OCS STUDY
MMS 86-0107

PROCEEDINGS
SUMMER TERNARY
GULF OF MEXICO STUDIES MEETING

September 1986

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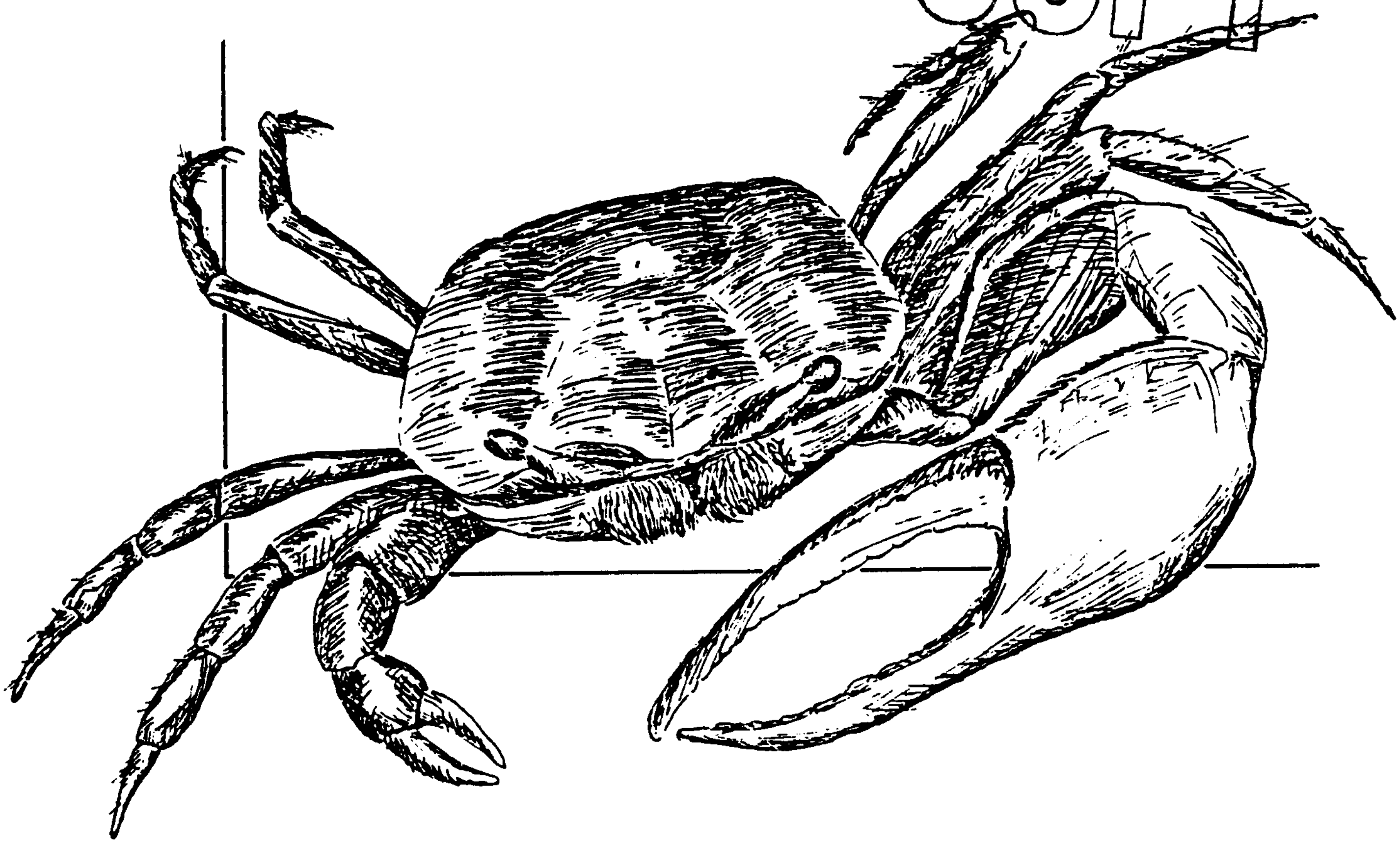

U.S. DEPARTMENT OF THE INTERIOR/MINERALS MANAGEMENT SERVICE

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OCS STUDY
MMS 86-0107

PROCEEDINGS
SUMMER TERNARY
GULF OF MEXICO STUDIES MEETING

held
September 3, 1986

at

Minerals Managemement Service
Twin Towers Building

Prepared under Contract 14-12-0001-29158

by

Science Applications International Corporation
4900 Water's Edge Drive, Suite 255
Raleigh, North Carolina 27606

submitted to

Minerals Management Service
Gulf of Mexico OCS Regional Office
New Orleans, Louisiana 70123-2394

October 1986

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

REPORT AVAILABILITY

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Gulf of Mexico OCS Region
U.S. Department of the Interior
1201 Wholesalers Parkway
New Orleans, LA 70123-2394
Attn: Public Information Unit
Phone: (504) 736-2519

DISCLAIMER

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MEETING SUMMARY

SEPTEMBER, 1986 TERNARY MEETING

1.0 INTRODUCTION:

On September 3, the Environmental Studies Group, of the MMS, Gulf Regional Office convened the second Ternary Meeting of 1986. These public meetings are held as a forum for information exchange between interested and involved parties. This generally includes MMS personnel, representatives of various MMS funded programs, state representatives, public interest groups, other federal agencies, and invited investigators working on problems similar to or supportive of those of the MMS.

The meeting consists of a representative from most of the MMS funded programs and other invited speakers making a presentation variously defining the program goals, schedule, methodology, present status and any important or relevant insights recently developed. The meeting schedule is such that there is ample opportunity for exchange between the speakers and audience. In addition, sufficient "unallocated" time is usually available for discussion between those in attendance.

2.0 MEETING ABSTRACTS:

At the meeting each speaker provides an abstract of material to be discussed prior to the scheduled talks so that others have an opportunity to become familiar with what is to be presented. This also allows question formulation without trying to simultaneously listen to an ongoing presentation. These abstracts form the basis for this Meeting Summary Report.

Abstracts included in this volume are copies of those provided by each speaker. No adjustments have been made to the form and substance of these submissions.

This report contains the following meeting material:

- Agenda
- Presentation Abstracts
- List of Attendees

These are Items 1, 2, and 3 and follow immediately.

Any questions regarding presented material should be directed to the appropriate speaker. General questions regarding the Ternary Meeting should be directed to the Environmental Studies Group in the MMS Gulf Regional Office.

ITEM 1

AGENDA

AGENDA

MINERALS MANAGEMENT SERVICE

ENVIRONMENTAL STUDIES TERNARY MEETING

SEPTEMBER 3, 1986

NEW ORLEANS, LA

TIME	SPEAKER	TOPIC
9:00 a.m.	Mr. Jerry Ford Florida A&M University	Meteorology Data Synthesis Study
9:30 a.m.	Dr. Daniel Moore Jaycor	Circulation Modeling Program
10:30 a.m.	Dr. Charles Lamphear Resource Economics and Management Analysis, Inc.	Indirect Socioeconomic Impacts of OCS Oil and Gas Development
11:00 a.m.	Dr. Van Waddell Science Applications International Corp.	Physical Oceanography Field Measurements Program
11:30 a.m.	LUNCH	
1:00 p.m.	Dr. Donald Cahoon Center for Wetland Resources Louisiana State University	OCS Development and Potential Coastal Habitat Alteration
1:30 p.m.	Mr. John Thompson Continental Shelf Associates, Inc.	Recovery of Seagrasses in the Florida Big Bend from Hurricane Effects
2:00 p.m.	Mr. Michael Tomlinson Environmental Science and Engineering, Inc.	Southwest Florida Shelf Ecosystems Program, Years 5 and 6
2:30 p.m.	Dr. Benny Gallaway LGL Ecological Research Associates, Inc.	Northern Gulf of Mexico Continental Slope Studies Update
3:30 p.m.	ADJOURN	

ITEM 2

EXTENDED ABSTRACTS

ABSTRACT
FOR
GULF OF MEXICO METEOROLOGICAL DATA BASE AND SYNTHESIS STUDY

MMS Ternary Meeting
September 3, 1986
New Orleans, LA

Submitted to: Environmental Studies Group
Gulf Regional Office
Minerals Management Service
New Orleans, LA

Submitted by: Jerry W. Ford
Florida A & M University
Tallahassee, FL 32307

GULF OF MEXICO METEOROLOGICAL DATA BASE AND SYNTHESIS STUDY

Background: Florida A&M University (FAMU), in conjunction with appropriate subcontractors, is currently under contract with MMS to obtain, manage, archive, and conduct some analyses of the relevant historical meteorological data sets in the Gulf of Mexico. In addition, FAMU will provide the data and results of preliminary analysis to appropriate MMS funded investigators working in the area.

This project began in the fall of 1984 with a projected completion date of April 1, 1986. The goal of the project was and remains as follows:

The compilation of an historical meteorological data base for the Gulf of Mexico:

- In digital format
- In a common format
- Perform a "first order" analysis of the data
- Provide as deliverables:
    - Data Catalog
    - Descriptive Summary

GULF OF MEXICO METEOROLOGICAL DATA BASE AND SYNTHESIS STUDY

Work in Progress: The data sets presently on hand represent the composite data from a number of studies and observational activities conducted in the gulf over a number of years. These include buoy, ship, and platform data.

The data sets collected to date are:

NODC TAPES

DESCRIPTION: Buoy data for Gulf of Mexico in standard NODC format

FILE	TAPE NAME	SEQUENCE	IDENTIFIER
0	W01696	(1) 1 of 1	W01696
1	W08925	(2) 1 OF 2	W08925
1	W04441	(3) 2 OF 2	W08925/W08925
2	W10797	(4) 1 OF 2	W10797
2	W07837	(5) 2 OF 2	W10797/W10797
3	W10730	(6) 1 OF 2	W10730
3	W12831	(7) 2 OF 2	W10730/W10730
4	W14057	(8) 1 OF 1	W14057

NCC TAPES

DESCRIPTION: National Climactic Center ship data for Marsden squares 81 and 82 (Jan. 1970 - Dec 1983).

TAPE NAME	FORMAT
W03292	TD-1129
W07636	TD-1129
W08073	TD-1129

GULF OF MEXICO METEOROLOGICAL DATA BASE AND SYNTHESIS STUDY

NODC BUOY DATA SET
GULF OF MEXICO

NUMBER	FIRST DATE	LAST DATE	RECORDS	ORIGINAL LOCATION LAT	ORIGINAL LOCATION LONG
EB02	73/03/21	73/09/29	1,660	27.5N	88.0W
EB04	75/08/13	77/12/29	20,288	26.0N	90.0W
EB10	73/01/01	76/01/20	9,667	27.5N	88.0W
EB12	73/06/22	75/03/07	7,741	26.0N	94.0W
EB31	73/03/08	73/05/22	415	27.0N	86.0W
EB32	73/01/28	75/01/08	971	27.5N	88.1W
EB36	73/03/09	73/04/16	89	26.1N	84.6W
EB44	76/11/20	77/12/31	9,212	26.0N	86.0W
EB52	73/02/28	73/04/25	340	26.0N	83.8W
EB53	73/03/07	73/03/31	92	29.8N	88.3W
EB61	73/02/21	77/05/08	3,232	26.9N	84.6W
EB62	74/11/08	75/01/06	365	29.0N	85.6W
EB71	76/09/19	77/12/09	21,567	29.0N	85.4W
42001	78/04/01	83/12/31	187,445	26.0N	90.0W
42002	78/01/21	83/12/31	202,376	26.0N	93.5W
42003	78/01/01	83/12/31	182,881	26.0N	86.0W
42004	78/12/23	79/02/11	341	27.5N	85.5W
42005	78/12/13	80/05/13	8,764	30.0N	85.9W
42006	79/08/25	80/03/23	27,800	26.5N	96.0W
42008	80/10/01	83/12/31	36,362	28.7N	95.3W
42009	80/10/01	83/08/10	63,682	29.3N	87.5W

NODC BUOY DATA SET (Cont)

NUMBER	FIRST DATE	LAST DATE	RECORDS	ORIGINAL LOCATION LAT	ORIGINAL LOCATION LONG
42010	81/04/01	82/03/29	7,878	29.7N	93.4W
42011	81/09/16	83/12/31	23,252	29.6N	93.5W
42012	83/08/10	83/12/31	8,472	29.9N	87.1W

Additional Data: In the Winter of 1985 and the Spring 1986 efforts were undertaken to include two additional large data sets in the body of collected data. The objective of this new effort was to convert certain analog data tapes to digital format and, thereby, to add to the body of digitized data two large historic meteorological data sets which have remained in analog format until this time. The analog data sets are the result of two meteorological/oceanographic observation programs conducted by several oil and gas companies in the Gulf of Mexico around the Mississippi River delta from September 1968 through November 1977. These observations are the result of two data gathering programs: Ocean Data Gathering Program (ODGP) conducted from September 1968 through November 1971 (4 years) and consisting of 248 analog tapes (some 14 day some 28 day) with observations of wind speed and direction and atmospheric pressure. The second data set is the Ocean Current Measuring Program (OCMP) conducted from September 1972 through November 1977 (5 years) consisting of 164 tapes (28 day tapes) of wind, wave and pressure data and 159 tapes of current data for a total of 571 analog tapes for the two programs.

The digitized meteorological data from the these two data sets will then be reviewed for quality assurance, continuity and consistency. The useful meteorological data from the two programs will then be analyzed to produce a first order statistical characterization and description of meteorological conditions for inclusions in the Data Catalog and Descriptive Summary agreed upon under the original contract.

The conversion of the OCMP and ODGP data sets into digitized format for inclusion in the data base proved too costly to be completed at this time.

Future Plans: A summary of work to be completed under the original term of FAMU´s agreement with MMS includes these items which remain to be completed:

1. Conduct a "first order" analysis of the data sets: The "first-order" statistical characterization and description of meteorological conditions in the Gulf of Mexico. This document will reply heavily on available information (in contrast of requiring extensive new analyses) and will be presented as a reference document for persons having backgrounds which may not include meteorology.
2. Develop the Data Catalog: FAMU will produce a catalog describing the composition of the final composite data set, clearly describing the sources

2. (Cont) of the information, including the originators address and reference to the literature when available, the general formats of the received data, the periods covered by the acceptable data, and the specific location(s) and identifier(s) of the reformatted data in the archived compilation. FAMU will provide a "descriptive summary" of the results of first level analyses of the data.
3. Develop the Draft Descriptive Summary: The Summary will include the following: Monthly, seasonal, and annual means, extremes and variance of velocity and stress components at each of the station. Using 40 hour low pass filtered data, we will compute basin scale curl of the wind stress (v x t) and evaluate curl calculations--especially in the western/central Gulf--to identify periods of positive and negative vorticity which could influence regional circulation patterns.
4. Develop the Final Descriptive Summary: The catalog and Summary will be provided to MMS in draft form for review. FAMU will make required changes and additions and, as provided for in the schedule of deliveries, will provide a final version.

The time required to complete these items in conjunction with appropriate subcontractors is estimated at 9 to 12 months to include the submission of the required deliverables.

GULF OF MEXICO METEOROLOGICAL DATA BASE AND SYNTHESIS STUDY

The sources for the meteorological data on hand are as indicated:

NAME	INFORMATION
Mr. Harold Kilpatric Department of Meteorology Love Building Florida State University Tallahassee, FL 30308 (904) 644-6205	General Meteo. Information
Dr. Jordan FSU Meteorology Library (904) 644-3222	Reference Books
Dr. Shu National Meteorological Center Louisiana State University (504) 388-2395/2396	Oil Co. Wind Data
Dr. Dana Thompson NORDA (Code 324) NSTL, Mississippi 39529	Gulf Buoy Data
Mr. Ben Davis National Climactic Data Center Federal Building Asheville, N.C. 28801-2696 (704) 259-0682	General Wx Data MARSDEN SQUARE Data
Mr. Bob Lobel Acting Chief Branch of Environmental Modeling MMS 644 12201 Sunrise Valley Drive Reston, VA 22091 (703) 860-6730	Reference Literature
Pennsylvania State University Department of Meteorology University Park, PA 16802	Reference Material
Mr. Mike McDermit U.S. Naval Postgraduate School Department of Meteorology Monterey, CA 93940 (408) 646-2516	Reference Material Possible Data Set

The sources for the data:(Cont)

NAME	INFORMATION
Ms. Pat Kirk National Oceanographic Data Center NOAA/NESDIS E/OC21 2001 Wisconsin Avenue, NW Washington, DC 20235 (202) 634-7500	NODC Data Base
Mr. Bob Stein NODC/D 742 2001 Wisconsin Avenue, NW Washington, D.C. 20235 (202) 634-7505	Oil Company Data (CONOCO)
Francis Mitchell NOAA/NODC E/OC 13 2001 Wisconsin Ave NW Washington DC 20235 (202) 634-7500	
Mr. Al Bargeski NODC (202) 634-7500	Gulf Oil Rig Data
Mr. Fred Kramer National Weather Service Tallahassee, FL (904) 576-6318	Local Wx Service (Tallahassee)
John W. Wolfe, Jr., PE Director-Environmental Affairs North American Production CONOCO INC. 600 N. Dairy Ashford Rd. P.O. Box 2197 Houston, TX 77252 (713) 293-2646	Meteorologist.
David Peters CONOCO	Meteorologist
John Burgbacher SHELL, N.O.	Meteorologist

The sources for the data:(Cont)

NAME	INFORMATION
Ken Schaudt Oceanographer Marathon Oil Co. P.O. Box 3128 Houston, TX 77253 (713) 629-6600	Oceanographer
John Heideman EXXON Production Research (713) 940-3711	Chief Meteorologist
Thomas Mitchell ARCO Oil Co. Dallas, TX	Chief Meteorologist
Gene Berek AMICO Oil Co. (918) 660-3000	Chief Meteorologist
Tony Fallon CHEVRON Oil Co. (213) 694-7787	Chief Meteorologist
Mike Spalane GULF Oil Co. (713) 754-0321	Chief Meteorologist
George Forestall SHELL Oil Co. (713) 663-2404	Chief Meteorologist
Bob Hamilton Evans/Hamilton 7214 S. Kirkwood Houston, TX 77072 (713) 495-0883	Digitize Data Sets Has ODGP Meteo data
Tim Swarthout Systems Analyst EVANS-HAMILTON,INC 7214 S. Kirkwood Houston, TX 77072 (713) 495-0883	Will work on ODGP & OCMP Digitizing

The sources for the data:(Cont)

NAME	INFORMATION
Elgin Landry MMS (504)736-2866	MMS Meteorologist
Bob Quayle Bob Brines NCDC	Marine WX
Dr. (Capt) Glenn Hamilton NDBC NSTL,Miss 39529 (601)688-2836	C-MAN data set

GULF OF MEXICO CIRCULATION MODELING STUDY

Daniel R. Moore

JAYCOR
NORDA Code 323, NSTL Station, MS 39529

INTRODUCTION

The Gulf of Mexico Circulation Modeling Study was started by MMS in October 1983 as an "extremely modest effort building on existing/ongoing modeling efforts in the Gulf of Mexico". The initial requirement was for an existing circulation model with capabilities approaching those required and the ability to deliver an "early simulation run". At the end of the four year program the requirement was for a circulation model of the entire Gulf with horizontal resolution approaching 10km, and vertical resolution (initially less important) approaching:

mixed layer:	1 - 10 m
thermocline:	10 m
deep layer:	100 m

with realistic bottom topography, coastline, and wind forcing, which must exhibit loop-current eddy shedding, and other known regional circulation features.

