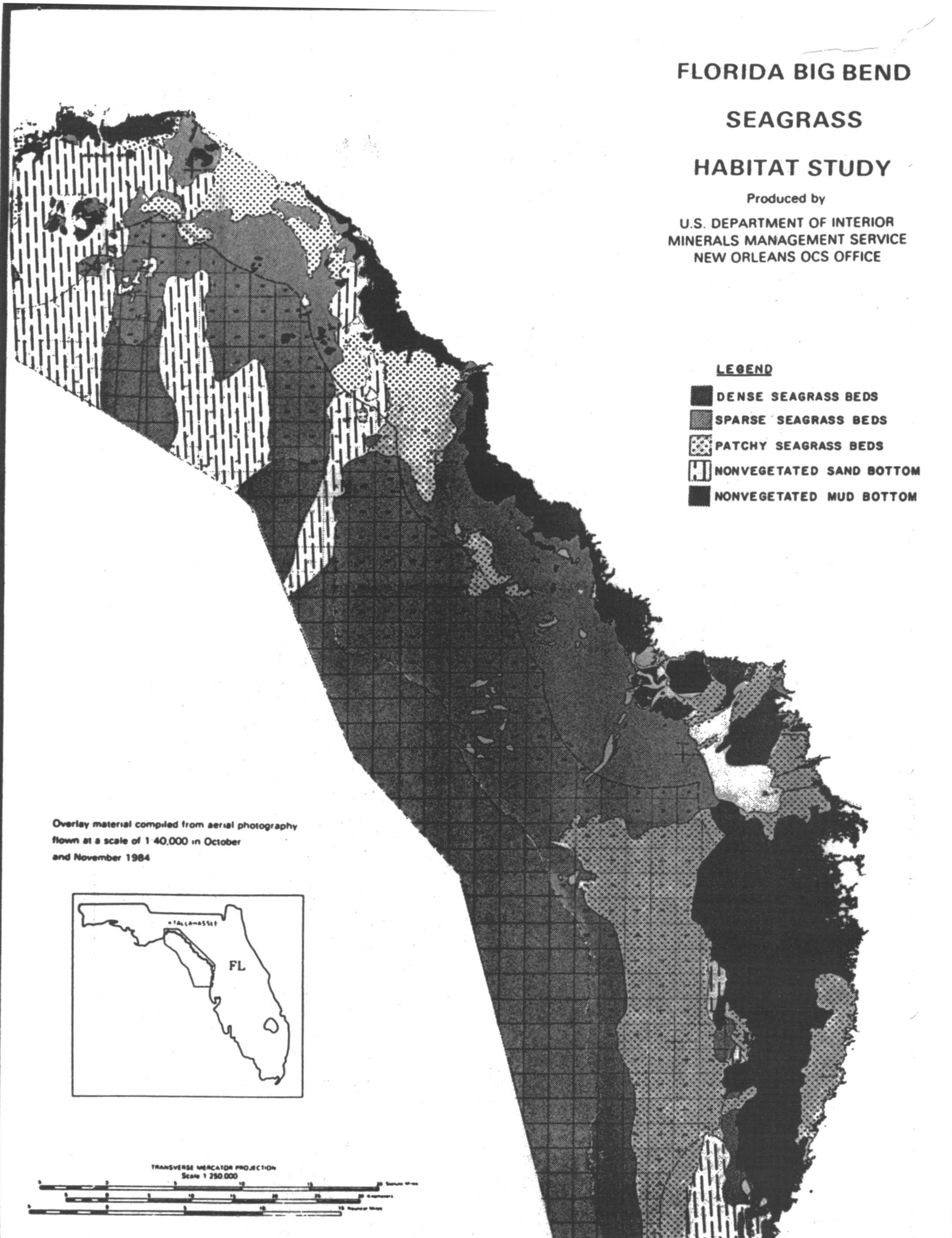

Figure IIIB.4 - Florida Big Bend Seagrass Habitat Study Composite Map Based on Aerial Plus Ground Truthing Data (Photographic Reduction)

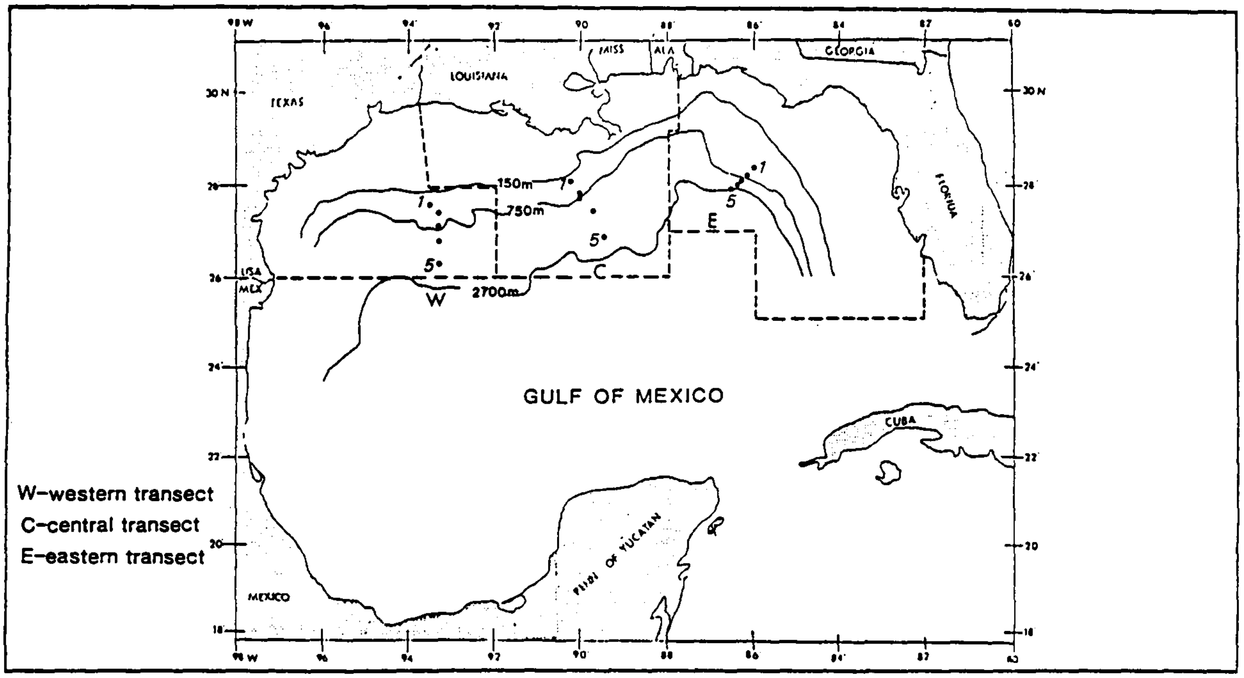

Figure IIIB.5 - Location of Transects and Stations, Within Western (W), Central (C) and Eastern (E) Gulf of Mexico Lease Planning Areas

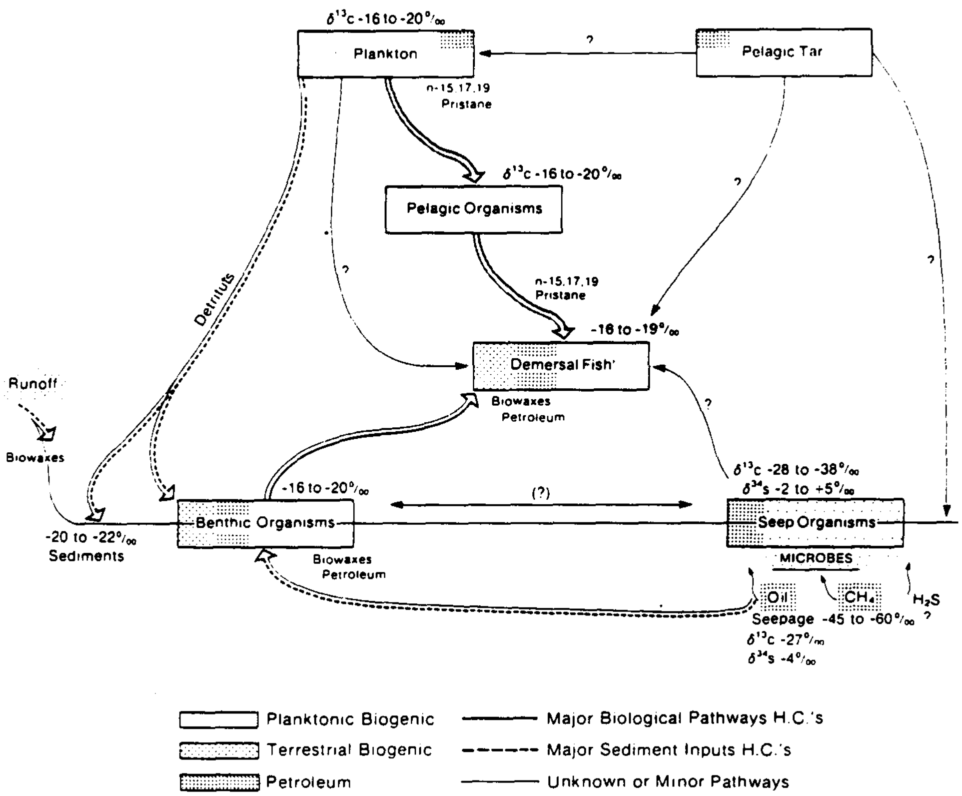

Figure IIIB.6 - Preliminary Suggested Sources, Pathways, and Interactions of Hydrocarbons on the Gulf of Mexico Slope (The Size of the Boxes Does Not Represent Quantitive Importance)

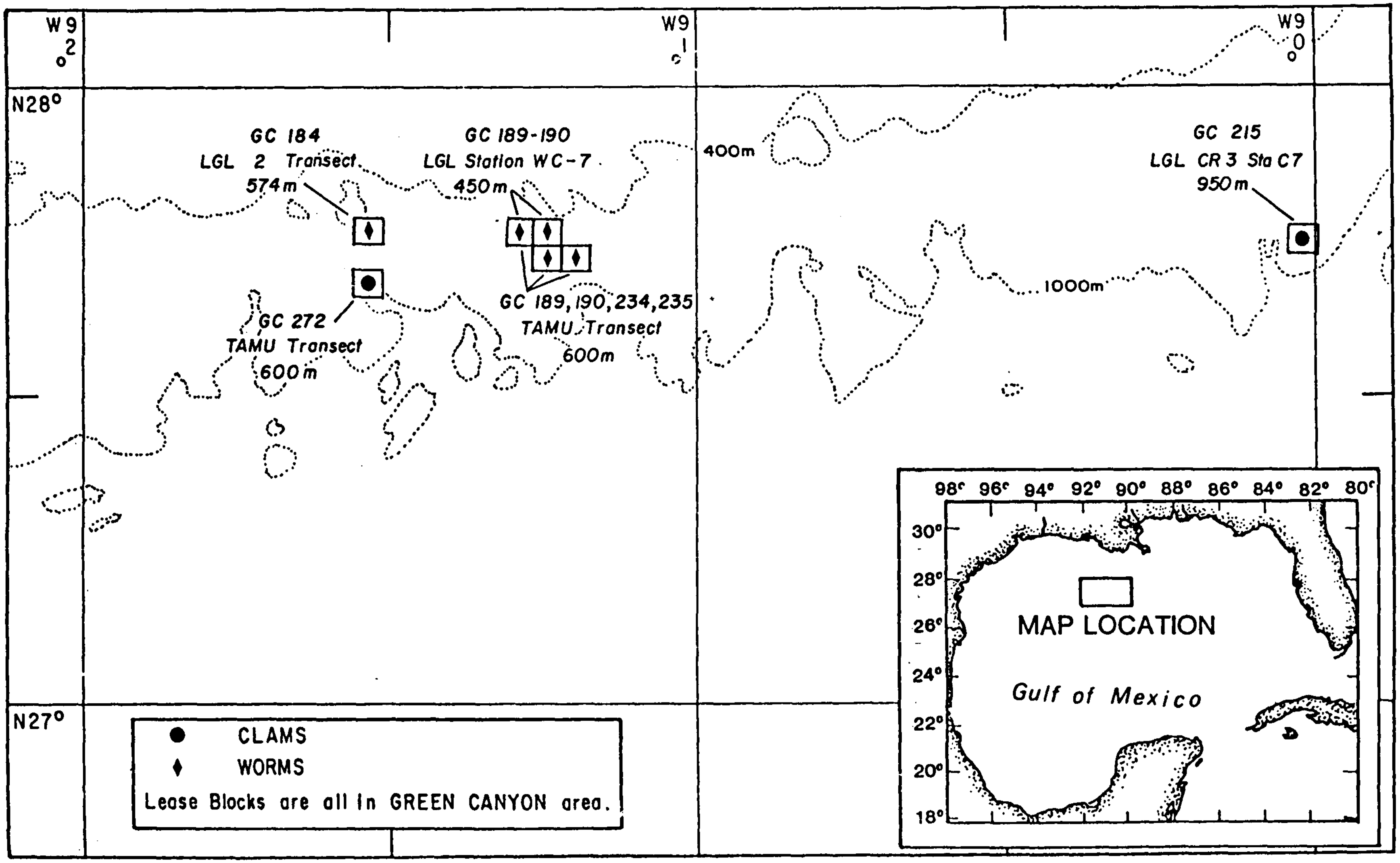

Figure IIIB.7 - Possible Seep Communities

PHYSICAL OCEANOGRAPHY I: SUMMARY EASTERN GULF OF MEXICO PROGRAM REPORT

Session: PHYSICAL OCEANOGRAPHY I: SUMMARY EASTERN GULF OF MEXICO PROGRAM REPORT

Chairmen: Dr. Murray Brown
Mr. Joe Perryman

Date: October 23, 1985

Presentation Title	Speaker/Affiliation
Physical Oceanography: Session Summary	Dr. Murray Brown Minerals Management Service
Minerals Management Service, Physical Oceanography Field Study	Dr. Evans Waddell Science Applications International Corporation
Observed Currents on the West Florida Continental Shelf	Dr. Wilton Sturges Department of Oceanography Florida State University
Summary of Results from the MMS Hydrographic Field Program	Mr. Jerry L. Miller Rosenstiel School of Marine and Atmospheric Science University of Miami
Bottom Currents on the Southwest Florida Outer Continental Shelf	Dr. Larry J. Danek Environmental Science and Engineering, Inc.
Variability of Inertial and Subtidal Frequencies on the Outer Portion of the West Florida Shelf	Dr. Peter Hamilton Science Applications International Corporation
MMS Satellite Studies in the Gulf of Mexico, 1983-1985	Dr. Fred M. Vukovich Research Triangle Institute
Lagrangian Drifters	Dr. James Lewis Science Applications International Corporation

Physical Oceanography: Session Summary

Dr. Murray Brown
Minerals Management Service

The Physical Oceanography Program was responsible for two sessions. One session was a wrap-up for the work that we've been doing in the Eastern Gulf of Mexico, which is nearing the end of its third year. The second focused on modeling work.

The MMS has deployed 32 current meters at 14 sites offshore southwest Florida with a data return of about 90%. We have described a very complex regime involving offshore forcing and wind forcing, finally obtaining relations that had eluded earlier workers. We are certain now that it does take a multi-year, multidisciplinary data set in order to determine the relation between these forcing factors.

We've been responsible for five major hydrographic cruises in the eastern Gulf--including, perhaps, one of the largest scale efforts in the Gulf of Mexico. We've looked at shelf edge interactions, water mass characterization and optical properties, and we've paid particular attention to current shear using different methodologies.

We are currently using, in fact, physical measurements in the Southwest Florida Shelf Ecosystem program, related to my own, to understand biological processes in the bethnic boundary layer. And these data are being added to the overall physical oceanographic data base. One valuable result is that we've confirmed the validity of the Cooper Circulation Model developed earlier in our program.

A closer look at the current data reveals considerable inter-annual and inter-seasonal variation in the apparent relations. An unexpected increase in certain intergetic modes in the summer has been related to the effects of the Loop Current. Remote sensing of the Gulf has aided considerably in logistical planning and in understanding various observed features. The role of cold intrusions in initiating eddy shedding has been further studied. An atlas of eddy trajectories toward the western Gulf has been prepared.

A final report from Years I and II is due in December, to be followed by publication of a final report in February, 1986.

In terms of data, rather than just the reports, all of our physical oceanographic data from the first two years will be at the National Oceanographic Data Center in December. Our ship-of-opportunity data are available to anyone on Telemail. Our buoy data are available through NOAA, through real-time satellite relay. This month we have one cooperative cruise at sea with an industry group, looking at a warm-cove eddy south of Louisiana, and another cruise is leaving next week on a Mexican Navy vessel.

This last point is very significant because we are proud to say that, working together with the Department of Oceanography at Texas A&M, our contractor has been able to establish an informal program of cooperation with the Mexican Navy that has achieved very much. We are currently mounting cooperative cruises, and we have been able to achieve a very favorable array of current meters in the western Gulf, which assures that we will obtain very high quality data during the current phase of the program, which has shifted to the western Gulf of Mexico.

In July of this year a major eddy was shed from the Loop Current and has been moving exactly toward the middle of the array that we put in about half a year ago. The current meters were replaced last week, so we're certain that the suite of equipment is complete and functional, and that we will obtain data that will characterize the interaction of these eddies with the Western Shelf.

Drifting buoys continue to be helpful in our program. One is currently located in the eddies that I just mentioned, and another will be deployed next week by the Mexican Navy for us in the Southwestern Gulf. In general, we continue to find more anti-cyclonic eddies in the whole Gulf system than we had originally expected.

We had a pleasant surprise yesterday, in that a visitor from another session was able to present new information from an unexpected source. Dr. Bonnie McGregor, from the U. S. Geological Survey, who's just been the Program Chief for the GLORIA Side-scan Sonar Program in the Gulf of Mexico, showed us interesting pictures that revealed very dramatic and very large bedforms in the deep Gulf that indicate significant currents at very great depths. These bedforms display wave lengths on the order of a mile and many extend for tens of miles.

We had a joint presentation by Dr. Dave Brooks from Texas A&M University and Captain Vazquez from the Navy of the Republic of Mexico. They are working together with us on our current and hydrographic studies in the Western Gulf, and have been instrumental in the design of an array on the Mexican and Texas slopes which will help us to understand better interaction between eddies moving in that direction and topography. We're looking at that area particularly as an important part of the regional circulation and in the Oil Spill Risk Analyses exercises which we perform.

Detailed hydrographic studies in the southwest Gulf frequently reveal small-scale features much more complicated than the simple conceptual model originally developed. For example, repeated surveys of the Bay of Campeche do not always show a neat cyclone. It was noted that a tongue of warm water entering the area at depth is reproduced by a circulation model, and several historical hydrographic surveys may now be explained.

A report by Lynn Shay, of the Naval Post-graduate School in Monterey, indicated that they have developed a model that may be used to simulate hurricane-generated currents. Early results show that concepts which have been held by other modelers about the simplifying assumptions which can be made are in fact incorrect.

Alan Wallcraft, from JAYCOR, who's the Program Manager for the Circulation Modeling Study program, reported on the progress that they're making in the surface circulation model for the Gulf of Mexico. They are entering the final high resolution phase where we'll achieve horizontal resolution of approximately ten km. We're looking for a much richer flow field from this implementation.

An additional effort that we've recently been able to fund through the Circulation Modeling Study program is a modification to allow the intersection of the several layers in the model with topography. They have achieved early results which look extremely promising.

Using the model as it is currently formulated at the 20-km resolution, however, they have been looking at currents in the lower layer because of recent interest in deep currents; and also because of some data that are coming from the hydrographic studies which indicated that there is a reverse current system under the Loop Current. The model duplicates these features.

Finally, in the Circulation Model Study we are beginning to implement thermodynamics. With the thermodynamic implementation in its earlier stage, we've been able to see extremely good reproduction of the Texas Shelf convergence zone.

Dr. Bob Cheney, from the National Ocean Service, gave a presentation on altimeter methodology using aircraft, which has recently been tested in the Chesapeake Bay area, with excellent results. In brief, NOS flies an airplane with 10-cm accuracy, using satellite navigation, and then employs a laser altimeter to determine the sea surface height. By calculating the location of the plane from the navigation system, you may estimate the sea surface height. Using a sufficiently accurate geoid, the two values may be differenced to estimate the sea surface height due to motions of the water. The method, if combined with hydrography, could allow the development of a high resolution geoid for the Gulf of Mexico, currently the critical data gap for altimetry work in the Gulf.

There may be a high-precision altimeter survey of the Gulf of Mexico in 1987, depending on the availability of navigation satellites. Possibly this would take place in coordination with our own Physical Oceanographic Program.

The National Ocean Service has recently developed an office to develop and disseminate products from satellite altimeters, an activity which we in the Physical Oceanography Program strongly support. It should be borne in mind that altimeter data will eventually become, perhaps, the primary tool in synoptic oceanography and could be of great value to us in the near future.

Jeff Hawkins, from NORDA, demonstrated the practical problems he has solved in extracting ocean feature information from seemingly contaminated thermal images. He also demonstrated how he has identified for us and other agencies several of the recent eddies that continue to be the subject of our study.

Dr. Harley Hulburt, from NORDA, gave us a report on some special work he's doing with modeling, looking particularly at something most people are not usually studying in the Gulf of Mexico: cold core features, which tend to be quite small. As a counterpart to remote sensing studies of cyclonic eddies, he has looked into the theoretical basis for their role in anti-cyclonic eddy generation. His work has succeeded in identifying two types of cold core features which are frequently observed.

Finally, I'd like to say that much integration and coordination has been achieved in our Physical Oceanography Program in three areas, of which we are extremely proud.

The Minerals Management Service, and researchers at Science Applications International Corporation and Texas A&M University who work for us in the Physical Oceanography Program have informally developed an excellent coordination with the Republic of Mexico which has allowed us to perform measurements which have not been possible before. We are extremely proud of that and we're very grateful to the Mexican Navy and to Captain Alberto Vazques, our liaison, for making all of these things possible.

Secondly, we have forged good links with industry. We have a research vessel at sea right now with industry researchers sharing data with us. There is a promise of much more data-sharing in the future.

And, thirdly, we have always sought to maintain good communications between our field measurements folks, who generally are in the field obtaining information to develop conceptual models of circulation, and our modelers. One of the principal weaknesses in any physical oceanography program might be one where the modelers would develop a simulation that looks quite elegant in its mathematics but would have no relationship to the real world. We've sought always to maintain close relations between the modelers and the physical measurement staff. I am able to report that the modeling work described to us yesterday showed that basin-scale and regional circulation features are well simulated.

Biography: Please see Session II.B, Paper 5.

Minerals Management Service, Physical Oceanography Field Study

Dr. Evans Waddell
Science Applications International Corporation

In October 1982, the Minerals Management Service (MMS) initiated a multi-year, physical oceanographic field study of the Gulf of Mexico (GOM) with a goal of establishing a better understanding of circulation patterns and processes and developing a data base which supports a concurrent and coordinated numerical circulation modeling program. The regional program emphasis has resulted in two complete years of observations in the eastern Gulf with a third year presently in progress. Coincident with this ongoing final eastern Gulf year, measurements in the western Gulf have been initiated. A progress report describing activities during and results of the first two years of eastern Gulf measurements is being submitted to MMS in the fall of 1986. At the completion of the eastern Gulf observations, another report will be produced which expands on prior work.

Program Years 1 and 2 had five major components which are being combined to develop a better understanding of eastern Gulf and Loop Current related circulation. These include:

- Subsurface currents, temperatures, and pressure along and across the shelf, on the slope, and beneath the Loop Current (Figure IIIC.1).
- Hydrographic surveys to document temperature, salinity, density, and nutrient fields on a regional or synoptic scale and as produced by important dynamic processes, e.g. Loop Current boundary filaments along the west Florida shelf.
- Satellite thermal imagery to describe diagnostic and characteristic sea-surface temperature patterns. These can provide an independent verification and description of evolutionary circulatory patterns.
- Lagrangian drifter trajectories which represent the cumulative influence of all local and time-dependent processes acting on the buoy. This is an important and different perspective than is provided by *in situ* current measurements.
- Ship-of-Opportunity (SOOP, Figure IIIC.2) XBT data that provide valuable and cost-effective documentation of the important and at times diagnostic temperature fields.

Except for hydrography and satellite imagery, the above measurements will continue during the third eastern Gulf year. All these measurements will also be made in the western Gulf.

In June 1985, subsurface current moorings were deployed on the slope and rise offshore of south Texas and northern Mexico (Figure IIIC.3). The horizontal and vertical instrument placement is designed to provide information regarding current patterns resulting from and associated with Loop Current eddies as they approach, interact with, and dissipate on the adjacent slope. For further documentation, hydrographic surveys will be made in and through these important features as they move across the central and western Gulf. In addition, every effort will be made to place drifting buoys in break-off eddies so that important dynamical processes can be resolved. Such drifting buoys also provide essential information about eddy position during summer and early fall (late June through early November) when the sea-surface temperatures are uniform, and, hence, satellite thermal imagery cannot resolve eddy positions or geometry.

During Program Years 1 and 2, an excellent data return was maintained for subsurface currents. These are being evaluated in conjunction with NWS winds from selected coastal and buoy stations. As discussed by others at the ITM, high-frequency tidal and inertial currents, which account for a large amount of west Florida shelf current variability, show strong seasonal and interannual variability, with means becoming fairly stable after two-year averaging periods.

Three eastern Gulf hydrographic surveys were completed (Figures IIIC.4a, IIIC.4b, and IIIC.4c) which variously documented subregional-scale dynamic features and regional-scale synoptic conditions. These data help provide a better understanding of mass, thermal, salinity, and nutrient fields for the Loop Current in general and boundary features or perturbations in particular.

These and other surveys provided needed and complementary subsurface and surface calibration data for the satellite thermal imagery that was obtained and evaluated during cool months (nominally November-June) when SST gradients can be resolved in the Gulf. The imagery also provided information regarding the size, scale, and evolution of Loop Current boundary features, and trajectories of Loop Current eddies.

Loop Current eddies are the focus of the Lagrangian drifter program task. Data from several recent and three older buoys were analyzed to partition relevant or diagnostic patterns of movement (e.g., translation, rotation, pulsation) and to help define the dominant mechanisms governing this motion. Buoys placed in eddies also provide operationally valuable information concerning eddy locations in warmer months when SST gradients are insufficient to resolve these features as they move and evolve. A recently deployed drifter ended up in the Loop Current proper and recirculated eight or more times before leaving the Gulf via the Florida Straits.

The extensive and successful SOOP program has been used by various program principals to characterize conditions and to help optimize the design of measurements and placement of instruments.

Western Gulf (Year 4) observations are on schedule and every indication is that a Loop Current eddy which separated at the end of June will move into our western Gulf subsurface mooring array (Figure IIIC.3).

Dr. Evans Waddell is Division Manager for Marine Science and Engineering with Science Applications International Corp. (SAIC). At present he is also Program Manager for the MMS-funded Physical Oceanography Program in the Gulf of Mexico. He received his PhD in Marine Science (Physical Oceanography) from Louisiana State University in 1972. His recent research involvement emphasizes shelf and shallow-water physical oceanographic processes.

Observed Currents on the West Florida Continental Shelf

Dr. Wilton Sturges
Department of Oceanography
Florida State University

A current-meter array was installed near 26° N on the west Florida continental shelf in January 1983, with moorings at 75 m, 180 m, and 1600 m depths. An additional mooring was installed near 27.5° N, at 180 m, the edge of the continental shelf. In January 1984, moorings near 26° N were also installed at 50 m and 3000 m depth. The inertial period motions are very energetic and are typically 40 to 60% of the total variance in a current-meter record. The energetic peak associated with these motions extends from approximately 22 to 29 hours. The tidal motions are easily resolved, but are much weaker than the inertial motions. At the outer edge of the shelf, bottom pressure gauges were also installed. Over a tidal excursion, the peak-to-peak signal observed at these pressure gauges during spring tides is approximately 0.8 meters. The edge of the shelf here is approximately 250 km offshore from Naples.

The low-frequency fluctuations at a coastal tide gauge are one measure of the longshore currents. There is high coherence between local winds and coastal waterlevel heights at periods of approximately two days and longer. The coherence is weakest in summer when winds are light and the forcing is weak. However, this coherence increases in the summer from south to north as expected from theory. Even in the summer the coherence is high between winds and the tide gauge at Cedar Key. During the second year of the mooring data, when there is a mooring at 50 m depth, we find high coherence between the longshore currents and the tide-gauge signals at periods from a few days to ten days. Coherence is high except in summer. In the longshore direction the flow appears to be essentially uniform vertically. In the onshore-offshore direction the phase reverses from the bottom layer to the upper layer. At the moorings at 50 and 75 m depth, there is high coherence, in the longshore direction, with very little phase shift, at periods from two to twelve days. On the outer part of the shelf, however, the coherence is much lower between currents observed at 75 m and at the shelf break. The coherence is low even in winter at the wind-driven frequencies.

There are moorings spaced in the longshore direction at the edge of the shelf. The phase difference can change from being nearly in phase, to being nearly out of phase, from one mooring emplacement to the next, depending (we suspect) upon how much of the observed motions are wind-driven or eddy-like.

With records pieced together from several mooring emplacements, records of one to two years are available. These show remarkably high coherence between longshore currents at 75 m and the tide-gauge signals, at periods as long as fifty days. Because there is little horizontal phase shift, it appears that there is little horizontal structure in the currents.

Just beyond the edge of the shelf, the currents (at Mooring A) have a "bimodal" structure depending on whether the Loop Current has meandered that far to the east, close to the edge of the continental shelf. During February 1983, shortly after the mooring program began, Mooring A appeared to be well within the Loop Current. The U and V velocity components at the 170 m instrument both exceeded 40 cm/s (with flow toward the southeast). A month later the V component was just as fast, however, in the opposite direction, when a large meander passed across the mooring. These events are observable in the satellite data. Likewise, the currents at Mooring G (in 3000 m depths) seem to be either "on" or "off" depending upon whether the Loop Current is present. The variations at Mooring A are usually in phase, vertically, with the exception of the occasional finding of a northward flowing deep counter current.

Because there are large fluctuations at periods of 3-10 days, mean values over a three month record will have no statistical reliability. Moreover, there is no evidence for an annual signal in the current-meter data, as the short-term variability is much larger than the annual signal. The mean value from one three-month emplacement to the next may change from 10 cm/sec to the north to 10 cm/sec to the south. However, the "long-term mean," as computed from a two-year record, approaches statistical reliability. The mean values are approximately twice their uncertainties. At almost all instruments in the array, the long-term (two year) mean flow is to the south. The only exceptions are at the bottom instruments, 1 m from the bottom, at the shelf break. At the upper instruments at the shelf break, the mean velocity is approximately 7 cm to the south, and is uncertain to approximately 2.7 cm/sec. At the 75 m depth mooring, however, the mean flow at the upper instrument (17 m depth) is only approximately 3 cm/sec, ± 1.4.

Farther to the north there is a third mooring at the shelf break, off-shore from Cedar Key. The upper instrument is at 50 m. Eddy-like features are seen there also, presumably propagating to the north. When these eddy-like signals pass, the observed speed are approximately 20 cm/sec, with time scales of several weeks. When hurricane David passed near the mooring, the inertial currents at 50 m were approximately 80 cm/sec.

Dr. William Sturges of the Department of Oceanography, Florida State University, studies various aspects of ocean currents: the mechanisms that drive currents just offshore, strong eddies in the Gulf of Mexico, and interpretation of geodetic leveling results along coasts. He earned the PhD from Johns Hopkins University in 1966.

Summary of Results from the MMS Hydrographic Field Program

Mr. Jerry L. Miller
Rosenstiel School of Marine and Atmospheric Science
University of Miami

INTRODUCTION

The hydrographic field program of the Minerals Management Service (MMS) was designed to characterize both the flow field and the water masses in the eastern Gulf of Mexico (GOM) and more specifically to examine Loop Current - shelf water interactions along the west Florida shelf (WFS). There are three mechanisms by which the Loop Current (LC) can influence the hydrographic conditions on the outer WFS:

- A simple bodily translation of the LC front on- or offshore.
- Meandering of the LC front along the shelf break due to frontal wave propagation.
- Eddies on the LC front resulting from unstable frontal waves.

The most obvious occurrence of translation is associated with generation of large eddies which upon pinching off and propagating toward the western Gulf result in the LC having only a minimal northward penetration into the GOM before exiting eastward through the Florida Straits. During such events the LC can exert minimal influence along the central and northern WFS. Frontal eddies provide a mechanism whereby cold, nutrient-rich water from beneath the LC not only can be brought up into the photic zone but also can move onto the outer shelf by cross-isobath currents. In addition, filaments of warm water from the surface layers of the LC proper can be injected onto the shelf.

With these three mechanisms in mind, the hydrographic data collection was designed to include both regional and Loop Current-wide sampling schemes. Five cruises were conducted between April 1982 and May 1984 in the eastern GOM. Data from the spring and fall 1982 cruises have been presented in detail at previous ITM's and were not repeated in this presentation. Results from the March and November 1983 and May 1984 cruises were summarized. The sampling strategy for all cruises was such that both immediately before and during a cruise all available pertinent information including satellite, aircraft and ship-based data were used to develop and -- when necessary -- to modify the sampling plan to meet the cruise objectives. During cruises which corresponded in time with moored current meter deployments, at least one hydrographic transect along the primary mooring line was made.

Several general comments which apply equally well to all five cruises can be made. A T-S plot of all data from the November 1983 cruise exhibits the expected signatures of Antarctic intermediate water, the warm, high salinity LC water and the relatively fresh continental edge water. These water masses were observed on all five cruises and the same general T-S relationship holds for all. Relationships among the various nutrients and physical parameters were generally as expected. Nitrate and phosphate were present in the 15:1 Redfield ratio; the nitrate maximum was in deep water at temperatures around 7-8°C; the silicate maximum was at about 27.5 sigma-T units; an oxygen minimum existed at a sigma-t of about 27.0.

SUMMARY OF 1983-84 CRUISES

March 1983

The March 1983 data consist of two long transects oriented southwestward across the LC extending from the southern WFS to the Yucatan Peninsula and separated by about one degree of latitude. Data collection on both transects was interrupted by strong weather events resulting in both transects being made up of two segments separated in time. Nevertheless, the data set can be considered synoptic with respect to the larger scale characteristics of the LC. Geostrophic velocities were greater in magnitude but confined to a smaller cross-isobath distance on the northward flowing western side of the LC compared to the southward flowing eastern side for both transects. A LC frontal eddy was observed in the T, S and density fields at the WFS shelf-break. Its presence was confirmed with available nutrient, chlorophyll and satellite-derived, sea-surface temperature data.

November 1983

Four transects extending from the central WFS to the central part of the Loop were occupied. A fifth transect was cut short because of weather. This regional survey covered the area from about 24.5°N to about 28°N, which includes most of the WFS. Satellite data indicated the presence of LC frontal eddy activity but no conclusive evidence of eddies was present in the hydrographic data. A chlorophyll maximum was observed on the WFS at the southern-most transect and was probably due to an isopycnal instrusion of high nutrient water.

May 1984

The May 1984 effort was more extensive than the previous surveys. It included both aerial surveys and ship-based mapping. The aerial data include expendable temperature and current probe data covering the entire LC and yield a three dimensional synoptic view of the large scale characteristics of the LC. The aerial current data show the same skewed velocity pattern that was inferred from the geostrophic velocities of the March 1983 cruise. Of particular interest in this data set were two areas of anomalistic cold water on the eastern side of the LC. These areas were evident in the satellite imagery prior to the cruise. The ship survey mapped this area extensively. Fifteen transects were obtained. Two transects were occupied several times and reveal a southward propagating LC frontal eddy corresponding to one of the cold anomalies observed in the aerial data set. The other cold anomaly, which was located southwest of the Dry Tortugas in the region where the LC turns east toward the Florida Straits, was mapped both at the beginning and at the end of the cruise. The hydrographic data reveal that it was a dome of cold water protruding southwestward into the LC which during the two week duration of the cruise retreated northeastward about one degree of longitude. Acoustic doppler current profiles were obtained to a depth of 200 meters beneath the hull of the ship every few minutes throughout the cruise. These current data confirm the (geostrophically) expected cyclonic circulation of both the LC eddy found along the WFS and this cold dome.

SUMMARY

Water masses and flow fields associated with the Loop Current and its perturbations in the eastern GOM have been characterized using data obtained during five hydrographic surveys. Interaction mechanisms which allow the LC to influence the hydrography and circulation of the outer WFS have been identified and described qualitatively. The limited number of observations of each of these mechanisms precludes quantitative statistical descriptions or predictions at the present time.

Mr. Jerry Miller is a PhD candidate in the Division of Meterology and Physical Oceanography at the Rosenstiel School of Marine and Atmospheric Science of the University of Miami. Prior to moving to Miami in August 1985, he was employed at the Skidaway Institute of Oceanography, Savannah, GA, where he worked with Dr. Larry Atkinson, principal investigator of hydrography for the MMS eastern GOM, Physical Oceanography Program. Mr. Miller participated in the planning and execution of the ship-based surveys. Mr. Miller received the BS in Marine Science from the University of South Carolina and the MS in Physical Oceanography from the University of Rhode Island.

Bottom Currents on the Southwest Florida Outer Continental Shelf

Dr. Larry J. Danek
Environmental Science and Engineering, Inc.

Bottom currents were measured on the southwest Florida outer continental shelf as one component of the Benthic Communities Study sponsored by MMS. The instruments were installed during December 1983, which was the beginning of Year 4 of the 6-year program. The instruments were also maintained during Year 5, and the data for that year are currently being analyzed.

The current meters used were ENDECO Type 174 axial flow instruments that recorded at 5-minute intervals. The instruments were installed 3 m above the bottom and were one component of instrument arrays that contained sediment traps, wave gauges, fouling plates, and time lapse cameras. Five of the arrays were installed along a transect beginning 50 miles south of Naples, FL, in 13 m of water and extending west to a depth of 125 m. Three additional arrays were installed during Year 5.

Speed and direction plots of the data from Year 4 indicate the tidal components were the dominant periodic components of the velocity field. Particularly at the 13 m station, the tides produced an alternating east-west current that clearly illustrated the peak tidal flows and, additionally, the change in magnitude of currents corresponding to the spring and neap tides. In deeper water the tidal currents changed from linear to more elliptical with a clockwise rotation and the magnitude of the oscillations was noticeably reduced.

Power spectra analysis of the data illustrated the dominance of the tides in the current data. The tidal energy was as much as three orders of magnitude higher than the background values. The energy was greatest at the semi-diurnal frequency in the shallow water, but the diurnal frequency became more dominant in deeper water. The inertial period for this area is about 27 hr; consequently, much of the energy increase near the diurnal tidal frequency was probably the result of increased inertial energy in deeper water. The frequency intervals used in the spectra analysis were not sufficient to separate the tidal energy from the inertial energy. Subsequent analysis on longer current meter records will define the ratio of energy in these two velocity field components.

To illustrate the change in energy distribution with distance offshore, three-dimensional plots of the computed power spectra were prepared. An example of the illustrations for the summer currents for both the east-west and north-south components is presented in Figure IIIC.5. The figure illustrates the following:

1. The dominant tidal energy in the east-west component,
2. Reduced tidal energy in north-south component near shore but increasing offshore,
3. Increasing energy at the diurnal frequency (and/or inertial frequency) with distance offshore,
4. Increasing energy in the low frequency range with distance offshore for both components,
5. Increasing energy with distance offshore in the high frequency range for both components.

Other information obtained from the current meter data includes the following:

1. Although tidal currents dominated in shallow water, the residual currents were very consistent flowing to the southeast at about 2 cm/sec.
2. Residual currents at the deep station were consistent to the south with intermediate stations varying with season.
3. Loop Current intrusions occurred at about 40-day intervals and were evident as strong currents to the north associated with a 3-5°C increase in temperature.
4. Loop Current intrusions may have even extended onto the shelf to depths of only 47 m.
5. Water current measurements in general agreed with previous MMS modeling efforts.

Subsequent analysis of Year 5 data will further define the extent of Loop Current intrusions on the shelf and better identify energy components near the diurnal tidal frequency and lower frequency components of the energy spectra. Coherence analysis of the data will also be conducted to determine the uniformity of flow across the shelf.

Dr. Larry J. Danek received his doctorate in Physical Oceanography in 1976 from the University of Michigan. Following two years as a research and teaching assistant, he worked for NOAA for two years at the Great Lakes Environmental Research Laboratory conducting water current and wave studies on the Great Lakes. Dr. Danek has been in the environmental consulting business for 10 years and has conducted studies in most regions of the United States including the Beaufort Sea and at international sites including the North Sea, Arabian Gulf, and South China Sea. Dr. Danek is currently Associate Vice President at Environmental Science and Engineering, Inc., in Gainesville, FL, and is the Director of Oceanographic Services.

Variability of Inertial and Subtidal Frequencies on the Outer Shelf of the West Florida Shelf

Dr. Peter Hamilton
Science Applications International Corporation

The MMS mooring transect across the outer shelf and slope at approximately 26°N has produced continuous time series of currents and temperatures of more than two years in length. These long time series from Mooring D on the 75 m isobath and Mooring C on the 180 m isobath were analyzed with a view to investigating the dominant variability. The current records are dominated by inertial/diurnal tide fluctuations, particularly at Mooring D. The diurnal tide was found to contribute only a small proportion of the signal, and the daily fluctuations were primarily inertial with a period of about 27 hours. The amplitudes of the inertial oscillations, obtained by complex demodulation, showed a maximum at mid-depth (approximately 30 cm/s) on Mooring D during the summer periods of 1983 and 1984 when local wind forcing was weak and stratification at a maximum. The weakly-stratified winter season, when storm wind events regularly move over the shelf, had much weaker inertial currents with maximum amplitudes nearer the surface, rather than lower in the water column. The forcing mechanism for inertial currents is usually the surface wind stress, and therefore these results are paradoxical. The implication is that the strong stratification supports inertial-internal wave propagation from offshore and there is some kind of local resonance at the 75 m isobath. The forcing mechanism for these summer inertial oscillations is unclear since local wind stress is very small.

Low frequency currents for Moorings D and C were examined for 1983 and 1984. In 1983 the longslope currents were weak (<20 cm/s) with no evidence of Loop Current or frontal eddy events. In 1984, there were three identifiable Loop Current incursions at C for which southward currents exceeded 60 cm/s. The largest event lasted about 30 days and was observed at both moorings. This contrast between the low-frequency current regimes for the two years is an indication of interannual variability of the Loop Current and its effect on the outer shelf.

Dr. Peter Hamilton is currently Senior Oceanographer at the Raleigh, NC, office of SAIC. His research interests include dynamics and numerical modeling of estuarine, shelf, and slope circulations. Prior to joining SAIC in 1978, Dr. Hamilton was a research associate at the University of Washington. His doctorate was obtained from the University of Liverpool (U.K.) and his thesis topic was the numerical modeling of estuaries.

MMS Satellite Studies in the Gulf of Mexico, 1983-1985

Dr. Fred M. Vukovich
Research Triangle Institute

NOAA and GOES infrared satellite data were combined with *in situ* data to study various circulation features in the Gulf of Mexico. In the eastern Gulf, emphasis was placed on the cold perturbations that form on the boundary of the Loop Current. In a 1983 case study, two cold perturbations were seen to merge and produce a very large perturbation. A large warm filament was associated with the large perturbation that was situated on a shoreward side of the cold perturbation. The warm filament pumped large amounts of warm water on the West Florida Shelf, producing major changes in the sea-surface temperature pattern on the West Florida Shelf.

In a 1984 case study, an extended cold dome was developed off the Dry Tortugas as a result of the motion of a cold perturbation. The cold perturbation was first detected on the northern boundary of the Loop Current and moved eastward, then southward along the West Florida Shelf to the Dry Tortugas. During this period, the cold perturbation was elliptical in form. Its major axis (approximately 200 km), situated along the main cold vector of the Loop Current, and its minor axis (approximately 100 km), perpendicular to the main flow axis of the Loop Current, remained relatively constant. However, when the perturbation reached the Dry Tortugas, the location of the major and minor axes of the perturbation relative to the mean flow vector of the Loop Current changed. The major axis was perpendicular to the mean flow vector of the Loop Current, and the minor axis was parallel to the mean flow vector.

As the perturbation approached the Dry Tortugas and the Straits of Florida, the perturbation moved directly southward instead of turning into the Straits of Florida. The bottom rose rapidly in the Straits of Florida, but the cold perturbation moved southward where the bottom remained deep. By moving southward, the cold perturbation produced an extended cold tongue, stretching westward towards the Campeche Bank. However, this cold tongue did not move to the Campeche Bank but eventually dissipated. It appeared that the bottom depth controlled the direction of motion of the cold perturbation which controlled the production of the extended cold tongue in this case.

In the western Gulf, 12 years of NOAA satellite data were used to study various aspects of warm rings which separate from the Loop Current. It was determined that there are three characteristic paths of movement of the rings: a northern path; a mid-Gulf path; and a path that takes the ring into the southern extremities of the western Gulf of Mexico. It was shown that all three paths eventually lead the ring to a region in the northwestern Gulf offshore Texas. As the rings moved from the eastern to the western Gulf, the speed of the ring was observed to oscillate. The oscillation was over a speed range from 1 to 8 km per day, on the average, and the period varied from 40 to 100 days. The average speed of the ring was approximately 5 km per day. After the rings separated from the Loop Current, their surface area decreased to about 55% of initial size in approximately 150 days and to about 31% of initial size in about 300 days.

Dr. Fred M. Vukovich, Director of the Office of Geoscience Programs at Research Triangle Institute, has studied applications of satellite data to meteorology and oceanography, specializing in combining satellite data with *in situ* data to study physical phenomena. He has been involved with the application of free-drifting buoys to study ocean features, including efforts to study cold rings in the Sargasso Sea and to study Gulf Stream frontal events and Loop Current structure.

Lagrangian Drifters

Dr. James Lewis
Science Applications International Corporation

Results of MMS-funded work with drifters released in Loop Current rings indicate that these rings tend to follow the deepest part of the Gulf of Mexico (Figure IIIC.6). This has also been seen in numerical modeling studies of the Gulf of Mexico (GOM). Drifter data indicate a total travel time across the GOM of six to eight months with the rings persisting for at least an additional five months after interacting with the continental slope off the Mexican coast. This indicates ring life spans of the order of one year.

The trajectory of drifter 3375 (Figure IIIC.6) was analyzed in conjunction with sea-surface temperature (SST) maps. Even though this drifter was not seeded in a Loop Current ring, it still showed strong anticyclonic motion. The SST data and the drifter trajectory showed the interaction of three anticyclones in the western GOM. First, the drifter looped around two anticyclones whose outer flow fields had temporarily coalesced along the Mexican coast. The data then showed northern translation of ring 3374 (Figure IIIC.6) along the Mexican coast as well as the coalescing of ring 3374 with another anticyclone in the northwest corner of the GOM. This latter phenomenon occurred as a new ring was breaking off the Loop Current.

Kinematic calculations show that differential motion within the rings is dominated by vorticity. This would indicate that a pollutant spilled within a Loop Current ring would tend to stay in the ring as it translates westward. The data from separate rings show some amazing consistencies with respect to kinematic variables. These consistencies, plus the near-identical paths of the rings, imply that a single process may be responsible for governing much of the movement of the ring across the central GOM.

Ring dynamic calculations are only preliminary, but thus far indicate two important processes. The first is vortex stretching about the center of the ring. Calculations show that this parameter oscillates in sign with about a 20-day period. The second phenomenon is the wobble of the central axes of the rings. Data show periods of persistent west-southwestward movement with interdispersed periods of the rings making small anticyclonic circles.

James K. Lewis, a senior scientist in oceanography for Science Applications International Corporation, has been involved with the drifting buoy program in the Gulf of Mexico since 1981. He is also currently working with Lagrangian techniques in the Arctic Ocean in the study of sea ice kinematics and dynamics. Dr. Lewis holds a BS in mathematics from Oklahoma State University, an MA in marine science from the College of William and Mary, and a PhD in oceanography from Texas A&M University.

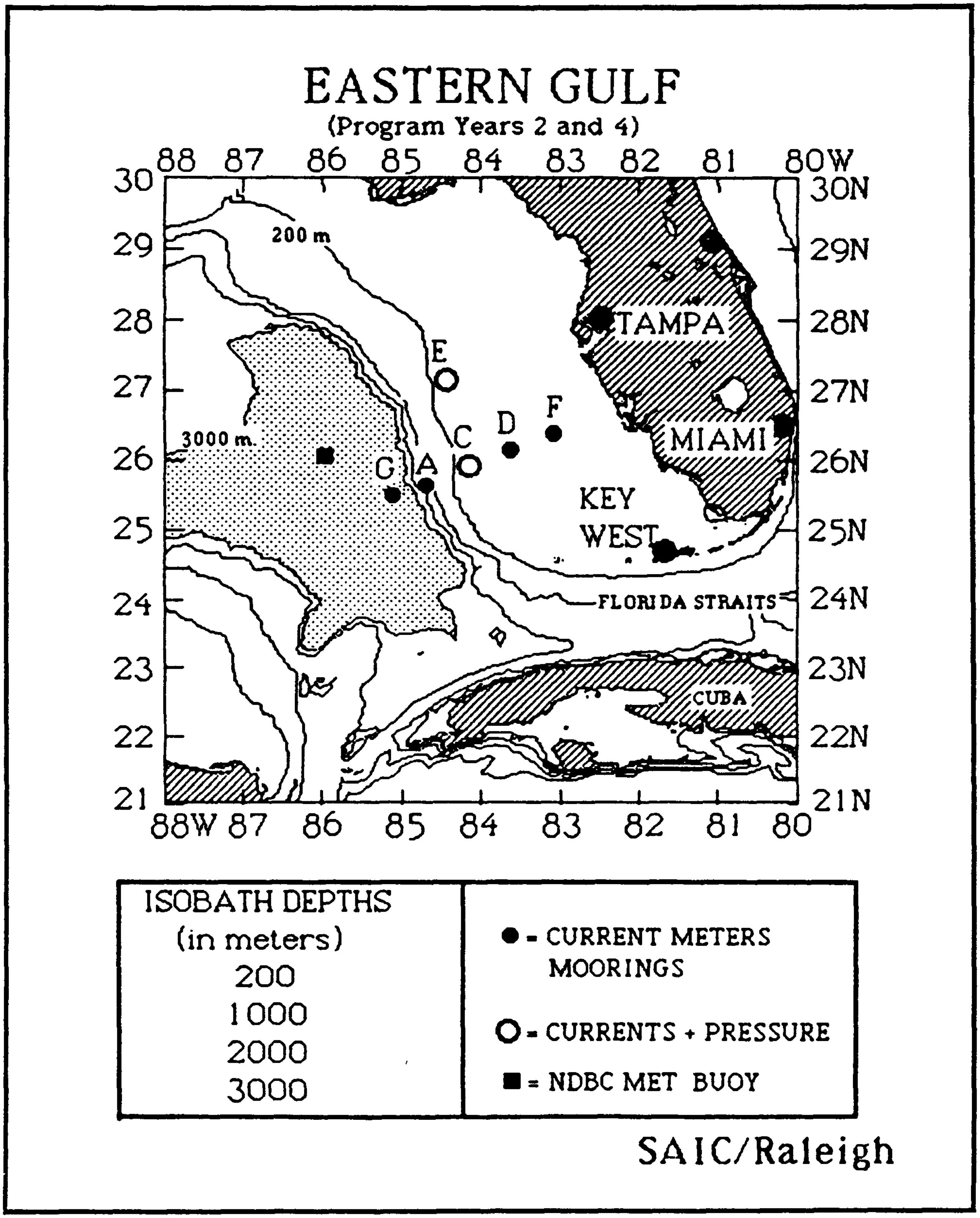

Figure IIIC.1 - Eastern Gulf Mooring Placement During Program Years 2 and 4. Recently a NSF/FSU Mooring Was Placed at the Shelf Break About 100 (1.6°) Miles North of Mooring E.

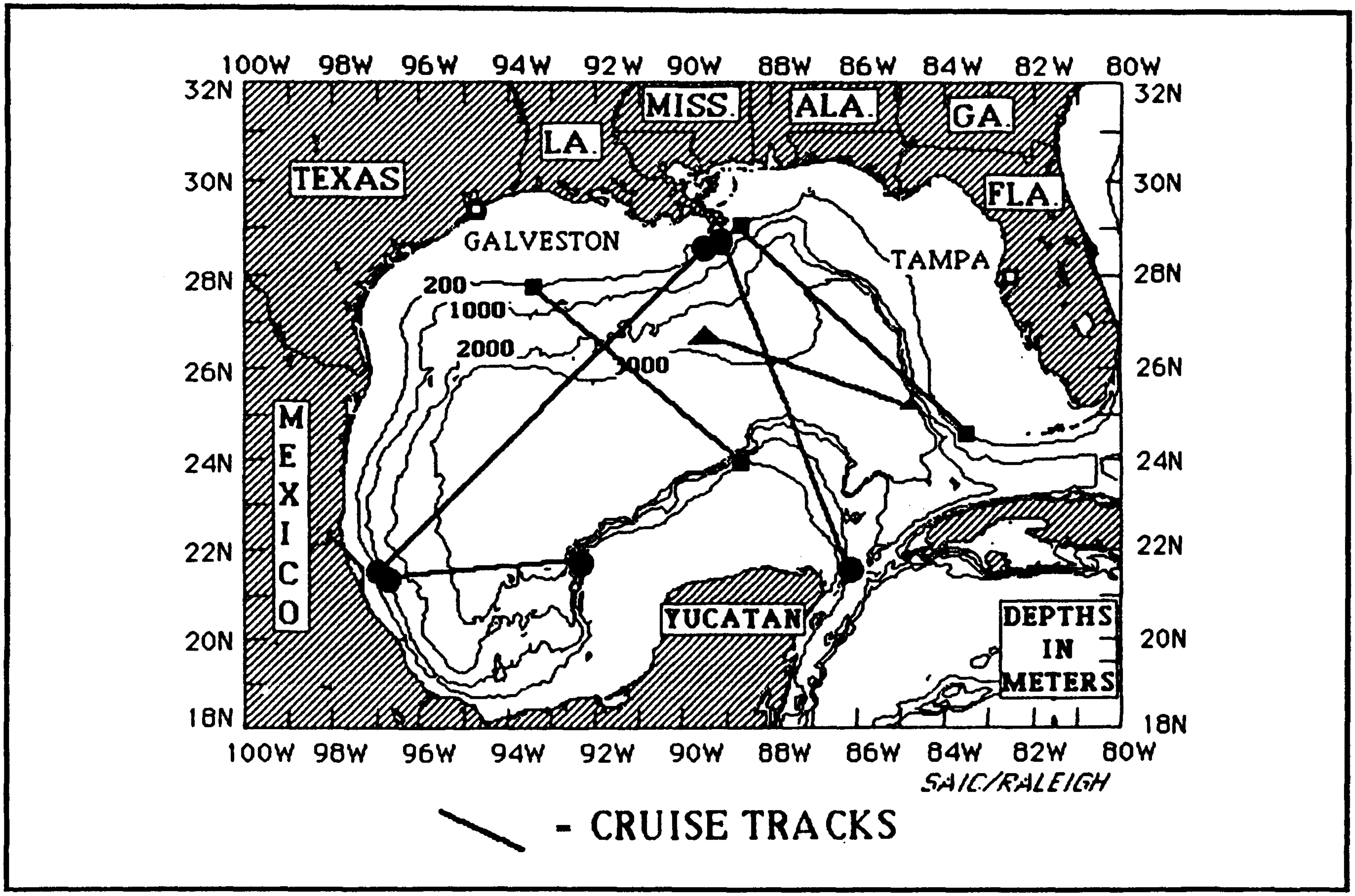

Figure IIIC.2 - Various SOOP Transects Presently Being Made to Support Physical Oceanography Program. The Repeat Period Varies from 10 to 45 Days.

