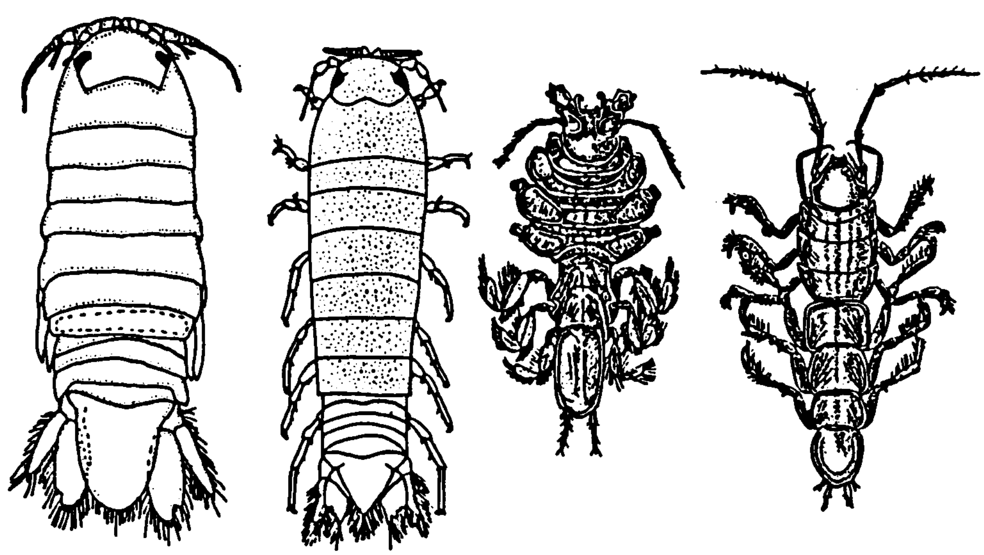
OCS STUDY
MMS 86-0053

PROCEEDINGS
SPRING TERNARY
GULF OF MEXICO STUDIES MEETING

March 1986



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

This report has been technically reviewed according to contractual specifications. It, however, is exempt from review by the Minerals Management Service Technical Publications Unit and the Regional Editor.

OCS STUDY
MMS 86-0053

PROCEEDINGS
SPRING TERNARY
GULF OF MEXICO STUDIES MEETING

held
March 18, 1986

at

Landmark Hotel
Metairie, Louisiana

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

May 1986

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

REPORT AVAILABILITY

Preparation of this report was conducted under Contract between the Minerals Management Service and Science Applications, Inc. Extra copies of the report may be obtained from the Public Information Unit (Mail Stop OPS-3-4) at the following address:

Minerals Management Service
Gulf of Mexico OCS Regional Office
U.S. Department of the Interior
1420 South Clearview Parkway
New Orleans, Louisiana 70123
Attn: Public Information Unit
Phone: (504) 736-2519

DISCLAIMER

TABLE OF CONTENTS

			Page
Table of Contents			i
1.	Introduction		1
2.0	Meeting Abstracts		1
	2.1	Agenda	4
	2.2	Extended Abstracts	5
	Indirect Socioeconomic Impacts OCS Activities		6
	Wetlands Loss in the Gulf Coastal Zone		24
	Continental Slope Ecosystems Study		26
	Physical Oceanography Field Measurements Program		39
	Physical Oceanography Circulation Modeling Program		48
	Southwest Florida Shelf Ecosystems Study		63
	MMS Physical Oceanographic Studies Southwest Florida Shelf		74
	MMS Biological Studies Southwest Florida Shelf		83
	MMS Seagrass Habitat Mapping Studies Northeastern Gulf of Mexico		86
	2.3	List of Registered Attendees	93

MEETING SUMMARY

MARCH, 1986 TERNARY MEETING

1.0 INTRODUCTION:

On March 18, the Environmental Studies Group, of the MMS, Gulf Regional Office convened the first 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

MARCH 18, 1986

METAIRIE, LA

TIME	SPEAKER	TOPIC
9:00 a.m.	Dr. Charles Lamphear Resource Economics and Management Analysis, Inc.	Indirect Socioeconomic Impacts OCS Activities
9:30 a.m.	Dr. Eugene Turner Louisiana State University Center for Wetland Resources	Wetlands Loss in the Gulf Coastal Zone
10:00 a.m.	Dr. Willis Pequegnat and Dr. Ian Rosman, LGL, Inc. Dr. Mahlon Kennicutt Texas A & M University	Continental Slope Ecosystems Study
10:45 a.m.	Dr. Jerry Wermund Texas Bureau of Economic Geology	MMS/University of Texas "Continental Margins" Project
11:00 a.m.	LUNCH	
1:00 p.m.	Dr. Evans Waddell Science Applications International Corporation	Physical Oceanography Field Measurements Program
1:30 p.m.	Dr. Alan Wallcraft Jaycor, Inc.	Physical Oceanography Circulation Modeling Program
2:00 p.m.	Dr. Larry Danek Environmental Science and Engineering, Inc.	Southwest Florida Shelf Ecosystems Study
2:30 p.m.	Dr. Murray Brown Minerals Management Service Gulf of Mexico OCS Region	MMS Physical Oceanographic Studies Southwest Florida Shelf
3:00 p.m.	Dr. Robert Avent Minerals Management Service Gulf of Mexico OCS Region	MMS Biological Studies Southwest Florida Shelf
3:30 p.m.	Dr. Robert Rogers Minerals Management Service Gulf of Mexico OCS Region	MMS Seagrass Habitat Mapping Studies Northeastern Gulf of Mexico
4:00 p.m.	Adjourn	

ITEM 2

EXTENDED ABSTRACTS

Analysis Of Indicators For Socioeconomic Impacts Due
To OCS Oil And Gas Activities In The
Gulf Of Mexico, Year II

Ternary Meeting
Gulf of Mexico Environmental Studies Program
Minerals Management Service
U.S. Department of the Interior
Metairie, LA 70010

Resource Economics & Management Analysis, Inc.
909 American Charter Center
Lincoln, NE 68508

March 18, 1986

ANALYSIS OF INDICATORS FOR SOCIOECONOMIC IMPACTS DUE TO OCS OIL AND GAS ACTIVITIES IN THE GULF OF MEXICO, YEAR II

I. Introduction

General Purpose

The general purpose of the socioeconomic impact study is to develop a program that Minerals Management Service (MMS) personnel can use to conduct socioeconomic impact assessments associated with known or assumed changes in the Outer Continental Shelf (OCS) oil and gas industries of the Gulf of Mexico (GOM). The capability of MMS to monitor the socioeconomic impacts associated with the oil and gas industries is very important because of the potential existence of significant boom-bust conditions within the energy sector. The Request for Proposal (RFP 3275) by the U.S. Department of Interior noted the following:[1]

> Since the first Outer Continental Shelf (OCS) oil and gas lease sale in 1954, the Gulf of Mexico (GOM) has become the most developed OCS region in the United States and the world. This position is certain to continue in the near future. Despite this history, however, there are still important questions which require information collection, analysis, and presentation. One area of such need is the extent of socioeconomic impact of federal OCS oil and gas activity on the U.S. coastal (onshore) region, particularly relating to income, employment, and population.

The study's general purpose contains three main parts: 1) Development of a socioeconomic program model that a) is operational on the MMS Perkin-Elmer system and b) can assess socioeconomic conditions at a multicounty level; 2) Test the reliability of the socioeconomic program model; and 3) Train MMS personnel on the use and maintenance of the socioeconomic program model. The remainder of this paper develops these parts in more detail.

Study Regions

The (multicounty) Study Areas are indicated below. (See also Figures One through Four.) These Study Areas were selected by MMS because they contain the major share of the oil and gas related activities. The coastal counties and parishes extend from Dade County in Southeast Florida to Cameron County in southernmost Texas. Inland counties and parishes are also included where offshore oil and gas support centers are known to exist (such as Lafayette, Louisiana); where offshore-related petroleum industries are established (such as the Mississippi River region in south Louisiana); and to account for all counties within Standard Metropolitan Statistican Area (SMSA) boundaries when one county is located on the coast (such as the Houston SMSA counties in Texas). Consequently, much of the immediate socioeconomic impact associated

1. U.S. Dept. of the Interior, Minerals Management Service 1985. Request for Proposal (RFP 3275).

Figure One
Eastern GOM Coastal Analysis Area: Florida

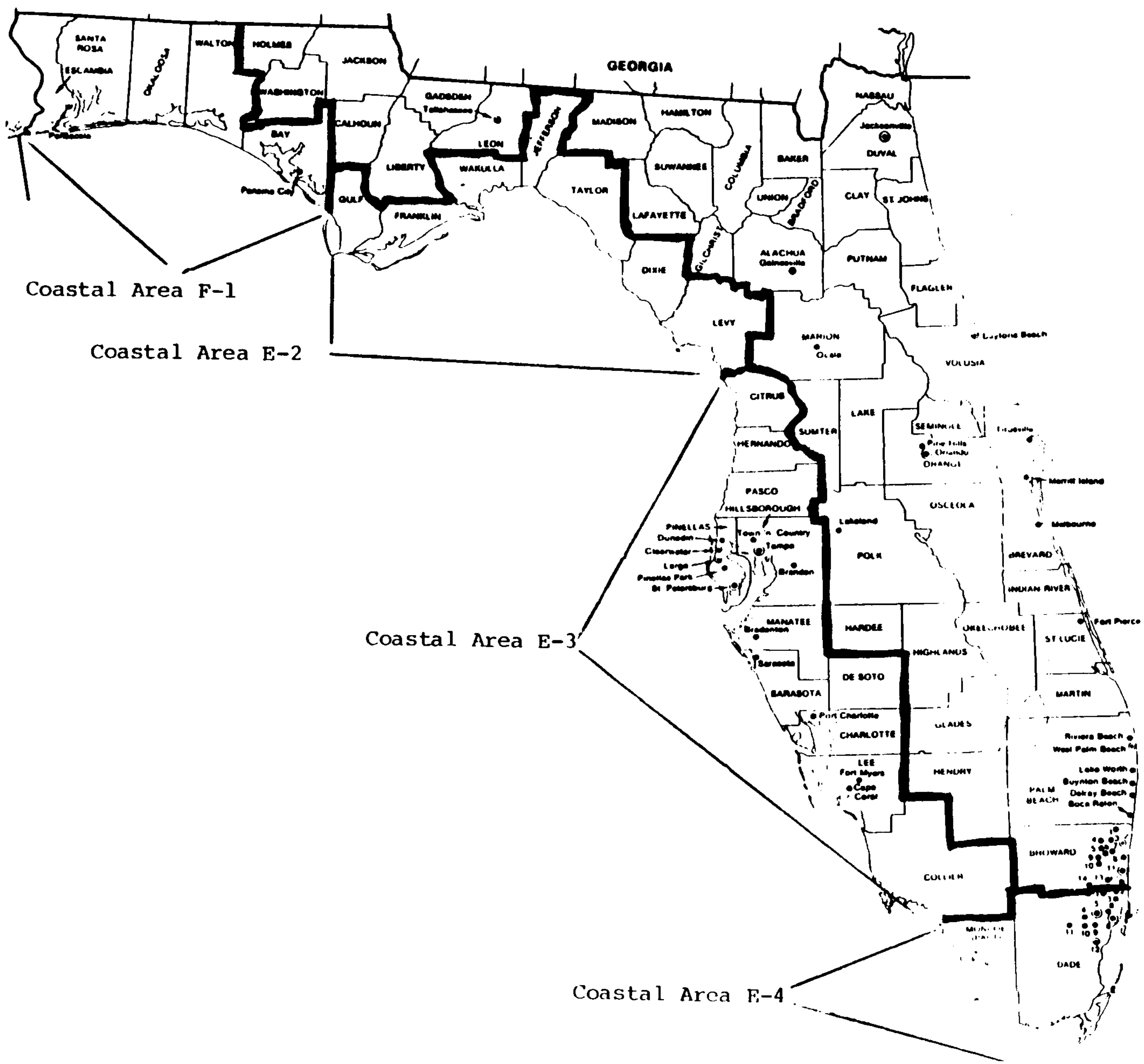


Figure Two
Central GOM Coastal Analysis Area:
Alabama and Mississippi

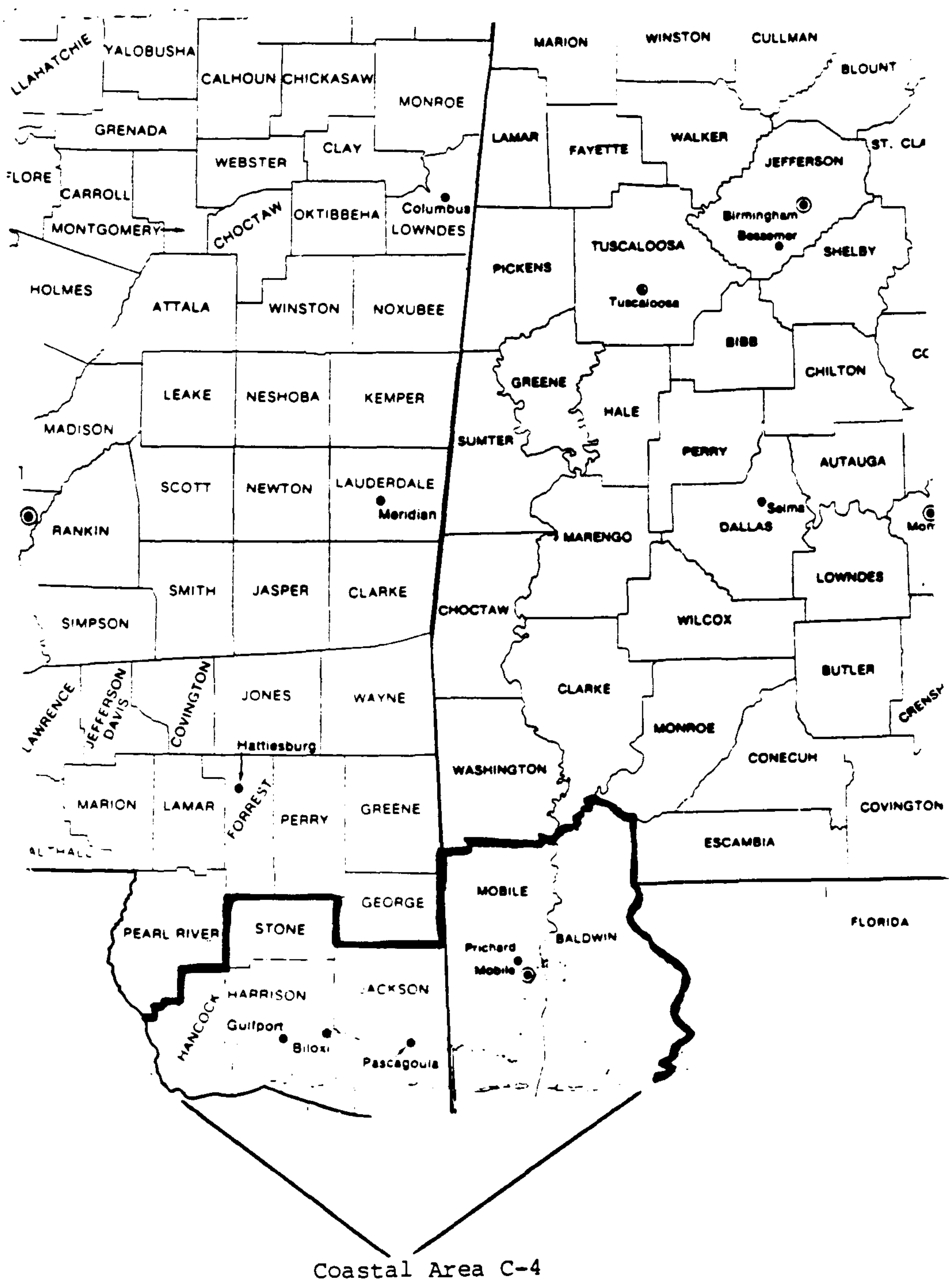


Figure Three
Central GOM Coastal Analysis Area: Louisiana

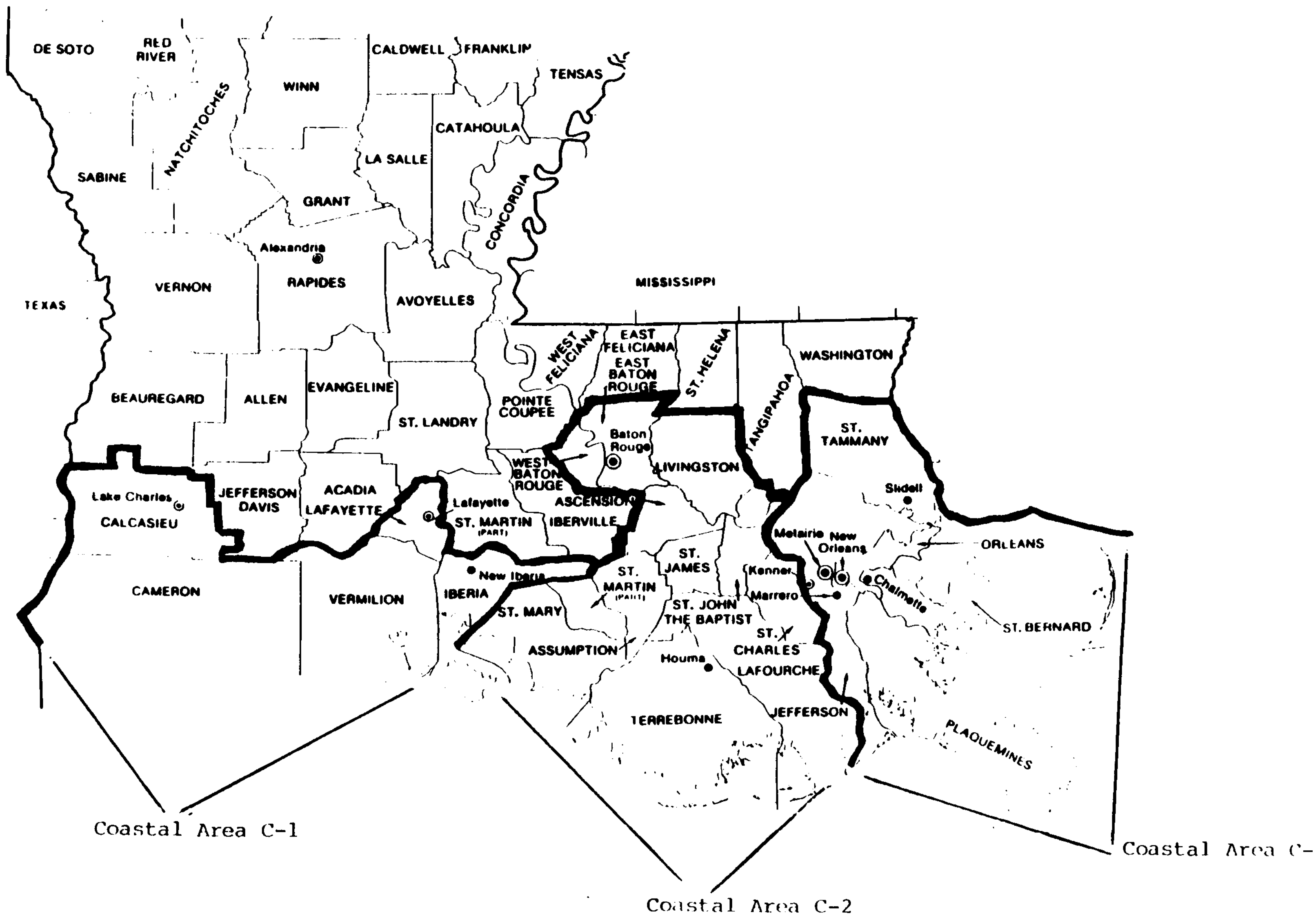
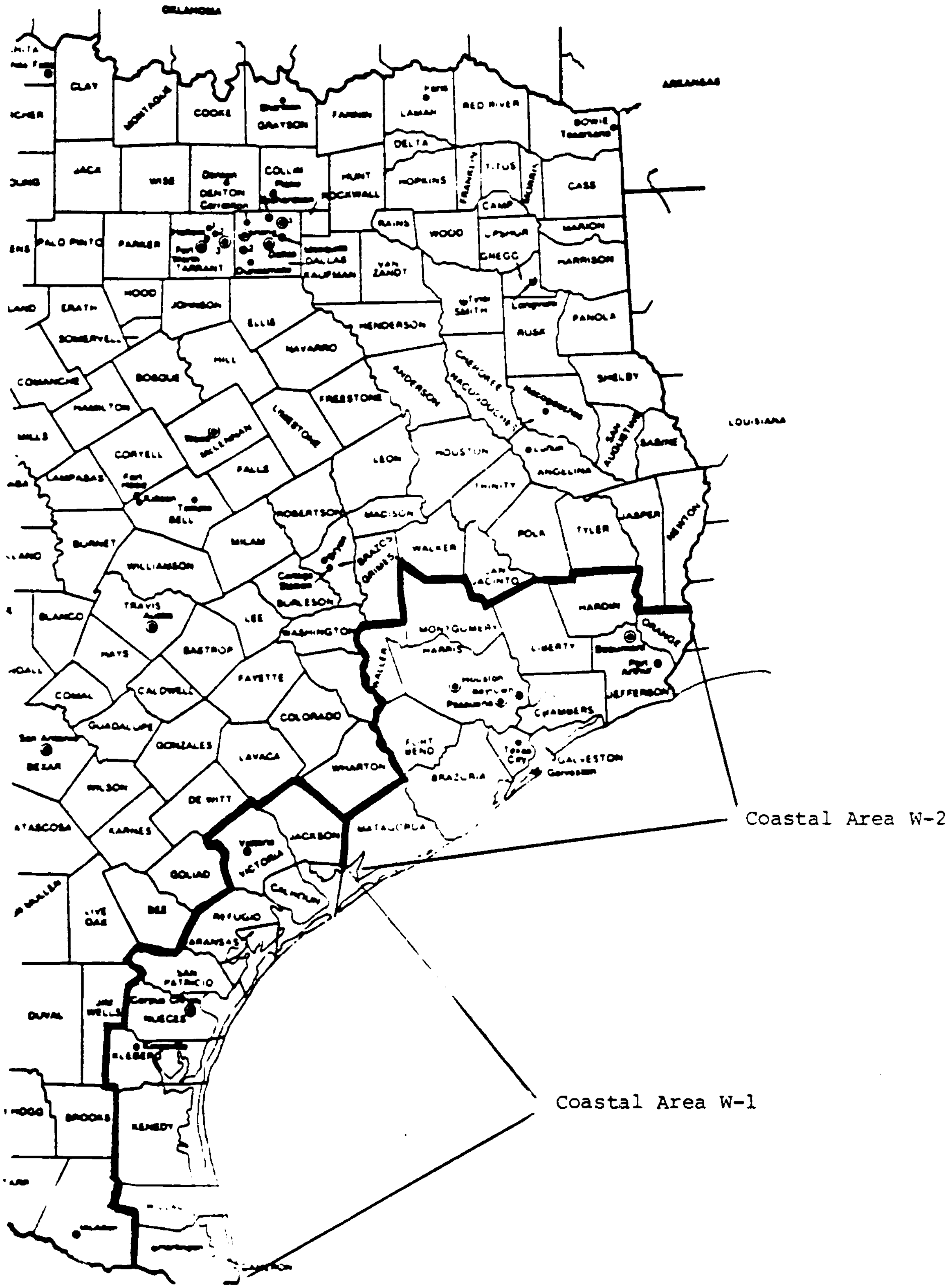


Figure Four
Western GOM Coastal Analysis Area:
Texas



with the dynamics of the oil and gas industries occurs in these counties. It should be noted, however, that this list may not be complete. For instance, it may be appropriate to include additional counties in one or more of the regions if it is determined later that the economies of these counties are significantly linked to the coastal economies.

Eastern GOM Coastal Analysis Area - this area includes twenty-five (25) Florida counties grouped into four coastal areas:

Coastal Area F-1 - Bay, Escambia, Okaloosa, Santa Rosa, Walton;

Coastal Area E-2 - Dixie, Franklin, Gulf, Jefferson, Levy, Taylor, Wakulla;

Coastal Area E-3 - Charlotte, Citrus, Collier, De Sota, Hernando, Hillsborough, Lee, Manatee, Pasco, Pinellas, Sarasota;

Coastal Area E-4 - Dade, Monroe.

Central GOM Coastal Analysis Area - this area includes twenty-six (26) parishes and counties in Louisiana, Mississippi, and Alabama grouped into four coastal areas:

Coastal Area C-1 (all are Louisiana parishes) - Calcasieu, Cameron, Iberia, Lafayette, Vermilion;

Coastal Area C-2 (all are Louisiana parishes) - Ascension, East Baton Rouge, Lafouche, Livingston, St. Charles, St. James, St. John the Baptist, St. Mary, Terrebonne, West Baton Rouge;

Coastal Area C-3 (all are Louisiana parishes) - Jefferson, Orleans, Plaquemines, St. Bernard, St. Tammany;

Coastal Area C-4 (includes both Mississippi and Alabama counties) -

Mississippi - Hancock, Harrison, Jackson, Stone;

Alabama - Baldwin, Mobile.

Western GOM Coastal Analysis Area - this area includes twenty-three (23) Texas counties grouped into two coastal areas:

Coastal Area W-1 - Aransas, Calhoun, Cameron, Jackson, Kenedy, Kleberg, Nueces, Refugio, San Patricio, Victoria, Willacy;

Coastal Area W-2 - Brazoria, Chambers, Fort Bend, Galveston, Hardin, Harris, Jefferson, Liberty, Matagorda, Montgomery, Orange, Waller.

Postulated Conditions

As many as ten postulated conditions or scenarios are being developed by MMS. These scenarios, called the direct effects, are to reflect the likely conditions within the oil and gas industries during the next several years. One scenario, called the Baseline condition, will be based on "existing oil and gas activities in the federal GOM OCS areas and future expected conditions without continued MMS GOM OCS lease sales."[2] Other scenarios will consist of a particular set of "leasing, exploration, and/or development conditions by MMS OCS planning area (i.e., Eastern, Central, Western)."[3] Factors that are being considered in the development of scenarios are oil and gas prices, resource potential, and other variables that affect industry interest in GOM OCS oil and gas resources.

MMS is defining these scenarios in terms of changes in industry outputs and industry employment within the oil and gas industries. As already noted, these estimates of output and employment changes are the so-called direct economic effects, which are based on different conditions or scenarios considered by MMS for the oil and gas industries. So-called indirect impacts can then be calculated on the basis of the direct effects. The following section outlines the basic methodology that is being developed to enable MMS to identify and measure the indirect socioeconomic effects.

II. Analysis

Model Evaluation

A number of methods are available for measuring socioeconomic impacts. Most common among these are econometric models (i.e., simultaneous equations models) and input-output models (i.e., interindustry analysis). Other methods exist, such as community base studies (or, export base analysis) and power series approximations, but these other methods are basically limited forms of input-output models.

Econometric models and input-output models are both being evaluated as potential methods for measuring secondary or indirect socioeconomic impacts for small geographical regions, such as the multicounty areas of the MMS study. However, it is quite evident that the econometric approach has been precluded because of certain needs or requirements set forth by MMS. Some of the more important requirements by MMS include 1) multicounty level assessments (i.e., individual assessments for the ten multicounty Study Areas defined earlier) and 2) industry detail at the four-digit S.I.C. code level,

---

2. Ibid.

3. Ibid.

whenever appropriate.[4] These two requirements alone preclude the development of econometric models, largely because the development of an econometric model for an area requires a time series data base that spans a relatively long series of years. Time series data on industry outputs, employment, incomes, and so forth simply do not exist at the four-digit level, especially for multicounty areas. Moreover, aggregate econometric models seldom consider production as anything but aggregates of final outputs. Interindustry transactions are typically aggregated until they disappear. Production of commodities which are to be used in the making of other commodities is, however, a major part of economic activity. Most important, interindustry detail is a necessary requisite to the estimation of indirect effects at an industry level, especially at the three- and four-digit SIC industry level. In light of the requirements and needs of MMS, the modeling technique that is being developed for this study is the regional input-output model.