THE EXISTING NORDA/JAYCOR MODEL (OCTOBER 1983)

This was a two layer, non-linear, hydrodynamic, free surface, semi-implicit, primitive equation ocean circulation model on a beta plane, with realistic coastline, and full scale bottom topography confined to the lower layer. The horizontal grid resolution was 0.2 degrees (20 by 22 km), with an upper layer rest depth of 200 m. The model can be driven by inflow through the Yucatan Strait compensated by outflow through the Florida Strait, and/or by winds.

PROBLEMS WITH THE EXISTING (1983) MODEL

1) Only 0.2 degree horizontal grid resolution - need 0.1 degree.
2) Model is hydrodynamic - thermohaline circulation particularly important during fall and winter, and over shelf areas.
3) Crude representation of the vertical density profile - need mixed-layer physics.
4) Model has full scale bottom topography (which is essential for a good simulation), but the layer interface(s) must not intersect the bottom. Shallowest topography in model is at 500m.

MODEL DEVELOPMENT PLAN

YEAR 1

Use existing 2-layer 0.2 degree Gulf of Mexico model. Find "best" representation of coastline and bottom topography. Initially use seasonal wind forcing and constant inflow, later simulations will use winds based on 12 hourly FNOC surface pressure analysis and time varying inflow.

Products:

One or more Gulf simulation surface current data sets, selected as the "best" available simulation to date (not all model experiments will be delivered). Data sets will be every 3 days for many eddy cycles (ten years or more) to capture the full Gulf circulation variability.

YEAR 2

Use 2-layer model, but on a 0.1 degree grid, and with lower eddy viscosity. Expect richer flow field, including wind induced flow instabilities. Some experiments will use 1-layer (reduced gravity) model, but all delivered simulations will have 2-layers.

Products:

One or more Gulf simulation surface current data sets, selected as the "best" available simulation to date (not all model experiments will be delivered). Data sets will be every 3 days for many eddy cycles (ten years or more) to capture the full Gulf circulation variability.

YEAR 3

Develop 3-layer model with bulk thermodynamics. Densities in the upper two layers will be allowed to change locally with time, under control of the equation of state and temperature equation added to model. Initially 0.2 degree simulations, later 0.1 degree grid will be used.

Expect to see thermohaline circulation and improved representation of permanent thermocline. Three layers also better resolve "hydrodynamic" circulation, and thinner upper layer increases accuracy of surface velocities.

In addition modify the 2-layer hydrodynamic and 3-layer thermodynamic models to allow the layer interfaces to intersect the bottom topography. This will allow the minimum bottom depth to be raised from 500m to about 20m. Layer intersection is not generaly found in layered ocean models, and so its successful implementation is less certain than other phases of the program.

However if successful it will significantly improve the realism of the simulations over the continental shelf.

Products:

One or more Gulf simulation surface current data sets, selected as the "best" available simulation to date (not all model experiments will be delivered). Data sets will be every 3 days for many eddy cycles (ten years or more) to capture the full Gulf circulation variability. At least one data set will also include sub-surface currents.

YEAR 4

Complete 0.1 degree 3-layer simulations. Then couple circulation model results to a mixed layer model (TOPS). TOPS is the Navy's operational mixed layer forecast model. Simplest version of TOPS is one dimensional, with 15+ fixed vertical levels covering upper 500m. It can accept geostrophic currents from any suitable source, the 3-layer model is suitable but the 2-layer (hydrodynamic) is not. Can use coarser grid for TOPS (0.2 or 0.4 degrees), possibly with finer coverage of selected regions (TOPS is 1-dimensional). It is applied only after spin-up of the circulation model.

This final coupled model will give detailed vertical density profiles, and greatly improve the simulation accuracy in shelf regions.

Products:

One or more Gulf simulation surface and sub-surface current data sets, selected as the "best" available simulation to date (not all model experiments will be delivered). Data sets will be every 3 days for many eddy cycles (ten years or more) to capture the full Gulf circulation variability. At the end of the final year a fully documented FORTRAN code and user guide for the final model versions will be delivered. No earlier codes will be delivered, since they may not be in a suitable form for distribution.

PROGRESS

YEARS 1 AND 2

All tasks in years one and two are complete and final reports have been accepted by MMS.

YEAR 3

The major thrust of the effort so far this year has been in the development of a version of the layered ocean model that will allow layer interfaces to effectively intersect the bottom topography. Thus removing what is probably the most serious deficiency of the present model, namely that the topography is confined to the lowest layer, i.e. its minimum depth is about 500m. When intersection occurs in a conventional layer model the layer thickness becomes negative which is clearly unphysical, leading to unrealistic results and, if the situation persists, catastrophic failure of the run due to undamped instabilities. The obvious solution of setting a minimum layer thickness at or about zero does not work because, (a) it leads to loss of mass, and (b) clamping the layer thickness induces dispersive ripples in the interface at the intersection point (i.e. we have an unresolved boundary layer). One promising approach to the layer intersection problem is to insure positive layer thicknesses via 'Flux Corrected Transport', a technique that was originally developed for fluid problems with shocks (Book et. al., 1981). In this method the continuity equation is solved for layer thickness using two different sets of transports, one obtained via a low order (highly dispersive) scheme guaranteed to give monotonic results and the other via a standard (ripple prone) high order scheme. The low order scheme used alone would prevent layer intersection, but it very rapidly damps out circulation features and therefore would not produce realistic simulations. Instead, the final layer thickness at each point is a linear combination of the two solutions, chosen to be a close as possible to the high order solution. Away from areas of layer intersection the high order scheme will be used alone and the solution will be identical to that without FCT, but near intersections just sufficient contribution from the low order scheme will be used to ensure a positive layer thickness. In other words, bottom topography is still confined to the lowest layer, but that layer can get very thin so there is effectively no contribution from the deep layer over the shelf and no limit on how shallow the bottom topography can be. This method has already been used with some success in a similar layered ocean model, both for interfaces that intersect the surface and more recently for layers that intersect the topography (Bleck et. al., 1983). The major problem with the method is that FCT is an inherently explicit scheme, in contrast to the existing ocean model which treats gravity waves implicitly (to allow much larger timesteps).

Two dimensional (x-z) versions of a two layer hydrodynamic model that uses FCT to allow layers to intersect the bottom have been tested on sections across the Gulf of Mexico on a 0.2 degree grid. Initial tests in three dimensions are in progress for the Gulf of Mexico on a 0.4 degree grid. A fully explict model's timestep would be controlled by the external gravity wave speed (about 150 m/s), but here the depth averaged flow is treated implicitly so the timestep depends on the internal gravity wave speed (about 3 m/s). The existing ocean model, with topography confined to the lowest layer, treats both external and internal gravity waves implicitly and can use a timestep 3 to 5 times longer than the FCT code. It may be possible to increase the speed of the new model by using a split-explicit formulation, i.e. by using a different timestep for the internal gravity wave calculation than for other components of the model. However, in the best possible case a model that allows layer intersection will be 1.5 to 2 times more expensive to run that a model that does not have this capability.

Figure 1 shows the region used for the two dimensional experiments, it is a section across the Gulf of Mexico at 26N on a 20 km grid. The position of each model grid point is indicated by a vertical line below the topography contour, in all the plots data is only available at grid points and straight lines are used to connect data values. The upper layer rest depth is 300 m over deep water, but is less near 98W and 82W where the continental shelf is shallower than 300 m deep. The lower layer is set to be at least 10 cm thick across the entire region, so there is a lower layer over the continental shelf although it is too thin to be seen in the plot. Figure 1 is for 2 days into an experiment to test the ocean model with no applied forcing. The layers are in exactly the same position as at the initial time, and the velocities are zero everywhere. This demonstrates that the model does not deviate from an initial rest state without applied forcing.

Figures 2 to 5 show only the upper 450 m of the water column for a gravity wave sloshing experiment where there is no applied forcing but the layer interface is initialized with a single period cosine profile across the region. Figure 2 shows the initial state with about 100m variation in the depth of the interface from east to west, note that the lower layer is again 10 cm thick where the topography is shallower than the expected interface depth. Figure 3 is for day 3 of the simulation, the layer interface is now almost level. Figure 4 is for day 6, the layer interface has moved up or down about 100m at each end to reverse the profile. It is no longer exactly sinusoidal however because gravity waves travel more slowly in shallow water than they do in deep water. The interface is level again between day 9 and day 10. Figure 5 is for day 12, the interface is again shallower to the west as it was on day 0, but the wave is almost square and the model blows up at day 15 as the wave 'breaks'. The conversion of the original wave into a breaking wave is to be expected given that gravity waves travel more slowly in shallow water. To demonstrate this, Figure 6 is from a similar experiment that increased the depth of the topography (the shallowest topography can be seen in the two lower corners of the plot). In this case FCT is not used, after 16 days (Figure 6) the interface profile is similar to that of the full scale topography experiment after 12 days (Figure 5).

REFERENCES

Bleck, R., C. Rooth, D.B. Boudra 1983: "Wind-Driven Spinup in Eddy-Resolving Ocean Models Formulated in Isopycnic and Isobaric Coordinates", Rosenstiel School of Marine and Atmos. Sc., U. of Miami, Florida.

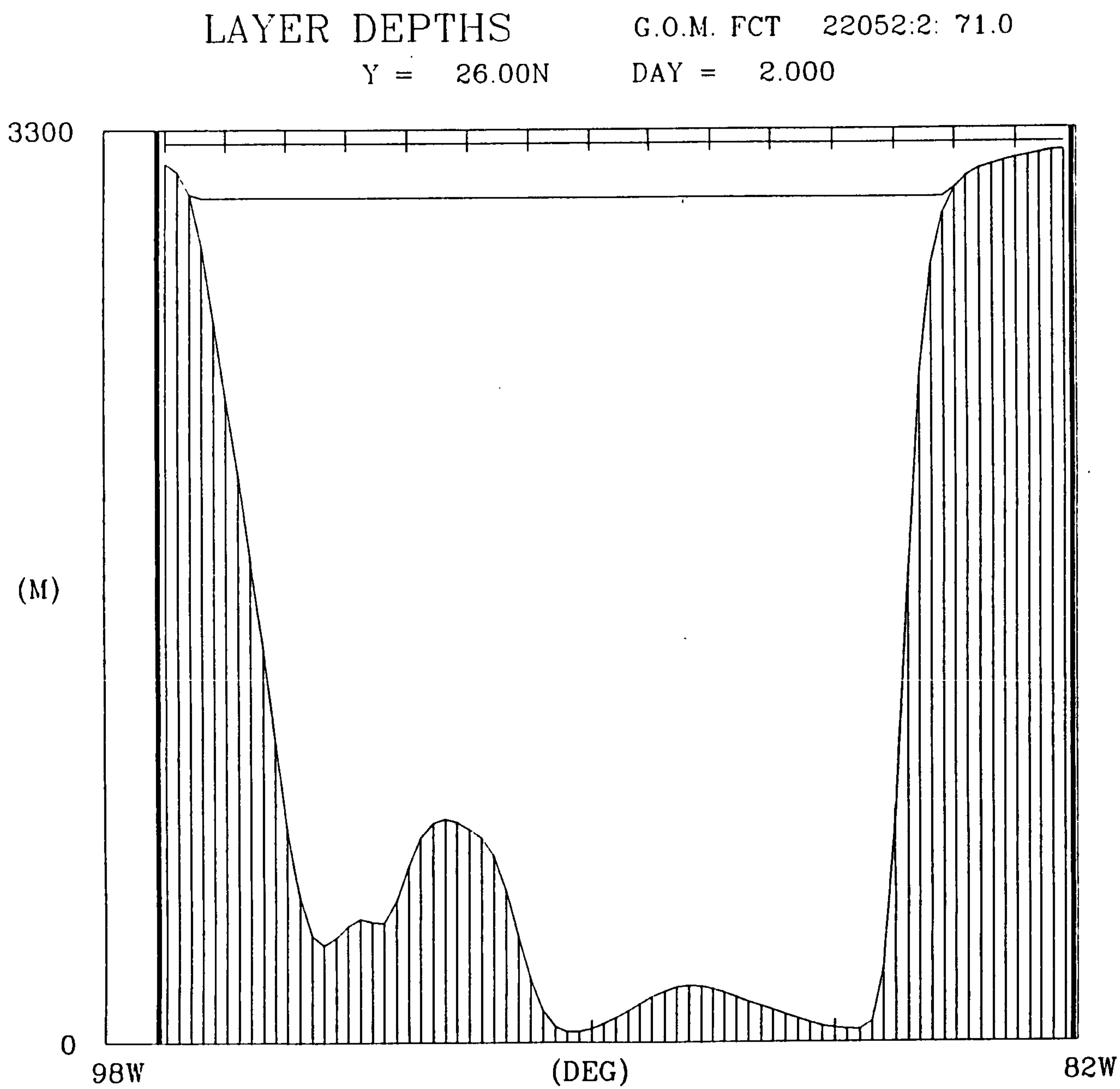
Book, D.L., J.P. Boris, S.T. Zalesak 1981: "Flux-Corrected Transport" in D.L. Book (ed), Finite Difference Techniques for Vectorized Fluid Dynamics Calculations, Springer-Verlag.

FIGURES

FIGURE 1: Layer depths for a two dimensional, two layer, hydrodynamic model with full scale bottom topography that uses Flux Corrected Transport to allow the layer interface to 'intersect' the topography. The figure is for day 2 of an experiment testing the stability of the rest configuration in the absence of external forcing. There has been no change over the 2 days. The lower layer is 10 cm thick at all points where the topography appears to intrude into the upper layer.

FIGURES 2 to 5: Layer depths for a two dimensional, two layer, hydrodynamic model that uses Flux Corrected Transport to allow the layer interface to 'intersect' the topography. Only the upper 450m of the water column is shown. The figures are for days 0, 3, 6, and 12 respectively. The simulation halted at about day 15 because the interface wave 'breaks'.