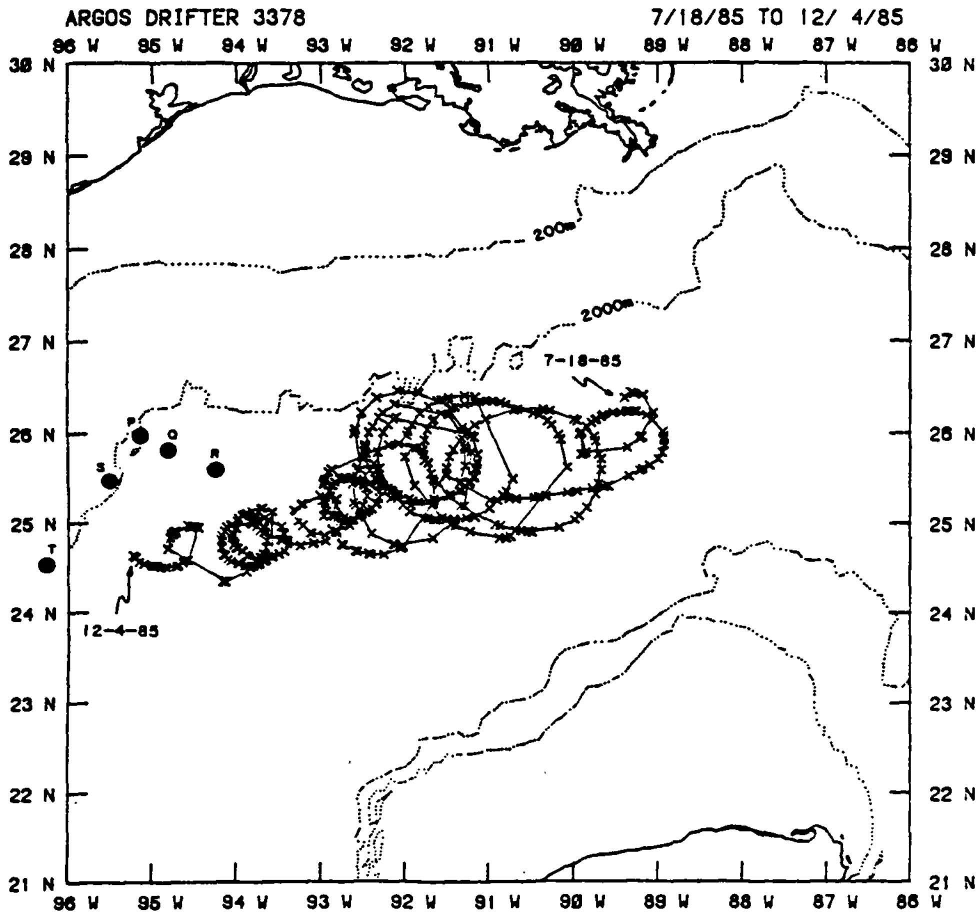

Figure IIIC.3 - Approximate Positions of Five Western Gulf Current Moorings (P,Q,R,S,T) Which Were Deployed in June 1985, Rotated in October, 1985, and Will Be Retrieved in June 1986. ARGOS Drifter Trajectory (Buoy No. 3378) is Also Shown. These Buoy Positions Were Obtained in Real-Time and Contain Data Gaps (Straight Line Segments) when the ARGOS Computer Could Not Be Assessed. Summary Data Tapes Will Contain Complete Buoy Trajectories.

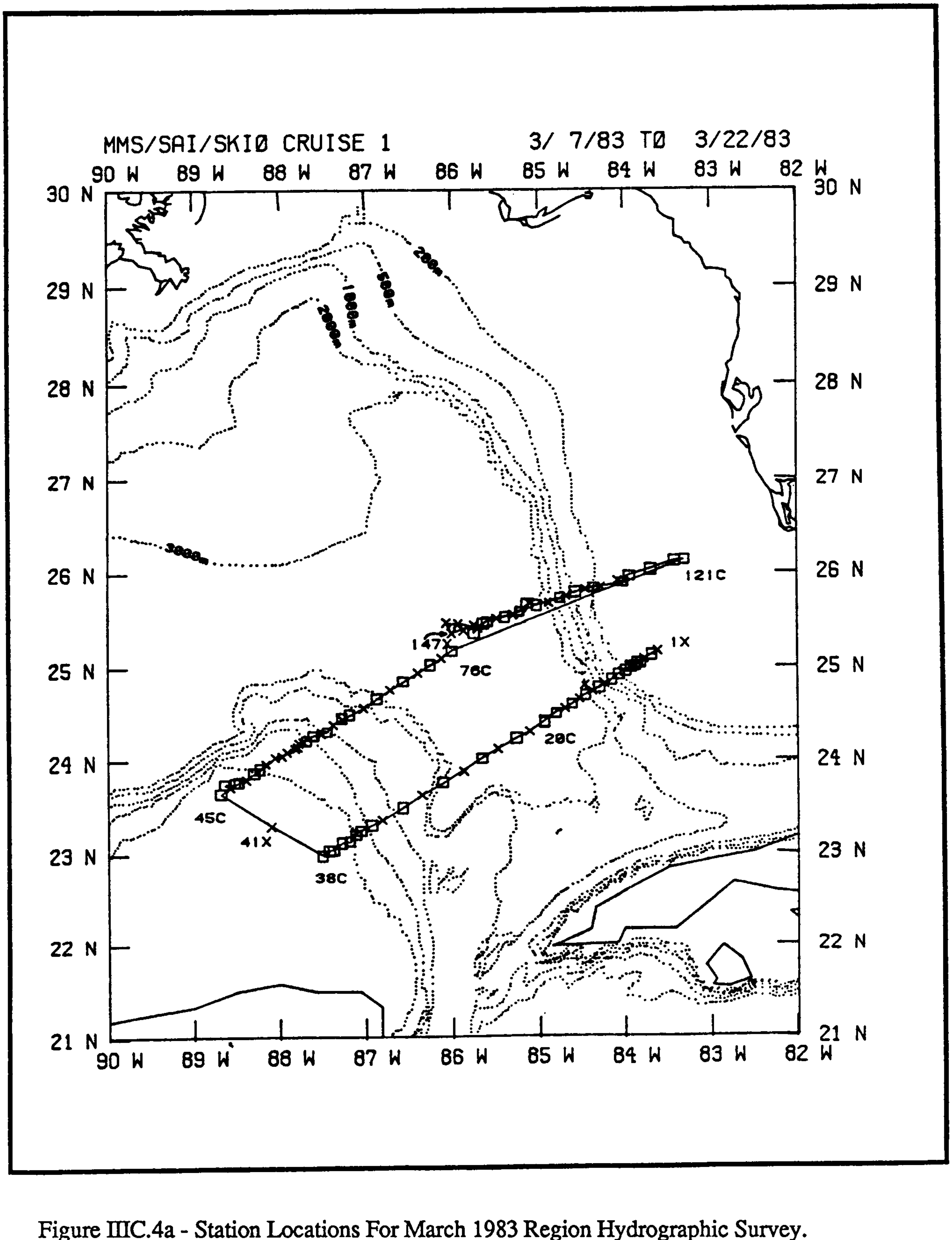

Figure IIIC.4a - Station Locations For March 1983 Region Hydrographic Survey. Southern Transect Went Completely Across the Loop Current Base

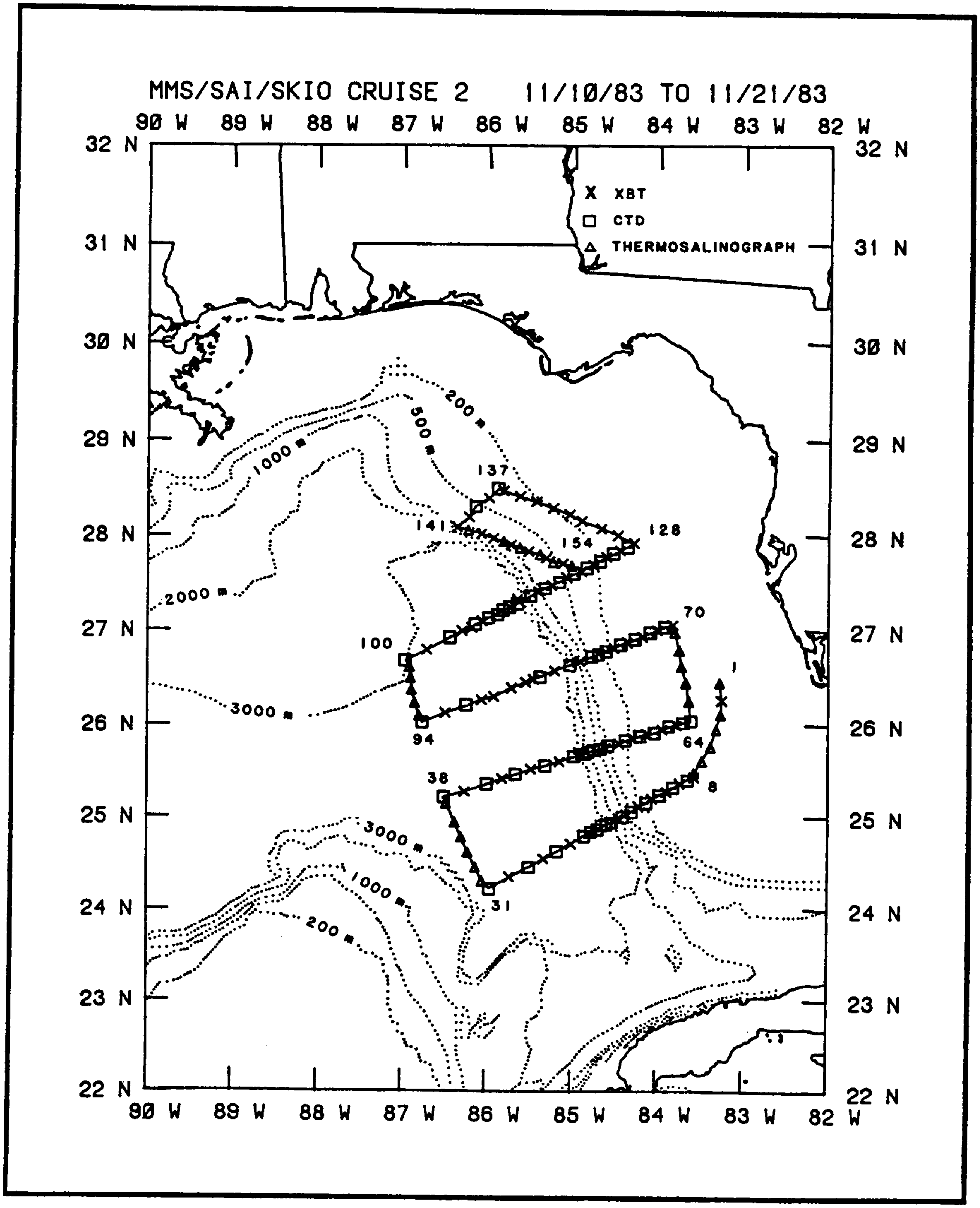

Figure IIIC.4b - Station Locations for November 1983 Regional, Loop Current, Eastern-Boundary, Hydrographic Survey

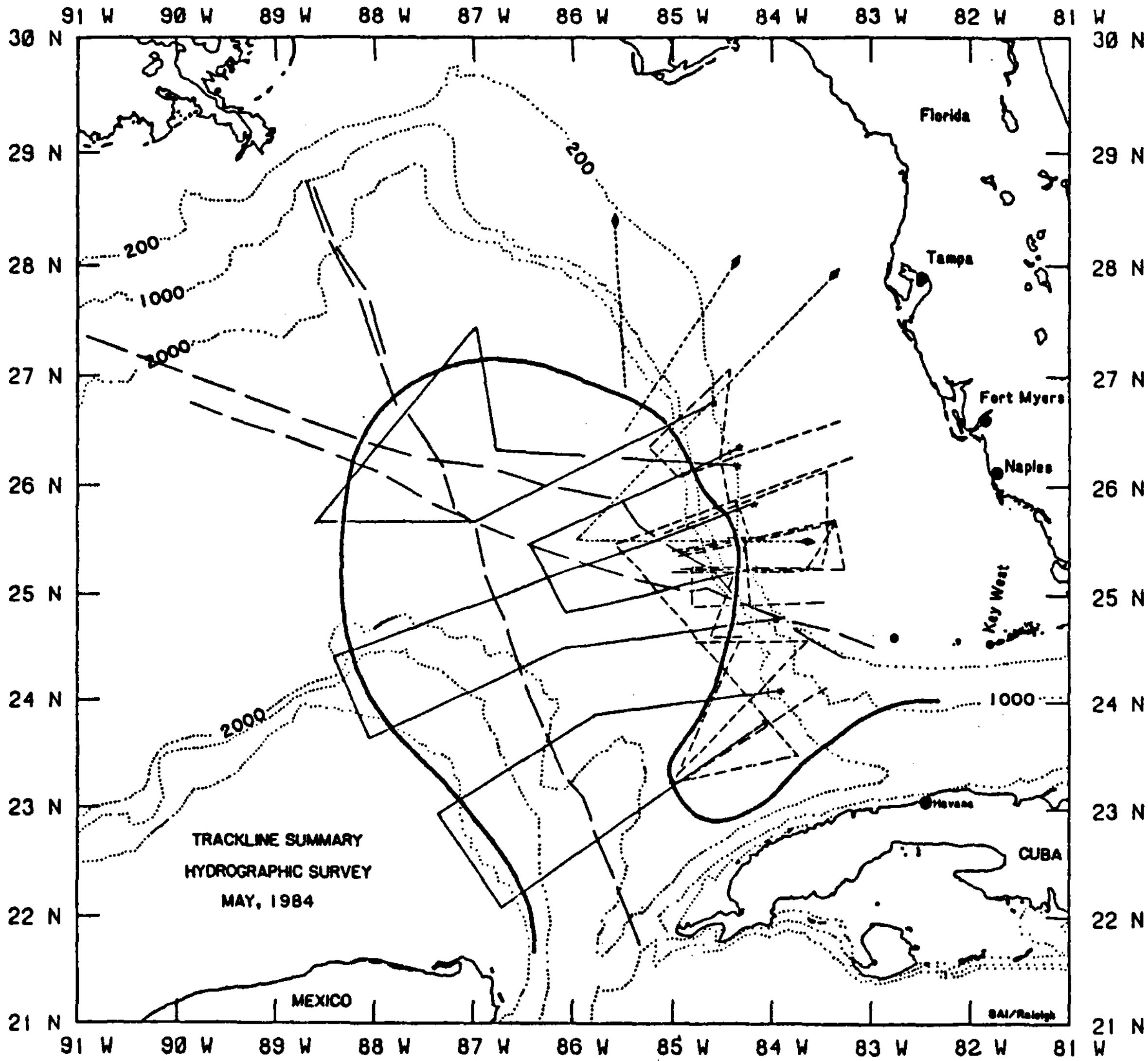

Figure IIIC.4c - Summary Plot of All Plane and Ship-Based Data Available for May 1984 Hydrography Survey. Includes SOOP Transects

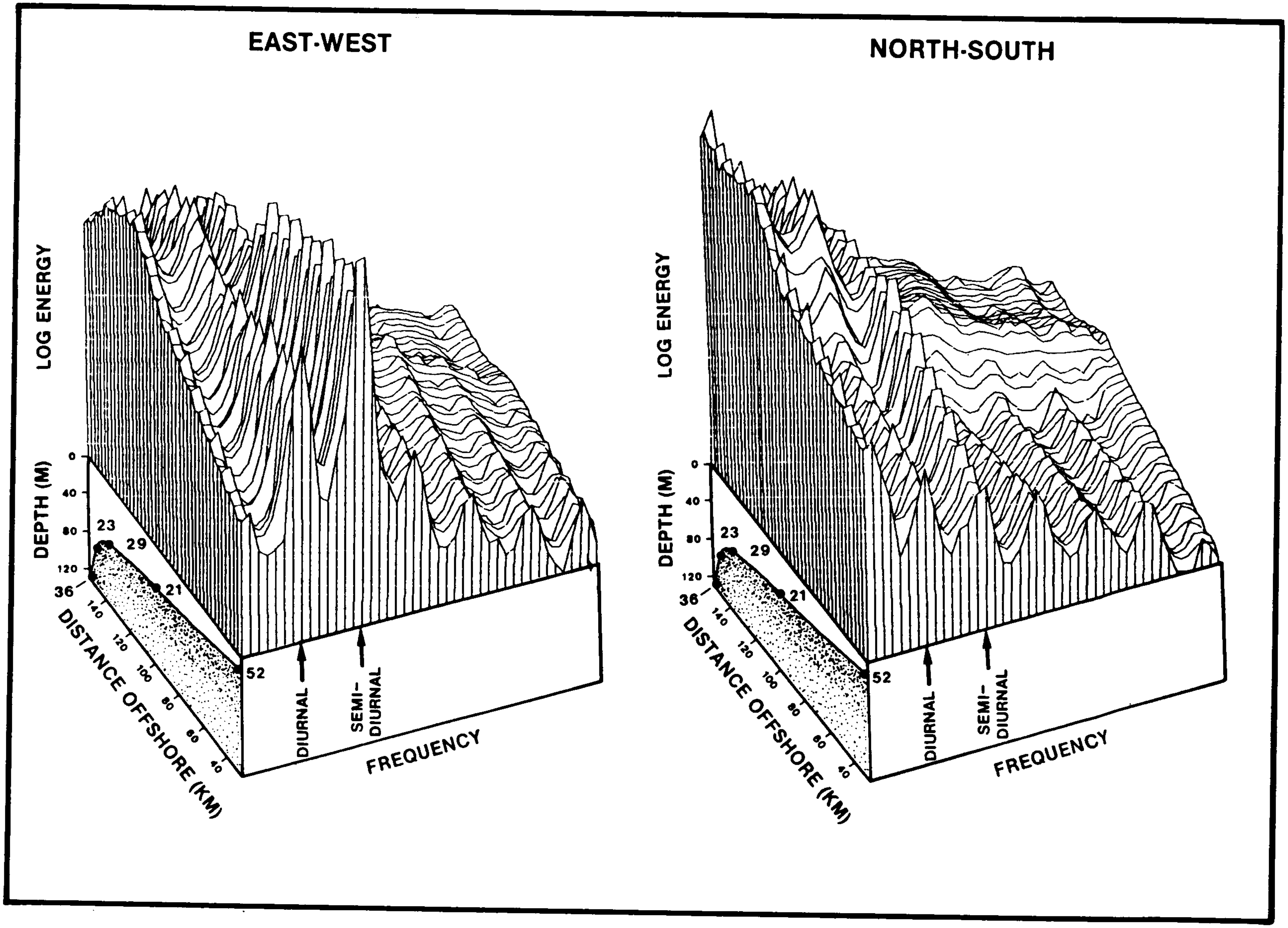

Figure IIIC.5 - 3-D Summer (1984) Energy Spectra, East-West and North-South Component

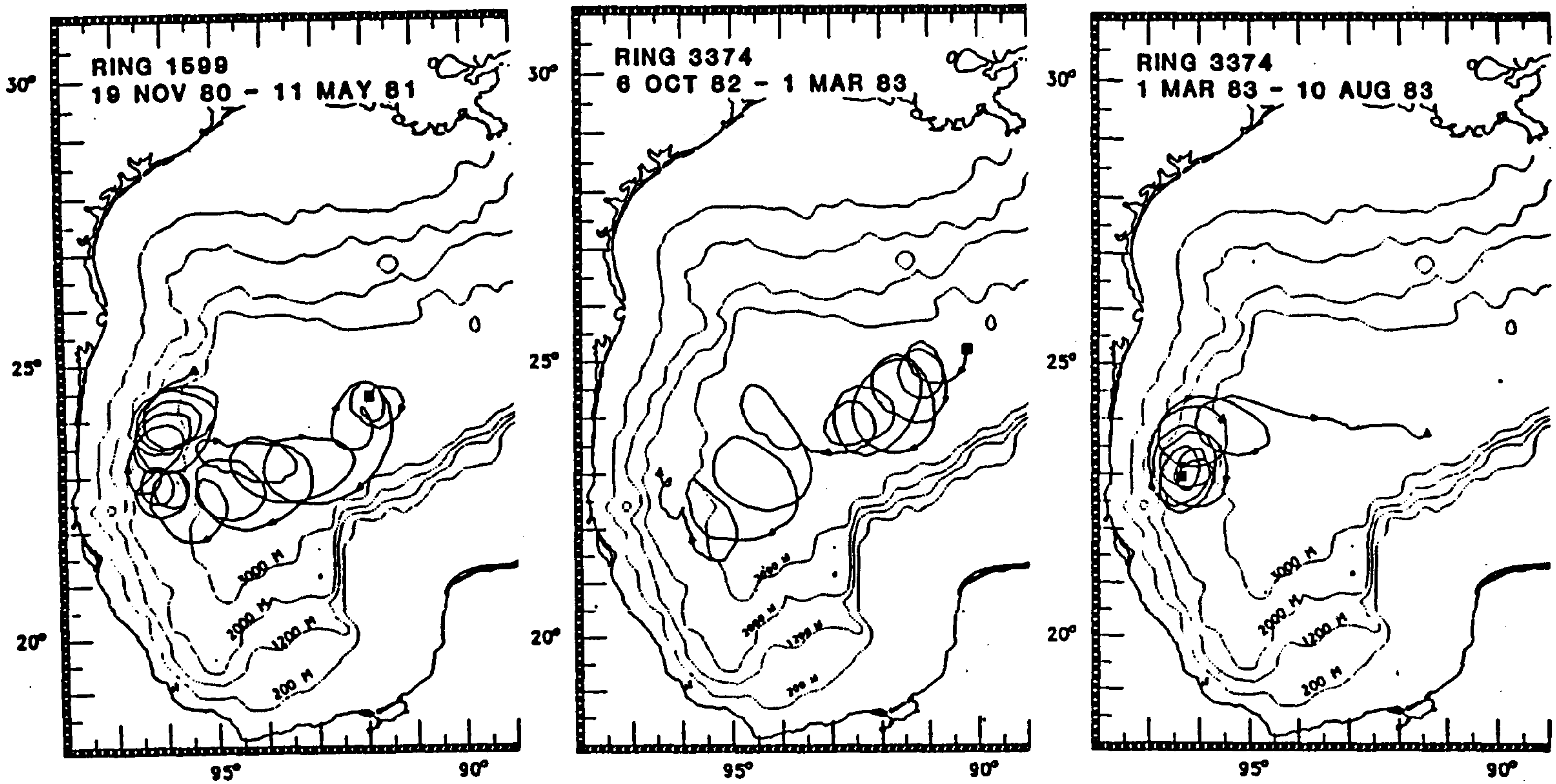

Figure IIIC.6 - Trajectories for Drifters 1599, 3374, 3375, and 3350. Depth Contours are in Meters. The Squares and Triangles Denote the Start and End Positions, Respectively.

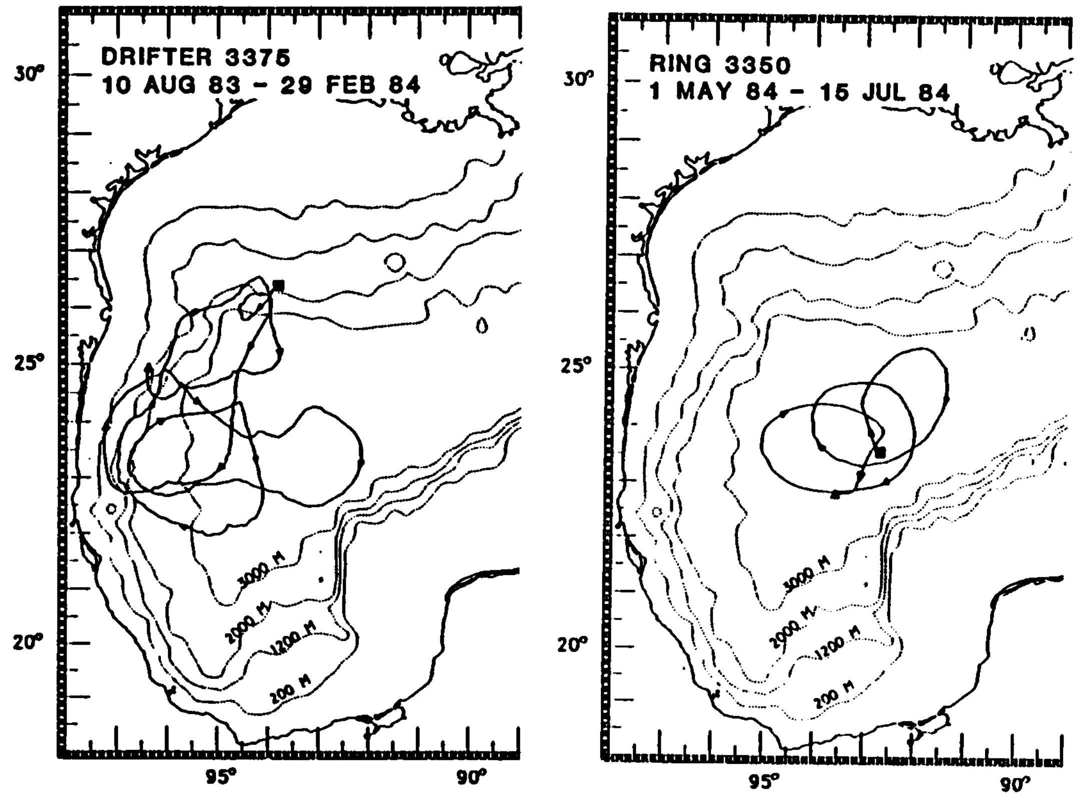

Figure IIIC.6 (Continued) - Trajectories for Drifters 1599, 3374, 3375, and 3350. Depth Contours are in Meters. The Squares and Triangles Denote the Start and End Positions, Respectively.

OIL DISPERSANTS I: USE IN THE GULF OF MEXICO

Session: OIL DISPERSANTS I; USE IN THE GULF OF MEXICO

Chairmen: Ms. Laura Gabanski
Mr. Ken Graham

Date: October 23, 1985

Presentation Title	Speaker/Affiliation
Session Summary for Oil Dispersants I: Use in the Gulf of Mexico	Mr. Ken Graham Minerals Management Service
Chemical Dispersants: Mechanism, Effectiveness, and Application Methods	Mr. Gerard P. Canevari Exxon Research and Engineering Company
Equipment, Supplies, and Response Capability in the Gulf of Mexico	Dr. J. P. Fraser Shell Oil Company
Letter of Agreement Among the USCG, EPA and State of Florida for Use of Dispersants	LCDR Tony E. Hart Marine Environmental Protection Branch Seventh Coast Guard District
Planning for Dispersant Use in Federal Region 6	Lieutenant Richard Wells United States Coast Guard

Session Summary for Oil Dispersants I: Use in the Gulf of Mexico

Mr. Ken Graham
Minerals Management Service

I will be summarizing the session on "Oil Dispersants I," entitled "Use of Dispersants in the Gulf of Mexico."

The purpose of the session was to give a broad overview on dispersant use in the Gulf of Mexico. It included such topics as: What are dispersants? How are they applied? What application equipment, dispersant supplies, and general response capability exist for use of dispersants? What progress is being made in developing contingency plans for dispersant use? The two subjects that were included here were the Florida letter of agreement with the U. S. Coast Guard and also plans for dispersant use in Federal Region Six, which includes Texas and Louisiana.

Our first speaker for that session was Mr. Gerry Canevari, of Exxon Research and Engineering. His subject was "Chemical Dispersants: The Mechanism of Chemical Dispersion, Effectiveness, and Application Methods of Dispersants." Mr. Canevari said that dispersants were surface-active agents which when applied to the surface of an oil slick would align themselves at the water/oil interface, thus reducing the interfacial tension between the oil slick and the water column, causing the oil slick to break up into fine droplets which are then dispersed through the water column and diluted. He stressed that proper dosage of the dispersants was necessary for an effective treatment and that this proper dosage had to be spread in an even layer across the surface of the oil slick. This can be done by using either boats or aircraft, but mainly by spraying techniques. To accomplish this, nozzles are fixed on the end of outboard booms to deliver the proper dosage. He also said that aerial applications tend to be more effective on large spills because of greater coverage in less time.

He also mentioned that the effectiveness of dispersants depended upon the type of crude oil that was spilled on the water surface. Not all types of crude oil are able to be dispersed using chemical dispersants. Also, the degree of weathering that the oil slick has undergone before dispersants are applied is an important factor. If the oil weathers too much, then dispersants are ineffective in dispersing them. In terms of effectiveness, he stressed that for types of crude which avail themselves to being dispersed, dispersants can be effective as a tool for fighting oil spills. In some outdoor tests they found cases where the oil slick was reduced to ambient concentrations of petroleum in the water in two and a half hours time. They can be a very effective tool if they're applied correctly.

He went on to discuss the fact that dispersed oil tends to cause less environmental damage than untreated oil slicks. Some of the reasons for this are the fact that dispersed oil goes into the water column, where it moves with the water current. It's not like an untreated oil slick that responds to surface winds and can be blown ashore. It moves with the water current and it also becomes diluted quickly.

Another factor for the reduced environmental impact of dispersed oil is that damage to marine fowl is lessened because the oil is dispersed into the water column where it won't impact marine bird life. Also, dispersed oil tends to be less persistent in the environment after an oil spill. In other words, when it's dispersed, it won't adhere to beach sand, bottom sediments, or other surfaces that happen to be present. This is helpful in letting oil wash out to sea, where it becomes diluted.

Environmental impacts of dispersed oil are also decreased because the fire hazard is reduced by dispersing the oil into the water column. Finally, dispersed oil will not form a tar-like residue which becomes a problem in many of the oil spills that we see.

Mr. Canevari concluded by saying that the decision to use dispersants must compare the impacts of the chemically dispersed oil with the untreated cohesive oil. Many times when you're looking and trying to evaluate the impact of using dispersants, the stress is put on what biological damage the dispersant alone might cause. In truth what you should compare is the dispersed oil versus an undispersed slick.

The other concluding point was that he highly recommends some type of pre-planning before an actual oil spill emergency would occur. Certainly you need to make sure that the adequate application equipment for dispersants is available and also adequate dispersant supply. The decision to use dispersants must be made very quickly in the oil spill cleanup process. The sooner that you can treat the slick, the more responsive it will be to the dispersant.

The second speaker was Mr. John Fraser of Shell Oil Company. His paper was entitled "Equipment, Supply, and Response Capability in the Gulf of Mexico." He started by addressing application equipment. Application equipment includes boats, helicopters, and fixed-wing aircraft. For boat application of dispersants, there are four boat-mounted spray apparatus available through the Clean Gulf Associates. These spray apparatus can be mounted on any boat of convenience, whether it's an oil company work boat or other type of vessel.

In discussing small planes and helicopters for application of dispersants, Mr. Fraser said that there were many vehicles available scattered across the Gulf Coast. The problem is that most of these potential vehicles are used in agricultural spraying and must be modified for dispersant application. Equipment for modifying small vessels and aircraft has to be on hand.

Mr. Fraser said that for major oil spills you need larger aircraft with capacity to spray dispersants quickly over a large area. A large capacity C-130 cargo aircraft unit which mounts into the back of any C-130 cargo plane is available through the Clean Caribbean Cooperative and MIRG. It is located at Fort Lauderdale. In addition a DC-4 aircraft has been modified for dispersant use and is stationed in Mesa, AZ. Both of those units could be onsite fairly quickly in the event of a large oil spill emergency.

In terms of dispersant supplies that might be available during an emergency, Mr. Fraser said that there was a 615-drum stockpile of selfmix concentrate dispersant, which was located in Houston, TX. A 500-drum dispersant supply is available in Fort Lauderdale, FL. These supplies would suffice during large-scale emergencies. Other major manufacturers of dispersants have their own stockpiles. The two largest companies would have about 200 drums of dispersant each available for an emergency and numerous lesser manufacturers of dispersants would have smaller stockpiles available. Manufacturers of dispersants could start manufacturing emergency dispersant supplies in about two to five days after the start of an emergency. Major suppliers could produce about 200 drums of dispersant per day.

Mr. Fraser concluded by saying that transporting spray apparatus such as planes or boats to the site, and resupplying the spray apparatus with dispersants during operation were the primary limiting factors which would slow response time during an emergency oil spill. He stressed that in order to obtain proper application of dispersants, it was necessary to have an experienced observer to direct dispersant applications onto the oil slick. Sometimes finding an experienced person for this task is difficult.

In assessing our present capabilities in the Gulf of Mexico including application units and supplies, we have the capability to disperse an oil spill of approximately 1000 barrels per day.

Our third speaker was Lieutenant Commander Tony Hart, who is with the Seventh Coast Guard District. He spoke on one of the oil spill contingency plans which includes dispersant use, namely the Florida Letter of Agreement. He stated that Florida has a large amount of sensitive coastal habitat. Because there's a lot of barge traffic and oil tankers that go by on the coast, it's vulnerable to oil spills. That makes it mandatory to have some sort of pre-planning procedure for dispersant use during an oil spill.

He discussed the National Contingency Plan, particularly Subpart H, which mandates that we consider the use of dispersants during an oil spill. For this reason, the Coast Guard approached EPA and the State of Florida to ask in what situations they could pre-authorize the use of dispersants to treat oil spills. Together with EPA and Florida, they came up with a Letter of Agreement that would give the on-scene coordinator for the oil spill the authority to authorize dispersant use without having to first contact the State of Florida or EPA.

The on-scene coordinator must first consider physical methods of oil removal whenever possible. Where containment is not possible, dispersants should be considered in reducing adverse environmental impacts or preventing loss of life. The on-scene coordinator was given a set of guidelines to use in making a decision on whether to use dispersants. Mechanical means will be used where possible. The on-scene coordinator also must consult a sensitivity atlas and a dispersant atlas that have been prepared by the State of Florida before making the decision to use dispersants. The on-scene coordinator in most cases has the option of using dispersants if the oil spill occurs more than three miles from shore and the water depth is greater than 65 ft deep. In the instances where spills are less than three miles from the Florida coast, if the water depths are greater than 32 ft, dispersants can be used when the environmental damages caused by dispersants would be less than economic and esthetic values of the resource to be saved.

He stated, in closing, that the Coast Guard has similar agreements in Puerto Rico where an on-scene coordinator could authorize dispersants without having to clear the decision with any regulatory agency. The dispersant use critera were slightly different, however.

Our final speaker was Lieutenant Richard Wells, who is with the Eighth Coast Guard District. He discussed "Planning for Dispersant Use in Federal Region Six," which includes Texas and Louisiana (the two states he's dealt with). He began by reviewing the federal regulations for dispersant use, including the National Contingency Plan. He stated that the situation in Region Six differed from Florida because they had no advance approval for an on-scene coordinator at an oil spill to use dispersant. Approval for dispersant use must be done on a case-by-case basis, depending on what the oil spill situation is.

They have made progress, though, in streamlining the approval process for quick use of dispersants. They developed a dispersant application form which an organization (for example the Clean Gulf Associates or an oil company) would complete to obtain authorization. They've also established a dispersant working group to research the technical and logictical aspects of dispersant use. Finally, they've also predesignated a regional response team that will be consulted when there's a request to apply dispersants.

The dispersant application form is about six pages long and requires a lot of detailed information. Because time is of the essence when considering dispersant applications on oil spills, Lieutenant Wells stressed that some type of pre-planning was needed for both the organization that might spray dispersants and the government entities responsible for making the decision on whether dispersants could be used.

He also stated that the Regional Response Team responsible for making decisions on dispersant use has the disadvantage in being scattered across Texas and Louisiana. When an application is received to use dispersants, they have to depend on telefax or other means to furnish the application to all the members. Response team members have to keep in communication by telephone because meetings are not always possible.

In closing, I felt the session provided useful background information on dispersant use in the Gulf of Mexico.

Ken Graham is currently employed as an environmental protection specialist by the Minerals Management Service, Gulf of Mexico OCS Region in Metairie, Louisiana. Prior to that time he worked as a biologist for the Jacksonville District, U.S. Army Corps of Engineers. He received the BA Degree in Biology from Luther College and the MS Degree in Botany from North Dakota State University.

Chemical Dispersants: Mechanism, Effectiveness, and Application Methods

Mr. Gerard P. Canevari
Exxon Research and Engineering Company

During the past several years, there has been an increasing acceptance of the concept that chemical dispersants can represent a viable oil spill response option and should be included in oil spill response contigency planning. One of the principal reasons for this attitude is the positive results of research programs that were initiated during the 1978-84 era.

THE MECHANISM OF CHEMICAL DISPERSION

When oil is spilled on water, it exhibits a cohesiveness or resistance to break up. This cohesive strength is due to the interfacial tension or contractile skin between the oil and water. A chemical dispersant reduces this interfacial tension and thereby promotes the breakup of the oil film into fine droplets that disperse into the water phase and can be carried away and diluted by normal ocean current and movement. More recently, dispersants have been formulated which reduce interfacial tension to such a low level that very little energy is required for the interfacial film breakup. In addition to promoting the generation of fine oil droplets, the surfactant also prevents their coalescence.

There are four processes in the dispersion mechanism:

1) Apply the dispersant (surfactant) to the oil layer at the proper dose rate.
2) Surfactant transfers to oil-water interface.
3) Surfactant orients itself at oil-water interface, reducing the oil-water interfacial tension.
4) Oil layer readily breaks up into fine droplets with the onset of some water movement.

THE PROPER APPLICATION OF THE DISPERSANT

Regardless of the chemical aspects, dispersion of the oil spill cannot be accomplished if the dispersant is not delivered to the oil at proper dosage. Dispersants can be applied from boats or aircraft spraying through sets of nozzles fixed on outboard booms. Aerial application can be performed by properly equipped helicopters or single- and multi-engine fixed wing aircraft. During the past five years or so, aerial application has been found to be the more effective and practical application vehicle for large spills. Extensive field tests during this latter period have advanced the state of knowledge so that the spray system can now be designed to ensure delivery of the chemical to the oil slick in an effective manner.

EFFECTIVENESS OF FIELD TRIALS

Full scale tests have been conducted under actual sea conditions in order to investigate "real life" effectiveness of chemical dispersion. An example of a field test conducted under proper conditions is the API- and EPA-sponsored dispersed oil research program conducted off the East Coast of the United States. A state-of-the-art, low mixing energy dispersant was applied by helicopter to four 10-barrel spills. A light Murban crude oil (API gravity 39) was used for two of the spills, and a heavier La Rosa crude oil (API gravity 24) was used for the other two. The chemical fate of the dispersed oil was monitored by an extensive sampling program. For the immediately dispersed Murban crude oil spill, 30 min after dispersion, concentrations of organics ranged from 11.0 ppm near the water surface to 0.9 ppm 9 m below the surface. Approximately a tenfold dilution occurred in the next 45 min. Finally, the oil concentrations approached background levels 2.5 hr after dispersion.

Rough material balance calculations, supported by visual and photographic evidence, indicated that Murban crude oil treated immediately was almost completely dispersed.

ASSESSMENT OF ENVIRONMENTAL IMPACT

When the dispersant is properly applied, the physical transformation of a cohesive intact surface slick into a dispersion of fine oil droplets yields the following benefits:

1) Dispersed oil moves with water current and dilutes in concentration as opposed to a surface slick that is driven by wind. This would prevent shore contamination if there is an onshore wind.
2) Damage to marine fowl is avoided since oil is removed from the surface.
3) Oil is prevented from wetting and adhering to beach sand, bottom sediment, and similar surfaces, thereby greatly reducing its persistence at the place of impact and minimizing biological damage.
4) Fire hazard is reduced by removing the support for combustion.
5) The formation of nuisance tar-like residue is prevented.

CONCLUSION

The viability and utility of chemical dispersants to mitigate oil spill damage has been well established. It should be emphasized that the comparison of environmental impact has to be made between the chemically-dispersed oil and the impact of an untreated, cohesive oil spill impacting a particular habitat. Research in both the field and laboratory has shown that chemically dispersed oil has no greater ecological impact and in most cases considerably less impact than untreated oil. The ecological effects of such untreated oil, particularly on sensitive shorelines, must always be considered if a decision is made to avoid the use of chemical dispersants.

The need for preplanning is also strongly recommended. Such preplanning involves both the readiness of proper application equipment and adequate dispersant supply as well as the identification of zones of impact where prompt decision on the use of chemical dispersants has to be made.

Mr. Canevari is an engineering advisor. He joined Exxon Research and Engineering in August 1953. During the past 20 years, he has been involved in the area of surface chemistry -- particularly in its application to engineering problems such as the separation of an immiscible dispersed liquid or of particulate matter from a liquid medium. Some techniques developed during this period that are now in use include a self-mix chemical dispersant to eliminate oil slicks, an improved oily water flocculant, and a surfactant film for suppression of hydrocarbon vaporization.

Equipment, Supplies, and Response Capability in the Gulf of Mexico

Dr. J. P. Fraser
Shell Oil Company

Subpart H of the National Contingency Plan authorizes the Federal On-Scene Coordinator, with concurrence from the EPA and the affected states, to approve use of chemical dispersants on an oil spill, providing that such use is appropriate. In this context, it is important to understand what dispersants are available and how much is on hand, what equipment is available for application of the dispersant chemicals, how much oil could be treated, and what is our capability.

Three types of equipment can be used to apply dispersants:

- Boat-mounted spray apparatus
- Equipment which is transported by and operated from a helicopter
- Fixed-wing aircraft equipped for aerial spraying

Boat-mounted spray equipment is owned by Clean Gulf Associates and could be installed on any vessel of convenience. This apparatus is designed for and dedicated to use in spraying dispersants. Four sets are owned by Clean Gulf Associates.

Aerial spray apparatus, both helicopter and fixed-wing aircraft, is available at many locations along the coastline of the Gulf of Mexico. Most of this equipment is used for application of agricultural chemicals and would need to be modified for use with dispersants. Modifications would include primarily the spray nozzles but could also include pumps, metering systems, and navigation equipment.

Although most of the aerial spray apparatus is designed for agricultural use, one major system, dedicated to use for application of dispersants, is stationed at Ft. Lauderdale, FL. This is a unit designed for ready installation in a C-130 cargo aircraft; it is under control of MIRG and Clean Caribbean Cooperative. In addition to this large (5500 gal. capacity) apparatus, a DC-4 spray aircraft (2500 gal. capacity) dedicated to dispersant application is stationed at Mesa, AZ, under contract to several West Coast cooperatives.

Dispersant supplies available in the Gulf of Mexico include a major stockpile (615 drums) of a self-mix concentrate dispersant, owned by Clean Gulf Associates and located in Houston. Clean Caribbean Cooperative has an additional 500-drum stockpile in Ft. Lauderdale, FL. Two major dispersant manufacturers each have about 200 drums of dispersant in storage in addition to the lesser stockpiles of other suppliers. In addition, all of these suppliers have the ability to manufacture additional supplies of these products within two-to-five days of the start of an emergency, if needed. Resupply rates from major suppliers are on the order of several hundred drums per day from each.

When we assess the oil spill response capability of the dispersant resources available in the Gulf of Mexico, it soon becomes evident that logistics will be limiting in most cases. Transit of the spray apparatus to the job site and resupply of the spraying equipment with dispersant are the primary limiting facts. A further limitation is the ability of the dispersant applicator, whether from boat or aircraft, to apply dispersants effectively to the oil owing to difficulties of surveillance and observation. However, a conservative analysis suggests that existing equipment and supplies, if properly managed, could disperse on the order of 1000 bbl/day of a typical South Louisiana crude oil and perhaps much more than this, assuming the oil has not weathered significantly and that the weather conditions (especially visibility) are appropriate.

Dr. J. P Fraser is a senior staff engineer with the Environmental Conservation-Manufacturing and Technical Department of Shell Oil Company. Dr. Fraser has been involved with oil spill research and response planning since 1969. He has served as an advisor for eight major spills. Dr. Fraser is a member of the American Petroleum Institute's Dispersant Task Force and serves on the Dispersants Committee of the National Research Council's Marine Board.

Dr. Fraser received his bachelor's degree in Chemical Engineering and PhD in Metallurgy from Cornell University.

Planning for Dispersant Use in Federal Region 6

Lieutenant Richard Wells
United States Coast Guard

The National Contigency Plan (NCP) identifies the players, authorities, and ground rules for response to chemical and oil discharges by federal entities. The most recent amendment to Subpart H of the NCP changed the 1982 era dispersant guidance of three paragraphs to the current three pages of guidance. Of major importance is that both the EPA and affected state must concur with the use of dispersants vice EPA concur and state being consulted as in 1982 regulations. Since then, the EPA has proposed further changes to the NCP and Subpart H. Among other things the proposed Subpart H recommends consulting with other appropriate federal agencies (trustees of natural resources DOI, DOC) as practicable.

Other regulations of interest are in 33 CFR 153 which are Coast Guard written regulations on notification, control, and removal of discharges of oil by nonfederal entities and the Coast Guard. Quotating from 33 CFR 153.305 on the methods and procedures for the removal of discharged oil:

"Each person who removes or arranges for the removal of a discharge of oil from coastal waters shall:

(a) Use to the maximum extent possible mechanical methods and sorbents that:

(1) Most effectively expedite removal of the discharge oil; and
(2) Minimize secondary pollution from the removal operations;

Note: The Federal OSC is authorized by the provisions of the National Contingency Plan to require or deny the use of specific mechanical methods and sorbents. Sorbent selection considerations of the OSC include hydrographic and meteorological conditions, characteristics of the sorbent, and availability of a mechanical method for containment and recovery.

(b) Control the source of discharge, prevent further discharges, and halt or slow the spread of the discharge by mechanical methods or sorbents or both to the maximum extent possible;

(c) Recover the discharged oil from the water or adjoining shorelines by mechanical or manual methods or both to the maximum extent possible;

(d) Use chemical agents only in accordance with the provisions of Subpart H of the N ationa l Contingency Plan and with the prior approval of the Federal OSC; and

(e) Dispose of recovered oil and oil contaminated materials in accordance with applicable state and local government procedures."

Certainly an equally crucial issue is the policies and procedures instituted by the regional and local response teams for dispersant application. NCP Subpart H, 33 CFR 300.84 authorizes advance approval or case-by-case approval of dispersants by the EPA and affected states. In Region 6 we opted for case-by-case approvals.

The State of Florida has endorsed advance approval by their letter of agreement among Florida, EPA, and the say that this is a result of a lack of consensus on dispersant usage by the RRT.

The Region 6 RRT dispersant preplanning efforts have led to creation of a dispersant application form, a dispersant working group to research technical issues, and a preselected RRT subgroup to consider all dispersant applications.

The dispersant application consists of six pages of required information and a page of instructions. Since finding the information and then putting it on the dispersant application will take time, preplanning on the part of the oil dispersers can be as critical as the preplanning by the RRT. Research before an oil discharge could speed the dispersant application process by reducing time to research and submit the application. Briefly, the application requires spill data, justification for chemical usage, and information on habitats and resources at risk, toxicological data, dispersed oil and oil movement forecasts, the proposed dispersant, environmental monitoring, and quality assurance plans.

Fully realizing the need for rapid response if dispersants are to be used on an oil spill, the RRT is depending on transmission of the dispersant application to the geographically separated RRT members by facsimile or telefax machines. The person desiring to apply dispersants will have to deliver a copy of the application to the OSC and the Dispersant RRT. This consists of the representatives from USCG, EPA, DOI, DOC, the affected state, and the Scientific Support Coordinator. Additionally conference calls are being used and computerized electronic mail is being investigated to speed communications.

Finally, in Region 6 the use of dispersants is dependent upon showing more good than harm will result from use versus nonuse of dispersants.

Lieutenant Richard Wells is the Assistant Chief, Eighth Coast Guard District, Marine Environmental Protection Branch in New Orleans, LA. He is also co-chair of the Federal Region VI Regional Response Team Dispersant Working Group, which preplans for dispersant usage in Region VI, which includes most of the Gulf of Mexico.

Letter of Agreement Among the USCG, EPA and State of Florida for Use of Dispersants

LCDR Tony E. Hart
Marine Environmental Protection Branch
Seventh Coast Guard District

With Florida's port traffic and her location adjacent to the shipping lanes between the Gulf ports and the southeastern Caribbean, Europe, and East Coast ports, the potential for a serious marine casualty off Florida is always present. While we have been extremely fortunate not to have suffered a major spill which might impact the coastline or the Keys, there have been mishaps which could have been disastrous. In August of this year as Hurricane Elena passed, the tankbarge *Texas*, with 4 million gal. of oil onboard, broke loose from its towing vessel a few miles north of the Dry Tortugas. The barge remained adrift for about 36 hours before the tow was re-established. Incidents such as this underscore the desirability and necessity of having an effective, coordinated contingency plan immediately available and ready to be placed into effect. This is especially true in areas such as Florida, where much of the coastline is either of great economic and recreational value or is environmentally sensitive and highly susceptible to severe damage from oil spills.

A few years ago if a spill occurred offshore, the typical response would be to track its movement and wait for it to come ashore before initiating cleanup actions. Use of the dispersants which could break up the slick offshore would most likely have been prohibited. Although many of today's responses would be similar, there is more of a willingness to use dispersants since they are less toxic than those of the 1960's and 1970's, and we now have more scientific data on them. Furthermore, Subpart H of the National Oil and Hazardous Substances Pollution Contingency Plan specifically authorizes the Federal On-Scene Coordinator to use dispersants under certain conditions. Subpart H also specifies the following:

> "RRT's should consider, as part of their planning activities, the appropriateness of using dispersants.... If the RRT and the states with jurisdiction over the waters of the area to which a plan applies approve in advance the use of certain products as described in the plan, the OSC may authorize the use of products without obtaining the concurrence of the EPA representative to the RRT or the states.

Before discussing development of our dispersant agreement, a word as to the federal spill response organization may be appropriate. Federal response activities can be broken down into three major levels: the National Response Team, Regional Response Team, and the pre-designated Federal On-Scene Coordinator. The National Response Team (NRT) is responsible for developing the national policy and is comprised of members representing 12 different federal agencies with specific responsibilities in response activities. The Regional Response Team (RRT) is comprised of members of the federal agencies represented on the NRT as well as persons from the various states and in some cases, municipalities, located in the federal region. The RRT serves as a regional planning body and is responsible for developing regional contingency plans which will ensure prompt spill response actions. During an actual, or potential, pollution incident the RRT may assist the pre-designated Federal On-Scene Coordinator by offering technical advice and coordination in removal activities. The pre-designated On-Scene Coordinator (OSC) is generally a representative from the EPA for inland spills and the Coast Guard for the spills occurring in coastal and offshore waters. The OSC is responsible for investigation of pollution incidents and for monitoring of cleanup operations when undertaken by the spiller. When the spiller does not take proper action, or is unknown, the OSC initiates a federal cleanup response using the 311(K) pollution fund.

It was through the RRT that we initiated our planning activities for the use of dispersants. As co-chairman of the Federal Region IV RRT, I proposed in late 1982 that the RRT appoint a dispersant committee to determine beforehand where and under what conditions accepted dispersants could be used by our Federal OSC's. Throughout 1983, members of this committee gathered information on dispersants, attended dispersant workshops being held around the country, and in doing so, developed a greater awareness of potential uses of dispersants and their limitations.

In January 1984 this committee held a meeting in Atlanta with the express purpose of identifying those situations in which the RRT could pre-authorize the OSC to use dispersants. The following recommendations came from the meeting:

1) That dispersants be given consideration along with other cleanup techniques when responding to offshore oil spills which pose a potential threat to coastal shorelines.

2) That the Coast Guard along with EPA and the State of Florida enter into discussions to determine if a prototype agreement on "pre-approved" usage of dispersants could be reached. It was hoped that if this agreement could be developed it would serve as a basis for similar agreements with the remaining Coastal Region IV states, Georgia and South Carolina.

Almost immediately after this meeting, work began on a dispersant agreement. I am pleased to say that these efforts were successful and that the agreement was jointly signed by the Seventh Coast Guard District, EPA Region IV, and Florida on 17 September 1984. We believe that this was the first such arrangment developed which pre-authorized the OSC to use dispersants. In the document, the three parties agree that physical removal of oil was still the preferred response method but recognized that in some cases this would not be feasible. In these instances, the effective use of dispersants should be considered to minimize serious environmental/economic damage or to prevent the loss of human life. The Letter of Agreement sets forth criteria under which dispersants can be used on or in the waters off the coast of Florida which are also within the boundaries of the Seventh Coast Guard District. I should note that the Letter of Agreement does not include the entire state of Florida since the Florida Panhandle west of 83°50' W longitude is in the Eighth Coast Guard District.

The decision to use dispersants rests solely with one of the three pre-designated Coast Guard OCS's in Florida. With certain noted exceptions, no further approval or consultation on the part of the OSC with the EPA or state is required. We believe that this agreement provides the OSC with a mechanism to consider and decide upon the use of dispersants and actually commence dispersant application in a much mcre timely manner than would be possible if the agreement did not exist. Timely response is always a key element, but especially so with dispersants, since the effectiveness is usually adversely affected by the weathering of oil. Delays would also result in the slick's spreading out and breaking up into smaller slicks, making uniform application more difficult. In addition to providing the OSC with authority to use dispersants, the agreement provides the OSC with specific guidelines regarding deliberations as to whether he/she should use dispersants. Guidelines specified in the agreement include:

1) The decision to use dispersants shall be made only after consulting the State of Florida *Oil Spill Dispersant Atlas* to ensure that an environmentally-sound decision is made. Each of the OSC's has a copy of the atlas and is familiar with its contents. In the event of a spill, the atlas can be consulted to readily ascertain whether the spill is in/or threatens an area where dispersant use is restricted or prohibited.

2) Dispersants may be used in open waters at least three miles from any shoreline where the water depth is at least 65 ft deep. Use inside three miles may be considered where the water depth is at least 32 ft deep and the economic/esthetic value of the recreational area is substantially greater than the environmental value.

3) Prior approval from the EPA and state are required if use of dispersants is contemplated in shellfish propogation or harvesting waters, over reef areas, in coastal marshes or mangrove forests.

4) Sinking agents are expressly prohibited.

Fortunately, no spills have occurred in Florida of the size and in the location where dispersants would be used. Consequently, our OSC's have not had to invoke the agreement. However, we consider the agreement a vital element of our overall contingency planning process and have begun efforts to enter into other similar agreements within our area of responsibility. Last month a draft agreement was prepared the Coast Guard, EPA, and Puerto Rico. This draft is now being reviewed, and we anticipate being able to sign the final agreement in November. Plans are underway to work out agreements with South Carolina, Georgia, and the U.S. Virgin Islands.

I would recommend that each region develop guidelines for dispersant use. Ideally these plans would identify areas where dispersants can be used as well as result in the least time delay in initiating dispersant application when a spill occurs. As far as I am aware, there is only one other dispersant agreement effective at this time and that is in Region II. Puerto Rico and Hawaii are close to signing letters of agreement.

Let us look at these others to compare and contrast and see what we can learn from the various approaches taken. The Puerto Rico and Hawaii agreements are in the same format as the Florida letter but differ in some of the conditions and have some unique provisions. Region II, however, took a completely different approach.

Region II has drafted what I call a "mechanism for decision making." They have done extensive preplanning, deciding what information is needed, where dispersants will definitely not be used, where they may always be used, and where a decision will have to be made on a case-by-case basis. They have developed or are developing detailed guidelines by location that specify, among other things, maximum application rates based on depth. This is unique to Region II. Information is gathered and fed into a decision tree. The last step before approval is concurrence among the USCG, EPA, affected state, DOI, and NOAA. Although concurrence is still required, it should be arrived at more quickly due to all the preplanning by the involved parties. I believe that in a few very limited areas, pre-approval agreements have resulted from the planning.

The format of the pending Puerto Rico agreement is the same as the Florida plan. The OSC may use dispersants 1/2 nautical mile from shore where the water is over 60 ft deep simply by notifying the EPA and Puerto Rico. Inside 1/2 mile or 60 ft depths, the OSC must get concurrence from Puerto Rico; however, if Puerto Rico is not able to provide a definite answer within 12 hours, then the OSC may proceed if he decides to. If dispersants are used, the agreement will require a post-incident debrief within 90 days to determine the effectiveness of the response.

The Hawaii agreement is also based on and similar to the Florida agreement. It has more conditions peculiar to the islands. The unique feature of this agreement is the requirements for documentation and evaluation for any actual usage. They are detailed and well thought out. I recommend that any of you who are working on such an agreement get a copy of this one and consider using similar provisions for documentation and evaluation. In Florida we are considering amending our agreement to include such provisions.