Development of Socioeconomic Program

a. Input-Output Framework

Regional input-output models provide a means of quantifying indirect effects, since the basic feature of input-output models is the accounting of interindustry transactions among the producing sectors.

To the nonspecialist, an input-output model may appear as simply several very large tables that contain a great amount of data. This description, while basically accurate as to the visual characterization of the model, fails to note that these numbers represent transactions among economic actors (sectors), indicating flows of goods, services, and money. In brief, an input-output model (i.e., the input-output tables) indicates where different industries, governments, and consumers purchase goods and services and where producers, in turn, sell their goods and services. As described by Emerson and Lamphear,[5]

> The main theme of (input-output analysis)...is economic interdependence. In a highly specialized economy such as that which characterizes the United States and its geographic components, several stages of production are involved in delivering a product or service to the ultimate consumer. Since numerous industries sell the majority of their output to other industries

---

4. Standard Industrial Classification (SIC) is a scheme for classifying commodities by number. For instance, SIC number 34, called Fabricated Metals Products, contains all fabricated metals products. Under this heading, SIC 341, called Metal Cans and Shipping Containers, contains metal cans and shipping containers. Extension to the four-digit level provides more detail. For example, SIC 3411 contains only metal cans. The eventual breakdown is to discrete products at the nine-digit level. See U.S. Bureau of the Budget, Standard Industrial Classification Manual (Washington, D.C., 1972).

5. Emerson, M. Jarvin; Lamphear, F. Charles. 1975. Urban-Regional Economics: Structure and Change. Boston: Allyn and Bacon; Chapt. Two.

rather than to final markets, this intermediate production demand represents a sizeable portion of the total activity of an economy. Nationally, for instance, interindustry transactions represent more than 50 percent of total dollar-value of transactions. Thus the activity of one industry may depend upon the activities of several other industries. These are the interrelationships that are captured in an input-output investigation.

To begin an understanding of the interrelationships captured in an input-output model, it is desirable to focus on a single column of numbers from an input-output model. This limited focus is especially useful for discussing the connection between interindustry transactions and economic impact effects.

The exercise that follows has been limited to a hypothetical illustration of a producing sector, called Light Manufacturing. It should be noted that the kind of input-output information used in this exercise for the Light Manufacturing sector is typical of all the sector information of an input-output model. Thus, what is learned from this hypothetical illustration is relevant to any producing sector of an input-output model.

b. Input-Output Information

Input-output information used for economic assessment purposes comes from the so-called Total Requirements Table of the input-output model. For illustrative purposes, the Light Manufacturing sector column of a hypothetical Total Requirements Table is given in Table 1.

Table 1

Total Requirements
Associated with Light Manufacturing
(hypothetical)

Sector Impacted	Total Impact
Light Manufacturing	1.0615
Heavy Manufacturing	0.0694
Trade	0.0199
Services	0.0302
F.I.R.E.[a]	0.0335
Utilities & Transp't.	0.0610
Other	0.5946
Total	1.8701

[a]F.I.R.E. represents the Finance, Insurance, and Real Estate sectors.

Table 1 actually includes several producing sectors besides the Light Manufacturing sector. In fact, the Table includes all the producing sectors identified in the hypothetical input-output model, but these producing sectors form the rows of Table 1. The single column in Table 1 is the total requirements associated with the Light Manufacturing sector. All producing sectors must be included even though the focus is on a single sector in order to account for the total economic multiplying effect.

The utility of input-output models for economic impact assessment purposes comes from the derived economic multipliers. The multiplier concept is based on the idea that when an investment or expenditure is made, economic activity is generated beyond the initial investment or expenditure. For example, after a company is in operation to produce, say, $1,000,000 worth of goods for sale to final demand, it must buy certain inputs (e.g., materials, finance charges, business services, etc.) from other businesses in order to produce the one million dollar's worth of goods for sale to final demand. These suppliers, however, must also purchase inputs in order to produce and supply the needed inputs to this company, and so on it goes. Therefore, the initial $1,000,000 of sales (output) to final demand is multiplied throughout the economy.

Turning to Table 1, the final demand multiplier for the Light Manufacturing sector is 1.8701, which is the column sum. This multiplier of 1.8701 means that approximately $1.87 is generated in the region's economy for every $1.00 of sale to final demand by the Light Manufacturing sector. Accordingly, a $1,000,000 sale to final demand by the Light Manufacturing sector multiplies throughout the region's economy by 1.87 for a total economic impact of $1,870,000.

The $1,870,000 of total economic impact includes both the direct effect and the indirect effect. The direct effect is the initial $1,000,000 of output (sales) to final demand by the Light Manufacturing sector. The additional $870,000 of total effect is the indirect economic effect, which represents increased demands (outputs) associated with related sectors.

Input-output information allows one to further disaggregate the indirect effects by sector. Returning to Table 1, the column elements provide sector detail of the indirect effects. For example, the indirect effect on the Utilities and Transportation sector is $61,000 (0.0610 x $1,000,000 = $61,000). Similarly, the indirect effect on the Heavy Manufacturing sector is $69,400 (0.0694 x $1,000,000 = $69,400). To determine the indirect effect on the Light Manufacturing sector, the direct effect must first be substracted from the total effect. Since the total effect to Light Manufacturing is 1.0615, the indirect effect is 0.0615. The 1.0000 (or $1.00) reflects the one dollar of sales to final demand. Recall, that a final demand multiplier, which is normalized on the basis of a one dollar of sale to final demand, reveals the total economic effect per one dollar of sale to final demand. The indirect effect of $61,500 (0.0615 x $1,000,000 = $61,500) means that the Light Manufacturing sector must purchase some materials from itself in order to produce the $1,000,000 of goods for sales to final demand. An intra-sector purchase (sale) does not necessarily mean that the firm selling to final demand actually buys materials from itself for production purposes. A sector, by definition, is a group of similar firms. It is quite conceivable that one or more firms would sell inputs to other firms within the same sector group; hence, intra-sector sales.

c. Extended Economic/Demographic Information

The basic economic information on gross sector transactions can be linked to employment effects, income effects, population effects, and so on. The usual procedure in input-output and economic impact analysis is to make the economic linkages (e.g., the linkage between industry transactions and income, or the linkage between transactions and employment) within the general input-output framework. Linkages between economic effects and demographic effects (e.g., the linkage between the employment effect and the associated change in resident population) are usually made outside an input-output framework. The use of certain population and demographic characteristics of the study area provides a way to make these linkages. In short, the input-output model is the "generator" for important economic information, and the economic information, in turn, is converted to other information, such as resident population change, housing demand, etc.

Most linkages between economic variables and noneconomic variables are quite straight forward. This can be seen by continuing with the Light Manufacturing illustration of Table 1 and convert the gross transactions effects to employment effects. (The conversion of transactions effects to income effects will not be discussed here because an understanding of this process is beyond this limited discussion of input-output analysis.)

To review, the final demand multiplier for the Light Manufacturing sector (Table 1) times the $1,000,000 yields a total transactions effect of $1,870,000. Also from Table 1, the total transactions effect by sector can be determined, as summarized below in Table 2.

Table 2

Total Economic Impact Associated
with One Million Dollar Sale to Final Demand
by Light Manufacturing
(hypothetical)

Sector Impacted		Total Transactions Effects
Light Manufacturing		$1,061,500
Heavy Manufacturing		69,400
Trade		19,900
Services		30,200
F.I.R.E.		33,500
Utilities & Transp't.		61,000
Other		59,460
	Total	$1,870,100

The sector transactions effects recorded in Table 2 can be converted to job equivalents by developing sector output-to-labor ratios for the study area. Suppose, for illustrative purposes, the sector output-to-labor ratios are as given in Table 3.

Table 3

Output/Unit Labor Ratios
(hypothetical)

Light Manufacturing	$27,000/1.00
Heavy Manufacturing	30,000/1.00
Trade	20,000/1.00
Services	18,000/1.00
F.I.R.E.	19,000/1.00
Utilities & Transp't.	50,000/1.00
Other	35,000/1.00

Combining the information from Tables 2 and 3 yields the economic effect in terms of employment equivalents (or jobs), which are given in Table 4.

Table 4

Employment Equivalent
Effects

Light Manufacturing	39.3
Heavy Manufacturing	2.3
Trade	1.0
Services	1.7
F.I.R.E.	1.8
Utilities & Transp't.	1.2
Other	1.7
Total	49.0

Forty-nine jobs are directly and indirectly associated with (or, supported by) the sale of one million dollar's worth of goods to final demand by the Light Manufacturing sector. If the one million dollars represented an expansion in sales to final demand by Light Manufacturing, then the forty-nine employees would represent additional employment to the community. Additional employment to a community means additional population, and so on it goes. By combining input-output economic information with demographic information, estimates on population change, migration, etc. can be determined.

A computer program is being written that will enable users within MMS to develop nonsurvey input-output models at the multicounty level. This program, to meet MMS requirements, is being developed for the Series 3200 Perkin-Elmer system. A variety of options or commands will be available in the program that will extend from the actual construction of nonsurvey input-output models to the estimation of indirect economic impacts, such as industry outputs, income, and employment.

d. Demographic Component

As already noted, changes in economic conditions ultimately mean changes in commuting patterns, migration, and population. The input-output framework identifies and measures the total economic effects associated with actual or postulated changes in an industry's output (or final demand), such as a change in demand for the outputs of the oil and gas industries.

A demographic component is being developed that converts employment changes to changes in migration and population in much the same way as noted in the above hypothetical illustration. This component is being made a part of the overall socioeconomic program model, which is to be operational on the 3200 Series Perkin-Elmer system.

In summary, the socioeconomic program model contains two components: the primary input-output component and the demographic component. The input-output component enables the user to construct nonsurvey regional input-output models and, in turn, calculate indirect economic impacts. The demographic component, then, converts the economic effects to population equilivants and migration effects. From the point of view of the user, the socioeconomic program model is simply a single program. That is, the program will contain a number of options which the user can invoke to move from input-output modeling, to economic impact assessment, and, finally, to population and migration estimations.

e. Program Verification

The socioeconomic program model uses existing and available economic and demographic data to construct nonsurvey regional input-output models for multicounty study areas and, then, to estimate socioeconomic effects for these areas. These data, and more importantly the quality of these data, may limit the program model's results to only approximations of the actual socioeconomic effects associated with changes in the oil and gas industries. This raises the obvious question of model reliability.

Model reliability will be checked by firstly developing a scenario, called the Baseline condition, which is being defined as a recent known change in the activity levels of the oil and gas industries and, secondly, by conducting a limited survey of key economic units in two of the ten Study Areas to ascertain directly the socioeconomic impact (if any) associated with the Baseline condition. Those industries most likely impacted by the oil and gas industries are identified in Figures Five and Six.

The results of the survey will be checked against the program model's results for the same Baseline condition. The two sets of results will be examined to determine if there is any reason to make modifications in the program model or to substitute data sources for model development and/or impact estimation.

III. Results

Program Installation & Training

A major part of the MMS study is the development of a socioeconomic program model and the installation of this program on the MMS Perkin-Elmer system. This effort is important because it allows for future MMS in-house analyses of indirect socioeconomic effects related to alternative federal GOM OCS oil and gas leasing, exploration and development forecasts.

A week-long training period is scheduled during the twelfth month of the seventeen-month study period. MMS participants will be trained during this time to operate the socioeconomic program on their Perkin-Elmer system. Training instructions and manuals will be provided and used during this training period. This training period will also include instructions on data file development and data management.

Final Report

Three volumes are scheduled as the final report to MMS representatives. Volume I is an Executive Summary that will focus mainly on the estimates of the indirect effects of industry output, income earnings, employment, and population for the Study Areas. This summary volume will also provide a brief discussion of the general socioeconomic characteristics of the Study Areas.

Volume II will be devoted to socioeconomic impact estimation. This volume will provide a thorough discussion of the evaluation of methodologies that led to the formulation of the socioeconomic program model for MMS use. Along with a discussion of the estimates of indirect effects, a discussion of the assumptions of the socioeconomic program and, most importantly, how these assumptions must be considered in future use of the socioeconomic program model by MMS personnel will be included in this volume. Lastly, an evaluation of the model's performance will conclude this volume.

The third and final volume will be a Technical Report on the operation and maintenance of the socioeconomic program model on the MMS Perkin-Elmer system. This volume will also cover the development of source files that are used in the operation of the socioeconomic program model. In short, this

Figure Five

Oil and Gas Construction Complex

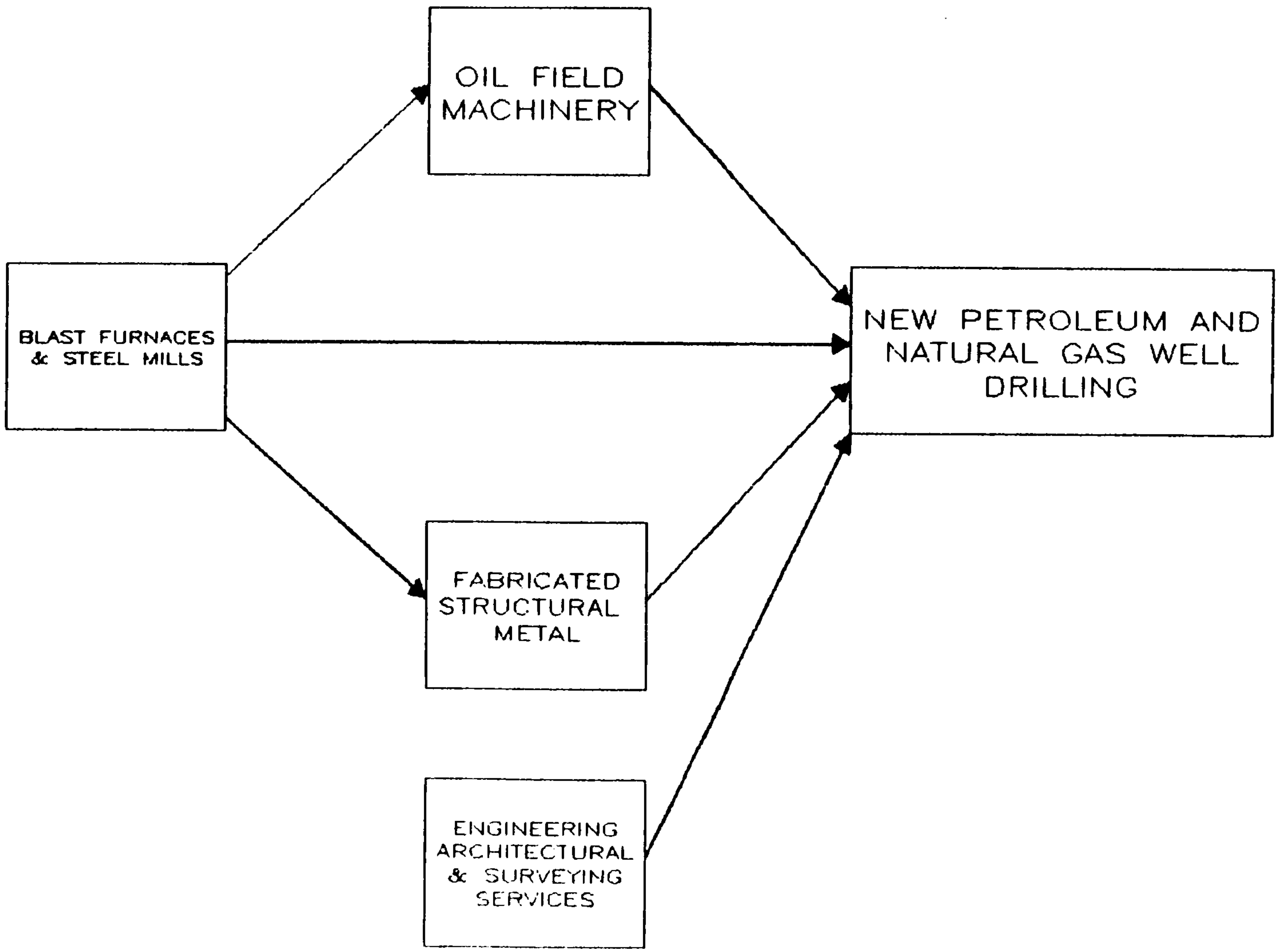
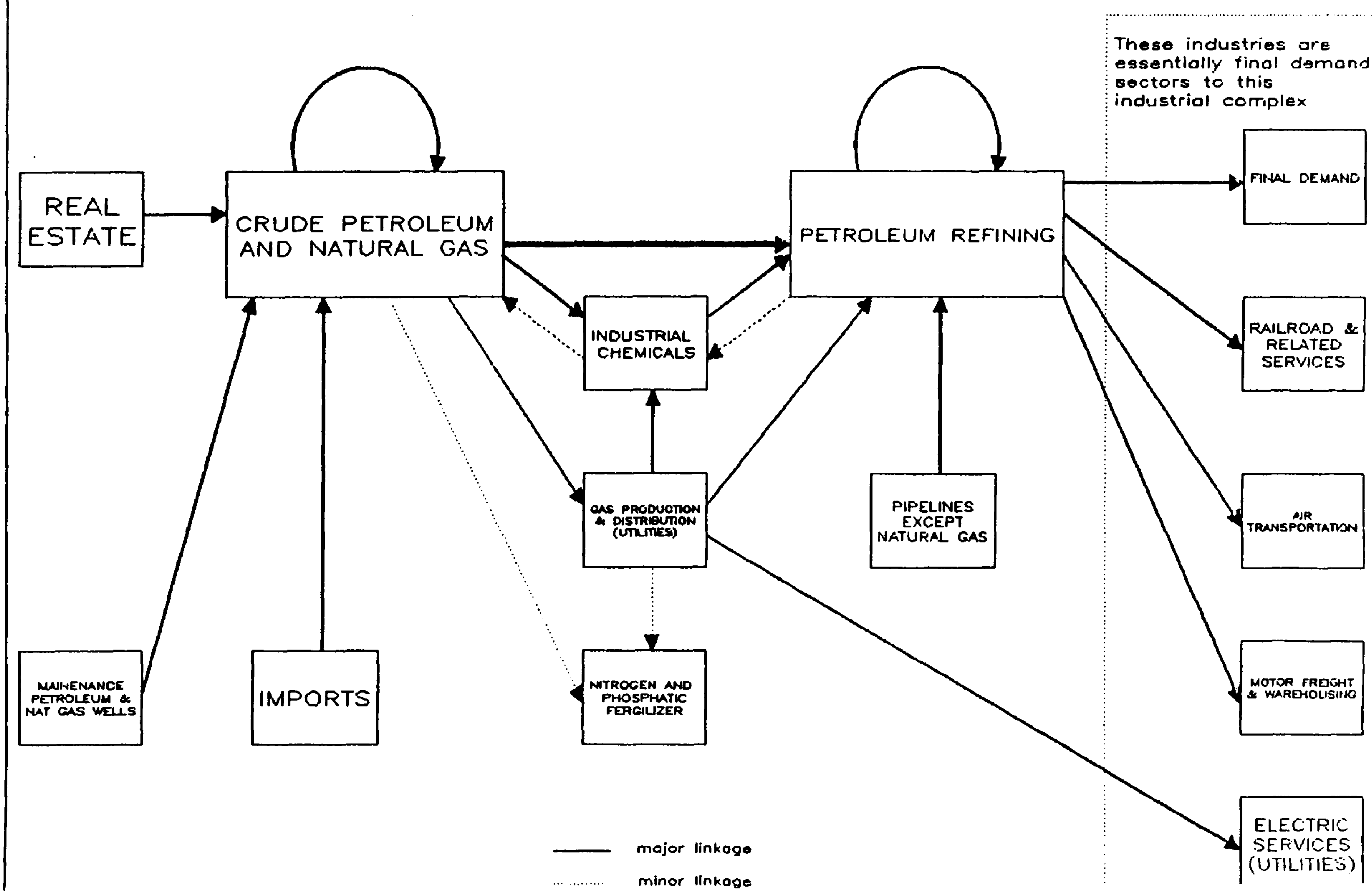


Figure Six

Oil and Gas Production Complex



volume will be a "user's" manual, and it will duplicate some of the training materials that will be used during the installation and training period.

ABSTRACT

MMS NEW ORLEANS TERNARY MEETING
MARCH 18, 1986

PROGRESS REPORT:
"OUTER CONTINENTAL SHELF DEVELOPMENT
AND POTENTIAL HABITAT DEVELOPMENT"

presented by

R. Eugene Turner
Center for Wetland Resources
Louisiana State University
Baton Rouge, Louisiana 70803

The contribution of OCS activities to landloss in the northern Gulf of Mexico coastal zone is the subject of a newly initiated study (October 1985) centered at Louisiana State University until December, 1987. The role of OCS impacts is being estimated by a scientific team which will use a variety of approaches, including aerial imagery techniques, analysis of existing data, laboratory experiments, and field studies. Thirteen task elements address all major factors contributing to coastal landloss to sort out the relative and interactive influence of OCS activities; these factors include geologic and soil subsidence, sea level rise, vertical soil accumulation, salt water intrusion, changes in sediment supply, spoil banks and canals, subsurface fluid withdrawal, navigation and natural geomorphic features. The distribution and direct impact of OCS pipelines is also being documented.

Salt water intrusion is being addressed in three ways: a) state and federal hydrologic records are being examined to determine the occurrence and extent of salt water intrusion and the climatic factors affecting temporal changes in salinity; 2) a computer model of hydrologic flow in a natural and man-made channel is being developed/adapted to study the effects of changes in channel morphology on salt water flow in a generic canal; and, 3) plant reactions to salt water intrusion and subsidence are being studied in field and laboratory experiments.

Subsidence and soil accumulation is being examined near and away from OCS pipeline corridors by recovery of chemical markers with datable horizons in the soil profile (ranging from 1 year to 200 years). Anticipated results are that the height, age and complexity of spoil bank configurations will be negatively associated with vertical soil accumulation, regardless of construction intent or method.

The impacts of subsurface fluid withdrawal on subsidence are being investigated using a synthesis of existing field data and numerical models.

Direct impacts are being estimated by collating all map information on OCS pipelines, using existing and new (1985) aerial imagery and selecting representative sites for study. Of the more than 130 pipelines crossing the study area, perhaps 30 will be investigated thoroughly. Less information is known about the others, and the necessarily proprietary nature of the information

or non-existence of the data restricts complete analysis of all pipelines. Navigation channels and their widening are included as a direct impact if they clearly support offshore OCS activities.

Changes in the surface and bedload sediment supply of the Mississippi River are being detailed through a complete mapping and statistical analysis of records (primarily USACOE) and historical maps of channel morphology from St. Louis to below New Orleans.

Finally, the analysis of aerial images from 1955 to provides a powerful tool to determine statistically significant temporal and spatial relationships between habitat changes and various OCS and non-OCS activities, natural features and ecologic context (e.g. plant type, substrate, and wave energy,) and geologic setting. These study aspects will also test the results gained from other study tasks.

The entire study is for 27 months and is being supervised by a Project Manager (R. E. Turner), a Science and a Business manager (D. Cahoon and R. E. Adams, respectively), and a Scientific Review Board (SRB) of 7 people representing industry, management and academics. We are presently working to gain final approval of the initial plans presented to the SRB in January 1986, and expect all study components to have final approval of detailed plans by April 1986.

ENVIRONMENTAL STUDIES PROGRAM

SPRING TERNARY MEETING

18 MARCH 1986

Report: Continental Slope Ecosystems Study

LGL Ecological Research Associates and Department of
Oceanography, Texas A&M University
Willis Pequegnat (LGL)

This report consists of three parts, viz., an overview by W.E. Pequegnat (LGL) of results derived from an analysis of data collected during the first three of the five cruises mounted from the inception of the project to the completion of the second year, a synthesis by M. Kennicutt (TAMU) of highlights of chemical findings and a report on the regional distribution of unique seep communities discovered by the group during the second year, and a detailed analysis by I. Rosman (LGL) of the spatial characteristics of local populations of the vestimentiferan and vesicomyid clams that comprise principal macrofaunal components of the seep communities.

The waters of the Gulf of Mexico are layered by distinct water masses that can be identified by temperature, salinity, and nutrient properties. During the first three cruises the identifying characteristics of these water masses were usually found at expected depth ranges. The influence of temperature upon the distribution of organisms is well known; hence it is important to note that in the study area the 10 degrees centigrade isotherm was observed at depths ranging from 350 to 400 m and that the temperature below 1300 m ranged between about 4.2 and 4.4 degrees centigrade. In general all sampling, both physical and biological, was carried out along three transects, located in the western, central and eastern Gulf of Mexico and ranging in depth from 200 to 2600 or so meters.

The faunal groups examined in this study consist of the megafauna collected by trawling, the macrofauna (greater than 0.3 mm in size) collected by the box corer, and the meiofauna (0.063-0.3 mm size) also extracted from box cores.

MEGAFAUNA

CRUSTACEA

The composition of the 104 species of benthic megacrustacea is shown in Table 1. One can see in the table that about 70% of the crustacean species extend their bathymetric range below the 1000-m isobath, which marks the upper edge of the abyssal regions of the slope.

ECHINODERMATA

Eighty-four species of megafaunal echinoderms were collected by the trawl from the three sampling transects (Table 2). Some 60% of the echinoderm species were collected at depths greater than 1000 m, and about 50% attained their maximum populations in the abyssal areas.

DEMERSAL FISH

A total of 112 species of demeral or benthopelagic fish has been collected on the three sampling transects. The zonal distribution of these fishes is very interesting (Table 3) in that it show a marked drop in numbers below the Upper Abyssal.

MEGAFAUNAL ASSEMBLAGES AND ZONATION

It is well known that the megabenthic fauna of the ocean undergoes a compositional change with depth from shore to the abyssal plain. This change appears not to be uniform along the axis of increasing depth. Indeed, it appears that different clusters of species predominate from shallow to deep environments along the axis. These clustering assemblages have been used to describe faunal zones of which four have been noted and designated in this study, viz., Shelf/Slope Transition Zone (to a depth of 450 m); the Archibenthal Zone (475 - 950 m); the Upper Abyssal Zone (975 - 2250 m); and the Mesoabyssal Zone (2275 - 2700 m).

MACROFAUNA

The present LGL collections from the northern Gulf of Mexico contain 980 taxa of macrofauna (Table 4). The most surprising find thus far is the extraordinarily large number of species in such groups as Tanaidacea, Isopoda, Bryozoa, and Sipuncula.

Table 1. Megafaunal Crustacea collected by trawl during Cruises I, II, and III of the LGL study.

Taxa	No. Of Species	% Of All Megacrustacea	No. Of Spp. At Or Below 1000 m	% Of Species Below 1000 m
CIRRIPEDIA	7	7	4	57
ISOPODA	2	2	2	100
AMPHIPODA	5	5	5	100
DECAPODA	89	85	62	70
Penaeidea	11		6	55
Caridea	24		12	50
Anomura	28		15	54
Paguridae	(9)		5	56
Porcellanidae	(1)		0	0
Chirostylidae	(2)		2	100
Lithodidae	(1)		1	100
Galatheidae				
Munida	(6)		2	33
Munidopsis	(9)		5	56
Macrura	9		5	56
Polychelidae	(4)		3	75
Nephropidae	(3)		2	66
Scyllaridae	(1)		0	0
Axiidae	(1)		0	0
Brachyura	17		3	18
STOMATOPODA	1	1	0	0
PYCNOGONIDAE (an arachnid)	1		1	100
	104 Crustacea	100	73	Ave. 70%

Table 2. Number of megafaunal species collected in echinoderm classes and their bathymetric distribution.