FIGURE 6: The top 450m of the water column on day 14 of an experiment similar to that in figures 2 to 5, but with deeper topography that does not intersect the layer interface. FCT was not used in this experiment.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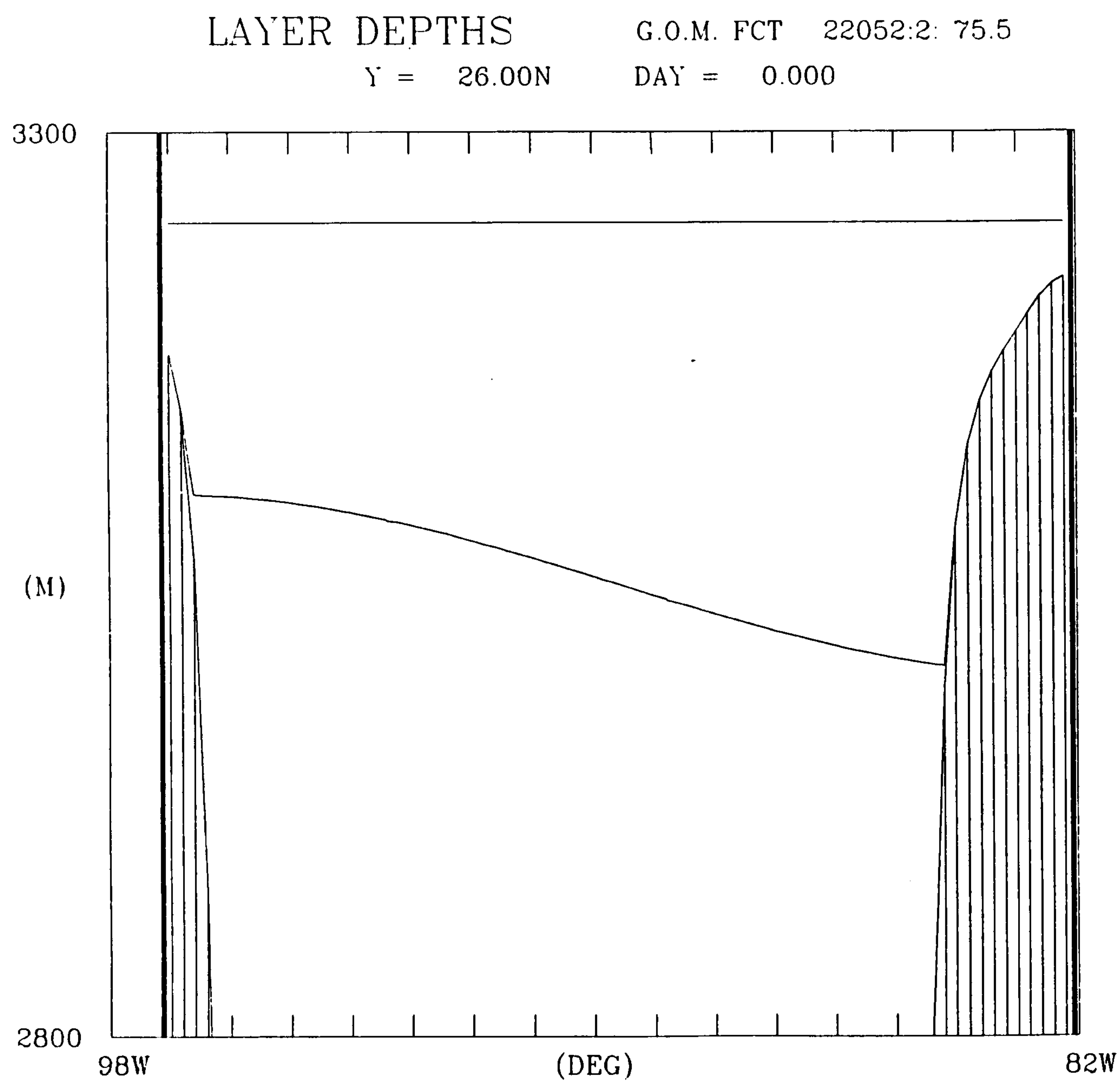
(DEG)
82W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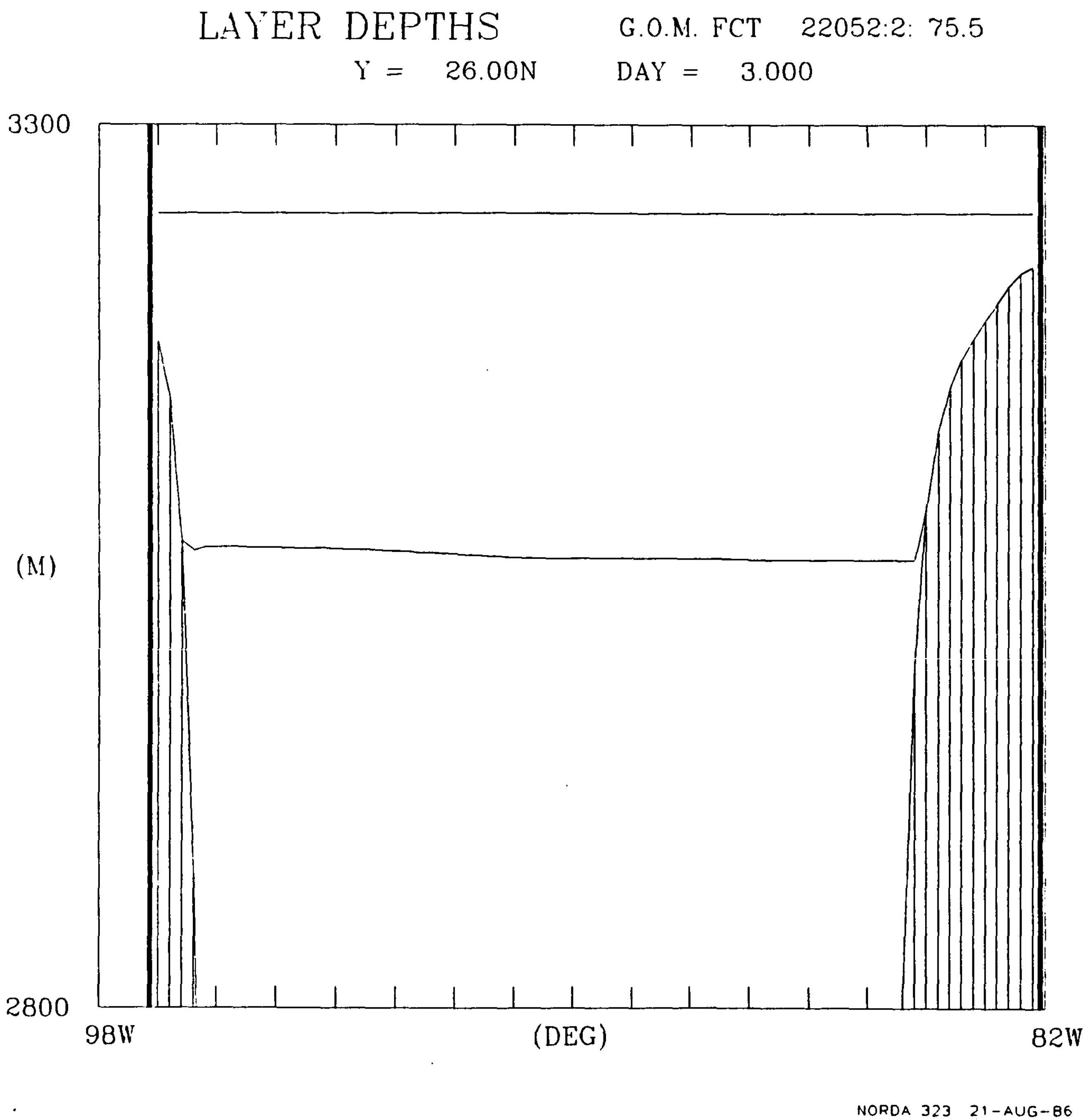
(DEG)
82W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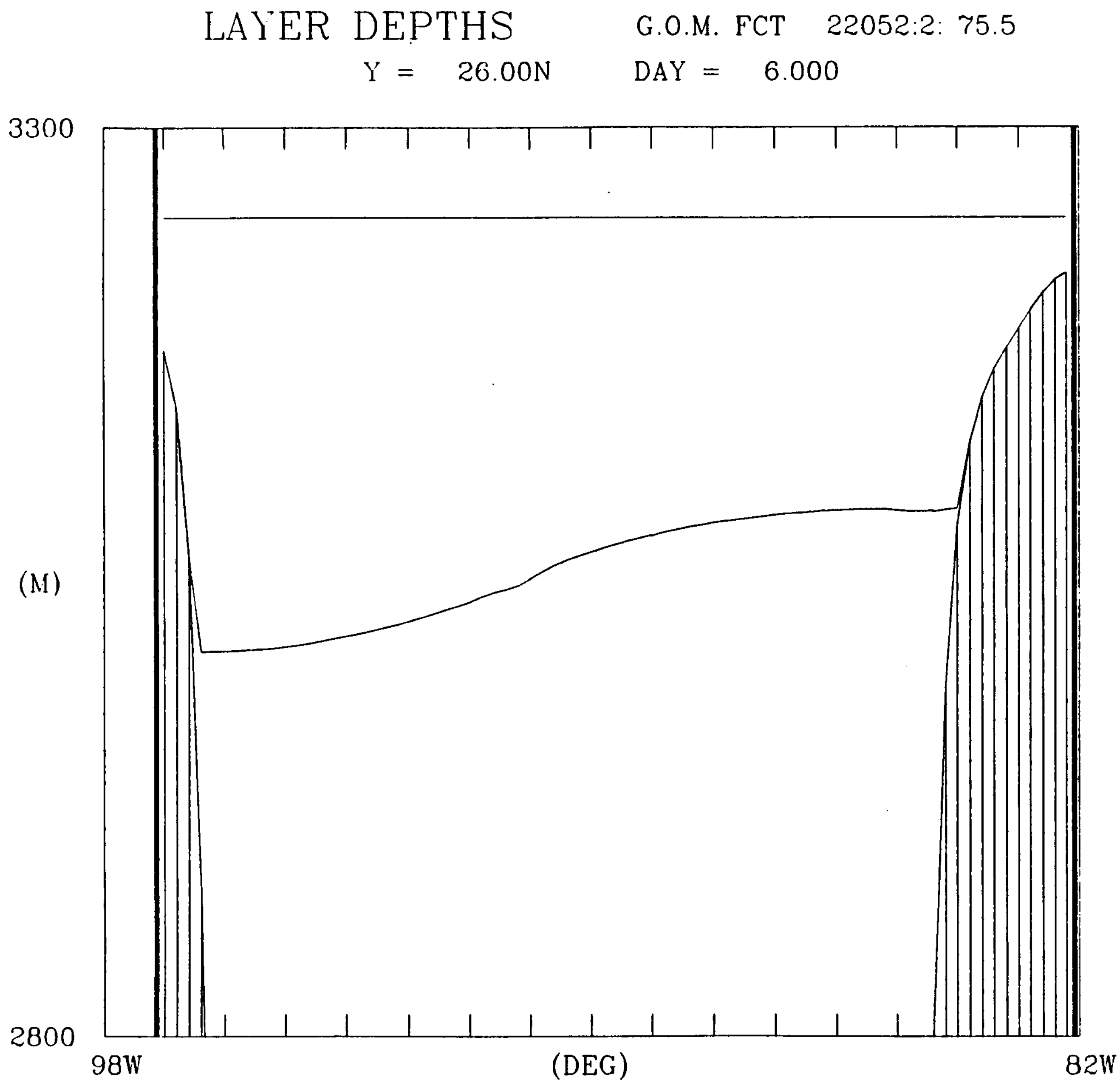
NORDA 323 21-AUG-86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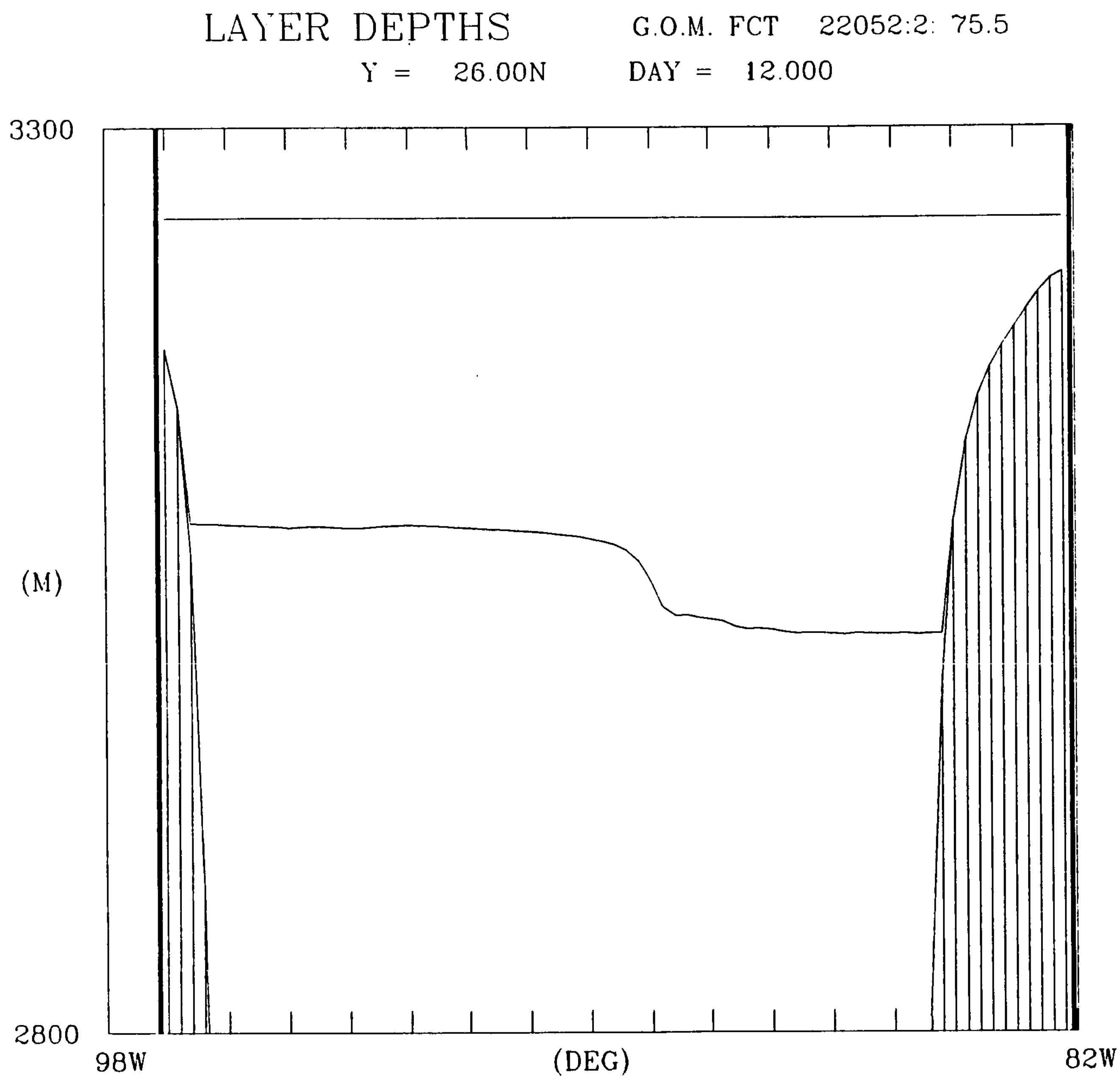

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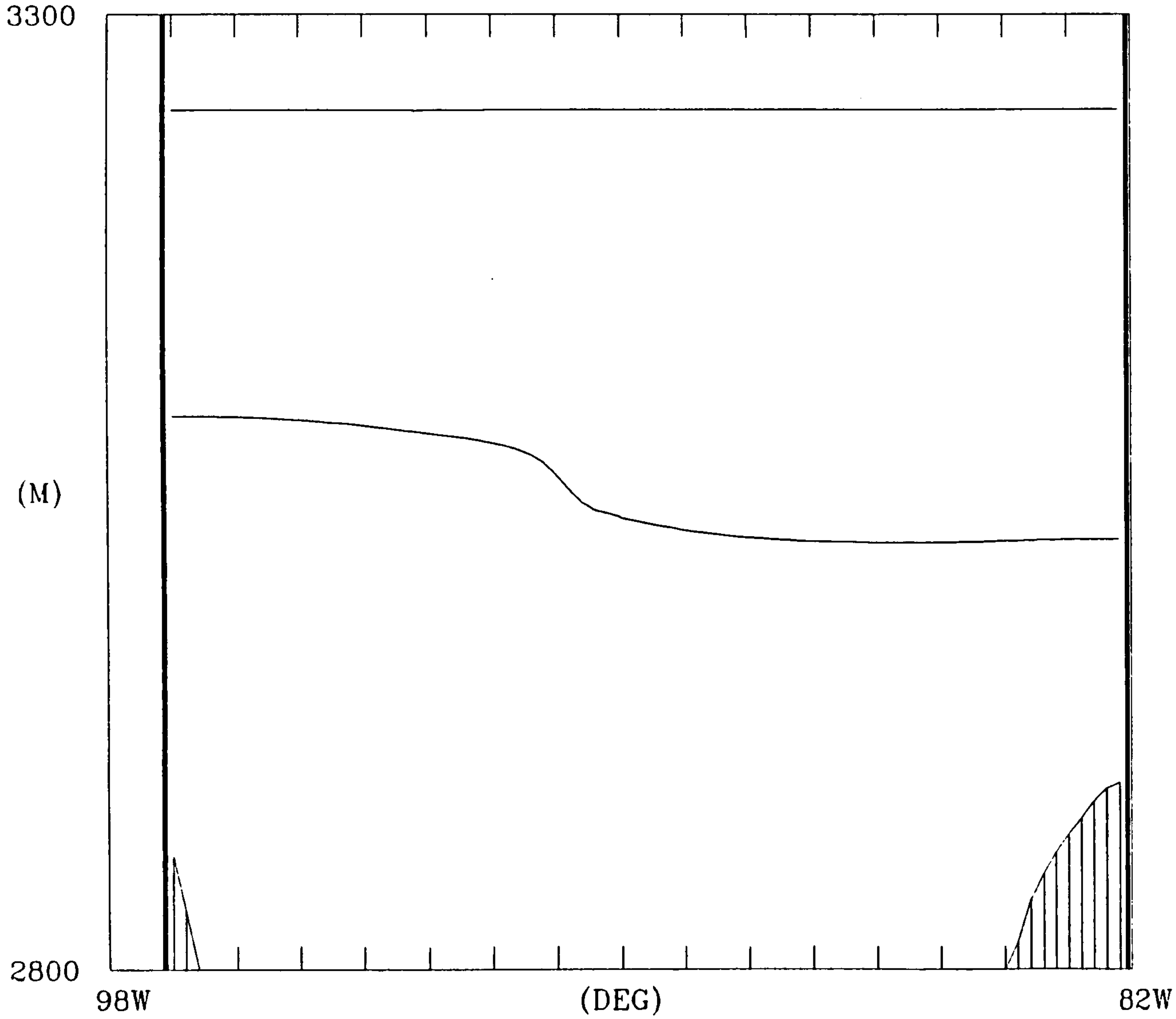

Indirect Socioeconomic Impacts of OCS Oil and Gas Development

I. Introduction

Changes in the outputs and employment levels of the oil and gas activities located in the Outer Continental Shelf (OCS) of the Gulf of Mexico (GOM) have a multiple effect on the outputs and employment levels of other industries located in the Coastal Areas. The magnitude of this effect or impact on coastal economies is now being investigated for the Minerals Management Service in a project entitled Analysis of Indicators for Socioeconomic Impacts Due to OCS Oil and Gas Activities in The Gulf of Mexico, Year II. The general purpose of this project is the development of a program that Minerals Management Service (MMS) personnel can use to regularly conduct socioeconomic impact assessments associated with known or assumed changes in the OCS oil and gas activities in the Gulf of Mexico. The principal study item of this project is the development of a model that can identify and measure the extent of socioeconomic impacts. This model will be referred to here as a socioeconomic impact assessment model.

II. Industry Categories

One of the first steps in the development of the socioeconomic impact assessment model was the formulation of an industry aggregation system that reflects the major industries operating in the Coastal Areas. Briefly, industry aggregation involved three basic steps. First, industries that directly relate to the oil and gas activities in the OCS/GOM were identified. These industries, called Primary Industries, were identified on the basis of the so-called direct impact scenarios, which are being developed by MMS personnel. These direct impact scenarios involve both the development of oil and gas activities in the OCS/GOM area as well as the production of oil and gas from the area. The Primary Industries are given in Table 1. These industries represent four categories: Mining, New Construction, Maintenance and Repair, and Manufacturing.

The second step was to identify industries that directly and indirectly support the Primary Industries. These industries are called Supportive Industries and were identified on the basis of information contained in the National I/O Use table.