After graduation from the U.S. Coast Guard Academy in 1971, **LCDR Hart** was assigned shipboard duties. Since 1974, he has been primarily assigned to the Coast Guard's port safety and marine environmental protection program in New York, Seattle, and Miami. He has a Master's Degree in Transportation Engineering from Seattle University.

BARRIER ISLANDS

Session: BARRIER ISLANDS

Chairmen: Mr. Mark Rouse
Dr. Norman Froomer

Date: October 23, 1986

Presentation Title	Speaker/Affiliation
Barrier Islands: Session Summary	Mr. Mark Rouse Minerals Management Service
Barrier Islands Systems: An Overview	Dr. Stephen P. Leatherman University of Maryland
The Littoral System and How It Works	Dr. Raymond F. McAllister Florida Atlantic University
Man's Impact on the Atlantic Coast Barrier Islands	Dr. Robert Dolan Department of Environmental Sciences University of Virginia
Barrier Island Response to Natural Processes and Human Activities -- Examples from the Texas Gulf Coast	Dr. Robert A. Morton Bureau of Economic Geology The University of Texas at Austin
Louisiana's Coastal Protection Master Plan: Barrier Island and Shoreline Restoration and Nourishment	Mr. David G. Chambers Louisiana Geological Survey
Alabama Coastal Barriers	Everett Smith Geological Survey of Alabama
Environmental and Construction Techniques Involved With the Installation of a Gas Pipeline Across Timbalier Island, Louisiana	Mr. David J. LeBlanc Texaco U.S.A.

Barrier Islands: Session Summary

Mr. Mark Rouse
Minerals Management Service

As a result of the transient migratory nature of barrier islands and their use by the offshore oil and gas industry for sites to develop offshore support infrastructure, which includes the construction of permanent support bases and pipelines, the Gulf coastal states have recognized the need to study the impacts of such activities on these landforms and adjacent areas. To this end, the governors' representatives of the Gulf's Regional Technical Working Group have recommended that a study be defined and implemented by MMS to examine the inter-relationship between such activities and these ecosystems. The thrust of the proposed study is to investigate the potential impacts of pipeline crossings and the water transport of oil and gas support and supply materials in passes constructed through, not only barrier islands, but riverine deltas and across estuarine and lagoonal environments.

The information presented in our session will be utilized, not only to inform the MMS staff with the complexities of such systems, but in order to focus our efforts in the direction needed for preparation of such a study. The session consisted of seven presentations that encompassed a broad spectrum of discussions related to barrier islands that ranged from a general overview of these landforms, to potentially mitigating impacts resulting from man's activities there.

Our first speaker was Dr. Stephen Leatherman with the University of Maryland. He presented a general overview of barrier island systems and their development. His talk highlighted four variables which are responsible for barrier island positions and trends. These included sea level position, which is rising very rapidly due to worldwide trends; natural subsidence; and the dewatering of fine sediments due to the fluid extraction of oil, gas, and water. This is particularly critical in Louisiana with rates of relative sea level rise approaching one centimeter per year or three to five times higher than that of the East Coast. The second variable is sea energy resulting from storms and hurricanes. The third was sand sediment supply, which is a key problem in Louisiana, as abundant supplies are not naturally available in comparison to other U.S. East and Gulf Coast areas. The final variable was human interference, which includes the building of groins, jetties, seawalls, and other projects such as beach nourishment, beach creation, and vegetation projects.

Our second speaker was Dr. Raymond McAllister of Florida Atlantic University. He discussed the littoral system as it relates to barrier islands and beach development, and the effect of man-made structures (jetties, groins, and seawalls) on sediment and sand transport along the shoreline. Additional discussion highlighted the use of sediment trapped by damming to be used to replenish and nourish the littoral system, and the use of highly organic sediments normally discharged offshore for the same purpose.

Dr. Robert Dolan, with the University of Virginia, discussed man's impact on barrier islands and highlighted his experiences on the U.S. East Coast, primarily those areas around Ocean City, MD, and Cape Hatteras, NC. He identified several projects that were undertaken by the Department of Interior to preserve the area surrounding and adjacent to the lighthouse at Cape Hatteras. Some $16 million were expended to preserve the area and included projects consisting of construction of a seawall, the use of groins, and beach nourishment. Of the projects tried, the beach nourishment efforts were the most successful; however, only about 25% of that effort remains.

According to the first three speakers, although means exist to prevent beach and shoreline erosion on a temporary basis, the best action would be to discourage any development in these areas.

Our fourth speaker was Dr. Robert Morton with the University of Texas, Bureau of Economic Geology. He addressed barrier islands' response to natural processes and human activities with examples from the Texas Gulf Coast. He stated that impacts on Texas barrier islands from human activities had progressively increased since the late 1800's with the permanent occupation of these islands principally related to shipping, ranching, and military defense. Recent activities causing the greatest environmental changes have been associated with the oil and gas operation, marine transportation, and recreational uses. Construction and stabilization of the navigational canals, production of hydrocarbons, and transportation of petroleum products have contributed immensely to national and regional economics; but they have also caused rapid shoreline changes, subsidence and fault activation, and fouled beaches. The most severe impacts would result in unanticipated permanent and widespread alterations that cannot be reversed naturally and would require remedial efforts. The quantification of human impacts is complicated by the regional climatic gradient, a broad diversity of subenvironments, and the variations in intensity of coastal processes.

Mr. David Chambers, of the Louisiana Geological Survey, reported on Louisiana's Coastal Protection Master Plan of barrier island and shoreline restoration and nourishment. The Louisiana Geological Survey has been charged with developing and administrating a ten-year two-phase coastal protection master plan to respond to the rapid deterioration of Louisiana's barrier islands and coastal wetlands. The plan calls for implementation of barrier island and shoreline restoration projects during phase one, as well as location and characterization of offshore sand deposits to be used in phase two of the beach nourishment. Phase one encompasses restoration of barrier island remnants cut by storm breaches, pipeline canals, and oil and gas exploration canals. Phase two will involve beach nourishment of barrier islands and beaches with offshore sand deposits located and characterized during phase one, which will include seismic sub-bottom profiles, vibracoring, and analysis of core sediments. These sands will be pumped to the barrier shoreline and used to enlarge the dunes and extend the beach seaward. Dune vegetation and sand fencing will be used to help stabilize the dune line.

Mr. Everett Smith, with the Geological Survey of Alabama, reported on Alabama's coastal barriers. He presented an overview on the Morgan Peninsula and Dauphin Island areas. He discussed the recent extensive damage to structures within these areas as a result of Hurricane Elena. He indicated the extreme vulnerability of conventional barrier structures to storm forces. He stated that although recent hurricanes have effected little change to these barrier island shorelines, the areas behind the barriers have been modified as a result of development of washover sand.

Our final speaker was Mr. David LeBlanc, with Texaco, who reported on Texaco's installation of a 4-in. gas pipeline across Timbalier Island in Terrebonne Parish, which is located some 65 miles to the southwest of New Orleans. After looking at several options, which included crossing the island with conventional pipeline techniques, routing around the island through Cat Island Pass, and using boring techniques along the proposed route, the conventional method was chosen. In order to minimize impacts associated with this alternative, it was stipulated that the pipe ditch could not at any time be completely open across the island and the route would have to be revegetated following construction. The line was installed in November of 1984, and through cooperation with LSU in April of 1985 portions of the right-of-way were revegetated using available plant species adjacent to the work site. Although it's early to analyze the final results, the tentative observations concluded that although the revegetated sites recover more quickly, the unplanted sites also exhibited rapid revegetation. He attributed this to the final elevation of the work area resulting from back-filling techniques used.

R. Mark Rouse is an oceanographer with the Minerals Management Service's Gulf of Mexico OCS Region. There he coordinates projects related to assessing the environmental and economic impacts of the federal OCS oil and gas program on the offshore and coastal environments of the Gulf. His recent work covers a broad spectrum of issues including water quality, water resources, coastal processes, and wetland erosion. Mr. Rouse received his BS degree in Oceanography from Lamar University and did graduate work through Louisiana State University. Prior to his work with MMS, he held positions with Seiscom Delta, Mobil, and with the Ocean Surveys Division of the U.S. Naval Oceanographic Office.

Barrier Island Systems: An Overview

Dr. Stephen P. Leatherman
University of Maryland

INTRODUCTION

The U.S. Atlantic Gulf coasts contain the longest chain of barrier islands in the world. These low-lying landmasses are unstable since they are composed of unconsolidated sediments (i.e., sands, gravels, and muds) and are exposed to open-ocean waves. In order to understand barrier islands and the problems created by human manipulation of barrier environments, it is necessary to consider their genesis and to define the reasons for and means of their evolution.

BARRIER GENESIS

It is important to understand where barrier islands came from so that we can determine where they are going. Not all islands have originated in the same manner; in some cases their origin is reasonably clear, whereas in other areas it appears that there may be a multiple causality.

Along the glaciated New England/New York coasts, barrier spits grew by longshore sediment transport from unconsolidated glacial debris with Holocene sea-level rise, and were converted to islands following inlet breaching. These barriers are known to have existed for at least the past 8,000 years based on radiocarbon dating of backbarrier saltmarsh peat found on the inner shelf and shoreface of the New York and mid-Atlantic bights.

The southeast U.S. barriers may have developed by multiple causality. The origin of the Outer Banks of North Carolina can perhaps be best explained by Hoyt's concept of dune ridge engulfment. Along the Georgia coast is a different type of barrier feature - the famed Sea Islands. These wide and unusually high and stable barriers have a Pleistocene age core with recent sediments welded onto the shoreface.

The Florida Gulf coast presents us with yet another variation on the theme. In Pinellas County, FL, barrier island positions and configurations are controlled by the subsurface geology as the loose sandy sediments of the barrier are perched on limestone bedrock. Farther north along this same shoreline, it has been shown by a comparison of historical aerial photographs that one small island actually grew upward from an offshore sand bar. This finding gives some credibility to Otvos's idea of barrier island genesis from the emergence of submarine bars.

It is well understood that the Mississippi River and its delta have been responsible for supplying sediment for barrier formation along the Louisiana coast. The Louisiana barriers represent a special case in that their platforms are composed of deltaic sediments (silts, clays, organics, and some fine sands), which are highly compressible. The delta, which built the entire coastal zone, is naturally subsiding, but withdrawal of fluids from the deltaic sediments has greatly exasperated and accelerated the settling, resulting in significant problems for the Louisiana barriers and landward-flanking wetlands.

BARRIER EVOLUTION

Processes responsible for landward barrier migration are the same worldwide, but their relative magnitudes vary greatly on a geographic basis. The translation processes--(1) inlets through construction of their large flood tidal deltas in the bay, (2) overwash transport across the barrier during storm conditions, and (3) direct sand movement by the wind (aeolian transport)--have all been well defined and are generally understood. These processes of landward sediment transfer are all operating within an environmental framework that sets the stage and indeed mandates barrier retreat.

The factors that affect barrier stability are (1) sea-level position, (2) sea energy, (3) sand supply, and (4) human interference. These four variables control barrier position and trend, i.e., (1) landward migration, (2) seaward accretion, or (3) vertical up-building or in-place drowning. Almost the entire U.S. coastline is showing a long-term trend of shoreline retreat, and the Louisiana coast is presently experiencing the highest rates of erosion on average of any of the coastal states. Therefore, these factors (sand supply and sea-level position) are out of balance along much of the U.S. coastline, but the problem is especially acute along the Louisiana coast.

Sea-level rise is believed to be the principal driving force (or forcing function) of shoreline retreat. This would explain the preponderance of erosion along geographically-dispersed coasts as variations in such factors as sand supply and storm severity are highly localized. During Holocene time (last 9-10,000 years), sea level has risen by 300 to 400 feet. Obviously any low-lying landmass, such as a barrier island, must be driven landward or it would be drowned in-place. During the past 100 years, sea level has risen about a foot along the U.S. East coast based on NOAA tide gauge data. While a portion of this rise (perhaps 5 inches) can be attributed to eustatic (worldwide) causes, the remainder is due to regional (neotectonics) and more localized influences.

There is variable subsidence due to natural compaction of unconsolidated sediments along the coastal fringe. Some coastal engineers, notably Dean M.P. O'Brien, have argued that this is the factor that is resulting in higher sea levels since almost all U.S. East and Gulf coast gauges are sitting on compressible coastal sediments. While this factor is quite important and even if it were the only factor, the fact remains that barrier position and hence dynamics depends upon relative sea-level rise whether locally, regionally, or worldwide-derived. In Louisiana the rates of relative sea-level rise are approaching 0.4 inches per year, which is 3 to 5 times higher than the East Coast. While worldwide trends are contributing to the problem, natural delta subsidences and, more importantly, artificially-generated compaction of sediments because of withdrawal of fluids (oil, gas, and water) are responsible for the rapid rate of erosion in the Louisiana coastal zone.

Sea energy as a factor is essentially noncontrollable as hurricanes occur sporadically in nature. During recent decades, most hurricanes have come ashore along the Gulf coast, including such major storms as Hurricane Camille in 1969 and H. Allen in 1983.

Sand supply is an acute problem in Louisiana as abundant supplies are not naturally available compared to other U.S. East and Gulf coastal areas. With a subsiding delta platform, barrier sands may be ultimately lowered below wave base; this is the one situation wherein a barrier must drown in-place and cannot perpetuate itself by landward migration.

Human interference takes many forms, including construction of buildings on the barrier surface to shoreline engineering devices. Since the Louisiana barriers are devoid of the expensive, high-rise type development all so characteristic of many urbanized coastal areas, the emphasis is placed on shoreline stabilization to hold the line and protect backbarrier marshes. Engineering approaches can be considered under two different categories: (1) soft (beach fill, dune building, salt marsh planting) and (2) hard (groins, jetties, seawalls, breakwater). As measured in other coastal states, success is location and time-dependent. Any attempt to stabilize the Louisiana barrier islands will be extremely expensive, and future failure is assured without continued, long-term maintenance projects.

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Professor Stephen Leatherman is a coastal geomorphologist in the Department of Geography at the University of Maryland. Dr. Leatherman has previously held academic positions at Boston University, the University of Massachusetts-Amherst, and Yale. Prior to his going to the University of Maryland, he served as the Director of the National Park Service's Research Unit at the University of Massachusetts. Dr. Leatherman's research interests involve barrier island dynamics, about which he has published a number of journal articles and edited/authored four books.

The Littoral System and How It Works

Dr. Raymond F. McAllister
Florida Atlantic University

Politicians, city engineers, and others concerned with beach erosion too often are not well grounded in the coastal engineering truths upon which decisions should be made. This paper attempts to put the workings of the littoral system (beach, nearshore bottom, and dunes) into proper perspective.

Wave energy runs the littoral system. With some help from the wind, which builds dunes, waves change the beach face from hour to hour, storm to storm, and season to season, always maintaining a dynamic equilibrium between the sea and shore.

Waves drive littoral drift. Anything which decreases the wave energy reaching a beach slows down the "littoral conveyor belt." As wave energy decreases, sediment deposits. This would be great except that beaches downdrift, they do not get their fair share of the sediment, and they retreat! There is no free lunch! You cannot remove sand from littoral drift to build out one portion of a beach without damaging another portion, downdrift. This was illustrated for a variety of man-made and natural devices and features, including groins and jetties, breakwaters, both surface and subsurface, artificial seaweed, sunken ships, artificial islands, and wave energy devices.

The point is made that naturally or artificially renourished beaches are nature's first line of defense against the sea, constantly changing to best diminish wave energy. The dunes are a second line of defense, a large emergency reservoir of sand, available when and if needed. Removal of the dunes and replacement with a seawall shows a criminal disregard of nature's plan for coastal defense.

Dr. Raymond F. McAllister is professor of ocean engineering at Florida Atlantic University in Boca Raton, FL. He is a marine geologist, diver, a tireless promoter of "oceaneering," and a prolific writer of professional papers and popular books about oceanography. Dr. McAllister is co-editor of McGraw-Hill's *Handbook of Ocean and Underwater Engineering* and has produced and hosted several television documentaries on oceanography. He is listed in *American Men of Science* and *World Who's Who in Science*.

Man's Impact on the Atlantic Coast Barrier Islands

Dr. Robert Dolan
Department of Environmental Sciences
University of Virginia

For many years it was accepted policy by several land management agencies to control natural events that were considered to be harmful. We now realize that natural change is often essential to the maintenance of geologic and ecologic systems; however, it is also clear that an uncontrolled natural system creates serious land management problems.

This contradiction can be a serious problem in areas subject to great physical change. The barrier islands of North Carolina have provided an excellent opportunity to study the dilemma land managers face today along the Atlantic coast. The low profile of these islands, their narrowness, and their exposure to high waves coupled with a gradually rising sea level have created a state of almost continual physical and ecological change.

The mid-Atlantic coast barrier islands adjust to storms, winds, and waves because there is little resistance associated with impenetrable landforms. Water flows between the dunes and across the islands with the result that energy is rapidly dissipated. On the sound side, the fringes of marsh act as a buffer to reduce erosion from waves and surges generated on the bays.

The combination of high tides and large waves occasionally succeeds in eroding the low-lying beach foredunes, carrying sediment completely across the island and into the marshes. This process of "oceanic overwash" has been well documented. Overwash plays an important role in marsh formation by replenishing sediments and creating new land on the sound side of barrier islands.

fencing to create a continuous barrier dune along the Outer Banks of North Carolina. Most of this construction took place in the zone comprising the original low beach dunes and a strip 30-100 m wide behind the foredune. This was augmented in the 1950's by the National Park Service so that at present an almost continuous mass of vegetation blankets the barrier island.

Years of artificial dune stabilization have greatly altered the geological features of the Outer Banks. A comparison of the altered condition with the profile of the natural condition demonstrates the extent to which stabilization has brought changes in the beach and dune morphology. The most striking difference between the natural and the controlled barrier island is the artificial barrier dune system and the change in beach width. The unaltered islands have beaches ranging from 125 to 200 m wide, averaging about 150 m. Along many of the Hatteras Island beaches which were altered 30 years ago, the shoreline has receded to widths of 30 m or less.

The high stabilized dunes not only divert salt spray from the zone immediately behind the dune, but they also prevent flooding and overwash. Because of this protection, the shrub community normally found near the back of the island has spread seaward, and in many places forms an impenetrable thicket 3-4 m high.

Oceanic overwash and the opening and closing of inlets creates serious problems in maintaining a permanent highway and local villages along the Outer Banks. In the past it has been necessary to clear the highways and roads when covered with sand deposited by overwash, and the roads have been rerouted several times when erosion destroyed the dunes and threatened the permanent routes.

Although the present system is undependable, endanagered, and expensive to maintain, alternatives are even more expensive and questionable in terms of economics. One approach has been to attempt to maintain the beaches by constructing groins or by pumping sand onto the beaches. Because the Outer Banks have already developed to the point where it is impossible to remove the highway, it must be maintained; however, as the system continues to narrow, new instances of overwash, erosion of the artificial barrier dunes, and inlet formation can be predicted. Many of the structures which have been built in the proximity of the shoreline are being lost and will be lost, and the highway will require relocation within a few years.

With the rapid deterioration of the barrier dune systems along the Outer Banks of North Carolina in recent years, and the large expenditure of resources necessary to re-establish or maintain them, or both, my research suggests that the concept of dune construction is highly questionable from a geological and an economic standpoint. If sea level continues to rise, as all evidence seems to suggest, the resources required to maintain extensive areas of barrier dunes may exceed the economic value attached to their existence. The barrier islands, in their natural condition, will survive. Natural islands are not being washed away; they are moving back by processes that were fundamental in their origin, processes that continue to be important if they are to be preserved in a natural state.

Dr. Robert Dolan is a professor in the Department of Environmental Science with the University of Virginia at Charlottesville. His current research interests are focused on the areas of coastal processes and geomorphology. He received his PhD degree from Louisiana State University, and has authored and co-authored numerous articles, papers, and books. Dr. Dolan has recently been selected to serve on a scientific board involved in reviewing the findings and monitoring the progress of an MMS funded wetlands study (G-538) aimed at quantifying both the natural and man-induced impacts to the Louisiana wetland complex.

Barrier Island Response to Natural Processes and Human Activities -- Examples from the Texas Gulf Coast

Dr. Robert A. Morton
Bureau of Economic Geology
The University of Texas at Austin

Gulf Coast barrier islands cover a broad spectrum of shapes and sizes that reflect their relative age, geologic history, and spatial stability. Some barriers are wide, thick, densely vegetated and have continuous foredune ridges that prevent overwash. The above-average elevations and overall stability of these high-profile (regressive) barriers are attributable to their seaward progradation several thousand years ago when sand supply was abundant. Other barriers have contrasting characteristics. They are narrow, thin, sparsely vegetated, and have discontinuous dunes that are separated by numerous, closely spaced washover channels that transect the islands. These relatively young, unstable low-profile (transgressive) barriers are migrating landward because of a deficient sediment budget. Along the Texas and Louisiana coasts these different barrier types occupy predictable positions that are adjacent to former active deltas. The retreating deltaic headlands pass laterally into transgressive barriers that, in turn, grade into regressive barriers within interdeltaic embayments. Waves refracted by the deltaic promontories created zones of littoral drift convergence where the barrier islands formed. Subsequent construction of jetties extending miles into the Gulf have compartmentalized the coast and have interrupted the littoral drift system.

Subenvironments of Gulf Coast barriers are defined and identified on the combined basis of physical processes, elevation, and biological assemblages. The most common and areally extensive subenvironments include: beaches, active and stable dune complexes, vegetated barrier flats, salt marshes, fresh-water ponds, washover terraces, washover channels and fans, tidal inlets, and wind-tidal flats. Historical monitoring of Texas barriers shows that both natural processes and human activities have been responsible for major changes in the distribution of subenvironments.

Barriers bordering the western Gulf of Mexico are storm dominated landforms because storm surges greatly exceed water levels produced by the low astronomical tides. During tropical cyclones, large volumes of sand are deposited across the barriers or are transported downdrift and seaward of the beach. Long-term beach erosion results from the cumulative losses of sand aggraded on the barriers or transported onto the inner shelf below normal wave base. These coastal processes coupled with relative sea level rise account for substantial land losses from some barriers.

Impacts on Texas barriers from human activities have progressively increased since the late 1800's when permanent occupation was principally related to shipping, ranching, and military defense. Recent activities causing the greatest environmental changes are associated with oil and gas operations, marine transportation, and recreational uses. Construction and stabilization of navigation channels, production of hydrocarbons, and transportation of petroleum products have contributed immensely to the national and regional economies, but they have also caused rapid shoreline changes, subsidence and fault activation, and fouled beaches.

The magnitude and severity of human impacts range from extremely short lived and spatially limited planned disruptions that are minimized and restored to prior conditions, to long-term and more extensive disturbances that are eventually modified by natural processes. The most severe impacts result in unanticipated, permanent, and widespread alterations that cannot be reversed naturally and that would require remedial efforts that are prohibitively expensive.

Quantification of human impacts on barriers is complicated by the regional climatic gradient, broad diversity of subenvironments, and variations in intensity of coastal processes. Improving our ability to predict the cumulative effects of specific activities will require detailed documentation and analysis of previous impacts.

Dr. Robert A. Morton is a 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 BA degree from the University of Chattanooga and his MS and PhD degrees from West Virginia University.

Louisiana's Coastal Protection Master Plan: Barrier Island and Shoreline Restoration and Nourishment

Mr. David G. Chambers
Louisiana Geological Survey

With land loss rates in coastal Louisiana exceeding 50 sq. mi/yr, preservation of the state's barrier islands and shorelines has become increasingly critical. The barrier islands and headlands serve as the first line of defense for buffering hurricane and tropical storm impacts. Without these barriers, storm surges and hurricane waves will impinge directly upon the fragile interior wetlands and will result in even more rapid deterioration than is presently being experienced. In addition, loss of the barrier islands will cause increased saltwater instrusion and will exacerbate the destruction of freshwater swamps and marshes at the upper ends of the state's estuarine basins.

The Louisiana Geological Survey has been charged with developing and administering a ten-year two-phase Coastal Protection Master Plan to respond to these problems. The Master Plan received final approval in early 1985, and calls for implementation of barrier island and shoreline restoration projects during Phase I as well as the location and characterization of offshore sand deposits to be used for Phase II beach nourishment.

Phase I, the first five years of the Master Plan, encompasses restoration of barrier island remnants cut by storm breaches, pipeline canals, and oil and gas exploration canals. These fragile barrier strips are typically characterized by extreme sand deficits, sparsely vegetated dunes, numerous overwash features, severly deteriorated and subsiding backbarrier wetlands, and in some instances accelerated shoreline erosion due to man-made structures. Restoration work will involve moving overwash sands gulfward to reform the dune line, constructing large cellular retaining basins, and subsequent infilling of the cells with sediment dredged from the backbarrier bays. Following settlement and adequate leaching of the newly dredged sediments, vegetation will be planted on both dunes and backbarrier deposits to help hold the sediment in place. These remedial measures will serve to raise the average barrier island elevation, restore the backbarrier marsh platform, and reduce the likelihood of storm breach formation and dune overwash. Additional benefits of restoration include increased potential for natural post-storm healing of any hurricane damages that are sustained after construction is completed.

Phase II will involve beach noursihment of barrier islands and beaches with offshore sand deposits located and characterized during Phase I by seismic sub-bottom profiling, vibracoring, and analysis of core sediments. Dredged offshore sands will be pumped to the barrier shoreline and used to enlarge the dunes and extend the beachface seaward. Dune vegetation and sand fencing will be used to help stabilize the dune fields..

REFER TO FIGURES IIIE.1 AND IIIE.2.

Mr. David G. Chambers is presently serving as Chief of the Coastal Protection Section, with the Louisiana Geological Survey in Baton Rouge, where he coordinates projects related to Louisiana's coastal wetland resources. Mr. Chambers received his BS degree at the University of Delaware and his MS degree in Marine Science from Louisiana State University. He has co-authored several fisheries papers and his current research interests lie in the area of mitigating shoreline and wetland erosion.

Alabama Coastal Barriers

Everett Smith
Geological Survey of Alabama

Alabama's coastal barriers extend from Perdido Key at the Alabama-Florida state line to the western end of Dauphin Island, with a total shoreline of about 45 miles. The eastern end of Petit Bois Island was formerly in the Alabama area, but the Alabama-Mississippi state line now lies between Petit Bois and Dauphin Islands. Dauphin Island is separated from the mainland by Mississippi Sound. Morgan Peninsula, a bay mouth bar of Mobile Bay, merges to the east with barrier areas that are separated from the mainland by the Intracoastal Waterway and by bays, coves, and bayous of Perdido estuary. Gulf shoreline of barriers east of the entrance to Mobile Bay is generally stable to slightly accretionary. Shoreline of Dauphin Island is stable to accretionary along Mississippi Sound, accretionary on its western end, and erosional along the eastern Gulf shoreline. The north shoreline of Morgan Peninsula (Bon Secour Bay and Mobile Bay shoreline) is predominantly erosional. Mobile Bay eastern shoreline is generally erosional, but erosion is proceeding at a lesser rate than along Mobile Bay western shoreline. Erosion along some parts of the western shoreline is as much as 7 ft per year. The north shoreline of Mississippi Sound behind Dauphin Island is undergoing rapid erosion, with loss of marsh and islands. Some marsh shoreline retreated as much as 140 ft betweeen 1955 and 1979.

Dunes are low to absent along much of the barrier shoreline. Several beach ridge systems are identifiable in the barrier areas east of the mouth of Mobile Bay. Many of these beach ridge areas have been truncated by erosion along the Gulf shoreline, suggesting a prevailing, long-term erosional trend, despite stable or accretionary trends during the past 30 years.

Housing construction has proceeded at a rapid rate along the barrier areas since 1979. Housing "set back" from dunes and littoral areas is now required. Recent extensive damage to structures on the barriers by peripheral winds of Hurricane Elaina indicate the extreme vulnerability of conventional barrier structures to storm forces. Recent hurricanes have effected little change on Gulf shoreline of the barriers. Shoreline behind the barriers has been modified by hurricanes primarily by development of washover fans.

W. Everett Smith is Assistant State Geologist for Alabama, and Director of Technical Operations of the Geological Survey of Alabama. He has investigated coastal geology, coastal geomorphology, and coastal habitats of the Alabama area, and has been involved with the state's coastal management program since its initiation.

Environmental and Construction Techniques Involved With the Installation of a Gas Pipeline Across Timbalier Island, Louisiana

Mr. David J. LeBlanc
Texaco U.S.A.

This is a report on Texaco's installation of a 4-in. gas pipeline across Timbalier Island in Terrebonne Parish, Louisiana. The line transports gas from a production platform about a mile and a half offshore to a tie-in point at a tank battery located just shoreward of Timbalier Island. Timbalier Island is a barrier island located about 65 miles southwest of New Orleans.

There is much concern in Louisiana over the status of its barrier islands. This is because the state's system of beaches and barrier islands has decreased in area by a reported 41% since 1887. In some cases shoreline retreat rates have been measured as high as 50 sq.mi/yr.

The islands are important for a number of reasons:

1. They protect the marshes and bays by forming a barrier or buffer to saltwater intrusion, storm surges, and high energy wave action;

2. They establish, in part, the baseline from which Louisiana's territorial waters are measured. Retreat of the shoreline ultimately translates into area transferring from state to federal ownership; and

3. They are popular recreational sites.

In considering this pipeline project, we realized the sensitivity of proposing a line across Timbalier Island. In fact, the Louisiana Coastal Management Division's guidelines state that ". . . all uses and activities shall be planned, sited, designed, constructed, operated and maintained to avoid to the maximum extent practicable significant . . . destruction or adverse alterations of . . . beaches, dunes, barrier islands . . . ."

One option to crossing the island would have been to go around the western end, through Cat Island Pass. In addition to being about twice as long as our proposed route, this alternative meant installing the line in a tidal pass. The Coastal Management Division's (CMD) guidelines frown upon projects in tidal passes just as much as upon those on barrier islands.

In January 1984, we held a pre-application conference with CMD representatives in an effort to resolve the quandary and select an option that best satisfied all concerns. We discussed three options:

1. Our proposed route: crossing the island with conventional pipe laying techniques;

2. Going through Cat Island Pass; and

3. Following the proposed route, but using boring techniques to cross Timbalier's shoreline.

The boring option was rejected because of the much higher cost and because of the environmental impact associated with bringing in and setting up the boring equipment. The Cat Island Pass option was rejected because of the high cost and additional environmental impact associated with the extra length of line and because of the drawbacks -- both operationally and environmentally -- of installing a pipeline in a pass that experiences swift currents and scour.

It was agreed, therefore, in the pre-application meeting, that the route across Timbalier was the most practical. However, in order to minimize the impacts associated with this alternative, the permit would stipulate two conditions: (1) the pipeline ditch could at no one time be open completely across the island, and (2) the pipeline route would have to be revegetated after construction.

We viewed this as an opportunity to investigate the benefits of revegetation as compared to allowing the worksite to recover on its own. We contacted Louisiana State University to provide expertise on the revegetation work, and proposed to the Coastal Management Division an experiment that would explore the merits of revegetation. The Coastal Management Division agreed.

The line was installed in November 1984. In April of 1985 portions of the right-of-way were revegetated using available plant species adjacent to the worksite. Some of the right-of-way was left unplanted for comparison.

It is still early to discuss final results because only six months have elapsed since the revegetation work. Some tentative observations can, however, be made. While it appears that the revegetated sites recover more quickly, the unplanted areas also exhibit rapid re-establishment of vegetative cover.

A critical factor in assuring rapid recovery appears to be the final elevation of the work area. In backfilling the pipeline ditch, some depressions were left where the spoil had been temporarily stockpiled. These areas have not recovered as well as the others.

A more definitive analysis of the results will be available next year, at which time we will have some statistically valid data on comparing revegetated sites to those left unplanted.

Mr. David J. LeBlanc is an environmental coordinator for Texaco's New Orleans Operations Division. During his 12 years with Texaco, he has worked in all disciplines of environmental regulation and is active on several environmental committees supported by industry. Mr. Leblanc received the BS degree in Marine Biology from Nicholls State University and the MS degree in Biological Oceanography from Florida State University.

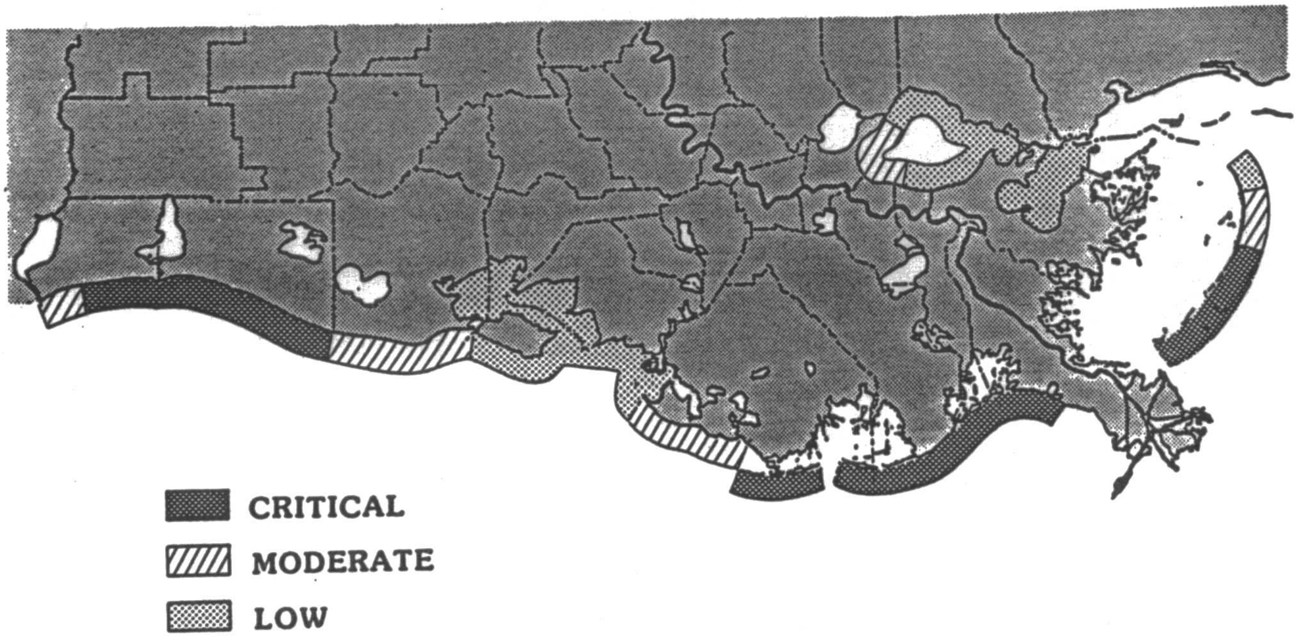

Figure IIIE.1 - Severity of Louisiana Shoreline and Barrier Island Erosion

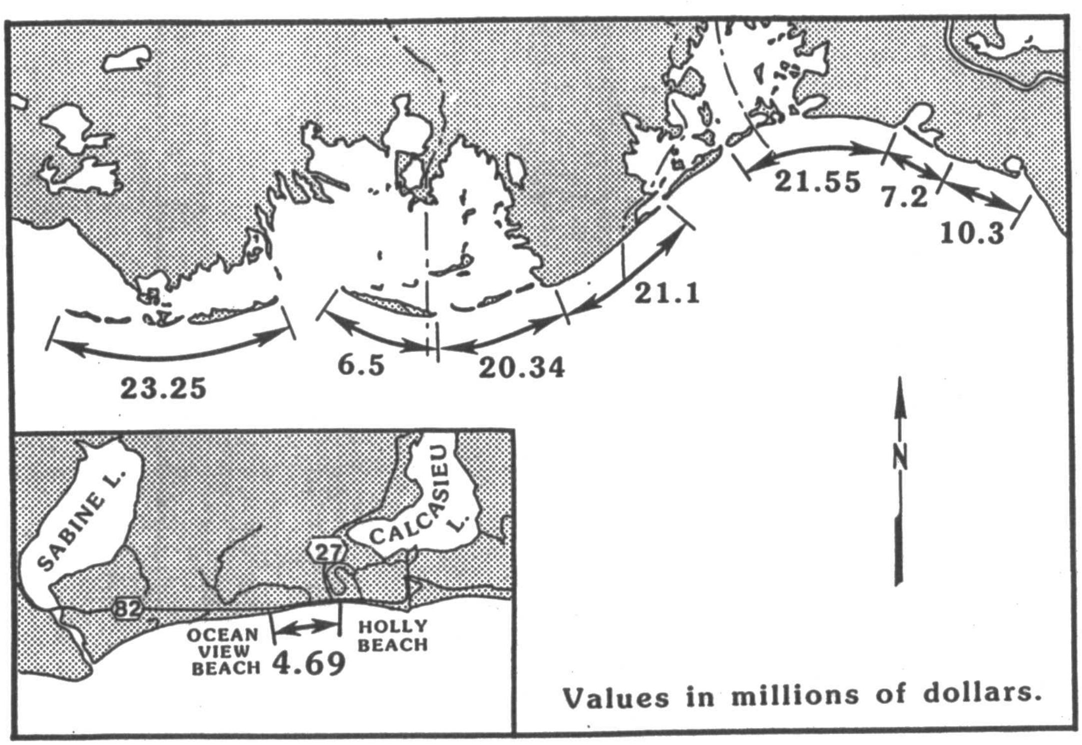

Figure IIIE.2 - Louisiana Shoreline and Barrier Island Restoration Costs

CULTURAL RESOURCES I.
CURRENT RESEARCH IN THE GULF OF MEXICO

Session: CULTURAL RESOURCE I. CURRENT RESEARCH IN THE GULF OF MEXICO

Chairmen: Ms. Melanie Stright
Mr. Rik Anuskiewicz

Date: October 23, 1985

Presentation Title	Author/Affiliation
Cultural Resources I - Current Research in the Gulf of Mexico: Session Summary	Ms. Melanie Stright Minerals Management Service
The Archaeological Significance of Sinkholes in the Eastern Gulf of Mexico	Dr. Ervan G. Garrison Civil Engineering Department Texas A&M University
Cultural Resource Investigations of Magnetic Anomalies in Mobile Bay	Ms. Dorothy Gibbens U.S. Army Corps of Engineers and Mr. Clell L. Bond Espey, Huston & Associates, Inc.
A Computerized High Resolution Underwater Ultrasound Triangulation Mapping System	Dr. Glen N. Williams Computer Science Department Texas A&M University and Dennis A. Hahn Shell Oil Company
Evaluation of Minerals Management Service Archaeological Management Zone 1	Mr. James Parrent Department of Anthropology Texas A&M University
Evaluation of Prehistoric Site Preservation on the Outer Continental Shelf: The Sabine River Area, Offshore Texas	Dr. Charles Pearson Coastal Environments, Inc. and Louisiana State University

Cultural Resources I - Current Research in the Gulf of Mexico: Session Summary

Ms. Melanie Stright
Minerals Management Service

The locations of historic shipwrecks, like any archaeological site, are governed by common factors which lend a certain predictability to their occurrence.

Where historically active shipping areas such as major shipping routes, ports, and harbors coincide with environmental factors such as shoals, reefs, and historic hurricane paths, the probability for locating shipwrecks is high.

The presentation by Mr. James Parrent, Texas A&M University, outlines a study proposal to evaluate these various cultural and environmental factors to predict better where shipwrecks might have occurred in the Gulf of Mexico.

The U. S. Army Corps of Engineers intensively investigated one such high probability area, Mobile Bay, AL, in order to locate any historic resources present within a proposed harbor deepening project area. The Corps of Engineers contractor, Espey, Huston & Associates, conducted an extensive magnetometer survey within the project area and investigated all unidentified magnetic anomalies to determine their source. The results of this investigation were presented by Mr. Clell Bond of Espey, Huston & Associates, and Ms. Dorothy Gibbons of the Corps of Engineers, Mobile District.

After shipwrecks are located, accurate mapping and recording of the site sometimes requires years of intensive effort.

Dr. Glen Williams, Texas A&M University, reported on a high resolution ultrasound underwater triangulation mapping system which allows rapid, accurate mapping of a shipwreck site, even in a blackwater environment. The system utilizes three ultrasound receivers, a stationary ultrasound transmitter, and a mobile transmitter linked to an IBM PC portable computer at the surface. After calibrating the positions of the receivers, the computer can calculate the position of the mobile transmitter through triangulation as it traces objects on the seabed. The rapidness and accuracy provided by this mapping system may make obsolete the present time-consuming and subjective underwater site mapping techniques such as hand sketching and photomosaics.

The locations of prehistoric archaeological sites, like historic shipwrecks, are governed by common factors which make their occurrence somewhat predictable. The cultural resources baseline study for the northern Gulf of Mexico (CEI, 1977) established criteria for predicting prehistoric site locations in the offshore environment. A 1982 study by the National Park Service established sedimentary criteria which would allow site/non-site determinations to be made from core-sized sediment samples in the offshore environment. These two studies provided the baseline data necessary to locate prehistoric archaeological deposits on the OCS. In 1983 MMS funded a study to test the predictive and sedimentary criteria established by the 1977 and 1982 studies. The final results of this 1983 study entitled "Prehistoric Site Evaluation of the Northern Gulf of Mexico: Ground Truth Testing of the Predictive Model" were reported by Dr. Charles Pearson of Coastal Environments, Inc.

Of the types of geomorphic features representing high probability areas for prehistoric site occurrence, only karst areas were not included in MMS's 1983 study. Freshwater springs, which often occur in association with these karst areas, provided not only a water source, but also a concomitant increase in plant and animal food resources for prehistoric man during periods of drier climatic conditions and lower standing sea level. Dr. Ervan Garrison, Texas A&M University, presented a proposal to locate submerged karst features (sinkholes) with associated springs offshore in the eastern Gulf of Mexico using infrared scanners and high-resolution side scan sonar systems. These sinkholes would then be investigated for the presence of associated archaeological deposits.

Coastal Environments, Inc. 1977 *Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf.* Prepared for Interagency Archaeological Services, Office of Archaeology and Historic Preservation, National Park Service, U.S. Department of the Interior. Baton Rouge, LA.

Coastal Environments, Inc. 1982 *Sedimentary Studies of Prehistoric Archaeological Sites.* Prepared for Division of State Plans and Grants, National Park Service, U.S. Department of the Interior. Baton Rouge, LA.

Melanie J. Stright obtained a BA in Anthropology from Ohio State University in 1976. From 1976 to 1978 she was District Archaeologist for the Rawlins District of the Bureau of Land Management in Rawlins, WY. In 1978 she became the staff archaeologist for the Gulf of Mexico Outer Continental Shelf Office, where she has worked on developing the marine archaeology program and geophysical survey requirements for oil and gas related high-resolution surveys. Her current research interests are the archaeological applications of remote-sensing methods, paleoenvironmental reconstruction, and Holocene sea level change.

The Archaeological Significance of Sinkholes in the Eastern Gulf of Mexico

Dr. Ervan G. Garrison
Civil Engineering Department
Texas A&M University

Inundated karst features such as sinkholes exist on the Outer Continental Shelf of the Eastern Gulf of Mexico. Terrestrial counterparts of these geological features have demonstrated clear evidence of prehistoric man's association with them, particularly in Western Florida. Holocene occupation of Little Salt Springs and Warm Mineral Springs by Archaic Period peoples is currently under archaeological study at these important sites. Occupation of these sinkhole springs occurred during periods of lowered sea stand. This is especially true for Warm Mineral Springs where Cockrell has dated skeletal remains to over 8500 years before the present (B.P.).

Since large areas of the now inundated Outer Continental Shelf were open to settlement as early as 18,000 years B.P., it is reasonable to assume that sinkhole springs active in the early Holocene should have had similar occupations by nomadic hunting and gathering peoples of this period. Springs are an exception to the scenario of fill by marine transgressional processes by the simple discharge of an amount of fresh water sufficient to offset the hydrostatic pressure of sea water and deposition of current transported sediments. Further, in areas of the Outer Continental Shelf such as that off Western Florida (Figure IIIF.1), sediment starvation regimes active there have resulted in little deposition of sediments like that typically observed in the central and western portions of the Gulf of Mexico.

Location of these submarine sinkhole springs presents a challenge to instrumental techniques typically used for other geophysical and remote sensing purposes. Two promising techniques for the location of submerged springs are (1) infrared scanning of the sea surface in the 8 to 12.5 micron band and (2) acoustical survey of the sea bottom with high resolution side scan sonar systems (100-500KHz). Both these techniques have proven successful in the detection of active and inactive submarine sinkhole springs off Jamaica and Western Florida.

An infrared scanner capable of sensing the sea surface infrared emission radiation in the 8 to 12.5 micron band by use of a mercury cadmium tellutide (trimetal) detector can map sea surface temperature to 0.2°C from an airplane flying at an elevation of 1000 to 2000 feet. To obtain only emission radiation rather than emission plus reflection, it is best to fly just before dawn or at night. A mrad detector will give a ground (sea) resolution of (pixel size) 1 foot by 1 foot when flown at 1000 feet of elevation. Band 6 (10.4 to 12.5 micron) of the Thematic Mapper of Landsat 4 yields only a 30m by 30m pixel size, which is far too large for the detection of submarine springs.

The detection of submarine sinkholes has been successfully accomplished off Western Florida using high resolution side scan sonar and digital recording/playback color depthfinders. A sonograph of such a sinkhole is shown in Figure IIIF.2. With instrumentation such as CTD probes (conductivity-temperature-dissolved oxygen sensors) mounted on ships and submersibles, it is further possible to locate precisely the submarine feature for archaeological exploration. If it is not an active spring, reliance on only acoustical detection gear coupled with precision navigation has resulted in the finding and relocation of such sinks as that shown in Figure IIIF.2.

No extensive investigations of these exciting offshore geological features have been conducted to date. The research discussed here has identified and field deployed these technologies successfully in the location of these sinkholes. Continued research may produce verifiable evidence of prehistoric man's early location and use of these same phenomena.

Dr. Ervan G. Garrison is an archaeologist and a lecturer and associate research scientist of Civil Engineering at Texas A&M University. His research interests include the application of geophysical instrumentation to the study of archaeological problems onshore and offshore. Of particular interest to Dr. Garrison is the clear demonstration of early man's presence on the now inundated continental shelf during the Late Quaternary.

Cultural Resource Investigations of Magnetic Anomalies in Mobile Bay

Ms. Dorothy Gibbens
U.S. Army Corps of Engineers
and
Mr. Clell L. Bond
Espey, Huston & Associates, Inc.

The U.S. Army Corps of Engineers, Mobile District, was authorized in the mid-1960's to examine the feasibility of deepening Mobile Harbor, Alabama. A feasibility report was completed in 1980 recommending channel deepening to 50 ft.

The proposed improvements include the following items: turning basin and anchorage area, transshipment facility, channel deepening to 55 feet at existing 400-ft width, passing lane, upper channel widening, disposal of new work material in Wilson Gaillard Island, and disposal of new work material in the Gulf of Mexico.

In compliance with current federal cultural resources laws and U.S. Army Corps of Engineers regulations, cultural resources investigations were initiated for the Mobile Harbor deepening project in 1982. Work performed in 1982 included archival and historic research on the prehistory and history of the study area, and a remote-sensing survey of all proposed work items. A total of 603 magnetic anomalies were recorded by the survey. However, correlation of magnetic data with side-scan sonar imagery revealed that most of the anomalies were produced by cable, pipe, and other modern ferrous debris.

In 1983, underwater archaeological investigations of the anomalies recommended for evaluation were initiated. One of the anomalous areas located within the limits of the proposed new turning basin proved to be part of the western arm of obstructions built by the Confederate engineers as part of the defenses of the City of Mobile during the Civil War. The remainder of the anomalies investigated in 1983 proved to be modern ferrous debris. Subsequently, in 1984, additional archaeological testing of the obstructions was completed. As a result of the 1984 testing program, the remains of a mid-19th century steamboat, the *Cremona*, and a wooden flat loaded with brick were documented. Additionally, the remains of a third vessel, believed to be the *Carondelet*, also sunk as part of the western arm of obstructions, were encountered. The Confederate obstructions, designated submerged historic site 1Mb28, have been determined eligible for inclusion in the National Register of Historic Places.

During the 1984 field season, three trenches placed at the bow, stern, and amidship of the *Cremona* were excavated. The hull, though broken in several places, was found to be in an excellent state of preservation. The hull was filled to varying depths with brick and other rubble. In addition to documenting the dimensions and construction of the *Cremona*, a trench placed to the north of that vessel identified a simply-constructed wooden flat loaded with brick. The lines of wooden pilings demarcating the western arm of obstructions were also delineated running diagonally from southeast to northwest across the turning basin. Planking and bricks were encountered exposed above the bay bottom at the southern end of the line of obstructions. This material is believed to represent the remains of the *Carondelet*.

In 1985, twenty-one anomalies within and adjacent to the Mobile Harbor Ship Channel were evaluated. Five were no longer in place in their positions as reported in 1982. The remaining 16 were identified as modern ferrous debris. In addition to identifying the anomalies located along the ship channel, the western end of the southern line of obstructions and southern end of the western line of obstructions were delineated by underwater archaeologists and recorded with side-scan sonar, magnetometer, and survey fathometer.

The highly variable environment of Mobile Bay, its considerable different water depths, and especially its potentially hazardous diving conditions, necessitated a flexible approach in terms of field methodology. The techniques and equipment of the investigations were continually refined during the 1983, 1984, and 1985 field seasons. In the areas of investigation, water depths varied from three to over 50 feet, and visibility, while typically limited by extreme turbidity to less than a foot, reached as much as 20 feet in the lower bay. Bottom conditions included mollusk reefs, as well as consolidated and unconsolidated silts and clays. The range of work platforms necessary to meet the various work tasks and Bay conditions included inflatable and rigid-hull skiffs, small steel barges, outboard power work boats, and diesel-powered crew boats. Underwater inspection of the anomalies was conducted using both open circuit SCUBA, as well as a surface-supplied air system.

The investigation of each anomaly involved up to eight steps: 1) Initially, the suspected position of each anomaly, as identified during the 1982 survey, was relocated, using a line-of-sight radio-positioning system, and buoyed; 2) after the positioning, the area was reinspected with the magnetometer to determine the strength, size, shape and characteristics of the magnetic signature; 3) after refining and rebuoying the suspected location, the position was again recorded using both the line-of-sight system and Loran C; 4) the area was then subjected to an initial diver inspection and tactile search; 5) if the divers failed to locate the anomalous object, additional magnet prospections were initiated using a diver-manipulated sensor; 6) after final location was made, a program of systematic probing was used to penetrate bottom sediments, with solid probes being used to penetrate to depths of eight feet and hydraulic probes penetrating up to 20 feet of sediment; 7) excavations were then conducted, depending on conditions, using propwash deflectors, hydraulic dredges and hydraulic jets; 8) where possible, the anomaly source was either then archaeologically documented and/or brought to the surface for inspection and removed from the area.

The Mobile Bay investigations have thus far documented a significant portion of American history, identifying both specific cultural resources of the Civil War as well as providing details of ship and harbor defense construction techniques. The investigations have also provided additional information on the interpretation of magnetic signatures.

Ms. Dorothy Gibbens is a cultural resource specialist with the U.S. Army Corps of Engineers, Mobile District. Obtaining her master's degree from Louisiana State University, she has conducted archaeological investigations in Central America and served with the Louisiana State Historic Preservation Office. For the past seven years, Ms. Gibbens has been with the Mobile District specializing in southeastern prehistory and marine survey archaeology.

Mr. Clell Bond is employed by and directs the cultural resources program of Espey, Huston & Associates, Inc., an engineering and environmental consulting firm headquartered in Austin, Texas. Actively engaged in cultural resources management for the past 15 years, his special interests are in historical and nautical archaeology.

A Computerized High Resolution Underwater Ultrasound Triangulation Mapping System

Dr. Glen N. Williams
Computer Science Department
Texas A&M University
and
Dennis A. Hahn
Shell Oil Company

A computerized high resolution ultrasound underwater triangulation mapping system has been developed for the Institute of Nautical Archaeology. This system determines the position of a mobile ultrasound transmitter using a stationary calibration ultrasound transmitter and three ultrasound receivers. All three receivers and both transmitters are hardlinked to the surface via data lines connected to an IBM PC portable computer. The receivers provide sixteen bits of resolution (1/2 millimeter) to the computer for calibration/triangulation purposes. The computer determines the location of the mobile transmitter at a frequency of ten hertz, time stamps the observations, graphically displays them in real time for shipboard/diver interactive communications, and optionally archives them for future post-processing and analysis.

Of keen interest to nautical archaeologists is the ability to record accurately the visual appearance of their underwater excavations. Currently, the techniques employed range from freehand sketches by underwater artists to more sophisticated stereoscopic photographs and videotaping. However, each of these methods has inherent disadvantages. First, the excavation must be at least partially visible for the artists/cameras to properly operate; in addition, the later translation of individual pictures to large mosaics includes an intrinsic amount of subjectivity by the artist. Finally, and most importantly, the large quantity of time to perform the recording is expensive. An alternative method minimizing both subjectivity and time would improve the efficiency and accuracy of the excavation recording tasks.

One such possible solution is electronic triangulation. By utilizing ultrasound pulses, instead of light, as the (primary) source of information, the stringent visibility requirement intrinsic to artists and cameras is removed. Also, the triangulation computations are performed by computer, thus assuring mathematical objectivity. Lastly, the construction of individual pictures and large mosaics is acomplished in real time during the survey and can be redrawn efficiently after a diving session, thus enabling timely reviews of the excavation progress.

The electronic hardware used with the computerized triangulation system consists of three ultrasound receivers, two ultrasound transmitters, and an integrated circuit control module designed to fit a long slot of an IBM PC portable computer.

The three ultrasound receivers are small objects; they measure approximately one inch in diameter and twelve inches in length. Their purpose is to filter digitally all incoming sound frequencies to detect the ultrasound pulse wave. When a receiver detects the designated ultrasound frequency, the receiver transmits a signal to the control module via an attached coaxial cable, acknowledging the arrival of the pulse.

The stationary ultrasound transmitter has approximately the same dimensions as the receivers. It is also attached to the control module via a coaxial cable. When instructed by the control module, the transmitter emits an ultrasound pulse for the receivers to detect.

The mobile ultrasound transmitter is similar to the stationary transmitter in control attachment and control. However, there exist two major differences. Although the electronics within the mobile transmitter are the same size as the stationary transmitter, the mobile transmitter is housed in a longer body with an attached handle for the diver to grasp; the general shape resembles an oversized revolver. In addition, the mobile transmitter has a small trigger switch with a red light emitting diode (LED) for simple diver/computer communications. The diver presses the switch when he is ready to trace an object, while the computer activates the light when it is ready for an object to be traced.

Lastly, the control module measures the time delays required for the mathematical geometric computations. Upon computer operator control, the control module simultaneously instructs the transmitter to emit an ultrasound pulse and counts the number of elapsed clock cycles until the return signals from the individual receivers are obtained. The counts are maintained in a series of sixteen-bit registers. If the elapsed number of clock cycles exceeds (2**16 - 1), the control module stops the counting process. This condition is hereafter referred to as a flooded gate response; a value of (2**16 - 1) is assigned to the time delay counter, a semaphore signaling the software that a valid time delay was not obtained. When all three time delays have been calculated, the computer control module signals the software of the availability of the delay values.

The computerized triangulation procedure consists of four major components: initialization, data input, point determination, and graphical display. When the program is started, the system geometry (transmitter/receiver relationships) is initialized, either from preset conditions or new survey parameters. The program stores the new parameters and proceeds to the data acquisition phase. On the decision of the operator, the initialization procedure can be re-executed to relocate the position of a receiver or completely establish a new underwater relative coordinate system.

The first phase of the data acquisition cycle consists of the data input. When invoked, this section of code performs a series of polls to the ultrasound transmitters and receivers via the computer control module. First, the mobile transmitter is instructed to emit a pulse. Next, the respective receivers will supply the experienced time delays as the number of clock cycles for the pulse to traverse the water. If a flooded gate response is experienced by any of the three receivers, the program displays an error message on the console and requests that the mobile transmitter emit another pulse. This cycle continues until eventually no flooded gate responses are recorded.

Next, the stationary transmitter will emit a pulse to be detected. Again, the receivers supply the time delays or record flooded gate responses. A series of five valid time delays are averaged to reduce the amount of variability within the observations.