Class	No. of Species	% of all Echinoderm spp.	No. Species Below 1000 m	% of Group Below 1000 m
Asteroidea	28	33	15	54
Ophiuroidea	30	36	13	43
Echinoidea	8	10	5	63
Holothuroidea	16	20	15	94
Crinoidea	2	1	2	100
	84	100	50	Ave. 60

Table 3. Zonal distribution of demersal fishes.

Zone	Species With Max. Pop.	Number That Are Found Shallower	Number That Are Found Deeper
Shelf/Slope Transtion	31	8	11
Archibenthal	44	4	11
Upper Abyssal	33	9	1
Mesoabyssal	4	2	0
Totals	112	23	23

Table 4. Distribution of macrofaunal species among faunal zones by depth of maximum density. Numbers in parentheses are other species that occur in the zone. Macrofauna collected by means of 0.1 m^2 boxcorer.

Taxa	Faunal Zones: Shelf/Slope Transition (150-450 m)	Faunal Zones: Archibenthal Zone (475-950 m)	Faunal Zones: Upper Abyssal (975-2250 m)	Faunal Zones: Mesoabyssal (2275-3225 m)	Totals Max. Dens. Only
Porifera	0 (0)	3 (4)	17 (3)	11 (0)	31
Coelenterata	5 (2)	6 (2)	5 (2)	0 (0)	16
Polychaeta	92 (62)	143 (87)	62 (84)	6 (50)	322
Gastropoda	10 (5)	6 (7)	8 (1)	0 (0)	24
Bivalvia	9 (11)	6 (16)	24 (5)	10 (9)	49
Scaphopoda	1 (2)	0 (6)	6 (3)	3 (3)	10
Myodocopa	3 (2)	9 (4)	2 (6)	1 (1)	15
Cumacea	6 (12)	20 (15)	23 (11)	6 (4)	55
Tanaidacea	10 (19)	53 (46)	63 (28)	21 (21)	147
Isopoda	11 (3)	24 (42)	51 (27)	14 (21)	100
Amphipoda	16 (13)	27 (20)	18 (15)	1 (6)	62
Sipuncula	16 (3)	12 (7)	8 (4)	1 (2)	37
Bryozoa	14 (6)	22 (7)	24 (6)	10 (3)	70
Brachiopoda	0 (1)	0 (1)	2 (0)	0 (1)	2
Ascidiacea	0 (0)	0 (2)	8 (0)	2 (1)	10
Asteroidea	1 (0)	0	1 (0)	0 (0)	2
Ophiuroidea	4 (1)	4 (4)	5 (2)	3 (0)	16
Echinoidea	0 (1)	0 (2)	1 (1)	2 (1)	3
Holothuroidea	1 (0)	2 (2)	6 (3)	0 (2)	9
Crinoidea	0 (0)	0 (0)	2 (0)	0 (0)	2
MAX. DENSITY TOTALS	199	337	336	89	980*
OTHER SPECIES TOTALS	(143)	(274)	(201)	(125)	
GRAND TOTALS IN ZONES	342	611	537	214	

*Does not include undetermined species of podocopid ostracods and a few oligochaeta.

MEIOFAUNA

As is to be expected the most abundant groups of the meiofauna were found to be the Nematoda, Foraminifera, and Harpacticoida (Table 5). In general there was an orderly decrease of total meiofauna per 10 cm^2 as the depth of sampling increased.

BENTHIC PHOTOGRAPHY

A total of 437 animals has been enumerated from digitized photographs of the 15 Cruise II stations. A comparison of estimates of megafaunal density between those derived from trawling and those from benthic photography has proved to be very interesting. In general, density estimates based upon photography exceeded trawl density estimates by one or two orders of magnitude. In a few cases species such as the holothurian Scotoplanes were observed on film but were not recorded from trawl data.

CONCLUSIONS

In view of the fact that analyses of data from Cruises IV and V are scarcely ready for analysis, it is obviously inappropriate to formulate any important conclusions at this time. It is anticipated, however, that when completed this study will make a significant contribution to our understanding of the ecology of the deep ocean.

Report: Distribution of Seep-type Taxa in the Northern Gulf of Mexico

M.C. Kennicutt II (TAMU)

The discovery of chemosynthetic, vent-like assemblages of organisms in an economically important region of the Gulf of Mexico continental slope has raised the question whether these sites are unique. To assess the areal extent of the organisms and the accompanying environments, an extensive trawling program was executed by Texas A&M University for the Offshore Operators Committee in February 1986. Several key indicators associated with these initial discoveries include the present of oil seepage, gas (CH_4) pockets (or hydrates), and/or H_2S; 3.5 KHz "wipeout"

Table 5. Comparison of meiofaunal densities derived from sampling the Eastern, Western, and Central Transects during Cruises I, II, and III. Note that the stations of Cruise III are arranged in order of increasing depth (see bottom line).

Meiofaunal Densities (No./10 cm^2 from top 5 cm of core) Transect and Cruise

Cruise II Stations Only (April 1984)

Taxon	West Transect 1	2	3	4	5	East Transect 1	2	3	4	5	Central Transect 1	2	3	4	5
Nematoda	165	96	107	68	65	122	108	116	95	112	483	254	229	204	145
Foraminifera	23	7	7	2	5	13	8	6	6	12	422	224	252	241	56
Harpacticoida	85	35	48	32	26	28	43	41	36	40	109	109	88	69	41
Polychaeta	15	6	9	6	3	9	11	12	8	4	30	30	14	12	4
Ostracoda	5	6	4	3	4	6	3	4	6	4	11	12	11	7	4
Kinorhyncha	7	0.5	1	1	2	3	0.5	2	1	1	16	2	5	3	2
Isopoda	1	0.3	0.2	1	0.2	1	0.2	1	0.3	0.4	3	2	2	1	0.3
Bivalvia	1	0.2	0.4	1	1	1	0.3	1	0.3	0	1	1	1	1	0.4
Tanaidacea	1	0.3	0.4	0.2	0	0.2	0	0.2	0.1	1	2	0.3	1	0.3	0.2
Halacarida	3	1	0.4	0.2	0.2	0.2	1	0.3	0	1	0.4	0.3	0	0.3	0
Cyclopoida	3	2	0	0	0.3	0	1	0.2	1	1	0.2	0	0	0.3	0.1
Loricifera	1	0.2	0.2	0	0	0.2	0.3	1.4	1	0	0	0	0.1	1.4	0.3
Sipuncula	1	0	0	0	0	0	0.2	0	0.1	0	0.4	0.4	1	0	0
Gastropoda	1	0	0.2	0.2	0	0	0.2	0	0.1	0	0.3	0	0.2	1	0.2
Tardigrada	0.2	0.2	0	1	1	0	0.3	1	0	0	0	0	0	0	0.2
Nemertinea	2	0	0	0	0.2	0	0	0	0	0	0	1	0.1	0	0
Aplacophora	0.2	0	0	0	0	0.3	0	0	0	0	0.3	0.1	0.1	0.3	0
Priapulida	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0.4
Bryozoa	1	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0
Scaphopoda	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0
Gastrotricha	0.2	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0
Nauplii	37	22	17	18	17	15	21	20	13	21	60	43	47	42	20
Station Total	353	177	165	134	125	199	198	206	168	198	1139	679	652	584	274
Depth (m)	355	604	854	1410	2497	352	627	846	1353	2826	353	600	838	1390	2389

Central Transect Only

Taxon	Cruise I (Nov. 1983) 1	2	3	4	5	Cruise III (Nov. 1984) 1	6	2	3	7	8	9	4	11	5	12
Nematoda	275	269	219	166	196	291	319	232	138	333	96	79	212	103	206	124
Foraminifera	59	30	29	15	14	133	314	62	102	119	94	147	163	106	51	44
Harpacticoida	114	130	94	67	48	83	90	100	71	87	59	58	67	43	52	31
Polychaeta	17	7	5	6	3	44	46	18	13	52	12	12	12	7	6	5
Ostracoda	9	11	8	5	4	9	11	13	10	14	10	8	14	6	4	9
Kinorhyncha	9	5	4	2	2	7	5	3	3	3	2	1	2	1	3	3
Isopoda	0.2	0.1	0.1	1	0	0.4	1	1	0.3	1	0.4	0.2	0.4	0.4	0.3	0.1
Bivalvia	1	1	1	1	1	1	1	0.4	1	3	2	2	1	1	1	1
Tanaidacea	1	0.2	0	0	0	3	1	0.3	1	2	0.4	0.3	0.2	0	0.4	1
Halacarida	0	0.1	0.1	0.3	1	1	1	0.4	0.2	0.3	0	0.2	1	0.4	0.2	0.4
Cyclopoida	0	0	0	0	0	0.4	1	1	1	1	1	0.4	1	1	0.3	0.1
Loricifera	0	0	0	0	0	0	0	0.1	0	1	0.3	0.3	1	1	0.4	0.4
Sipuncula	0.1	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0	0
Gastropoda	0.3	0	0.1	0	0	1	5	0	0	1	1	0.2	1	1	0.1	0.3
Tardigrada	0	0.1	0.1	0	0.1	0	0	0.3	0	1	0.1	0	0	0.3	0	0.1
Nemertinea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0
Aplacophora	0.1	0.4	0.1	0	0	1	0.2	0.2	0.4	2	0	0.3	0	0	0.2	0
Priapulida	0	0	0	0	0.2	0.1	0	0	0	0	0.1	0.2	0	0	0	0.1
Bryozoa	0	0	0	0	0	0	0.3	0	0	0	0	0	0.1	0.3	0.1	0.1
Scaphopoda	0.1	0	0	0.2	0	0.1	1	0	0.1	0.3	0.3	0.2	0.2	0.3	0.3	0.3
Gastrotricha	0	0	0	0	0	0.3	0	0	0	0.3	0	0	0	0.1	0.1	0
Nauplii	33	37	34	21	25	33	55	47	33	45	34	31	49	38	44	27
Station Total	519	491	395	285	294	608	842	479	374	666	313	340	525	310	370	247
Depth (m)	363	615	852	1381	2474	357	492	633	883	1020	1192	1429	1477	2105	2518	2943

zones; unusual biological assemblages (vent-like taxa); and anomalous tissue carbon isotopic compositions. Previous studies have shown that: (1) these organimsm are present in at least ten blocks in the mid-Louisiana slope area, (2) oil seepage and high sediment hydrocarbon concentrations occur in many slope blocks, (3) hydrates are present at more than nine sites, (4) many seismic wipeout zones have been recorded on the slope and (5) vent-type taxa have been recovered at more than nineteen locations worldwide. Using the previously described indicators, 39 locations on the northern Gulf of Mexico continental slope were evaluated for the presence of these communities.

Thirty of the 39 trawls crossed recognizable seismic "wipeout" zones. In order to assess the chemical and geologic environment, a sediment core was also taken on each of the trawl lines, preferably in a seismic "wipeout" zone if it was present. At eight locations, oil staining was observed in the core. Eleven cores had obvious gas pockets (one hydrate), presumably methane, and 19 cores had an obvious H_2S odor. Several target organisms known to be asssociated with the chemosynthetic food chain were chosen and their occurrence at the 39 locations was as follows: *Calyptogena ponderosa*-4, *Vesicomya cordata*-5, *Bathymodiolus sp.*-4, unidentified neogastropod-11, *Vestimentiferan* tube worm (3 species)-13, and black pogophorans-11. The presence of an organism was inferred from empty shells and tubes as well as from living specimens. Except for four (~8%), all of these occurrences (48) were associated with trawls that crossed seismic wipeout zones. Initial carbon isotopic analyses confirmed the anomalously light tissue carbon isotopic compositions. Values of $\delta^{13}C$ (°/oo vs. PDB) ranged from -31.1 to -52.6 °/oo for chemosynthetic based organisms. Preliminary conclusions are that (1) the conditions and organisms of interest occur at numerous locations across the northwest Gulf of Mexico continental slope, (2) the highest incidence of oil staining/gas pockets $(CH_4)/H_2S$ is as follows: Green Canyon > Garden Banks > East Breaks, Mississippi Canyon, Atwater Valley and Ewing Banks, (3) these chemosynthetic organisms are preferentially associated with seismic "wipeout" zones (though possibly not exclusively), and (4) these organisms may represent a significant biomass on the slope suggesting that chemosynthesis is an important process in the deep ocean.

Photographic Analysis of Seep-type Organisms
in the north-central Gulf of Mexico

Ian Rosman (LGL)

Photo-transects from the north-central Gulf of Mexico have shown the presence on soft substrate of aggregations of vestimentiferan tube worms and vesicomyid clams that are thought to depend upon chemosynthetic processes for nutrients (Paul et al., 1984). The tube worms and clams, which occurred at separate locations, were discovered during the MMS Continental Slope Study. The tube worms, identified as _Lamellibrachia_ sp. (M.L. Jones, per. comm.), were found on a transect at 27°45.6'N and 91°13.1'W at depth of ~460 m (Fig. 1a-b). The clams, identified as at least two species of the genera _Calyptogena_ and _Vesicomya_ (F.J. Rokop, pers. comm.), were found on a transect at 27°45.6'N and 89°59.1'W at a depth of ~940 m (Fig. 1c-d).

The photographs were taken with a camera suspended from the vessel so that the plane of focus was parallel to the bottom. The camera was equipped with a 28 mm, fixed-focus lens and was loaded with a 100 ft roll of 35 mm color-film. An altimeter mounted next to the camera recorded the altitude above the bottom in each photograph. Photographs were exposed 8 sec. apart as the vessel slowly drifted along the transect. The scale of the photographs was calculated from their exposure altitudes and the acceptance angles of the camera lens. Developed transparencies were projected onto the platen of a microcomputer-driven digitizer; the digitizer was used to record the counts and dimensions of the tube worms and clams. Combining these records with the scale of the photographs and their position along the transect yielded estimates of the size of the organisms and esimates of their density along the transect.

The photo-transect on which _Lamellibrachia_ sp. were found was 4616 m long and was in close vicinity to seismic "wipe-out zones" associated with petroleum seepage; _Lamellibrachia_ sp. occurred on a 1000 m segment of the transect. A total of 439 _Lamellibrachia_ sp. tubes was seen in a photographed area of 471 m^2. The mean density of _Lamellibrachia_ was 0.93 individuals per m^2. The obturaculum plume was visible on only 15% of the _Lamellibrachia_ sp.; thus it is possible that many of the tubes were the remains of dead individuals. This aggregation of tube worms is extremely diffuse and sparse when compared with aggregations of the tube worms

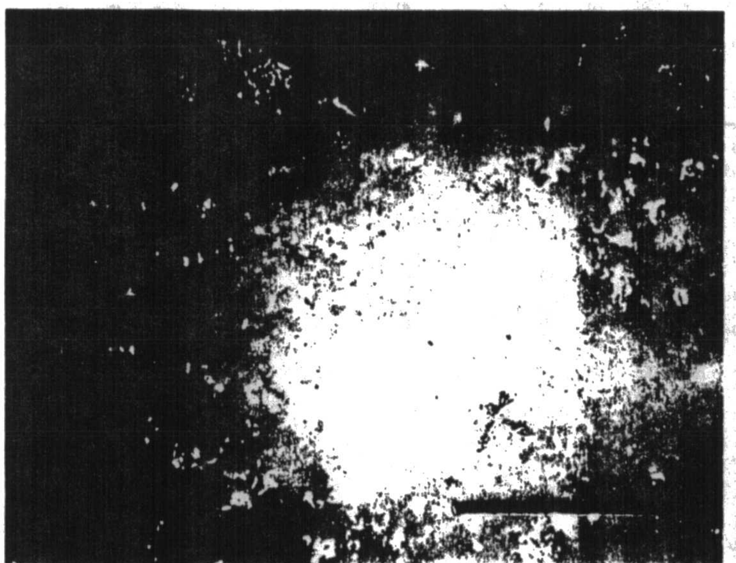


Fig. 1a. Vestimentiferan tubeworms with bacterial mats; Station WC7, depth 433 m.

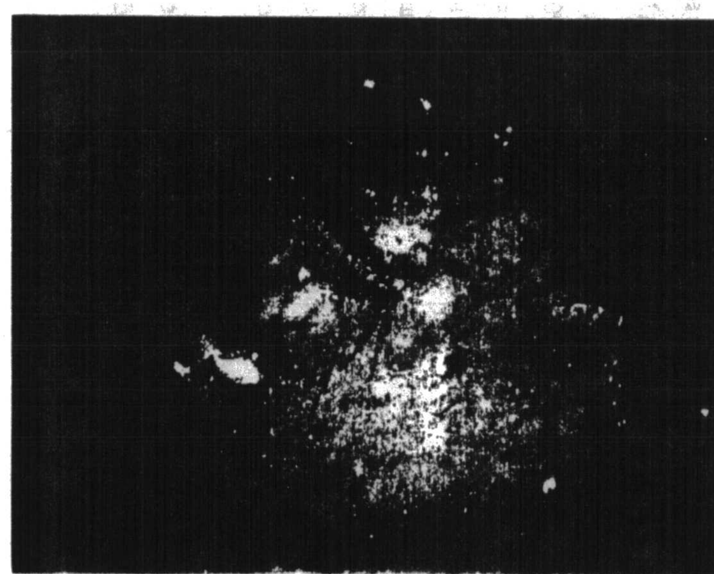


Fig. 1b. Vestimentiferan tubeworms and greeneye <u>Chloropthalmus agassizi</u>; Station WC7, depth 439 m.

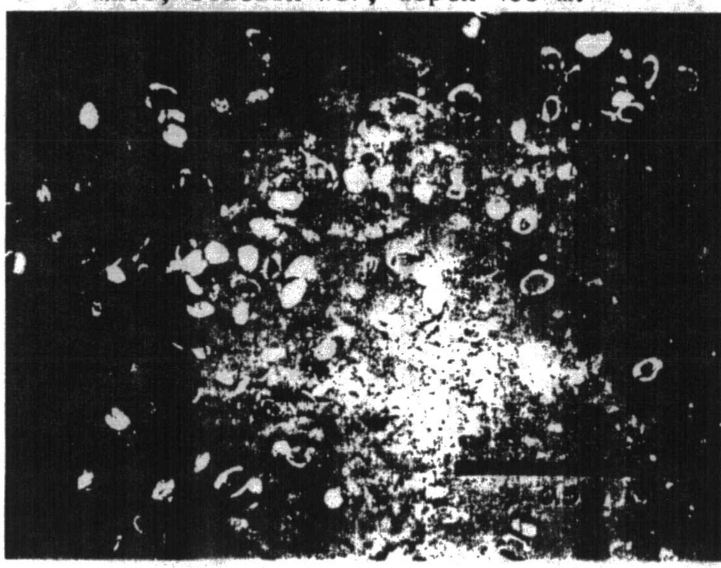


Fig. 1c. Aggregation of live and dead vesicomyid clams; Station C7, depth 948 m.

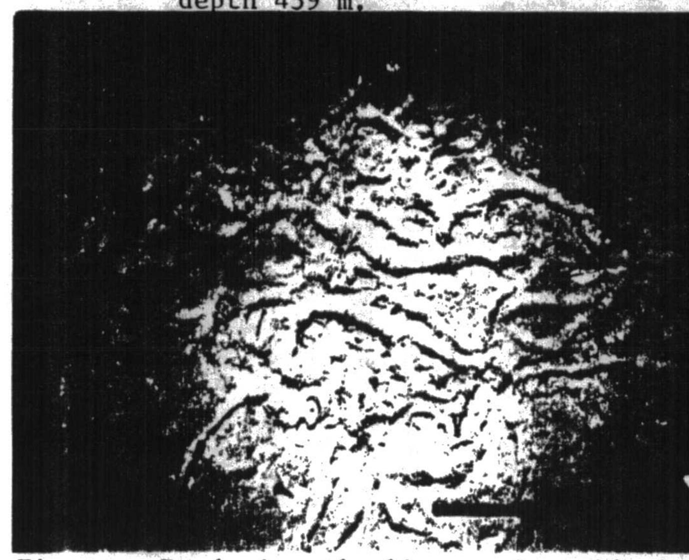


Fig. 1d. Predominantly live vesicomyid clams and furrows in sediments; Station C7, depth 949 m.

Figure 1a-d. Photographs of <u>Lamellibrachia</u> sp. and Vesicomyidae.

Riftia seen at hydrothermal vents (Corliss et al. 1979), and *Escarpia laminata* reported from the base of the Florida Escarpment (Hecker, 1985). The sparse densities suggest either a marginal population of a species more abundant elsewhere, or a species particularly adapted to marginal concentrations of nutrients.

The photo-transect on which the vesicomyid clams were found was 1520 m long; clams were seen on two segments of the transect which were respectively 140 and 95 m long. The two aggregations had respective densities of 2.23 (s.e. 0.67) and 2.71 (s.e. 2.27) clams per m^2. From repeated observations of distinctive, furrowed trails in the sediment, we concluded that these clams actively burrowed across the sea-floor. Live clams were consistently seen amid a scatter of dead shells, the mean ratio of live clams to dead clams (shell halves/2) was 1:3 and 1:5, respectively, in the two aggregations. These vesicomyid aggregations were apparently greater in width and more temporarily stable than vesicomyid aggregations at hydrothermal vents (Hessler et al., 1985).

For a given aggregation, determination of changes in clam density over time can be tested using photo-transects similar to those described here. Sample size, that is the number of photographic frames monitored, will depend upon the magnitude of change one is interested in detecting and the degree of certainty with which the change is to be ascertained. Assuming that all aggregation of vesicomyid clams being monitored are similar to those described above, the sampling effort required to detect a unit change in density of clams per m^2 can be plotted as a power curve. Figure 2 shows the number of change in density of up to 1 clam per m^2. It can be seen that a change of 0.5 clams per m^2, or ~20% of persent densities, could be detected with 95% certainty by repeating an 800 frame transect.

Literature Cited

Corliss, J.B., J. Dymond, L.I. Gordon, J.M. Edmond, R.P. von Herzen, R.D. Ballard, K. Green, D. Williams, A. Bainbridge, K. Crane, T.H. van Andel. 1979. Submarine thermal springs on the Galapagos Rift. Science, 203(4385), pp. 1073-1083.

Hecker, B. 1985. Fauna from a cold sulfur-seep in the Gulf of Mexico: comparisons with hydrothermal vent communities and evolutionary implications. Biol. Soc. Wash., No. 6, pp. 465-473.

Hessler, R.R., W.M. Smithy and C. H. Keller. 1985. Spatial and temporal variation of giant clams, tube worms and mussels at deep-sea hydro thermal vents. Biol. Soc. Wash. Bull. No. 6, pp. 411-428.

Paull, C.K., B. Hecker, R. Commeau, R.P. Freeman-Lynde, C. Neumann, W.P. Corso, S. Golubic, J.E. Hook, E. Sikes, and J. Curray. 1984. Biological communities at the Flordia Escarpment resemble hydrothermal vent taxa. Science. Vol. 226, pp. 965-967.

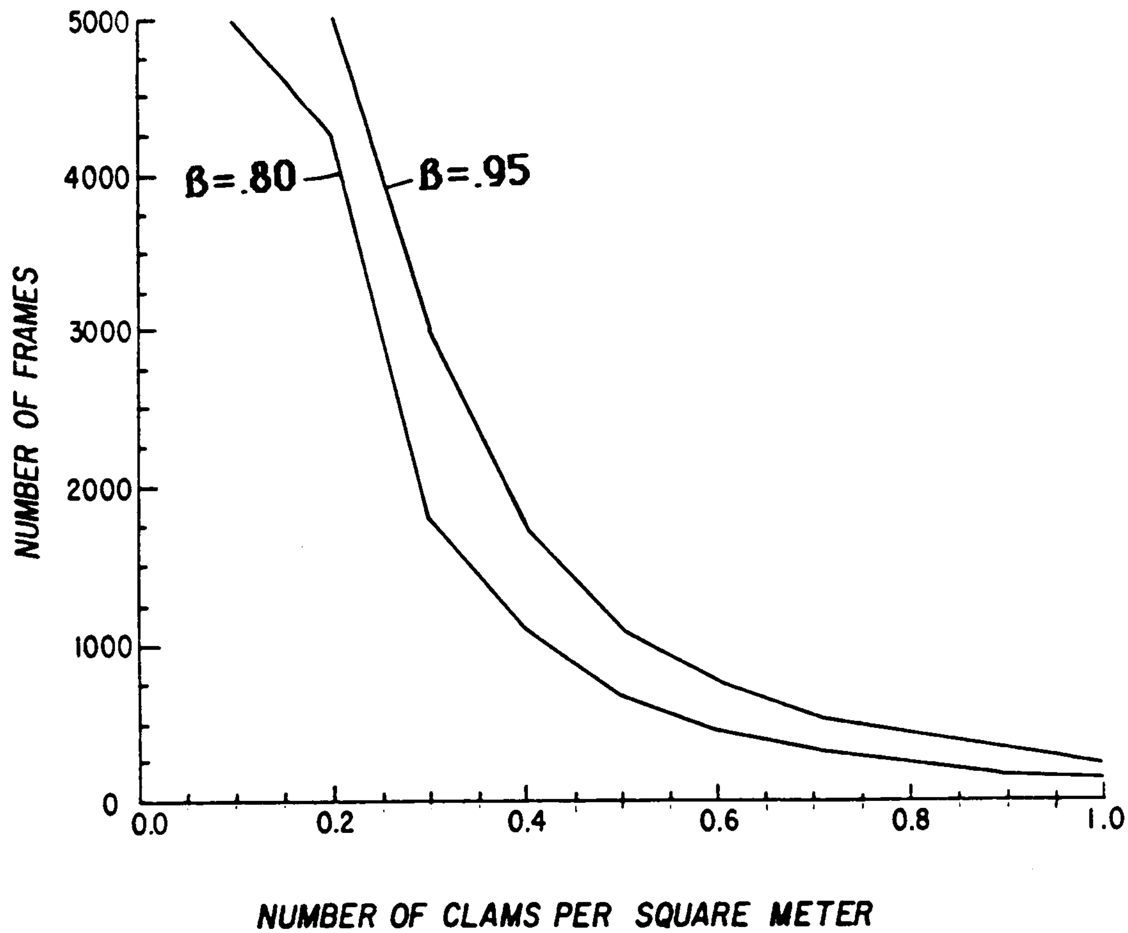


Figure 2. Power curve showing the number of frames required to detect a unit change in density of clams per m^2 within an aggregate.

<u>ABSTRACT</u>

GULF OF MEXICO
PHYSICAL OCEANOGRAPHY PROGRAM

MINERALS MANAGEMENT SERVICE
TERNARY MEETING

MARCH 18, 1986

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

Abstract

In October 1982, The Minerals Management Service initiated a multi-year, physical oceanographic field study of the Gulf of Mexico 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 three complete years of observations in the eastern Gulf (Program Years 1, 2, and 4). The first two years of data has been summarized in a Progress Report submitted to the MMS in March 1986. At the completion of ongoing analysis of the third year of data, an addendum to the Year 1 and 2 Final Report will be submitted.