The National Use table for 1977 records the amount of input (by commodity) required (or purchased) by each industry in order for that industry to produce its output. (1977 is the most recent year for which national input-output information is available.) With this information, important suppliers of inputs to the oil and gas industries could be identified. Since suppliers of inputs to the oil and gas industries also require inputs for production purposes, the list of important

Table 1

PRIMARY INDUSTRIES

1. Mining

    Crude Petroleum and Natural Gas Mining (I/O No. 8.0000)

2. New Construction

    New Petroleum and Natural Gas Well Drilling (I/O No. 11.0601)

    New Petroleum, Natural Gas and Solid Mineral Exploration (I/O No. 11.0602)

3. Maintenance and Repair

    Maintenance and Repair of Gas Utility Facilities (I/O No. 12.0207)

    Maintenance and Repair of Petroleum Pipelines (I/O No. 12.0208)

    Maintenance and Repair of Petroleum and Natural Gas Wells (I/O No. 12.0215)

4. Manufacturing

    Petroleum Refining (I/O No. 31.0101)

Note: I/O numbers represent the I/O code numbers used in the 1977 national I/O study by the Bureau of Economic Analysis of the U.S. Department of Commerce.

supportive industries was expanded to include all important indirect suppliers. Table 2 contains the list of Supportive Industries, which consists of 50 industries that have been incorporated into the socioeconomic assessment model.

Table 2

SUPPORTIVE INDUSTRIES

1.	3.0001	Forestry Products
2.	*3.0002	Commercial Fishing
3.	4.0001	Agricultural, Forestry, & Fishery Services
4.	5.0000	Iron & Ferroalloy Ores Mining
5.	6.0200	Nonferrous Metal Ores Mining, Except Copper
6.	7.0000	Coal Mining
7.	9.0001	Dimension, Crushed & Broken Stone Mining and Quarrying
8.	*14.0700	Canned & Cured Sea Foods
9..	*14.1200	Fresh or Frozen Packaged Fish
10.	20.0100	Logging Camps & Logging Contractors
11.	20.0200	Sawmills & Planing Mills, General
12.	25.0000	Paperboard Containers and Boxes
13.	27.0100	Industrial Inorganic & Organic Chemicals
14.	30.0000	Paints & Allied Products
15.	36.1200	Ready-mixed Concrete
16.	37.0101	Blast Furnaces & Steel Mills
17.	37.0102	Electrometallurgical Products
18.	37.0105	Steel Pipes & Tubes
19.	37.0200	Iron & Steel Foundries
20.	38.0800	Aluminum Rolling & Drawing
21.	38.1000	Nonferrous Wire Drawing & Insulating
22.	40.0400	Fabricated Structural Metal
23.	40.0600	Fabricated Plate Work (Boiler Shops)
24.	40.0700	Sheet Metal Work
25.	41.0100	Screw Machine Products & Bolts, Nuts, Rivets, & Washers
26.	42.0402	Metal Coating & Allied Services
27.	42.0500	Miscellaneous Fabricated Wire Products
28.	42.0800	Pipe, Valves, & Pipe Fittings
29.	45.0300	Oil Field Machinery
30.	61.0100	Ship Building & Repairing
31.	65.0100	Railroads & Related Services
32.	65.0300	Motor Freight Transportation & Warehousing
33.	..65.0400	Water Transportation
34.	65.0600	Pipe Lines, Except Natural Gas
35.	66.0000	Communications, Except Radio and TV
36.	68.0100	Electric Services (Utilities)
37.	68.0200	Gas Production & Distribution (Utilities)
38.	69.0100	Wholesale Trade
39.	69.0200	Retail Trade
40.	70.0100	Banking
41.	70.0400	Insurance Carriers
42.	72.0100	Hotels & Lodging Places
43.	73.0101	Miscellaneous Repair Shops

Table 2

SUPPORTIVE INDUSTRIES
(continued)

44.	73.0104	Computer & Data Processing Services
45.	73.0105	Management & Consulting Services, Testing & Research Labs
46.	73.0107	Equipment Rental & Leasing Services
47.	73.0200	Advertising
48.	73.0301	Legal Services
49.	..73.0303	Accounting, Auditing & Bookkeeping, & Misc. Services, n.e.c.
50.	74.0000	Eating & Drinking Places

*These industries, while not part of the oil and gas industrial complex, were included in the final list of significant supportive industries because of their importance to coastal economies.

Finally, the third step was to classify all remaining industries as Universal Industries. Fifty-nine Universal Industries were identified for the socioeconomic impact study. These industries are listed in Table 3 along with the Primary and Supportive Industries. The total number of industries that are being used in the socioeconomic assessment model for the ten Coastal Areas is 116.

Table 3

MMS I/O SECTORS

1. Livestock & Livestock Products
2. Other Agricultural Products
3. Forestry Products**
4. Commercial Fishing**
5. Agricultural, Forestry, & Fishery Services**
6. Iron & Ferroally Ores Mining**
7. Nonferrous Metal Ores Mining, Except Copper**
8. Coal Mining**
9. Crude Petroleum & Natural Gas*
10. Dimension, Crushed & Broken Stone Mining and Quarrying**
11. Other Stone & Clay Mining and Quarrying
12. Chemical & Fertilizer Mineral Mining
13. New Petroleum Pipelines
14. New Petroleum & Natural Gas Well Drilling*
15. New Petroleum, Natural GAs, & Solid Mineral Exploration*
16. Other New Construction
17. Maintenance & Repair of Gas Utility Facilities*

Table 3

MMS I/O SECTORS
(continued)

18. Maintenance & Repair Of Petroleum Pipelines*
19. Maintenance & Repair of Petroleum & Natural Gas Wells*
20. Other Maintenance & Repair Construction
21. Ordnance & Accessories
22. Canned & Cured Sea Food**
23. Fresh & Frozen Packaged Fish**
24. Other Food & Kindred Products
25. Tobacco Manufacturers
26. Textiles & Apparels
27. Logging Camps & Logging Contractors**
28. Sawmills & planing Mills, Generals
29. Other Lumber & Wood Products
30. Furniture & Fixtures
31. Paper & Allied Products, Except Containers
32. Paperboard Containers & Boxes**
33. Printing and Publishing
34. Industrial Inorganic & Organic Chemicals**
35. Other Chemicals & Selected Chemical Products
36. Plastics & Synthetic Materials
37. Drugs, Cleaning & Toilet Preparations
38. Paints & Allied Products**
39. Petroleum Refining*
40. Petroleum Products
41. Rubber & Misc. Plastics Products
42. Leather, Footwear & Other Leather Products
43. Glass & Glass Products
44. Ready-mix Concrete**
45. Other Stone & Clay Products
46. Blast Furnaces & Steel Mills**
47. Electometallurgical Products**
48. Steel Pipes & Tubes**
49. Iron & Steel Foundaries**
50. Other Primary Iron & Steel Manufacturing
51. Aluminum Rolling & Drawing**
52. Nonferrous Wire Drawing & Insulating**
53. Other Primary Nonferrous Metals Manufacturing
54. Metal Containers
55. Fabricated Structural Steel**
56. Fabricated Plate Work (Boiler Shops)**
57. Sheet Metal Work**
58. Other Heating, Plumbing & Fabricated Structural Metal Products
59. Screw Machine Products & Bolts, Nuts, Rivets, & Washers**
60. Other Screw Machine Products and Stampings
61. Metal Coating & Allied Services**

Table 3

MMS I/O SECTORS
(continued)

62.	Misc. Fabricated Wire Products**
63.	Pipe, Valves, & Pipe Fittings**
64.	Other Fabricated Metal Products
65.	Engines & Turbines
66.	Farm & Garden Machinery
67.	Oil Field Machinery**
68.	Construction & Mining Machinery, Except Oil Field Machinery
69.	Materials Handling Machinery & Equipment
70.	Metalworking Machinery & Equipment
71.	Special Industry Machinery & Equipment
72.	General Industrial Machinery & Equipment
73.	Miscellaneous Machinery, Except Electrical
74.	Office, Computing, & Accounting Machines
75.	Service Industry Machines
76.	Electrical Industrial Equipment & Apparatus
77.	Household Appliances
78.	Electric Lighting & Wiring Equipment
79.	Radio, TV, & Communication Equipment
80.	Electronic Components & Accessories
81.	Miscellaneous Electrical Machinery & Supplies
82.	Ship Building & Repairing**
83.	Other Transportation Equipment
84.	Scientific, Photographic & Medical Equipment
85.	Miscellaneous Manufacturing
86.	Railroads & Related Services**
87.	Motor Freight Transportation & Warehousing**
88.	Water Transportation**
89.	Pipe Lines, Except Natural Gas**
90.	Other Transportation & Warehousing
91.	Communications, Except Radio & TV**
92.	Radio & TV Broadcasting
93.	Electric Services (Utilities)**
94.	Gas Production & Distribution (Utilities)**
95.	Gas, Water, & Sanitary Services
96.	Wholesale Trade**
97.	Retail Trade**
98.	Banking**
99.	Insurance Carriers**
100.	Other Finance & Insurance
101.	Real Estate & Rental
102.	Hotels & Lodging Places**
103.	Personal & Repair Services, Except Auto
104.	Miscellaneous Repair Shops**
105.	Computer & Data Processing Services**
106.	Management, Consulting, Testing, & Research Lab. Services**

Table 3

MMS I/O SECTORS
(continued)

107. Equipment Rental & Leasing Services**
108. Advertising**
109. Legal Services**
110. Accounting, Auditing & Bookkeeping
& Miscellaneous Services**
111. Other Business Services
112. Eating & Drinking Places**
113. Automotive Repair & Services
114. Amusements
115. Health, Educational, & Social Services
& Nonprofit Organizations
116. Other Industry

Note: Industries that are marked with one asterisk are Primary Industries; industries marked with two asterisks indicate a Supportive Industry.

III. Socioeconomic Impact Model

The socioeconomic impact model provides a means of quantifying indirect effects, since the basic feature of the model is the accounting of interindustry transactions among the 116 producing sectors noted in Table 3.

The construction of such a model requires a substantial amount of data on industry sales and purchases (or, from/to information) for a single accounting period, such as a calendar year. The amount of information required is extensive because from/to information must be developed for all the producing sectors identified in the model. Moreover, this information is expensive because is is not available at the local level for public use. Therefore, from/to information must be obtained from either industry surveys or nonsurvey techniques.

Survey based models were popular in the early 1960s, when state and federal agencies provided generous funding to underwrite industry surveys. Today, with restricted funding for regional economic modeling, a full survey approach is unthinkable. As a result, recent work in regional socioeconomic impact modeling has focused on limited survey techniques or, more typically, nonsurvey techniques. The MMS study is restricted to nonsurvey techniques.

Nonsurvey techniques rely entirely on secondary data sources. Nonsurvey based socioeconomic models for U.S. regions, like the ten Coastal Areas, are usually based on national input-output coefficients. Techniques are then employed to adjust these national coefficients to reflect the region's production input coefficients. The use of national coefficients, of course, involves the fundamental assumption that for similar industries there are no substantial differences between national and regional technical relationships. Significant differences occur only in trade relationships, and these differences are considered in the adjustment process.

An important empirical question is how accurate are these nonsurvey techniques for generating regional from/to information for regional socioeconomic impact models? To be sure, there is no "true" regional socioeconomic impact model to compare nonsurvey results. Clearly, survey based models contain error, since they are constructed from sample information. In order to evaluate the validity of the MMS nonsurvey model, two Coastal Areas, called test areas, have been selected to conduct a limited survey of several industries within these areas. The test areas are Coastal Area E-3 (Charlotte, Citrus, Collier, De Soto, Hernando, Hillsborough, Lee, Manatee, Pasco, Pinellas, and Sarasota counties in Florida) and Coastal Area W-2 (Brazoria, Chambers, Fort Bend, Galveston, Hardin, Harris, Jefferson, Liberty, Matagorda, Montgomery, Orange, and Waller counties in Texas)

IV. Model Validation

Industries located in the two test areas have been selected to be surveyed. These industries represent a full range of economic activity, including mining, construction, manufacturing, transportation, and services. A total of ten industries have been tentatively selected for the survey, which are indicated below. This list may change, depending on the availability of firm identification for mailing purposes, etc.

1. Construction: New Petroleum and Natural Gas Well Drilling
2. Maintenance & Repair of Petroleum Pipelines
3. Inorganic & Organic Industrial Chemicals
4. Canned & Cured Sea Foods Processing
5. Fresh or Frozen Packaged Fish
6. Fabricated Structural Metal
7. Oil Field Machinery
8. Motor Freight Transportation & Warehousing
9. Newspapers Publishing and Printing
10. Transportation Pipelines, except Natural Gas

The particular selection of firms to represent the above industries is based on maximum industry coverage, meaning that only the largest firms, based on employment size, have been chosen.

Industry specific questionnaires have been developed for each of the ten industries, meaning that all questionnaires have been designed to capture individual industry characteristics, especially the input requirements or the operating expenses of the industry. To this end, the questionnaires emphasize the expense statement rather than the incomes statement of a firm's accounts. Importantly, this emphasis is consistent with the information requirements of the procedure to validate the reliability of the nonsurvey regional socioeconomic impact models for the Study Areas. In brief, the procedure focuses on industry input requirements. From a practical standpoint, the emphasis on operating expenses is also consistent with typical firm response. Firms, especially branch plant operations, typically provide more detailed information on production than on sales. This likely reflects the management structure of many corporate enterprises. Management at the branch plant (or production) level handles production. Marketing and sales decisions are handled at the home office level, which is typically separated (even geographically separated) from the production division.

Questionnaire results will be used to validate the nonsurvey socioeconomic impact model. With questionnaires scheduled for mailing in September, the process of model validation is planned for October.

ABSTRACT

GULF OF MEXICO PHYSICAL OCEANOGRAPHY PROGRAM

MINERALS MANAGEMENT SERVICE TERNARY MEETING

SEPTEMBER 3, 1986

SUBMITTED BY:
SCIENCE APPLICATIONS INTERNATIONAL CORP.
RALEIGH, NORTH CAROLINA

Abstract

Introduction

In October, 1982, the Minerals Management Service initiated a multiyear physical oceanographic field study in the Gulf of Mexico with a goal of establishing an improved understanding of circulation patterns and to create a data base which can be utilized by a concurrent and coordinated MMS-funded circulation modeling program. Program Years 1 and 2 of the field study have been completed. Years 3 (Western Gulf) and 4 (Eastern Gulf) are ongoing. All field measurements for Years 3 and 4 have been completed except for drifting buoy data and ship-of-opportunity casts, both of which are continuing.

At the 1986, Fall Meeting of the American Geophysical Union(AGU) to be held in San Fransisco in Decenber, there will be a special session concerning Gulf of Mexico, Phyusical Oceanographic Processes. Most principal investigators on MMS-funded physical oceanographic programs will be making presentations. This session which will be co-chaired by Dr. Murray Brown (MMS) and Capt. Alberto Vazquez (Mexican Navy) provides an excellent opportunity to make the larger scientific community further aware of the substantially improved understanding of various Gulf of Mexico physical oceanographic conditions.

Western Gulf -- Year 3

All subsurface mooring were retrieved at the end of April, 1986. The decision to retrieve a month early was made to help enhance data return. The concencus of opinion was that by April, most of the conditions and measurements hoped for had been taken. To leave the moorings in place longer may have increased the possible record length but substantially increased the liklihood of data/equipment loss. During the retrieval cruise, and extensive XBT survey was conducted which is allowing the evolution of rings interacting with the slope to be better resolved and understood(Figure 1)

Only Buoy # 3379, a full FGGE buoy, continues to drift in the western Gulf. It was initially released in a Loop Current eddy which detached early in 1986. At this time, it is making large anticyclonic loops in the western Gulf. (Figure 2). Buoy # 3378, which was released in June, 1985 in the eddy that eventually interacted with the western Gulf slope in the vicinity of our moorings, recently moved across the Gulf to the east and was entrained in the Loop Current. It was retrieved by fisherman as it moved out of the Gulf south of the Florida Keys. Buoy # 3353 left the organized eddy circulation in the western Gulf and moved onto the Texas outer shelf where it was found and retrieved by a shrimper. (Figure 3).

Eastern Gulf -- Year 4

As indicated at the previous Ternary Meeting in March, all instruments in the eastern Gulf were recovered at the end of January, 1986. Recently, through MMS, the program has received three months of current measurments made just offshore of Ceder Key, Florida in 17 meters of water. These current time series, which were made in part as a hurricane moved by and over the instrument moorings, have been processed, analyzed and distributed to program PI's and MMS. These measurements provide a supplement to Dr. Sturges', NSF-funded instruments at the adjacent shelf break and the MMS-funded instruments to the south. These additional records showed some influence from the hurricane, although it is quite likely that the instrument's impellor was partially and/or completely fouled during part of the the measurment period. The considerable data taken was consistant with the expected wind-driven circulation pattern.

The Draft Final Report for Year 4 will be submitted to MMS in November, 1986.