After the time delays between the transmitters and receivers have been established, the position determination routine is invoked. First, the sound travel rate and mass flow vector are calculated using the averaged time delays from the stationary transmitter via the calibration equations. Next, the location of the mobile transmitter is computed by translating the time delays experienced from the mobile transmitter. Then, the calculated coordinates are stored in an archive file for future reference. Finally, control is passed to the graphic display section.

Subsequent to the computation of the location of the mobile transmitter, the calculated point is graphically displayed within the XY-plane of the relative coordinate system in real time for the operator to view.

The computerized ultrasound triangulation mapping system is designed for and implemented on an IBM PC portable computer. The computer software is written in MicroSoft BASIC and is executed in compiled form with an 8087 Math coprocessor. A ten hertz control module sampling rate was experienced with this configuration. While the software was being written at Texas A&M, the hardware was being designed and built by Martin Wilcox of Applied Sonics, Inc. The hardware and software components were generated and debugged independently.

The first version of the computerized triangulation procedure was tested in a swimming pool with the surveyed object being a brick. A following test was performed at a Civil War wreck site in the York River, Virginia, and the system functioned as designed.

A second version of a computerized triangulation procedure is currently being designed with modifications to both hardware and software components. The stationary ultrasound transmitter and three ultrasound receivers will be replaced by four ultrasound transducers, capable of both transmitting and receiving ultrasound pulse waves.

The computerized ultrasound triangulation mapping system is a more feasible and economically better system of recording the physical characteristics of underwater excavations than are artist's sketchings and stereoscopic photography. This has been proven by the ease of operation of the mapping system during the preliminary tests. However, as with any new developments, future research can greatly aid the evolvement of the computerized triangulation system. In addition, sensitivity and parametric tests are required to establish the limits of the software and hardware components.

Dr. Glen Williams is an associate professor of computer science at Texas A&M University. His primary areas of interest include computational algorithms in numerical methods and computer graphics and their applications to the oceanic engineering environment. Contributional areas include surface/sub-surface oil spill transport and diffusion, submarine slope stability and geologic process simulation and modeling. He received his BS, ME, and PhD degrees in Civil Engineering from Texas A&M University.

Evaluation of Minerals Management Service Archaeological Management Zone 1

Mr. James Parrent
Department of Anthropology
Texas A&M University

Archaeological studies are conducted in the Gulf of Mexico (GOM) as part of the offshore oil and gas leasing program because of the great number of historic shipwreck sites located there. Accordingly, the Minerals Management Service (MMS) Manual for Archaeological Resource Protection (draft) requires that archaeological baseline studies be updated as new data become available. These baseline studies, containing predictive models which deal with the location of both prehistoric and historic cultural resources, are the foundation for MMS decisions on where to invoke the archaeological survey requirement. No systematic evaluation of historic archaeological resource data has been accomplished since Coastal Environments, Inc., (CEI) completed a report titled "Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf (CEI 1977)." The CEI study was utilized by MMS to establish the present cultural resource management zones.

The present study will compile information collected since 1977 and will consider additional factors which contribute to site location and preservation on the GOM Outer Continental Shelf (OCS). It is anticipated that the present study will more clearly define historic archaeological resource areas on the GOM OCS, thereby avoiding costly surveys in areas where the potential for archeological sites is low.

Volume II of CEI's 1977 report addresses the historic cultural resources which may be found on the GOM OCS. Questions concerning the validity of certain aspects of this volume and the archaeological management program on the OCS have been raised by industry, Gulf Coast State Historic Preservation Officers, the Sierra Club, and the professional archaeological community. Industry, for example, has expressed concern over the amount of money and effort spent on the required lease block surveys in Archaeological Management Zone 1 (AMZI) versus the sparsity of information gained about historic shipwrecks. Another point was raised by the Sierra Club when they responded to the call for comments on the Draft Environmental Impact Statement (DEIS) for 1984. They questioned the following statement in the DEIS: "Due to the general lack of a data base for OCS cultural resources, the expected impact from offshore development is uncertain." In their written response, the Sierra Club asked (1) "What are you going to do about the lack of a data base for OCS cultural resources?" and, (2) "How will you alleviate this problem?" (MMS 1983).

Archaeologists from academia, federal agencies, and state agencies have raised the following questions: (1) Why has so little information about historic shipwrecks been recovered from the lease block surveys in Zone 1? (2) In view of what is known about GOM prevailing wind and ocean current directions, are the sailing routes depicted in CEI's report accurate? (3) How do factors such as bottom sediment types, depth of unconsolidated sediments, water depth, and energy zones affect the state of preservation and integrity of shipwreck sites? (4) Why does the Zone 1 boundary follow, for the most part, the 20-m bathymetric curve, disregarding the influences of such major ship concentrating factors as important historic ports, major harbors, and inland waterways? (5) What is the correlation between historic shipping lanes and historic hurricanes, and how has this correlation affected the shipwreck pattern in the GOM? These questions plus others will be addressed by the present study.

The question about the lack of historic shipwrecks found as a result of lease block surveys can be explained by the fact that industry chooses to avoid almost all magnetic anomalies located during the surveys rather than identifying them. Other questions are not so easily answered. However, new data germaine to the issues are available. For example, preliminary investigation of GOM prevailing wind and currents, coupled with a review of historic maps, suggests that historic shipping routes were different than previously thought. However, it must be emphasized that many maps and historic documents must be examined before any conclusions are reached by the present study.

Another question deserving attention is whether or not shipwrecks will be preserved in high energy zones in the GOM. Claims by some that historic shipwrecks, in areas of high energy, will be scattered and of minimum historic value are not supported by recent investigations. In August 1984, an historic shipwreck located in the GOM Eastern Planning Area was investigated by MMS personnel. Site reports, on file at the Florida Division of Archives, History, and Records Managment Office in Tallahassee, show that, when first discovered, the shipwreck was very well preserved, even though it was in an area of high energy (Parrent 1984). It is well documented that preserved historic shipwrecks can be found in very high energy zones (Arnold and Weddle 1978, Bass 1975, Hoyt 1984, and others). However, before conclusions can be reached by the present study, environmental conditions in the various areas of the GOM must be examined thoroughly to determine their role in the preservation or destruction of shipwreck sites.

Clearly there remains a need to examine the various factors affecting the occurrence and preservation of historic shipwreck sites. These factors need to be analyzed, weighed, and developed into a framework which will assist in determining where the most probable locations of preserved sites are on the OCS. This new and comprehensive approach may lead to recommendations for changing the boundary of AMZ1 in the GOM. In general, archaeologists would like to see the area of Zone 1 increase while other individuals would like for the area to decrease or perhaps not to exist at all. Only through rigid scientific investigation can the concerns of industry, as well as those of the archaeological community, be addressed. Ideas or boundaries not supported by scientific data will always be open to criticism.

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Mr. Parrent is a research scientist/archaeologist with the Department of Anthropology at Texas A&M University. For the past year he has been working with the Minerals Management Service Gulf of Mexico Region through an Interagency Personnel Agreement. Mr. Parrent's responsibilities included the re-evaluation of the historic cultural resource zone in the Gulf of Mexico. He received the BA in Anthropology from Wright State University, and the MA, specializing in nautical archaeology, from Texas A&M University.

Evaluation of Prehistoric Site Preservation on the Outer Continental Shelf: The Sabine River Area, Offshore Texas

Dr. Charles Pearson
Coastal Environments, Inc.
and
Louisiana State University

For the past decade there has been an increasing interest in the prehistoric cultural resources potential of the continental shelves of the world. Many would agree that given certain conditions, prehistoric sites established on the continental shelf during periods of lower sea stand would have withstood the effects of rising seas and now remain preserved on the submerged portions of the shelf. One of the settings which provides that set of conditions conducive to site preservation is a filled stream valley -- especially the larger valleys which with sea level rise develop into estuaries and slowly fill with sediments before being completely inundated. Archaeological deposits can become covered by and encapsulated in estuarine sediments and remain intact beneath the erosive impacts of transgressive seas. Developing statements concerning the occurrence and distribution of archaeological deposits in these offshore settings requires, first, the projection of a culture history for the area with its attendant settlement patterns probably best drawn from onshore analogies; second, an assessment of the geologic history of the area; and third, the identification of the geomorphic processes which have occurred relative to their effect on archaeological site preservation.

To date several studies relying on these types of data have produced what appear to be reasonable models of site occurrence and preservation in large stream valleys on the North American continental shelf (Belknap and Kraft 1981; Coastal Environments, Inc. 1977; Kraft Belknap and Kayan 1983; Masters and Fleming 1983). Testing these models, however, is another and more complicated problem. It requires a technology that permits the identification of submerged and buried landforms which have a high likelihood of containing cultural remains and it also requires a method for collecting samples from these landforms. In essence it demands a practical geological/geophysical approach to an archaeological problem. Fortunately, this technology is today available in the form of a variety of instruments which permit refined mapping of the shallow subsurface geology and in a range of coring devices which can collect an analyzable sample from a submerged target landform.

This paper discusses a project undertaken by Coastal Environments, Inc., to test a predictive model of site occurrence and preservation developed in an earlier baseline study of the cultural resources potential of the OCS (Coastal Environments, Inc. 1977). This project is being sponsored and funded by the Minerals Management Service of the Department of the Interior.

The project was conducted in two phases. The first phase involved the collection, evaluation, and synthesis of archaeological, geological, seismic, and bore hole data from the study area. The second phase involved the collection and analysis of vibracore samples taken from target areas which had been identified from the seismic records as potential cultural resource locales.

The region selected for implementation of this study is a 35-mile-square area in the offshore Sabine-High Island region of eastern Texas and western Louisiana containing the relict- filled channels of the late Pleistocene to Holocene age Sabine River Valley (Figure IIIF.3). This late Pleistocene river system provided an ideal research universe for the present study largely because a series of published works is available which provides information on the present setting and geologic history of the trench area. Of particular importance is the published work of H. F. Nelson and E. E. Bray (1970) which delineates the Pleistocene river system and the subsequent changes it underwent with sea level rise. In addition to the work of Nelson and Bray, an extensive body of seismic and bore hole data collected relative to oil industry activities is available from the area, and the regional geology has been well studied (Aronow 1971; Aten 1983; Bernard 1950; Bernard and LeBlanc 1965; Bernard LeBlanc and Major 1962; Berryhill 1980; Curray 1960; Nelson 1968).

Other factors which make the buried Sabine Trench conducive in the search for submerged sites are (1) the river system was active and the region was subaerially exposed when prehistoric populations occupied the region; (2) the river system was active for at least 12,000 years, sufficient time to permit the accumulation of an extensive archeological record, possibly including multicomponent, stratified sites; (3) relict features having a high probability for both site occurrence and preservation had been identified within the valley system; and, (4) importantly, these landforms are often not deeply buried and many are within the range of vibracoring, the sampling technique used in this study.

Working from the base provided by Nelson and Bray, we have augmented and refined their model of the geology of the area using previously collected seismic and bore hole records. Information from over 100 lease block surveys, 23 pipeline rights-of-way surveys, and 35 borings were examined. An extensive amount of additional seismic data was collected within the study area in an effort to locate and map accurately landforms on which archaeological sites may occur. Added to this were 77 vibracores taken at five high probability locales. Samples were taken from these vibracores in an effort to refine further the local geology and to test for cultural deposits. Types of analytical techniques conducted included radiocarbon dating as well as grain size, point count, pollen, foraminifera, and geochemical analyses.

In every case, vibracores struck the target landsurfaces within one to three feet of the suspected depth derived from the seismic records. This indicated accuracy in terms of positioning and provided a satisfying measure of reliability in terms of our interpretation of features the seismic records.

The analysis of all of the collected seismic and core data has provided information on the geologic history of the study area and its archaeological potential. In most respects our findings correspond closely to those developed by Nelson and Bray relative to the configuration and age of the buried Sabine Trench. A major departure from Nelson and Bray is our identification of extensive areas of relict Deweyville floodplain within the Sabine Trench area.

On seismic records Deweyville surfaces usually appear as an initial hard reflector beneath which there is a void or little indication of variability in the sediments. This signal is distinctly different from that produced by the earlier Prairie/Beaumont Pleistocene features. The Prairie/Beaumont terrace is characterized by distinctive multiple parallel reflectors through which the pinger generally achieved considerable penetration, up to 100 feet.

The features identified from seismic and bore hole data have been interpreted through correlation with the known on-shore Sabine system. The data demonstrate that extensive areas of buried late Pleistocene/early Holocene landforms are preserved in the offshore study area. Many of the offshore settings identified are known on the basis of onshore archaeological data to be locales commonly associated with prehistoric settlement.

It is impossible here to discuss all five offshore areas from which vibracores were taken in the search for evidence of cultural activity. Rather a brief discussion of one of the locales is presented. The location discussed is about ten miles offshore in lease block Sabine Pass 6, along the eastern side of the former Sabine River valley. Figure IIIF.4 presents a plan view of the area derived from the seismic records. Contour lines are in feet below the seafloor to the identified Deweyville surface. The track of the seismic survey vessel and vibracore locations are also shown in Figure IIIF.4.

The basal deposits consist of Deweyville terrace clays and, in the stream and the modern Sabine Valley, pre-transgressive freshwater organic deposits. Immediately above these organic deposits is a fluvial silty clay facies which is interpreted as a submarine, possibly subaerial, river mouth deposit. Blanketing this deposit is a thin stratum of sandy to silty clay, heavily burrowed and containing numerous *Rangia cuneata* shells. The shells exhibit minimal wear, so disturbance has not been great. Foraminifera species in this deposit indicate moderate salinities. This facies is interpreted as a low-energy, transgressive deposit, probably formed with the initial expansion of estuarine systems into the area. The conditions when this stratum was formed were evidently conducive to *Rangia* growth. This blanketing disturbed zone was noted in all of the areas examined and is critical in marking the boundary of transgression. Archaeological materials are expected to be found primarily within or beneath this deposit.

Above this initial transgressive facies is a massive deposit of gray clay which represents bay/estuarine fill. The massiveness and homogeneity of this deposit suggest relatively rapid sedimentation. The uppermost stratum in the section consists of heavily-burrowed clay containing varieties of marine shell. This facies represents modern open gulf seafloor deposits.

The areas of critical importance are the organic deposits which rest atop the Deweyville terrace bordering the filled stream. These, shown in black, were contacted by three cores. Pollen samples from these deposits contain a high percentage of grasses and a diversity of arboreal types suggesting an upland/swamp interface. Point count analysis of samples from these deposits produced large quantities of charred wood and vegetation, nut hulls, seeds, fish scales, and bone. Much of the bone is carbonized and some is definitely calcined. In addition to fish bone are fragments from reptiles and other small animals. The quantity of bone fragments is extremely high. Some of the samples produced projected counts of over 700 fragments of bone per kilogram of sample.

The critical question of course is whether these are or are not cultural deposits. In the very small samples collected, we did not anticipate that finding an identifiable artifact would be a high probability. Rather, it is the sedimentary character and content of the deposit which are most likely to be useful in making this assessment. The basis against which a decision can be made as to the "siteness" of a deposit are the results of an earlier study by Coastal Environments which attempted to identify, through several types of analyses, the characteristics of coastal archaeological site deposits relative to natural deposits (Gagliano et al. 1982). That study indicated that the simple particle content, derived from point counts, provided useful parameters for distinguishing coastal archaeological sites from non-sites. We know of no other data set which provides the necessary comparative model for making this assessment.

That earlier study indicated that the simple co-occurrence of certain components in particular size fractions could be used to distinguish cultural from non-cultural deposits at a statistically reliable level. Owing to space limitations, only the quantitative results of the point count analyses are discussed here. In the two size fractions examined (-1 phi and 0 phi), the critical element for distinguishing between cultural and non-cultural deposits was the simple occurrence of bone alone or the presence of bone and charred organic material. These results suggest that the organic deposit in Sabine Pass 6 has a high probability of being a cultural deposit. Based on that previous model, that probability is very high, ranging from 88 to 100%.

We do, however, question the strength of this identification because of limitations in our comparative model. That model did not encompass all possible non-cultural coastal settings. Particularly relevant here are buried peat and organic deposits. Studies in coastal Louisiana indicate that bone can occur in these deposits, although in small quantities, and apparently no evidence of burned bone has been reported (Coleman 1966). The knowledge that bone can occur in buried natural deposits weakens the argument that the material is cultural; however, this may be offset by the presence of burned bone, the quantity of which seems to be inordinately high to be a natural occurrence. Thus we are left with the situation that while the deposit is suspected of being cultural in origin, we are unable to quantify that likelihood because of the narrowness of our comparative model.

Several other locations within our study area produced similar tantalizing examples of possible cultural remains. While the indicators for these being truly cultural in origin are strong in all cases, there is room for question. The results of geochemical analyses, not yet finalized, may allow for a more definitive identification.

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Dr. Charles E. Pearson is Senior Archaeologist for Coastal Environments, Inc., Baton Rouge, LA, and Adjunct Assistant Professor of Anthropology for the Department of Geography and Anthropology at Louisiana State University, Baton Rouge, LA. Dr. Pearson obtained the PhD in Anthropology from the University of Georgia in 1979 and the MA in Anthropology from the University of Georgia in 1976.

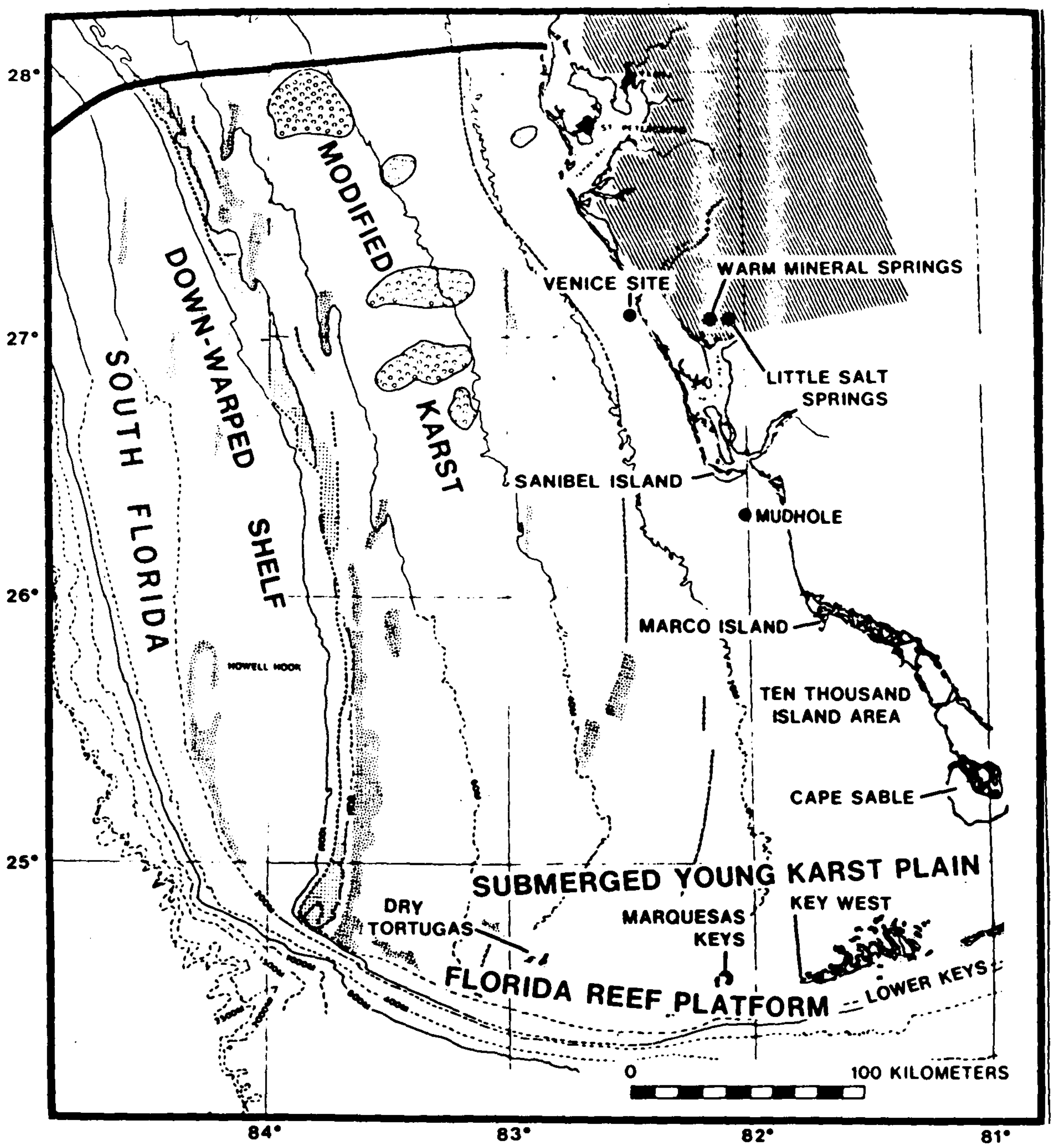


Figure IIIF.1 - Karst Plain-Western Florida Shelf

SONOGRAPH OF 96 FATHOM SINKHOLE,
EASTERN GULF OF MEXICO,
OCS 50/100 METER SCALES

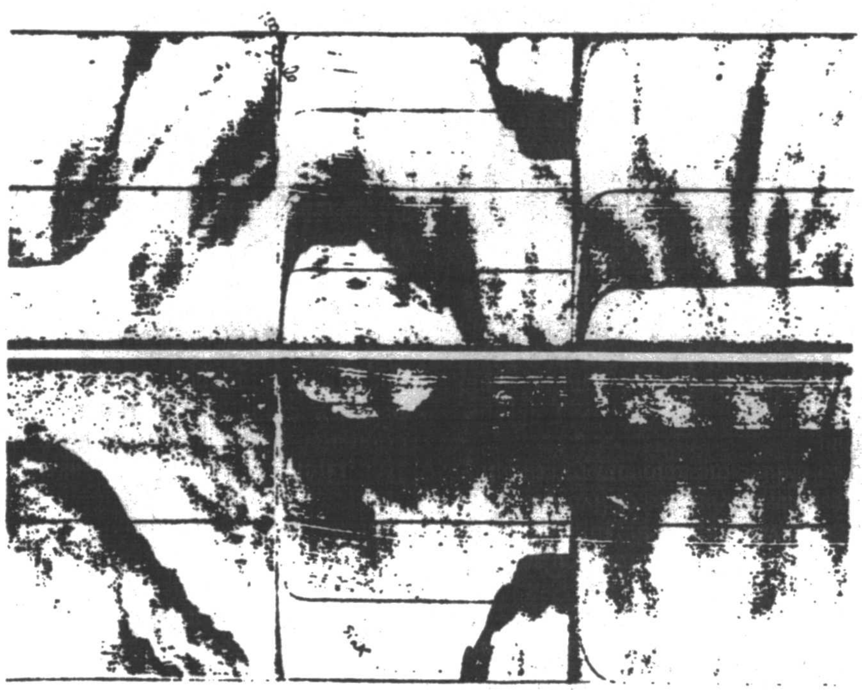


Figure IIIF.2 - Sonograph of 96 Fathom Sink

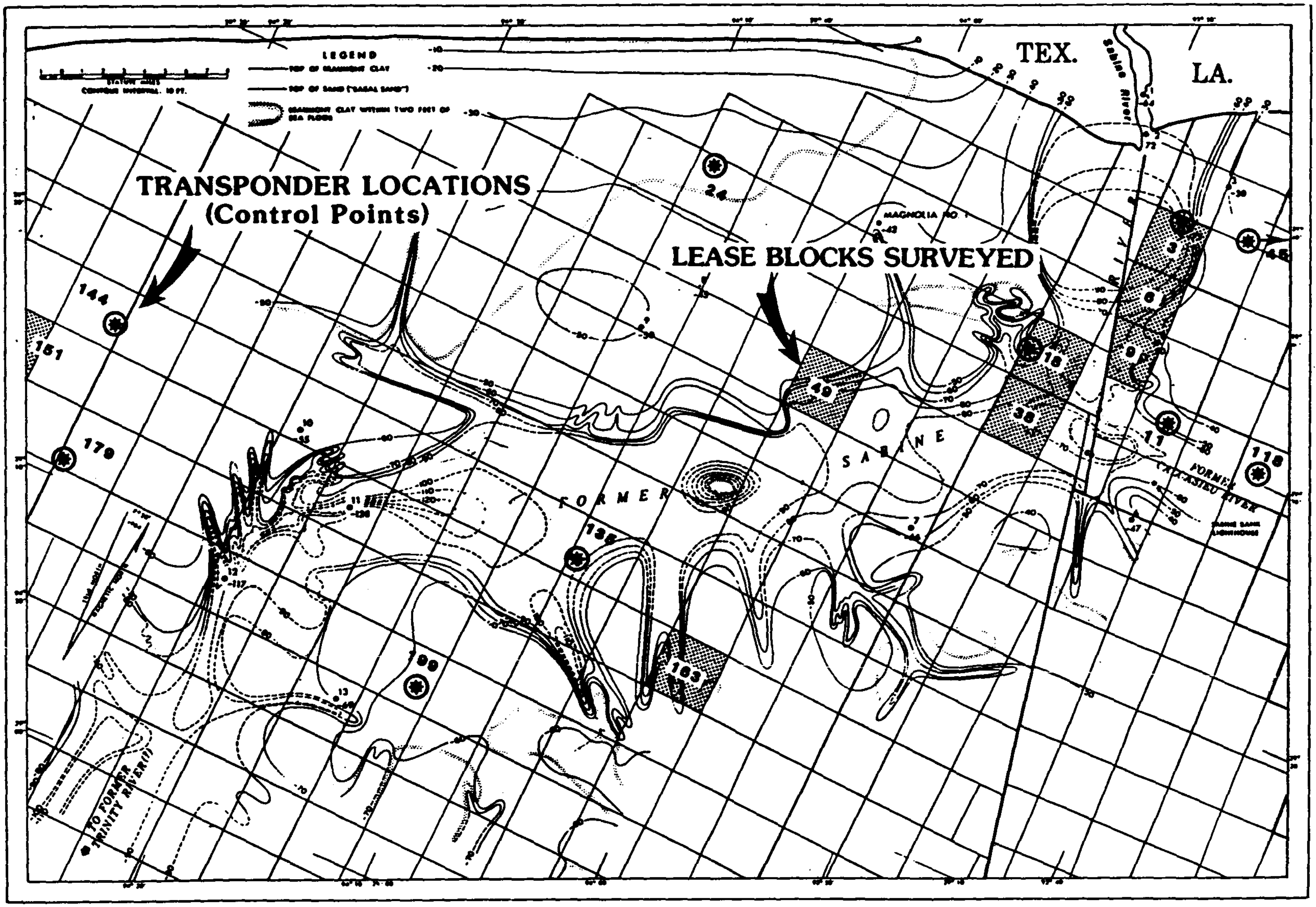


Figure IIIF.3 - The Study Area Showing the Lease Blocks Selected for Close Order Seismic Survey

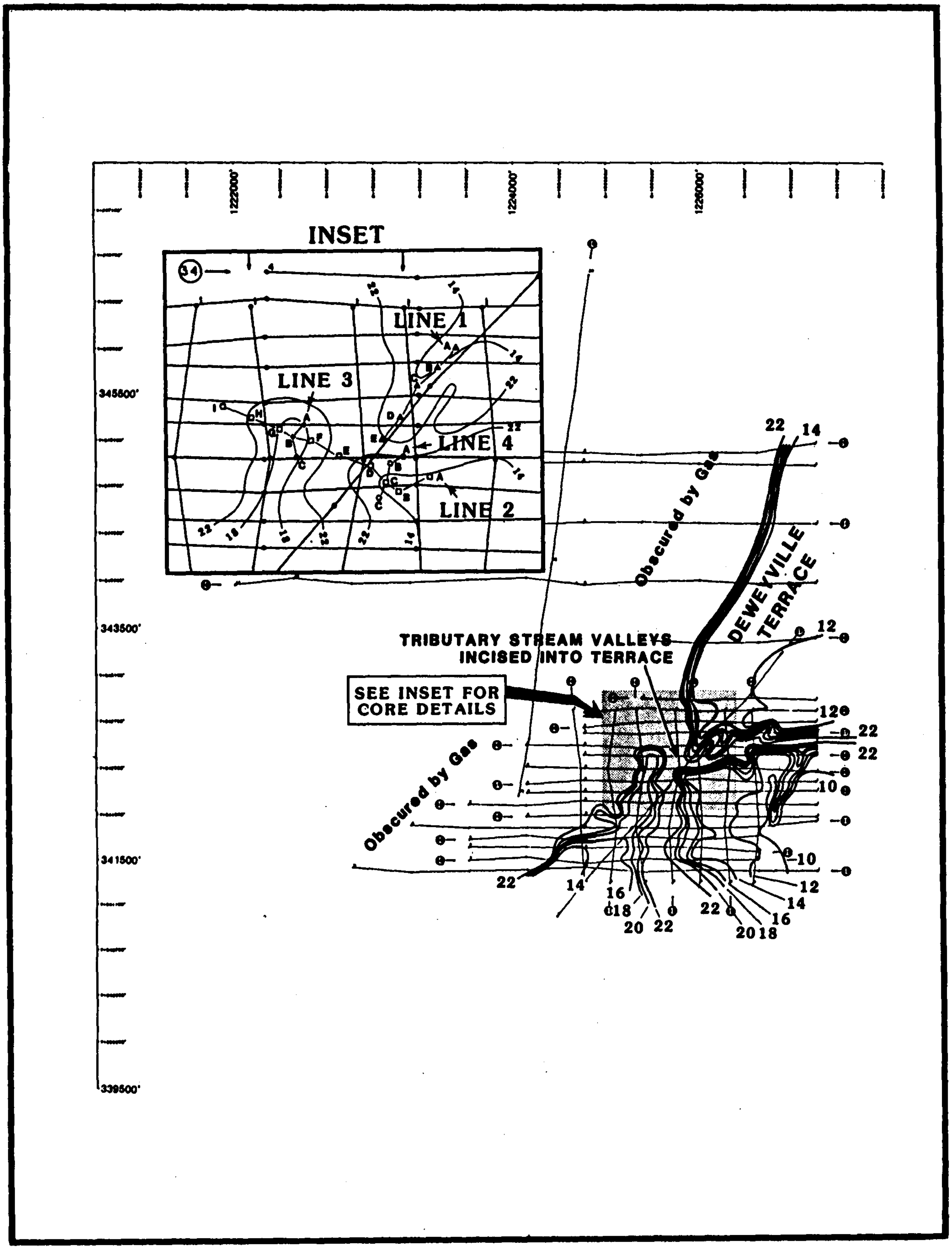


Figure IIIF.4 - Plan View of Pretransgressive Surfaces, Lease Block Sabine Pass 6

ECONOMIC ASPECTS OF DEEPWATER OPERATIONS

Session: ECONOMIC ASPECTS OF DEEPWATER OPERATIONS

Chairmen: Mr. Felix Dyhrkopp
Dr. Norman Froomer

Date: October 23, 1985

Presentation Title	Author/Affiliation
Economic Aspects of Deepwater Development: Session Summary	Dr. Norman Froomer Minerals Management Service
Abstract of Socioeconomic Impacts Due to Offshore Oil and Gas Activities in the Gulf of Mexico	Mr. Gary Brown Centaur Associates, Inc.
Economic Changes in the Petroleum Industry	Mr. G. Allen Brooks Vice President Offshore Data Service, Inc.
Economic Impact of Deepwater Development on the Platform Construction Industry	Mr. Griff C. Lee Griff C. Lee, Inc.
Marine Systems for Deepwater Production	Mr. Andrew Hunter Conoco, Inc.

Economic Aspects of Deepwater Development: Session Summary

Dr. Norman Froomer
Minerals Management Service

The growing industry interest in leasing deepwater offshore tracts (greater than 600 ft water depths) and the discovery of commerical reservoirs in these tracts suggest that deepwater development will become an increasingly more important factor in Gulf of Mexico oil and gas activities. This session provided a perspective on what the impacts of this trend may be on local employment and economic conditions, and on how the economic conditions in the oil and gas industry may affect the development of these deepwater tracts.

The first speaker, Mr. Gary Brown of Centaur Associates, Inc., presented the results of an MMS-funded study that is just being completed. The objective of the study was to quantify the direct economic impacts of OCS activities in 1984 on employment and expenditures in the affected coastal states. Payroll and contract expenditure data were obtained from nine companies on the Offshore Operators Committee and the figures from these companies were scaled upward to represent the universe of OCS operators. Some of the information generated by this study includes producer companies' payroll expenditures by personnel position, place of employment, place of residence, expenditures to contractors, and the number of jobs created as a result of contract expenditures.

Mr. G. Alan Brooks, the next speaker, was not optimistic about economic conditions in the oil and gas industry during the next year or two, and perhaps even longer. Between 1981 and 1983 there was a decline in industry activity in the Gulf of Mexico, which was reversed in 1983 by an area-wide leasing program. By 1985, however, industry recognized that the price outlook for petroleum was not going to improve as soon as expected, and prices of $20 a barrel or less were possible. Mr. Brooks does not predict any changes in economic conditions during 1986. Although there has been increased drilling in water depths greater than 600 ft in the Gulf of Mexico, price uncertainty makes projections about deepwater activity levels difficult. He believes that it is certainly unrealistic to expect a surge in deepwater drilling to fill the surplus capacity that exists in the industry today.

The next speaker, Mr. Griff Lee, discussed the impacts of deepwater development on the platform fabrication industry. The impacts of deepwater drilling on platform engineering and technology have been substantial. It is difficult, however, to assess the economic impacts. To date, seven deepwater platforms have been constructed at a cost of about one billion dollars. Four more platforms are currently being constructed. With a 50% reduction in platform construction employment during the past several years, current deepwater projects are not going to alter substantially economic conditions. Deepwater construction in the Gulf of Mexico has the potential to evolve into a major ingredient in the offshore industry, but it is certainly not going to provide a panacea for the current downturn in oil and gas activity levels.

The marine support industry consists of the boats that service the rigs and platforms in the Gulf of Mexico. Mr. William Hightower, a Vice-President of Tidewater, Inc., discussed the impacts of deepwater development on this industry. The marine support industry evolved to service the shallow water jack-up rig market. The deepwater, or floating rig, market is new and still rather small. The industry has recently geared up with new construction, re-fitting old boats, and the moving of boats from overseas to the Gulf of Mexico to be ready to service deepwater projects; but the anticipated market for these special boats has never developed. Today, nearly one half of the available deepwater service boats are idle.

The last speaker in the session, Mr. Andrew Hunter of Conoco, Inc., injected an optimistic note into the economic perspective on deepwater development. He described Conoco's efforts to develop reserves in Green Canyon Block 184. He emphasized that deepwater technology is continental slope technology. Water depths can vary considerably over the extent of the block. In Green Canyon 184, for example, water depths range from 1200 to 1800 ft. It is therefore essential to know the reservoir characteristics before designing a production platform because the water depth to design for will be unknown until then.

There are several options to choose from for a deepwater platform. Conoco used a modified tension-leg platform that was developed originally in the North Sea. The size and cost of the platform had to be reduced to make such a platform economically feasible with the smaller reservoirs in the Gulf of Mexico. Mr. Hunter feels that today Conoco has the 2500 ft water depth production problem solved even at $25 a barrel oil, and he is ready to start working at 4000 ft.

Dr. Norman Froomer is Social Science Analyst in the Environmental Studies section of the Gulf of Mexico Regional OCS office. He earned a PhD in Geography and Environmental Engineering from the Johns Hopkins University and was on the faculty of the University of New Orleans prior to coming to the MMS.

Abstract of Socioeconomic Impacts Due to Offshore Oil and Gas Activities in the Gulf of Mexico

Mr. Gary Brown
Centaur Associates, Inc.

A one year study, "Analysis of Indicators for Socioeconomic Impacts Due to Oil and Gas Activities in the Gulf of Mexico," was funded by the Minerals Management Service to provide the economic information necessary to address many of the socioeconomic questions related to oil and gas development in the Gulf of Mexico. The scope of this undertaking was to estimate the direct primary and the direct secondary economic impact of offshore oil and gas exploration, development, and production in the Gulf of Mexico. The direct primary effect is the employment and wages and salaries associated with the offshore producers. The secondary direct effects are the employment and wages and salaries for the contract and support businesses which result from the purchases by the offshore producers. The determination of the indirect and induced effects are to be the focus of an independent investigation in 1986.

The study determined the impacts per unit of activity for use in the environmental impact assessment process. Other study objectives were to determine the geographic distribution of primary direct impacts at the county/parish level and document the relationship between place of work and place of residence for personnel employed by the offshore producers.

INFORMATION SOURCES

Since virtually none of this information was available from existing secondary sources, the Socioeconomic Subcommittee of the Offshore Operators Committee was formed to supply the required data. The nine offshore producers represented on the Socioeconomic Subcommittee were:

• AMOCO	• CHEVRON	• CONOCO
• EXXON	• GULF	• MOBIL
• ODECO	• SHELL	• TEXACO

These nine producers were responsible for over 50% of the offshore energy production in the Gulf of Mexico in 1984.

Four types of data were assembled as part of this effort. Three of these were provided exclusively by the OOC Socioeconomic Subcommittee member companies. This information included producer employment records for 1984, producer expenditure records for 1984, and activity budgets for specific projects undertaken in 1984. Economic impact ratios for the offshore contract and support industries were developed through discussions with approximately 50 firms supporting offshore operations in the Gulf of Mexico. Employment resulting from the purchases of goods and services was derived by applying key business ratios for each service industry to total expenditures by producers. Physical measures of activity were converted to expenditures based on actual detailed project records supplied by the participating companies.

DIRECT EMPLOYMENT IMPACT OF OFFSHORE PRODUCERS

An estimated 23,936 person years of employment at production companies were directly the result of offshore oil and gas leasing in the Gulf of Mexico in 1984. Of the estimated 23,936 positions with the offshore production companies, 9881 were located offshore and 14,054 were located on shore. An estimated 80% of the offshore Gulf of Mexico workers and over 90% of the on shore workers reported to work sites located in Louisiana. Over 10,000 of these on shore positions were located in the New Orleans area. Almost 1000 workers were located in Texas, either onshore or offshore.

Total payroll going to producer employees due to Gulf oil and gas activity in 1984 was $854,832,486.

Producer personnel records were also analyzed by residence location. There were employees of the offshore producers with residences in 26 states. More than 19,500 producer employees were residents of Louisiana, 1960 lived in Mississippi, and 1413 were from Texas. Residence was broken down to the county/parish level.

The personnel information for the offshore producers was also analyzed to determine the following:

- Producer employment, payroll, and job descriptions by work site;
- Producer employment and payroll by residence location;
- Producer employment and payroll by staging area; and
- Producer employment and payroll by offshore work site.

Producer personnel records were also analyzed to develop matrices to document place of employment/place of resident relationships.

EXPENDITURE IMPACTS OF OFFSHORE PRODUCERS

Offshore producers had a major economic impact on both the regional and national economy through their heavy use of contracting for offshore services and their purchases of materials. Data on these expenditures were collected directly from producers and were converted to payroll and employment. Expenditures to support producers' offshore activities in the Gulf were:

- Air transportation - $264 million
- Boat, barge and marine transportation - $506 million
- Catering services - $76 million
- Cement - $178 million
- Contract labor and engineering services - $1.3 billion
- Contract exploratory drilling - $717 million
- Contract development drilling - $835 million
- Diving - $28 million
- Drilling Fluids, mud logging, & chemicals - $389 million
- Fuel and utilities - $289 million
- Pipeline & pipelaying - $190 million
- Platform fabrication - $489 million
- Platform installation - $118 million
- Production enhancement - $228 million
- Tubulars - $629 million
- Seismic and geophysical sercices - $280 million
- Well logging, wireline and perforation - $478 million
- Field operating expenses, other field services and tools - $1.1 billion

In total an estimated $8.75 billion was spent in the Gulf of Mexico in 1984 by field operators. Combined 1984 producer purchases, expenditures, and contracts for offshore activities in the Gulf of Mexico resulted in an estimated $2.59 billion in wages and salaries with contractors and other general businesses. Contractors and businesses supplying goods and services to the offshore producers in the Gulf of Mexico generated approximately 97,500 full-time equivalent positions.

The major employment impacts with the contractor industries are as follows:

- Boat, barge, and marine equipment - 6074 employees;
- Contract labor and engineering - 19,005 employees;
- Contract exploratory drilling - 7748 employees;
- Platform and equipment fabrication - 7170 employees;
- Other field services and tool rentals - 13,656 employees.

Out of a total of 97,386 positions created by producer expenditures, an estimated 28,955 are located primarily offshore, 20,085 have an offshore component, and 48,347 are located exclusively on land. Contractors and suppliers to the offshore producers were estimated to have made an additional $3.89 billion of purchases from their suppliers and other businesses to support their sales to the offshore operators.

ANALYSIS OF PRODUCER ACTIVITY BUDGET DATA

Budget summaries for the six major types of activities conducted in offshore oil exploration, development, and production were used to develop a mechanism for converting physical activity measures, such as number of platforms, into estimated economic activity. The six activity types included geophysical surveying; exploratory and delineation drilling; development drilling; platform fabrication and installation; pipelaying; and production, operations, and maintenance. From this budget information, models for determining expenditures and, thus, impacts based on physical descriptions of activities were derived. These models enable producers to predict and explain their costs of oil exploration, development, and production activities.

Michael Frankel and **Garry Brown** are Vice Presidents of the consulting group Centaur Associates, Inc., and served as the principal investigators. They have jointly worked on seven prior projects to document the economic or social impacts of offshore oil and gas development on the East, West and Gulf Coasts of the United States, the Alaskan Bering Sea, the United Kingdom North Sea, and the Norwegian sector of the North Sea. Prior to conducting work for the offshore industry, Mr. Frankel managed 15 projects to determine the socioeconomic impacts of energy development of

BLM lands. Mr. Brown previously participated in 12 economic or financial studies of various fisheries in the Gulf of Mexico. Mr. Frankel holds a BS degree in Electrical Engineering from Bucknell University. Mr. Brown received his MBA from the George Washington University and BA in Economics from Bucknell University.

Economic Changes in the Petroleum Industry

Mr. G. Allen Brooks
Vice President
Offshore Data Service, Inc.

This talk will focus on two subjects. First, I want to talk about the changes in the petroleum industry which will affect the future levels of exploration and development, primarily in the Gulf of Mexico. Second, I want to focus on what has happened in the deepwater drilling and development market.

A quick review of history sets the stage for today and where we, as an industry, may be heading. In 1973, the war between Egypt and Israel resulted in the Arab countries instituting an embargo on oil shipments to the U.S. and a dramatic increase in world oil prices. Saudi Arabian oil prices were increased from \$3/B to \$11/B. For the next four years, the price of oil was generally flat in nominal dollar terms and because of worldwide inflation, actually declined in real terms. Oil demand was weak in 1975 as the result of the worldwide recession caused by the hike in oil prices. Worldwide oil demand fell 2.5%, or one million barrels per day. Beginning in 1976, oil demand recovered along with the world economies and continued to grow through 1979.

In the 1979-80 period, the Iranian government was overthrown and the fear of a shut-off of oil flow from the MIddle East resulted in another jump in world oil prices from \$13/B to \$36/B. It was this event which started the BOOM in the petroleum industry. However, demand started to fall as conservation from the 1973 price rise took hold. No one was paying attention to the fact that OPEC production had peaked and non-OPEC oil production was rising dramatically. The seeds of the industry bust were sown!

The industry boom which started in 1979-80 was predicated on a series of premises which all proved wrong. Industry people believed the following:

1. Oil and gas prices would continue to escalate;
2. Energy conservation and interfuel substitution would have little or no impact on demand;
3. Oil prices and the market could be managed;
4. Drilling and development opportunities were l imited only by equipment and personnel;
5. Borrowing to buy revenue-generating assets or reserves in the ground was smart because one would be paying back with cheaper dollars and values would be escalating;
6. Earnings growth of companies was a function of astute management rather than market driven.

As these premises fell by the wayside, both oil and oil service companies got into business and financial trouble.

The bust in the business began in 1981 when European product prices fell and company profit margins were reduced by two-thirds. In 1982 offshore activity stopped growing, but the fleet of equipment didn't stop expanding. By 1983, offshore activity was falling rapidly.

The turnaround in industry activity came as a direct result of area-wide lease sales in the Gulf of Mexico. In 1983, the petroleum industry spent \$4.9 billion to acquire 5.4 million acres. Drilling activity picked up in the fall and continued to increase steadily through the end of 1984. Worldwide, offshore activity was helped by the actions of the UK and Norway governments through granting tax relief and by leasing acreage to stimulate drilling and field development.

On January 1, 1985, the world changed. Oil companies woke up to a different outlook for future oil and gas prices. No longer was a drop in price questioned. The possibility of \$20/B or below was a real possibility. Natural gas demand in the U.S. was worse than expected. In addition, the mergers of oil companies was affecting the structure and activity of the industry. Collectively, the oil industry reached a decision that they would allocate a greater share of their cash flow back to the shareholders. The return has been accomplished through stock repurchases, mergers and acquisitions, increased dividends, and the creation of master limited trusts.

What is the outlook for the industry? We are just completing a new study on the next five years in the Gulf of Mexico. In 1986, our view is that "what you see is what you're going to get." The key to a better or worse outlook is a function of oil prices in the spring and the natural gas supply/demand situation this winter.

The offshore industry optimism of recent times has been built on the large inventory of leases acquired in the 1983-85 area-wide sales by oil companies. Historically, though, 17% of all blocks leased in 1974-1979 were returned to the government undrilled. Some oil companies believe that this ratio will rise to between 33% and 50%. In support of this contention, some 25% of all blocks bought in 1983-85 were purchased with per acre prices of under $200/acre. This can be considered a marginal investment by the oil companies. Because drilling costs will be much greater than these marginal lease bonus payments, the companies can walk away without a severe financial cost. Even with a large return ratio, there will still be a large amount of acreage to explore and a substantial amount of work to accomplish. The problem for the service industry is that there exists too much equipment for future demand levels and too much debt for the companies.

Turning to the deepwater market, we find this to be the brightest spot for the offshore industry. We define deepwater as water depths of 600 ft or greater. Deepwater wells spud have increased steadily over time. The most dramatic change has been in the Gulf of Mexico, which has been helped by discoveries. Since 1975, we have counted 31 deepwater discoveries. The problem with this total is that many times the initial discovery wells are reported as dry holes. This was the case both with Mobil Oil's Green Canyon 18 block in 760 ft of water and Shell Oil's Bullwinkle field in 1350 ft of water. Both presently have platforms under construction.

The key to deepwater activity is the price of oil. If we examine the economics of a Green Canyon field done by Merrill Lynch and look at the internal rate of return (IRR) calculations at different price levels, the effect on the economics of a drop in oil prices becomes clear. Oil companies want to have a 25% IRR or better, and this can only be accomplished with prices at present levels.

If one looks at the Sohio figures on where a $30 barrel of oil is spent, fully 22% goes for development costs. Only $0.60 goes for drilling. The ability of the service industry to reduce development costs in deepwater field development projects offers the greatest chance for the oil companies to make more money. With declining oil prices, reduced development expenditures may enable oil companies to hold their rate of return on investment steady.

When we look at the distribution of leased acreage in its primary exploration term, some 24% is in water depths greater than 600 ft. The May and August 1985 sales saw 30% and 40% figures, respectively. More important is the fact that there hasn't been much change in the ratio of deepwater acreage bought with low bids (under $200/acre) or high bids (over $500/acre).

The challenge for the domestic petroleum service industry and oil companies is to develop technology to drill and develop deepwater fields more cheaply than in the past. This is imperative in a period of flat or falling oil prices. Once this technology is developed, it can then be exported to all other parts of the world, just as the industry has done in the past.

REFER TO FIGURES IVA.1 - IVA.3 AND TABLES IVA.1 - IVA.4.

Allen Brooks is a vice president of Offshore Data Services, Inc. In this capacity, Mr. Brooks serves as senior analyst in Offshore Data's research division as well as a member of the company's governing board. In the past year, Brooks has been the lead author of two important studies published by the firm: "Offshore Mobile Rig Outlook to 1990" and "Gulf of Mexico Opportunities 1984-86." Prior to joining Offshore Data Services in 1982, Mr. Brooks spent 10 years as a petroleum investment analyst for Underwood, Neuhaus & Co. and Citicorp. Mr. Brooks is a Certified Financial Analyst and holds an MS degree in Economics from Cornell University and a BA degree in Economics from the University of Connecticut.

Economic Impact of Deepwater Development on the Platform Construction Industry

Mr. Griff C. Lee
Griff C. Lee, Inc.

As in most other industries, competition has driven the offshore contractors to build a better product, to reduce cost, and to improve performance. However, a major part of the industry's improved technology has resulted from the continued progress into deeper water. The benefits from deepwater construction have been substantial: improved engineering capabilities and construction techniques, as well as several generations of new fabrication and construction equipment. Unfortunately, it is not easy to determine the economic impact. The added investment costs owing strictly to deepwater have been high, and it is indicated that they have not been recovered to date. The income from deepwater construction has not been as large as might be expected. However, it has been a factor in the continued progress of the industry.

The platform construction industry progressed from 20 ft of water in 1947 to 475 ft in 1975. This was a gradual evolution making it difficult to gauge the economic effects. In the next three years, the depth range more than doubled with platforms in 850 and 1025 ft. The engineering and development performed for these two platforms was a major technical advancement. This marked the first real separation between deepwater and the gradual growth of the industry.

Seven structures have been installed in the Gulf of Mexico in water depths greater than 600 ft, as listed in Figure IVA.4. The total "structural" cost of these seven platforms was approximately $945 million. This includes the total cost of each platform and conductors, but not the drilling rig or production equipment. As shown in Figure IVA.5, the total cost of offshore construction in the Gulf of Mexico was approximately $2.8 billion for the years of 1982 through 1985. During that time, deepwater construction (over 600 ft) amounted to approximately $450 million or 16%. Not exactly a dominant figure, but certainly a vital part of an industry struggling to work through a severe downturn.

Possibly, the best indicator of the financial condition of the industry would be to review the offshore employment. A survey of Gulf of Mexico contractors, as shown in Figure IVA.6, indicates that during the two-year period of 1982 and 1983, employment dropped almost 50%. This is the total of all employment in the fabrication years, offshore platform and pipeline construction, and the support staff. Main office and engineering personnel were not included. This survey covered only the five largest contractors. Had information been available for the entire industry, the reduction would probably have been worse since many of the smaller firms had a much larger reduction in staff or did not survive. Another example of the condition of the offshore construction industry is shown in Figure IVA.7, which illustrates the utilization of the derrick barges in the Gulf of Mexico during the last few years. Even with the addition of the deepwater structures, this has been a difficult period for the construction industry.

One of the problems with deep water construction is the "start-stop" effect. Deepwater construction requires special skills and equipment which must be assembled to start the job. Unless work on other deepwater structures continues, much of the expertise is lost and must be rebuilt again. As an example, although not owned by the contractor, the special equipment built for the "Cognac" platform has never been used again. The launch barge built for the "Cerveza" and "Ligera" platforms has been used only once or twice since.

The design of deepwater structures has also caused problems for the engineering firms. Detailed analysis systems are required to perform the dynamic response and fatigue designs necessary for deepwater structures. These systems have been developed, then modified or replaced as new computers and more advanced technology has become available. It is doubtful if the use of these systems on paying jobs will be sufficient to recover the cost of development.

What are the future prospects for the industry? As listed in Figure IVA.8, there are four deepwater platforms under construction at the present time; three are scheduled for installation in 1986 and one in 1988. The total cost of these four platforms is approximately $495 million. Other deepwater structures, some of alternate concepts, are under consideration but have not been approved for construction. Unless commitments are made soon, there will be no deepwater installations in 1987.

The information above relates only to the construction industry operating in the Gulf of Mexico. Currently, deepwater construction is also underway for the West Coast of the U.S. Generally, these structures are being fabricated in the far east and will be installed by foreign contractors. The economic effect on domestic contractors will not be significant.

The future prospects for deepwater platforms will depend on the availability of leases, the discoveries made on these leases, and the demand (and price) for oil and gas. Recently, a large number of deepwater leases have been awarded. Figure IVA.9 shows total leases awarded by year as well as the number for water depths over 600 ft. It is indicated that more deepwater leases were sold in 1982 and 1983 than in all the previous years. There is reason to expect that the construction of deepwater platforms will continue if discoveries are made, and if the price of oil will justify the investment.

Deepwater construction has had a substantial effect on technology, less on economics. Large investments have been required and are still continuing. If a "Profit and Loss" statement could be developed for the deepwater construction industry, it is expected that it would show a loss. If the construction of deepwater structures continues at a steady pace, this picture could change. The potential is there. Although the work to date may not have been profitable, developing the capability of deepwater construction was necessary from a long-range and public interest standpoint.

ACKNOWLEDGEMENT

Information and assistance from the following firms is acknowledged and certainly appreciated: Arco, Avondale, Brown & Root, Chevron, Exxon, Gulf Marine, McDermott, Mobil, Raymond, Shell, Sohio, Union Oil of California, and Zapata.

Griff C. Lee is a consulting engineer in private practice, formerly Group Vice President-Engineering and Vice President of Research & Development with McDermott. He earned a BE in Civil Engineering from Tulane and an MS from Rice. He has 38 years experience in the design and construction of offshore platforms, pipelines, and production facilities. He is an honorary member of the American Society of Civil Engineers and was elected to the National Academy of Engineering in 1980.

Marine Systems for Deepwater Production

A Means to Economically Produce 20,000 Barrels of Oil Per Day in 2,000 Feet of Water

Mr. Andrew Hunter
Conoco, Inc.

COMMENTARY

In 200 ft of water almost anyone can install a platform, drill wells, process the oil and make a profit -- selling oil at $25 a barrel. In 2000 ft of water, it is still necessary to drill wells, process the oil and make a profit -- selling oil at $25 a barrel. Obviously, it is more expensive in 2000 ft of water, but that expense must be tempered with the economic realities of a site-specific development. The deepwater production of hydrocarbons is not a philanthropic activity. The risk and cost must show a reasonable rate of return on investment, or the money will be spent elsewhere. Accordingly, we must develop "space-age" technology with "down to Earth" price tags.

INTRODUCTION

Offshore leases have, in recent years, been offered in ever increasing waterdepths. Today there are many oil companies possessing tract portfolios in waterdepth ranges of 1000 ft to 6000 ft. Conoco is one of those companies, and our exploration group almost routinely drills in depths beyond 2000 ft in the Gulf of Mexico. Its goal is to discover petroleum reserves which the production group can profitably develop. We in the production group have developed several viable production schemes which permit selection on a site-specific basis, with all factors brought into consideration. In the time allotted, one can only generalize on the technological diversity available, how it is evaluated and applied to a site-specific development.

Technological solutions will jump in and out of contention usually on the bases of reservoir characteristics, waterdepth, and location.

<u>Reservoir</u> characteristics will govern the number of wells required and the directional drilling limitations. Can all the wells be drilled from one platform location?

<u>Waterdepth</u> and payloads affect system design to widely different degrees and all systems have technological and economic limits of attractiveness.

<u>Location</u> plays a major role in system selection, based on site conditions, proximity to existing facilities, and logistic support. Most deepwater leases occupy areas over the continental slope. Reservoir mapping and delineation wells may call for a revised platform location incurring a waterdepth change of hundreds of feet. Conoco has gone through this reservoir/waterdepth/location exercise for its Green Canyon Block 184 lease. For the last five years, systems have come and gone from contention, reservoirs have grown and shrank, waterdepths have changed from 1200 ft to 1800 ft. Today we have a system.

GREEN CANYON BLOCK 184

GC 184 is a classic mid-depth block, approximately 100 miles from the nearest (northerly) landfall, no pipelines within 30 miles, and the waterdepth varying from 800 ft to 2100 ft. As reservoir mapping proceeded, the platform waterdepth went from 1200 ft to 1350 ft to 1500 ft to 1600 ft to 1800 ft and finally came to rest at 1760 ft.

At 1200 ft, after an intensive study of fixed structures, guyed towers, buoyant towers, floating production (semisubmersibles), and TLP's. . .the fixed platform was selected.