Program Year 3, which is ongoing at this time, concentrates on measurements that relate to the western and central Gulf. Specifically, the Yr. 3 objective is to document characteristics and circulation patterns associated with Loop Current eddies as they translate westward and eventually interact with the slope in the western Gulf. Much of the field work on this program has recently been completed and the analysis is beginning. To date, all program objectives are being fulfilled. An eddy has been tracked using imagery and drifting buoys as it moved directly into the subsurface current arrays. In addition, several aerial or ship-based surveys have been successfully completed (See discussion below). Analysis of these data sets will contribute substantially to an understanding of eddy dynamics and kinematics under the design conditions. there is concern is for the moorings presently in the water. These instruments contain all the current data taken while the eddy has been influencing the mooring arrays. We are discussing with MMS the advisability of an early retrieval or a supplemental rotation to help decrease the probability of instrument and hence data loss.

A summary of data return for eastern Gulf currents is shown in Figure 1. Shelf and shelf-break currents have been well documented for three years. Similarly, the circulation patterns associated with the Loop Current and the region below the Loop Current have been measured extensively. Other aspects of the three years of eastern Gulf measurements have been described in program reports and at prior Ternary Meetings.

The three years of measurments allow a preliminary comparison of model simulations with field measurements. Toward this end, JAYCOR, the numerical modeling contractor, has created time series of currents which are roughly comparable to the MMS funded observations. Because of the present capability of the two-layer model being used, only an upper- and lower-layer, vertically integrated velocity could be simulated for each of the mooring sites. This model-observation comparison is not complete, however, two things are apparent:

- Lower-layer velocities produced by the model are probably under estimates.
- The absence of an interface-bottom intersection results in over estimates of shelf currents.

Adjusting for these two factors would quite likely improve agreement between the model and field data..

Of additional interest is the occurance of northward or upcoast directed currents on the slope and under the Loop Current. What is observed may be contrary to an intuitive conception of circulation patterns. This is illustrated in Table 1 which shows that over long intervals currents measured by Mooring A had a northward directed component approximately 50% or more of the time. A similar but slightly less pronounced pattern is seen in observations from Mooring G in 3275m of water. On Mooring A, below the top instrument the mean current is directed upcoast at

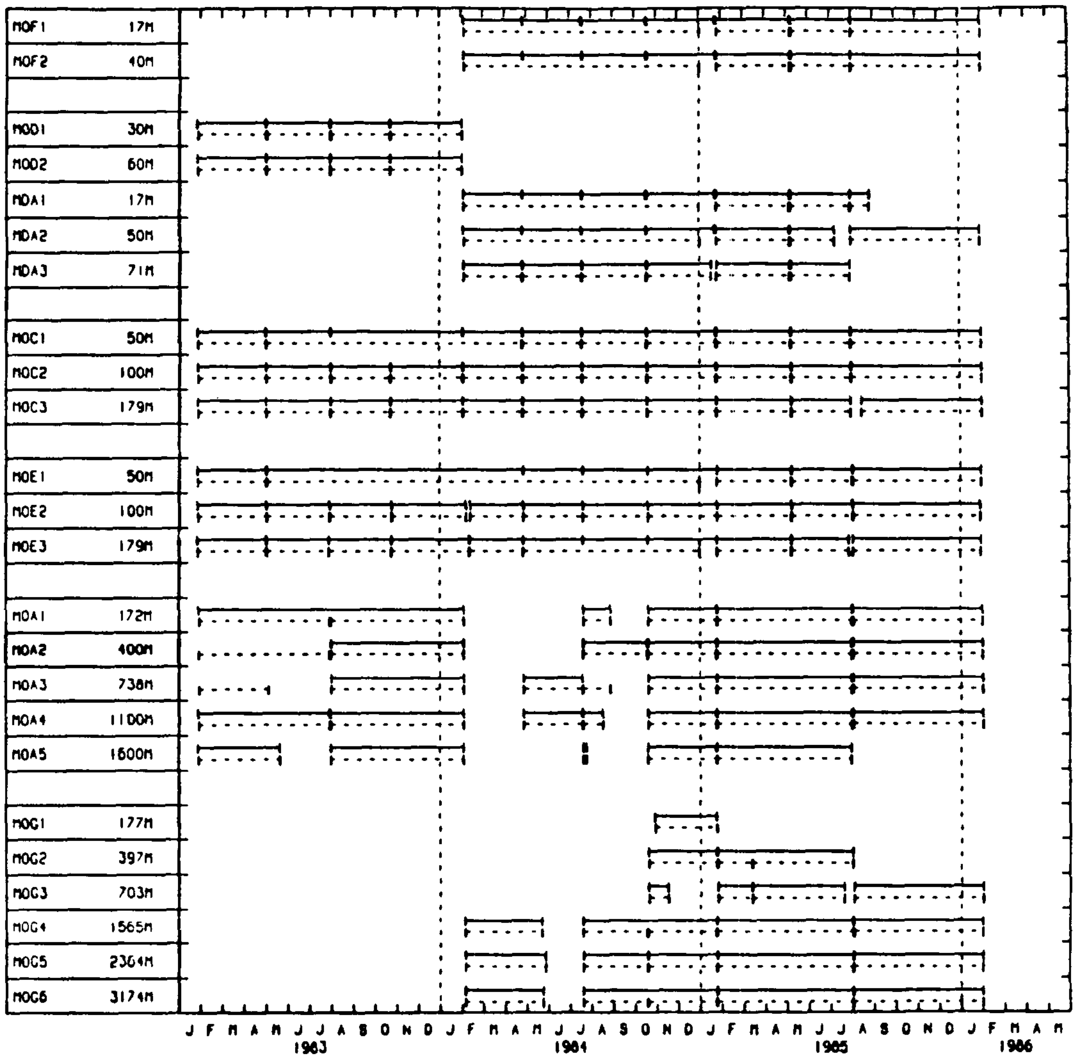


Figure 1. Time lines for subsurface currents measured in the eastern Gulf during three years of the Gulf of Mexico, Physical Oceanography Program. Note that Mooring D configuration was altered after the first year and replaced with Mooring DA. Moorings F and G were initiated at the beginning of the second measurement year.

STATION ID	DEPTH(m)	PTS./DAYS	% to NORTH
A1	172	3300 / 824	47%
A2	400	1849 / 462	58%
A3	738	1847 / 461	73%
A4	1100	3298 / 824	62%
A5	1600	1107 / 277	71%
(1700 m)			
G1	177	318 / 80	41%
G2	397	353 / 88	44%
G3	703	919 / 230	30%
G4	1565	2210 / 552	48%
G5	2364	2210 / 552	45%
G6	3174	2210 / 552	46%
(3275 m)			

Table 1. Preliminary statistics of upcoast (approx. northward) directed currents on Moorings A and G. Observations used in these computations were generally from time series segments which were unbroken for more than 4 months. This included most observations. For moorings and depths that had abundant data some isolated segments were not used. When computing final statistics all appropriate data will be used; however, these results will not change appreciably.

magnitudes comparable to the down-coast velocities at 180 m. It is relevant to remember that the relatively narrow, high-velocity core of the Loop Current is diminished on the order of 50% at 200-250m depth. Therefore, a substantial down-coast transport probably occurred above the upper instruments.

With cooperation among MMS, the Mexican Navy, TAMU and SAIC, a major western Gulf hydrographic cruise was successfully completed in January 1986 using the research vessel *B/O ALTAIR*. The goal of the measurment scheme was to document a major Loop Current eddy as it interacted with the adjacent shelf. The cruise track, station locations and station types are shown in Figure 2. Shown in Figure 3 is a preliminary drawing of the depth of the 8°C isotherm. The cruise data is being integrated and evaluated at this time. It is clear that the cruise not only documented the feature of interest, but also clearly showed that the eddy and associated cyclonic feature to the north bracket the subsurface moorings. In addition, two MMS buoys were and are circulating in this Loop Current, anti-cyclonic eddy (Figures 4 and 5).

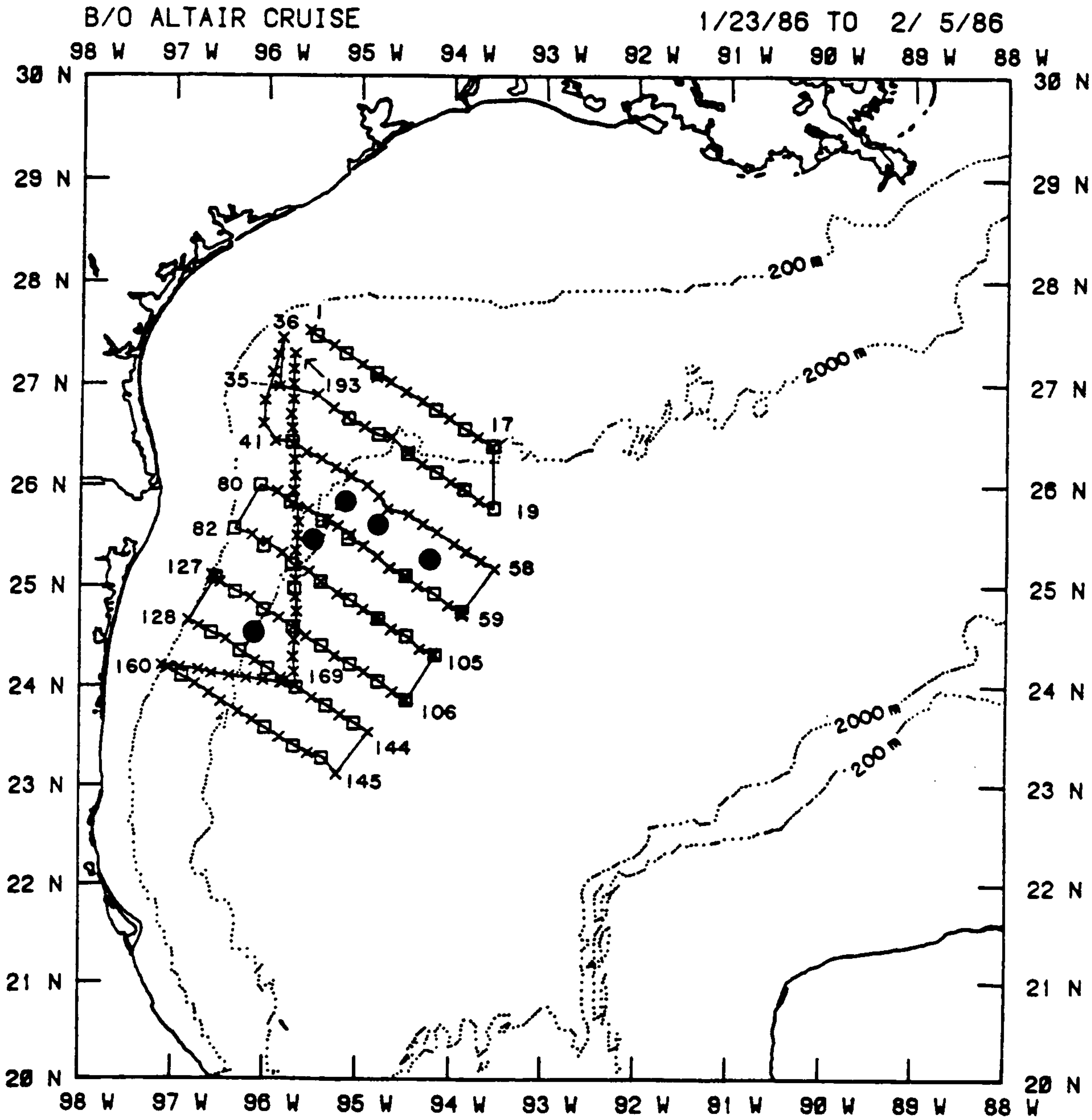


Figure 2. Cruise track of the *B/O ALTAIR* and the location of all CTD and XBT stations occupied during the 23 January - 6 February 1986 hydrographic cruise.

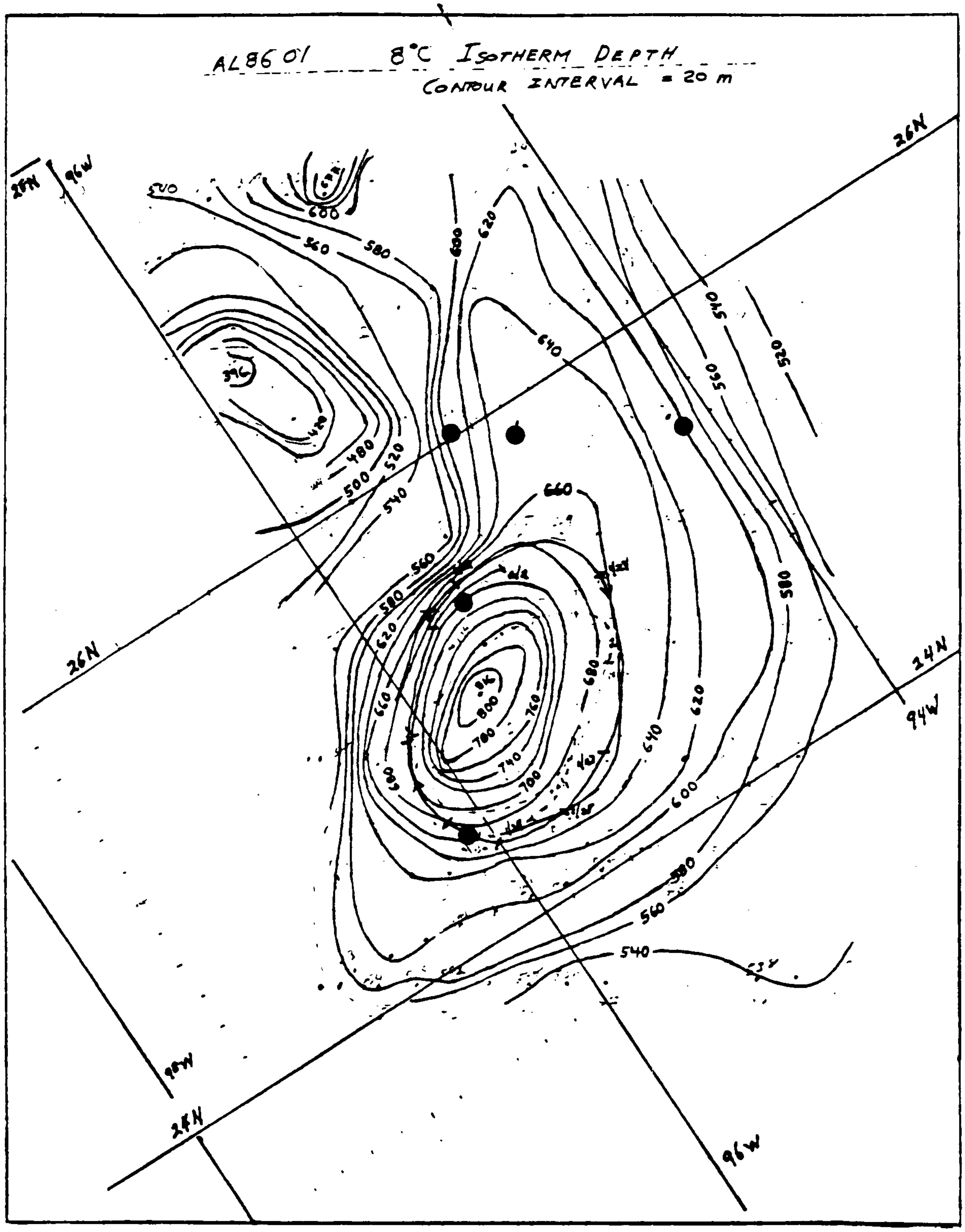


Figure 3. A preliminary drawing of the depth of the 8°C isotherm as measured during the Jan.-Feb. hydrographic survey. In subsequent analysis, computer contoured plots will be created.

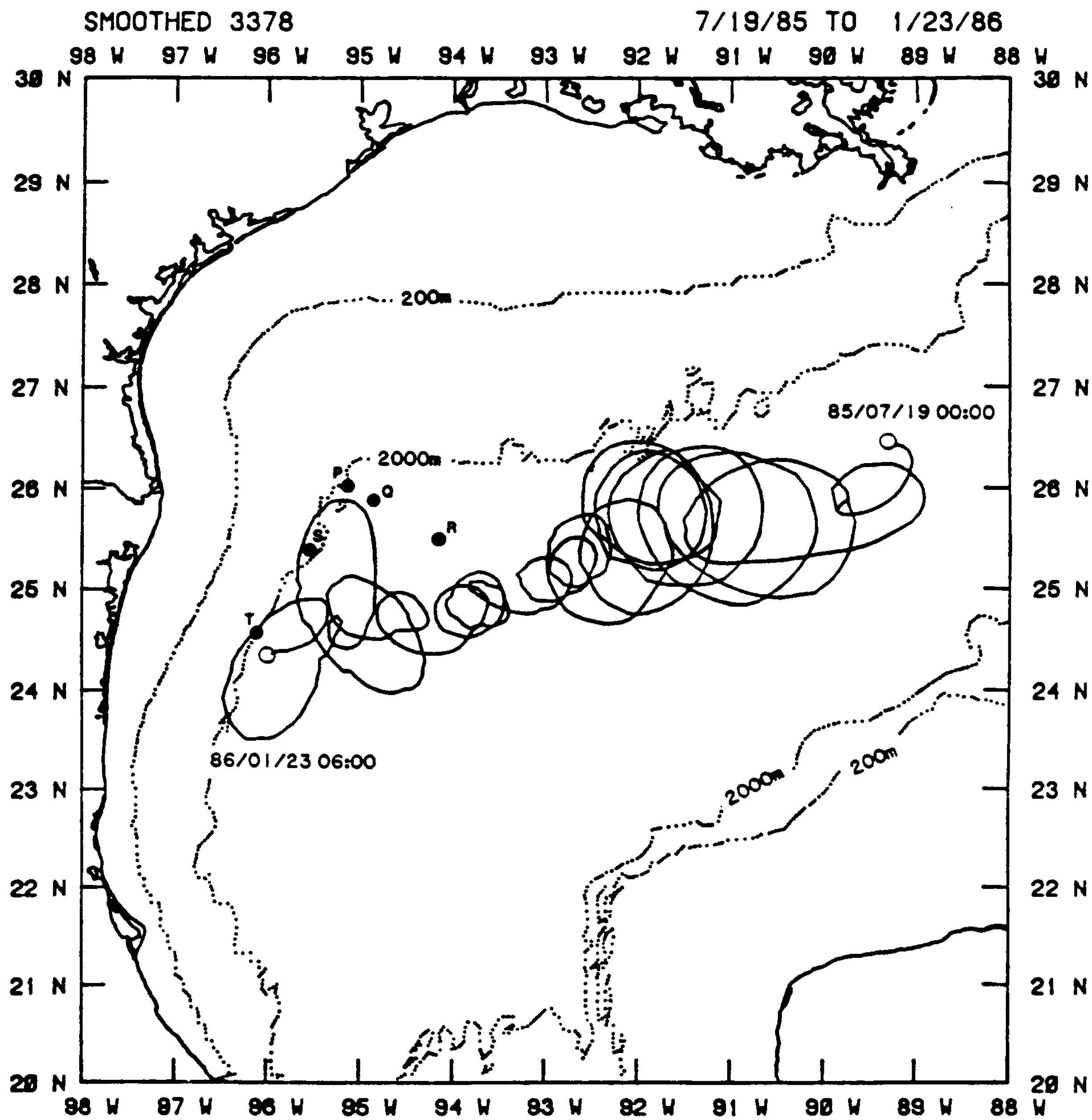


Figure 4. Trajectory of ARGOS Drifter No. 3378 from the time of its deployment on 18 July 1985 through 23 January 1986, the start date of the hydrographic cruise.

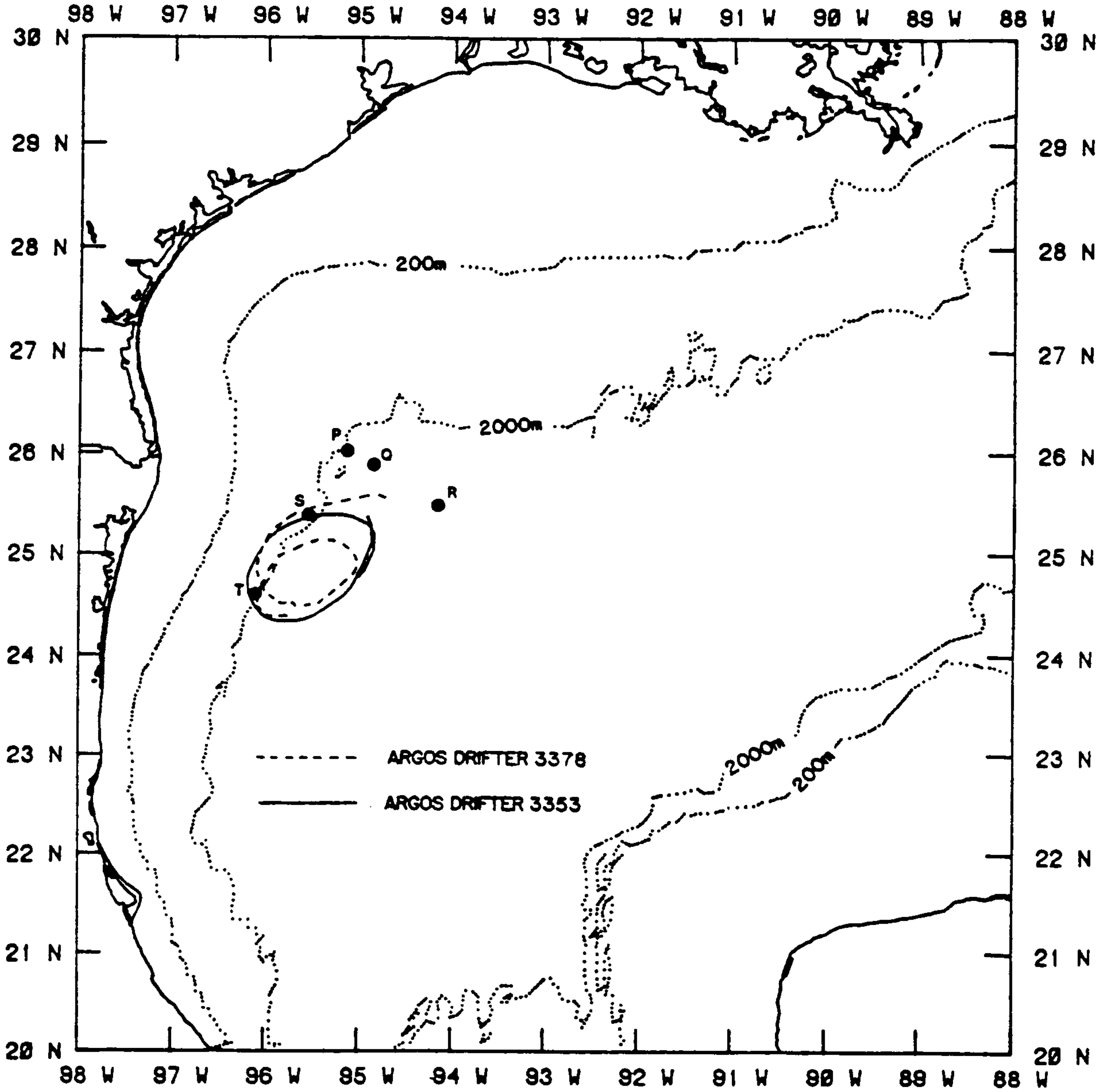


Figure 5. Trajectories of ARGOS Drifters No. 3378 and 3353 during the hydrographic cruise.

GULF OF MEXICO CIRCULATION MODELING STUDY

ALAN J. WALLCRAFT

JAYCOR

WINTER TERNARY STUDIES MEETING

March 1986

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 is 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. Horizontal grid resolution is 0.2 degrees (20 by 22 km), with a upper layer rest depth of 200 m. The model is driven by inflow through the Yucatan Strait compensated by outflow through the Florida Strait, and/or by winds.

PROBLEMS WITH THE EXISTING 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:

- Early delivery of a Gulf simulation without wind forcing. Wind data set based on FNOC's 12 hourly global surface pressure analysis (1966 - 1982), processing funded by NORDA. Gulf simulation surface current data set selected as the "best" available simulation to date (October 1984), will be forced by "FNOC" winds. Not all model experiments will be delivered. Gulf data set 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 successfull implementation is less certain than other phases of the program. However if successfull 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

YEAR 1

All tasks in year one are complete and a final report has been accepted by MMS. The final surface currents delivered to MMS consisted of 10.3 years sampled every three days on a 0.2 degree grid from Experiment 68. This experiment was forced by both (time invarient) inflow through the Yucatan Straits and by winds from the Navy Corrected Geostrophic Wind data set. Representitive surface current plots are shown in Figs 1 to 3.

YEAR 2

All tasks in year two are complete and a draft final report has been delivered to MMS. Two surface current data sets will be delivered to MMS, one with port forcing only and the other with both port and wind forcing.

Figures 1 to 4 show interface deviations by season for two experiments driven solely by wind stress, they have no Loop Current forcing. Experiment 31 was performed before the MMS contract was awarded; it is driven by a seasonal wind stress climatology by Elliott based on ship observations. Experiment 202/11.0 was performed recently; it is very similar to experiment 31 except it uses a monthly climatology from the Navy Corrected Geostrophic Wind data set. Both simulations exhibit an annual repeat cycle and give similar circulation patterns in most areas. Experiment 202/11.0 has stronger currents than the ship wind driven simulation. This is to be expected since ship winds often underestimate wind strengths. The major difference between the two simulations is in the winter and spring seasons in the south west Gulf. Experiment 31 exhibits strong upwelling but 202/11.0 shows relatively weaker downwelling at these times. This is consistent with the very different wind stress curls of the two wind sets in this region, but it is difficult to obtain independent data to judge which is more nearly correct. Wind forcing appears to be about as significant as Loop Current forcing in the western Gulf.

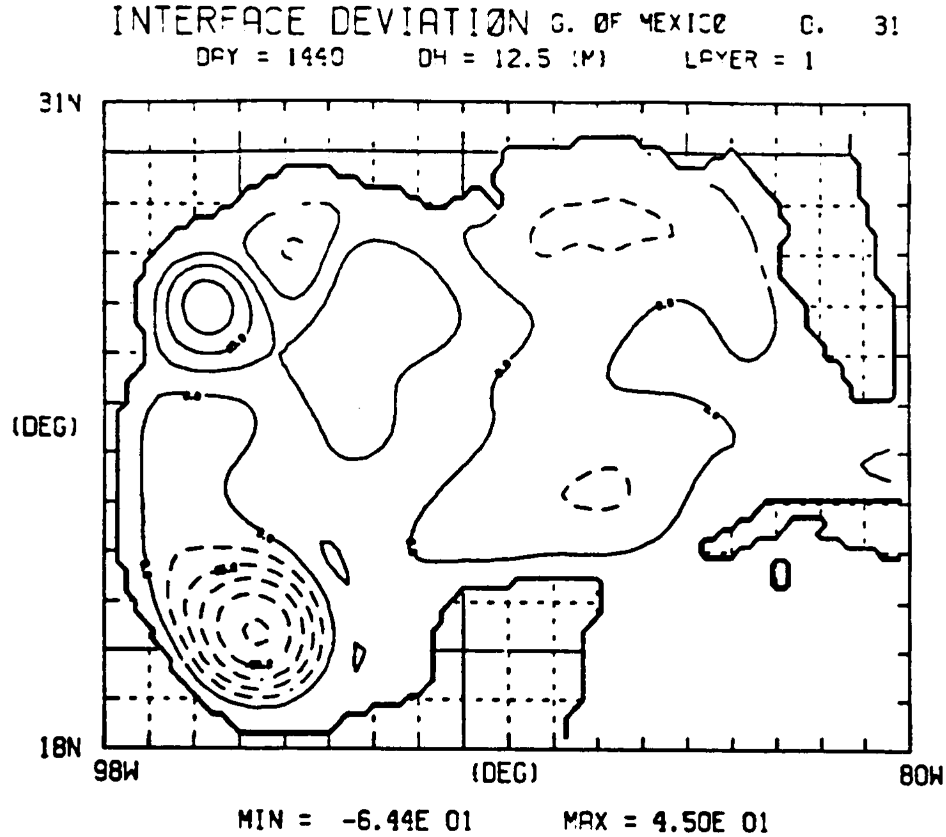
Figures 5 and 6 show upper and lower layer currents from Experiment 201/17.0, which is on a 0.1 degree grid and has Loop Current forcing only (no winds). In Figure 5 the Loop Current is about to shed a large eddy, and a Loop Current eddy that had shed about 300 days previously has split into two off the coast of Mexico. Figure 6 is 180 days later; the eddy has shed from the Loop Current and has migrated to the central Gulf, but is is preceeded by a second large eddy that has developed from the two halves of the Loop Current eddy shed more than 400 days previously.