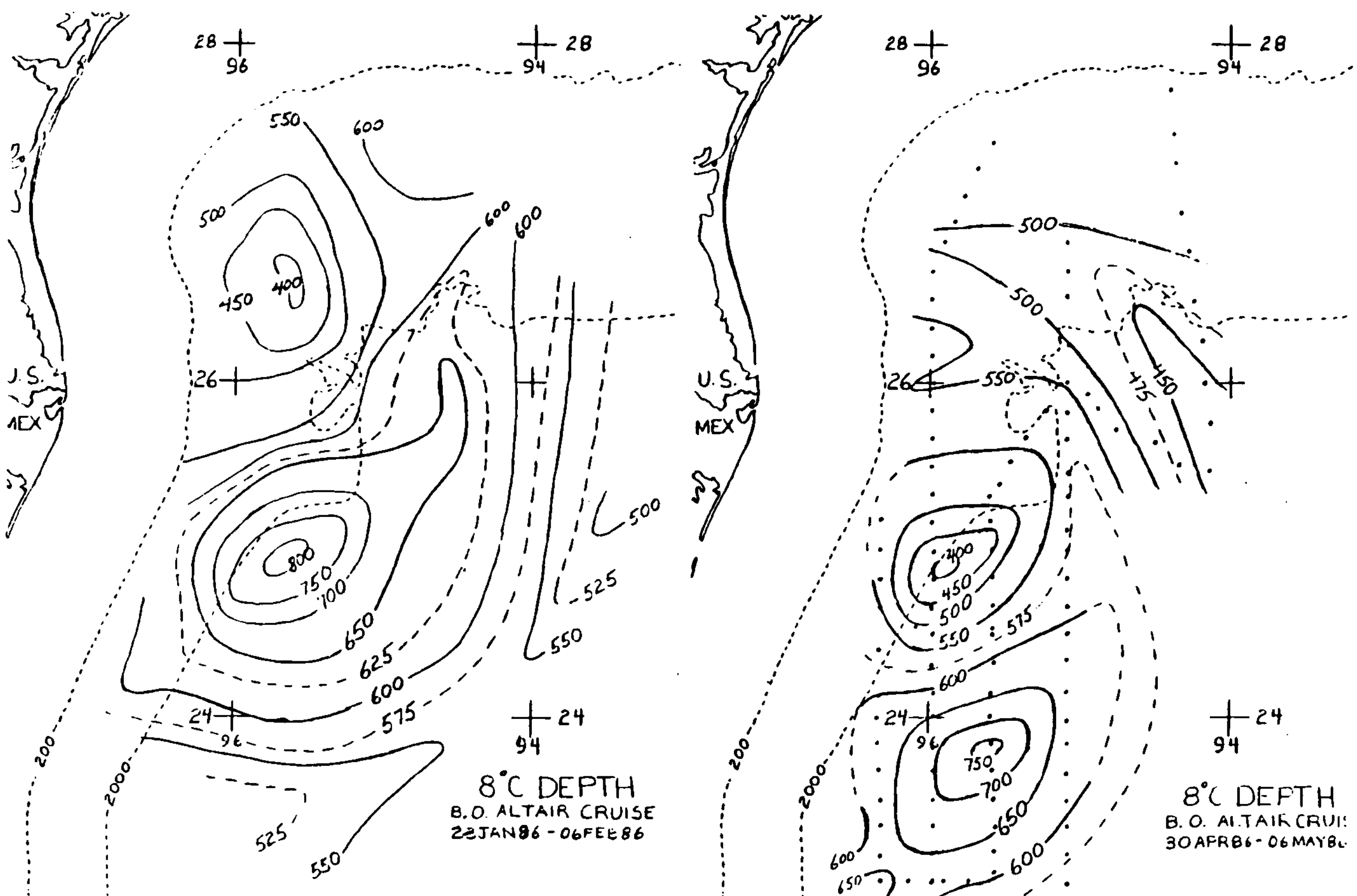

Figure 1. Contour plots of $8^{o}C$ isotherm during Jan - Feb. 1986 hydro-survey

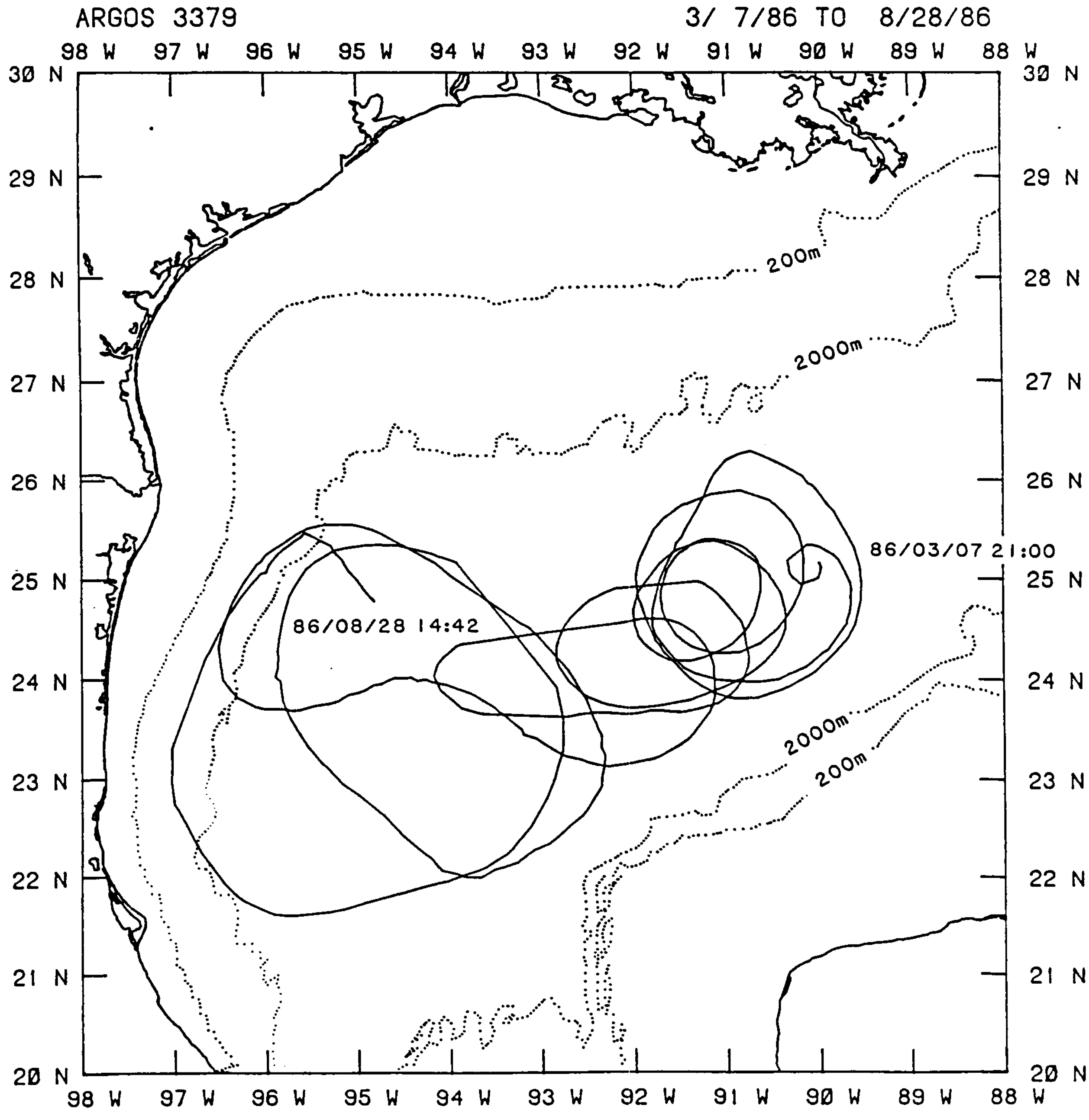

Figure 2. Trajectory for Buoy #3379.

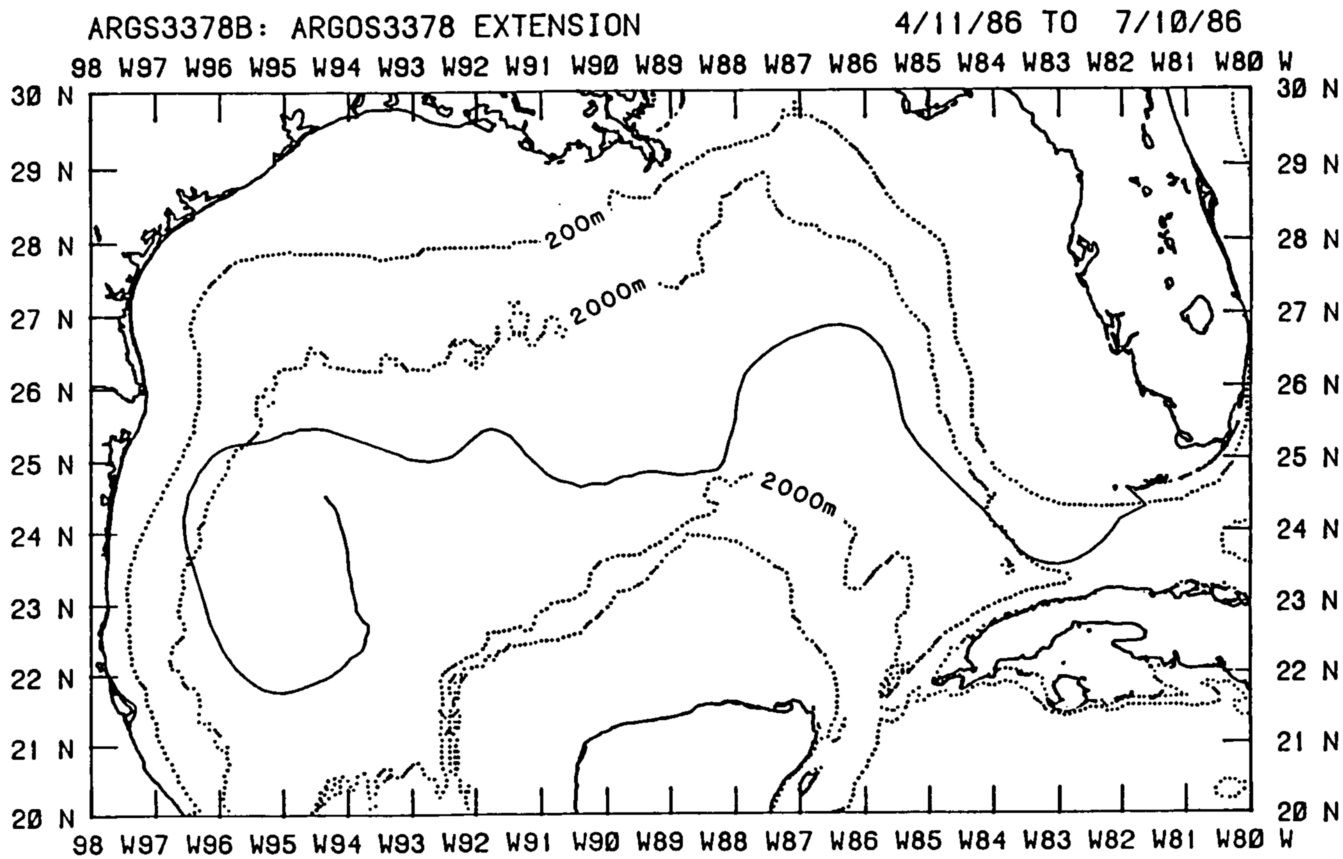

Figure 3a. Trajectory of Buoy #3378.

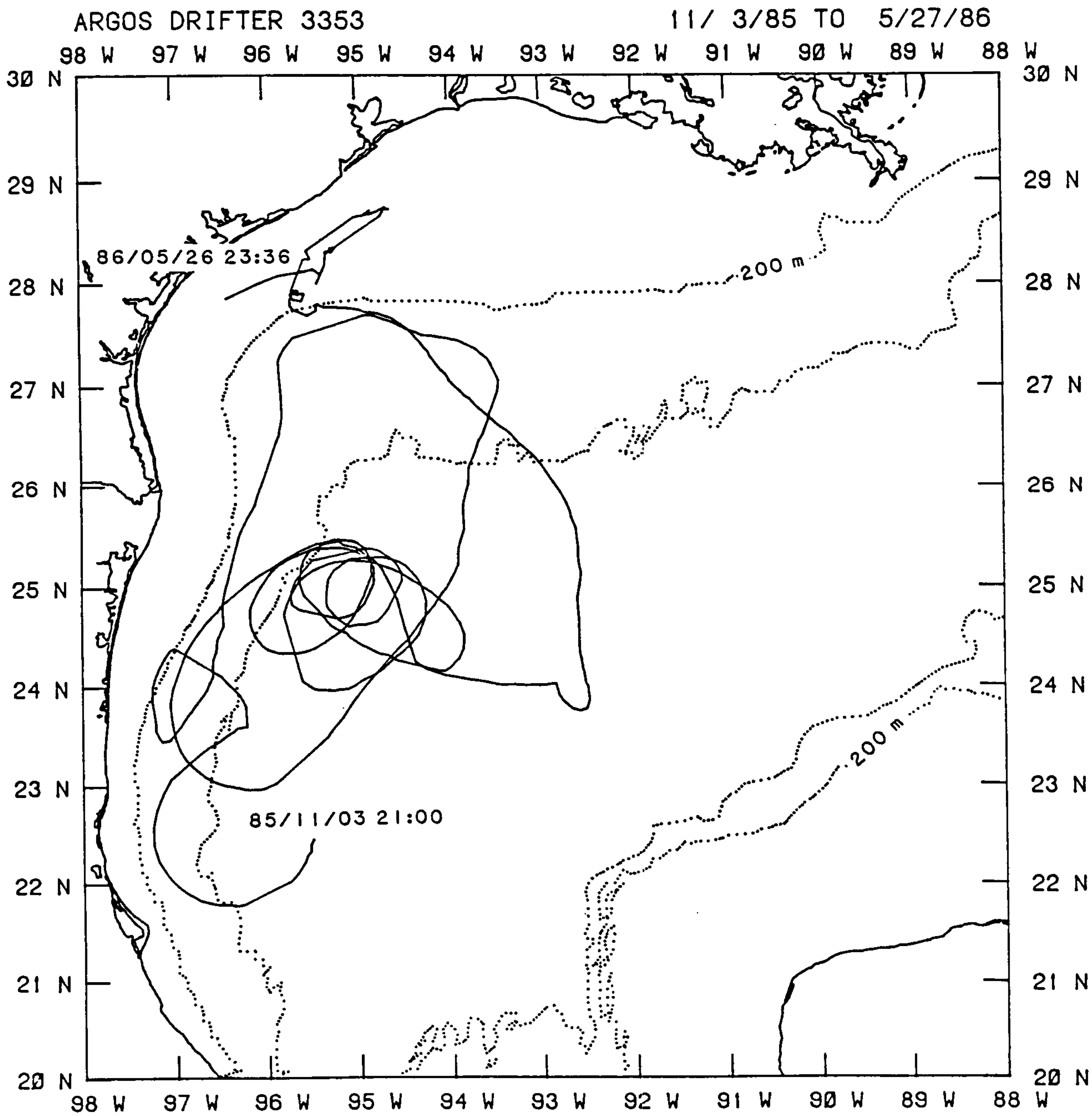

Figure 3b. Trajectory of Buoy #3353.

OCS DEVELOPMENT AND POTENTIAL COASTAL HABITAT ALTERATION

Contractor: Louisiana State University, Center for Wetland Resources

Presented by: Dr. Donald R. Cahoon

Abstract

During the past five months, we have completed Task 1, the establishment of methodology, and commenced all phases of the research. The experimental design was finalized through the cooperative efforts of the Science Review Board, Minerals Management Service staff, and Louisiana State University scientists. The project is directed toward understanding the mechanism of coastal submergence (is it increased subsidence, decreased land building, or both?), what impact OCS and onshore oil and gas development have on this mechanism, and what portion of the coastal land loss problem is due to direct as opposed to indirect causes. To address these goals, the project raises six majors questions aimed at analyzing the processes and patterns of land loss. Each of these major questions has been broken down into specific questions that can be tested by scientific methods. To facilitate analysis of these questions, the project staff has been divided into subgroups, each investigating a specific set of processes or patterns. The subgroups are: direct impacts; saltwater intrusion; subsidence; sedimentation; and aerial imagery.

While completing Task 1, gaps in our knowledge were identified and new technical approaches proposed to fill them. Thus, the original project design has been expanded to include an additional modelling effort analyzing the subsurface movement of saline water through the marsh from canals, a broader scope of effort for analyzing salt water intrusion in major navigation canals, plus an analysis of the amount of sediment that would have flooded the marshes had the Mississippi River not been leveed.

The project is analyzing impacts along the Gulf coast from eastern Texas, through Louisiana, to western Mississippi but our research efforts are being intensely focused on three geographic regions in south Louisiana: western Barataria Bay (Lafourche Parish); eastern shore of Atchafalaya Bay (western Terrebonne Parish), and the Chenier Plain (Cameron Parish). Since approval of the project design in late spring, all subgroups have commenced research efforts focusing initially in these areas. The progress of each subgroup over the past five months is reviewed.

ABSTRACT FOR
ASSESSMENT OF HURRICANE DAMAGE IN THE
FLORIDA BIG BEND SEAGRASS BEDS

(CONTRACT NO. 14-12-0001-30188)
MMS TERNARY MEETING
METAIRIE, LOUISIANA

3 SEPTEMBER 1986

SUBMITTED TO:

Environmental Studies Group
Gulf of Mexico Regional Office
Minerals Management Service
Metairie, Louisiana

SUBMITTED BY:

M. John Thompson
Senior Staff Scientist
Continental Shelf Associates, Inc.
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ABSTRACT

In 1984-1985 the Minerals Management Service (MMS) contracted a study to map and investigate the seagrass beds of Florida's Big Bend area. This program delineated 232,893 ha (575,479 acres) of dense seagrass beds (composed of *Thalassia testudinum*, *Syringodium filiforme*, and *Halodule wrightii*), 498,034 ha (1,230,642 acres) of sparse seagrass beds (composed of *Halophila decipiens*, *H. engelmanni*, and algal species, along with live bottom assemblages), and 279,722 ha (691,193 acres) of patchy seagrasses and live bottom, where all five species may be found.

During the 1985 hurricane season four major storms passed through the Gulf of Mexico (Figure 1). Reports from coastal observers and from long-term seagrass studies being conducted in Florida's Big Bend area indicated these storms, particularly Hurricanes "Elena" and "Kate", substantially impacted seagrass beds. Hurricanes represent important, short-term, environmentally disruptive phenonoma upon continental shelves and the existence of an extensive data base on the Big Bend seagrasses provided an ideal opportunity to quantify hurricane associated impacts over large geographical areas. Responding to this opportunity, the MMS extended the Florida Big Bend Seagrass Habitat Study (Contract No. 14-12-0001-30188) to include one additional field survey assessing the impacts of, and recovery from, these hurricanes in the seagrass beds off Florida's Big Bend.

The combined impacts and recovery assessment survey took place in August of 1986. Twenty of the original 50 quantitative signature control stations established for assessing seagrass densities on the aerial imagery of October 1984 were resampled. Sampled stations included 11 offshore from Tarpon Springs, Florida, approximately 97 to 129 km (60 to 80 mi) from the area of maximum hurricane impacts, and nine offshore of Cedar Key ranging from 0 to 39 km (0 to 24 mi) from the zone of maximum impact. Portions of three of the nine diver tow transects run in February 1985 were also resampled by divers riding towed, underwater sleds. In addition, three long-term seagrass monitoring stations established in June of 1985 and lying directly under the track of Hurricane "Elena" were quantitatively resampled, as well as two live bottom stations within the same area.