> At 1350 ft. . .the fixed platform was selected
>
> At 1500 ft. . .the fixed platform was selected
>
> At 1600 ft. . .(1983). . .the fixed platform ran out of money and technical contention
>
> At 1800 ft. . .recognizing the economic limitations, Conoco reviewed its compliant structure options, looking at semisubmersibles, tankers, and tension leg platforms.

EVALUATION AND SELECTION

All three systems work at that waterdepth. The converted semisubmersible and converted tanker provided the lowest cost surface real estate, but the associated high cost subsea well systems negated these savings. The fully integrated TLP was too expensive, but a simplified, lightweight design proved economically attractive. The tension leg well platform (TLWP) was born in January 1984, the conceptual design was completed in 1984, and the preliminary design was completed in 1985. Subject to management and partner approval, the project should commence in 1986, and oil production will commence in 1988. Owing to its multi-piece component design (i.e., foundation, mooring system, surface vessel, and topside facilities), main fabrication contracts can be let in 1987, for delivery in 1988. The year 1988 will see a new waterdepth record for a permanent installation. It will also make money from a reservoir previously thought non-commercial at this waterdepth.

Andrew Hunter is Supervisor of Special Marine Projects at Conoco, Inc. He has been involved in the design and development of deepwater production

platforms for the Green Canyon Area in the Gulf of Mexico. Mr. Hunter, a registered Mechanical Engineer from the United Kingdom, also has extensive platform design experience in the North Sea.

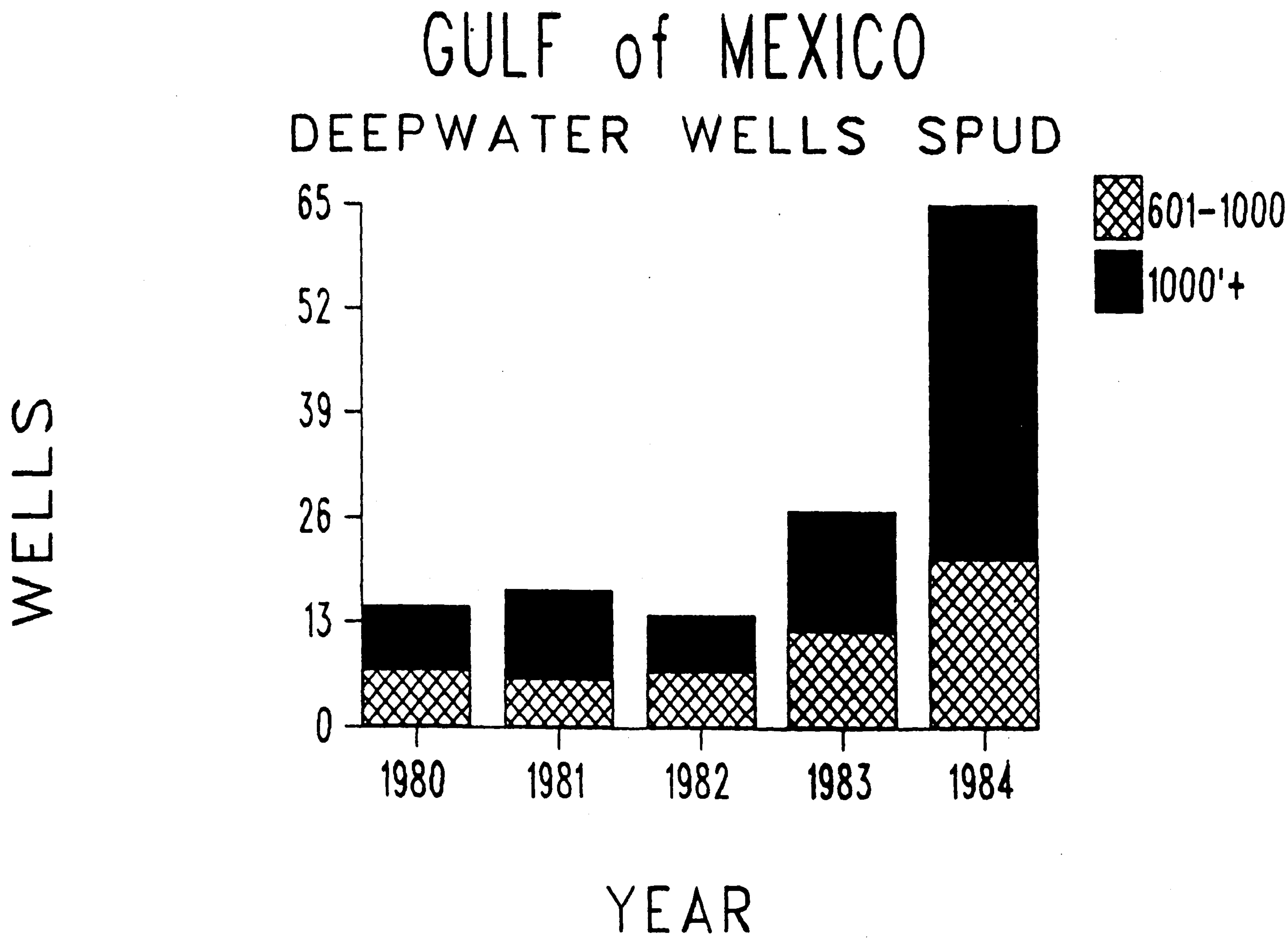


Figure IVA.1 - Gulf of Mexico - Deepwater Wells Spud

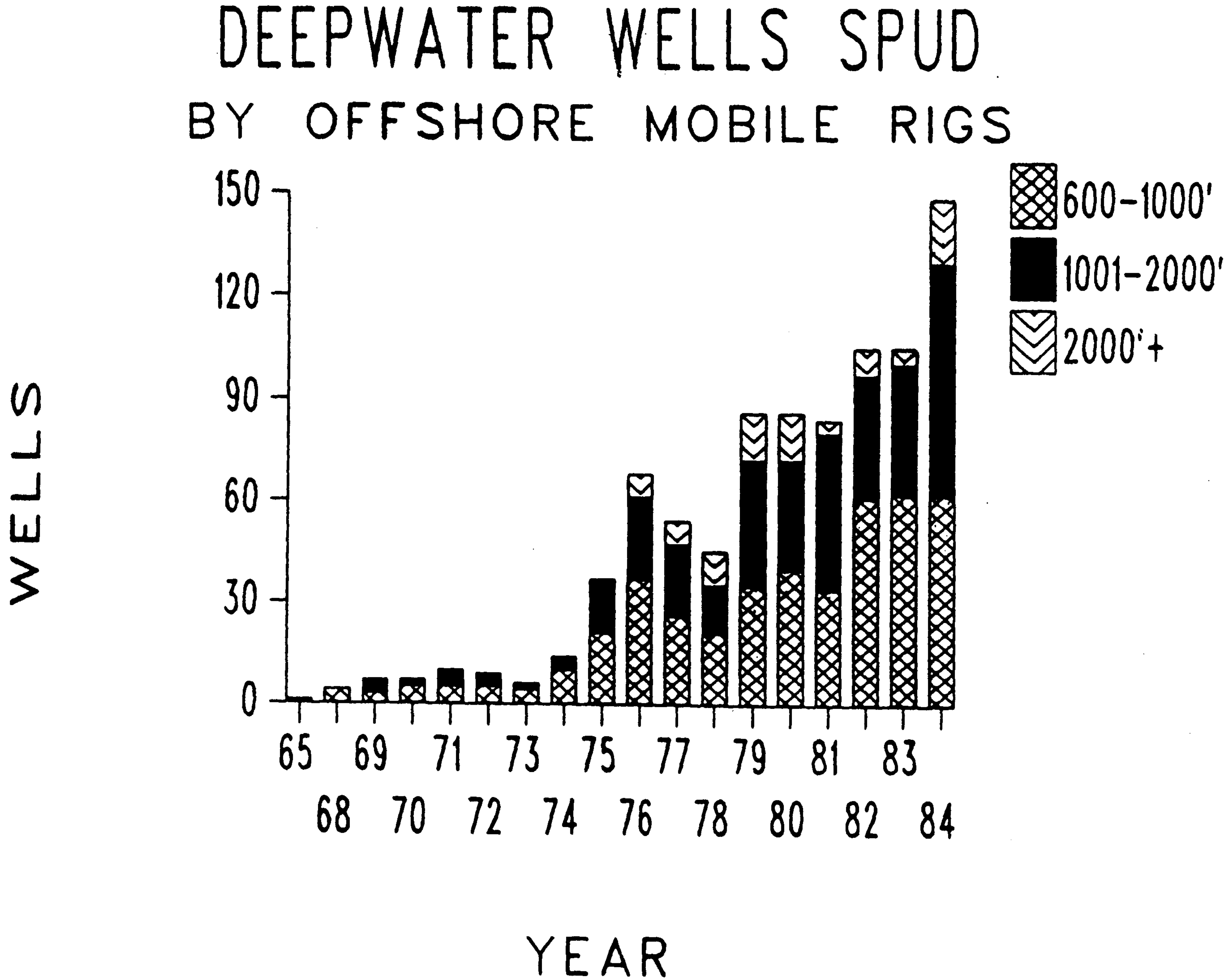


Figure IVA.2 - Deepwater Wells Spud By Offshore Mobile Rigs

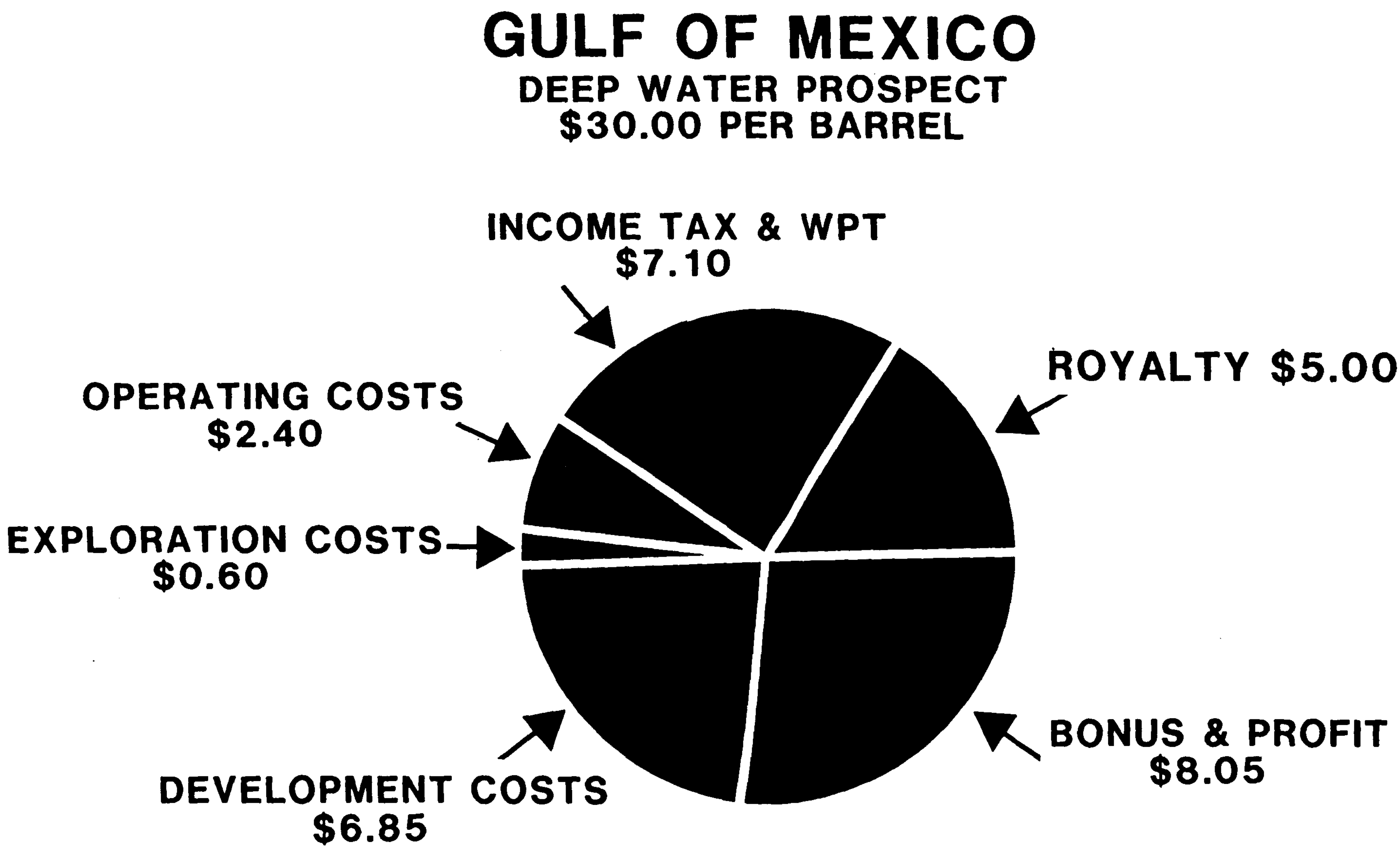


Figure IVA.3 - Gulf of Mexico Deepwater Prospect

Figure IVA.4 - Gulf Of Mexico Existing Deepwater Platforms

GULF OF MEXICO
EXISTING DEEP WATER PLATFORMS

- SHELL "COGNAC"
  MISSISSIPPI CANYON BLOCK 194
  INSTALLED 1978
  1025' WATER DEPTH

- CHEVRON
  GARDEN BANKS 236
  INSTALLED 1979
  685' WATER DEPTH

- ARCO
  MISSISSIPPI CANYON 148
  INSTALLED 1980
  651' WATER DEPTH

- UNION OIL CO. OF CALIFORNIA "CERVEZA"
  EAST BREAKS 160-A
  INSTALLED 1981
  935' WATER DEPTH

- UNION OIL CO. OF CALIFORNIA "LIGUERA"
  EAST BREAKS 160-B
  INSTALLED 1982
  925' WATER DEPTH

- EXXON "LENA"
  MISSISSIPPI CANYON 280
  INSTALLED 1983
  1000' WATER DEPTH

- ZAPATA
  EAST BREAKS 110
  INSTALLED 1984
  660' WATER DEPTH

Figure IVA.5 - Gulf of Mexico Offshore Construction

GULF OF MEXICO
OFFSHORE CONSTRUCTION

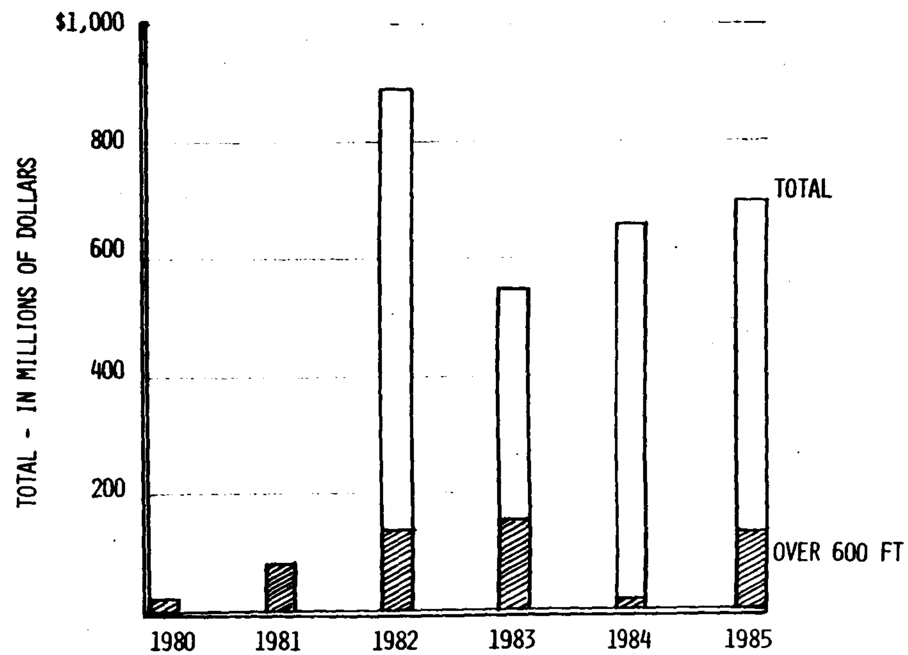


Figure IVA.6 - Gulf of Mexico Total Offshore Construction Employment - Five Major Contractors

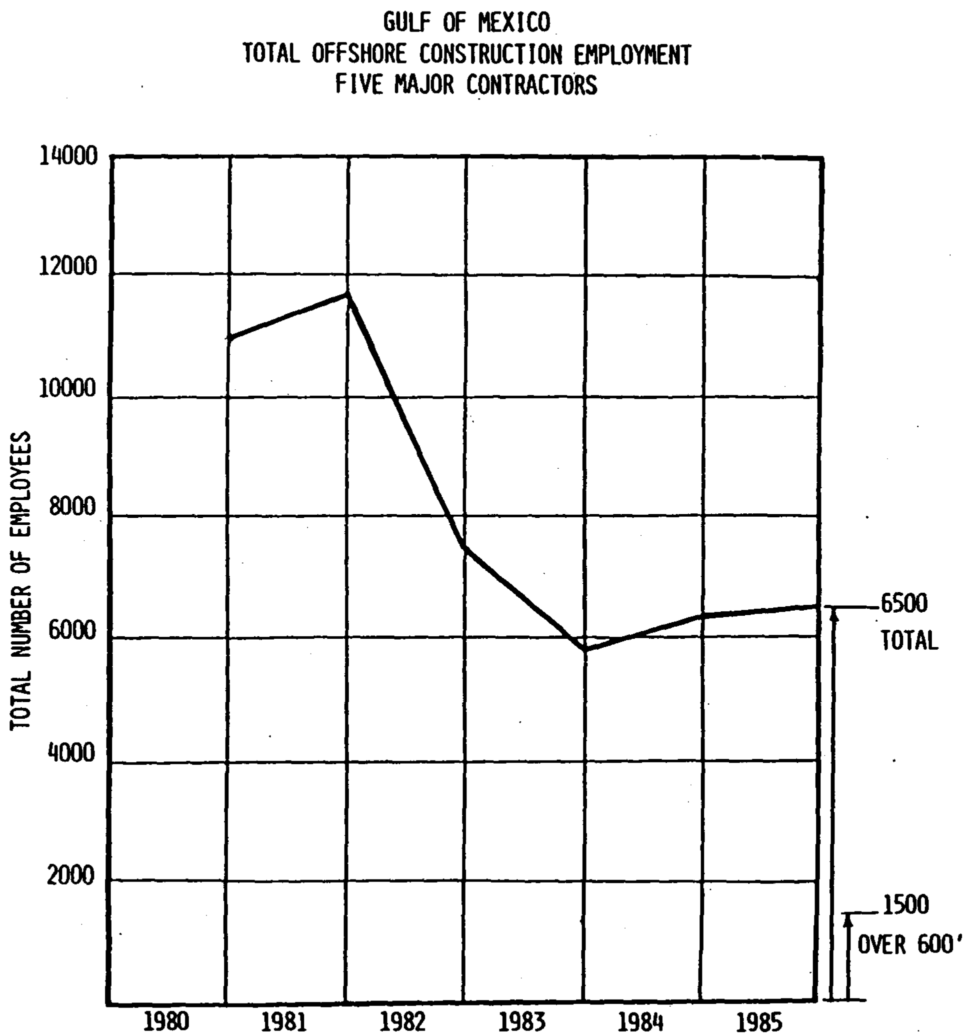


Figure IVA.7 - Gulf of Mexico Derrick Barge Utilization

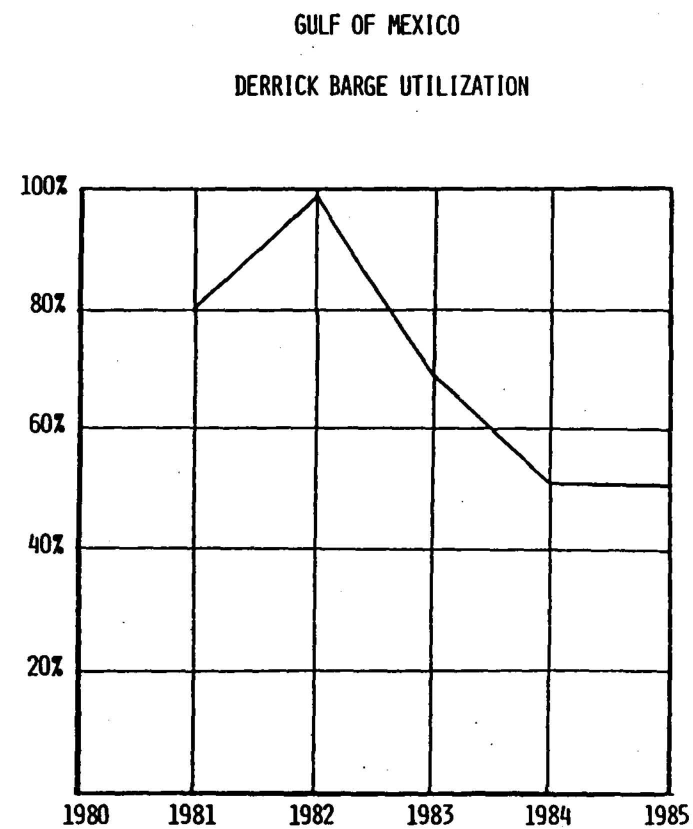


Figure IVA.8 - Gulf of Mexico Deepwater Platforms Under Construction

GULF OF MEXICO

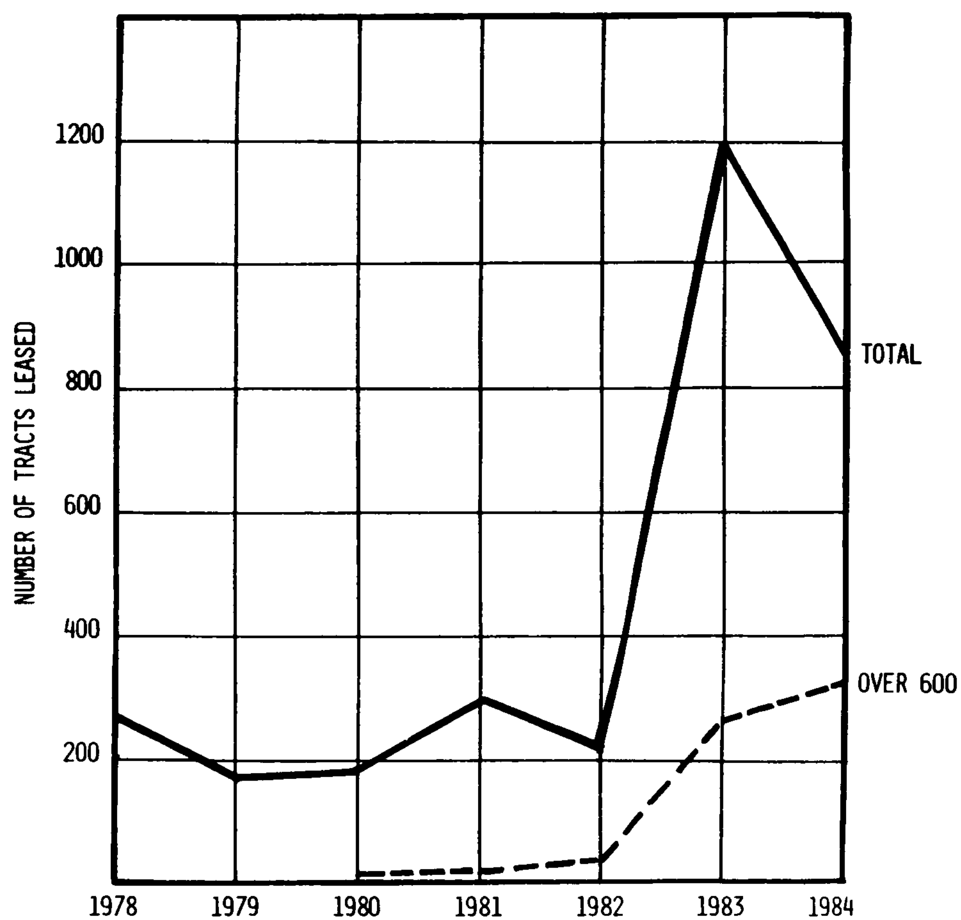
DEEP WATER PLATFORMS UNDER CONSTRUCTION

SHELL "BOXER"	-	GREEN CANYON 19 INSTALLATION SCHEDULED 1986 750' WATER DEPTH
SHELL "BULLWINKLE"	- -	GREEN CANYON 65 INSTALLATION SCHEDULED 1988 1350' WATER DEPTH
SOHIO	-	EAST BREAKS 165 INSTALLATION SCHEDULED 1986 863' WATER DEPTH
MOBIL	-	GREEN CANYON 18 INSTALLATION SCHEDULED 1986 760' WATER DEPTH

Figure IVA.9 - Gulf of Mexico OCS Lease Sales

GULF OF MEXICO

OCS LEASE SALES



GREEN CANYON ECONOMICS

Investment		Total
Exploratory Wells:	4 wells @ $6.5 MM per well	$26.0
Development Wells:	25 wells @ $3.0 MM per well	$75.0
Platform Cost:		$250.0
Completion Costs		$25.0
Production Equipment		$30.0
Lease Bonus		$20.0
Pipeline		$5.0
Other (6 + 6)		15.0
Sub Total		$446.0
Add: Abandonment Cost		50.0
Total		$496.0

	Economic Assumptions
Reserves:	100 million barrels
Initial Production:	40,000 bopd
Decline Curve:	12-15%
Average Royalty:	One Sixth
Lifting Costs:	$50,000 per well month plus $3MM annual insurance and transportation charges $1.50 per barrel.
Pricing:	Crude Prices flat for 3 yrs and escalate 4% thereafter.
Taxes:	Assume corporate tax rate of 46% and that parent company has pre-production income available to offset intangible expenses.

($ Millions)

Year	Cash Outflow	Production (mil/bbl)	Revenues	Lifting Costs	DDA	Pretax Cash Flow	Taxes	Cash Flow
1984	(35)					(35)	0	(35)
1985	(18)					(18)	(6)	(12)
1986	(63)					(63)	(17)	(46)
1987	(270)				15	(285)	(63)	(207)
1988	(60)				22	(82)	(11)	(49)
1989		15	303	40	36	227	78	185
1990		15	303	40	41	222	96	167
1991		15	303	40	40	223	103	161
1992		12	268	37	18	213	98	133
1993		11	237	34	18	185	85	118
1994		8	197	31	3	163	75	91
1995		7	164	28	3	133	61	75
1996		5	136	26	2	108	50	61
1997		4	113	24	2	87	40	49
1998		3	94	23	1	70	32	39
1999		3	79	22	1	55	25	31
2000	(50)	2	65	21	1	(7)	(3)	(3)
Totals	(496)	100	2,262	366	204	1,197	643	757

Estimated Internal Rate of Return*	
Crude Price ($bbl)	IRR
$18.00	16.7%
$20.00	19.4%
$25.00	25.3%
$30.00	30.3%
$35.00	34.8%

*Note: Internal Rate of Return Assumptions are not risk adjusted for the possibility of unsuccessful wells. Success rates in the Flex Trend average 1 out of 7 exploratory wells drilled.

Table IVA.1 - Green Canyon Economics

Table IVA.2 - Gulf of Mexico Active Leases and Blocks (As of January 1985)

GULF OF MEXICO ACTIVE LEASES AND BLOCKS
(As of January 1985)

Water Depth	Acreage	Percentage	Blocks	Percentage
0-50'	2,031,187	14.3%	425	15.6%
51-100'	2,673,896	18.9%	516	19.0%
101-150'	1,562,526	11.0%	292	10.7%
151-200'	1,243,586	8.8%	240	8.8%
201-250'	1,036,513	7.3%	196	7.2%
251-300'	513,314	3.6%	102	3.7%
301-350'	293,465	2.0%	57	2.1%
351-400'	266,348	1.8%	55	2.0%
401-600'	913,189	6.4%	201	7.4%
601-1000'	802,051	5.6%	143	5.2%
1001-2999'	2,312,882	16.3%	405	14.9%
3000'+	462,862	3.2%	82	3.0%
TOTAL	14,111,819	100.0%	2,714	100.0%

Winning Acreage Bids Under $200/Acre In Recent Lease Sales By Water Depth

Water Depth	May 1983	Aug. 1983	Jan. 1984	Apr. 1984	July 1984	May 1985	Aug. 1985
0-100'	37 (30)	25 (28)	25 (33)	24 (21)	24 (21)	20 (19)	17 (20)
101-200'	26 (21)	18 (20)	17 (19)	18 (16)	29 (26)	18 (17)	17 (20)
201-300'	10 (8)	6 (7)	8 (10)	11 (10)	5 (4)	3 (3)	4 (4)
301-600'	11 (9)	5 (6)	2 (3)	14 (12)	9 (8)	7 (7)	4 (4)
601-1000'	5 (4)	8 (9)	6 (8)	2 (2)	8 (7)	5 (5)	3 (3)
1001-1500'	6 (5)	3 (3)	9 (12)	13 (12)	6 (5)	1 (1)	5 (6)
1501'+	28 (23)	24 (27)	9 (12)	30 (27)	32 (28)	49 (48)	36 (42)
	123 (100)	89 (100)	76 (100)	112 (100)	113 (100)	103 (100)	86 (100)

( ) Percent

Table IVA.3 - Winning Acreage Bids Under $200/Acre In Recent Lease Sales By Water Depth

Recent Acreage Leased at $500/Acre or Above Bid By Water Depth

Water Depth	May 1983	Aug. 1983	Jan. 1984	Apr. 1984	Aug. 1984	May 1985	Aug. 1985
0-100'	116 (38)	65 (39)	1 (6)	45 (31)	25 (26)	53 (43)	8 (27)
101-200'	62 (20)	43 (26)	4 (22)	13 (9)	15 (15)	24 (20)	7 (23)
201-300'	33 (11)	16 (10)	10 (56)	9 (6)	9 (9)	13 (11)	4 (13)
301-600'	58 (19)	21 (12)	-	32 (22)	15 (15)	16 (13)	2 (7)
601-1000'	14 (4)	11 (7)	3 (17)	7 (5)	14 (14)	4 (3)	6 (20)
1001-1500'	13 (4)	5 (3)	-	16 (11)	6 (6)	2 (2)	-
1500'+	10 (3)	7 (4)	-	24 (16)	13 (13)	10 (8)	3 (10)
	306 (100)	168 (100)	18 (100)	146 (100)	97 (100)	122 (100)	30 (100)

( ) Percent

Table IVA.4 - Recent Acreage Leased at $500/Acre or Above Bid By Water Depth

MMS SOUTHWEST FLORIDA SHELF ECOSYSTEMS STUDIES

Session: MMS SOUTHWEST FLORIDA SHELF ECOSYSTEMS STUDIES

Chairman: Dr. Robert M. Avent

Date: October 23, 1985

Presentation Title	Speaker/Affiliation
Southwest Florida Shelf Ecosystems: Session Summary	Dr. Robert M. Avent Minerals Management Service
Southwest Florida Shelf Studies -- Years 1,2, and 3	Dr. Neal W. Phillips Continental Shelf Associates, Inc.
Models of Plankton Dynamics on the Outer Southeastern U.S. Continental Shelf	Dr. Eileen E. Hofmann Department of Oceanography Texas A&M University
Southwest Florida Benthic Communities Study, Years 4 and 5: Major Biological Findings	Dr. George S. Lewbel LGL Ecological Research Associates, Inc.
Southwest Florida Shelf Benthic Communities Study	Dr. Larry Danek and Mr. Michael S. Tomlinson Environmental Science and Engineering, Inc.

Southwest Florida Shelf Ecosystems Studies: Session Summary

Dr. Robert M. Avent
Minerals Management System

Our session convened to discuss the five-year Southwest Florida Shelf Ecosystems Studies Series. The presentations reviewed several elements: The first described the first three years of descriptive work, during which a series of twelve observational and geophysical transects were traversed and various sampling stations were established. This was the descriptive phase of the study, delineating soft and live bottom communities and habitats. It was followed by an excellent presention on physical and biological interactions off the East Coast of the United States. Presentations on the final (fourth and fifth) years followed. Here we digressed from the descriptive phase of the study and went into a study of the processes that affect certain selected "live bottom" communities.

The first speaker, Dr. Neal Phillips, of Continental Shelf Associates, Inc., recounted the results of years one through three. The area of study for all years is the region between Charlotte Harbor and the Florida Keys, and from a depth of less than 20 m out to 200 m. It encompasses a large number of communities within a fairly small latitudinal interval. The five original transects were all east-to-west transects. Several long shore segments were added during years two and three and additional transects were established in about 50 m of water and seaward near the Continental Shelf edge where, erroneously, we expected to find some exposed reef trends.

On those transects, the primary methodologies included a combination of sub-bottom profiling, side-scan sonar, video tape coverage, and still photography.

Thirty stations were established the first year, and the same number of stations (but in different areas) for the second year were covered. Additional stations less than 20 m deep were studied during the third year as requested by the State of Florida. These were in Florida Bay and in some of the live bottom and grassbed areas south of 26^{o}N. They found about ten, more or less, recognizable community types and about six or eight habitat types in the region. These were mapped out in a habitat atlas and described in two final reports. The term "live bottom" is poorly described in legal terms for use in management purposes. There was considerable discussion at session's end on exactly how "live bottom" should be defined.

The second paper was given by Dr. Eileen Hofmann of Texas A&M University. She discussed her work on modeling of physical and biological interactions off the East Coast. Someone might ask why a topic about the East Coast was presented in a session oriented to southwest Florida. Dr. Larry Atkinson, who had done the work in our area, was unable to participate, and he suggested that we ask Dr. Hofmann to present her approach. Off southwest Florida the Loop Current interacts with shelf waters. Off the East Coast there is a similar interaction with the Florida Current and the Gulf Stream. So, her approach would be useful off the southwest Florida shelf, assuming that enough data could be obtained to drive the model.

She employed a series of three models. The first was a fairly simple Lagrangian particle tracking model to compute particle residence times. The second model is a biological model dependent on ten coupled differential equations describing relationships among nutrients, phytoplankton, and zooplankton. This model incorporates functions such as selective feeding, growth, nutrient uptake and assimilation rates, molting, growth, and the like. She has had the luxury of having excellent data sources from a number of investigators, including Larry Atkinson and Jim Yoder and others to afford comparisons to real life situations. The third model was a coupled physical-biological model. Dr. Hoffman demonstrated examples of interactions.

Following the break, Drs. Danek and Lewbel (Environmental Science and Engineering, Inc., and LGL Ecological Research Associates, Inc.) joined together to discuss years four and five.

MMS felt that the past three years of descriptive work was adequate, and that continuing this effort would yield diminishing returns. We therefore changed direction and focused on physical processes and their influences on selected community types.

Five different types of live bottom were selected, each representing what we believed to be a type that might be impacted by oil and gas operations. These varied in water depth from 13 m out to over 100 m. During Year 4, five *in situ* arrays were implanted. In Year 5, an additional three were established in selected new areas. These arrays were serviced quarterly. They variously contained instrumentation including current meters, time-lapse cameras, thermographs, and wave gauges. Fouling plates and sediment traps were added. These were also supported by NOAA data buoy information, as well as quarterly spot checks on hydrography. At each station ESE and LGL made quarterly trawl and dredge collections and took other accessory measurements.

Among the findings was that currents are predominantly tidal in nature. In some cases currents are high enough to resuspend quite a bit of sediment. The time-lapse camera did not indicate any current ripple marks. The resuspension of sediments (as recorded in sediment traps) was highest at the shallowest station, number 52. There they calculated that as much as 700 metric tons per square kilometer per day were being resuspended and dropped back down on the biological communities. At deeper stations, resuspension was calculated to be one or two orders of magnitude less -- but probably still significant. Resuspension is believed to occur largely during storms.

The fouling plates showed very little fouling except at the shallower stations.

A lively discussion at the end of the day centered on the detection of, significance of, and management and protection of "live bottom" communities.

Robert Avent received the MS and PhD degrees in Biological Oceanography from Florida State University in 1970 and 1973. His main fields of interest include marine physiological ecology and deep-sea biology. He has pursued investigations on the biological effects of hydrostatic pressure, animal zonation, and reef morphology. He has worked in the consulting industry and for state government. He came to BLM/MMS in 1981 from the National Marine Fisheries Service.

Southwest Florida Shelf Studies -- Years 1,2, and 3

Dr. Neal W. Phillips
Continental Shelf Associates, Inc.

In 1980, the Minerals Management Service (MMS) initiated a multiyear investigation of benthic habitats and biota of the southwest Florida continental shelf as part of the Environmental Studies Program. The first two years of field sampling (Southwest Florida Shelf Ecosystems Study) were completed in 1982. A third year of field sampling (Southwest Florida Shelf Regional Biological Communities Survey) was completed in 1983. Reports and visuals from Years 1 and 2 and visuals from Year 3 have been submitted to the MMS in final form. Completion of the Year 3 final report is expected shortly.

Major study elements during all three years were (1) habitat mapping; (2) benthic station sampling; and (3) hydrographic sampling. Methods and significant findings are summarized below.

HABITAT MAPPING

Twelve transects were surveyed to produce shelfwide habitat maps. Total linear coverage was approximately 1700 km. During Year 1, five east-west transects (A-E) were surveyed between the 20 m and 200 m isobaths (Figure IVB.1). During Year 2, a north-south transect (F) was added. During Year 3, three east-west transects were extended inshore of the 20-m isobath and six new north-south transects (G-L) were surveyed (Figure IVB.1).

Mapping was accomplished using a combination of geophysical (sidescan sonar, subbottom profiler, precision fathometer) and remote photographic (black-and-white television, 35-mm color still camera) instrumentation. Substrates and geological features were delineated through interpretation of videotapes, photographs, and geophysical records. Benthic habitats were categorized on the basis of visually conspicuous epibiota seen in the videotapes and photographs. Results were compiled into two Marine Habitat Atlases -- one summarizing Year 1 and 2 data and the other summarizing Year 3 data.

A major focus of habitat mapping efforts was the delineation of "live bottom." Live bottom areas are benthic habitats where sessile epibiota are attached to hard substratum consisting of rock outcrops, rock covered by a thin sand veneer, or a surface rubble layer of algal nodules or shell rubble.

The overall incidence of live bottom along the survey transects was about 33%. Nearshore areas (10-20 m water depth) were typified by a high incidence of live bottom consisting of dense gorgonian growth interspersed with areas of seagrass/algal cover. Live bottom incidence was lower farther offshore (25-70 m water depth), presumably reflecting a thickening of the sand veneer overlying hard bottom. The lush gorgonian growth was replaced by a large variety of sponges and algae. A narrow middle shelf (60 to 90 m water depth) zone was characterized by widespread live bottom consisting of a coralline algal nodule substratum and associated biota, including small sponges and a variety of perennial algae. A unique area of coralline algal pavement and plate corals (*Agaricia* spp.) was seen on Transect E in this depth range. Several different types of live bottom were seen on the outer shelf, including "prominence" areas colonized by sponges, hydroids, antipatharians, ahermatypic stony corals, and fishes; areas of low-relief hard bottom protruding through a thin sand veneer; and areas of shell rubble colonized by crinoids.

Although these general patterns emerged from the mapping surveys, live bottom incidence and composition varied widely with location. The results should not be used to infer the presence or exact type of live bottom at a particular new location.

BENTHIC STATION SAMPLING

A total of 25 live bottom and 29 soft bottom stations were sampled to further characterize shelf benthic biota. Representative station locations were selected following the habitat mapping surveys (Figure IVB.1). During

Year 1, 15 live bottom and 15 soft bottom stations in water depths of 20 to 100 m were sampled during fall and spring. During Year 2, 5 live bottom and 4 soft bottom stations were replaced by new stations in water depths of 100 to 200 m. These new stations and the remaining Year 1 stations were sampled during summer and winter. During Year 3, 5 new live bottom stations and 10 new soft bottom stations -- all in water depths of 10 to 20 m -- were sampled during fall and spring.

Live Bottom Stations:

At each live bottom station, three dredge samples and one trawl sample were collected, and a television/still camera survey was conducted during each sampling cruise. Divers collected additional samples at the Year 3 stations. They established and photographed 35 0.5 m^2 quadrats, measured sediment thickness, and harvested quadrat epibiota for biomass determinations.

Live bottom station sampling resulted in the collection and identification of 1320 species from dredges and 699 species from trawls. Crustaceans and molluscs were the most speciose groups in the dredge collections, whereas fishes and crustaceans accounted for most of the species collected by trawl. Species richness within most groups was highest at mid-shelf stations. Cluster analyses conducted by gear type for all taxa and selected groups revealed primarily depth-related zonation patterns. The influences of various environmental variables that are correlated with water depth could not be separated.

One demonstrably influential environmental variable is sediment thickness. Year 3 quadrat sampling showed that the thicker the sand veneer overlying hard bottom, the lower the biomass and percent cover of sessile epibiota (with the exception of macroalgae and seagrasses).

Soft Bottom Stations:

Infaunal and sediment samples were collected at each soft bottom station. Year 1 and 2 infaunal samples were collected remotely using a 0.057 m^2 box corer, whereas Year 3 samples were collected by divers using a 0.016 m^2 hand corer. Sediment samples were collected and analyzed for grain size, carbonate, and hydrocarbons during all three years. Trace metals were also analyzed in Year 1 sediment samples. During Years 1 and 2, an otter trawl sample was collected and a television/still camera survey performed at each soft bottom station. During Year 3, some additional infaunal samples were collected along a transect from live bottom to soft bottom within a live bottom station.

Mean infaunal abundances at soft bottom stations ranged from about 3000 to 12,000 individuals m^{-2}, with little apparent shelfwide pattern. Infaunal species richness and diversity were highest at the live bottom station sampled during Year 3 and at middle shelf stations sampled during Years 1 and 2. Cluster analyses revealed zonation patterns relatable to water depth and sediment composition variables.

Trace metal and hydrocarbon analyses of soft bottom station sediments indicate background concentrations typical of a pristine environment. Elevations resulting from offshore oil drilling will be apparent and easily detectable should they occur.

HYDROGRAPHIC SAMPLING

Hydrographic profiling was conducted at each Year 1 and 2 station (some stations were not sampled on all cruises) and each Year 3 live bottom station. Temperature, salinity, dissolved oxygen, and transmissivity were profiled with water depth. Year 1 and 2 profiling also included measurements of light penetration and concentrations of nutrients (nitrate, phosphate, and silicate) and chlorophyll. Some additional surface salinity and temperature measurements were made during Year 3 habitat mapping surveys. Results were used primarily to characterize the shelf hydrographic environment.

Additional hydrographic sampling was conducted during the "Year 2 modification" contract. The purpose of this adjunct study was to investigate hydrographic consequences of Loop Current intrusions. Hydrographic, nutrient, and primary productivity sampling across an intruding Loop Current filament demonstrated upwelling of cold, nutrient rich water in the core of cold water between the filament and the main Loop Current flow. The resulting enhanced subsurface primary productivity associated with Loop Current intrusions could provide pulses of particulate organic matter to the benthos from an otherwise oligotrophic water column.

Dr. Phillips is a marine ecologist with Continental Shelf Associates, Inc. He received a BA in Biological Sciences and an MS in Marine Studies from the University of Delaware and a PhD in Ecology from the University of Georgia. His research has focused on the importance of detritus in marine benthic food webs. Since joining Continental Shelf Associates in 1983, Dr. Phillips has been involved in interpretation of benthic biological data from Years 2 and 3 of Southwest Florida Shelf studies.

Models of Plankton Dynamics on the Outer Southeastern U.S. Continental Shelf

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The Gulf Stream, through various mechanisms, provides almost continuous upwelling of nutrient-rich water along the outer shelf break region of the South Atlantic Bight, that portion of the continental margin between Cape Hatteras, NC, and Cape Canaveral, FL. Three numerical models were constructed to investigate the effect of one of these upwelling mechanisms -- Gulf Stream frontal eddies -- on biological production. The first, a Lagrangian particle tracking model, was used to investigate the residence time of particles on the outer southeastern shelf. Model results indicate that the location of the Gulf Stream relative to the shelf break, the presence of frontal eddies, and the changing physical environment of the shelf waters greatly affect particle residence times. The second model consists of a system of ten coupled ordinary differential equations that describe interactions among nitrate, ammonia, two phytoplankton size groups (greater than and less than ten microns), microzooplankton, and five zooplankton size categories. Simulations performed with this model indicate that biological processes, such as selective feeding by zooplankton on the phytoplankton, can significantly alter the structure of the lower trophic levels. In the third model, the ten-component biological model was coupled to a physical model that uses circulation and temperature regimes derived from an optimal interpolation of current meter data obtained on the outer southeastern shelf. The optimally-derived temperature and flow fields provide "real time" spatial and temporal variability for the biological components. The simulated phytoplankton fields suggest that the maximum primary production occurs at the boundaries of the upwelling features. Additionally, the upwelling-downwelling cycle can produce significant onshelf and offshelf fluxes of nitrate and carbon. Zooplankton production and abundance is limited by the short time scale associated with the upwelling.

Dr. Eileen E. Hofmann is an assistant research scientist in the Department of Oceanography at Texas A&M University. Her research interests are in the area of modelling physical-biological interactions in marine ecosystems. The goal of this research is to provide a framework for understanding processes in the marine environment.

Dr. Hofmann received her BS in biology from Chestnut Hill College in Philadelphia, PA. She received her MS and PhD in Marine Science and Engineering from North Carolina State University.

Southwest Florida Benthic Communities Study, Years 4 and 5: Major Biological Findings

Dr. George S. Lewbel
LGL Ecological Research Associates, Inc.

INTRODUCTORY NOTE

A station location map and a discussion by Dr. Larry J. Danek of the results of hydrographic and sedimentary investigations conducted during this program is provided separately in the following abstract.

PROGRAM STATUS

The Southwest Florida Benthic Communities Study is just beginning its sixth year. Research during Years 1-3 was conducted by Woodward Clyde Consultants and Continental Shelf Associates, Inc. The prime contractor for Years 4-6 is Environmental Science and Engineering, Inc. (ESE). Major biological portions of the program are subcontracted by ESE to LGL Ecological Research Associates, Inc. (LGL). Year 4 included four sampling cruises (Nos. I-IV). The annual report for the fourth year of the southwest Florida benthic communities study was submitted to MMS in July 1985 by ESE and LGL.

All five sampling cruises (V-IX) scheduled for Year 5, have been completed. Sample analysis and data entry are 90% complete through Cruise VIII. Some of LGL's major findings from Year 4 and 5 are presented below, following a review of biological sampling design. Year 6 will consist of a synthesis and summary of findings from Years 1-5.

BIOLOGICAL SAMPLING DESIGN

During Year 4, 15 stations were sampled off the southwest Florida coast. These included 10 sites designated as Group I stations, which were sampled only twice in order to complete seasonal studies begun in previous years. Group I stations included five live bottom and five soft bottom sites, in a line roughly parallel to shore within the 20-m depth contour. Five additional live bottom sites representative of selected community types were designated Group II stations, and sampled quarterly in Year 4. Group II stations were placed along a transect perpendicular to shore, and ranged from 13-125 m in depth.

Year 4 biological sampling at Group I soft bottom stations included infaunal studies under ESE's direction.

LGL's sampling at all live bottom stations (Group I and II) included trawling for fishes; dredging for epifaunal invertebrates; and underwater television (UTV) surveys for fishes, invertebrates, and habitat characterization. In addition, Group II stations were sampled for settling organisms through the use of fouling plates attached to instrument arrays. At two Group II stations during Year 4, a time-lapse camera (TLC) documented the movements of sediment and large organisms.

During Year 5, Group I stations were deleted from the program, except for one station "upgraded" to Group II status. Group II stations from Year 4 continued to be sampled during Year 5, along with two new Group II stations. Dredging was discontinued at the old Group II stations, because samples from Years 1-4 were considered adequate for taxonomic purposes. We have continued trawling and UTV work at all stations, and have arrays with fouling plates and TLC hardware at nearly all stations.

MAJOR BIOLOGICAL FINDINGS

The use of several types of gear to sample the same kinds of organisms resulted in a broader understanding of the communities surveyed, as well as of the advantages and limitations of each type of gear. UTV and trawls both provided fish samples; and UTV and dredges both surveyed benthic invertebrates and plants.

UTV surveys were extremely useful in describing benthic communities, mainly because a very large area (at least 15,000 m^2) could be surveyed at every site. Taxonomic resolution of UTV data depended on the type of organisms seen. Invertebrates and plants often could not be identified beyond the family level. However, large-area estimates of the abundance of such multi-species groupings using UTV are undoubtedly more reliable than those obtained through any other means.

In general, stations were similar to descriptions provided by other contractors during the first years of the program. Although Group II stations spanned a wide depth range and differed greatly from one another in flora and fauna, Group I stations were in shallow water along roughly the same depth contours and tended to be quite alike. Based on previous reports, half the Group I stations were expected to be live bottom and the remainder to be soft bottom; however, the distinction between the two types was vague. Most of the stations had wide areas of carbonate sand interrupted with many low-relief outcrops of coral or rock, and masses of sponges that often projected through sediment. Many of these sponges were very large (reaching 1 m in height), indicating (1) despite the presence of soft sediment, the hard substrate beneath was not deeply buried; and (2) the hard substrate must sometimes be exposed for a time in order for settlement of sponge larvae to take place.

These observations call into question the current concept of "live bottom," a poorly defined term which invites misinterpretation by laymen. In the study area, hard substrate is sometimes exposed, sometimes covered by sand. Whether or not organisms that settle on hard substrate can survive subsequent inundation by sand depends upon the length and timing of exposure, as well as their own resistance to sand scour, growth characteristics, and partial or complete burial. Furthermore, much of the soft substrate has large sponges, gorgonians, and other invertebrate colonies projecting through it. These organisms have grown to sufficient size to resist burial and offer points of attraction to other fauna such as fish. Fish were often seen concentrated in gorgonian beds or associated with large sponges on "soft" bottom. In addition, areas of soft bottom alternate with live bottom in a patchwork fashion in many locations, and sampling variability could account for major differences between transects a few meters apart. These findings militate strongly against categorizing extensive areas of the bottom as either "live" or "soft" bottom, even if one accepts the jargon; the dichotomy is frankly inadequate to describe the biological situation and perpetuates misunderstanding.

There was no obvious seasonality -- i.e., temporal variability -- in densities of benthic organisms between cruises at most stations, except for large algae which were abundant briefly at several of the shallow stations. Since most of the organisms visible on UTV were large and presumably long-lived (e.g. corals, barrel sponges), one would not expect *a priori* differences in their densities between seasons. Intensive synoptic surveying for these organisms is therefore probably more cost-efficient than seasonal surveying, effort being equal.

Fishes were relatively easy to identify to species in UTV samples. At most sites, more fishes were identified in UTV samples than with trawling. Some species (e.g. porkfish, *Anisotremus virginicus*; half the damselfishes; and half the serranids [groupers and basses]) were sampled only with UTV. Many families of fishes were rather widespread among stations, especially predators such as serranids and synodontids (lizard fishes). For example, there were at least two species of serranids at every station during Year 4, and *Epinephelus morio*, the red grouper, was present at eight out of ten stations. Some families such as lutjanids (snappers) and haemulids (grunts) were restricted to the inner shelf, whereas other families such as priacanthids (bigeyes), emmelichthyids (bonnetmouths), and holocentrids (squirrelfishes) were observed only in deep water.

Trawl samples were most useful for facilitating the identification of fishes seen on UTV, for expanding the taxonomic checklist for each station, and for analysis of stomach contents and life history parameters. However, trawls were routinely shredded at live bottom stations and missed many species seen with UTV. Trawl data were extremely variable between cruises and stations. There was little overlap in species composition among stations. The most common species overall were the blackear bass, *Serranus atrobranchus*; the tattler grouper, *Serranus phoebe*; and the offshore lizardfish, *Synodus poeyi*. In general, fish abundance was rather low, with most species averaging fewer than one individual per 10-minute trawl at each station.

Although the dredge collected many epifaunal invertebrates, the samples were not quantitative despite attempts to standardize the time spent on the bottom. The dredge frequently clogged with large sponges or filled to overflowing. Since it was impossible to know when the dredge stopped sampling during the tow, sample abundance estimates could not be compared to one another. Consequently, dredged samples were analyzed using procedures designed for presence/absence data. We are working with several different algorithms for cluster analyses based on presence/absence data, evaluating each for applicability to our data. Dredged samples of epifaunal invertebrates showed distinct zonation of species by depth for most groups of organisms. Community characterizations using constancy and fidelity analyses indicated major differences among stations for most large taxonomic groups. In general, motile taxa such as crabs, starfish, and echinoids were fairly similar in species composition between shallow stations (< 20 m), but showed rapid changes with increasing depth. Habitat-forming groups such as hermatypic corals had a similar shallow-water distribution, and changing in species composition with depth. For example, shallow live-bottom stations had *Siderastrea*, *Montastrea*, and other hermatypic corals; at deeper stations, agariciid corals that prefer lower light levels became dominant, giving way to ahermatypic corals at the deepest stations.

Time lapse camera (TLC) samples provided long-term data for fishes that were attracted to arrays. The TLC records revealed relative species abundance, arrival times, and residence times, as well as diurnal activity patterns. Although it was impossible to separate multiple records of the same individuals from single sightings, the data can be analyzed statistically through the use of repeated measures procedures. Most species showed surprisingly rapid arrival times, often within hours of installation of arrays. There were pronounced differences in fish abundance from one day to the next. Many species such as jewfish (*Epinephelus itajara*) were near the arrays during the day and left (perhaps to forage) at night. In some cases, mutual exclusion seemed to occur; for example, when jewfish were present, smaller groupers (*Mycteroperca* spp.) tended to be absent. Large fishes and turtles took up semi-permanent residence under arrays, causing data loss by damaging equipment such as TLC electrical cables and fouling plates.

Ceramic fouling plates on arrays proved effective collectors of settling species for many taxa. The longer the period of exposure, the greater biomass of material present on the plates. Large amounts of fouling material grew on plates at shallow stations, although plates from deeper stations (> 50 m) were almost bare. Fouling was greatest in the spring. The main organisms settling on plates were serpulid polychaetes, hydroids, and barnacles (especially *Balanus trigonus* and *B. venustus*).

Steel plates were extremely difficult to analyze due to the formation of bubbles of rust and subsequent flaking of attached organisms. We recommend against their use in future studies. Bags were used to enclose plates individually upon collection. Samples from these bags contained large numbers of motile invertebrates such as amphipods, underscoring the necessity for bagging plates upon retrieval.

Dr. George S. Lewbel received his BA degree in Zoology in 1967 from the University of California, Berkeley. He was awarded the MS in Marine Biology in 1969 and PhD in Biological Oceanography in 1976, both from Scripps Institution of Oceanography. Upon receiving his doctorate, he worked with Science Applications, Inc., for two years on programs on the west coast. Subsequently he taught at Bates College in Maine. His present position is Senior Scientist at LGL Ecological Research Associates, Inc., Bryan, TX. His primary research interest lies in the field of marine benthic community dynamics.

Southwest Florida Shelf Benthic Communities Study

Dr. Larry Danek
and
Mr. Michael S. Tomlinson
Environmental Science and Engineering, Inc.

Objectives of the Southwest Florida Shelf Benthic Communities Study for Years 4 and 5 were to investigate:

1. Community structures for live and soft bottoms;
2. Hydrographic structure of the water column;
3. Sedimentary characteristics and sediment transport;
4. Relationships between biology and hydrography sedimentation, and geography;
5. Dynamics of live bottom communities;

6. The integration of available literature with collected data;

7. Methods to quality assurance and quality control program; and

8. Future work needs.

The field studies included seasonal cruises, with sampling conducted at two sets of stations (Figure IVB.2). One set of stations (Group I stations: < 20-m water depth) was sampled during fall 1983 and spring 1984, and consisted of the five hard bottom and five of the 10 soft bottom stations that were sampled during the winter 1982-1983 and summer 1983 (Year 3 study). This sampling essentially completed the seasonal baseline descriptive study of the inshore area.

Ten replicate infauna samples were collected at each of the soft bottom stations during both cruises. In addition, sediment samples and hydrographic measurements were made at each station to define the soft bottom habitat. At the five hard bottom stations, dredging, trawling, underwater television, benthic still photography, sediment sampling, and hydrographic measurements were completed during both cruises.