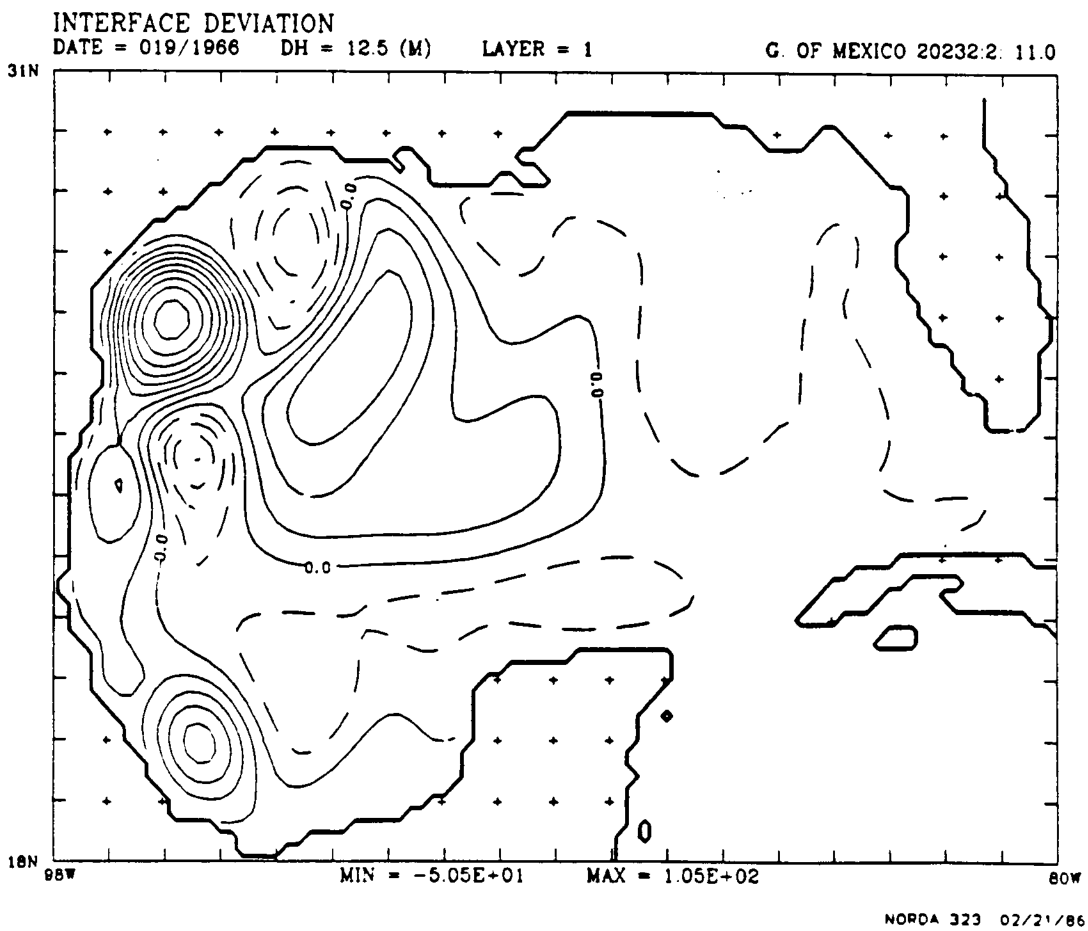
Figures 7, 8, and 9 show upper layer currents every 90 days for a full Loop Current eddy cycle from Experiment 201/16.0 (which will be delivered to MMS). This experiment has both Loop Current and wind forcing. The wind forcing consists of monthly averages every month from 1967 to 1978, in the figures the wind forcing is from 1969. However the use of actual winds does not imply that this is a prediction of the Gulf at that time, i.e. this is a simulation not a hindcast. Maximum upper layer current speeds are about 30% higher in the wind and Loop Current forced case (201/16.0) than in the Loop Current only case (201/17.0).

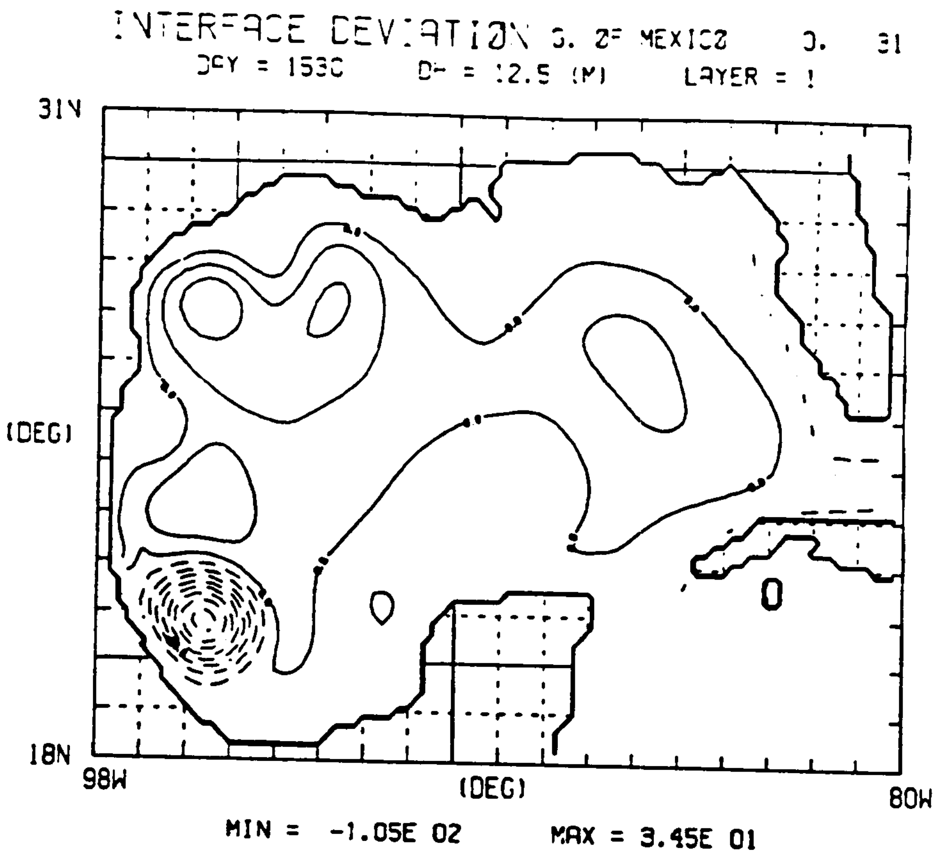
FIGURES 1 - 4: Instantaneous view of the interface deviation for the Winter, Spring, Summer and Fall respectively from two simulations driven solely by climatological winds.
(a) Experiment 31 driven by seasonal ship winds, and
(b) Experiment 202/13.0 driven by monthly winds from the Navy Corrected Geostrophic Winds data set. The contour interval is 12.5m, with solid contours representing downward deviations.

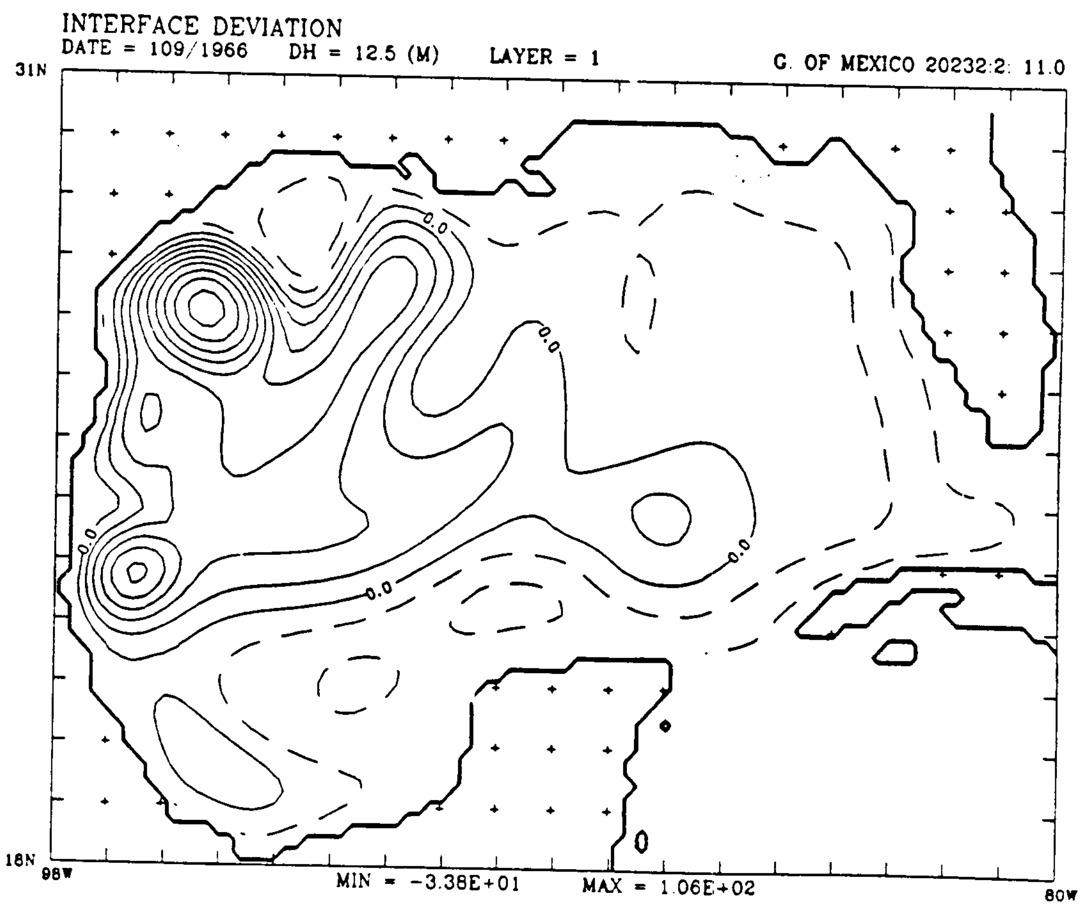
FIGURES 5 and 6: Instantaneous view of the (a) upper, and (b) lower, layer averaged velocities from Experiment 201/17.0 on model days 2340 and 2520 respectively. Since this experiment has no wind forcing the assigned dates (169/1966 and 349/1966) are arbitrary. Vectors are only plotted at every second model grid point, i.e. every 0.2 degrees, and all velocities greater than 50 cm/sec are plotted as 50 cm/sec.

FIGURES 7 - 9: Instantaneous view of the upper layer averaged velocities from Experiment 201/16.0 on model days 3240, 3330, 3420, 3510, 3600, and 3690. The assigned dates (339/1968 to 058/1970) indicate the applied wind forcing, but the experiment was not a hindcast and the ocean currents in the Gulf on that date might have been quite different from those shown. Vectors are only plotted at every second model grid point, i.e. every 0.2 degrees, and all velocities greater than 50 cm/sec are plotted as 50 cm/sec.

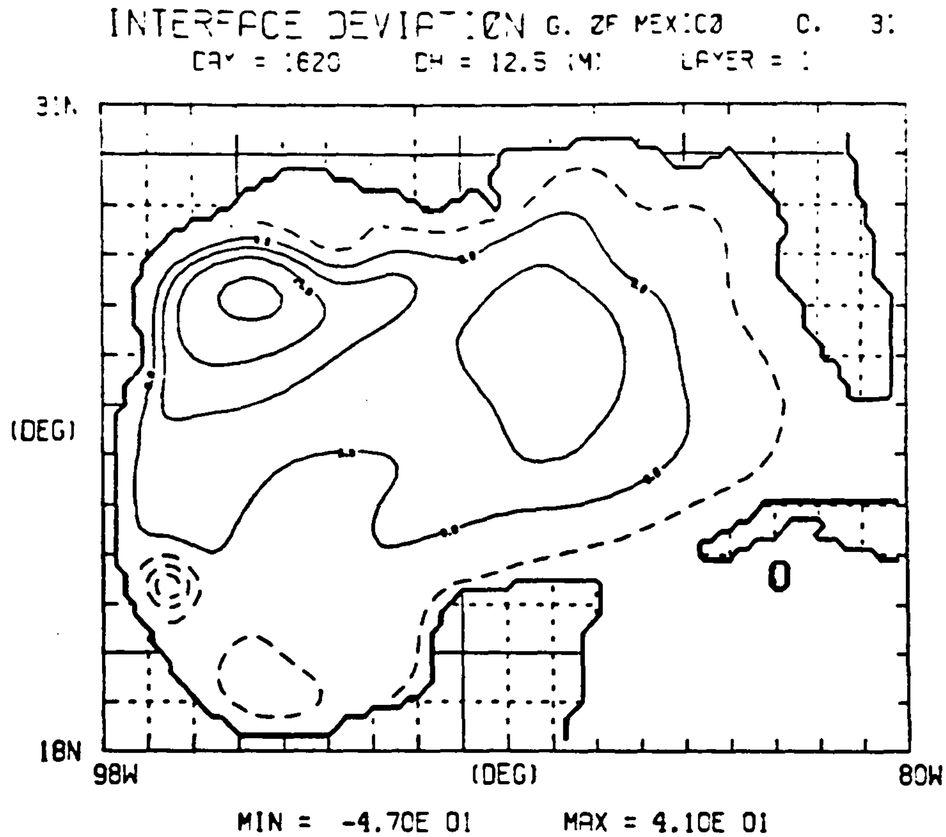

INTERFACE DEVIATION G. OF MEXICO C. 31
DAY = 1440 DH = 12.5 (M) LAYER = 1
31N
(DEG)
18N
98W
(DEG)
80W
MIN = -6.44E 01 MAX = 4.50E 01

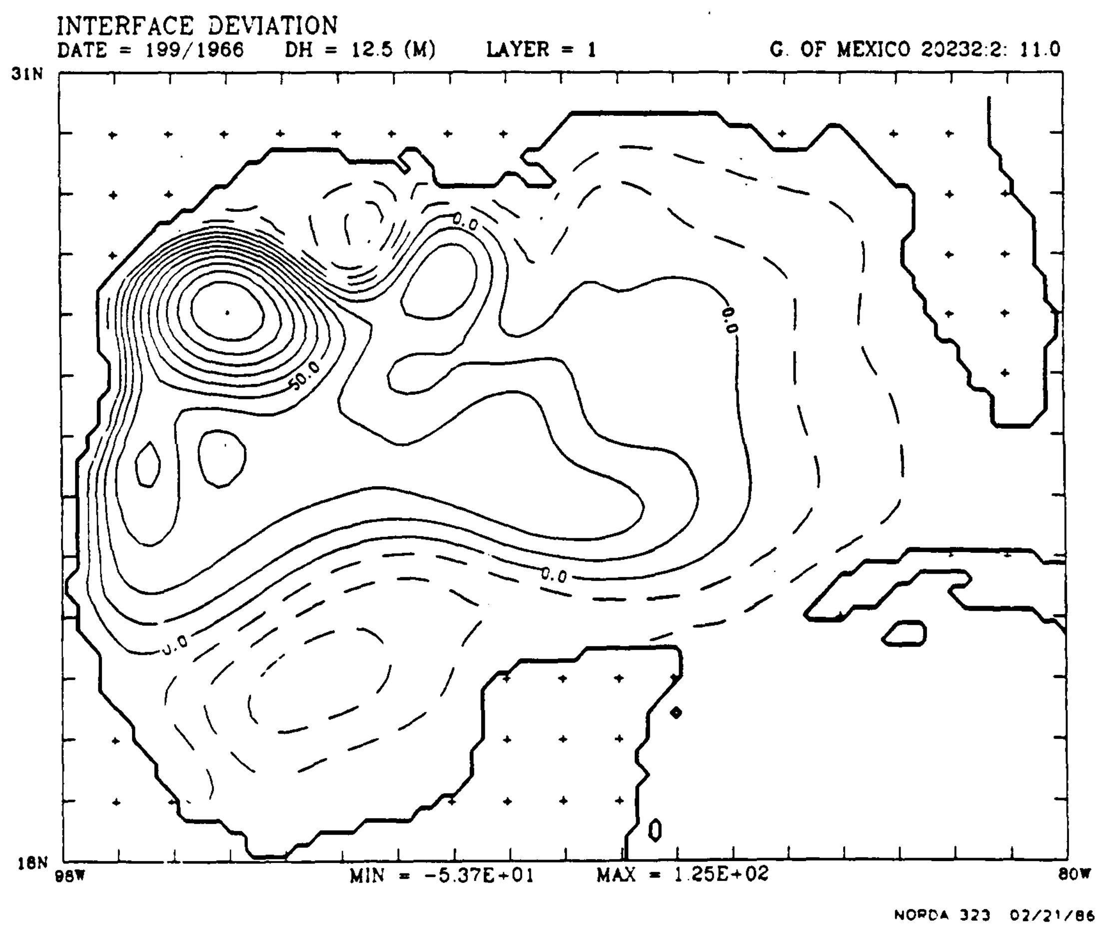

INTERFACE DEVIATION
DATE = 019/1966 DH = 12.5 (M) LAYER = 1
G. OF MEXICO 20232:2: 11.0
31N
18N
98W
80W
MIN = -5.05E+01 MAX = 1.05E+02
NORDA 323 02/21/86

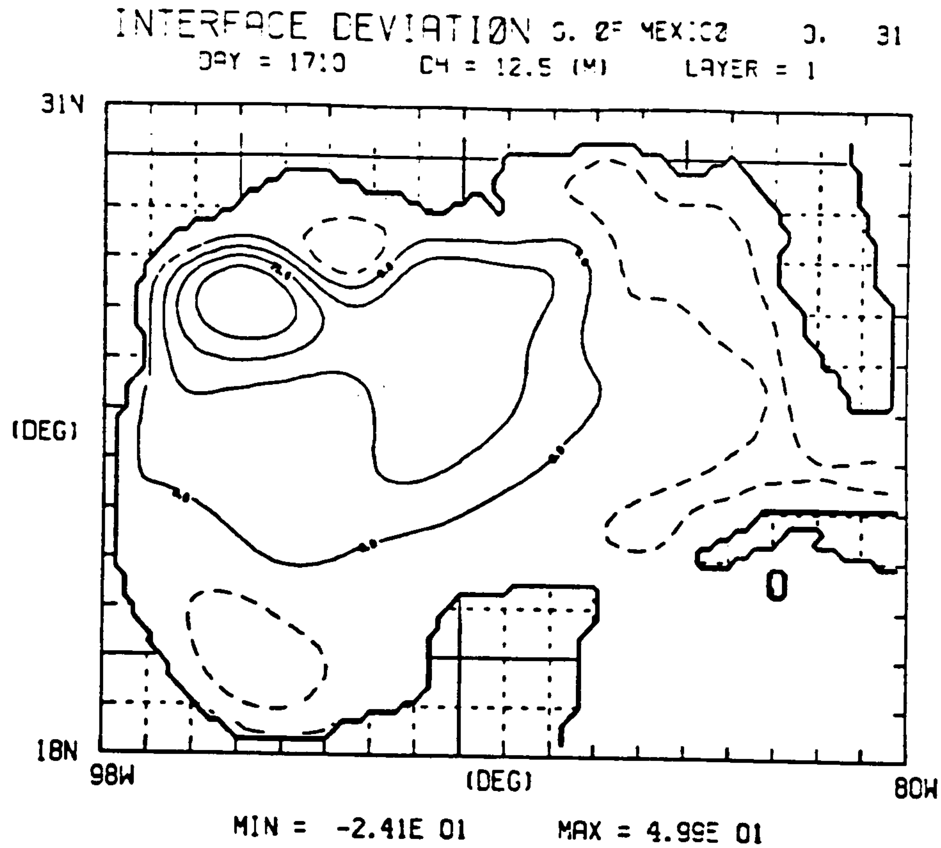


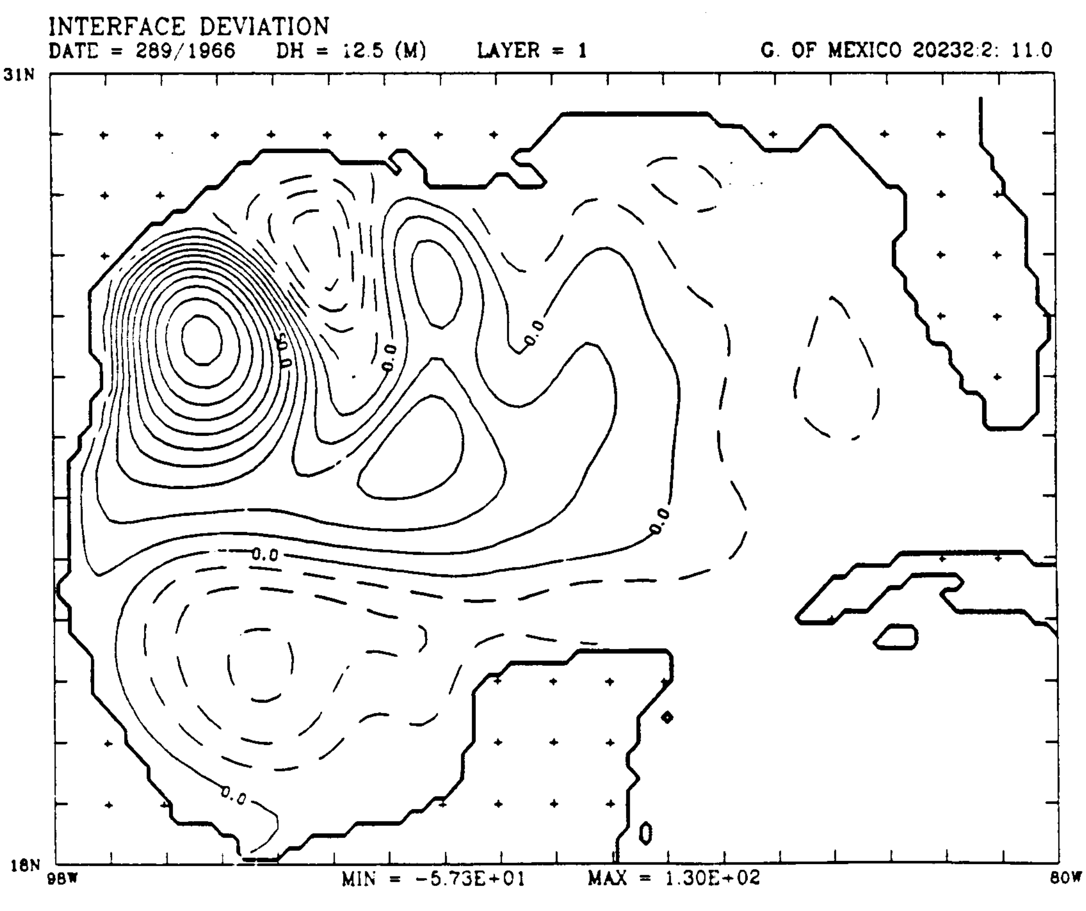


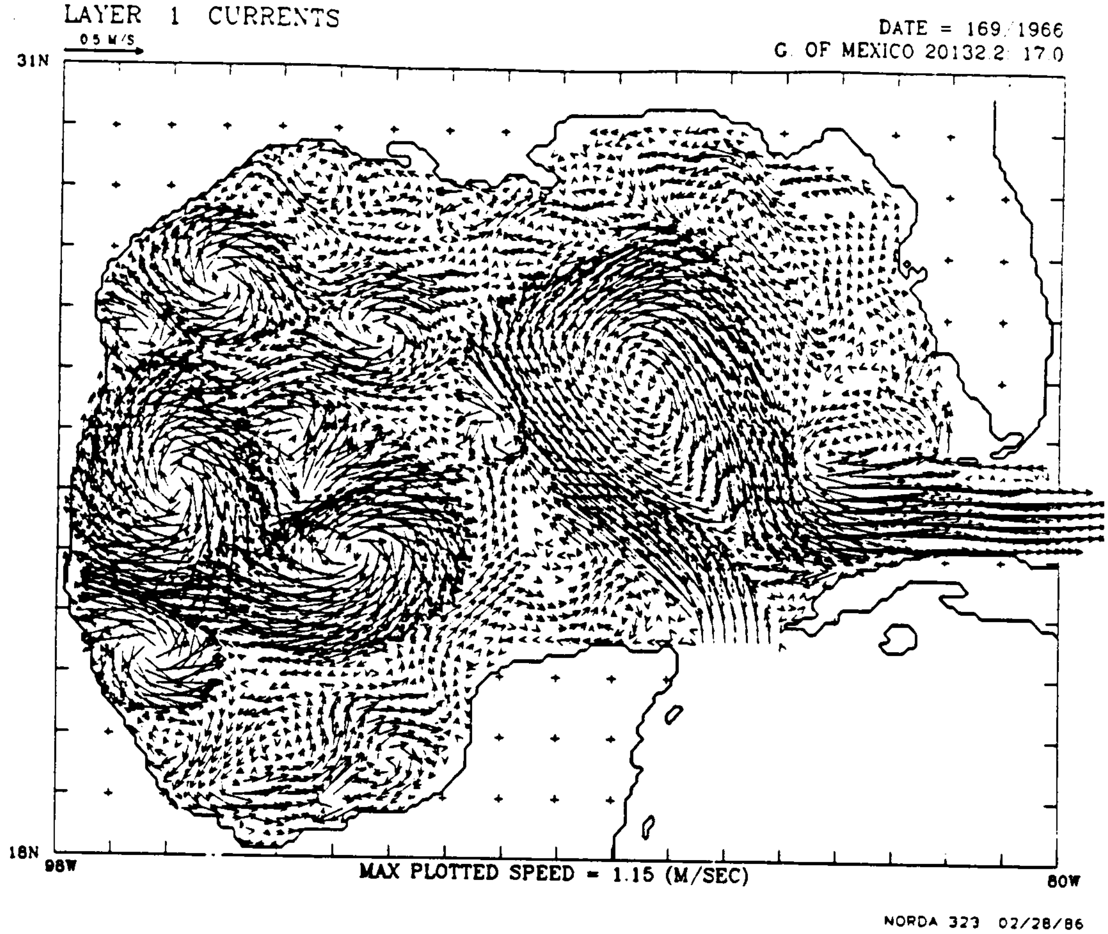
NORDA 323 02/21/86


INTERFACE DEVIATION G. OF MEXICO
DH = 12.5 (M)
18N
98W
(DEG)
80W
MIN = -4.70E 01 MAX = 4.10E 01

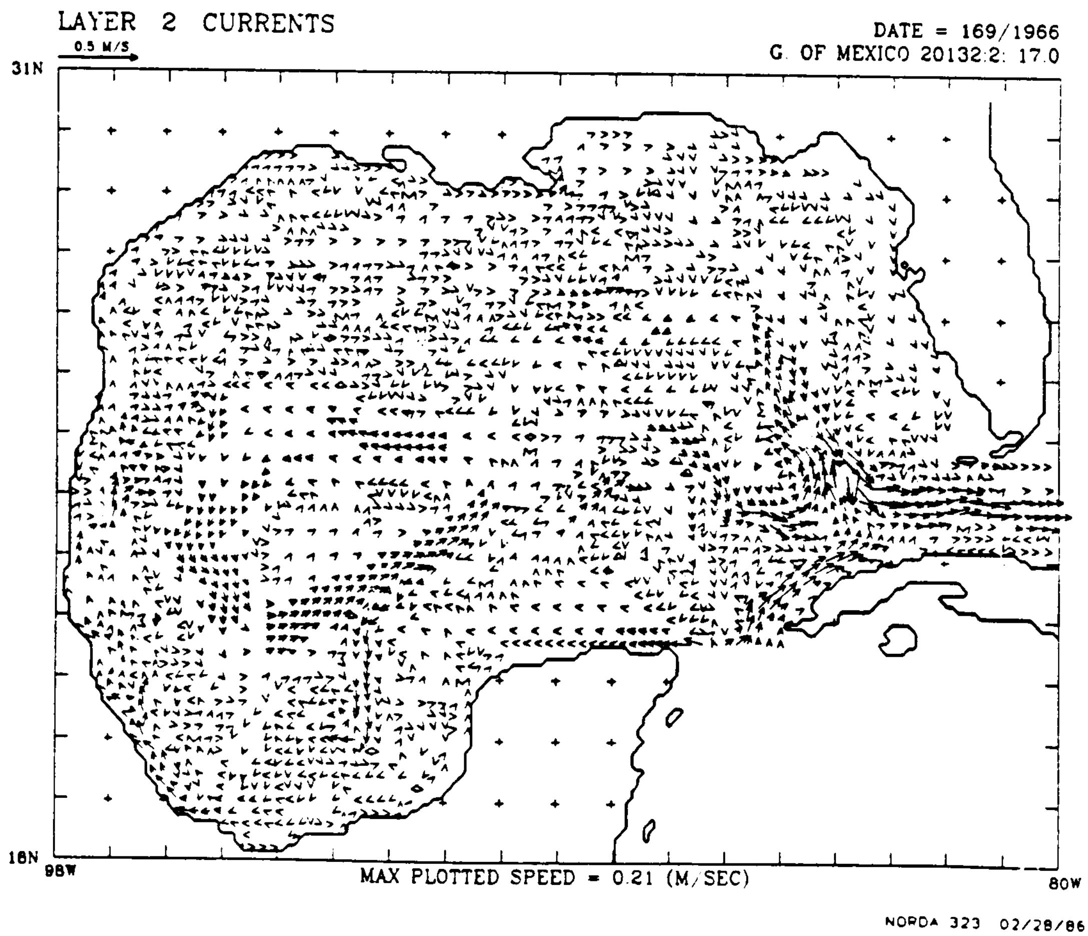

INTERFACE DEVIATION
DATE = 199/1966 DH = 12.5 (M) LAYER = 1
G. OF MEXICO 20232:2: 11.0
31N
18N
98W
MIN = -5.37E+01 MAX = 1.25E+02
80W
0.0
50.0
NORDA 323 02/21/86