Qualitative, on the spot observations suggest complete recovery for both the dense inshore *Thalassia* - *Syringodium* - *Halophilia* grass beds and the sparse offshore *Halophilia* grass beds in the area offshore

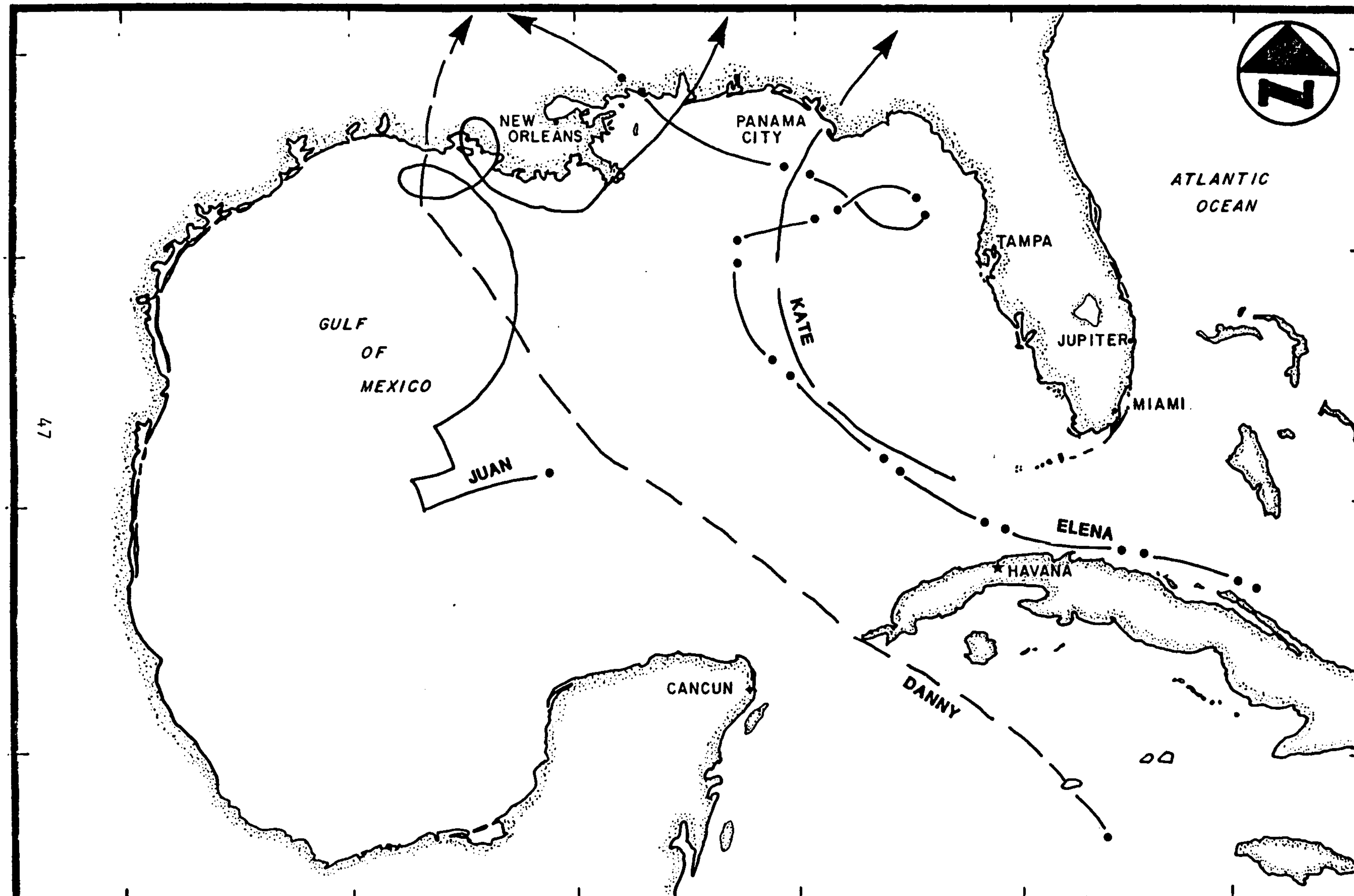

FIGURE 1. MAJOR HURRICANES OF THE 1985 SEASON.

from Tarpon Springs. Off Cedar Key, in and near the area where Hurricane "Elena" stalled for approximately 48 h, recovery also appeared to be taking place, but at a slower rate. Observational data suggest that in some areas Hurricane "Elena" scoured the bottom sediments, changing the physical characteristics of some of the sampling stations.

Quantitative photographic data from the sampling stations and qualitative observational data from diver and TV tows conducted during the August field effort are still being analyzed. Final products will include leaf density and biomass comparisons among the stations sampled and percent coverages of various habitats from the towed transect data. In November 1986 a complete summary of three years of research on Florida Big Bend seagrass habitats, including final results from this follow-up survey, will be presented at the annual Information Transfer Meetings, scheduled here in New Orleans.

ABSTRACT

SOUTHWEST FLORIDA SHELF ECOSYSTEMS PROGRAM

prepared by
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.,
LGL ECOLOGICAL RESEARCH ASSOCIATES, INC.,
and
CONTINENTAL SHELF ASSOCIATES, INC.

prepared for
MINERALS MANAGEMENT SERVICE
TERNARY MEETING (SEPTEMBER 3, 1986)

INTRODUCTION

Environmental Science and Engineering, Inc. (ESE), LGL Ecological Research Associates, Inc. (LGL), and Continental Shelf Associates, Inc. (CSA) are currently completing the sixth and final year of the Southwest Florida Shelf Ecosystems Program. The objectives of this program are to:

1. Determine the potential impact of OCS oil and gas offshore activities on live-bottom habitats and communities which are integral components of the southwest Florida shelf ecosystem.
2. Produce habitat maps that show the location and distribution of various bottom substrates.
3. Classify broadly the biological zonation across and along the shelf, projecting the percent of the area covered by live/reef bottoms and amount covered by each type of live/reef bottom.

To meet these objectives, a 5-year field data collection program was conducted. The first 3 years of investigations (conducted by Woodward Clyde Consultants and CSA) effectively addressed Objectives 2 and 3. An additional 2-year study was designed specifically to investigate the biological and physical processes that, in combination with the first 3 years of investigation, would provide the information needed to better assess potential impacts of offshore development. A final year (Year 6) was added for synthesis and interpretation of available data, development of a conceptual model, and impact assessment of offshore oil development. This abstract presents the status, methods, and results of Years 5 and 6 of the Southwest Florida Shelf Ecosystems Program.

PROGRAM STATUS

As of December 1985, all field data were collected and analyzed. The results of these field investigations are presented in five annual reports submitted to MMS. The Year 5 Annual Report is currently being revised in preparation for final submission to MMS. Collection of relevant outside information for the sixth year of the program is approximately 50% complete; data synthesis is approximately 25% complete; valued ecosystem components (VECs) have been chosen; and development of the conceptual model has begun. Following completion of these tasks

ESE/LGL/CSA will assess the probable impacts of offshore oil and gas development on the southwest Florida shelf ecosystem. The results of this investigation will be submitted in a final report to MMS.

METHODS

During Year 5, intensive quarterly sampling of five stations sampled during Year 4 (Stations 52, 21, 29, 23, 36) continued, and three other stations were added for intensive study (Figure 1) Two of the three stations had been sampled in previous years (Stations 44 and 7). The third station (Station 55), situated between the Dry Tortugas and the Marquesas, was a new station established during Year 5. This station was chosen primarily because it was at a key location within the boundary of the shelf and would provide valuable information for subsequent modeling efforts. Also shown in Figure 1 are two new transects (X-1 and X-2) which were surveyed with underwater television and side scan sonar. These transects were added to supplement the habitat mapping studies completed in previous years.

Instrumented arrays, each equipped with a current meter, sediment traps, and settling plates, were deployed and maintained at all eight stations. All stations but Station 36 (because of its depth) were equipped with time-lapse cameras. Stations 52 and 55 were also equipped with wave and tide gages. Hydrographic data were collected at all eight stations with a CSTD and Niskin bottles. These data consisted of temperature, salinity, dissolved oxygen, pH, and transmissivity. Bottom sediment samples were also collected from each station.

Epifauna and fish were sampled at all but Station 44 using underwater television, benthic still photography, and trawls. At Stations 7 and 55, dredge tows were made to supplement epifauna data. The other stations had been sampled with dredges extensively, therefore, dredging was discontinued at these six stations during Year 5.

RESULTS

Only the results from Years 5 and 6 will be presented in this abstract. Results of the preceding 4 years are presented in the annual reports for those years.

Physical Data: A summary of the individual Year 5 station physicochemical characteristics is presented in Table 1. This table includes a description of the station location, depth, substrate type, biological assemblage, years during which the station was studied, hydrographic and chemical oceanographic data, and dynamic physical oceanographic characteristics (current and wave data).

The southwest Florida continental shelf is a broad (approximately 200 km), flat limestone platform with relatively few areas of high relief. The shelf slopes gently to the west. In most locations, low-lying, hard substrates either alternate with or are covered by a thin veneer of coarse carbonate sand.

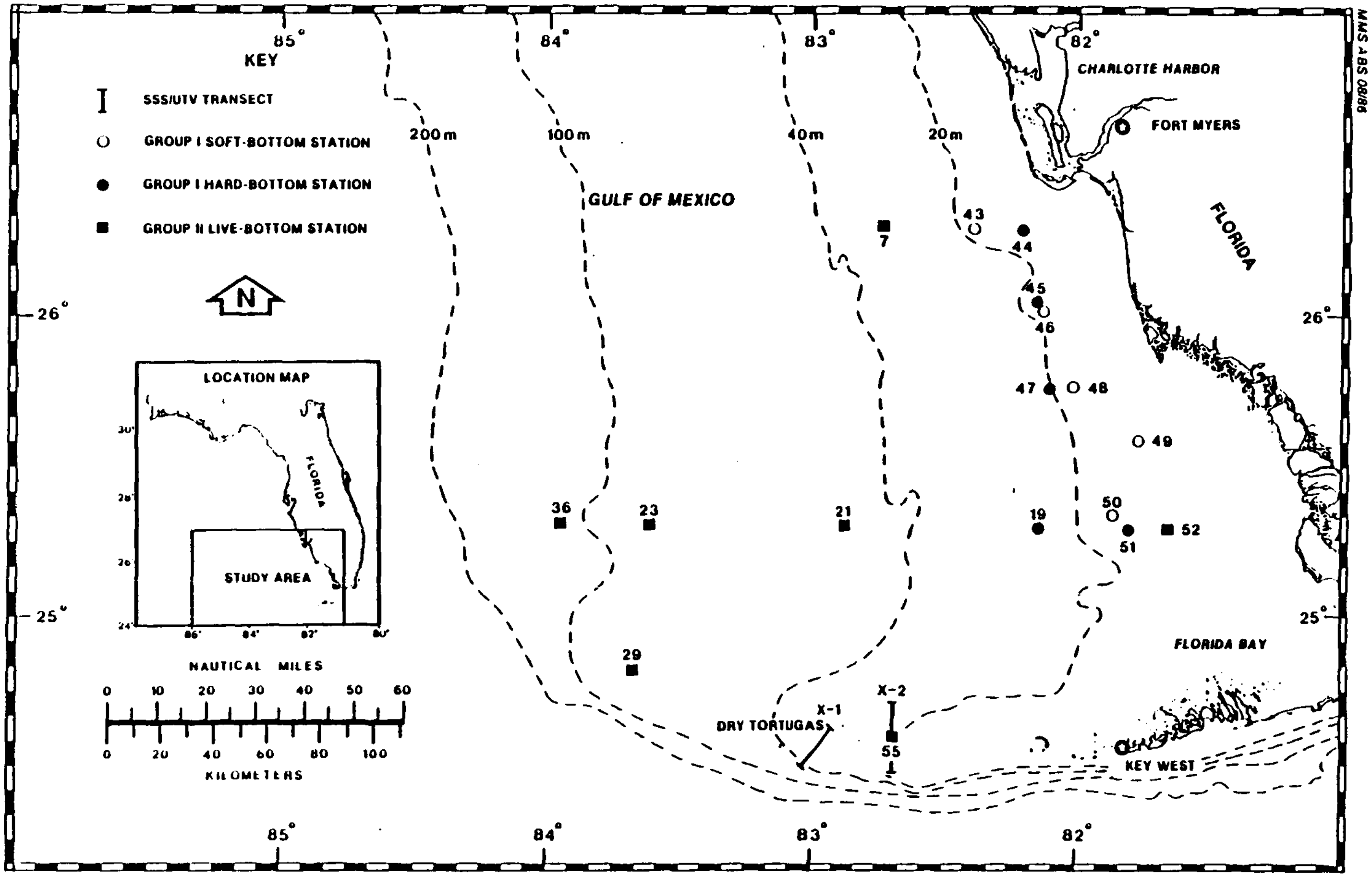

Figure 1 STATION AND INSTRUMENTED ARRAY LOCATIONS FOR YEARS 4 AND 5

TABLE 1. STATION DESCRIPTION SUMMARY

GENERAL STATION INFORMATION FOR THE YEAR 5 STATIONS

Station	Year*	Depth (m)	Latitude (N)	Longitude (W)	Lease Block**	Distance*** from Shore (km)	Substrate†	Assemblage††
44	3,4,5	13	26°17.71'	82°12.66'†††	CH 697	20	TS-HS	In-Live I
55	5	27	24°36.17'	82°41.96'	TLL	175	TS-HS	In-Live I
7	1,2,5	32	26°16.98'	82°43.66'	CH 686	58	TS-HS	In-Mid Live II
52	3,4,5	13	25°17.53'	81°39.82'	PR 655	48	TS-HS	In-Live I
21	1,2,4,5	47	25°17.26'	82°52.16'	PR 683	133	TS-HS	In-Mid Live II
23	1,2,4,5	74	25°16.89'	83°37.79'	PR 667	194	AN-S-D	Mid-Algal
29	1,2,4,5	60	24°47.51'	83°41.19'	DT 138	229	AN-S-D	Agaricia
36	4,5	126	25°16.50'	83°57.21'	PR 661	219	TS-HS-D	Out Crinoid

*Years during which data were collected.
**CH = Charlotte Harbor.
PR = Pulley Ridge.
DT = Dry Tortugas.
TLL = falls within Three League Line.
***Distance to nearest point of land excluding the Florida Keys.
†TS-HS = thin sand over hard substrate.
AN-S-D = algal nodules over sand with depressions.
TS-HS-D = thin sand over hard substrate with depressions.

††In-Live I = Inner Shelf Live-Bottom Assemblage I.
In-Mid Live II = Inner and Middle Shelf Live-Bottom Assemblage II.
Mid-Algal = Middle Shelf Algal Nodule Assemblage.
Agaricia = Agaricia Coral Plate Assemblage.
Out Crinoid = Outer Shelf Crinoid Assemblage.
†††Location of array.

SUMMARY OF NEAR-BOTTOM HYDROGRAPHIC AND WATER CHEMISTRY CHARACTERISTICS FROM 5-YEAR FIELD STUDY*

Station Number	Salinity (°/oo)	Temperature (°C)	DO (mg/l)	Transmissivity (%)	Light Pen. (K^1)	Chl. a (mg/m^3)	NO_3 - NO_2 (umole)	PO_4 (umole)	SiO_2 (umole)
44	34.8 - 36.0	20.3 - 29.6	5.6 - 10.1	77-100	0.14 - 0.38	ND	ND	ND	ND
55	35.8 - 36.5	22.0 - 28.0	5.9 - 9.3	83-94	0.11 - 0.19	ND	ND	ND	ND
7	35.6 - 36.5	19.1 - 27.8	7.7 - 9.4	90-99	0.08 - 0.17	0.1 - 0.9	0.1 - 0.3	<0.1 - 0.1	1.0 - 3.0
52	35.1 - 36.3	17.0 - 30.8	6.3 - 9.4	67-100	0.11 - 1.13	ND	ND	ND	ND
21	35.9 - 36.7	19.5 - 27.3	6.1 - 10.3	82-100	0.08 - 0.68	0.5 - 1.0	0.1 - 0.3	0.1 - 0.1	1.0 - 2.0
23	36.1 - 36.7	17.5 - 24.3	6.1 - 9.3	87-97	0.06 - 0.11	0.3 - 0.6	0.8 - 4.0	0.1 - 0.4	1.0 - 3.5
29	36.1 - 36.6	17.5 - 26.0	6.4 - 8.6	36-98	0.07 - 0.19	0.1 - 0.6	2.0 - 4.0	0.2 - 0.3	1.0 - 2.0
36	36.1 - 36.7	15.0 - 23.8	4.4 - 6.6	38-98	0.06 - 0.08	<0.1 - 0.1	5.0 - 10.0	0.6 - 0.7	3.0 - 5.0

*Notes with respect to individual parameters:
Salinity—ranges are based on 4 to 12 data points collected during 1 to 5 years.
Temperature—Ranges are based on periodic measurements as well as continuous measurements over 1 to 2 years.
Dissolved Oxygen—same as salinity.
Transmissivity—same as salinity. Years 4 and 5 data adjusted by cruise so that the maximum was 100 percent.
Light Penetration—calculated using $1.7/D_s$, where secchi readings (D_s) were made during Years 4 and 5.
Chlorophyll a—ranges are based on 4 data points (Years 1 and 2) except for Station 36 (Year 2 only).
NO_3 - NO_2—same as Chlorophyll a.
PO_4—same as Chlorophyll a.
SiO_2—same as Chlorophyll a.

SUMMARY OF DYNAMIC PHYSICAL OCEANOGRAPHIC DATA FOR YEARS 4 AND 5

Station Number	Average Current Speed (cm/sec)	Modal Current Speed (cm/sec)	Modal Current Direction	Current Speed ≥20 cm/sec (%)	Net Current Speed (cm/sec)	Net Current Direction (°Ton)	Wave Orbital Velocity ≥20 cm/sec (%)
44	8.4	5 - 10	S	4.6	1.4	132	3.39*
55	10.4	0 - 5	NNE - SSW	13.3	1.4	176	1.36
7	5.2	0 - 5	S	0.6	1.0	182	1.91†
52	10.8	0 - 5	E - W	13.7	1.4	128	2.99
21	7.3	5 - 10	ENE - WSW	1.2	0.9	138	0.12*
23	7.5	0 - 5	ESE - WNW	1.8	1.1	253	0.01*
29	8.9	5 - 10	SW	4.5	1.0	175	0.25*
36	8.9	5 - 10	S	5.0	1.3	43	0.0*

*Estimated using Station 52 wave data.
†Estimated using NDBC Buoy #42003 wave data.