Five other live bottom stations, each representing a separate epifaunal community type, were sampled during each of four seasons -- fall 1983, winter 1983-1984, spring 1984, and summer 1984. These stations are referred to as Group II stations and were at water depths ranging from 13 to 125 m.

The Group II stations were sampled quarterly during Year 4 and are also scheduled to be sampled quarterly during Year 5. Sampling at these stations consisted of dredging, trawling, underwater television, benthic still photography, sediments, and hydrography. In addition, *in situ* instrument arrays were installed at these five stations. Each array contained a current meter that measured current speed and direction, temperature, and conductivity; three sets of sediment traps at elevations of 0.5 m, 1.0 m, and 1.5 m above the bottom; and 10 sets of substrate plates that were scheduled to be retrieved at three-month intervals over the two-year study. Also, the arrays at the two shallowest stations each contained a wave and tide gauge and time-lapse camera to document sediment transport and biological recruitment. These arrays were serviced quarterly and continued to be maintained during Year 5. In addition, three additional arrays were installed for the Year 5 studies.

Instrumented arrays were used to collect the majority of the physical oceanographic and sediment data. An examination of current speed and direction data obtained from the array current meters indicated that the currents were tidally influenced at all stations. The magnitude of tidal influence did, however, decrease with distance offshore and depth. The currents varied from dominant east-west tidal currents in 13 m of water to more elliptical trajectories further offshore. These trajectories were frequently dominated by lower frequency currents. The energy spectra estimates of the data corroborate the observations made from speed and direction data. These spectra not only indicated that much of the energy associated with the currents occurred at the diurnal and semi-diurnal frequencies, but that much of this energy was concentrated in the east-west component, particularly closer to shore. The energy spectra also suggested that energy at the lower frequencies became more important further offshore.

Resultant velocities were computed for four of the stations. Resultant velocities for the stations closest inshore (depth, 13 m) and farthest offshore (depth, 125 m) were nearly constant for the three seasons examined (winter, spring, and summer). At the inshore station, resultant current velocities were less than 2 cm per second (cm/s) to the southeast; those offshore were below 4 cm/s to the south. Those stations between the nearshore and offshore stations were seasonally variable both in terms of speed and direction, but the currents always had an offshore component rather than easterly component.

The current meters deployed at the Group II stations also measured continuous temperature and salinity. Although salinity generally varied only slightly, temperature variations were more pronounced. Long-term temperature variations were associated with the seasons; however, short-term phenomena were also observed. Concurrent water velocity records revealed higher speeds and unidirectional currents (usually to the north) associated with short-term elevations in temperatures between 3 and 5° C. These phenomena were believed to be the result of Loop Current intrusions or eddies. Frequently, the temperature current phenomena would occur at only one or two stations; rarely, if ever, would these phenomena be observed across the entire shelf.

Of particular importance with respect to sediment transport is the amount of time near-bottom currents exceeded the threshold speed needed to resuspend and transport bottom sediments. The sediments throughout the Southwest Florida shelf are generally coarse carbonaceous sands. Consistent resuspension of sands requires current speeds in excess of 40 cm/s; however resuspension of finer sediments (particularly those with a high water content) can occur at current speeds > 20 cm/sec... The frequency of occurrence of these extreme bottom currents was examined by season. For the seasons examined (winter, spring, and summer), currents in excess of 20 cm/s occurred less than 6% (and usually less than 3%) of the time at all stations except the nearshore stations. At the nearshore station, the currents exceeded 20 cm/s 18 and 25% of the time during winter and spring, respectively.

An examination of sediment trap and time-lapse camera data indicated that sediment resuspension was episodic and that near-bottom currents were not the only factor contributing to sediment resuspension. Wave energy was especially important, which precluded significant sediment resuspension in deep water. As an example, although current speeds at the deepest station (125 m) were occasionally high enough to resuspend sediments, this did not occur. At the shallowest station (13 m), sediment was resuspended with lower current speeds, but only when associated with a storm and large waves. The hydrographic structure of the overlying water was surveyed with a series of seasonal CSTD profiles. With the exception of the deeper stations, the water column was generally well mixed. Evidence of a thermocline was observed usually at stations deeper than 50 m.

Dr. Larry J. Danek received his doctorate in Physical Oceanography in 1976 from the University of Michigan. Following two years as a research and teaching assistant, he worked for NOAA for two years at the Great Lakes Environmental Research Laboratory conducting water current and wave studies on the Great Lakes. Dr. Danek has been in the environmental consulting business for 10 years and has conducted studies in most regions of the United States including the Beaufort Sea and at international sites including the North Sea, Arabian Gulf, and South China Sea. Dr. Danek is currently Associate Vice President at Environmental Science and Engineering, Inc., in Gainesville, FL, and is the Director of Oceanographic Services.

Mr. Michael S. Tomlinson received his bachelor's degree in Geological Oceanography in 1973 from the University of Washington. As an assistant oceanographer at the University of Washington, he spent two years collecting and analyzing biological and chemical oceanographic data from Ice Station T-3 (Arctic Ocean), Gulf of Alaska, and Puget Sound. Mr. Tomlinson has worked as an environmental consultant for 11 years and has conducted multidisciplinary oceanographic studies in the Gulf of Mexico, Bering Sea, United States east coast, North Sea, and Arabian Gulf. Mr. Tomlinson is currently Staff Oceanographer at Environmental Science and Engineering, Inc., in Gainesville, FL.

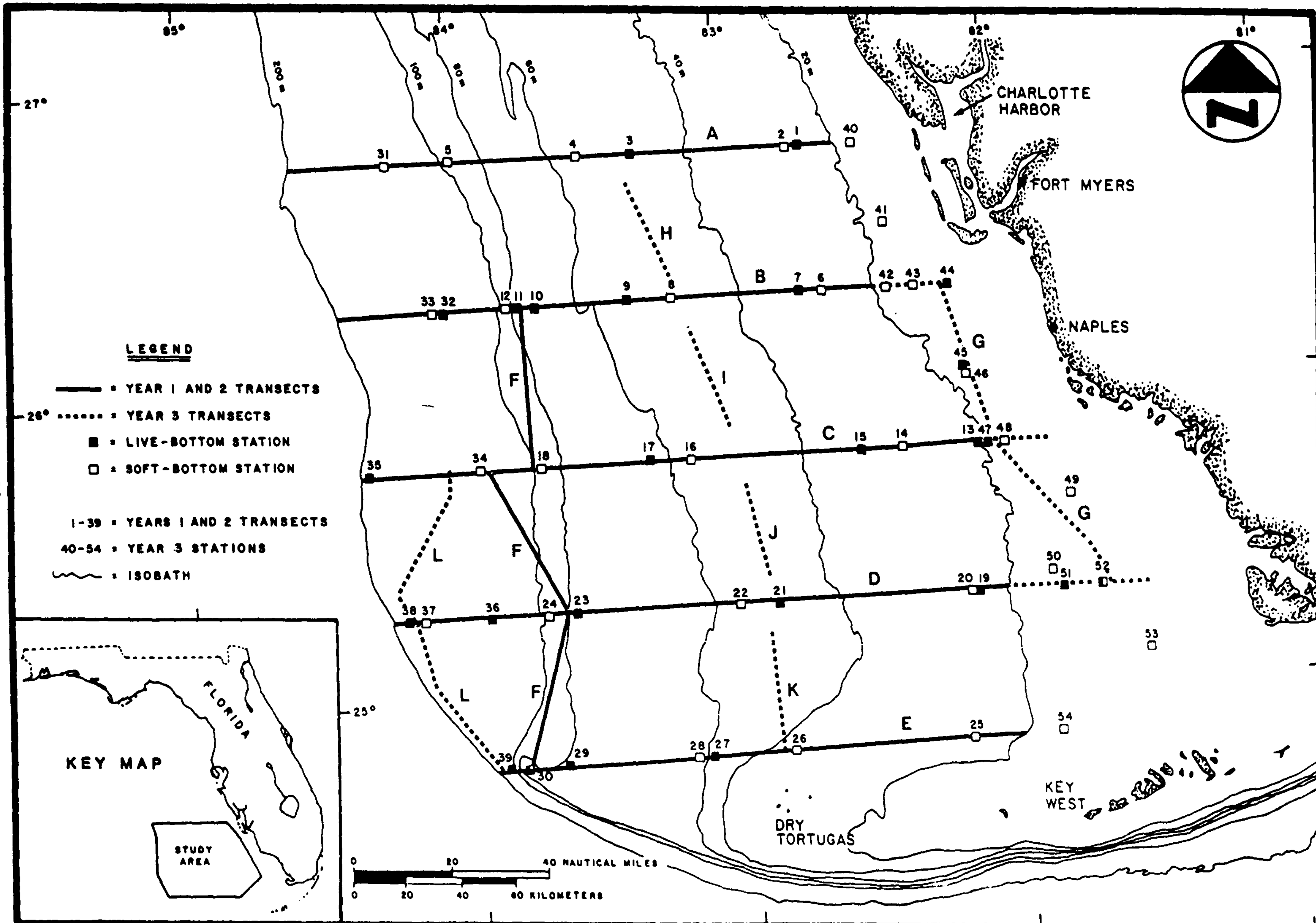

Figure IVB.1 - Transects Surveyed and Stations Sampled During the First Three Years of Southwest Florida Shelf Studies

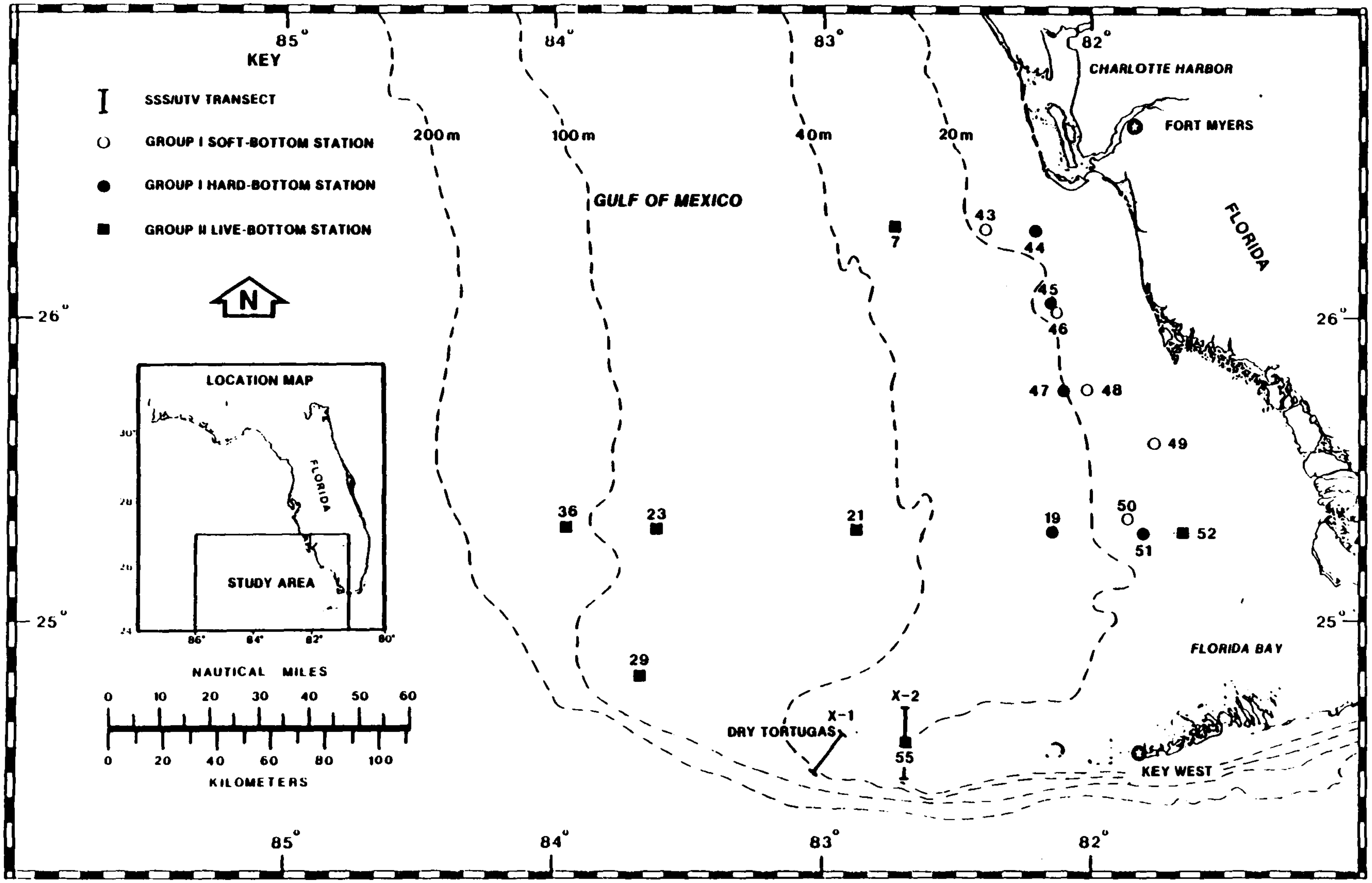

Figure IVB.2 - Year 4 and 5 Station Locations

PHYSICAL OCEANOGRAPHY II:
PROGRESS REPORTS FROM COORDINATING PROGRAMS

Session: PHYSICAL OCEANOGRAPHY II: PROGRESS REPORTS FROM COORDINATING PROGRAMS

Chairmen: Dr. Murray Brown
Mr. Joe Perryman

Date: October 23, 1985

Presentation Title	Author/Affiliation
Current Meter Moorings and Hydrographic Study Plans in the Western Gulf of Mexico	Dr. David A. Brooks Texas A&M University and Captain Alberto Vazquez Navy of the Republic of Mexico
Intrusion Current in the Campeche Canyon	Captain Alberto M. Vazquez and Sr. Hugo C. Herrera Oceanografia-Veracruz, Mexico
Effects of an Initial Current Regime on the Oceanic Response to Hurricanes	Mr. L.K. Shay and Dr. R.L. Eisberry Department of Meteorology U.S. Naval Postgraduate School
Gulf of Mexico Circulation Modeling Study	Dr. Alan J. Wallcraft JAYCOR
Aircraft Altimetry for Ocean Circulation Monitoring	Mr. Robert E. Cheney and Dr. Gerald L. Mader and Mr. Bruce C. Douglas National Geodetic Survey Charting and Geodetic Services National Ocean Service, NOAA
Comparing High Resolution Thermal Imagery to Drifting Buoy and Ship-of-Opportunity Data	Mr. Jeffrey D. Hawkins U.S. Naval Oceanographic Research and Development Activity
Cyclonic Eddy Generation in the Eastern Gulf of Mexico	Dr. Harley E. Hurlburt U.S. Naval Oceanographic Research and Development Activity

Current Meter Moorings and Hydrographic Study Plans in the Western Gulf of Mexico

Dr. David A. Brooks
Texas A&M University
and
Captain Alberto Vazquez
Navy of the Republic of Mexico

In February 1985, as part of Year 3 of the MMS funded, Gulf of Mexico, Physical Oceanography Program, an L-shaped array of five current meter moorings was designed as an "antenna" to intercept a Loop Current eddy as it drifted westward over the continental margin of the western Gulf of Mexico. With the cooperation of the Mexican Navy, the array was deployed in June of 1985 by Science Applications International Corp., using a Mexican Navy vessel, the B/O*Altair*. The long leg of the "L" contained three moorings aligned with the 2000 m isobath, with the two southern moorings located in Mexican waters. The orthogonal offshore leg contained two moorings, the deeper of which was located in about 3500 m. With international scientific collaboration, it was possible to position the array where it was likely to intercept an arriving Loop Current eddy.

In July 1985, an eddy that had separated from the Loop Current was seeded with a Service ARGOS tracked drifter. From deployment to October, 1985, the drifter made clockwise circuits in the eddy while translating westward toward the western Gulf array. By the time of the present Information Transfer Meeting (22-24 October 1985), the eddy was about 100 km east of the outermost mooring and apparently was headed on a "collision course" with the mooring "antenna." During the week prior to the meeting, again with the cooperation of the Mexican Navy and the B/O*Altair*, the moorings were recovered, current meters serviced, and arrays re-deployed. Thus, fresh instruments were in place probably no more than a month before the eddy is expected to influence the outermost mooring. We have an unprecedented opportunity to observe the interaction of a Loop Current eddy with the waters of the continental margin in the Western Gulf, using an instrumented array designed expressly for the purpose. The opportunity exists because of a mixture of good fortune, careful planning, and, most importantly, international cooperation.

While servicing the current meters in October 1985, the B/O*Altair* also ran several XBT sections through the array area, providing baseline temperature information at a time when no major eddy was influencing the instruments. Earlier in the year, as part of a Mexican hydrographic study, several surveys were conducted in the southwestern part of the Gulf, providing additional background data.

In November, an AXBT survey will establish the temperature structure of the approaching Loop Current eddy before it is significantly distorted by shoaling topography. This survey will provide a critical "before" look at the structure of the eddy, which will be contrasted with the "after" structure to be determined as the eddy passes through the current meter array and eventually disperses over the continental slope and shelf.

REFER TO FIGURE IVC.1.

David A. Brooks is Associate Professor of Oceanography at Texas A&M University, College Station, TX. He earned a PhD in physical oceanography from the University of Miami, FL. His present research interests include field studies of the circulation in the Gulf of Mexico and the Gulf of Maine and theoretical studies of ocean currents and their instabilities.

Alberto Vazquez Biography: See Session IV.C, Paper 2.

Intrusion Current in the Campeche Canyon

Captain Alberto M. Vazquez
and
Sr. Hugo C. Herrera
Oceanografia-Veracruz, Mexico

In 1962, Nowlin and McLellan (1967) observed in the Campeche Canyon a dynamic topographic protrusion which extended southward from a main western Gulf anticyclone (Figure IVC.2). To better document characteristics and persistance of such a feature, eight hydrographic cruises were made between October 1970 and November 1971. On several of these cruises this local dynamic topographic ridge appeared in the horizontal and vertical hydrographic sections (e.g. Figure IVC.3).

Additional surveys in 1985 provided further information regarding conditions in the Campeche Canyon just west of the Campeche Bank. Selected preliminary results from three of these surveys are presented below:

- February 1985 -- Portions of two well-defined anticyclones were observed (Figure IVC.4). One at 21.5°N/94°W is probably associated with a larger anticyclonic western Gulf eddy. The isotherm spacing suggests a westward-directed current on the eddy's south side. The second warm-core feature, located at 19.6°N and 93.8°W, is elongated northeast-southwest and is probably influenced by the adjacent slope and shelf.

• May 1985 -- 15°C isotherm topography indicates cyclonic features in the northern and southern portion of Campeche Canyon (Figure IVC.5). The anticyclonic feature to the west of the cyclones is less energetic than seen in February 1985.

• September 1985 -- Figure IVC.6 shows an anticyclone in the northern study area which is well connected with the southwestern area through the Campeche Canyon. The western ridge of the local cyclone reduces the sectional area in the Campeche Canyon, suggesting increased local currents. The northern series of 15 stations (22.5°-24°N; 92.5°-94.5°W) was suggested by Texas A&M University and supports an ongoing study of the western Gulf (see Abstract by Brooks and Vazquez in these Proceedings).

This research was supported by Secretaria de Marina and CONACYT, Mexico.

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Alberto Vazquez is a Captain in the Navy of the Republic of Mexico. He earned an MS degree in oceanography from Texas A&M University and presently resides in Veracruz, Mexico. His scientific research interests include studies of the hydrography and circulation of the western and southwestern Gulf of Mexico.

Effects of an Initial Current Regime on the Oceanic Response to Hurricanes

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and
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PROJECT HISTORY

This work is supported by the Office of Naval Research (ONR) under the project entitled "Oceanic Response to Strong Atmospheric Forcing." The research is a study of the ocean current response using both observational evidence and a multi-level primitive equation model with an embedded mixed layer (Adamec et al., 1981). The model is forced with a translating hurricane by displacing the grid underneath the atmospheric forcing (Price, 1981;1983). The data sets include ocean current, direction, and temperature observations acquired prior, during, and subsequent to the passage of Hurricane Frederic during 1979 and drifting buoy data collected during the passage of Hurricane Josephine during 1984 (Black et al., 1985a and b).

ACCOMPLISHMENTS

The Frederic current observations have been analyzed using linear normal mode theory of inertial-gravity waves (Shay and Elsberry, 1985). The major finding in the normal mode decomposition was that the barotropic mode contributed about 40% of the observed variability. A summation of the barotropic mode and first two baroclinic modes accounted for 80% of the observed near-inertial wave variance. Another key feature is that the amplitude of the near-inertial currents was markedly different because of the presence of pre-storm mean currents which were at right angles at two of the current meter arrays. The vorticity of the mean flow also shifted the frequency of the inertial-gravity waves by about 3% below the local inertial frequency. Preliminary analyses of the buoy data from Hurricane Josephine indicate that the buoys were embedded in the North Atlantic Subtropical Front. The hurricane-induced circulation was only evident in two of the buoy trajectories. Both sets of observations were acquired in regions of initial currents. However, previous numerical studies have assumed quiescent ocean conditions. Therefore, the purpose of the present study is to include realistic initial ocean currents to understand the modifications to the ocean response to hurricane forcing.

SIGNIFICANT FINDINGS

The model was initialized with a geostrophically balanced current field in the along-track direction using an AXBT profile (Black, 1983). The direction and intensity of the flow was changed in each numerical experiment, for example +v, -v, and -2v along-track initial flow (Figure IVC.7). The significant findings of this study are that the forced response is sensitive to these variations in the initial flow regime. In the +v case, the hurricane-induced velocity field is augmented by the initial flow in the front half of the storm. Conversely, the hurricane-induced velocity is diminished by the geostrophically balanced current in the -v cases. In the rear half of the storm, the hurricane-induced velocity is augmented by the -v and -2v cases, whereas the +v initial flow decreases the hurricane-induced flow. As time passes, a phase separation starts to develop between the various regimes with the +v case leading in phase. This is suggestive of modal separation as studied by Gill (1984).

The inertial period averaged current amplitudes in the thermocline from the Frederic observations are compared to the numerical experiment for the -v initial flow at 100 km (Figure IVC.8). There is close agreement from 0 to 1.5 d and after 3 d, but during the period from 1.5 to 3 d, the model simulation and observations differ by roughly 20 cm/s. This difference of 20 cm/s is apparent throughout the water column. Note that the model storm speed was 3.5 m/s, but the actual speed of Hurricane Frederic was about 6.5 m/s. For fast moving storms, linear theory predicts that the wake is filled with baroclinic inertial-gravity waves (Geisler, 1970). In contrast, as the storm speed decreases, more energy goes into vertically averaged flow. However, there is still a deficit of 20 cm/s associated with the slower moving storm in the simulations. Hence, the difference of 20 cm/s between the current observations and the numerically simulated currents lies in the neglect of a barotropic component.

RECOMMENDATIONS

Analyses on the numerical simulated current data are continuing and are being compared to the currents observed during the passage of Frederic. Although inclusion of initial currents improves the agreement with the Frederic observations, it appears that a barotropic component will have to be included in the model. The model will also be initialized with a cross-track baroclinic flow regime (i.e., an along-tract temperature gradient) for comparison with the Frederic data collected along the northern rim of the DeSoto Canyon. Similar type experiments will also be conducted for comparison with the Josephine buoy data. Sinusoidal variations in this baroclinic zone with cyclic boundary conditions may also be imposed to simulate eddies along the front.

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Mr. Lynn Shay was awarded a BS (1976) and a MS (1983) in Physical Oceanography from the Florida Institute of Technology and the Naval Postgraduate School (NPS). He is a PhD candidate in the Physical Oceanography program at the NPS and is working on the oceanic response to hurricane forcing problem.

Dr. Russell Elsberry was awarded a BS (1963) in Mechanical Engineering and a PhD (1968) in Atmospheric Sciences from Colorado State University. He is a professor in the Department of Meteorology at NPS. His primary research interest focuses on tropical cyclones and their impact on atmospheric and oceanic circulations.

Gulf of Mexico Circulation Modeling Study

Dr. Alan J. Wallcraft
JAYCOR

This presentation is on the second year of a four-year numerical ocean circulation modeling program for the Gulf of Mexico funded by MMS. The aim of the program is to upgrade progressively, in modest increments, an existing numerical ocean circulation model of the Gulf so the final model has a horizontal resolution of about 10 km and vertical resolution approaching 1 to 10 m in the mixed layer, 10 m at the thermocline and 100 m in the deep water. Throughout the four-year period, the validity of the upgraded model will be continuously tested, and velocity field time series delivered periodically based on the most realistic simulation of Gulf circulation available (JAYCOR, 1983).

Experiments in the first year were with the existing NORDA/JAYCOR two-layer hydrodynamic primitive equation ocean circulation model of the Gulf on a 0.2 degree grid (Hurlburt and Thompson, 1980). They concentrated on correctly specifying the coastline and bottom topography for maximum realism in circulation simulation and on how best to include wind forcing. Details of selected experiments were presented in the annual progress report (Wallcraft, 1984). Simulated surface currents sampled every three days on a 0.2 degree grid covering the Gulf for ten years were delivered to MMS from an experiment with both wind and port forcing.

Experiments in the second year, now in progress, use the same two-layer hydrodynamic model as before but on a 0.1 degree horizontal grid, which allows a lower eddy viscosity to be used. A richer flow field and wind-induced instabilities are expected. Features that are poorly resolved at 0.2 degrees, such as the cyclonic eddies that move around the wall of the Loop Current, should be more accurately simulated on the finer grid.

Figures IVC.9 to IVC.11 are from a 0.1 degree simulation forced entirely by constant inflow through the Yucatan Straits with compensating outflow through the Florida Straits. It has no wind forcing. Layer averaged currents are plotted every 0.2 degrees (i.e., every second model node) for both layers. In Figure IVC.9 a large anti-cyclonic eddy is about to shed from the Loop Current in the upper layer, and there are cyclonic lower layer eddies in the deep water off the southwest Florida shelf and in the southwest Gulf. Figure IVC.10 is for 90 days later. The upper layer eddy has broken off from the Loop Current. Deep water flow is now mainly to the south along the Florida slope area, and there is an anti-cyclonic deep water eddy in the central west Gulf flanked by two cyclonic eddies. Figure IVC.11 is for 180 days after Figure IVC.10. The Loop Current has repenetrated into the Gulf. The large anti-cyclonic eddy has moved into the southwestern Gulf and has spontaneously generated a cyclone to form a cyclone anti-cyclone pair in the upper layer associated with a cyclonic eddy in the deep water.

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Dr. Wallcraft has been the principal investigator for JAYCOR's ocean modeling effort since 1981, overseeing and participating in projects in the areas of model development, model comparison, diagnostic software, data preparation, and the numerical ocean modeling of semi-enclosed seas. His early Gulf of Mexico experiments were probably the first mesoscale eddy resolving simulations of any semi-enclosed sea to include a realistic coastline and full scale bottom topography. Dr. Wallcraft received his BSc in Mathematics and Computer Science from Essex University and his PhD in Numerical Analysis from Imperial College, London.

Aircraft Altimetry for Ocean Circulation Monitoring

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Tests conducted in July 1985 employing the Global Positioning System (GPS) in a differential mode have shown that the trajectory of an aircraft can be determined with an accuracy of 10 cm (Mader et al., 1986). This new capability, combined with aircraft altimetry, can be exploited in the study of ocean dynamics. We propose to conduct an airborne survey of the eastern Gulf of Mexico to map precisely the marine geoid along GEOSAT satellite altimeter tracts. This information, together with GEOSAT profiles of sea height, would enable continuous monitoring of surface circulation in the Gulf.

PROJECT HISTORY

Altimetry has been shown to be one of the most useful satellite data types for observing global variations of sea level and ocean circulation (Cheney et al., 1983; Fu and Chelton, 1985). However, the lack of accurate geoid models greatly reduces the utility of these data for determination of absolute surface currents. In addition, the small footprint (a few kilometers) of a satellite altimeter combined with its global coverage provide poor synoptic capabilities for relatively small regions such as the Gulf of Mexico.

An aircraft altimeter system could complement satellite altimetry by overcoming many of the deficiencies inherent in satellite systems. Not only could regional synoptic surveys be performed, but also deployment of expendable probes would enable simultaneous measurement of surface topography and sub-surface temperature structure. The aircraft would therefore be able to measure both the total (altimetric) sea height and the dynamic height. The difference between the two is approximately equal to the geoid. In this way, the aircraft becomes an independent tool for mapping the marine geoid.

Laser and radar altimeters with precisions of a few centimeters are operated routinely from aircraft for ocean wave studies (Jackson et al., 1985; Hoge et al., 1984). However, application of aircraft altimetry to topographic profiling of larger-scale circulation features has not been possible. The reason is that with currently operating systems, navigation errors in the vertical direction quickly become large compared to the 10-cm accuracy required for ocean current profiling. Our proposed solution is to track GPS carrier phase in a differential mode to determine continuously the aircraft position at the centimeter level. These techniques have been used to obtain centimeter accuracies for fixed receivers (Bossler et al., 1980), but the application to moving platforms has only recently been demonstrated (Mader et al., 1986).

EXPERIMENTAL PROCEDURE

Flight tests were conducted in July 1985 over Chincoteague Bay in cooperation with the NASA Wallops Flight Center. Two GPS receivers were used: one at a fixed position on the ground, and one on the P-3 research aircraft to provide its position as a function of time. As the aircraft was flown along the length of the bay, the GPS receivers obtained a set of four observations (one from each satellite) every three seconds. The basic measurement is phase of the GPS carrier signal, and three-dimensional relative position information is computed from the phase differences. These data enable determination of the aircraft height above the ellipsoid. The aircraft height above the water surface was simultaneously monitored with the onboard laser altimeter. The altimeter provided 500 elevation observations per second which were reduced to 1-sec average heights having an accuracy of a few centimeters.

Chincoteague Bay was chosen for the test because of its immediate proximity to Wallops, and because the terrain in the area is very flat and the bay shallow. Undulation of the geoid along the bay is therefore extremely small, with rms deviation of the geoid from a plane only about 2 cm.

SIGNIFICANT FINDINGS

One critically important test result was that the GPS system can be operated on an aircraft in the differential mode without significant loss of signal acquisition. It is especially significant that no data were lost during take-off when the aircraft underwent maximum acceleration.

Figure IVC.12 shows the height comparison between the GPS system and the laser altimeter during one transect of the Bay. Remarkably, the two profiles agree at the 10-cm level, demonstrating accurate recovery of the aircraft trajectory with differential GPS ranging. It may be possible to further improve the agreement by incorporating data collected by the aircraft inertial navigation system and tide gauge data gathered at several sites around the Bay.

RECOMMENDATIONS

An aircraft system capable of gathering height profiles accurate to 10 cm in an absolute reference frame will have many applications. In addition to ocean studies, an aircraft altimeter could be used to map polar ice sheets or measure regional land subsidence. Additional tests will be needed before such a system can be declared operational. The Chincoteague Bay test flight took place within a 30-km radius of the ground receiver. Subsequent experiments will be performed to determine whether 10-cm accuracy can be achieved when the separation between aircraft and ground receivers is 1000 km or more.

Ultimately we plan to survey the eastern Gulf of Mexico to enable determination of the surface circulation. The concept involves both aircraft and satellite altimeters, but does not require the two data sets to be gathered at the same time. Beginning in mid-1886, the GEOSAT orbit will be modified to produce a ground track which repeats at 17-day intervals. This yields a uniform grid of approximately 150 km in the Gulf. We will use the aircraft system to determine the geoid along these same tracks. These geoid profiles can then be subtracted from corresponding GEOSAT altimeter profiles to obtain dynamic topography. The result would be a map of surface circulation in the eastern Gulf, updated at intervals of 17 days and extending for the lifetime of the GEOSAT exact-repeat mission.

Because the complete constellation of 18 GPS satellites will not be in place until 1988, it is unlikely that a complete aircraft survey can be performed during the lifetime of GEOSAT. Because the gravity field is constant in time, however, aircraft altimeter mapping of the geoid along GEOSAT tracts at any time will enable reconstruction of the surface circulation for the entire repeat-track mission. If this technique is successful, it could be applied to future satellite altimeter missions to enable real-time current monitoring.

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Robert Cheney is Chief of the Satellite and Ocean Dynamics section of the Geodetic R&D Laboratory. He has been involved in the analysis of altimeter data for ocean circulation since SEASAT in 1978.

Gerald Mader is a member of the Advanced Technology section of the Geodetic R&D Laboratory. He has recently demonstrated the feasibility of precise dynamic positioning using GPS.

Bruce Douglas is Chief of the Geodetic Research and Development Laboratory of the National Geodetic Survey. His interests lie in development and application of advanced geodetic techniques such as satellite altimetry and GPS to earth and ocean sciences.

Comparing High Resolution Thermal Imagery to Drifting Buoy and Ship-of-Opportunity Data

Mr. Jeffrey D. Hawkins
U.S. Naval Oceanographic Research and Development Activity

INTRODUCTION

The Remote Sensing Branch at NORDA has utilized a variety of spaceborne and aircraft mounted sensors to locate and study the mesoscale oceanographic features in the Gulf of Mexico (GOM). This effort to detect the positions and movement of the Loop Current and warm/cold core eddies was initially begun to provide comparison data for numerical ocean model output. Since then, it has enlarged to cover a variety of study areas because of the sometimes unique GOM ocean-atmosphere conditions.

The GOM numerical model of Hurlburt and Thompson (1982) has simulated the main characteristics of the Loop Current System: 1) northward penetration, 2) NW elongation, 3) eddy shedding, and 4) retrenchment of the Loop Current. This sequence of events has been verified by satellite infrared (IR) data over the last 5-10 years (Hawkins, 1983, and Vukovich, 1979) and intense hydrographic surveys carried out by the Minerals Management Service (MMS). This combination of satellite, hydrographic, and ocean model data has significantly increased our knowledge of the GOM's circulation.

Each of these methods for detailing the GOM's mesoscale circulation has some drawbacks. (1) IR data typically is useless from July-Sept and reveals only surface features, (2) hydrographic data is costly and time consuming, and (3) numerical ocean models lack the resolution and forcing functions required to duplicate some important features. This report will detail efforts to stretch the application of IR data to track summertime eddies and verify their existence with other data sources.

ACCOMPLISHMENTS

NORDA has recently begun operation of a Satellite Data Receiving and Processing System (SDRPS) which can acquire digital NOAA and Defense Meteorological Satellite Program (DMSP) polar orbiter data and Geostationary Operational Environmental Satellite (GOES) imagery. This capability provides global 4 km IR coverage twice/day and 1 km data for selected areas. NORDA's antenna location enables it to collect all NOAA data from the Advanced Very High Resolution Radiometer (AVHRR) viewing the GOM. Thus, during the past summer, data from NOAA-8 and 9 have been periodically captured, "earth-located," and atmospherically corrected in an attempt to find warm core eddies.

A large Loop Current-generated warm core eddy formed sometime in early July as the Loop extended well to the NW. Shortly thereafter, on 9 July 1985, NOAA-9 IR data indicated a small sea surface temperature (SST) gradient, banded in such a way as to suggest the northern semicircle of this eddy. Some high cirrus clouds obscured a segment of the viewing area while other low level cumulus clouds formed a noticeable line. This line of clouds formed an extension to the SST gradient and when combined described a circular 250-300 km diameter feature.

The full resolution (1 km) AVHRR IR data was able to see a portion of the eddy because of its high thermal sensitivity (0.12°C). Thus, when displayed on a CRT using the 8 bit (255 count/grey values) range of data encompassing all GOM SST's, an analyst can stretch the contrast and brightness to bring out subtle ocean SST features. The task was made easier by knowing the general area to look in, but the combination of SST gradients and cloud boundaries did attract immediate attention.

Low level cumulus clouds have often been observed to form along sharp SST fronts delineating the north wall of the Gulf Stream as well as the Loop Current. Strong air-sea interaction processes can rapidly bring about cloud formation under the right atmospheric conditions. It is also possible for much smaller SST gradients to form a cloud line if the prevailing synoptic situation is favorable. Previous NORDA P-3 flights have noticed cloud formation in the GOM over weak fronts. It does not occur all the time, but when available can provide a key piece to the overall picture.

An approximate boundary and center position were derived and sent to Dr. Murray Brown of MMS. These values were independently verified by MMS as they surveyed the eddy with XBT's and deployed a drifting buoy. The satellite-tracked drifting buoy began a clockwise rotation within the warm core eddy, allowing researchers to watch the eddy's migration to the central and perhaps western GOM.

The XBT survey done by Dr. Van Waddell of Science Applications International Corporation (SAIC) defined clearly the large, warm, deep eddy. The depth of the 22°C (20°C) isotherm plunged below 200m (250 m) as the thermocline dropped sharply. This was in stark contrast to ambient GOM waters where 22°C water was at about 50-75 m.

The eddy continued moving west while tracked by the drifter. However, a combination of (1) GOM SST homogeneity, (2) clouds, and (3) large atmospheric attenuation of IR signals made it impossible to see the eddy via IR imagery. Instead, a second warm core eddy was seen a month later on 8 Aug 1985. It was located at approximately 23.5 N, 92.5 W, or about 200 km SW of the first warm core eddy as marked by the buoy still contained within its circulation. The formation mechanism for this second eddy is a mystery at this time, and its proximity to the other eddy raises many questions concerning possible interaction. MMS plans to seed this second eddy with a satellite-tracked drifter as soon as a XBT survey pinpoints its center position. [Editor's Note: A drifting buoy was deployed in this eddy by the Mexican Navy and MMS on November 3, 1985.]

This 8 Aug 1985 image was enhanced to take advantage of the full thermal and spatial capabilities of the AVHRR sensor. The eddy's 0.5 C°SST gradient along its edge was enough to be detected easily. Why it had this large a surface signature in August is unknown at this time. Subsequent imagery in September reveals the eddy's location is undetectable via IR methods. Thus, some mixture of IR remote sensing and drifting buoys is the bare minimum needed in order to track these features.

Other examples of drifter tracks verifying IR feature detection have occurred in the GOM. A buoy placed in a potential warm eddy in early April 1985 was seen later to have been located in a warm filament off the mouth of the Mississippi River. It appears a cold slug of Mississippi River water carried the drifter to the north wall of the Loop Current. It then raced away to the SE, staying just inside the warm east wall of the Loop Current. As it reached the SE GOM, it rounded a large cool intrusion penetrating 150 km out into the Loop Current. The buoy proceded to accelerate out of the Florida Straits until it was disabled in an unfortunate incident.

RECOMMENDATIONS

Infrared data do suffer significant drawbacks when trying to detect GOM mesoscale ocean features during the hot, humid summer months. However, recent imagery indicates that conditions existed whereby two warm core eddies were independently found and subsequently verified with in situ data. Full thermal and spatial resolution AVHRR data can thus be combined with drifting buoys to track GOM eddies year round and increase our knowledge of the circulation for a variety of applications. This effort should be significantly enhanced when GEOSAT Extended Repeat Mission altimeter data are available in the next 18 months.

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Mr. Jeffrey D. Hawkins is an oceanographer in the Remote Sensing Branch of the Naval Ocean Research and Development Activity (NORDA), Bay St. Louis,

MS. His work has included the use of high resolution infrared satellite data to detect the mesoscale circulation in the Gulf of Mexico and then compare it with results generated from numerical ocean models. Other work focuses on the application of satellite derived sea surface temperatures and ice at Navy oceanographic centers. Mr. Hawkins received his BS and MS in Meteorology from Florida State University.

Cyclonic Eddy Generation in the Eastern Gulf of Mexico

Dr. Harley E. Hurlburt
U.S. Naval Oceanographic Research and Development Activity

Strong cyclonic eddies have been observed to form in association with the Loop Current (Vukovich and Maul, 1985). This has also been observed in numerical models with low eddy viscosity (100 m^2/s) and large amplitude topography resembling the Gulf of Mexico. Figure IVC.13 shows results from an idealized simulation used to study the assimilation of altimeter data (Hurlburt, 1986) and not intended for realistic simulation of the Gulf of Mexico. Nonetheless, Figure IVC.13 shows the development and evolution of two types of cyclonic eddy in association with the Loop Current, one on the external side of the Loop, the other on the internal side. Both types are illustrated in Figure IVC.13a.

The external ones form SSW of the loop center (Figure IVC.13e) and move around the perifery of the loop at about 15 km/day. Figures IVC.13(a-d) and IVC.13(e-j) illustrate the evolution of three such eddies. Explosive development NW of the loop center is illustrated in Figure IVC.13b and to a lesser extent in IVC.13h. The external cyclonic eddies are prevalent only during the few months prior to eddy-shedding by the Loop Current.

The cyclonic eddies that develop on the inside of the loop form SE of the loop center, show little movement and have a lifetime of 10-60 days. They form during any part of an eddy cycle with an irregular period that is roughly 75 days. Two examples are illustrated in Figures IVC.13(a-b) and IVC.13(e-g).

Vukovich and Maul (1985) have associated cyclonic eddies that reach the strong cyclonic curvature SE of the loop center with eddy separation from the Loop Current. Figure IVC.13 shows mixed results in that regard. Figure IVC.13d illustrates the smallest response to an eddy that has moved around the loop. Figure IVC.13b shows the pinched neck of the loop caused by an eddy formed on the inside of the loop, but Figure IVC.13c shows the neck unpinched. Figure IVC.13h shows what appears to be eddy separation when both types of cyclonic eddy act in concert, but Figure IVC.13i shows the loop and eddy rejoined. Finally, Figure IVC.13j shows eddy separation coincident with the arrival of another cyclonic eddy of the external variety, an event that had little effect in Figure IVC.13d.

Cyclonic eddies may exert some influence on the timing of an eddy shedding event, but are not central in determining the eddy shedding period (approximately 400 days in this experiment). For a discussion of the eddy-shedding period see Hurlburt and Thompson (1980, 1982).

Hurlburt (1986, Section 5.5) discusses the dynamics and energetics of the cyclonic eddies illustrated in Figure IVC.13. Both types result from baroclinic instability, but the manifestation of the instability is profoundly affected by the topography. In flat bottom experiments with episodic baroclinic instability, an episode is marked by rapid westward propagation of the Loop Current and associated deep eddies. In the process the loop breaks into multiple *anticyclonic* eddies (Hurlburt and Thompson, 1980, 1982). Such behavior may be observed in the Gulf of Mexico when baroclinic instability occurs over the central abyssal plain; but when baroclinic instability occurs in the vicinity of the Campeche Bank as in Figure IVC.13, the topography (1) suppresses eddy generation in the lower layer over the upper portion of the steep topographic slopes and (2) impedes the westward propagation of the deep eddies formed in the Yucatan Channel. This prevents rapid westward propagation of the Loop Current. Instead, baroclinic instability is manifested by two types of cyclonic eddy associated with the Loop Current as shown in Figure IVC.13.

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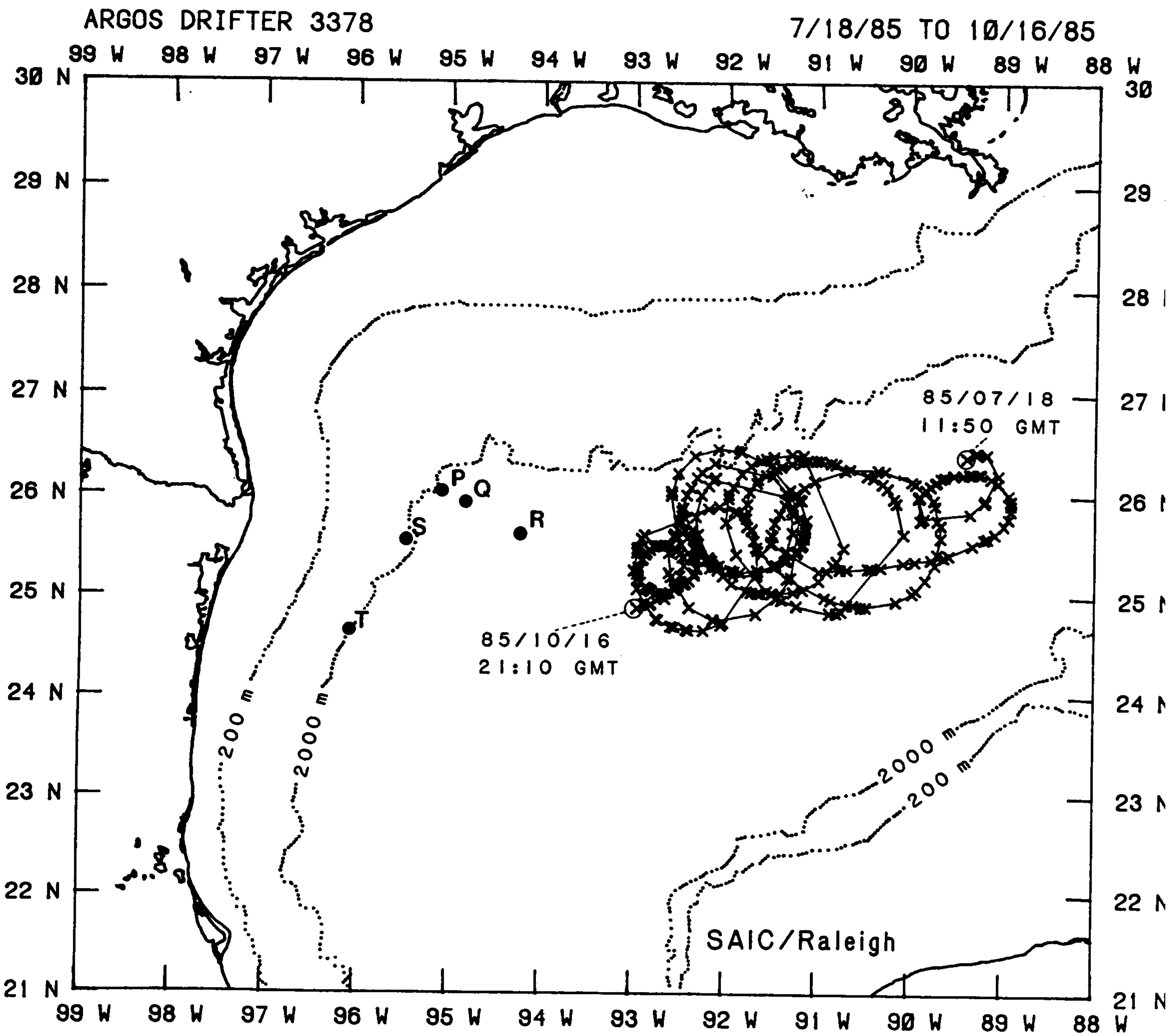
Dr. Hurlburt received the PhD from Florida State University in 1974. Since 1977 he has been Numerical Ccean Modeler at the Naval Ocean Research and Development Activity. There he is a member of the

Ocean Dynamics and Prediction Branch, which has a mission to develop an ocean prediction capability for the U.S. Navy. His current research interests include the investigation of ocean dynamics using numerical models, ocean prediction, and the assimilation of altimeter data by ocean models.

Figure IVC.1 - ARGOS Drifter 3378 (7/18/85 to 10/16/85)



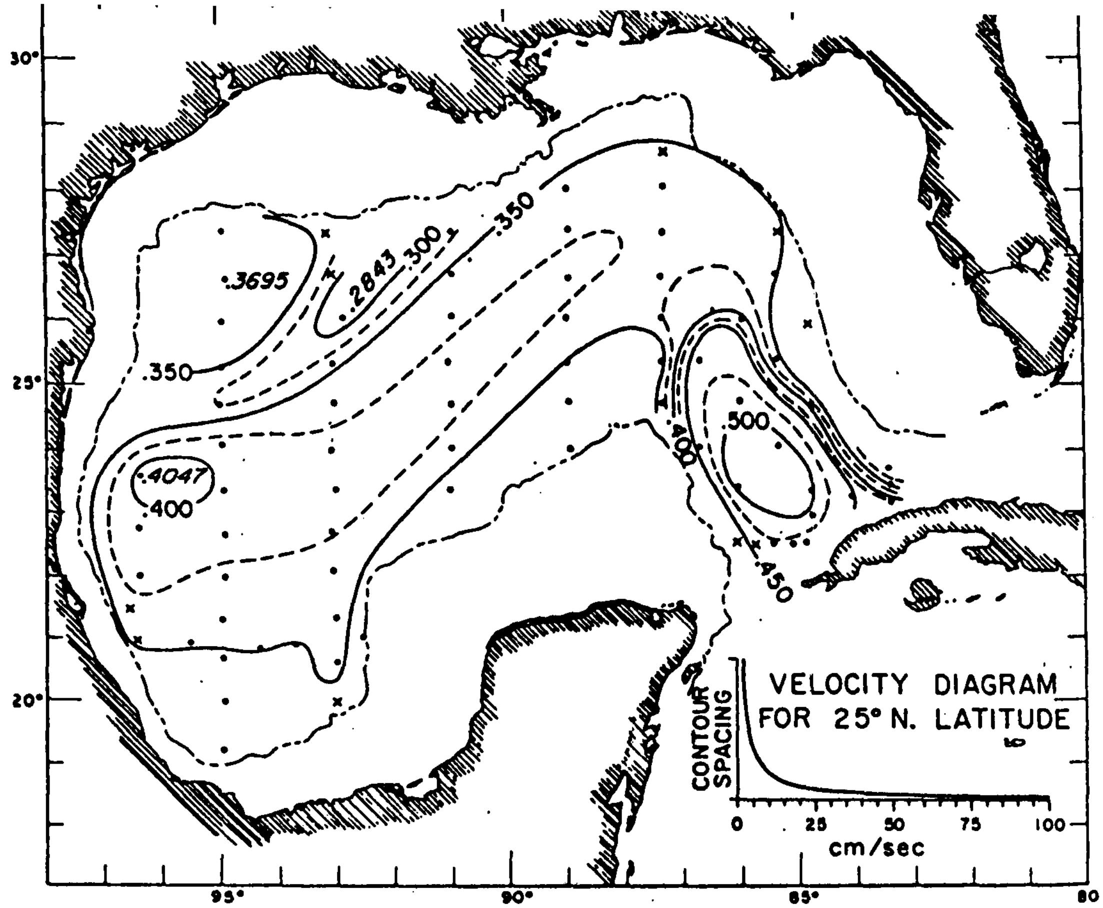


Figure IVC.2 - Dynamic Topography of the 500-db Surface Relative to the 100-db Surface. Contour Interval-0.025 Dynamic Meters. March 1962 (HIDALGO 62-H-3). X Indicates Some Extrapolation

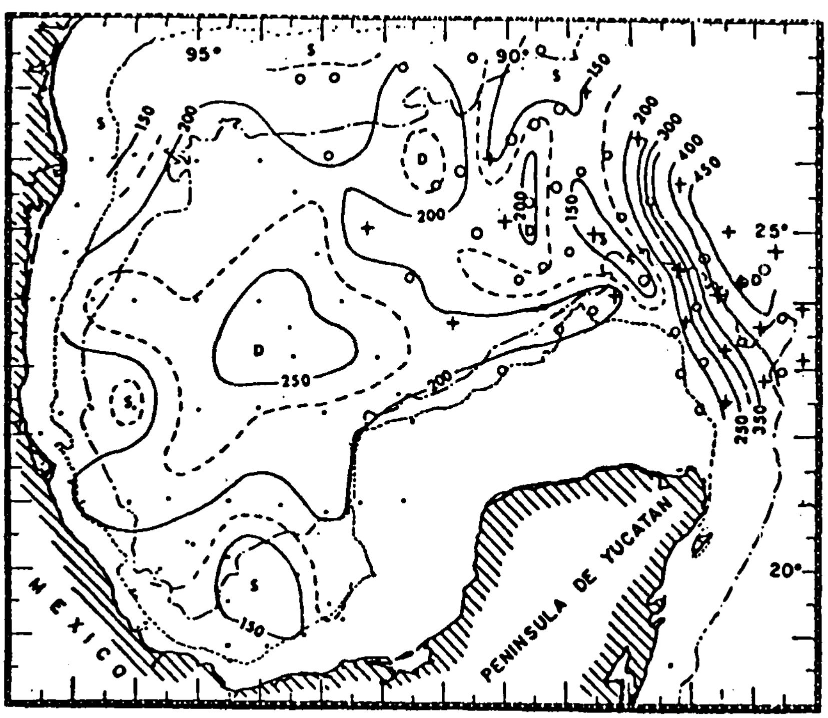


Figure IVC.3 - Topography--(Meters) of 15°C Surface. (COSMA 70-12) and 70-A-14 Cruises

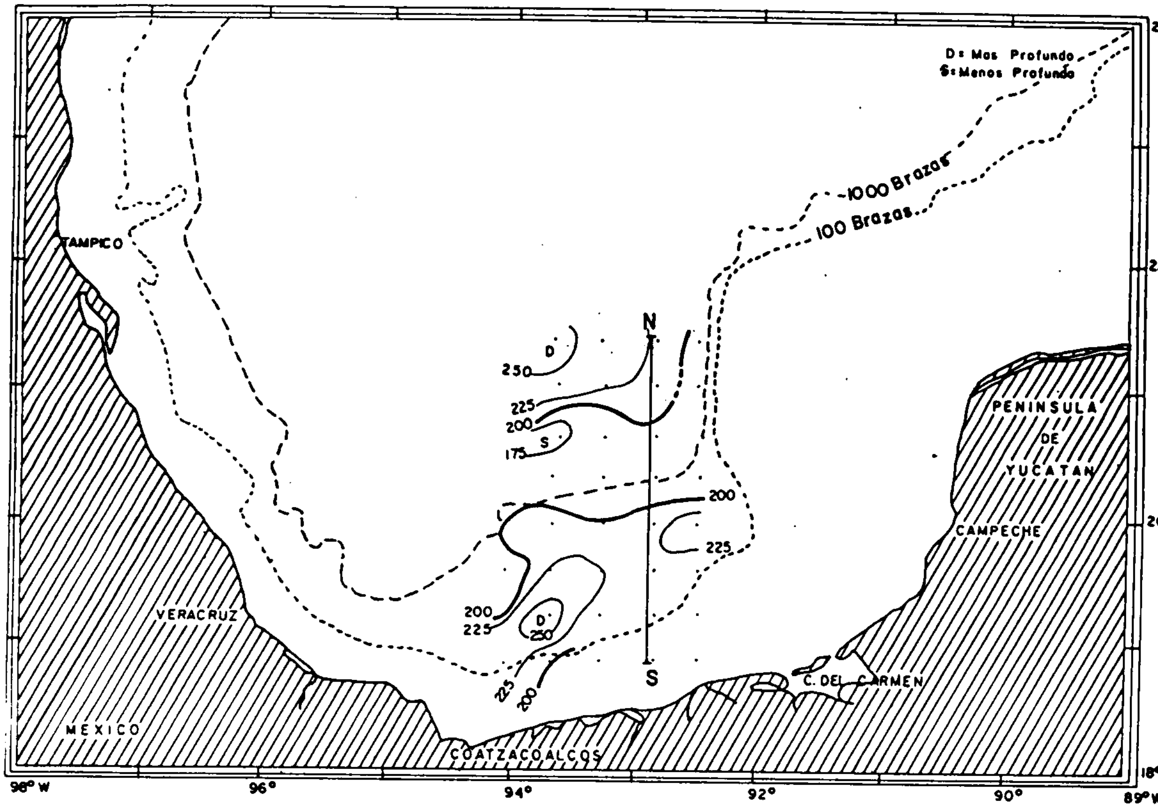


Figure IVC.4 - Topografia (Metros) de la Superficie Isotermica de 15°C
4-12 Febrero 1985