INTERFACE DEVIATION G. OF MEXICO2 D. 31
DAY = 1710 DH = 12.5 (M) LAYER = 1
31N
(DEG)
18N
98W
(DEG)
80W
0
MIN = -2.41E 01 MAX = 4.99E 01

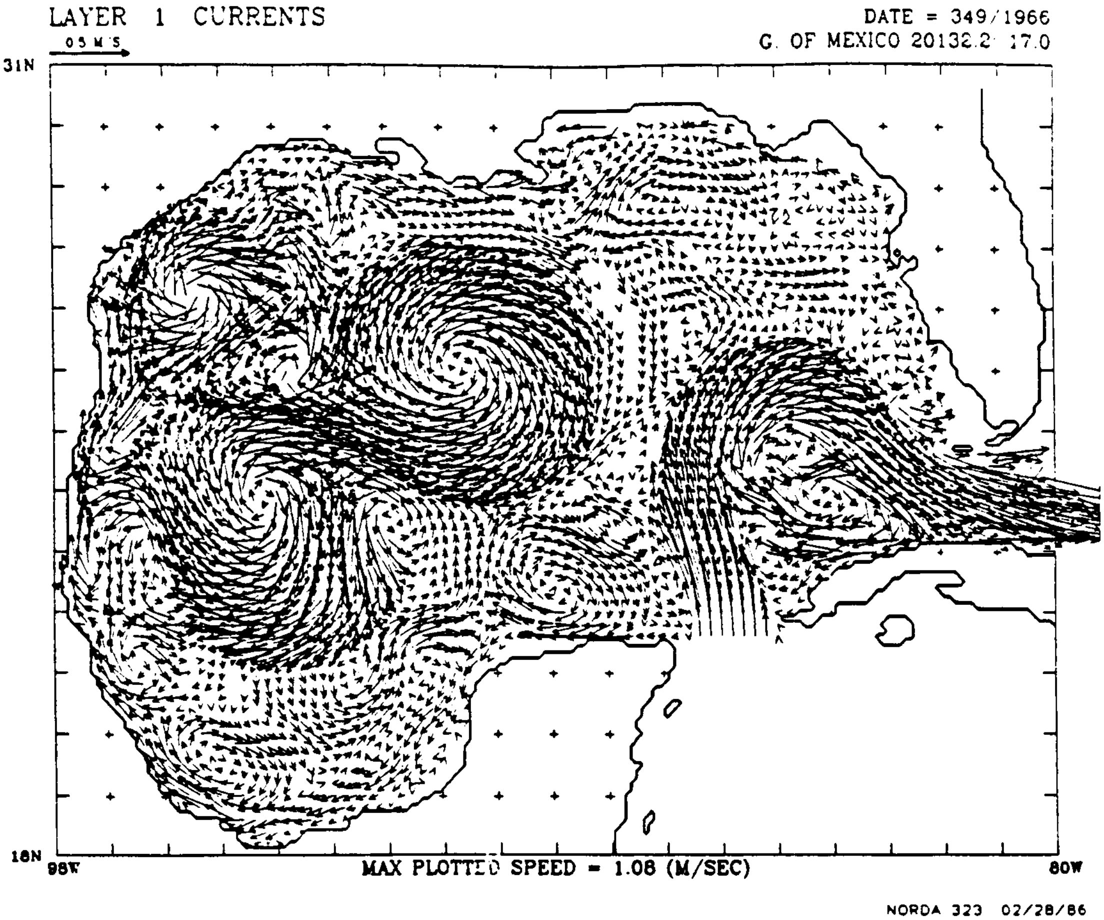

INTERFACE DEVIATION
DATE = 289/1966 DH = 12.5 (M) LAYER = 1 G. OF MEXICO 20232:2: 11.0
31N
18N
98W
80W
0.0
0
MIN = -5.73E+01 MAX = 1.30E+02
NORDA 323 02/21/86

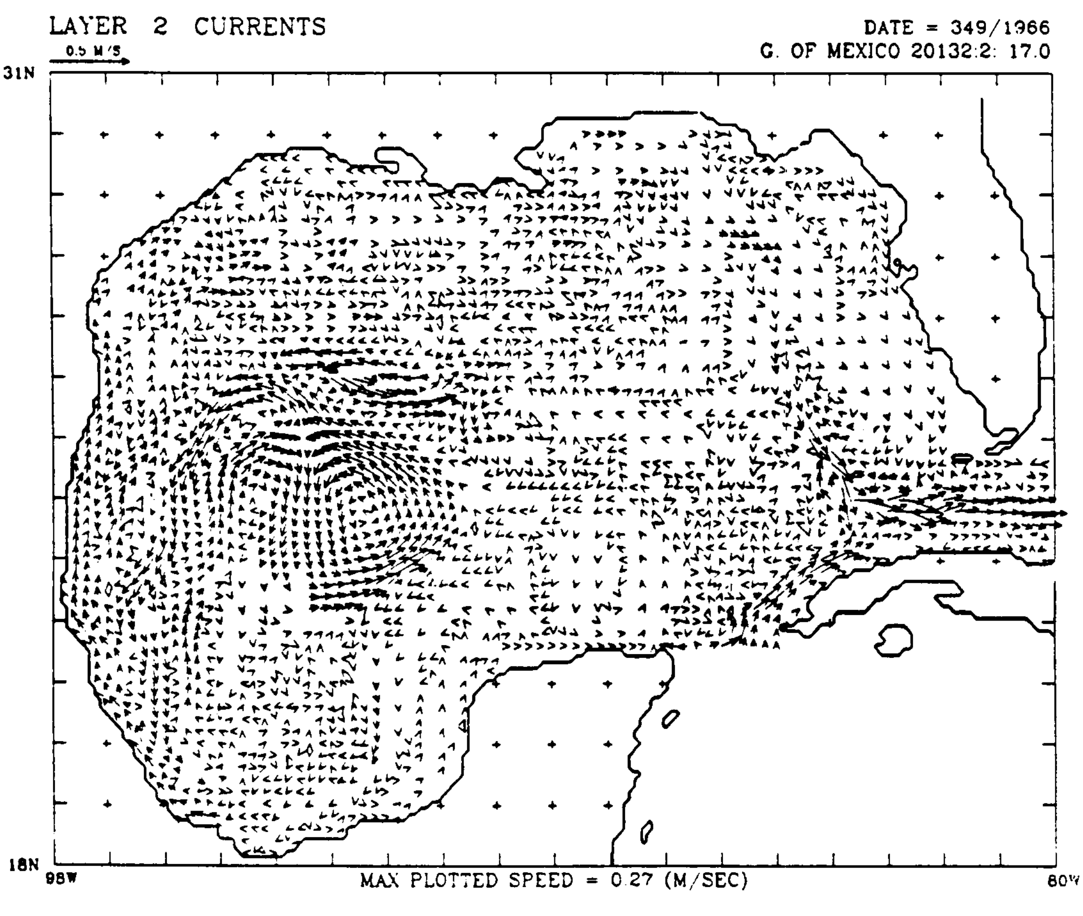


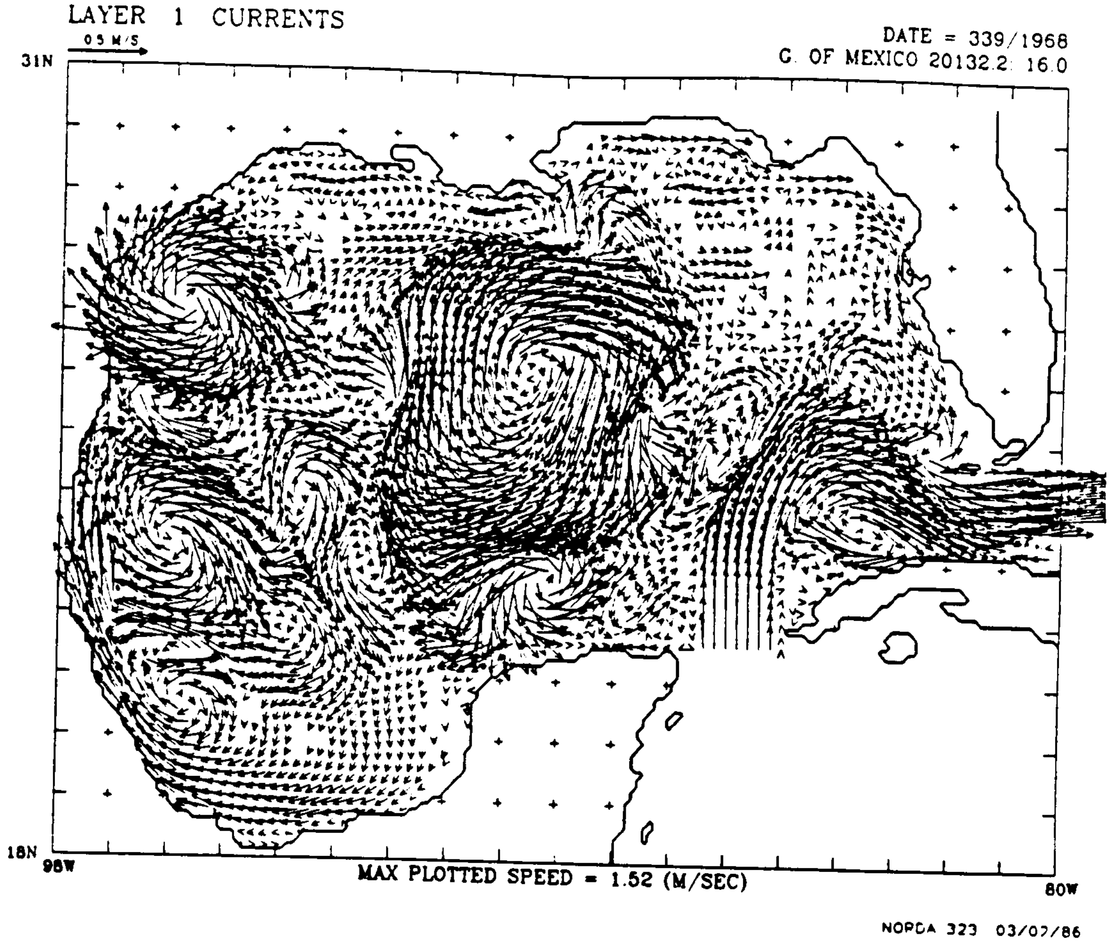
LAYER 1 CURRENTS
0.5 M/S
DATE = 169/1966
G. OF MEXICO 20132.2: 17.0
31N
18N
98W
80W
MAX PLOTTED SPEED = 1.15 (M/SEC)
NORDA 323 02/28/86

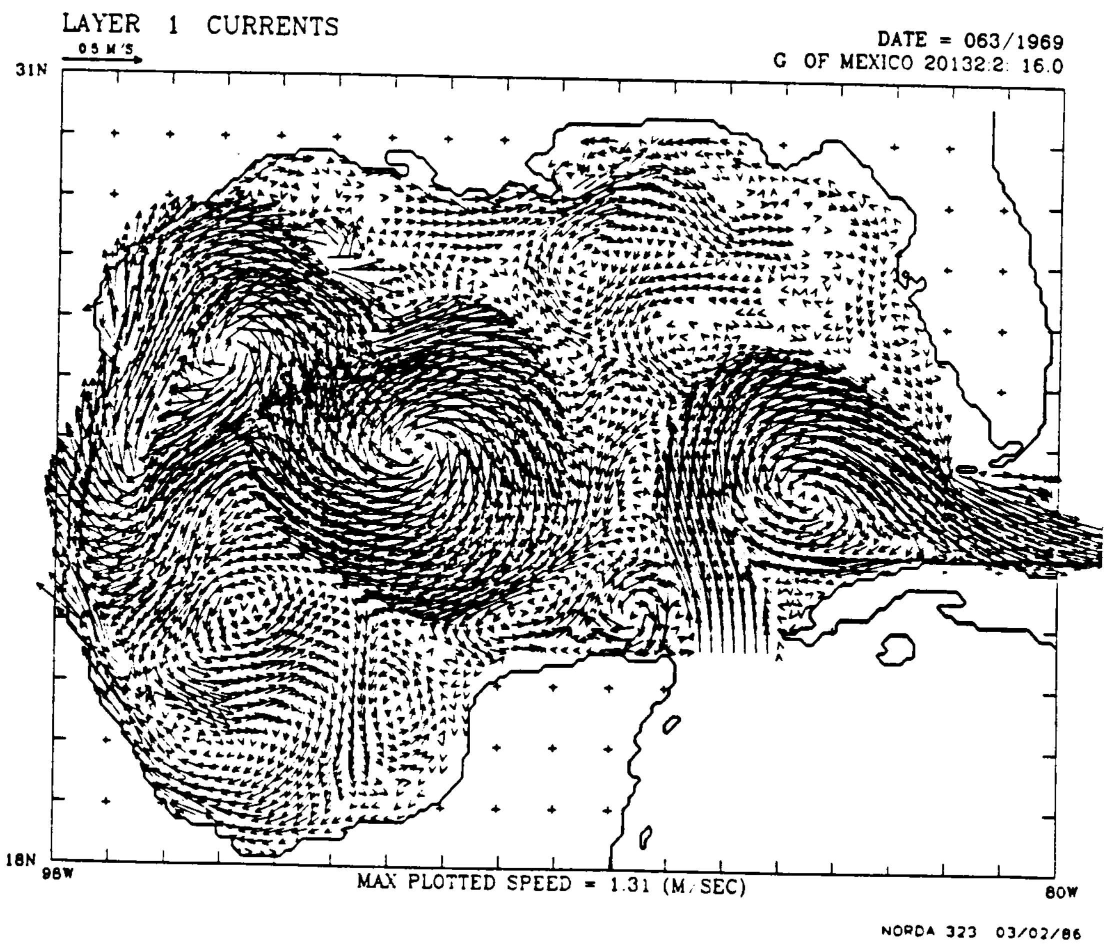


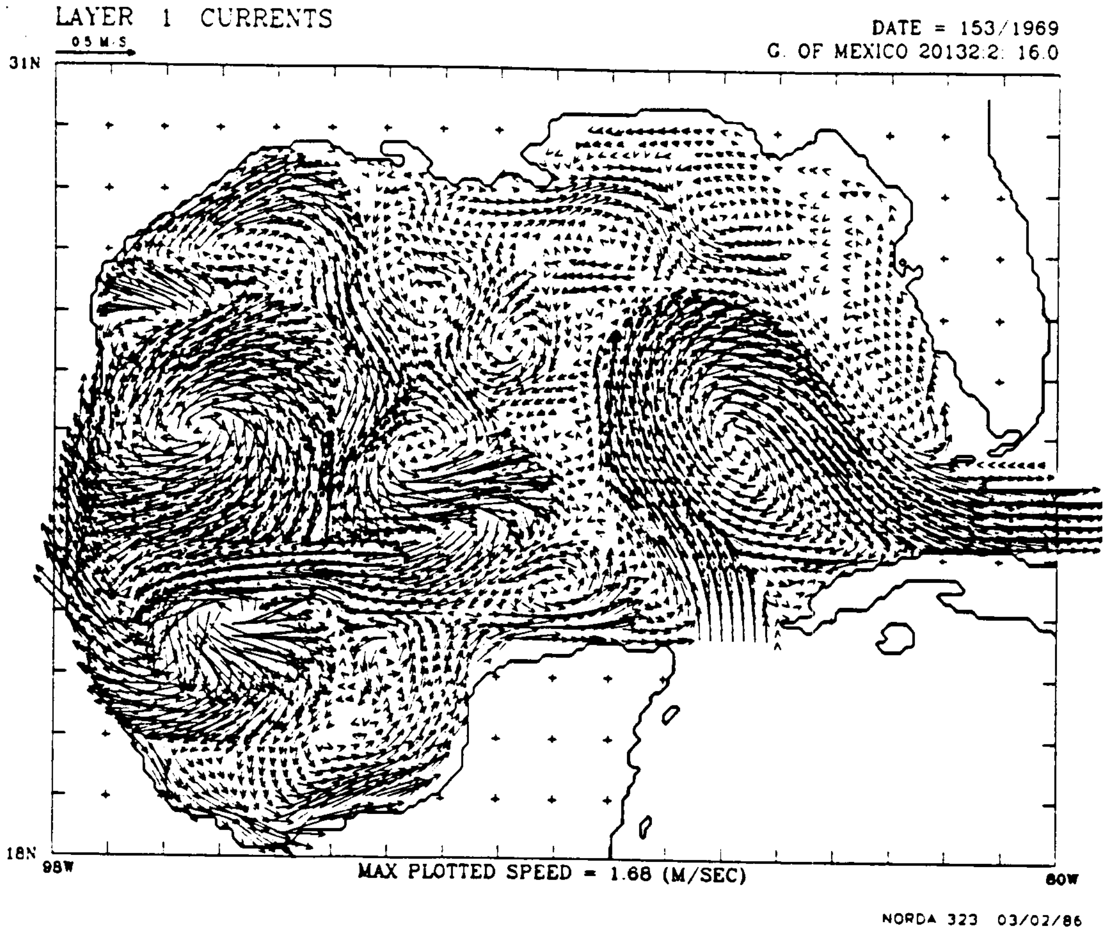
LAYER 2 CURRENTS
0.5 M/S
DATE = 169/1966
G. OF MEXICO 20132.2: 17.0
31N
18N
98W
80W
MAX PLOTTED SPEED = 0.21 (M/SEC)
NORDA 323 02/28/86

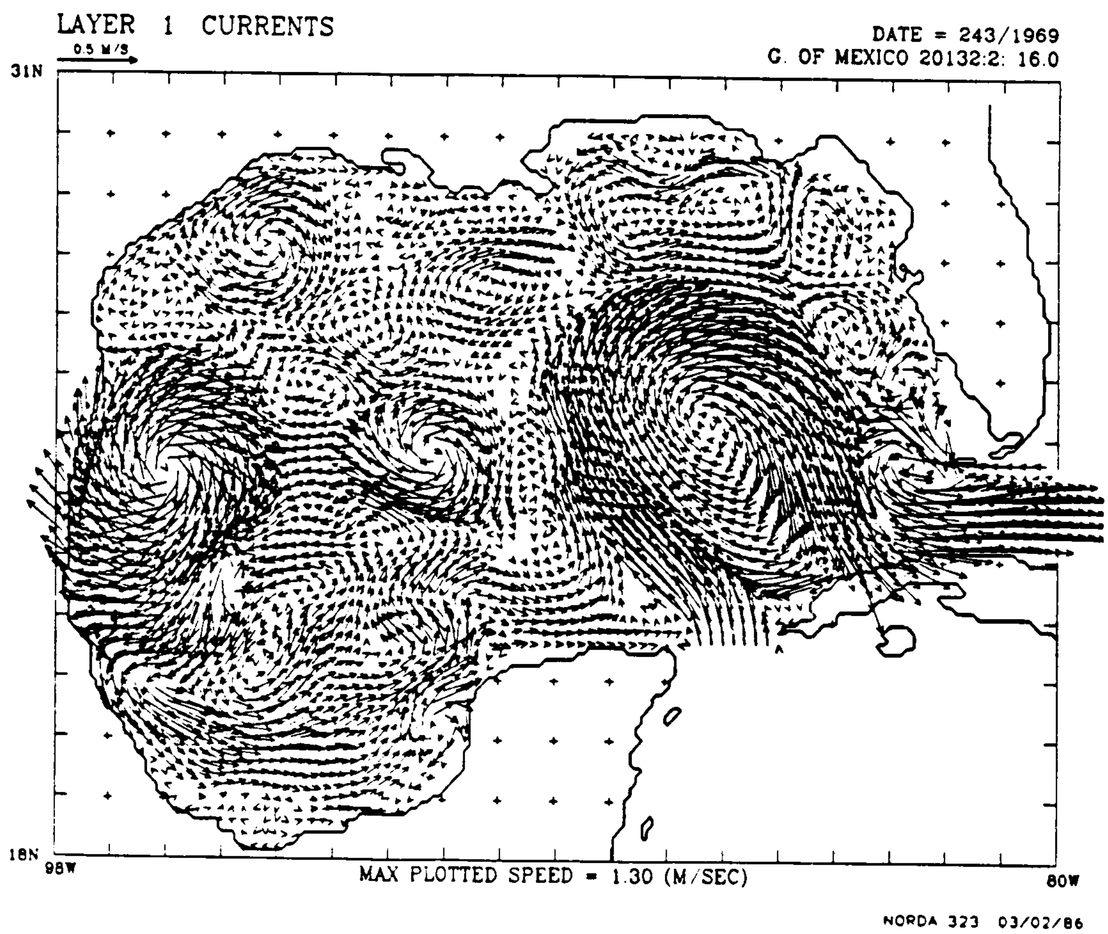

LAYER 1 CURRENTS
0.5 M/S
DATE = 349/1966
G. OF MEXICO 20132.2: 17.0
31N
18N
98W
MAX PLOTTED SPEED = 1.08 (M/SEC)
80W
NORDA 323 02/28/86

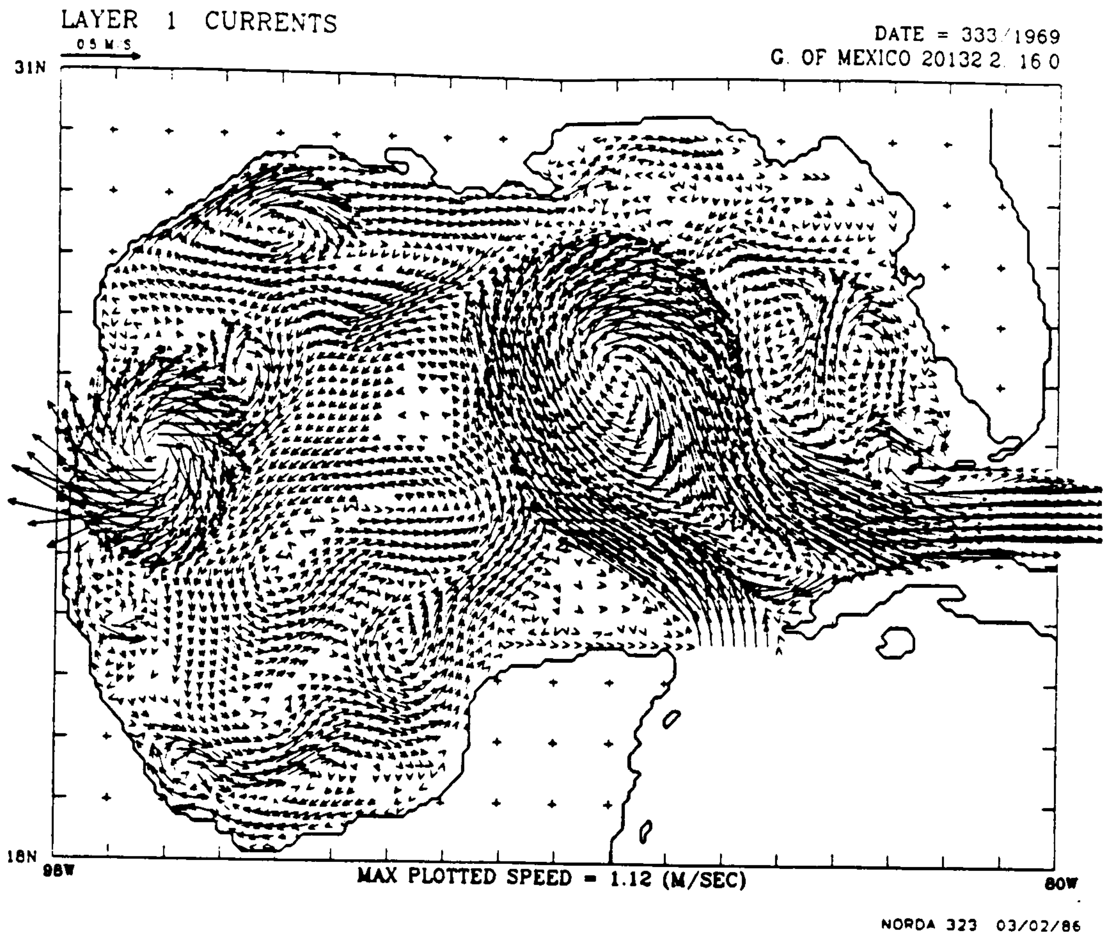

LAYER 2 CURRENTS
0.5 M/S
DATE = 349/1966
G. OF MEXICO 20132:2: 17.0
31N
18N
98W
MAX PLOTTED SPEED = 0.27 (M/SEC)
80W
NORDA 323 02/28/86