In general, hard substrates such as coral heads and bedrock project less than 2 m above the bottom, although larger depressions, pinnacles, and other more irregular geological features are found toward the outer edge of the shelf. Immediately beyond the shelf, the continental slope deepens rapidly, with the 1,000-m isobath approximately 50 km seaward of the 200-m isobath.

Bottom currents usually range from 10 to 30 cm/sec. The near-bottom currents of the shallower nearshore stations are dominated by the semidiurnal component of the tides. Farther offshore, in deeper water, this semidiurnal component becomes less important and the diurnal component begins to predominate (at the latitude of the study area, however, the local inertial frequency is at nearly the same frequency as the diurnal component, therefore, it is difficult to separate the two energy bands).

The power spectra for the summer currents and the winter currents were similar. The differences are illustrated in Figure 2. Energy levels in the diurnal component in deeper water were higher in the summer than in the winter. This was probably the result of increased energy at the inertial frequency because inertial currents generally are much stronger in the summer when there is a thermocline. The winter spectra, however, had higher energy levels at the low-frequency components. This was a direct result of the higher average current speeds in the winter that were produced by the stronger winter winds.

The net currents (summarized in Table 1) provide some indication of the speed with which materials (sediment, plankton, nutrients, or pollutants) are transported into and out of the study area. Generally, the deeper stations have less consistent net currents (with respect to direction) whereas the net currents at the shallower stations exhibit considerable constancy, usually setting to the south or southeast at less than 2 cm/sec.

At least two short-term phenomena significantly affect the current regime on the southwest Florida shelf. The first phenomenon involves the intrusion of Loop Current eddies onto the shelf. These intrusions are characterized by a noticeable increase in current speed, a tendency for the current direction to become constant, and an increase in the near-bottom water temperature of 2° to 4°C. The effects of an intrusion may extend nearly across the shelf, but generally stay outside of the 20-m isobath. The second phenomenon to affect the current regime is the passage of major storms (tropical storms or hurricanes). Currents speeds at stations nearest the center of storms increased from an average of <10 cm/sec to peak speeds of approximately 60 cm/sec.

Wave action is variable on the shelf; the greatest mean wave height occurs between September and April. Passing tropical storms and fronts during the fall and winter produce the highest waves, usually in conjunction with winds from the east and northeast. The average significant wave height within the study area is <1 m 95% of the time, but waves exceeding 5 m can occur during storms. Under storm conditions, waves can resuspend and transport sand in shallow water, but during more normal

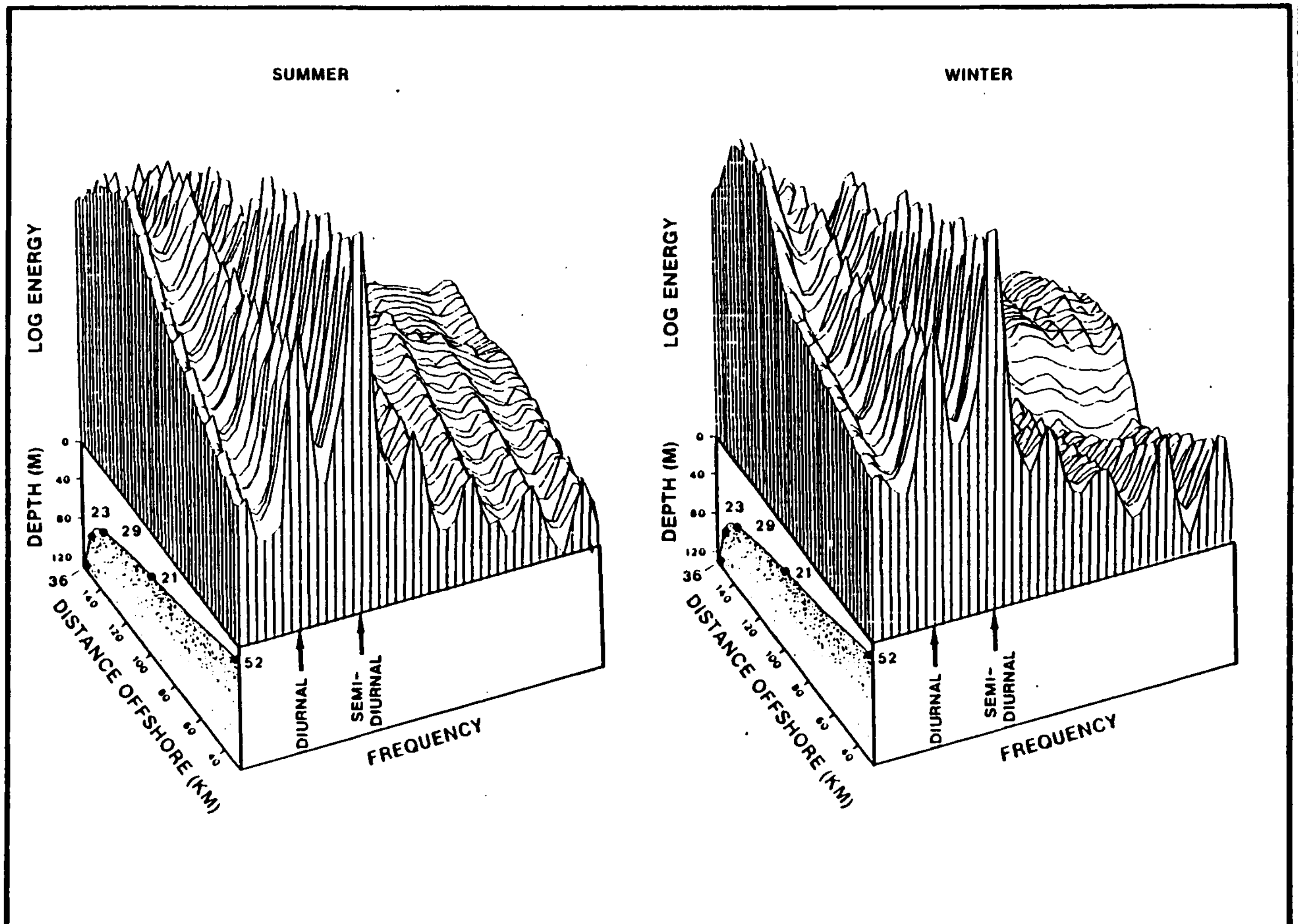

Figure 2 3-D SUMMER (1984) AND WINTER (1983-84) ENERGY SPECTRA, EAST-WEST COMPONENT weather and in greater depth, the effect of waves on bottom sediments is negligible.

Our results suggest that the wind-driven currents, tidal currents, and surface wave-induced bottom orbital velocities operate in concert to resuspend and transport significant quantities of sediment in the study area. Further, it appears that recurring weather patterns do not cause significant quantities of sediment resuspension and transport at depths exceeding 50 m. Those stations with the greatest sediment resuspension were also the stations where wave-induced motion exceeded 20 cm/sec more often (i.e., the shallower stations). A plot of sediment deposition rate versus depth of water (Figure 3) reveals a strong correlation (as high as 0.8) between depth and sediment deposition rate. At Stations 52 and 55, the currents exceeded 20 cm/sec more than 13% of the time, indicating that these areas are more susceptible to sediment movement. The current speeds at Station 36 (125 m) exceeded 20 cm/sec 5.6% of the time; however, only minute quantities of sediment were collected in the sediment traps because virtually no wave energy penetrated to the bottom. Consequently, the current may have been strong enough to initiate sediment movement in the form of bed load transport, but were not strong enough to resuspend the sediments. Wave motion probably plays the most important role in sediment transport at those stations in water less than 50 m in depth.

A summary of the field data from the 5-year field study and information collected from literature is presented in Figure 4 for five cross-shelf stations. This figure is presented not only to provide a description of the physical environment as it changes with depth, but also to illustrate the stresses or ranges in the physical parameters that help determine the composition of the biological communities.

Biological Data: The southwest Florida shelf is a mosaic of biological communities that reflects the extremely patchy nature of the substrate. Where sand is present, starfish, conch, and sand dollars are abundant. Large sponges, corals, and other organisms project through the sand. These larger organisms provide habitat and shelter for thousands of other species of smaller animals and plants, as well as focal points for many fishes.

On hard substrate in shallow water, sessile animals dependent on sunlight (e.g., corals and gorgonians) and sponges are dominant. Low-lying coral reefs that include many Caribbean species can be recognized. In deeper water, organisms that can tolerate lower light levels are abundant (e.g., agariciid corals, crinoids, the alga Anadyomene, and red algal nodules). The plate corals and algal nodules harbor cryptic or rare species, such as abalones. Virtually all areas of the shelf that are not covered with deep sand--and those areas that have large animals such as sponges anchored on hard substrate and projecting through the sand--can be considered to fall within the current MMS definition of "live-bottom" (Figure 5).

Several hundred different fishes have been identified on the southwest Florida shelf, including grunts, snappers, groupers, and other species of potential commercial and recreational interest. Much of the area is

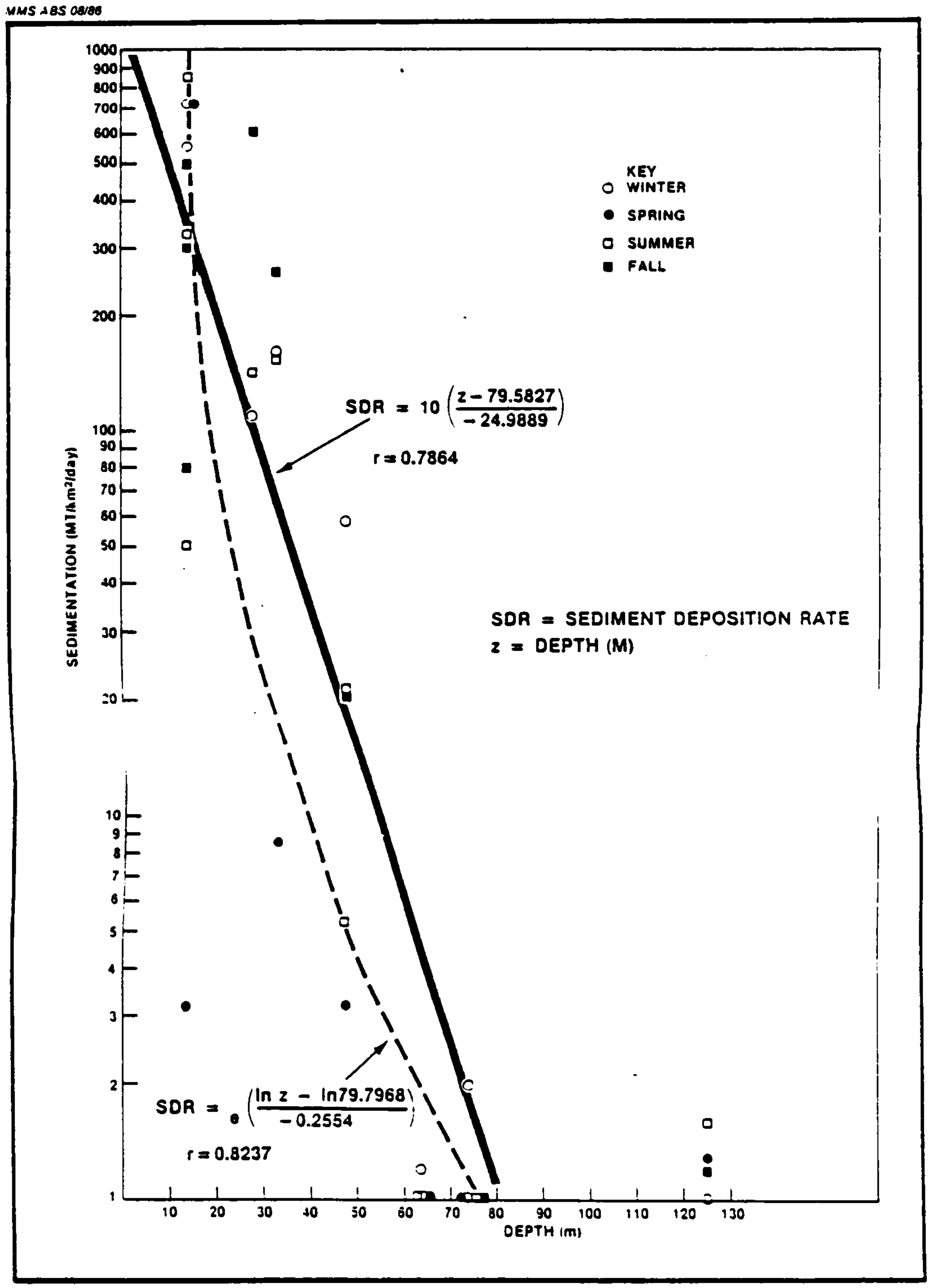

Figure 3 SEDIMENTATION RATES FROM SEDIMENT TRAPS VERSUS DEPTH

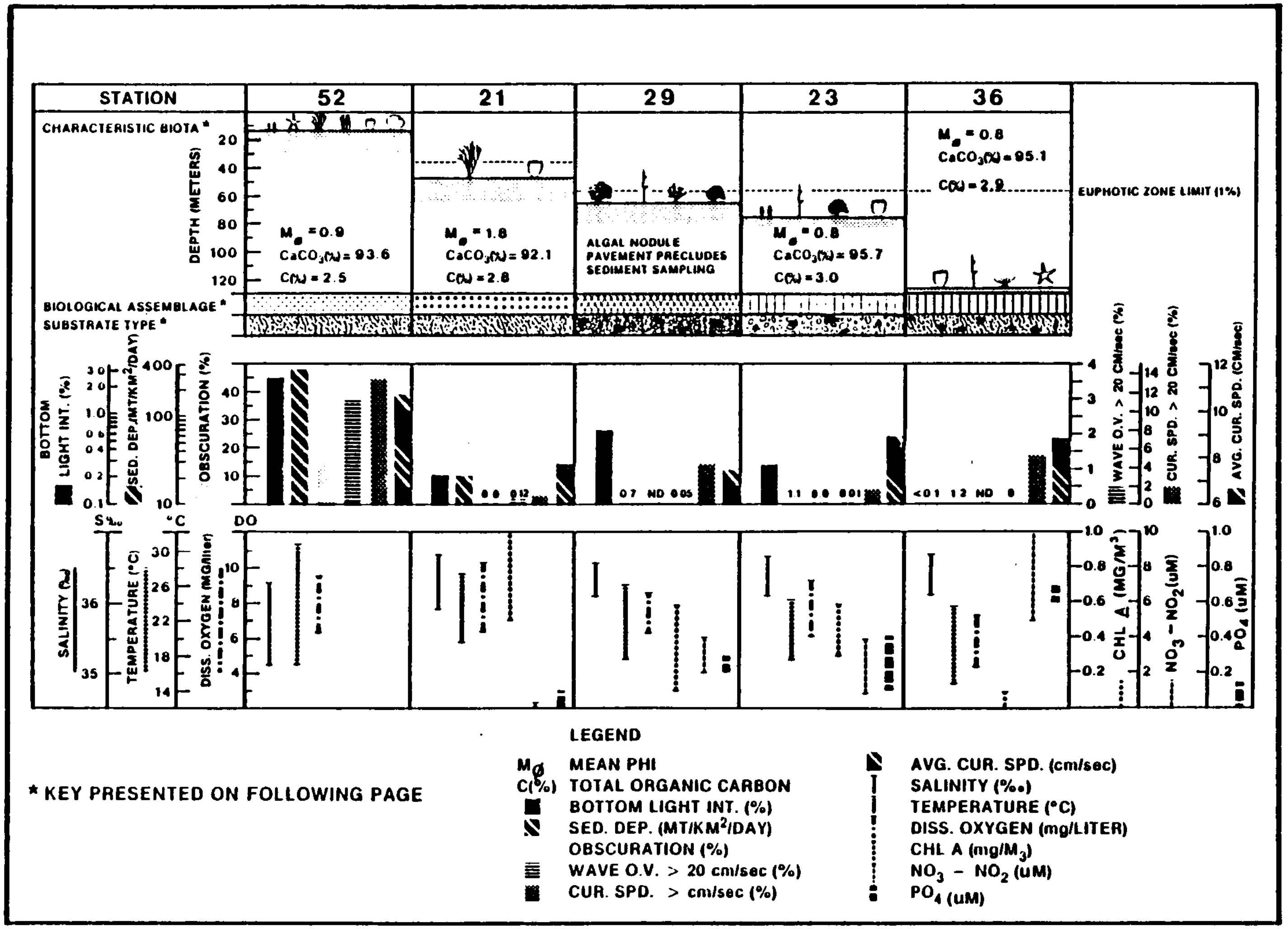

Figure 4 CROSS-SHELF BIOLOGICAL, PHYSICAL, AND CHEMICAL STATION CHARACTERIZATION OF SELECT GROUP II STATIONS

MMS ABS 08/86

SUBSTRATE TYPES

THE SUBSTRATE TYPES WERE MAPPED USING A COMBINATION OF GEOPHYSICAL RECORDS (SIDE SCAN SONAR AND UNIBOOM) UNDERWATER TELEVISION AND STILL CAMERA DATA. THE SUBSTRATE IS SHOWN AS A PATTERN SUPERIMPOSED OVER THE BATHYMETRIC DATA

THIN SAND OVER HARD SUBSTRATE. EXTENSIVE AREAS WITH A MOBILE THIN SAND OR SILT VENEER OVER A HARD SUBSTRATE ARE FOUND THROUGHOUT THE SHELF. THE VENEER IS GENERALLY LESS THAN 0.3 m THICK AND OFTEN CANNOT BE DISTINGUISHED ON THE SUBBOTTOM PROFILE RECORDS. SPARSE POPULATIONS OF ATTACHED EPIFAUNA REFLECT THE THIN SAND VENEER. THIS TRANSITIONAL BOTTOM CATEGORY INCLUDES PATCHES OF BOTH EXPOSED HARD SUBSTRATE AND THICKER SAND COVER

CORALLINE ALGAL NODULE LAYER OVER SAND. THIS BOTTOM TYPE REPRESENTS SOFT BOTTOM AREAS COVERED BY A VARYING THICKNESS OF CORALLINE ALGAL GROWTHS USUALLY IN THE FORM OF LOOSE NODULES

ALGAL NODULE PAVEMENT WITH AGARICIA ACCUMULATIONS. THIS BOTTOM TYPE REPRESENTS AREAS WITH A FUSED PAVEMENT OF CORALLINE ALGAL GROWTHS, CORALLINE DEBRIS AND CORALS. IN MANY PLACES ENCRUSTING CORAL (Agaricia spp.) PLATES ACCUMULATE AND FORM A DISTINCTIVE SURFICIAL CRUST

DEPRESSIONS. CIRCULAR DEPRESSIONS OF THE SEA FLOOR (POCKMARKS) ARE FOUND IN DISTINCT AREAS THROUGHOUT THE MIDDLE AND OUTER SHELVES. THE DEPRESSIONS ARE 2 TO 20 m ACROSS AND UP TO 3 m DEEP. POSSIBLE SOURCES INCLUDE COLLAPSE FEATURES IN THE UNDERLYING CARBONATE SEDIMENTS AND/OR SPRINGS. (SYMBOLS REFLECT APPROXIMATE RELATIVE DENSITY OF DEPRESSIONS AS SEEN ON SIDE SCAN SONAR RECORDS)

BIOLOGICAL ASSEMBLAGES

THE BIOLOGICAL ASSEMBLAGES WERE MAPPED FROM UNDERWATER TELEVISION AND STILL CAMERA DATA SUPPLEMENTED BY SEASONAL SAMPLING CRUISES. NINE ASSEMBLAGES HAVE BEEN RECOGNIZED AND ARE SHOWN BY SPECIFIC PATTERNS IN A STRIP BENEATH THE BATHYMETRY/SUBSTRATE MAP

INNER SHELF LIVE BOTTOM ASSEMBLAGE I. THIS ASSEMBLAGE IS FOUND IN WATER DEPTHS OF 20 TO 27 m WHERE THERE IS AN EXPOSED HARD SUBSTRATE. THE AVERAGE DENSITY OF ATTACHED MACROFAUNA IS GREATER THAN ONE PER m^2. PREDOMINANT BIOTA INCLUDE LARGE GORGONIANS, SPONGES, HARD CORALS, ASCIDIANS, HYDROZOANS AND ALGAE. THE FAUNA ARE GENERALLY LARGER AND HAVE A HIGHER BIOMASS PER UNIT AREA THAN ASSEMBLAGE II.