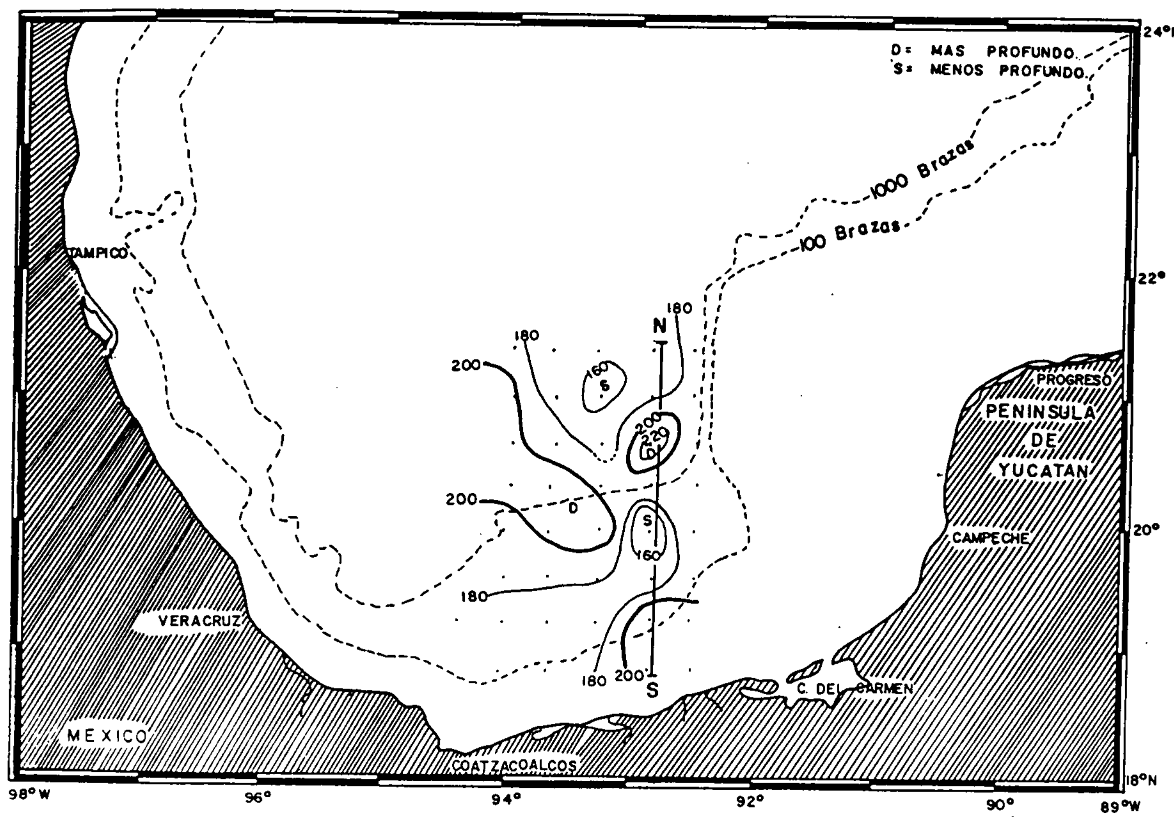


Figure IVC.5 - Topografia (Metros) de la Superficie Isotermica de 15°C
16-26 de Mayo de 1985

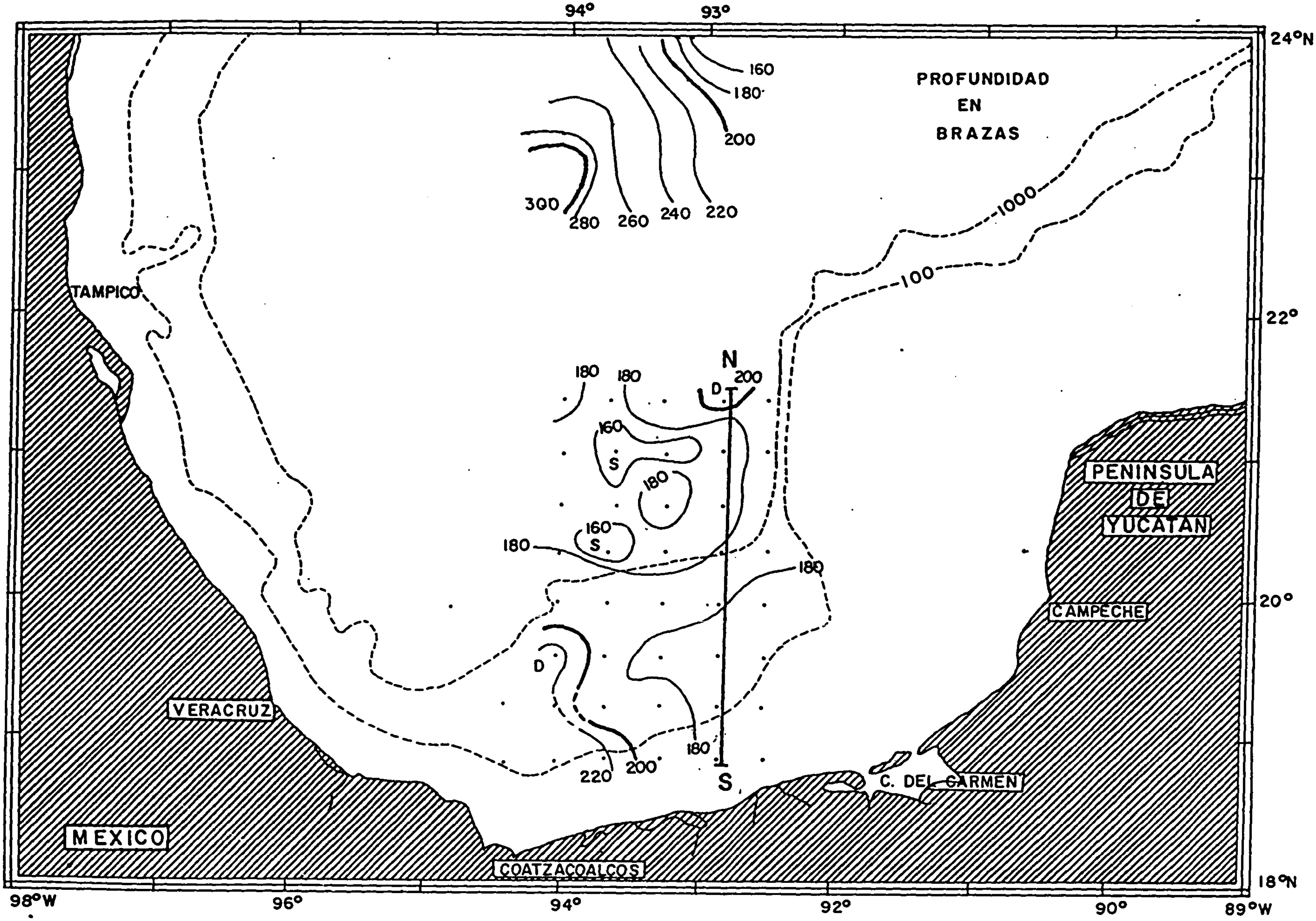


Figure IVC.6 - Topografia (Metros) de la Superficie Isotermica de 15°C
9-19 de Septiembre de 1985

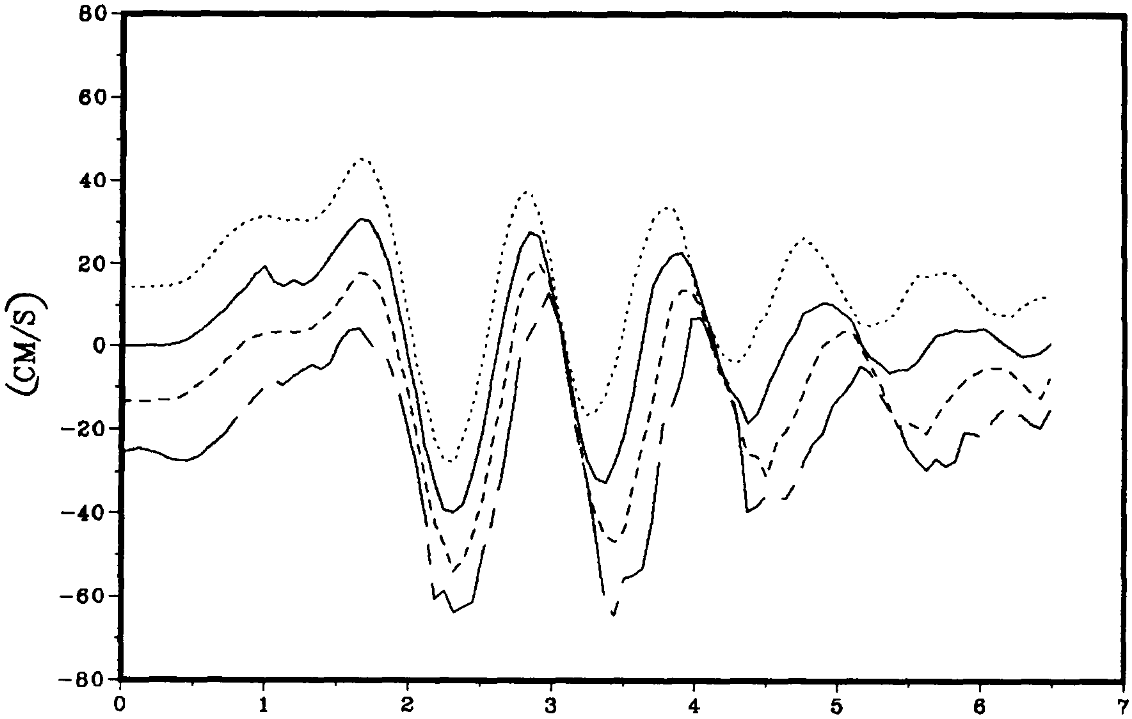


Figure IVC.7 - V-Component Time Series of Numerical Simulations for the Control C (Solid), +V (Dotted), -V (Dashed) and -2V (Dashed-Dotted) Experiments

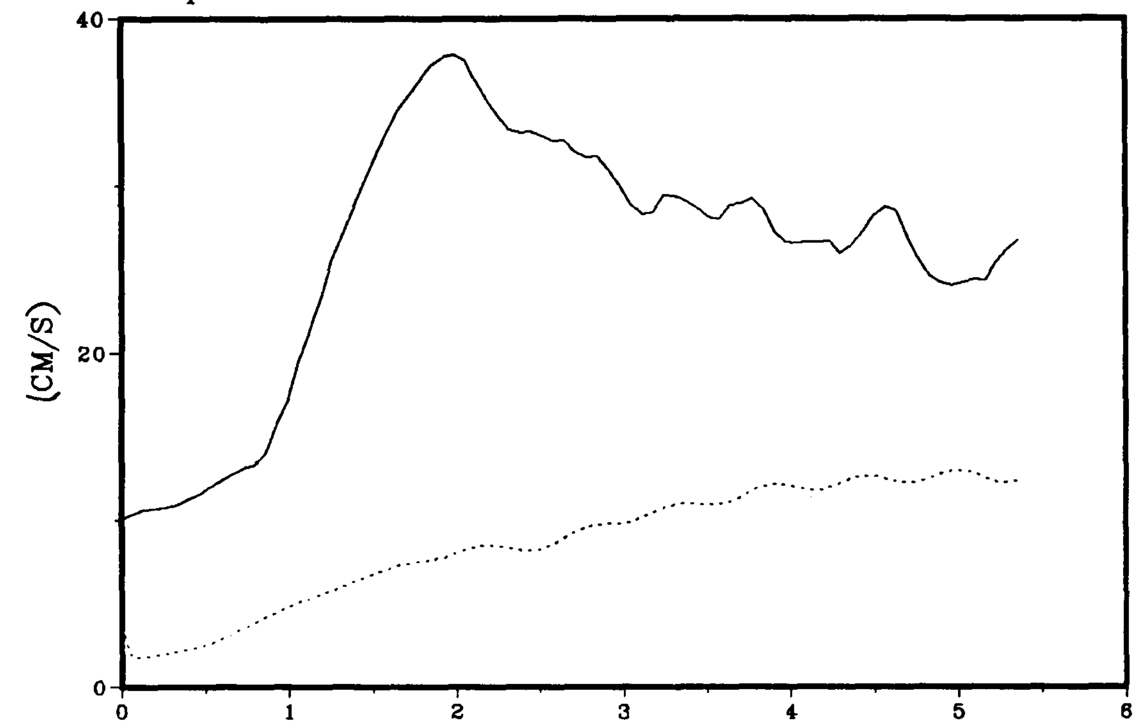
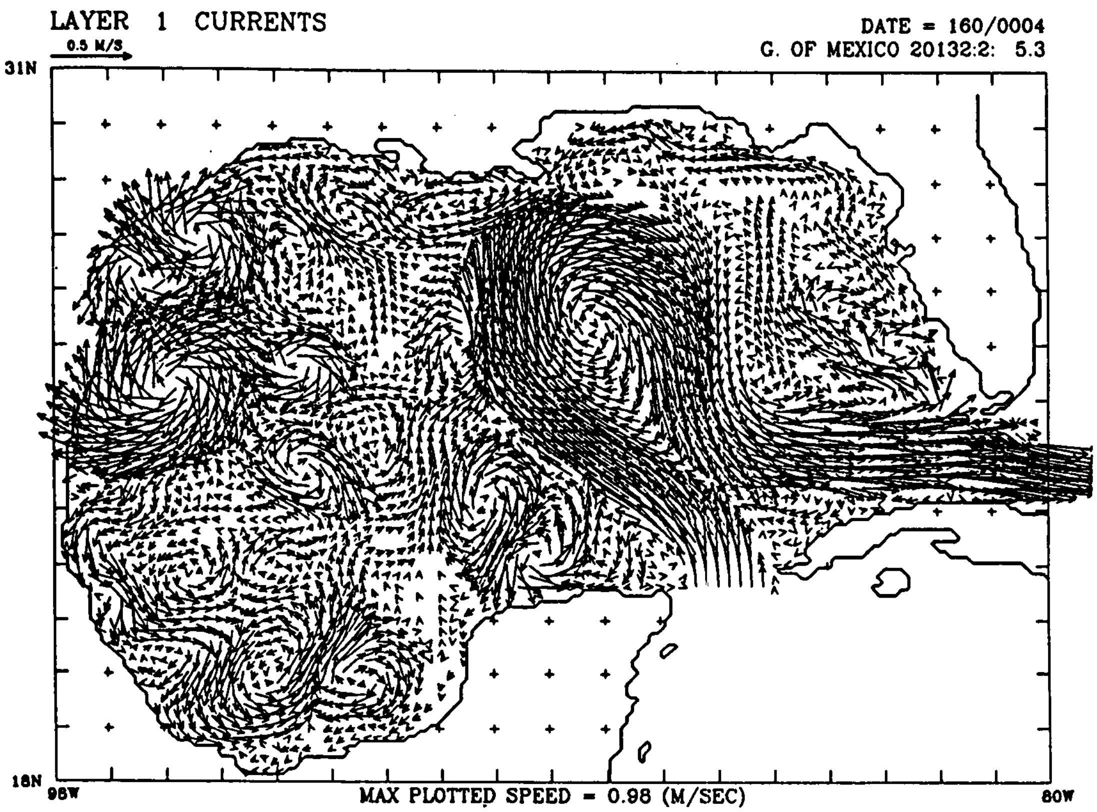


Figure IVC.8 - Time Series of Thermocline Current Amplitudes Averaged Over Running Inertial Periods for the Frederic Observations (Solid) and the Numerical Simulations for the -V Initial Flow (Dashed)

Figure IVC.9 - Instantaneous View of Upper and Lower Layer Depth Averaged Velocities from Experiment 20132:2:5.3 on Model Day 160 of Model Year 4. This Experiment is Driven Entirely by Inflow Through the Yucatan Straits. Vectors are Only Plotted at Every Second Model Grid Point, i.e. Every 0.2 Degrees.



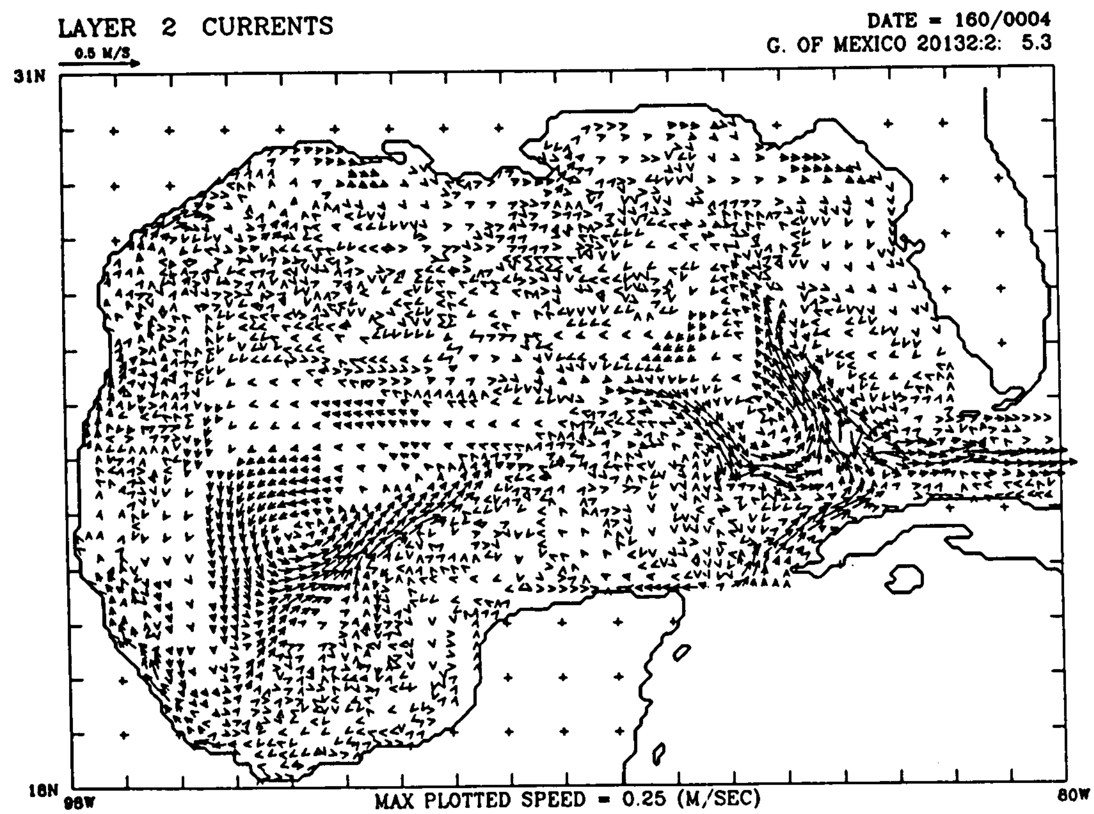
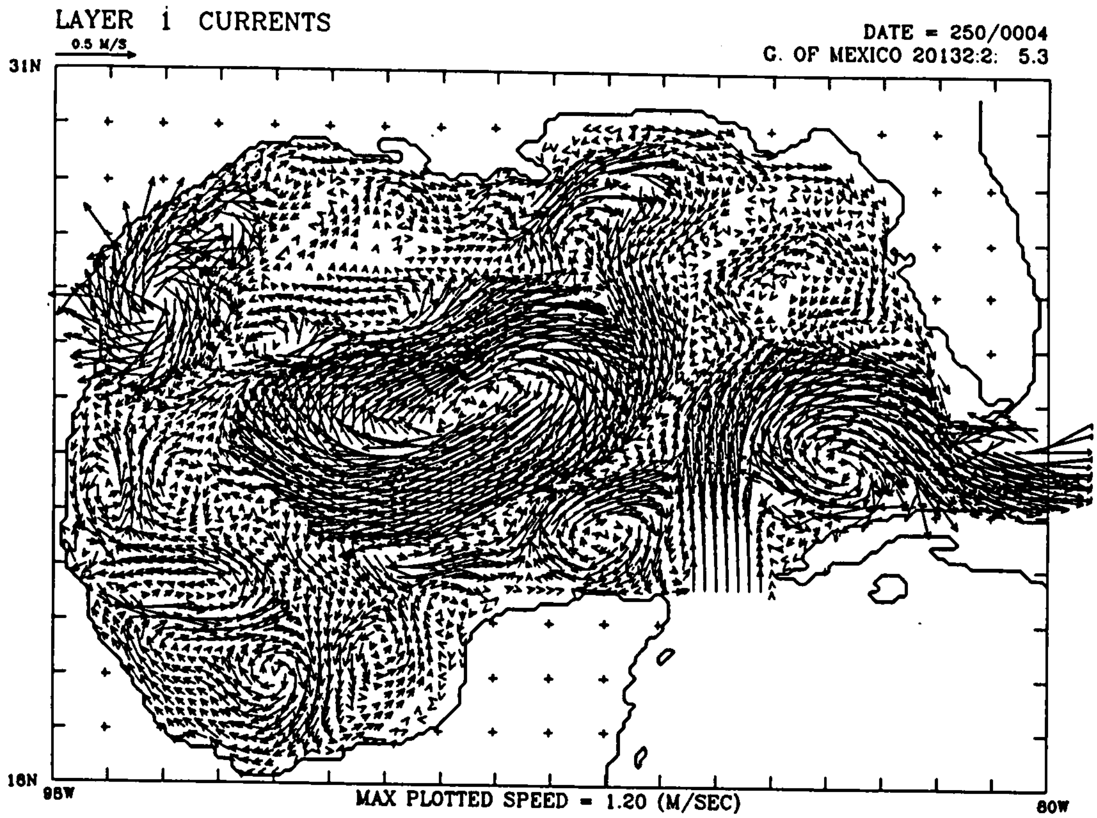


Figure IVC.10 - Instantaneous View of Upper and Lower Layer Depth Averaged Velocities From Experiment 20132:2:5.3 on Model Day 250 of Model Year 4.



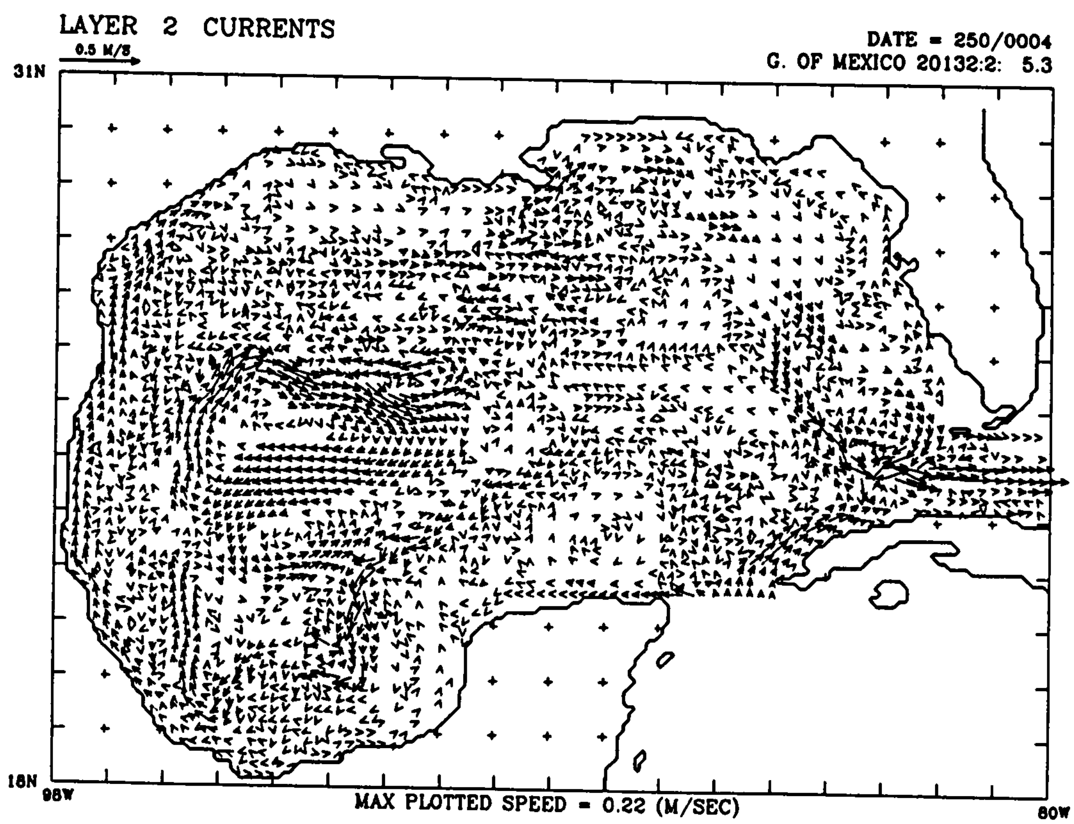
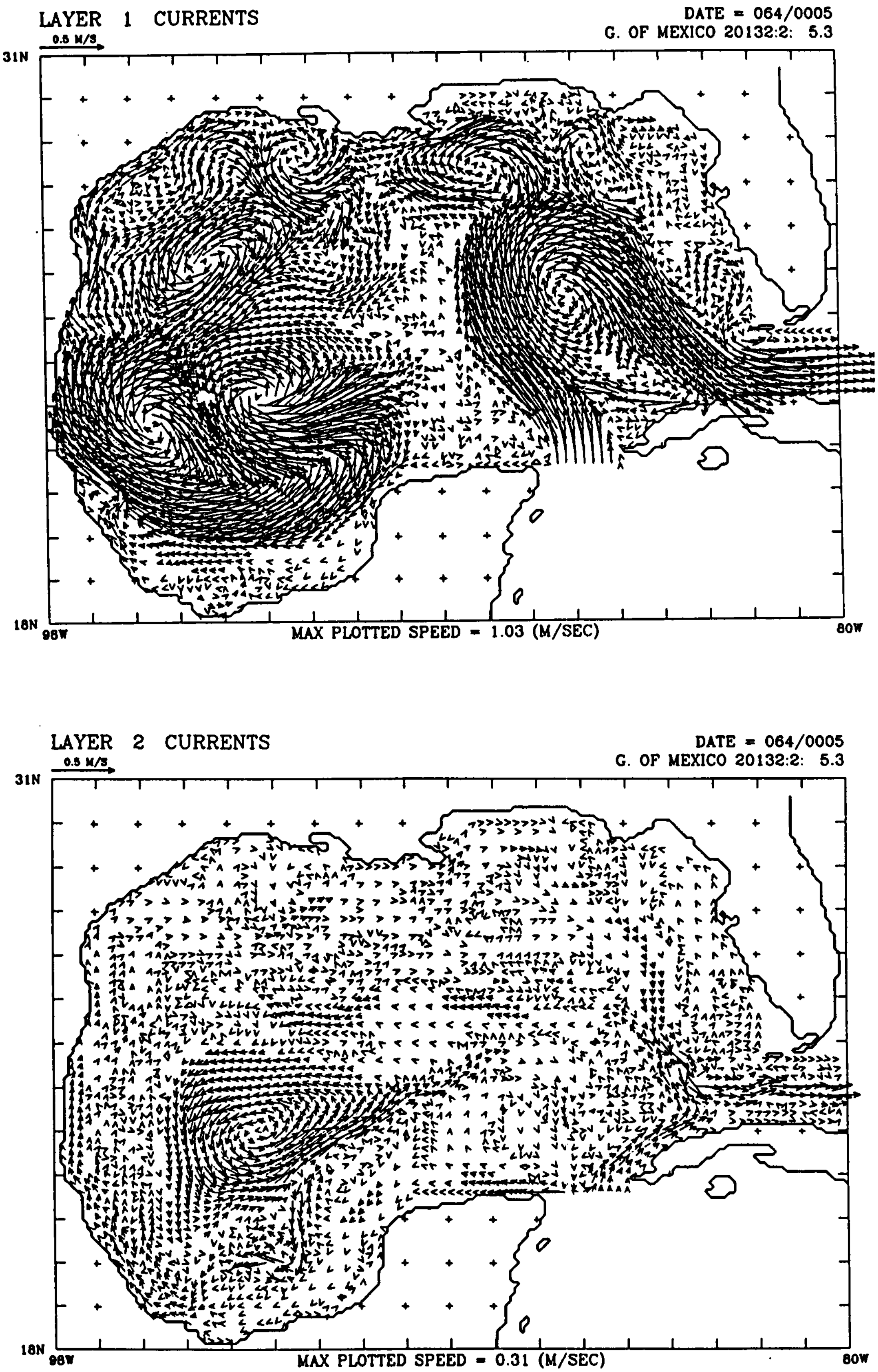


Figure IVC.11 - Instantaneous View of Upper and Lower Layer Depth Averaged Velocities From Experiment 20132:2:5.3 on Model Day 64 of Model Year 5



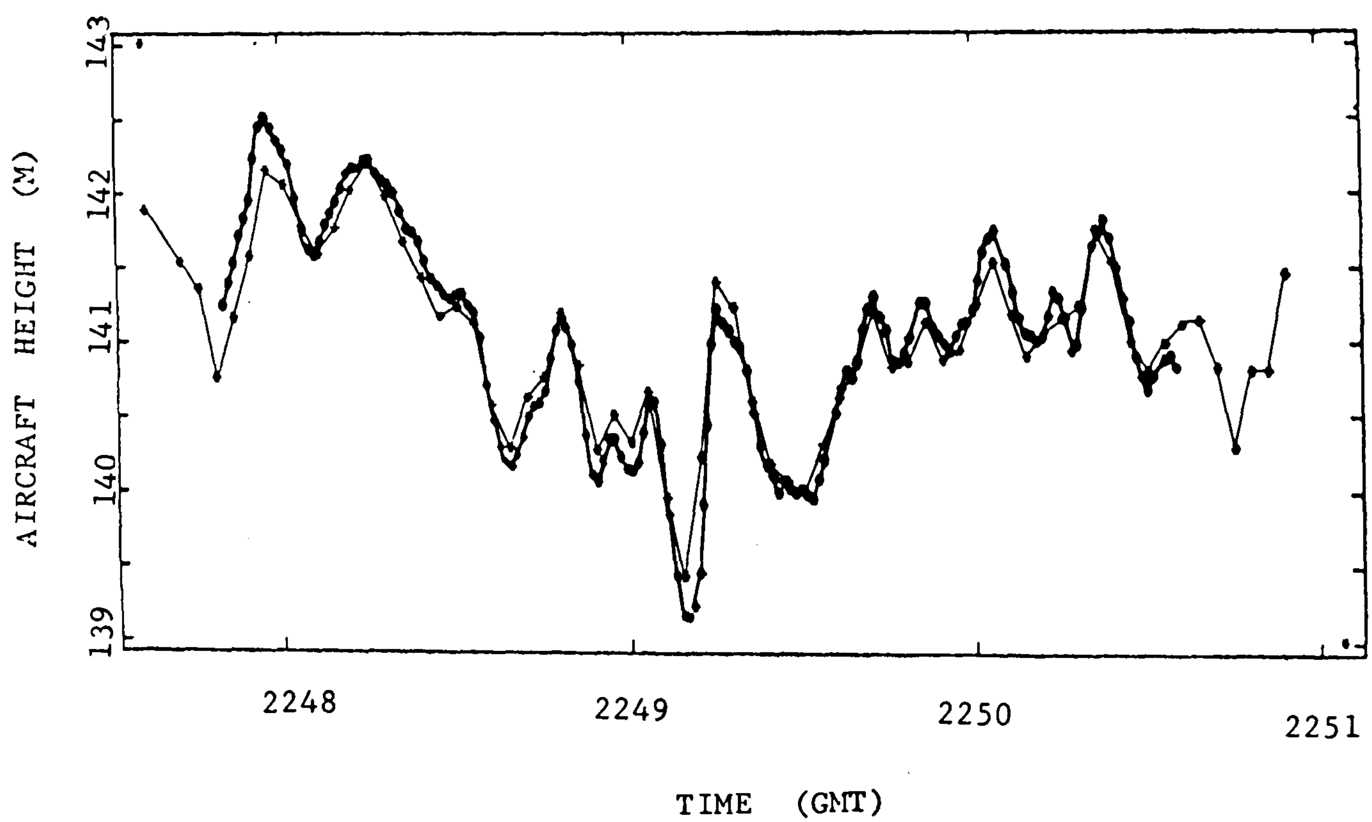


Figure IVC.12 - Profiles of Aircraft Height Above Chincoteague Bay Determined from GPS and the Onboard Laser Altimeter During the July 1985 Test Flight. GPS Positions Computed at 3-Sec Intervals are Shown by the Thin Line. Altimeter Measurements Averaged Over 1-Sec Intervals are Shown by the Thick Line. RMS Agreement Between the Two Independent Measurements is Better than 10 cm Demonstrating the Ability of Differential GPS to Determine Accurately the Trajectory of an Aircraft. This new Capability Will Enable the Aircraft Altimeter to Map Sea Surface Topography Much Like a Satellite Altimeter. The Aircraft System has the Added Advantages of Synopticity and the Ability to Gather Simultaneously Subsurface Ocean Structure Data by Deploying Expendable Instruments

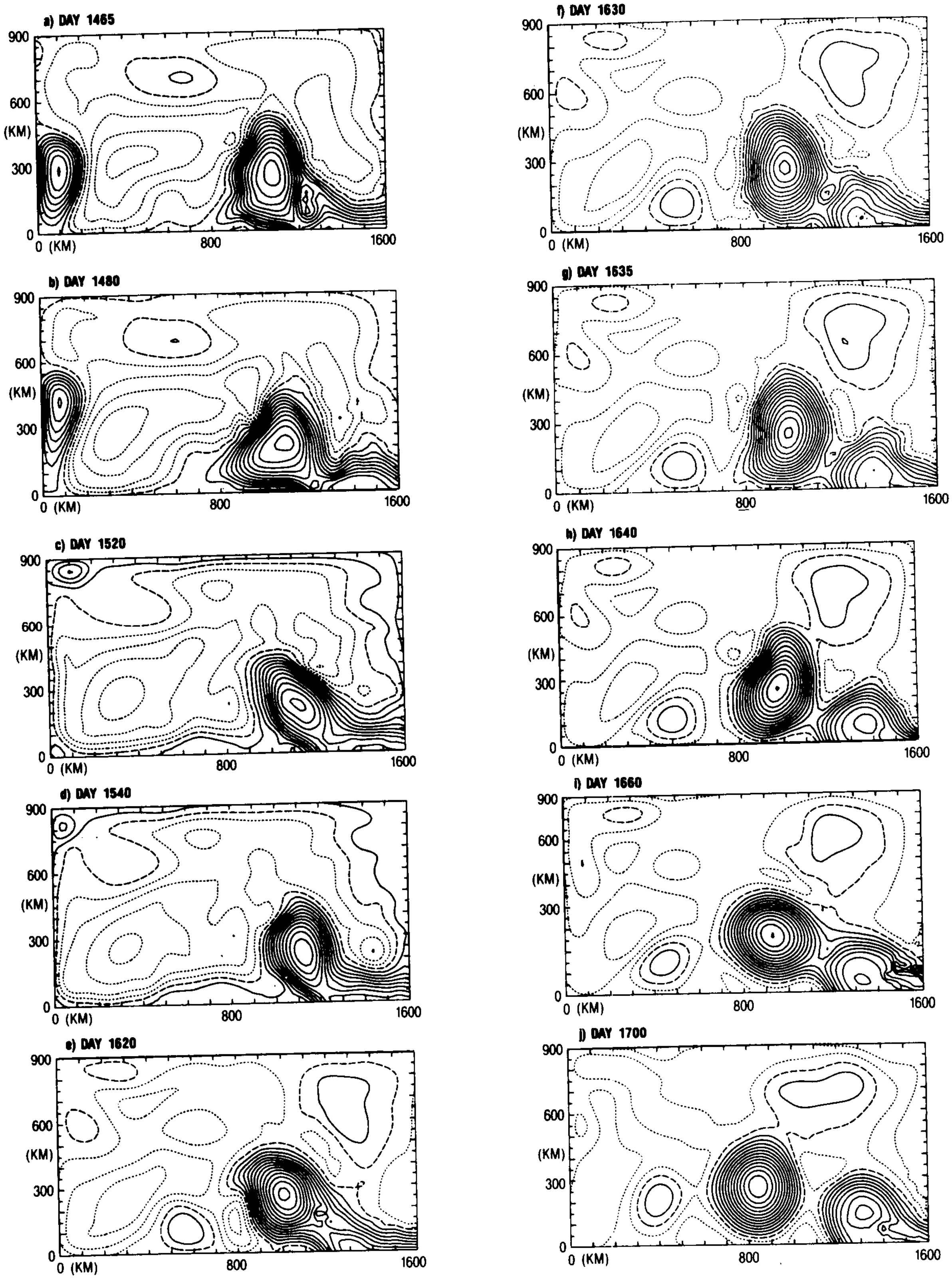


Figure IVC.13 - Maps of Density Normalized Pressure Anomaly in the Upper Layer, p_1, From an Idealized Simulation of the Gulf of Mexico. The Simulation Shows the Evolution of Two Types of Cyclonic Eddy Associated with the Model Loop Current in the Eastern Part of the Basin. The Contour Interval is $.5 m^2/s^2$ With Dashed Contours ≤ 0. Because $p1 = g_n$, the Contours for p_1 are Approximately 5 cm Contours for the Free Surface Elevation, n.

OIL DISPERSANTS II: BIOLOGICAL EFFECTS

Session: OIL DISPERSANTS II: BIOLOGICAL EFFECTS

Chairmen: Ms. Laura Gabanski
Mr. Ken Graham

Date: October 23, 1985

Presentation Title	Speaker/Affiliation
Session Summary for Oil Dispersant II: Biological Effects	Ms. Laura Gabanski Minerals Management Service
Methodology for Dispersed Oil Toxicity Studies with an Overview of Findings	Dr. Jack W. Anderson, Director Southern California Coastal Water Research Project Authority
A Field Trial on Dispersant Use in Tropical Coastal Waters	Charles D. Getter and Mr. Thomas Ballou Research Planning Institute, Inc.
Effects of Oil and Dispersants on Rhizophora Mangroves	Dr. Howard J. Teas Biology Department University of Miami
Effects of Chemical Dispersants and Dispersed Oil on Birds	Dr. Peter H. Albers U.S. Fish and Wildlife Service
Impact of Crude Oil and Methods of Restoration in a Gulf of Mexico Salt Marsh	Dr. J.W. Fleeger and Dr. R.D. DeLaune and Mr. W.A. Patrick, Jr. Louisiana State University

Session Summary for Oil Dispersant II: Biological Effects

Ms. Laura Gabanski
Minerals Management Service

The Oil Dispersants II: Biological Effects Session consisted of an introductory paper on methods for dispersed oil toxicity studies and papers on biological effects of dispersants on tropical marine communities, rhizophora mangroves, avian life, and a salt marsh.

Dr. Jack Anderson, Director of the Southern California Coastal Water Research Project Authority, presented a paper entitled "Methodology for Dispersed Oil Toxicity Studies With an Overview of Findings." Dr. Anderson found that dispersant alone was ten times less toxic than oil to the mysid, Mysidopsis bahia in 96-hour LC50 tests. In studies with He discovered that the shrimp *Pandalus danae* was three times more tolerant in the fall than in the spring to dispersed oil. Also, dispersed weathered oil was seven times less toxic than dispersed fresh oil to the same species. Dr. Anderson found that oil particles were toxic to fish whereas the aromatic component of oil was toxic to shrimp. In field experiments, he found oil to be more toxic to detritovores than to filter feeders. Finally, Dr. Anderson recommended using toxicity index, that is, the number of days it takes to attain 50% mortality times the concentration in parts per million as a basis of comparison for constant concentration and dilution exposures.

Mr. Thomas Ballou, with the Research Planning Insitute, Inc., presented a paper entitled "A Field Trial on Dispersant Use in Tropical Coastal Waters." Mr. Ballou and his colleagues studied the effects of dispersed oil on tropical marine ecosystems, which included coral, seagrass, and mangrove communities. They found that oil had a much greater impact on mangroves than did dispersed oil. Also, both dispersed and undispersed oil had no effect on seagrass growth rates. However, sea urchins and sponges within the grass beds were very sensitive to dispersed oil but unaffected by oil alone. Finally, dispersed oil had a greater effect on growth rates and epifauna and epiflora of corals than did oil alone.

The next presentation entitled "Effects of Oil and Oil Dispersants on Rhizophora Mangroves" was given by Dr. Howard Teas, of the University of Miami. Dr. Teas found that oil causes mortality in rhizophora mangroves by dissolving the lipid component of cell membranes allowing salt to enter the subsurface roots. In his experiments, Dr. Teas discovered that a glycol ether-based dispersant applied to oil before it reaches the subsurface roots resulted in no difference in plant mortality from the controls.

Dr. Peter Albers, of the U.S. Fish and Wildlife Service, presented a paper entitled "Effect of Chemical Dispersants and Dispersed Oil on Avian Life." Dr. Albers indicated that there is very little research on the effect of dispersants on birds. He stated that there is no evidence that dispersed oil causes birds less harm than oil alone. However, since there is a paucity of research, more work needs to be done, particularly using real world field situations, to determine if dispersing oil into the water column causes less harm to birds than untreated oil.

Dr. John Fleeger, of Louisiana State University, presented the last paper, entitled "Impact of Crude Oil and Methods of Restoration in a Gulf Coast Salt Marsh." The effects of various methods of marsh restoration, including the use of a dispersant, for oil spill mitigation in a *Spartina alterniflora* salt marsh were studied. Dr. Fleeger and his colleagues found that the crude oil only application resulted in no reduction of macrophyte standing crop or gross Carbon Dioxide-Carbon fixation rate; however, the dispersant followed by oil treatment did. They reported that macrofauna and meiofauna exhibited no oil-induced mortality. Macrofauna density decreased in the dispersed oil treatment plots, whereas meiofauna did not exhibit a change in density. The authors concluded that the best response to oil spills in salt marshes is no cleanup at all.

Ms. Laura Gabanski is an oceanographer with the Minerals Management Service Gulf of Mexico Regional OCS Office. She has been analyzing issues concerned with the use of dispersants over the past year for Gulf of Mexico OCS environmental impact statements. This work has included providing input to the Region 6 Regional Response Team Dispersant Working Group. She has also developed a study profile on dispersant toxicity for the MMS FY 1987 Proposed Studies Plan.

Ms. Gabanski received her BA degree in Biology from Lake Forest College and MS degree in Oceanography from Old Dominion University.

Methodology for Dispersed Oil Toxicity Studies with an Overview of Findings

Dr. Jack W. Anderson, Director
Southern California Coastal Water Research Project Authority

Screening tests have been conducted to compare the relative effectiveness and toxicity of most of the available chemical oil dispersants. Fourteen products were tested for effectiveness with Prudhoe Bay crude oil at 15°C using the Mackay-Nadeau-Steelman (MNS) apparatus.

Dilutions of the chemicals with seawater were tested on the mysid *Mysidopsis bahia*, to produce 96-hour LC50 values (25°C). These values were combined with the effectiveness data to produce a ranking where the most acceptable products were most effective and least toxic. Cost of the chemical could also be used in the ranking, where effectiveness times cost is divided by LC50 values. The lowest ratio would be the most acceptable chemical.

Dispersed oil research has shown that the product of time (in days) and concentration (in ppm), called the toxicity index (in ppm-days), can be used to define the tolerance of different species under various flowing exposure conditions. For the shrimp *Pandalus danae*, the toxicity index was between about 3 ppm-days (summer) and 10 ppm-days (winter) when tested under both constant and diluting (8- and 24-hour) exposure conditions. Using fractions of Prudhoe Bay crude, the elimination of monoaromatics (alkylbenzenes) from the oil produced a dispersed oil which was seven times less toxic than fresh oil. While the tolerance of shrimp was related to the aromatic content of the oil, drastic reduction of these compounds in the test fraction did not greatly alter the effects on the fish *Ammodytes hexapterus* (sand lance). Most mortality in sand lance occurred between four and seven days both during and after exposure, indicating a gradual deterioration in metabolic systems.

Field experiments conducted with trays of sediment (control, oiled, and oil plus dispersant) have shown little if any difference in the effects of oil alone or oil plus dispersant at equal total ppm of hydrocarbons. The detritivore *Macoma inquinata* is more sensitive and accumulates more aromatic hydrocarbons than the filter-feeding clam *Protothaca staminea*. Recent field experiments have shown that dispersions of oil in shallow water have produced surface sediment concentrations of about 20-100 ppm, and these levels are much lower than those used in our tests (2,000-3,000 ppm) with *M. inquinata* and *P. staminea*.

It is recommended that future screening tests for new dispersants use approaches similar to ours. After the effectiveness and toxicity of the specific dispersant chemical have been defined, the organisms and environment of concern should dictate additional experimentation. Key factors to consider in the Gulf of Mexico are volatilization-toxicity relationships (including response time and effectiveness), impacts on larval shrimp, and the relative sorption of droplets of dispersed oil or droplets of oil alone to suspended sediments.

REFER TO TABLES IVD.1 AND IVD.2.

Dr. Anderson was recently appointed Director of Southern California Coastal Water Research Project Authority in Long Beach, CA. His previous position was Associate Manager of the Marine Research Laboratory of Battelle, Pacific Northwest (1976-1985). Past and present research has concerned the effects of physical and chemical perturbations of estuarine and marine ecosystems on the physiology of organisms.

Dr. Anderson received his BA and MA in Biology from California State University, Long Beach, and his PhD from the University of California, Irvine.

A Field Trial on Dispersant Use in Tropical Coastal Waters

Charles D. Getter
and
Mr. Thomas Ballou
Research Planning Institute, Inc.

Research Planning Institute, Inc., (RPI) has implemented a long-term program of research on the fate and effects of oil spills and dispersants on coastal tropical areas. Tropical Oil Pollution investigations in Coastal Systems (TROPICS) is an integrated study to allow examination of possible trade-offs of impacts between intertidal and subtidal tropical ecosystems and to establish whether the application of dispersant to spilled oil in nearshore tropical areas is an ecologically safe means of minimizing damages to these habitats.

Studies have been conducted to measure biological, chemical, and physical parameters prior to, and for seven months after, experimental spills. Monitoring of the fate and effects of dispersed and undispersed oil in the nearshore tropical ecosystem will be conducted for one and a half years after the experimental treatments. Detailed measurements are being made of the mangroves and seagrasses to determine effects on primary productivity, growth, general condition, and survival. Infauna and epifauna are being monitored to estimate changes in density and diversity, and motile macrofauna are being observed to determine changes in distribution and behavior. Corals are being measured to determine changes in growth, abundance, and coverage; and the infauna, epifauna, and resident fish communities are being monitored as well. Chemical monitoring of the water column, sediments, and biota is being conducted using discrete and flow-through pumping techniques, utilizing large-volume extraction techniques, replicate sediment cores, and tissue samples of dominant biota. Samples are being analyzed using ultraviolet fluorometry (UV), gas chromatograph (GC), and GC/mass spectrometry.

Preliminary results indicate that dispersant usage on oil spills may be useful in the prevention of intertidal (mangrove forest) damages. The majority of focus presently is on the "subtidal trade-offs" at the sites, which include changes in seagrass/coral communities adjacent to the mangrove shoreline.

Mr. Thomas Ballou received a BS degree in Biology at the University of South Carolina. He is working toward his MS degree at the University of South Carolina in the Department of Marine Science. His research deals with the effects of oil and dispersants on marine gastropods. Mr. Ballou is also a research assistant at the Research Planning Institute, Inc., in Columbia, SC, where his research experience includes field and laboratory studies on the effects of oil and dispersants on the marine environment.

Effects of Oil and Dispersants on Rhizophora Mangroves

Dr. Howard J. Teas
Biology Department
University of Miami

Rhizophora mangroves are widely distributed on a worldwide basis and are frequently the ones impacted by oil. The results reported at the Information Transfer Meeting were from experiments begun in 1983, using *Rhizophora* mangroves growing along the banks of an unused seawater cooling canal at the Florida Power and Light Company's Turkey Point Power Plant, which is located about 25 miles south of Miami, FL. Replicated plots of mangroves were used for the experiments. Unweathered south Louisiana crude oil at a rate of 10 gal per sq m was used for oil treatments. One treatment was oil only; in another, oil-treated mangrove plots were given a 24-hour post-oiling spray with high pressure (100 pounds per sq in.) seawater directed at the soil and prop roots. Other plots received 24-hour post-oiling spray washes with non-ionic water-based dispersant in seawater. Control plots were untreated or were given washes with seawater or non-ionic water based dispersant in seawater. Another set of plots was treated with oil plus glycol ether-based dispersant applied to the soil and lower prop roots of the trees in a low pressure seawater spray.

Tree health was reported for 6, 12, 18 and 24 months. Oil treatment resulted in the eventual deaths of approximately 30-50% of the trees, with or without post-oiling washes. Approximately 4-7% of trees in control plots were dead at 24 months; however, only 3% of trees treated with oil dispersed in glycol ether based dispersant died in 24 months. Mortalities from oil or oil followed by washes were significantly different from controls as well as from the oil plus glycol ether-based dispersant treated plots.

It was concluded that there is probably no value in treating oiled Rhizophora trees with high pressure seawater or dispersant plus seawater washes after 24 hours. The very low mortality from treatment with oil plus glycol ether-based dispersant suggests that every effort should be made to disperse oil slicks before they reach shore because dispersed oil appears to be nontoxic to mangroves. Protection of mangroves from oiling is especially important because the restoration of an oil-killed mangrove shoreline by natural regeneration requires at least 15-20 years, and even this regrowth may not occur if shoreline erosion results from the loss of mangroves.

Dr. Howard J. Teas is a professor of Biology at the University of Miami. He has worked on physiology and ecology of mangroves for the last 12 years. The present project summarizes work on oil and dispersants carried out under an American Petroleum Institute grant. His coworkers were Dr. Eirik O. Duerr, Research Associate, University of Miami, and Dr. J. Ross Wilcox, Chief Ecologist with the Florida Power and Light Company. Dr. Teas obtained his PhD from the California Institute of Technology.

Effects of Chemical Dispersants and Dispersed Oil on Birds

Dr. Peter H. Albers
U. S. Fish and Wildlife Service

Birds can be protected from spilled oil by (1) removing the oil before it reaches birds, (2) moving birds out of the path of the oil, or (3) altering the physical nature of oil so that its impact on birds is decreased. The first two methods are often inadequate, particularly in large spills or during bad weather. The use of chemical dispersants is an alternative that is faster and easier than removing the oil or moving the birds. Dispersants move oil from the water surface into the water column, where it is kept by wave action. It is assumed that the minute particles of dispersed oil will not adhere to bird feathers and that the chemical dispersant in the water will not adversely affect birds.

Tests of dispersant effectiveness permit estimates of the proportion of surface oil removed, but there is no published field evidence on the efficacy of dispersants in protecting birds from surface oil. Laboratory work with mallard ducks (*Anas platyrhynchos*) showed that ducks exposed to dispersant (6.7 ppm in water) in water were less bouyant and stayed wet longer than controls or ducks exposed to oil. Ducks exposed to dispersed oil (oil:dispersant ration of 30:1) were just as soaked as ducks exposed to dispersant alone and had plumage that was just as matted as the ducks exposed to oil. Ducks exposed to oil and dispersed oil exhibited significantly increased basal metabolic rates when placed in a cold chamber immediately after 1 hour of exposure. Ducks exposed to dispersant did not exhibit an increase, but the investigators were concerned that if the ducks were exposed longer than 1 hour to the dispersant in water, the observed wetting of feathers would increase. Some aspects of the previously described work[1] are questionable, but it is appropriate to conclude that the dispersant tested (Corexit 9527) might not be as beneficial as previously assumed, particularly if the dispersant is sprayed on the birds. Theoretical calculations indicate that the amount of dispersed oil picked up by a bird diving through subsurface water beneath a chemically dispersed oil slick would be very small.[2] Experimental confirmation of these estimates and a determination of the minimum amount of oil needed to kill a diving bird are needed.

A few toxicological investigations have evaluated the effects of dispersants (mostly Corexit 9527 or unidentified Corexit dispersants) on seabirds and mallard ducks. Studies using wild birds, i.e., herring gulls (*Larus argentatus*) and Leach's storm-petrel (*Oceanodroma leucorhoa*) showed that ingested dispersant or dispersed crude oil had no greater impact on weight gain, organ weights, corticosterone levels, or plasma thyroxine levels than did crude oil alone.[3,4,5] Ingested dispersant and ingested dispersant mixed with crude oil had less of an effect on the weight gain and blood chemistry of young mallards than crude oil alone.[6] An egg-oiling experiment revealed that dispersant alone or mixed with crude oil was as toxic to mallard embryos as crude oil.[7] Dispersant sprayed on water did not affect mallard incubation or egg hatching, and mallards exposed to partially dispersed crude oil had about the same hatching success as those exposed to undispersed crude oil.[8] Dispersed crude oil caused a greater reduction in mucosal water and Na^+ transfer in the intestines of pekin mallard ducklings than did undispersed crude oil.[9] In summary, published research indicates that dispersants should not be sprayed on birds or their eggs, and that ingestion of dispersed oil might cause some negative effects on salt water tolerance.

Guidelines for the use of chemical dispersants in oil spill response have been developed, or are in the process of development, by the American Society for Testing and Materials,[10] various federal and state agencies, and regional oil spill cooperatives. Considerations for all components of the coastal ecosystem will be incorporated into decisions for the use of chemical dispersants.

[1] Lambert et al. 1982. Bull. Environ. Cont. Toxicol 29:520-524

[2]Peakall et al. 1985. Unpublished manuscript

[3]Butler et al. 1979. Bull. Mt. Desert Is. Biological Lab. 19:33-35

[4]Miller et al. 1980. Bull. Mt. Desert Is. Biological Lab. 20:137-138

[5]Peakall et al. 1981. Environ. Res. 24:6-14

[6]Eastin and Rattner. 1982. Bull. Environ. Contam. Toxicol. 29:273-278

[7]Albers. 1979. Bull. Environ. Contam. Toxicol. 23:661-668

[8]Albers and Gay. 1982. Bull. Environ. Contam. Toxicol. 29:404-411

[9]Crocker et al. 1974. Environ. Pollut. 7:165-177

[10]Lindstedt-Siva et al. 1984. STP 840, ASTM, Philadephia, PA pp 363-377

Dr. Peter H. Albers is a wildlife biologist with the U.S. Fish and Wildlife Service at the Patuxent Wildlife Research Center, Laurel, MD. He has conducted research on the effects on wildlife of petroleum, metals, acidic deposition, and agricultural pesticides. Dr. Albers is a member of an ASTM Task Force developing guidelines for the use of chemical dispersants in oil spill response and is author of the section on birds.

Dr. Albers received his BS from the University of Montana, his MS from the University of Guelph, Ontario, Canada, and his PhD from the University of Michigan.

Impact of Crude Oil and Methods of Restoration in a Gulf of Mexico Salt Marsh

Dr. J.W. Fleeger
and
Dr. R.D. DeLaune
and
Mr. W.A. Patrick, Jr.
Louisiana State University

South Louisiana crude oil (2 liters $\cdot$ m^{-2}) was applied to replicated plots in a Louisiana *Spartina alterniflora* salt marsh. Various marsh restoration methods were evaluated for mitigating the impact of crude oil on salt marsh biota. Treatments included (1) control - no oil; (2) oil only - no clean up; (3) oil application with mechanical water flush after 24 hr - flush rate of 632 l $\cdot$ min^{-1} for 5 min; (4) oil followed by application of water-based detergent (dispersant) followed by water flush -

dispersant concentration 0.3 $1 \cdot m^{-2}$; (5) dispersant followed by water flush; (6) dispersant followed by oil - no water flush to simulate aerial application and (7) oil followed by removal of vegetation. Macrophyte effects were determined by dry weight measures of standing crop after 1 year and by periodic measure of Carbon Dioxide fixation rates. Macroinfauna and meiofauna densities were estimated before and at various dates up to 144 days following oil application. Oiling the marsh caused no reduction in macrophyte standing crop or gross Carbon Dioxide fixation rate. Cleanup was therefore not beneficial to *S. alterniflora*. Undiluted dispersant (with no water flush) did reduce macrophyte standing crop and Carbon Dioxide fixation. Macroinfauna and meiofauna showed no oil induced mortality. Macroinfauna decreased only in treatments with oil and dispersant mixed, indicating that oil and dispersant are more influential together than either one alone. Meiofauna densities increased in oiled plots from 5 to 60 days after application. Nematodes increased first, followed by copepods. Meiofauna did not respond to treatments with dispersant; however densities did increase in water-flushed and clipped plots. Given the modest effect of crude oil on all levels of biota examined, the best response to oil application is no cleanup action at all.

Dr. John W. Fleeger is an Associate Professor of Zoology at Louisiana State University. His research interests include benthic ecology, marine zoology, and theoretical ecology. Dr. Fleeger received the BS degree from Slippery Rock University; MS degree from Ohio University; and PhD from University of South Carolina.