LAYER 1 CURRENTS
0.5 M/S
DATE = 339/1968
G. OF MEXICO 20132.2: 16.0
31N
18N
98W
80W
MAX PLOTTED SPEED = 1.52 (M/SEC)
NORDA 323 03/02/86

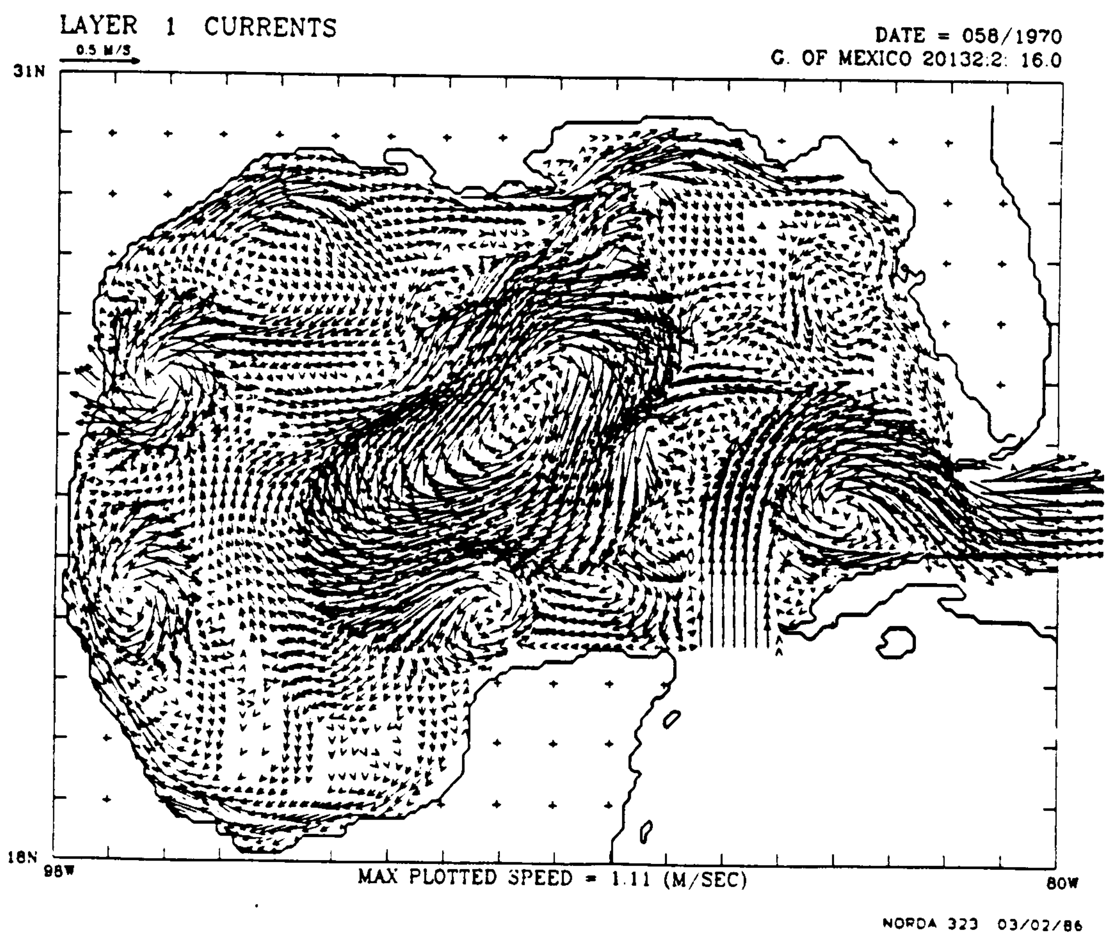

LAYER 1 CURRENTS
0.5 M/S
DATE = 063/1969
G. OF MEXICO 20132.2: 16.0
31N
18N
98W
80W
MAX PLOTTED SPEED = 1.31 (M/SEC)
NORDA 323 03/02/86


LAYER 1 CURRENTS
0.5 M/S
DATE = 153/1969
G. OF MEXICO 20132:2: 16.0
31N
18N
98W
80W
MAX PLOTTED SPEED = 1.68 (M/SEC)
NORDA 323 03/02/86


LAYER 1 CURRENTS
0.5 M/S
DATE = 243/1969
G. OF MEXICO 20132:2: 16.0
31N
18N
98W
80W
MAX PLOTTED SPEED = 1.30 (M/SEC)
NORDA 323 03/02/86



LAYER 1 CURRENTS
0.5 M/S
DATE = 333/1969
G. OF MEXICO 20132 2 16.0
31N
18N
98W
MAX PLOTTED SPEED = 1.12 (M/SEC)
80W
NORDA 323 03/02/86



LAYER 1 CURRENTS
0.5 M/S
DATE = 058/1970
G. OF MEXICO 20132:2: 16.0
31N
18N
98W
MAX PLOTTED SPEED = 1.11 (M/SEC)
80W
NORDA 323 03/02/86

SOUTHWEST FLORIDA SHELF BENTHIC COMMUNITIES STUDY--YEAR 5

Prepared by:

Larry J. Danek
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
Gainesville, FL

George S. Lewbel
LGL ECOLOGICAL RESEARCH ASSOCIATES, INC.
Bryan, TX

Prepared for:

MINERALS MANAGEMENT SERVICE
Environmental Studies Group
Gulf of Mexico Regional Office
Metairie, LA

MMS TERNARY MEETING
March 18, 1986
Metairie, LA

INTRODUCTION

The objective of the Southwest Florida Shelf Benthic Communities Study for Years 4 and 5 was 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. Integrate available literature with collected data;
7. Maintain quality assurance and quality control program; and
8. Define future work needs.

The Year 4 sampling was completed in August 1984 and the Draft Annual Report and subsequent Final Report were submitted in early 1985. The Year 5 field studies began in December 1984 and were essentially a continuation of the 2-year program begun the previous year. There were, however, several modifications to the program that included:

1. Addition of three instrumented arrays, one each at Stations 7, 44, and 55 (see Figure 1) making a total of 8 arrays;
2. Installation of time lapse cameras at all arrays except Station 36;
3. Installation of an additional wave and tide gauge at Station 55;
4. Deletion of sampling at soft bottom stations;
5. Deletion of dredge sampling at previous hard bottom stations;
6. Inclusion of a High Resolution Benthic Photography transect using a diver-held underwater video camera; and
7. Addition of 30 miles of underwater video and side scan sonar transects.

The above items were incorporated with the onging tasks that included the following sampling at five established stations:

1. Hydrography;
2. Otter trawling;

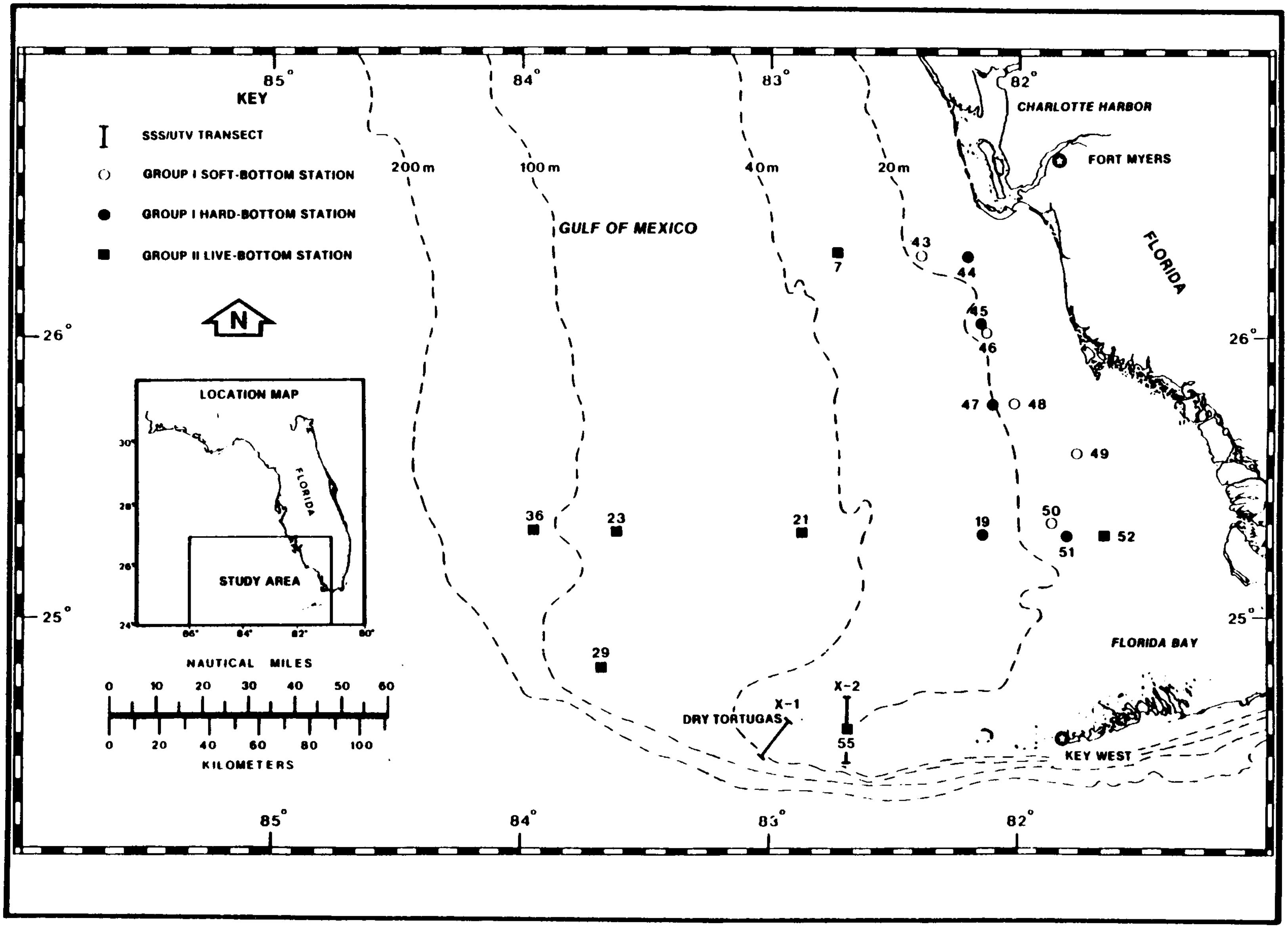


Figure 1 YEAR 4 AND 5 STATION LOCATIONS

3. Sediment sampling;
4. Underwater television and benthic still photography; and
5. Instrumented arrays containing
   - -current meter,
   - -fouling plates,
   - -sediment traps,
   - -time lapse camera, and
   - -wave and tide gauge (2 stations).

Project Status

All sampling for the Year 5 studies was completed in December 1985. This completes all sampling for the 2-year Southwest Florida Shelf Benthic Communities Study. In the two years of this study the following accomplishments were made:

- 116 km of sea floor were surveyed with underwater television and benthic still cameras;
- 111 triangular dredge samples were collected;
- 58 otter trawls were conducted;
- 72 CSTD hydrographic stations were occupied (including salinity, temperature, conuctivity, dissolved oxygen, pH, transmissivity and depth);
- 44 sediment grab samples were collected;
- 4 high resolution benthic video surveys were conducted at Station 52 with a diver-held video;
- 100 samples of fish and invertebrate tissue were collected, frozen and archived in the event that chemical analysis of various parameters would be required at a later date;
- Instrumented arrays (equipped with sediment traps, fouling plates, current meters, time-lapse cameras, and wave gauges) were maintained for two years at 5 stations and for one year at 3 additional stations; and
- 55 km of sea floor were surveyed with side scan sonar and underwater television on transects extending southwest from the Dry Tortugas and between the Dry Tortugas and the Marquesas.

The overall data recovery for the two years was approximately 80 percent. The loss of 20 percent of the data is primarily attributed to array instrument malfunction, the loss of two arrays during the two years, and damage by fishermen or fish. The only portion of the study not completed was a deep hole survey which was to have included detailed bathymetry, hydrography, underwater television survey, and fish sampling of a 1,000 ft deep hole near the shelf break. This survey was deleted suring the last cruise because of severe weather.

RESULTS

Physical Data

The results of the 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 dirunal and semi-dirunal 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. To illustrate the distribution of energy with varying depth three-dimensional power spectra were plotted using the energy spectra from five current meter records. Examples of these plots for the east-west and north-south components of the summer energy spectra are presented in Figure 2.

An examination of sediment trap and time-lapse camera data indicated that sediment resuspension was episodic and that near-bottom currents, although important, were not the only factor contributing to sediment resuspension. Wave energy was also important, which precluded

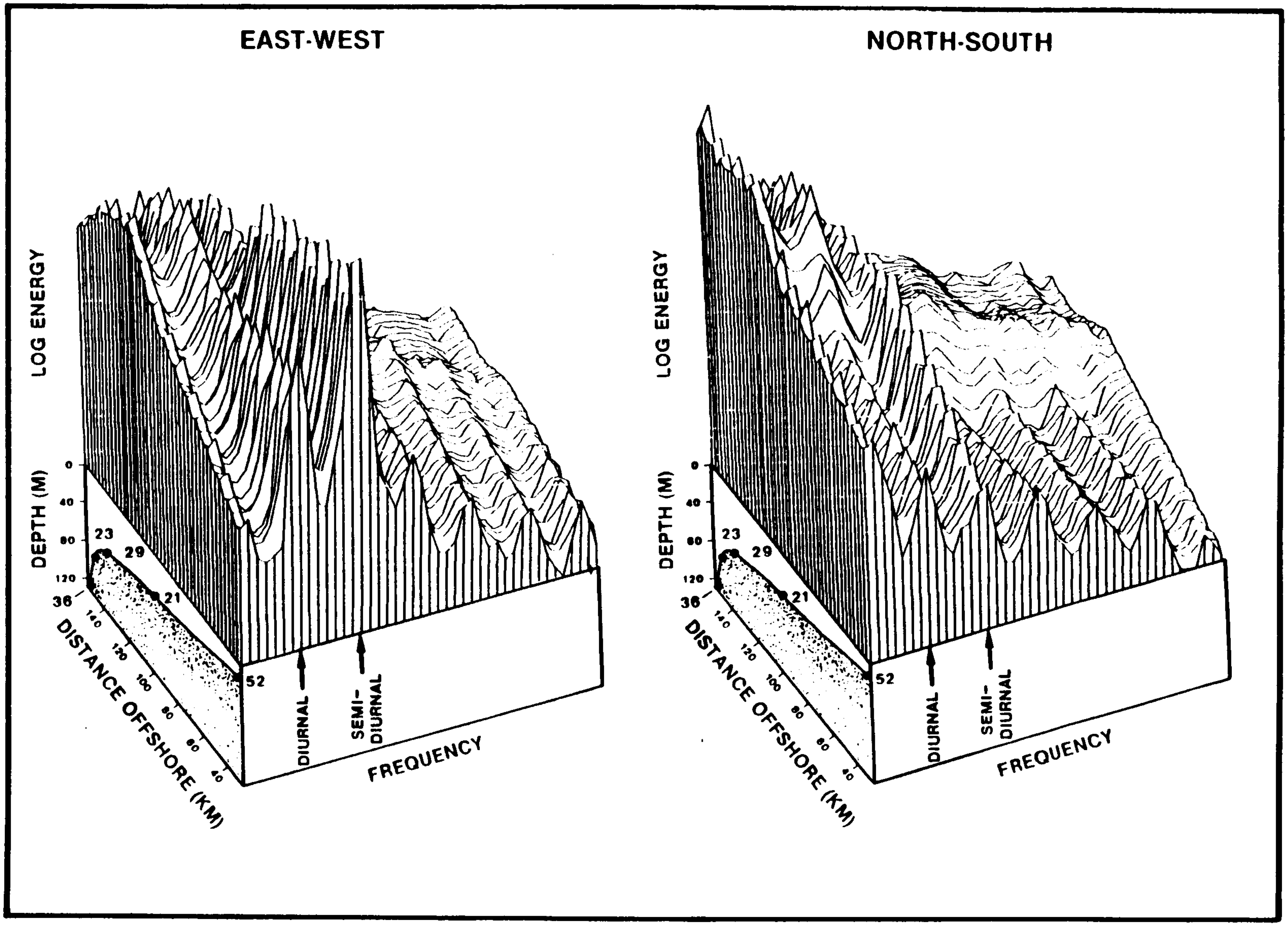


Figure 2 3-D SUMMER (1984) ENERGY SPECTRA, EAST-WEST AND NORTH-SOUTH COMPONENT significant sediment resuspension in deep water. As an example, although current speeds at the deepest station (125 m) were occasionally high enough to resuspend sediments, this did not occur. At the shallowest station (13 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.

Biological Data

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 considerable length of time in order for settlement of sponge larvae to take place.

There was no obvious seasonality--ie., 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.

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, dredge samples were analyzed using procedures designed for presence/absence data. These procedures are robust and have few statistical assumptions to violate; are economical and rapid to run; and are sufficiently powerful to describe the benthic communities.

Several different algorithms for cluster analyses based on presence/absence data are being evaluated for applicability to the data. Dredge samples of epifaunal invertebrates showed distinct zonation of using constancy and fidelity analyses indicated major differences between 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.

The next step in the program is to merge the results of the physical and biological components of the study to determine the important physical parameters that affect the distributions and densities of the biota. This process was begun by sumarizing all of the physical data to illustrate the environmental conditions present at each station. This information will be used to determine the physical parameters and environmental stresses that dictate which biota exist at each station. This information will then help assess what impacts may result if additional stresses are applied to the system. The results of the data summarization are presented in Figure 3.

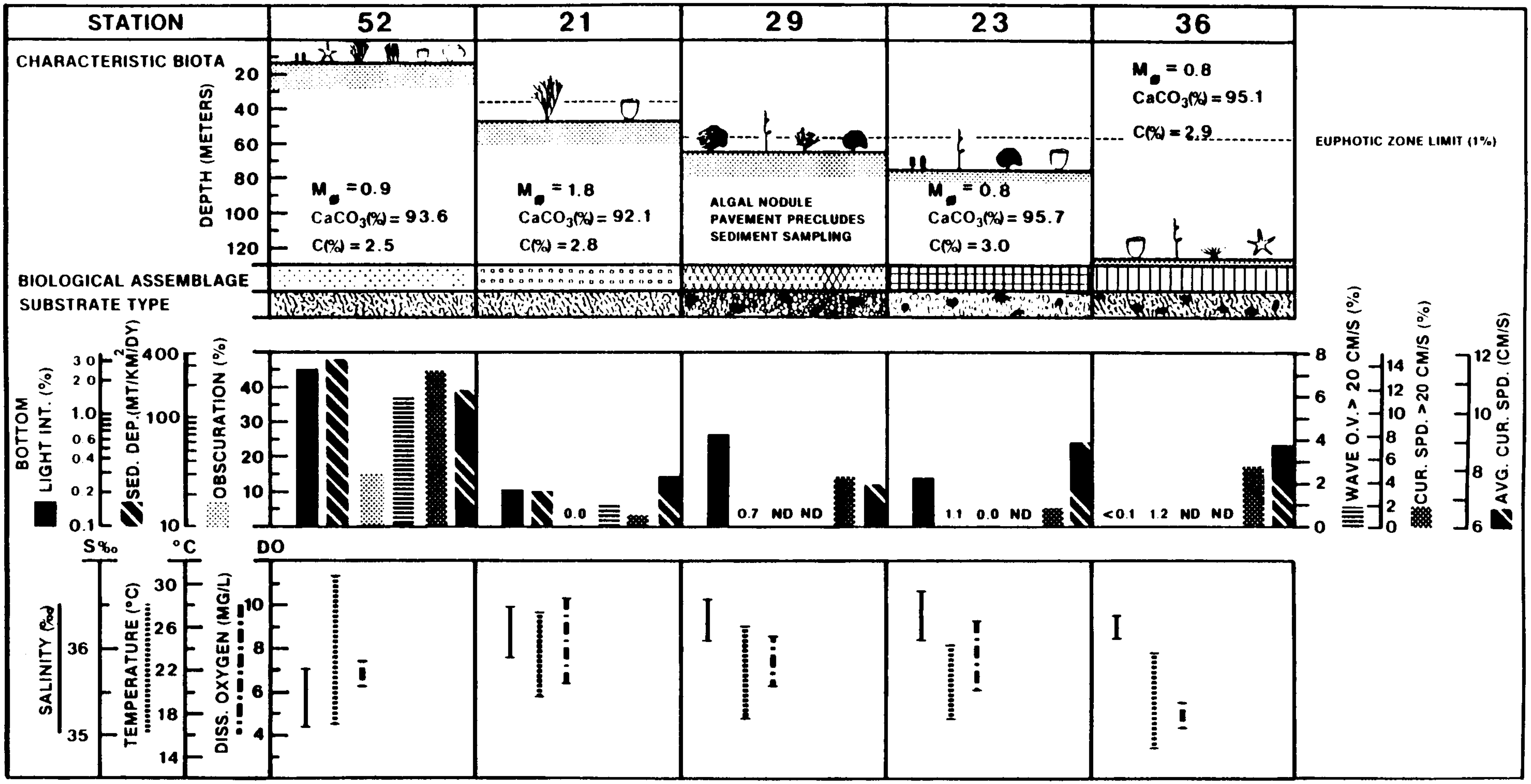


Figure 3 CROSS-SHELF STATION CHARACTERIZATION

LEGEND

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 118 TO 168 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

Species	Group
Halimeda spp	ALGAE
Anadyomene menziesii	ALGAE
	HYDROZOANS
Muricea elongata, *Pseudoplexaura* spp., *Eunicea* spp., *Pseudopterogorgia* spp	GORGONIANS
Antipatharia spp	GORGONIANS
Agaricia spp	HARD CORALS
Siderastrea spp	HARD CORALS

Figure 3 (continued) CROSS-SHELF STATION CHARACTERIZATION

PHYSICAL MEASUREMENTS PROGRAM ACCOMPLISHMENTS ON THE SOUTHWEST FLORIDA SHELF, 1983-1985

Dr. Murray L. Brown
U.S. Minerals Management Service

INTRODUCTION

From January 1983 to February 1986, the MMS has maintained two complementary arrays of current measurement moorings on the Southwest Florida Shelf. One array (approximately between 26°N and 25°N) was deployed by Science Applications International Corporation (SAIC), as part of the physical oceanography studies series; the other (closer to 25°N) was deployed by Environmental Science and Engineering Inc. (ESE), as a part of a marine ecosystems study concerning transport of suspended sediments in the benthic boundary layer during storms.

This brief paper is to catalog the current data sets obtained, and to provide brief descriptions of the current features identified in the data analysis. The implications of these findings for the circulation modeling program are addressed. This analysis is for the field data collected during Years I and II of the 3-year program; an update will be provided later, when Year III data will have been analyzed. This analysis has benefited from a workshop held on February 6, 1986, in Tallahassee, Florida, where much new data were available; these recommendations, therefore, should be considered to replace informal comments and documents provided to you on this subject earlier.

DATA CATALOG

The current data obtained during the two coordinated studies are catalogued in time-line form on Figure 1. The SAIC data (letter designations) are from five across-shelf moorings (A, C, D, F, and G) and a northern offset location (E) (Figure 2). The ESE data are from four across-shelf moorings (21, 23, 36, and 52) and a southern offset location (29) (Figure 3: Group II Stations). The SAIC Station G was added during Year II after returns from Station A indicated that it was too shallow to capture a complete record of Loop Current circulation. The precise instrument levels at SAIC D were adjusted (DA) during the program. The ESA Stations 7, 44, and 55 (not shown in Figure 3) were added during the final year, and will not be discussed here. The overall data return from all deployments is on the order of 80%, a very successful value, particularly in light of heavy fishing activity in the area and (believed) submarine operations off the shelf.