INNER AND MIDDLE SHELF LIVE BOTTOM ASSEMBLAGE II. THIS ASSEMBLAGE IS FOUND IN WATER DEPTHS OF 25 TO 71 m WHERE THERE IS AN EXPOSED HARD SUBSTRATE. THIS ASSEMBLAGE HAS A HIGHER NUMBER OF SPECIES OF SPONGES AND A LOWER BIOMASS PER UNIT AREA THAN ASSEMBLAGE I. PREDOMINANT BIOTA INCLUDE SPONGES, HARD CORALS, SMALL GORGONIANS, ASCIDIANS, BRYOZOANS, HYDROZOANS, AND ALGAE

MIDDLE SHELF ALGAL NODULE ASSEMBLAGE. THIS LIVE BOTTOM ASSEMBLAGE IS FOUND IN WATER DEPTHS OF 62 TO 108 m. THE NODULES ARE FORMED BY THE COMBINATION OF CORALLINE ALGAE WITH SAND, SILT, AND CLAY PARTICLES. SMALL SPONGES, CORALS, AND OTHER ALGAE ARE ALSO PRESENT

AGARICIA CORAL PLATE ASSEMBLAGE. THIS ASSEMBLAGE IS FOUND IN WATER DEPTHS OF 64 TO 80 m. LIVE HARD CORALS, GORGONIANS, SPONGES AND ALGAE LIVE ON A DEAD HARD CORAL-CORALLINE ALGAE SUBSTRATE

OUTER SHELF CRINOID ASSEMBLAGE. THIS ASSEMBLAGE OCCURS IN WATER DEPTHS OF 110 TO 160 m. LARGE NUMBERS OF CRINOIDS AND SMALL HEXACTINELLID SPONGES OCCUR ON A COARSE SAND OR ROCK RUBBLE SUBSTRATE

CHARACTERISTIC BIOTA

SYMBOLS REPRESENTING THE CHARACTERISTIC BIOTA ARE SHOWN BENEATH THE BIOLOGICAL ASSEMBLAGE PATTERNS. A DASHED LINE INDICATES A SPARSE POPULATION DENSITY. SOFT BOTTOM BIOTA SYMBOLS INDICATE THE GENERAL GROUPS REPRESENTED IN SOFT BOTTOM AREAS. LIVE BOTTOM BIOTA SYMBOLS INDICATE CHARACTERISTIC SPECIES AND SPECIES GROUPS REPRESENTED IN LIVE BOTTOM AREAS

SOFT BOTTOM BIOTA

MACROPHYTIC ALGAE

ASTEROIDS

CRINOIDS

SCATTERED ATTACHED EPIFAUNA, MOSTLY SMALL SPONGES

LIVE BOTTOM BIOTA

ALGAE:
Halimeda spp.
Anadyomene menziesii

HYDROZOANS

GORGONIANS:
Muricea elongata, Pseudopterogorgia spp., Eunicea spp., Pseudoplexaura spp.
Antipathes spp.

HARD CORALS:
Agaricia spp.
Siderastrea spp.

Figure 4 (cont'd)

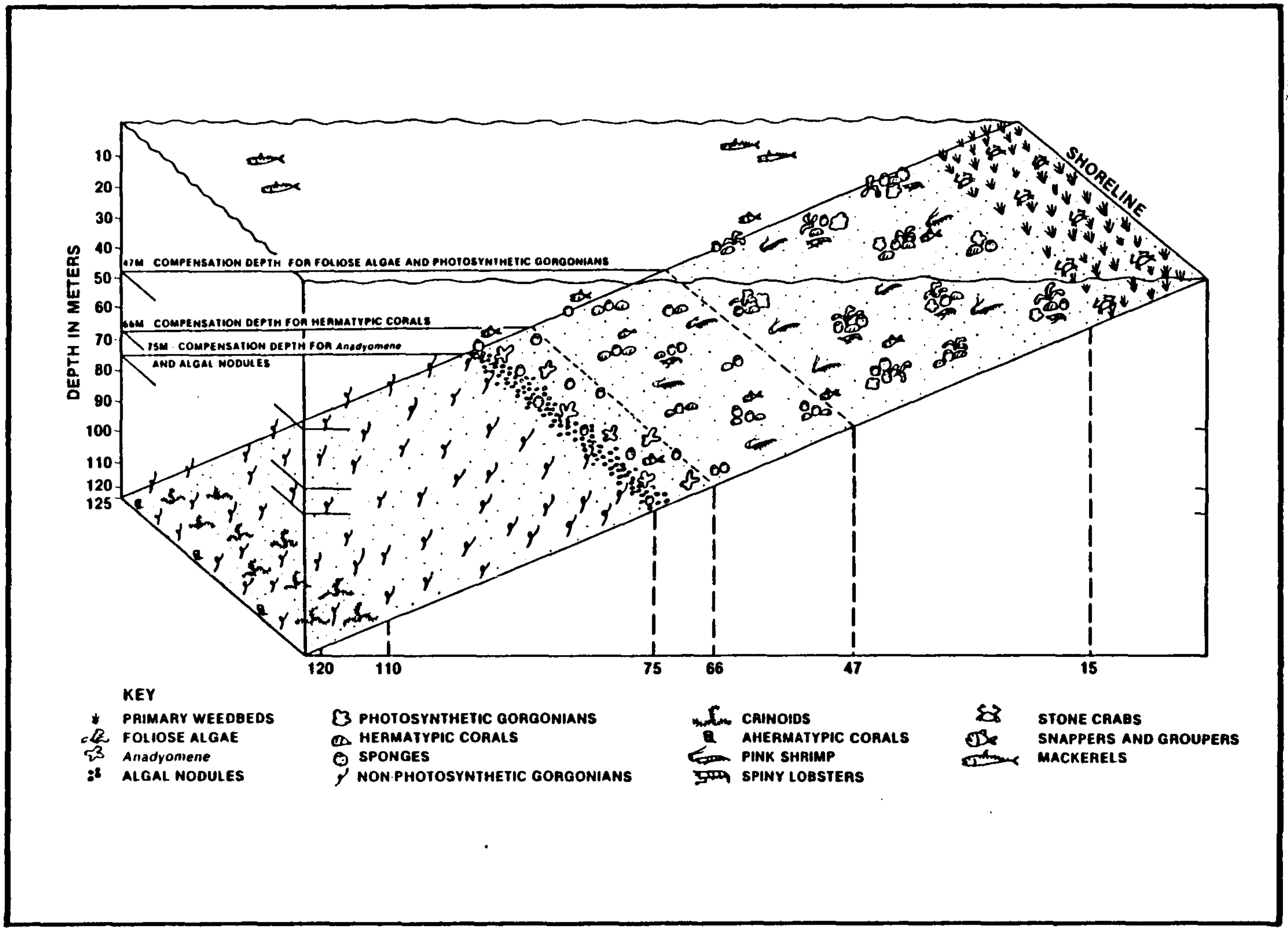

Figure 5 SCHEMATIC REPRESENTATION OF DEPTH DISTRIBUTION PATTERNS OF MAJOR COMPONENTS OF THE LIVE BOTTOM FLORA AND FAUNA OF THE SOUTHWEST FLORIDA SHELF

unsuitable for trawling due to outcrops of hard substrate, masses of sponges, or other bottom features, and must be fished either with traps or by hook and line. There also are several deep (perhaps >1000 m) "holes" (subsidence or solution holes) near the edge of the shelf; these deep holes are reported to harbor large numbers of fish, especially snappers, and may be of great commercial and scientific interest.

Artificial high-relief structures such as petroleum platforms are likely to attract and concentrate many fishes, sea turtles, and fishermen, based on all three having been attracted to our research equipment. Artificial structures will also provide habitat for many sessile organisms, such as oysters and barnacles. These fouling or settling species will settle primarily in shallow water (less than 50 m), and will provide food and shelter for hundreds of additional species.

Light is a primary controlling factor in the distribution of large benthic organisms on the shelf (Figure 4). Other primary controlling factors are probably the availability of suitable hard substrate for recruitment of larvae and the movement of sand. In many areas of the shelf, hard substrate is alternately exposed and then covered by a thin layer of sand. Depressions are probably always filled with sand, whereas ridges and promontories are scoured at their bases but rarely or never covered. Thus, how much hard substrate is exposed, and how long it is exposed, depend on topography as well as sand movement in response to currents. The shallow shelf benthic organisms are probably well adapted to survive unpredictable, occasionally heavy, sand movement. The shallow shelf ecosystem quite possibly evolved in the face of episodic benthic "wipeouts."

Sand movement appears to be episodic in nature, rather than a slow, gradual process. This conclusion is confirmed by time-lapse camera evidence, which showed little change in sand depth except during major storms. A second line of evidence also supports this conclusion indirectly. Gorgonians, sponges, corals, and other large, sessile fauna were present at most sites, usually projecting through a layer of sand rather than attached to exposed limestone. Although they must have been able to withstand sand scour at their bases, these animals must first have settled on hard substrate, and then grown to a sufficient size to resist burial by the time the sand returned and prevented further recruitment. These communities (based on the size of individual organisms) may be considered mature, and have probably taken years to develop.

On hard substrate exposed only for a short time, or eventually buried deeply by sand, newly settled and smaller organisms (e.g., settling species such as barnacles and hydroids) are probably killed. These settling species depend upon rapid settlement, growth, and reproduction on bare substrate. They probably include many of the organisms that grew on settling plates and array frames during this study.

Activities adversely affecting settling species will probably be inconsequential (or undetectable) at most sites in the long run, since these species are transitory by nature, and can repopulate on anything from buoys to oil rigs in short order.

Activities that alter the distribution or abundance of habitat-formers such as gorgonians, sponges, and algal nodules would have local consequences for many other species. Whether or not those consequences would adversely affect any biological parameter would depend upon the species and the scale of the activity, of course. Damaging a gorgonian bed, for example, would reduce fish densities locally, and reduce or eliminate many other motile and sessile species that normally find refuge in that bed. However, since most of the shallow shelf has huge gorgonian beds, it is also likely that many of these organisms would find suitable habitat nearby.

Damage to corals is likely to have long-term effects, because coral growth rates are typically low. Damaging or killing corals on projections above the bottom would also undoubtedly destroy a number of other benthic invertebrates associated with corals. Eliminating corals from any given area might, however, have little affect upon many fishes. Fishes use both natural projections (outcrops) and relatively bare, artificial structures (arrays) as orientation aids and gathering spots, rather than as food sources. For example, most fishes censused in this study feed at night on sand flats away from arrays or coral heads, where they aggregate in the daytime.

Algal nodule beds exist in deep, clear water, where relatively little light is present. They may already be near their compensation depth and any reduction of light by burial or prolonged increased turbidity might be harmful to them. However, no specific information is available on this subject.

Information Synthesis and Conceptual Modeling: The following is a brief outline to the ESE/LGL/CSA approach to information synthesis and conceptual modeling for Year 6 of the Southwest Florida Shelf Ecosystem Program:

1.0 CHARACTERIZATION OF STUDY AREA
2.0 CONCEPTUAL MODELING
- 2.1 Delineation of Distinguishable Communities
  - 2.1.1 Introduction
  - 2.1.2 Distribution of Community Components
  - 2.1.3 Community Characterization and Dynamics
  - 2.1.4 Relations with Other Nearby Communities
- 2.2 Nature of Impacts from Offshore Petroleum Activities
  - 2.2.1 Nature of Oil and Gas Related Activities
  - 2.2.2 Impacts of Oil and Gas Related Activities on Southwest Florida Shelf Habitats
  - 2.2.3 Impacts of Oil and Gas Related Activities on Southwest Florida Shelf Ecosystems
- 2.3 Nature of Impacts from Offshore Petroleum Activities on VECs
  - 2.3.1 Selection of VECs
  - 2.3.2 Analysis of Impacts on VECs
- 2.4 Submodel Development and Integration
- 2.5 Data and Information Gaps

3.0 IMPACT ASSESSMENT

ABSTRACT

CONTINENTAL SLOPE ECOSYSTEM STUDY

MMS NEW ORLEANS TERNARY MEETING

SEPTEMBER 3, 1986

Presented by

B.J. Gallaway, Ph.D.
LGL Ecological Research Associates, Inc.
1410 Cavitt Street
Bryan, Texas 77801

The Continental Slope Ecosystem Study is in Year III of a four-year program. All originally planned cruises have been successfully completed and an additional submersible cruise is scheduled for September 1986 to investigate selected seep communities. Two Annual Reports have been submitted and the Year III Annual Report is scheduled for submittal in December 1986.

Recent observations of chemosynthetic organisms around sites of petroleum seepage on the continental slope in the central Gulf of Mexico are reviewed. Several community types and spatial distributions of chemosynthetic organisms have been observed at seep sites. This variation is probably attributable to the non-uniform distribution of petroleum seepage, the type of petroleum present, and the amount of the seepage. Overall, however, areas characterized by petroleum seepage provides a good indicator that chemosynthetic organisms may be present.

ITEM 3

LIST OF REGISTERED ATTENDEES

Minerals Management Services
Ternary Meeting
September, 1986

James Barkuloo, U.S. Fish & Wildlife Serv., Ecological Services Div., 1612 June Ave., Panama City, FL 32405

Dr. Wayne D. Bock, Spectro Scan, Inc., 2851 S.W. 31 Ave., Miami, FL 33133

Paul Bradley, U.S. Army Corps of Engineers, P.O. Box 2288, Mobile, AL 36628

Richard M. Butler, Jr., ENDECO, Inc., 13 Atlantis Drive, Marion, MA 02738

Donald R. Cahoon, LSU, Center for Wetlands Resources, Baton Rouge, LA 70803

Gary Couret, DNR/CMD, Coastal Mangement, 400 Royal Street, New Orleans, LA 70130

Rick Dawson, U.S. National Park Service, Everglades National Park, P.O. Box 279, Homestead, FL 33030

Lynn Davidson, Greenpeace, 1411 Conn. Ave. SE, Washington, DC 20009

Mark Fisher, John Chance & Assoc., Regulatory & Environmental, 200 Dulles Drive, P.O. Box 52029, Lafeyette, LA 70506

Jerry Ford, Florida A&M University, College of Engineering Sciences, Tallahassee, FL 32307

Benny J. Gallaway, LGL, 1410 Cavit St., Bryson, TX 77801

Ruben G. Garza, Geo-Marine Inc., 2821 Aspen Ct. W, Plano, TX 75074

Randall A. James, Shell Offshore Inc., Frontier, 701 Poydras, P.O. Box 61011, New Orleans, LA 70161

Michael P. Jansky, U.S. EPA, Environmental Services Div., 1201 Elm Street, Dallas, TX 75270

Paul G. Johnson, Governor's Office of Florida
Off. Planning & Budgeting
The Capitol, Tallahassee, FL 32301

Brian Kelly, U.S. Coast Guard, MEP
500 Camp Street, New Orleans, LA 70130

Tim Killeen, CMS/La. Dept. of Natural Resources, Coastal Management, 400 Royal St., New Orleans, LA 70130

Charles Lamphear, REMA, Inc., 909 American Charter Center, 206 South 13th St., Lincoln, NE 68508

Deborah Leffler, LSU, Center for Wetland Resources, Baton Rouge, LA 70820

Harold Loyacano, Rt. 3, Box 455, Pearl River, LA 70452

Bethlyn McCloskey, RTWG, MMS, 5113 Bissouet Drive. Metairie, LA 70003

Gail McGee, Science Applications International Corporation 4900 Water's Edge Drive, Raleigh, NC 27606

Drew Michel, Royal Technologies, Inc., 1601 Belle Chasse Hwy., Suite 202, Gretna, LA 70053

Bob Mink, State Oil and Gas Board of Alabama, Geophysics & Offshore, P.O. Box O; Hackberry Lane (420), Tuscaloosa, AL 35406

Dan Moore, Jaycor, NSTL, MS. 29529-5004

Allan Mueller, U.S. Fish & Wildlife Service, Ecological Services 17629 El Camino Real, #211, Houston, TX 77058

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The Department of the Interior Mission

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

The Minerals Management Service Mission

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

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

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