	Prudhoe Bay crude		PBC + dispersant E		PBC + dispersant B	
	Spring and Summer	Fall and Winter	Spring and Summer	Fall and Winter	Spring and Summer	Fall and Winter
Constant exposures	4 + 0.1* (12)	16 + 0.8 (6)	-	11 + 1.1 (12)	8 + 1.3 (10)	-
Dilution exposures						
8 hour			-	8 + 0.3 (8)	8 + 0.4 (3)	>7 - 12 (4)
24 hour			5 + 0.5 (15)	10.0 + 0.6 (16)	5.6 + 0.4 (3)	12 + 1.1 (9)

* The values shown are means and standard errors and the parenthetical values are the numbers of the data points which consisted on one tank with 30 animals in constant flow tests or one tank of 20 animals each in diluting exposures.

Table IVD.1 - Summary of Toxicity Index Data (PPM-Days) for *Pandalus Danae* and Dispersed and Non-dispersed Prudhoe Bay Crude Oil

Dispersant	(15°C) Dispersant:Oil Ratio (DOR_{90})[1] ($x10^3$)	(25°C) 96-H LC_{50} PPM	RET[2]
Arochem D-609	7	29.0	2
Finsol OSR-7	38	204.0	2
Corexit 9527	9	31.9	3
Corexit 7664	500	515.0	10
Petrocon N/T#4	18	15.0	12
Magnus Maritec	12	8.0	15
Petromend	8	3.7	22
BP1100WD	9	1.4	64
BP1100X	150	17.0	88
Corexit 8667	28	2.0	140
Slick-A-Way	240	16.0	150
Ameriod	110	6.7	170
Conco K	580	3.5	170
Atlantol AT-7	130	6.6	197

[1] DOR_{90} is the ratio of dispersant to oil required to disperse 90% of the oil.
[2] RET = Relative effective toxicity = (DOR_{90} x 10^4)/LC_{50}.

Table IVD.2 - Relative Effective Toxicity

TRASH AND DEBRIS
ON GULF OF MEXICO SHOREFRONT BEACHES

Session: TRASH AND DEBRIS ON GULF OF MEXICO SHOREFRONT BEACHES

Chairmen: Mr. Villere Reggio
Mr. Raymond Churan

Date: October 23, 1985

Presentation Title	Author/Affiliation
Trash and Debris on Gulf Of Mexico Shorefront Beaches	Mr. Villere C. Reggio, Jr. Minerals Management Service and Mr. Raymond Churan U.S. Department of the Interior
National Parks and Seashores: Drums and Hazardous Waste	Mr. Max Hancock, Chief Ranger Padre Island National Seashore
Trash and Debris on the Beaches of Padre Island National Seashore	Mr. Robert King National Park Service Padre Island National Seashore
State and Local Beaches	Dr. John M. Gosdin, Director Natural Resources Division Office of the Governor of Texas
Removal, Sampling and Disposal of Abandoned Drums Containing Suspected Unknown Hazardous Substances from the Beaches of Mustang Island and Padre Island, Texas	Lieutenant Commander Glenn F. Epler United States Coast Guard
Marine User Group Panel Discussion, Petroleum Industry	Mr. John Burgbacher GOM Offshore Operators Committee
Shipping Industry Perspective	Mr. Joseph Cox American Institute of Merchant Shipping
The Recreation and Tourism Industry Perspective	Dr. Robert B. Ditton Department of Recreation and Parks
A West Coast Perspective	Ms. Judie Neilson Oregon Department of Fish and Wildlife

Trash & Debris on Gulf of Mexico Shorefront Beaches

Mr. Villere C. Reggio, Jr.
Minerals Management Service
and
Mr. Raymond Churan
U.S. Department of the Interior

This session was designed to focus primarily on inorganic, non-biodegradeable floatables, that is, solid waste products associated with use, development, and enjoyment of the marine environment and its resources. Although beaches can be affected by other derivatives of man and nature such as tar balls, oil spills, dead fish, or uneaten food stuffs, today we keyed in on those persistent products such as plastics, wood, rope, containers, marine implements, products, and byproducts manufactured by man, used by man, and disposed of by man. The common denominator is that these waste products are buoyant to some degree and are not readily digestible by the marine environment or its critters.

As the saying goes, "It's not nice to fool mother nature," for she will become ill and vomit the foreign matter she's unable to assimilate. Unfortunately the ocean's favorite place to get sick and chuck its undigested material is often on the beach, or the same place where man comes to enjoy the ocean. It's as if the sea is vindictive and trying to turn the tables by throwing its waste back at man where it hurts most. And hurt it does, for a beach strung with man's trash and debris adversely affects the quality of man's recreation experiences. It also increases beach maintenance and administrative costs and may even be a serious health hazard. Floating marine debris is also a hazard to navigation and a threat to marine mammals, birds, turtles, and fish.

Man's presence, range, use, mobility, and resource exploitation of the Gulf of Mexico has increased dramatically since the OCS program began about 30 years ago. That trend continues and accelerates through expanded national and international trade, expanded oil and gas leasing and discoveries, expanded fisheries development and enhancement, and an expanded military presence. The 80's have brought us new technologies, new initiatives, and new laws encouraging American expansion of fisheries, minerals, and economic development within 200 miles of our continental margins. As our presence offshore increases, our wasteload generated offshore also increases. The persistent floatables nonchalantly, innocently, inadvertently, or deliberately disposed of in isolated or congested locations inshore or far from shore are picked up by the Gulf's transport mechanisms, combined with similar instances occurring at hundreds, maybe thousands of locations throughout the Gulf every day and night, and are ultimately brought back to shore by nature, if not by man. Free floating trash is not evenly deposited or infrequent along our coastline but is chronic, growing, serious, and disportionately directed at some of our prime recreation and vacation shorefronts. The objective of this session was to gain a better understanding of the nature, scope, causes, and effects of the beach debris problem as it relates to the Gulf of Mexico and those knowledgeable and concerned with responsible use, development, and enjoyment of the marine environment. Without a better understanding of the nature of the problem, we cannot effectively begin to seek satisfactory solutions.

The National Park Service, the U.S. Coast Guard, and the State of Texas defined the scope and nature of the beach litter problem primarily affecting the Western Planning Area of the Gulf of Mexico. Texas and Oregon, two geographically and environmentally distinct states with a similar problem, demonstrate how concern and leadership at the state level can make a difference in understanding the beach litter problem and initiating comprehensive awareness campaigns, legislation, cooperation, and action projects to do something about it. The petroleum, shipping, and recreational industries document their concern for this problem and its effects and relate what specific actions are being taken or recommended within each industry to counteract, minimize, or further understand the causes and effects of beach trash derived from the marine environment.

As a final postscript, we quote from Secretary Hodel's message to all Interior employees in announcing the Department's public awareness campaign on citizen responsibilities for the public lands: "All Americans need to feel that public lands are really their lands. They need to take pride in them and treat them as carefully as they would their own lands."

Villere Reggio Biography: Please see Session II.F

Ray Churan is the Department of the Interior's Chief Environmental Coordinator for the Southwest Region of the United States. He serves as the Department's representative on the Regional Response Team responsible for overseeing and coordinating public and private responses to major pollution events. Ray has been instrumental in initiating public action and support in evaluating and removing potentially hazardous materials from Texas coastal beaches.

National Parks and Seashores: Drums and Hazardous Waste

Mr. Max Hancock, Chief Ranger
Padre Island National Seashore

Padre Island National Seashore in Texas; Gulf Islands National Seashore in Florida, Alabama and Mississippi; and Everglades National Park in Florida are the areas administered by the National Park Service which border the Gulf of Mexico. To one degree or another they all share the problem of trash and debris from the Gulf washing up on their shores. However, Padre Island National Seashore suffers the greatest impact. This area includes a barrier island which stretches from Corpus Christi in the north, 68 miles to Port Mansfield in the south. It is unique in that strong offshore Gulf currents, which are the movers of both surface and subsurface debris, converge near the Big Shell Beach area, which is roughly in the middle of the national seashore. These currents are instrumental in making Padre Island the biggest dumping grounds on the Gulf coast.

Of most immediate concern are 30- and 55-gallon drums. Prior to 1981, the National Park Service recognized that drums washing ashore on the National Seashore might contain substances hazardous to humans or the environment. This assumption was based on the following information.

1. Labeling on some drums indicated hazardous substances were originally contained in the drums and some might still contain the same material.

2. Some likely sources for the drums washing ashore are drill rigs, production platforms, crew boats, and cargo ships, all of which are known to carry or use hazardous materials.

3. Some drums bulged, indicating a reaction was had been taking place inside.

The National Park Service's concern for visitors and the environment was supported by the following observations:

1. Substances were noted leaking onto the beach from damaged and rusted drums.

2. Bullet holes in drums indicated visitors had been using the drums for target practice. Substances also leaked from the bullet holes.

3. Drums were being used by visitors as wind breaks and campfire reflectors, as indicated by the campfire remains.

Until 1981, the National Park Service picked up drums on an irregular basis as time and funds allowed. No records were kept on numbers. In 1981, the park obtained $10,000 for drum removal; 170 were collected. Owing to the length of time they had been rusting on the beach, only about 20 still contained substances. As the park personnel began trying to dispose of them, they became aware of the new laws which had been enacted which required that the contents be analyzed to determine proper disposal. A chemist and friend of the park arranged for testing free of charge. Most of the contents were petroleum-based, and there was no problem in disposal.

The park began keeping a rough count of the drums. In 1982, in the southern 55 miles of the park, there were 40; in 1983, 20 more had accumulated and it had increased to 60; and by April of 1984, there were 80. There were also 26 drums collected from the more concentrated visitor use areas in the northern part of the park. Twenty-one of these contained substances. However, because of stringent new regulations, they could not be disposed of.

In the fall of 1984, as a result of the reporting requirements of Section 103(c) of CERCLA, (Comprehensive Environmental Response, Compensation and Liability Act), the problem finally got the attention of higher authority and specialists from the Department of the Interior and NOAA made an on-site inspection. They agreed that there was indeed a problem. It was reported to the EPA, which declared the situation hazardous and made SUPERFUND money available for immediate cleanup through the Coast Guard Marine Safety Office in Corpus Christi.

On December 5, 1984, a planning meeting was held with all parties concerned, and on December 10, a response plan was finalized. Peterson Maritime under contract from the Coast Guard proceeded to remove 260 drums from the beaches between Port Aransas and the Mexican border (roughly 130 miles). One hundred twenty-six of these contained substances and were placed at a temporary holding site at the park along with 21 drums previously collected by the park. This action was completed on January 15, 1985. Contents of the 147 drums were sampled, analyzed, and disposed of through a contract with TECO, a hazardous waste dump at Robstown, TX. The cost of this first removal action was approximately $200,000.

The second removal action began while the testing and disposal for the first removal was still in progress. In January, 25 drums were collected. In February, 37 drums were collected. In March, 53 drums were collected, and in April, 37 drums were collected. Of the 152 drums assembled, 95 contained substances. These have been sampled and analyzed. However, as a result of stricter disposal laws, they remain at the park pending location of a suitable licensed disposal site.

The third removal action began on April 29, 1985, when a drum washed up on Malaquite Beach in front of the park's primary visitor use facility. A sheen around the drum indicated it was leaking. A portion of the beach was flagged off, and the Coast Guard was notified. Because of the contractor's location in Houston, it took seven hours for them to arrive. In a situation like this, additional impacts arise. First, if it is decided that a one hundred yard zone is required to safeguard the public, the entire beach is closed. In the summer, this deprives the public of the only guarded swimming beach in the park. The park concessioner relies on the public use at this beach for his livelihood. A drop in use greatly affects his profits. Since Malaquite Beach is a destination point for many people, closure requires media notification. This can lead to undue public alarm, since Malaquite Beach means all of the North Padre Island beaches to many people. In short, a drum can have a much greater impact than just the $1300 that the removal of this one drum cost.

The third removal action also included 14 drums in May, 10 drums in June, 2 drums in July, 7 drums in August and 8 drums in September. Of these 41, 28 contained substances. There are now 181 drums stored at the park for which no disposal site has yet been found.

Since the program began, the contents of the drums which have been analyzed have varied widely. Many of the drums have been used as miscellaneous fluid waste collection containers. Some have apparently fallen from transport vessels and still have their original contents. A very few have extremely deadly contents that could kill a person through minor skin contact or inhalation. Even though the latter are not common, they dictate the degree of caution which must be taken with all drums.

A situtation which all but prevents attacking this problem at the source is that a majority of the drums have no markings to indicate who is responsible for their ending up in the Gulf. For those that may originally have markings, such as rig numbers, the abrasion and corrosion the drums are exposed to in the water and on shore rapidly remove the identifying marks.

In 1985, the EPA indicated it would probably not be able to continue funding for this project, so the National Park Service began its own preparations to deal with this hazardous waste problem. National Park Service's Washington office made available $70,000 for supplies, equipment, personnel, and training. Future budget requests have included funding to allow the National Park Service to assume the total responsibility for this program.

Perpetual cleanup is not the answer, however. The National Park Service feels that the solution is to prevent the drums from getting into the Gulf waters to start with. With the appropriate federal agencies and industry working together, adequate laws, suitable incentives, and toxic waste disposal facilities in port can be created and this problem can be controlled.

Further information and detailed data can be obtained from the Superintendent, Padre Island National Seashore, 9405 South Padre Island Drive, Corpus Christi, TX 78418.

Max Hancock, a 31-year veteran of the National Park Service, is Chief Ranger at Padre Island National Seashore. He has also served in Rocky Mountain National Park, Chiricahua National Monument, Great Smoky Mountains National Park, Yellowstone National Park, the National Park Service's Washington Office, Grand Canyon National Park, and Chickasaw National Recreation Area. Mr. Hancock is a graduate of Colorado State University with a BS in Forest Recreation. In addition to public safety responsibilities, he also coordinates oil and gas exploration and production by leasees operating in the park.

Trash and Debris on the Beaches of Padre Island National Seashore

Mr. Robert King
National Park Service
Padre Island National Seashore

The National Park Service has long recognized the existence of a beach debris problem at Padre Island National Saeshore. Since the park's founding in 1962, the litter on our beaches has prompted many visitor complaints. Through the years, attempts have been made by the Park Service to alleviate or at least reduce this problem. These attempts have met with limited success, and in some cases have even been detrimental to the very ecosystem which they were intended to preserve. Beach cleaning machines of various designs have also been enlisted in this fight; however, their inability to deal with the wide range of trash items commonly found on our beaches has limited their usefulness. The least environmentally damaging and most effective method of trash removal is manual. However, in the present climate of budget considerations and with the reality of 60 miles of seashore beaches in need of attention, this method is not a viable consideration. Presently, the park spends $10,000 per year on its beach cleaning efforts, which are concentrated on the 0.5 mile of beach which receives the greatest visitor use.

Most recently, the increased frequency of 30- and 55-gallon drums (some containing hazardous chemicals) washing ashore has brought this trash problem to the forefront.

The heart of the problem is that Padre Island National Seashore occupies that portion of the Texas coast which is the natural dumping ground for the northern and southern longshore current complex. These two currents sweep the entire eastern portion of the Gulf of Mexico and converge on a 10-mile (27° N Lat.) stretch of beach in the middle of the national seashore. Both floating and subsurface suspended debris are transported by these currents and deposited along the beaches just north and south of the convergence zone.

In an effort to better document this problem and in an attempt to identify possible sources of this debris, the following studies were initiated.

METHODS AND RESULTS

On March 21, 1985, Padre Island National Seashore was divided into three zones north to south: Zone 1, the northernmost zone is 17.7 mi. long and is supplied by the southward longshore current. Zone 2, the convergence zone, is 10 mi. in length and is centered at 27° N Lat. Zone 3, the southernmost zone, is 30 mi. long and is supplied by the northward longshore drift current. These zones reflect the dominant coastal current pattern of the Texas coast. All beaches which receive either regular or sporadic cleanup efforts were excluded from this study.

Each zone was divided into tenths of miles, yielding zone lengths of 177, 100, and 300, respectively. Random numbers were used to locate a point in each zone from which a 100 m by beach-width quadrat was established. The polarity of the next random number following that which established site location determined whether the quadrat was measured to the north or south of the sample point, i.e., even - to the north, odd - to the south. Once the quadrat was established, trash removal was begun. All trash was examined, cleaned of sand, and classified as either "Domestic" or "Oil/Gas" and placed into a corresponding plastic bag. The bags were transported to the Gulf Ranger Station, where each was weighed.

Descriptive statistics for the trash recovered from each zone are presented in Table IVE.1. Large items were recorded but not removed from the beach. A list of these items for each zone is presented in Table IVE.2. Trash densities from Table IVE.1 were expanded to estimate total weight of all trash present on park beaches, Table IVE.3.

In addition to the above study, a project utilizing the above methodology was begun in August 1985. This study will incorporate a total of six sample sites: two sample sites in Zone 1, one in Zone 2, and three sites in Zone 3. In addition, an effort will be made to determine the effect of natural beach cleaning processess, such as storm tides, covering by blowing sand, and the ultimate beach cleaner, the hurricane. Initial site cleanups took place in August 1985, Table IVE.4. Sites will be cleaned monthly until September 1986. Table IVE.5 shows the results of the first month's sampling.

DISCUSSION

These studies were begun in an effort to document and quantify a major problem threatening the recreational beaches of Texas. These preliminary results do not yet identify trends or trash deposition patterns, but they do provide evidence that offshore activities (both oil/gas and shipping) contribute significantly to this problem. The following is a discussion of some additional aspects of these studies and a brief description and identification of some variables which may play a major role in this trash deposition problem.

The trash categories of domestic and oil/gas are not exclusive: there is a component of oil/gas included in the domestic category. These studies separated trash items conservatively: domestic items originating from oil and gas activities could not be identified and were placed in the domestic classification. A number of items from oil and gas operations were conspicuous by their presence in all three zones. What follows is a list of these items in order of abundance:

1. Plastic sheeting
2. Computer 9-track write-enable rings
3. Seismic markers, bamboo poles with lead weight, batteries and styrofoam floats attached
4. Drilling pipe thread protectors
5. Diesel oil and air filters
6. Deck light bulbs

A comparison of these two studies, Tables IVE.1 and IVE.4, indicates that they are in good agreement with respect to the trash densities for domestic, oil/gas, and total density categories among the zones. The ratios of domestic/oil, however, vary more than might be expected. This variation may be more representative of the number of trash-generating activities which are either ongoing or which have taken place within each zone's respective current system between sampling dates than a true indication of sampling error. Oil and gas activities have increased greatly in the Zone 1 current area as opposed to the current area of Zone 3. The convergent zone, Zone 2, might be expected to reflect an increase in trash generating activities in either current zones 1 or 3.

This is indeed the case as the domestic/oil ratio increases from 1.79:1 to 2.57:1.

Trash deposition rates (lbs/day) for the three zones are shown in Table IVE.5. As might be expected, Zone 2 (Convergence Zone) shows the highest rate of trash accumulation. These rates of trash deposition would be expected to vary with seasonal movement of the longshore current complex, the occurrence and frequency of natural beach cleaning processess, and the number of trash-generating activities taking place within each current sweep area. These factors would not be expected to impact the ratios of domestic/oil and gas as greatly because they would exhibit the same effect on both types of debris. Though some types of trash may float and react to current movement differently, at this time we have no methods to identify such differential movement characteristics. The ratios of domestic/oil and gas vary greatly among the zones; however, it is evident that perhaps as much as 50% of the trash in all three zones is oil and gas related. As this study progresses, these ratios, as well as the trash densities, will become much more important.

The results of both these studies have been expanded to provide an estimate of all trash occupying the park beaches, Table IVE.3. These estimates are very similar except for the oil and gas component of both Zones 1 and 3. Both these zones show dramatic increases in weights of oil and gas-related trash. These numbers are subject to the same influencing factors for trash deposition described above. These amounts of trash are large -- they rival the trash production for many small cities. Most of the trash items are plastic or plastic derivatives. Plastic sheeting is the most abundant, with plastic buckets and bottles close behind. One pound of this sheeting will cover 28 ft^2 of beach.

It is obvious that trash on Texas beaches is a problem. Steps need to be taken in the near future to reduce and reverse the magnitude of this problem.

Robert King, Chief of Environmental Services at Padre Island National Seashore, has been with the National Park Service for four years. He has worked with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, National Ocean Survey, and the California Department of Fish and Game. He received his BA in Fresh Water Ecology from the University of California at Berkeley and his MA in Marine Biology from San Francisco State University. Mr. King prepares environmental assessments for oil and gas activities and directs research activities within the park.

State and Local Beaches

Dr. John M. Gosdin, Director
Natural Resources Division
Office of the Governor of Texas

Being highly visible and widely publicized, litter and debris on Texas coastal beaches have been a problem for many years. The problem is increasing in magnitude with increased oil and gas, commercial shipping and fishing, and recreational activity in the Gulf of Mexico.

Removal and disposal of litter are placing a fiscal burden on city and county budgets. The Legislature has not responded by providing additional state funding. In fact, the state beach cleaning program, which is administered by the Texas Parks and Wildlife Department, narrowly escaped elimination by the 69th Legislature. Initially zeroed out by the Legislative Budget Board, the Governor's Executive Budget recommended it be continued at a higher level ($500,000 per year). The program finally was continued, but at reduced levels.

On August 30, 1984, Governor Mark White directed the Texas Coastal Marine Council to undertake a study of actions to reduce the state's beach litter problem. A series of public hearings was held along the coast, and it was determined that between 70 and 90% of beach litter and debris orginates from offshore sources. This is outside the jurisdiction and control of local governments.

As a result of the study, Governor White signed the following bills and resolutions passed by the 69th Legislature: SB 1302 (Truan) holding the operator of a boat or motor vehicle liable for litter offenses; SB 1303 (Truan) increasing penalties for litter offenses; SCR 97 (Truan) requesting assistance from the U.S. Coast Guard in strict enforcement in policing offshore rigs of littering laws in the Gulf of Mexico; and SCR 99 (Truan) directing the creation of a public-private sector awareness program to focus attention on, and reduce, the beach litter problem through visible public education and information activities. The Texas Department of Highways and Public Transportation was designated the lead agency.

THE PROBLEM

Beach litter in Texas is

- coastwide in scope, and the most visible litter problem in the state.
- increasing in volume.
- offensive to beach users.
- a popular topic for media attention.

- a negative incentive for tourists visiting Texas beaches.

- detrimental to local coastal economies.

- causing frequent and vocal complaints to local, state, and federal officials.

- placing an increasing and unwanted fiscal burden on local officials.

- creating an unwanted, negative image of the oil and gas industry.

THE SOLUTION

A three-point Texas program is underway to address the beach litter problem: continuing to clean Texas beaches through enhanced public-private coordination and cooperation; reducing litter at the sources through highly-visible public-private sponsored education and awareness programs; and better enforcement of anti-litter laws.

The following identifies a number of actions which are being taken for litter cleanup:

a. Local coastal officials are being urged to consider supplementing local and state funds for beach cleaning by soliciting beach cleanup assistance from volunteer groups in the local communities.

b. Using Nueces and Brazoria Counties as models, county judges, commissioners courts, and prosecutors are being urged to consider the use of county prisoners for beach cleaning and other community services as an alternative to fines, or jail time, where appropriate.

c. The Texas Department of Corrections, the State Department of Highways and Public Transportation, and the Parks and Wildlife Department will identify areas where the use of inmates for park cleaning and beach litter removal could result in net benefits to the state.

Various actions to carry out a coordinated public awareness program are as follow:

a. Pursuant to Senate Concurrent Resolution 99, the State Department of Highways and Public Transportation has been designated as the lead agency to develop a statewide litter awareness program in conjunction with the public and private sectors.

b. The assistance of individual companies and trade associations representing the offshore oil and gas industry, Texas ports, commercial shipping, commercial fishing, and recreational boating and fishing is being requested. Assistance will be specifically for the development and dissemination of information, posters, brochures, and films concerning the l litter problem in Texas and the need to dispose of litter properly.

c. Hotel-motel associations will be contacted to provide materials to association members on the coast which remind visitors/tourists of the need to maintain clean beaches. Trash bags and brochures will be furnished for placement in hotel and motel rooms.

d. Grocery bag manufacturers will be contacted regarding the printing of anti-litter slogans on grocery bags. Retail beverage outlets will also be contacted for use of similar carryout bags.

e. Assistance of appropriate companies or trade associations which benefit from parks, recreation, and/or tourism will be requested in order to provide trash bags, trash barrel signs, etc. which communicate anti-litter slogans.

f. Educational institutions will be approached to develop and distribute anti-litter educational information for dissemination within the Texas public school system.

In addition, litter enforcement will be addressed as follows:

a. All law enforcement agencies, law enforcement associations, and judicial associations will be informed of the changes in the state's litter laws to include higher individual penalties for littering and liability of the operator of a motor vehicle or boat if littering occurs.

b. The State of Texas supports the EPA's stronger regulations governing the disposal of solid wastes from oil and gas operations in federal waters of the Gulf of Mexico.

Dr. John M. Gosdin, Director of the Natural Resources Division in the Office of the Governor of Texas, coordinates programs for more than 45 state agencies. He is responsible for the development of policy positions for the Governor for natural resource issues, including ocean incineration of toxic wastes, barrier islands, fish and wildlife management, and oil and gas development. He earned a PhD in Management at the University of Texas at Austin.

Removal, Sampling and Disposal of Abandoned Drums Containing Suspected Unknown Hazardous Substances from the Beaches of Mustang Island and Padre Island, Texas[1]

Lieutenant Commander Glenn F. Epler
United States Coast Guard

SUMMARY OF EVENTS

On 10 October 1984, Marine Safety Office (MSO) Corpus Christi received a report that several 55-gallon drums suspected of containing hazardous materials had washed up on the beaches of South Padre Island. Two drums labeled trichloroethylene and one drum with no markings were discovered on the beach and eventually removed and properly disposed. This incident marks the first time that MSO Corpus Christi became aware of the problem involving drums containing suspected hazardous materials washing ashore.

Since this time, over 300 drums have been removed, sampled, analyzed, and disposed. The area affected by these drums washing ashore is quite extensive: it involves the entire barrier island chain within the Corpus Christi Marine Safety Zone, which consists of Matagorda, San Jose, Mustang, and Padre Islands, an area approximately 160 miles in length.

At the suggestion of the Department of Interior (DOI) representative to the Sixth Federal Regional Response Team (RRT), on November 20, 1984, a reconnaissance of Padre Island beaches was performed to assess the potential hazards to employees and park visitors. A tour of a 12-mile stretch of beach revealed a count of 29 drums. The drums encountered were in generally poor condition, showing the effects of sea water, surf action, and salt air. At least half of the drums were rusted through, broken, or missing bung stoppers so that they did not hold contents at the time of the inspection. A few full and intact drums were seen on the beach. Several drums were found partially full. The lack of seals on the bungs suggested that the contents of the drums might not match that indicated by any type of labeling. On most occasions, however, there were no distinguishable markings or identification found on the drums, thereby creating the problem of not being able to identify the contents, a source, or responsible party. In addition to the 55-gallon drums mentioned above, numerous 1- to 5-gallon and 30-gallon plastic containers were seen on the beach. Some of these were intact and contained fluids of various colors and consistency.

There have been no reports of personal injuries from exposure to the contents of drums or other containers; however, the potential for serious health risk from the general public becoming exposed to one or more of these drums is very real. The public hazard was certainly the Coast Guard's and the Park Service's greatest concern, and efforts to remove the drums revolved around that priority. Evidence of public contact with the drums was obvious. In one instance, two drums had been positioned to act as a wind break and cooking grill support for a camp fire. One of the drums had the side burned through, while the other was intact with some liquid contents. Several drums had been placed along the beach drive-path, perhaps to mark the way, act as supports for surf fishing equipment, or ease removal by the beach maintenance crew. Several of the drums inspected on the beach contained bullet holes. One such drum was intact, except for three holes of about 0.30 in. A liquid had seeped from this drum through the holes and evaporated to leave a white flocculent residue.

Shortly after this DOI survey, MSO Corpus Christi acted as federal On Scene Coordinator (OSC) and initiated a federal removal action under the Conservation, Environmental Response, Compensation, and Liability Act (CERCLA). The reason that this drum removal incident was initiated as a CERCLA cleanup was because of the uncertainty of the contents of the drums and the public's access to the beaches.

It is the responsibility for the Coast Guard to provide emergency response actions to potential or actual releases of hazardous substances that present a significant threat and occur within our area of responsibility, as outlined in the National Contingency Plan, Memorandum of Understanding between the U.S. Coast Guard and EPA, and the DOT/EPA Instrument of Redelegation.

An initial planning meeting was held at MSO Corpus Christi on 5-6 December 1984 to determine a course of action for removing and disposing of the drums located on the beach. The participants of this meeting included personnel from the Marine Safety Office, Gulf Strike Team, Peterson Maritime Services, Inc., Texas Water Commission, Department of Interior (U.S. Park Service), Environmental Protection Agency (Technical Assist Team), and NOAA (Scientific Support Coordinator).

An overflight on 6 December 1984 indicated approximately 180 drums lying on the beach between Port Aransas and the U.S./Mexico border. Of these 180 drums, it was estimated that about 30-40 of them would require overpacking. It was decided that the drums would be removed from the beach and stored in one staging area until all drums were removed. Sampling of the drums would be conducted after all drums were staged. Finding an acceptable area to temporarily stage the drums appeared to become a problem. There was no area along the beach that would meet Texas or RCRA standards for a temporary storage area of hazardous materials. The area near the Ranger Station, where Park Service personnel already had some drums stored, appeared to be the best alternative location for setting up the staging area. On the south end of Padre Island, there was no acceptable area for staging. All overpacking of drums would be conducted in Level C protection (i.e., full-face air purifying cannister respirator, chemical resistant clothing, emergency escape breathing apparatus) prior to moving to the staging area. If a problem arose, then the response personnel would increase to Level B protection (i.e., self-contained breathing apparatus, chemical resistant clothing). Level B protection was used for all leaking drums and those drums that appeared to have questionable integrity.

The action that was taken to cleanup the drums from the beach was broken down into three phases. The first phase involved the removal of the drums from the beach to the staging area. The second phase involved sampling the drums. The third phase was final disposal. Two goals were established: (1) to cleanup the beach area of all drums from Port Aransas to the US/Mexico border and (2) to establish a future beach maintenance program between DOI/EPA/USCG for removing drums of suspected hazardous substances.

Based on the chemical analysis from Microbiological and Biochem Assay (M.B.A.) Laboratory in Houston, Texas, an agreement was reached between the Coast Guard contractor, Peterson Maritime Services, Inc., and TECO to allow the OSC to separate the drums into five different categories for disposal.

DOT PROPER SHIPPING NAME	HAZARD CLASS	UN/NA CODE	DRUMS
Non-hazardous Liquid Waste	N/A	N/A	34
Hazardous Waste Solid NOS	ORM-E	NA 9189	2
Waste Oxidizer NOS	Oxidizer	UN 1479	1
Hazardous Waste Liquid NOS	ORM-E	NA 9189	96
Waste Flammable Liquid NOS	Flammable Liquid	UN1993	10

A total of 141 drums was disposed of at TECO, of which 34 drums were labeled non-hazardous liquid waste. These 34 drums contained mostly motor oils and diesel oils. A Coast Guard federal project number was obtained on 28 March 1985 for the disposal of these drums under the Federal Water Pollution Control Act.

During the course of this cleanup operation, there was no planned action to try to determine the source of these beached drums, other than looking for some type of identification or other markings on the drums. The vast majority of the drums were in such poor condition that no labels or other markings were found on them. Because of the lack of identification, it was impossible to determine the responsible party.

This particular CERCLA incident was finally closed on 29 March 1985. A second CERCLA incident had already been opened prior to this date to effect emergency removal of additional drums that had washed ashore. Because of the recurring nature of these drums being washed ashore, each CERCLA incident is being opened for a certain period of time, or until enough drums have accumulated at the staging area, so that a more cost-effective sample analysis program can be established. Conducting these CERCLA incidents on a time frame basis also facilitates the management of the funds and paperwork. The only other option would be to open up a CERCLA case and never close it. Since the drums are continually washing ashore on a regular basis, they are in constant need of removal from the beach, analysis, and disposal. Conducting a continuing CERCLA incident for removal of these drums would not be very practical.

CAUSE OF THE INCIDENT

The apparent cause of this incident is the illegal, deliberate, or inadvertent dumping, dropping, or throwing of these drums, causing the drums to wash up onshore. The responsible parties for these actions are presently unknown. As Gulf of Mexico current analysis suggests, these drums may have come from anywhere in the Gulf of Mexico and the Caribbean. Since the drums were in a rusted and weathered condition, as previously pointed out, it is impossible to track back through a supplier and locate the point at which they were lost. Thus the actual contents of the containers is the only bit of information that is available to help locate the probable source of the drums. Two very broad source categories are the marine transportation/energy exploration industry (ships, supply boats, offshore drilling and production platforms) and coastal industry (waterfront facilities, storage, supply, production, and repackaging).

The potential sources of litter and other industrial waste in Texas and Louisiana offshore waters is very large. There are approximately 1032 manned oil rigs and platforms and 2327 unmanned platforms operating in the Gulf of Mexico off the coasts of Texas and Louisiana. These rigs are serviced by a large number of support vessels. There are over 2000 large commercial vessels transiting these waters monthly. In addition, there are hundreds of barge transits monthly in these areas. There are over 700 commercial fishing vessels and over 11,000 pleasure vessels operating on Galveston Bay alone. The prevailing westerly currents in the western Gulf carry the effluent from the Mississippi, Sabine, and Neches Rivers to the Texas shores, as well as the effluent from the various Texas rivers which flow to the Gulf of Mexico. The current surface patterns show that refuse from the Caribbean and Atlantic sea lanes can very easily be transported to the western Gulf beaches.

Unless the drums are completely stopped from being dumped into the Gulf of Mexico and its sources, this situation will exist for a very long time.

SOME RELEVANT STATISTICS - AS OF 01 OCT 85

- No. OF DRUMS REMOVED UNDER THESE CERCLA PROJECTS — 306
- No. OF DRUMS CONSIDERED HAZARDOUS ACCORDING TO RCRA — 170
- PERCENTAGE OF DRUMS CONSIDERED HAZARDOUS — 56%
- TOTAL COST THUS FAR (SINCE DECEMBER) — $344,268
- AVG COST PER DRUM — $1,125

See Table IVE.6 for further details of several drum removal operations.

[1] The opinions and assertions expressed are those of the authors and do not necessarily represent the views of the U.S. Coast Guard.

LCDR Glenn F. Epler is presently the Port Operations Officer at the Marine Safety Office, Corpus Christi, TX. He is primarily responsible for the activities relating to the oil and hazardous material response posture for the Marine Safety Office. He has been closely involved with these drum removal operations since they began in October 1984. LCDR Epler is a graduate of the U.S. Coast Guard Academy and received his MS in Transportation Management from Florida Institute of Technology in 1982.

Marine User Group Panel Discussion Petroleum Industry

Mr. John Burgbacher
Gulf Of Mexico Offshore Operators Committee

The offshore oil and gas industry is a complex business, both in terms of the variety of operations that occur daily and in the number of people involved.

Drilling and producing operations are currently taking place throughout the Gulf of Mexico with the heaviest concentration off the Louisiana coast followed by offshore Texas. These activities are supported by a large number of onshore supply bases with Venice, Leeville/Grand Isle, Morgan City, Intracoastal City, Cameron, and Galveston being the most active. Currently 175 mobile drilling rigs and 67 platform rigs are operating in the Gulf. There are a total of 3900 platforms of various sizes and configurations in state and federal waters. These are serviced by about 1000 vessels, including cargo boats, standby boats, field service boats, and crew boats. In addition, seismic programs involve a small number of water craft.

Data generated for the MMS's socioeconomic study indicate that some 25,000 company personnel are involved directly in the drilling and producing activities in the Gulf, 10,000 of which are located offshore at any one time. Another 37,000 contract employees are reported to be offshore daily.

OCS Order #1 and #7 and EPA NPDES discharge permits govern the handling and disposal of waste materials. Order #1 requires that all materials of a certain size shipped offshore be properly identified. Order #7 prohibits the discharge of containers and similar solid waste materials into the ocean and defers to the EPA for other wastes. Contractors must be informed in writing, prior to contract execution, of the lessee's obligation to prevent pollution.

The handling of trash and debris varies somewhat from company to company, but generally includes the following. Empty drums or drums containing wastes are returned to shore for reclamation or disposal. As with any material used offshore, these drums are manifested for both transport to and from the drilling rig or production platform, by either a "Dangerous Cargo Manifest" if hazardous substances or wastes are involved or a bill of lading. Theoretically, any loss in transit should be detected by the receiving location. Most drum loss occurs while the vessel is in route during rough seas or in the transfer from vessel to platform/rig or vice versa. To minimize the problem in handling individual drums, carrier racks are in common use.

Plastic sheeting, which is used to cover certain offshore items, and small chemical pails represent a significant portion of the beach litter attributed to oil and gas activities. These items along with other trash are normally shipped to shore in waste containers. On occasion, these are overfilled, increasing the chance for loss in transit. Some operators are utilizing compactors, which not only reduce the volume of wastes to be handled but also contain it within tough plastic bags for easy transport.

As an organization, the Offshore Operators Committee's (OOC) main thrust to date has been an attempt to apprise the membership of this problem and to enlist support in eliminating this adverse impact. In addition, we are currently in the process of contracting for the preparation of a training film on this subject for use by offshore personnel. Member companies have also initiated steps to increase worker awareness, both company and contractor. These have included letters, discussions during weekly safety meetings, and bulletins. Some are strengthening their manifest system to ensure that lost items are accounted for.

One of the biggest deterrents to a successful program is the sheer numbers of workers involved, some of whom may be highly transient. Reaching them on a fairly consistent basis will be difficult. The problem is further complicated by the fact that many of the contract personnel, such as boat crews, are not directly supervised by the lessee. We would like to point out that even if we are successful in developing a high awareness level throughout the Gulf, adverse weather conditions will, at times, result in some loss of trash and debris. We hope this volume will be considered manageable by those responsible for the various parks and beaches.

Next year we hope we can report that additional progress has been made in reducing the volume of beach litter attributable to our industry. And, with the help of other users of the Gulf waters, those who frequent these beaches will find them in a much improved condition.

John A. Burgbacher is the Senior Staff Environmental Engineer for Shell Offshore, Inc. He is responsible for safety and environmental conservation throughout the Offshore West Division. Mr. Burgbacher also serves as Chairman of the Offshore Operators Committee's Fishery Advisory Subcommittee, which develops industrywide positions and direction on environmental and fishery issues occurring anywhere in the Gulf of Mexico.

Shipping Industry Perspective

Mr. Joseph Cox
American Institute of Merchant Shipping

Mr. Cox related the philosophy, concerns, problems, and controls of ocean pollution from the perspective of the American merchant marine. Historically, almost all garbage and waste materials on ships at sea were disposed of at sea. Even though the national and international concern for environmental pollution has resulted in new attitudes and controls among shippers, problems, convenience, and human nature are cause for continued contribution of some ocean litter from merchant ships which may ultimately impact coastal beaches. Mr. Cox noted that the U.S. Department of Agriculture through the Food and Drug Administration prohibits ships engaged in foreign commerce from disposing of garbage on shore.

Mr. Cox believes the best way to regulate and control pollution from the merchant marine is through international concensus. He related that in 1978, under the auspices of the United Nations, the International Maritime Organization (IMO) drafted the MARPOL document accepted by the maritime community. The MARPOL agreement led to two annexes addressing ocean pollution from oil and hazardous or chemical wastes. These annexes were agreed upon and accepted by most countries.

Other annexes drafted under MARPOL but not universally accepted included one addressing garbage and trash disposal at sea. The United States was among the countries not willing to adopt immediately this annex which would have limited the types of containers ships could use and prohibited dumping of plastics at sea. Mr. Cox indicated the garbage and trash annex as well as others addressing sanitation from sewage lines on ships and packaged hazardous goods is currently under review by IMO, and he believes they will be acceptable to the U.S. and become mandatory in the next few years. He went on to say the merchant shipping industry has changed, and American flag ships are no longer the pollution sources they were in years past. Bulk oil and bulk chemical carriers have modernized as necessitated by international conventions, and containerization has significantly reduced packaging and consequently waste at sea. Most foodstuffs delivered for use on merchant ships today are in degradable containers (no plastics).

Mr. Joe Cox is Director of Marine Affairs with the American Institute of Merchant Shipping (AIMS) located in Washington, DC. AIMS represents the bulk trades and two container companies or approximately 85% of the U.S. capacity to move cargo. Mr. Cox, who spent time at sea in his early career, currently represents the merchant marine in legislative and regulatory matters.

The Recreation and Tourism Industry Perspective

Dr. Robert B. Ditton
Department of Recreation and Parks

The coastal recreation and tourism industry involves much more than just attractions. It includes all supporting infrastructure (i.e., hotels, motels, campgrounds, resorts, condominiums, retail sales, gas stations, restaurants, charter and partyboat services, marinas, fishing piers, and beach services) as well as transportation systems that allow tourists to reach the coast.

The industry is big business, very big business. Unfortunately, the industry is fragmented. There is no one voice for coastal recreation and tourism interests, and rarely do the constituent elements in the industry take unified action.

Tourism and recreation in Texas is now the second largest industry in the state. It is ranked behind the oil and gas industry but ahead of agriculture. Tourism expenditures in Texas last year totaled $13 billion. These data are provided to the State of Texas by the U.S. Travel Data Center in Washington, DC.

To understand the role that the coast plays in statewide tourism, the 17 coastal counties were partitioned out from the total list of 254 counties. This revealed that there were four coastal counties in the top ten when ranked by extent of tourism expenditures. Of the $13 billion spent annually in Texas for tourism and travel expenditures, over 1/3 (or $4.5 billion) is spent in the 17 coastal counties. About 1/3 of the state's tourism jobs and payroll are located in the 17 coastal counties as well.

The Texas coastal recreation and tourism industry is concerned with any condition that may adversely affect visitors to the coast. These include crime, shark attacks, jelly fish and Portuguese men-of-war, weather that is either too hot or cold, oil spills, tarballs (a persistent problem on Texas beaches), litter, and unsightly conditions. Some of these conditions can be dealt with; others can not. The industry would support any precautions that can be taken to avoid problems where controls are possible. We are concerned that visitors who have had a bad experience on the Texas coast may not return. They may vacation elsewhere (outside the state of Texas) and take their money with them.

The industry is also concerned with the cognitive responses of others (non-visitors) to conditions as reported on the coast. For example, the psychological effects of an oil spill on tourism revenues are often worse than the actual spill effects on tourism. When conditions are reported by the media, visual images act to shape people's behavior. As trash and debris are deposited on Texas beaches (and government is unable to cope with the problem), people will stay away. They will say that Texas beaches are dirty and communicate this to their friends. This problem will likely persist long after the trash and debris problem is solved (if it is solved). Psychologists call it cognitive dissonance.

The industry hopes there will be more attention to the trash and debris problem before it gets picked up by the media. When this occurs, the recreation and tourism industry will encounter heavy losses in revenue. Tourism dollars will be lost to the state as tourists seek other beach destinations.

Despite the dollars and cents of coastal tourism, beach cleaning support for public beaches does not appear to be a high priority item in Texas. In 1984 twelve political jurisdictions on the coast received a total of $391,568 from the state for beach cleaning purposes. These funds were matched on a 50/50 basis by local jurisdictions using hotel/motel occupancy tax monies or other sources of revenue. In the most recent legislative session, it was thought there would be a total elimination of beach cleaning funds. In fact, there will be a 26% reduction in funds for 1985-86. Obviously, there is insufficient support for these kinds of expenditures with inland legislators. There is a need for increased public support for these programs.

The situation at the Padre Island National Seashore is another matter entirely. As a federal jurisdiction, the area does not qualify for state beach cleaning monies. To the extent the trash and debris problem is not remedied at the Seashore, park visitation may be affected (with a reduction in associated economic impacts in the region).

The industry recommends that the MMS launch an investigation to learn the source of the OCS-related trash and debris coming ashore on the Texas coast and to implement and/or enforce regulations regarding platform operations so as to reduce the problem.

Robert B. Ditton is Professor of Recreation and Parks at Texas A&M University. He serves as Director of the University's Marine Recreation Management and Development Program and guides research activity relating to recreation and the marine environment. Dr. Ditton has authored several books and professional publications on marine recreation and the effects of recreational activity on economic development. In the last 10 years Dr. Ditton has researched the interrelation of offshore oil and gas development with marine recreational activity and development.

A West Coast Perspective

Ms. Judie Neilson
Oregon Department of Fish and Wildlife

On October 13, 1984, some 2100 volunteers collected 26.3 tons of plastic debris from Oregon's coastal beaches in just three hours. They gathered useful information, previously non-existent, on the incidence and volume of marine debris on the coast. Of perhaps even greater longterm significance, the exercise generated considerable public interest and recognition of the scope and magnitude of the problem.

As a direct result of this project, a national network of lay people and professionals is now exchanging information about the marine debris problem. Similar cleanups were organized for September and October of 1985 in Washington, California, Oregon, Hawaii, New Jersey, and the New England states. These efforts resulted in 7000 volunteers collecting 150 tons of marine debris.

Horizon Video of Newport, Oregon, in cooperation with the Oregon Department of Fish and Wildlife and Oregon Society for the Plastics Industry, produced a twelve minute video film about Oregon's first cleanup. Funding for the film came from foundations, industry, and private individuals and organizations. The video is available for loan or sale. It presents the issue of entanglement and ingestion by wildlife of marine debris and tells the story of Oregon's cleanup in 1984. Interviewed in the film are volunteers who participated, a commercial fisherman, two marine biologists, representatives from the plastics industry and the Oregon Sanitary Service Institute, and the project organizer.

The formation of a network of government agencies and individuals interested in the marine debris problem has been an important element in coordinating and planning future cleanups. There is definitely a need to expand the scope of the cleanups in an effort to identify the source of marine debris and begin to address how it can be reduced, principally through education. In some cases, a change in technology could help reduce the life of certain products which cause the most harm to wildlife.

"A Nuts and Bolts Guide to Organizing a Beach Cleanup" has been prepared for distribution around the United States in an effort to help establish cleanup and reporting procedure standards. General information pamphlets on plastic debris, sample posters, questionnaires, and fact sheets are also available to anyone requesting the information.

The main focus of the cleanups now being conducted is the documentation of the marine debris and an attempt to determine its content and rate of accumulation. The National Marine Fisheries Services is funding several programs to compile and analyze the data in the central clearing house. Each volunteer is asked to fill out a questionnaire and return it to the Oregon Department of Fish and Wildlife. This will also give an overview of the volunteer's age, sex, and amount of beach covered, as well as the percentage of rope, fishing gear, styrofoam, buckets, and bottles collected. This cleanup is not an anti-litter campaign. The focus is on marine debris which is either deliberately or accidentally discarded at sea or into rivers which empty into the ocean. I recommend that each coastal state goverment sponsor a beach cleanup or work to establish a regular cleanup to document what type of material is ending up on the beach.

In addition to the hazards to fish and wildlife species, other speakers at this conference have examined the negative impact marine debris on beaches has to tourism and repeated use by recreationists. Because of dense development along every coastline, there is increased pressure for use of the beaches. The presence of sheets of plastic, rope, fish net, and large chunks of styrofoam on the sand is a deterrent to many people who then chose to spend their leisure time and money in other locations. Tourism is now the second largest industry in many coastal states. Cleaning up the beaches and educating the public about the problems of marine debris are a legitimate use of state monies.

Judie Neilson is the Executive Assistant to the Director and Commission of the Oregon Department of Fish and Wildlife. She became interested in the proliferation of plastic debris into the natural environment after learning of the problems of entanglement and ingestion of plastic materials by wildlife. She organized a cleanup of Oregon's 350-mile coastline in 1984. The project has attracted nationwide attention, and she is now involved in educating the public about marine debris and coordinating similar cleanups in other coastal states.

SUMMARY TRASH SURVEY
PADRE ISLAND NATIONAL SEASHORE
MARCH 1985

ZONE	ZONE SIZE (MILES)	SAMPLED AREA (SQ. METERS)	TRASH WEIGHT (LB) DOMESTIC	OIL	TOTAL	DENSITY (LB/SQ M) DOMESTIC	OIL	TOTAL	RATIO (WT) DOMESTIC/OIL
ZONE 1	17.7	5300	285.7	96.5	382.2	0.054	0.018	0.072	2.96:1
ZONE 2	10.0	4300	208.9	116.4	325.3	0.049	0.027	0.076	1.79:1
ZONE 3	30.0	8000	185.2	73.0	258.2	0.023	0.009	0.032	2.54:1

Table IVE.1 - Results of Trash Survey on Padre Island National Seashore
March 28 - April 3, 1985

ITEMS NOT REMOVED FROM
SAMPLE QUADRATS

SOUTHWARD LONGSHORE DRIFT ZONE	CONVERGENCE ZONE	NORTHWARD LONGSHORE DRIFT ZONE
All items removed	2-piles 3 ft. dia. x 2 ft. high polypropylene line	2 - 4 ft. x 4 ft. wooden pallets 2 - 15 ft. bamboo poles used for offshore seismic surveys 1 - wooden wire spool 3 ft. dia. 1 - plastic 5-gal. container (contents unknown)

Table IVE.2 - List of All Items Not Removed From Study Quadrats

ESTIMATED TOTAL WEIGHT OF TRASH IN TONS
ON PADRE ISLAND NATIONAL SEASHORE

	MARCH 1985 DOMESTIC	OIL/GAS	TOTAL	DOMESTIC	OIL/GAS	TOTAL
ZONE 1	40.75	13.58	54.33	48.53	81.91	130.44
ZONE 2	16.95	9.34	26.29	16.38	6.37	22.75
ZONE 3	44.40	17.38	61.78	57.87	42.06	99.93
TOTAL	102.10	40.30	142.40	122.78	130.34	253.12

Table IVE.3 - Estimates of the Total Amount of Trash Present on Padre Island National Seashore Beaches Taken From the March and August 1985 Studies

SUMMARY TRASH SURVEY
PADRE ISLAND NATIONAL SEASHORE
AUGUST 1985

	SITE	ZONE SIZE (MILES)	AREA SAMPLED (M^2)	TRASH WEIGHTS (LB) DOMESTIC	OIL/GAS	TOTAL	DENSITY (WT/M^2) DOMESTIC	OIL/GAS	TOTAL	RATIO/(WT) DOMESTIC/OIL
ZONE 1	1	17.7	7297	274.2	462.8	737.0	0.0376	0.0634	0.101	0.59:1
ZONE 2	1	10.0	4291	163.8	63.7	227.5	0.0382	0.0382	0.053	2.57:1
ZONE 3	1	30.0	8936	183.2	183.2	366.4	0.0205	0.0205	0.041	1:1
	2		7687	202.6	97.2	299.8	0.0264	0.0126	0.039	2.08:1
	3		6450	164.1	497.4	661.5	0.0254	0.0771	0.103	0.33:1

Table IVE.4 - Results of Initial Cleanup of Sample Sites for Year-Long Trash Survey On Padre Island National Seashore, August 1985

RESULTS OF THE FIRST MONTH'S RE-CLEAN OF ZONES 1, 2, 3

ZONE	SITE	DAYS SINCE INITIAL CLEANUP	RATE OF TRASH DEPOSITION LB/DAY	TRASH WEIGHT (LB) DOMESTIC	OIL/GAS	TOTAL	TRASH DENSITIES (lb/M^2) DOMESTIC	OIL	TOTAL	RATIO (WT) DOMESTIC/OIL
ZONE 1	1	54 DAYS	2.05	37.1	73.9	111	0.0051	0.0101	0.0152	0.50:1
ZONE 2	1	45 DAYS	6.75	170.0	133.0	304	0.0396	0.0310	0.0700	1.27:1
ZONE 3	1	33 DAYS	1.51	27.0	23.0	50	0.0030	0.0026	0.0056	1.17:1
	2	32 DAYS	3.56	58.0	56.0	114	0.0075	0.0073	0.0148	0.99:1
	3	38 DAYS	3.52	20.8	113.2	134	0.0032	0.0176	0.0208	0.18:1

Table IVE.5 - Results of the September Re-Clean of the Trash Deposition Sites on Padre Island National Seashore

Table IVE.6 - Separate Drum Removal Operations

ITEM	EV2	EV3	EV4	EV5	EV6
Cost	$197,261	$69,599*	$49,410*	$16,698*	$11,300*
No. of Drums Removed	141	94	26-(36)	18	(17)
No. of Hazardous Drums	107	52	5	6	
Per Cent Hazardous	76%	55%	19%	33%	
Cost per Drum	$1,844	$740	$1,373	$928	$665

*NOTE: THESE COSTS DO NOT INCLUDE COST OF DISPOSAL OF THE DRUMS

CULTURAL RESOURCE II.
SYMPOSIUM ON REMOTE SENSING SURVEYS

Session:	CULTURAL RESOURCE II. SYMPOSIUM ON REMOTE SENSING SURVEYS
Chairmen:	Ms. Melanie Stright Mr. Rik Anuskiewicz
Date:	October 23, 1985

Presentation Title	Author/Affiliation
Session Summary	Ms. Melanie Stright Minerals Management Service

Cultural Resources II - Symposium on Remote Sensing Surveys

Ms. Melanie Stright
Minerals Management Service

This session had two primary goals. The first was to discuss recurrent problems in archaeological survey data quality and report adequacy, and the second was to obtain industry comments to planned revisions to Notice to Lessees (NTL) 75-3 (revision No.1).

Three major problems, all involving the magnetometer, were discussed.

The first problem involves the NTL requirement for recording magnetometer sensor tow depths. To meet this requirement, various companies in the marine survey industry have responded either by using depth sensors on the magnetometer sensor or cable, or by calculating tow depth based on vessel speed and the amount of cable out. The latter method results in an approximation of the magnetometer sensor tow depth for the entire survey. Although the sufficiency of this method was defended by one symposium participant, it does not approach the accuracy of continuous tow depth measurements from a depth sensor. Due to the importance of having the sensor as close to the seafloor as possible to detect the relatively small ferrous masses present in an historic shipwreck site, and due to the importance of knowing the position of the sensor in calculating potential ferrous masses from an anomalous signature, the use of mechanical depth sensors will be required by MMS for future surveys.

The second problem discussed was the use of a "zero-mode" (level-mode) setting on the magnetometer for archaeological surveys. It has been stated by the company using this setting that since the primary function of the instrument is to search for anomalies by operating it in zero-mode, the low-frequency variations in the local field are eliminated and the system only responds to rapid anomalous changes from a central print position on the strip chart recorder.

A proton magnetometer records the <u>frequency</u> of the signal generated by precessing protons within a hydrocarbon fluid such as kerosene, alcohol, or water. The frequency of this precession can be directly related to the earth's ambient magnetic field and local magnetic disturbances (anomalies) within that field. When operating in zero-mode, the magnetometer is recording the <u>average amplitude</u> of the precession signal rather than the frequency. This operating mode was developed for use in areas having a steep magnetic gradient, such as exists around oil and gas structures, in order that smaller magnetic sources such as flow lines could be located. When operating in zero-mode, the average amplitude of the precession signal reaches a minimum value directly over a ferromagnetic object due to the quicker decay of the signal. The effect of averaging the amplitude of the precession signal would be to average background noise levels and low intensity, short duration anomalies out of the data recorded. Since an historic shipwreck often is represented only by a low intensity anomaly (e.g., 5-gammas), zero-mode is not considered an acceptable mode of operation for conducting archaeological surveys.

A third problem discussed is the use of magnetometer strip chart recording scales of greater than 100-gammas, full scale. Recordings at this scale do not permit easy identification of low-intensity anomalies or accurate determination of background noise levels. Therefore, strip charts using a single recording mode of greater than 100 gammas full scale are inadequate to ensure detection of low-intensity anomalies caused by historic shipwrecks. Strip charts using a dual recording mode are acceptable if one of the traces is 100 gammas or less, full scale.

On March 5, 1986, MMS issued a Letter to Lessees to clarify the above three points of the NTL survey requirements.

Another minor issue discussed by the symposium participants was the magnetometer sampling rate. It was agreed that a three-second sampling rate, which is being used by some marine survey companies, is inadequate to ensure detection of short-duration anomalies. A magnetometer sampling rate of one second will be required when MMS produces the second revision of NTL 75-3.

Biography: Please see Session III.F

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