PROGRAM PHILOSOPHY

Although there are persistent, well-known circulation systems in the coastal sea, such as the Gulf Stream, these features are few, and their areal extent is limited. At most locations the instantaneous movement of the water is the result of many additive motions, of widely differing directions and velocities, driven by local or regional mechanisms. The notion of "ocean current," however, is closely bound in the public mind to a broadly organized, relatively strong movement of the water without regard to temporal or spatial variation. In reality, the long-term average current at some location on the continental shelf

Figure 1

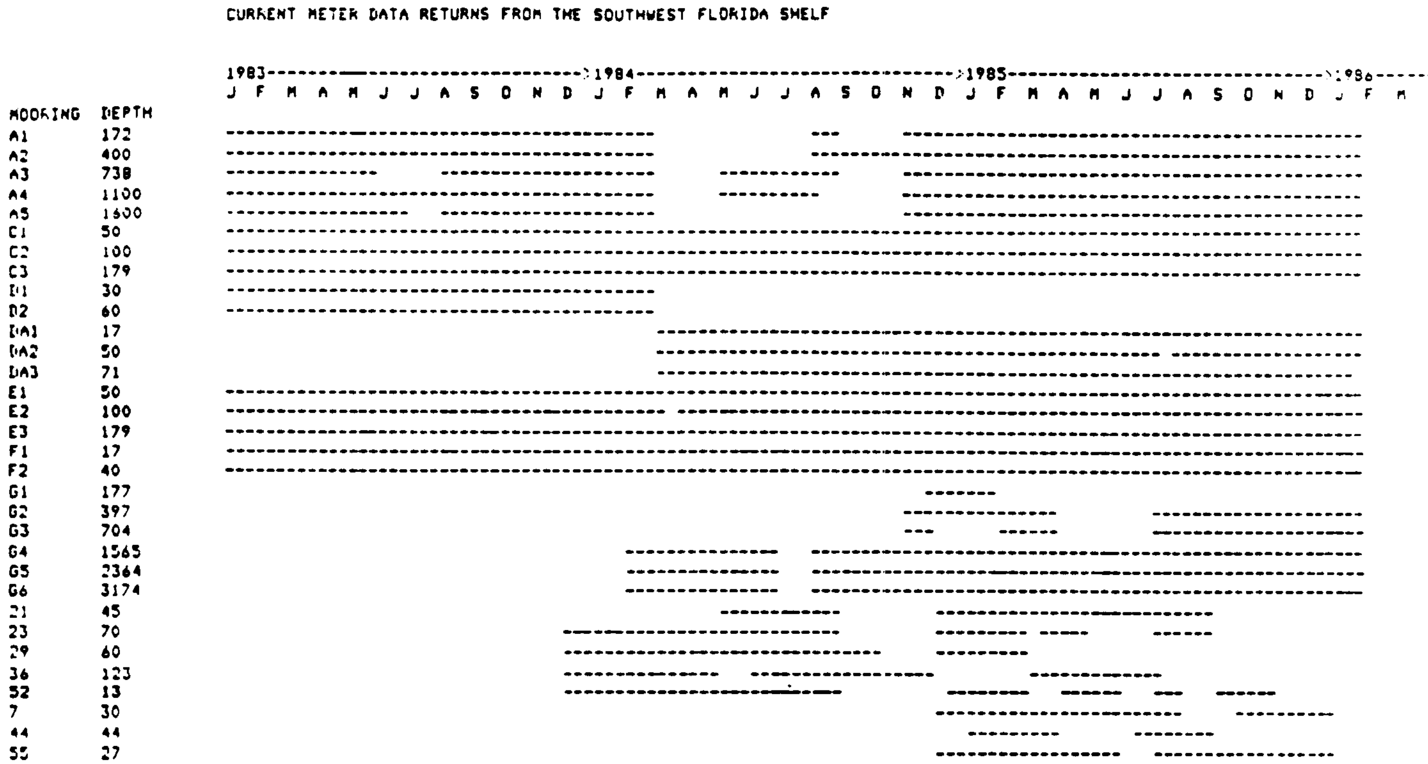
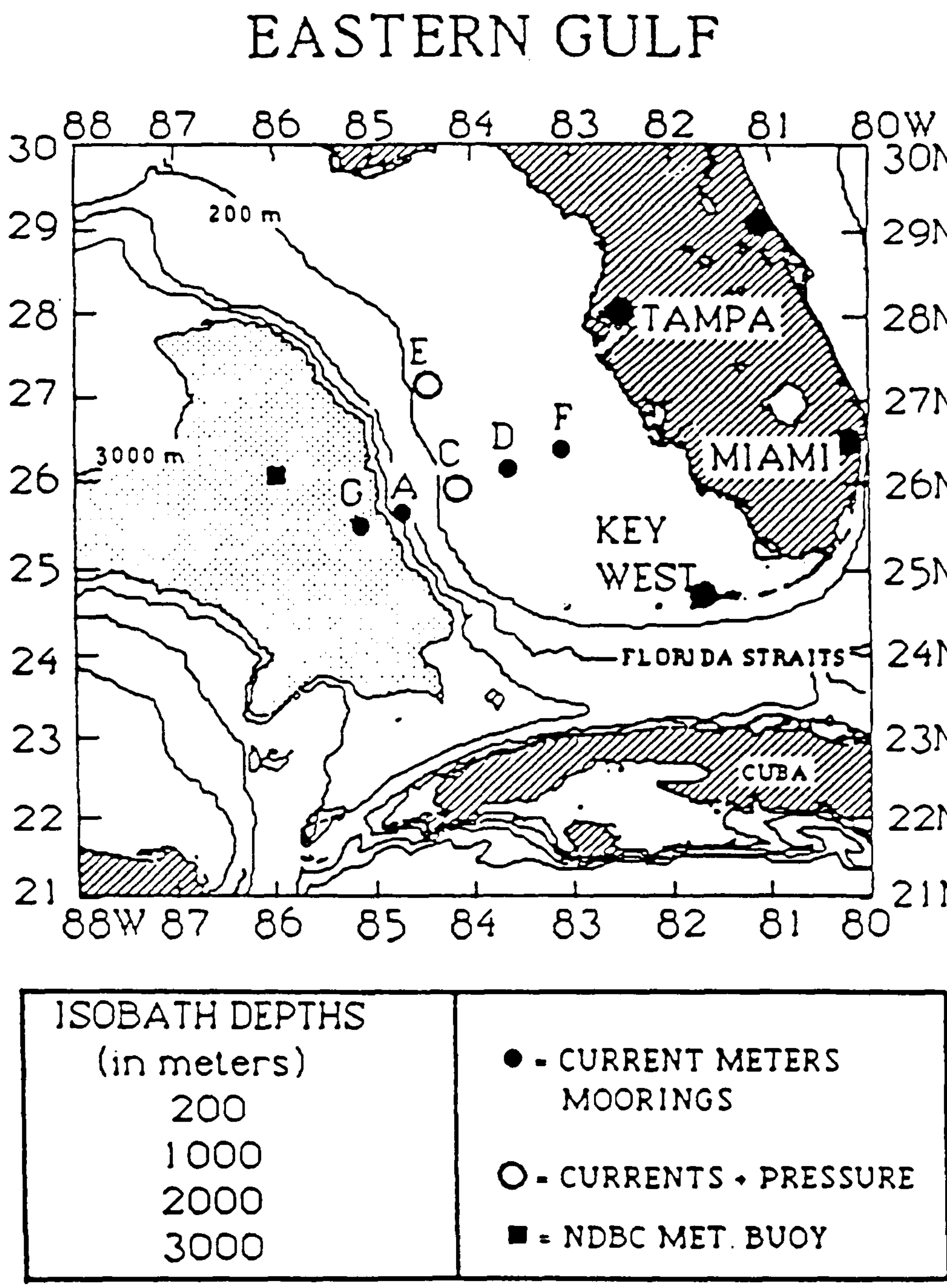
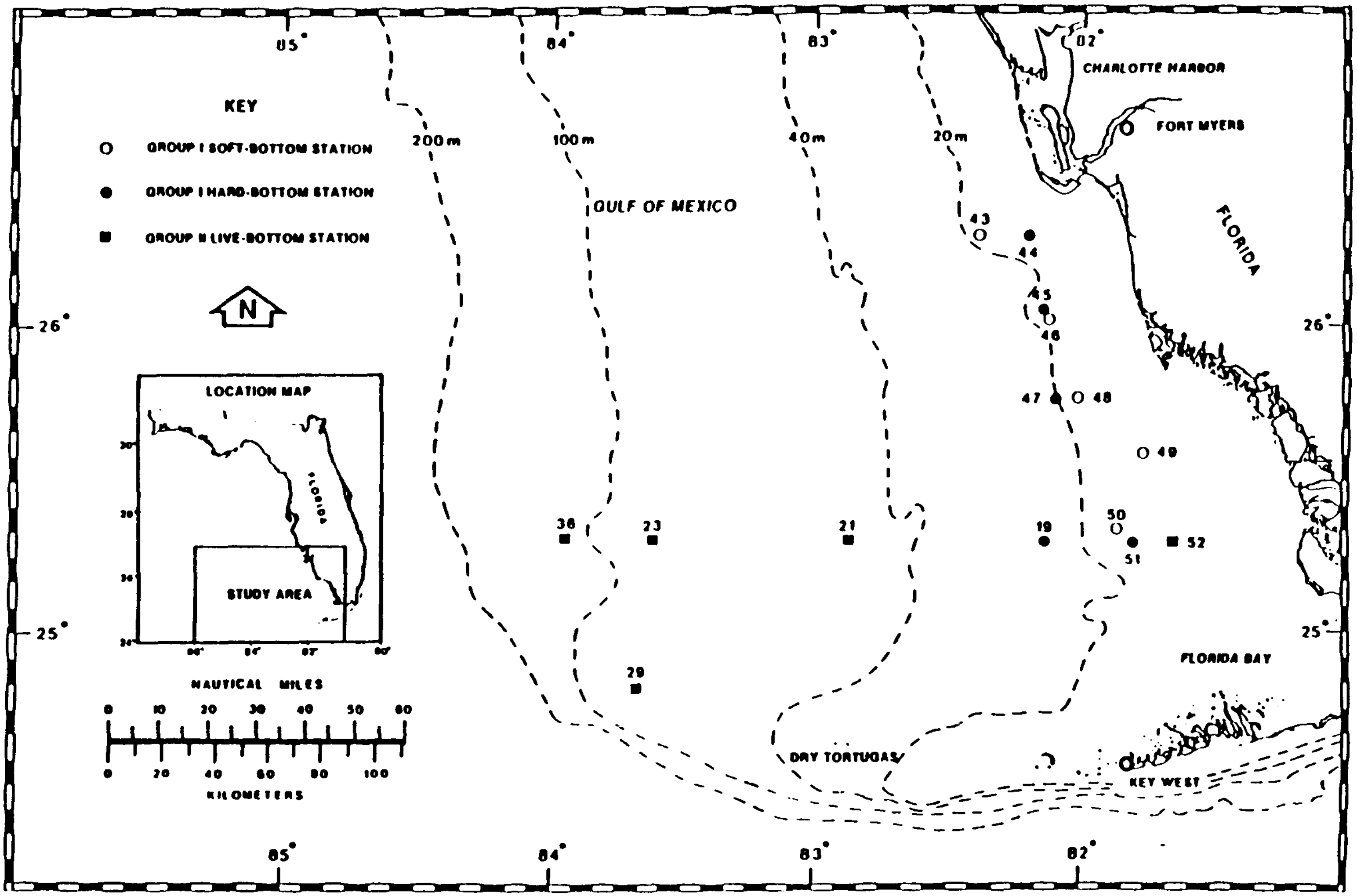

CURRENT METER DATA RETURNS FROM THE SOUTHWEST FLORIDA SHELF
1983 1984 1985 1986
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A
MOORING DEPTH
A1 172
A2 400
A3 738
A4 1100
A5 1600
C1 50
C2 100
C3 179
D1 30
D2 60
DA1 17
DA2 50
DA3 71
E1 50
E2 100
E3 179
F1 17
F2 40
G1 177
G2 397
G3 704
G4 1565
G5 2364
G6 3174
21 45
23 70
29 60
36 123
52 13
7 30
44 44
55 27

Figure 2



Caption: Locations of SAIC current meter moorings



STATION LOCATIONS AND INSTRUMENT ARRAY LOCATIONS FOR YEAR 4

Figure 3

may well be a very small value (or even zero!) while the temporal variability experienced at that site -- as well as the instantaneous differences between currents at that site and another not too distant site -- may be substantial. It is the task of the physical measurements program to discover within the current data sets the time and length scales of the separate current motions, and --hopefully-- to identify the forcing mechanisms responsible for them. Given the ocean assessment or management needs of the responsible agency, moreover, it is the job of the circulation modeling program to simulate some, but not usually all of these motions, since certain motions may (1) represent presently intractable numerical problems; (2) be negligible, given relative magnitudes, agency interests, etc.; or (3) be parameterized or dealt with by appropriate model assumptions or boundary conditions.

In summary, at most locations in the sea there is no single quantity which may be called the "current," even for specific months or seasons. Usually many separate water motions are simultaneously present, each of significant magnitude; while long-term averages may be calculated, they are not as valuable as information concerning the causes and time- and length-scales of the separate motions. A circulation modeling effort generally aims to simulate a subset of important water motions selected on the basis of program goals as well technical limitations.

CURRENT CONTRIBUTIONS

Based on two years of data, six classes of water motion have been identified and analyzed in the first progress report (final due February 28, 1986). They are briefly described below and summarized in Table 1.

Tidal Currents: Tidal currents decrease from a maximum value of about 15 cm/sec near shore to negligible values at the shelf break. Shoreward of about 150 m, they exhibit semidiurnal behavior; beyond that point they are diurnal. Close to the coast the onshore/offshore components predominate; this effect vanishes at greater depths with water motion being generally equal in all directions. At the shoreline itself, however, the motions are strictly along-shore. The typical movement of a water parcel (tidal excursion) near the shore would be 2-3 km.

In general the tides have been quite well studied, with the exception of inner Florida Bay and the shallow regions of the Florida Key where a tortuous shoreline geometry exists. Since the maximum residual velocity that could result from tidal cycling is on the order of 2 cm/sec, exclusion of tides from circulation modeling is, therefore, justified. The OSRA methodology includes a physical enlargement of coastal "target areas" in order to deal with such matters as the spatial spreading of oil spills and tidal currents.

Inertial Currents: Inertial currents are motions which have been caused by the displacement of water by an event of short duration, such as the passage of an atmospheric front or disturbances along the shelf boundary by the Loop Current. Once established, the motion is damped by friction and eventually dissipates. The motions are characteristically circular, due to the Coriolus force, exhibiting a frequency fixed by the local latitude. On the Southwest Florida Shelf strong inertial currents were found, with amplitudes ranging from about 25 cm/sec

Table 1

ABULAR SUMMARY OF CURRENT INFORMATION DEVELOPED DURING YEARS I & II OF THE MINERALS MANAGEMENT SERVICE'
PHYSICAL OCEANOGRAPHY PROGRAM IN THE EASTERN GULF OF MEXICO

CURRENT FEATURE	GENERAL TIME SCALE (or BAND PASS)	MAXIMUM VALUE (cm/sec) (A if amplitude)	GENERAL LENGTH SCALE (km)	DEPTH (m)	0	25	50	100	200	400	800	1600	3200
				SAIC No.s			F D Da		CE			A	G
				ESE No.s	W	ZX	YS U T	V	(See Note)				
TIDAL CURRENTS	12/24 HOURS	25	2-3		<----Semidiurnal--------------------- 25 cm/sec			;-----------------Diurnal------------------------------> 8 cm/sec	4 cm/sec				
INERTIAL CURRENTS	27 HOURS	20A	3		Not seen	<------------------------------------ - - - - 20 cm/sec			10 cm/sec	Very weak		WINTER: Weaker SUMMER: Stronger	
SYNOPTIC-SCALE WIND CURRENTS	3-10 DAYS	25-30	10-100 (5-day event)		<------Strong--/------Reduced------/-Weak - - - 25-30 cm/sec							WINTER: Stronger SUMMER: Weaker	
LONG-TERM WIND CURRENTS	(>30 DAYS)	20				--Weak-----/----Strong--------/--Obscured by Loop Current 5 cm/sec		20 cm/sec				WINTER: Stronger SUMMER: Weaker	
LOOP CURRENT INTRUSIONS	5-20 DAYS	20-100	200					<<==========Filaments, Frontal Waves=======					
LOOP CURRENT	NEAR-ANNUAL	100-200							<<======Loop Current Front======================				

NOTE- ESE STATIONS DESIGNATED ABOVE MAY BE RELATED TO THE ORIGINAL REPORT AS FOLLOWS:
#21=S #23=T #29=U #36=V #52=W #7=X #44=Y #55=Z

FEBRUARY 19, 1986

at about 30 m to about 10 cm/sec at about 300 m. They are significantly stronger in summer, indicating a minor role for wind forcing. A typical radius for these circular motions would be about 3 km.

Synoptic-scale Wind Currents: When water motions at periods shorter than 40 hours are suppressed by appropriate mathematical filters, movement caused by regional-scale atmospheric "events," such as the passage of a front, is apparent -- particularly in winter -- in peaks occurring every 3-10 days. Typically the longshore component of the wind event and of the measured current are coincident in time and similarly directed. Values range from about 25-30 cm/sec nearshore to negligible values near the shelf edge.

Synoptic-scale wind currents have traditionally been the highest frequency wind-driven motions included in MMS regional ocean circulation studies, supplemented at the National Headquarters by local, high frequency (less than 30 hours) wind forcing derived from a wind transition matrix. The cut off between these two levels of forcing has not been made completely clear; recent recommendations by a group of experts impanelled to evaluate methodologies for the North Carolina offshore area may lead to more precise definitions and specifications for the separate usages. Recently the GOM OCS Region's modeling contractor has opted to use monthly-averaged winds during "third-generation" modeling runs, although synoptic-scale forcing will remain an option. The 10-100 km water movement associated with a typical 5-day frontal passage is not lost; however, by this strategy, as much of the same wind energy is still contained in the long-term winds described below.

Long-term Wind Currents: When water motions are averaged over a 30-day period, the long-term effects of winds and possibly other factors are apparent. These currents are generally related to the average winds for the same period (as above), but probably also contain a signal reflecting the long-term coupling between the Loop Current and the shelf. Strongest values (about 20 cm/sec) occur in the interval from 50-200 m. Offshore, the signal is obscured by the Loop Current; inshore, the motions rapidly decrease to negligible values at about 25 m.

The long-term wind current (greater than 30 days) identified by the present data are conceptually related to those modeled by New England Coastal Engineers (NECE) for the entire West Florida Shelf, due to the similarity between averaging intervals (monthly winds). In the broadest view, they may be the appropriate high frequency end of the wind-driven component for the OSRA exercise, since future runs will be multiyear in scope to deal with the non-annual Loop Current cycle. Indeed, in shelf areas not affected by Loop Current intrusions, this motion may be closest to the popular notion of a non-periodic "ocean current."

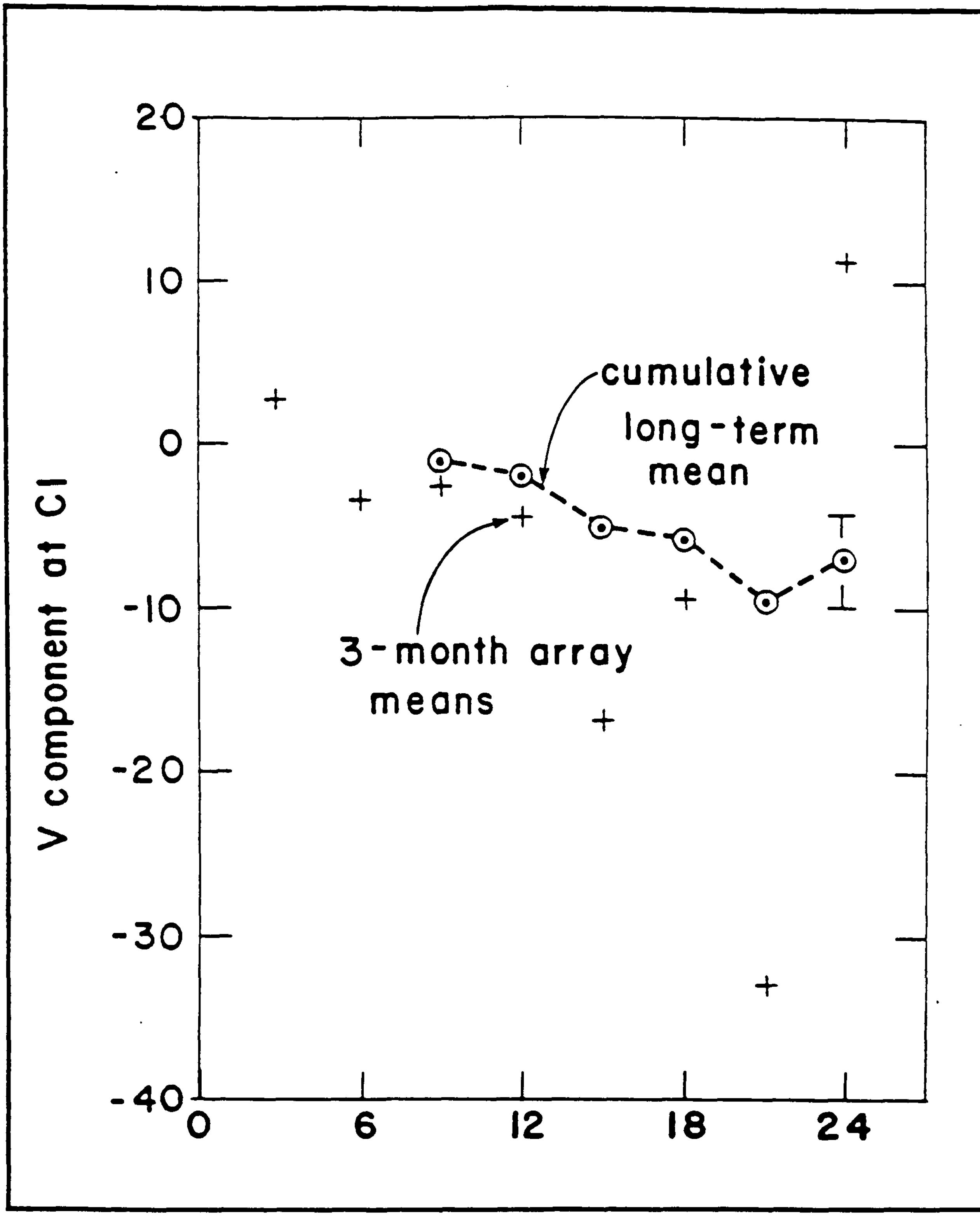
Loop Current Intrusions: Wave-like structures and filaments along the Loop Current front, and possibly also detached eddies, may create strong currents (up to 100 cm/sec) as far onto the shelf as about the 100-m isobath. These events occur over time scales from 5-20 days, affecting areas of up to 200 km in length.

Loop Current: The Loop itself may intrude onto the shelf to about the 200-m isobath, with currents of up to 200 cm/sec.

THE AVERAGE CURRENT

As a point of comparison with the separate motion descriptions provided above, the cumulative long-term mean current component in the along-shore direction has been calculated for one location (Figure 4). The values range from about -1 to -10 cm/sec, where the minus sign denotes southward-trending motion. Although a value of about -5 cm/sec could be cited as "the average current" at the site, its magnitude is hardly significant in light of the identified component motions.

Figure 4



A comparison between mean values computed from individual 3-month mooring records (plus signs) and the cumulative mean from the entire record up to that time for long-shelf component, upper current meter (50 m), Mooring C.

SOUTHWEST FLORIDA ECOSYSTEMS STUDIES

ABSTRACT

The Southwest Florida Shelf Ecosystems Study began in 1980 and was originally designed to be a 3-year, interdisciplinary study of the biogeochemical character and seasonal community patterns occurring across the continental shelf in the region.

The overall objectives defined by the Bureau of Land Management [(BLM) now the Minerals Management Service (MMS)] for the Southwest Florida Shelf Ecosystems Study were as follows:

1. To 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. To produce habitat maps that show the location and distribution of various bottom substrates. This was done by exploring several widely spaced transects across the southwest Florida shelf.

3. To broadly classify the biological zonation and along the shelf, projecting the percent of the area covered by each type of live/reef bottom.

To meet these objectives, the study was conducted over a 3-year period. A variety of geophysical, hydrographic, and biological features were studied along five east-west transects across the southwest Florida shelf and additional N-S transects (Figure 1). Geophysical data--bathymetric, seismic, and side scan sonar surveys--were collected along each transect. Visual data--combining underwater television (UTV) and 35-millimeter (mm) still color photography--were collected between 20 and 200 m. Finally, a broad range of hydrographic measurements, water column samples, bottom sediment and benthic biological samples (e.g., triangle dredge, otter trawl, and box cores) were collected at stations located along the various cross-shelf study transects.

The geophysical and visual data were combined with results obtained from benthic sampling to refine the gross sea bottom/substrate type identifications into interpretations of specific community types, with emphasis on diversity, biomass, and recreational and commercial value.

Under a Year 2 contract modification (which was essentially a separate third year of studies), two seasonal hydrographic cruises were conducted in 1982 to yield a hydrographic analysis of temperature, salinity, transmissivity, phytoplankton, chlorophyll a, phosphates, nitrates, nitrites, and dissolved silica. Primary productivity was measured during both cruises and correlated with nutrient and other physio-chemical data. A simultaneous overflight by the National Aeronautics and Space Administration (NASA) Ocean Color Scanner during the April cruise was completed to investigate chlorophyll and productivity throughout the region during the spring bloom. Optical oceanographic measurements were also taken.

The first three years of investigations effectively addressed Objectives 2 and 3 listed previously. However, it was determined that to effectively assess the

potential impacts of OCS oil and gas activities, more must be known about the dynamics of the ecosystem and natural stresses that are imposed on the systems by existing physical processes. Consequently, an additional 2-year study ("Southwest Florida Shelf Benthic Communities Study") was designed to investigate the biological and physical processes of the southwest Florida shelf that, in combination with the first three years of study, would provide the information needed to better assess potential impacts of offshore development.

The Year 4 field study mounted four seasonal cruises, with sampling conducted at two sets of stations. One set was scheduled to be 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 winter 1982-1983 and Summer of 1983 (Year 3 study). This sampling essentially completed the seasonal baseline descriptive study of the inshore area.

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 "Group II" hard-bottom stations (described in Table 1) were selected for intensive seasonal sampling and installation of instrumental arrays that would be maintained for two years.

The most important data to result from this study are provided by the UTV studied and *in situ* arrays.

Table 1. Descriptions of Years IV and V Stations

Sampling Years	Station	Depth (m)	Depth Zone	Substrate	Assemblage
IV and V	52	13	Inner Shelf	Sand Over Hard Substrate	Soft Coral Assemblage I
IV and V	21	47	Middle Shelf	Sand Over Hard Substrate	Live Bottom Assemblage II
IV and V	23	74	Middle Shelf	Algal Nodule Layer/Sand	Algal Nodule Assemblage
IV and V	29	64	Middle Shelf	Algal Nodule Pavement	*Agaricia* Coral Plate
IV and V	36	125	Outer Shelf	Sand Over Hard Substrate	Crinoid Assemblage
V	7	32	Inner Shelf	Sand Over Hard Substrate	Live Bottom Assemblage I
V	44	13	Inner Shelf	Sand Over Hard Substrate	Live Bottom Assemblage I
V	55	27	Inner Shelf	Sand Over Hard Substrate	Live Bottom Assemblage I

Each array contained the following instrumentation:

1. One ENDECO 174 current meter located 3 m above the bottom.

2. Three sets of sediment traps, one each at depths of 0.5 m, 1.0 m, and 1.5 m, installed on each array and serviced quarterly.

3. Artificial substrate plates (ten racks of plates consisting of six replicate tiles, certain plates on each array retrieved and replaced each quarter).

4. Time-lapse cameras installed on the arrays (Stations 52 and 21 only for Year IV) to monitor sediment transport and recruitment and growth rates.

5. Sea Data wave and tide gages installed on selected shallow arrays (to document the wave climate and tidal fluctuation).

The arrays were designed to remain in place for the duration of the 2-year study (Years IV and V) and were serviced quarterly.

These studies demonstrated the existence of at lease nine biological assemblages and at least five bottom habitat types. These are dispersed across the shelf in a complex matrix. Overall the southwest Florida study area has about one-third of its benthic habitat which could be classified as live bottom. Exposed rocky substrates are quite uncommon. Sediment resuspension appears to be an important factor only at the shallowest stations. No sand waves or ripples (signs of current induced sediment movement) are virtually absent. Recolonization rates are highest in shallow water and decline seaward. The region is essentially pristine in its content of sediment hydrocarbons and trace metals. Major soft and live bottom types are generally aligned parallel to shore and isobaths in the region in response to bottom characteristics, light intensity, and hydrography.

Florida Big Bend Seagrass
Habitat Study

Ternary Meeting
Gulf of Mexico Environmental Studies Program
Minerals Management Service
U.S. Department of the Interior
Gulf of Mexico Regional Office

Submitted by
Robert M. Rogers
Environmental Studies Section

March 18, 1986

ABSTRACT

Extensive seagrass/algal beds occur on the west Florida continental shelf between Ochlockonee Bay and Tarpon Springs--a region known as the Florida Big Bend. Recent industry interest in offshore oil and gas drilling in the Big Bend area has produced concerns about possible environmental impacts to benthic organisms, particularly seagrasses and associated biota. In response, the Minerals Management Service (MMS), as the Federal agency responsible for prediction and management of oil- and gas-related environmental impacts, initiated the Florida Big Bend Seagrass Habitat Study. Study results will be of use in buffer zone discussions associated with upcoming eastern Gulf of Mexico lease sales and in formulation of lease sale biological stipulations.

Until this study, overall seagrass distribution patterns within the Florida Big Bend area were poorly known. Previous seagrass studies in the area relied on published reports and diver surveys to estimate seagrass distribution near shore [water depths less than 10 m (33 ft)]. Very little study was devoted to the seagrass/algal beds known or presumed to extend farther offshore. The Florida Big Bend Seagrass Habitat Study was designed to map seagrass distribution patterns in both nearshore and offshore portions of the Florida Big Bend area.

The objectives of the Florida Big Bend Seagrass Habitat Study were:

1) To map and inventory seagrass beds in the Big Bend area using a combination of aerial photography (remote sensing) and shipboard "ground truthing";

2) To determine the seaward extent of the major seagrass beds; and

3) To classify and delineate major benthic habitat types in the area.

The study consisted of three parts:

1) A pre-overflight ground-truthing cruise (Cruise 1);

2) Remote sensing overflight encompassing the study area; and

3) A post-overflight ground-truthing cruise (Cruise 2) to verify interpretation of remote sensing data.

Due to the lack of data on seagrass distributions in deep water, ground-truthing efforts focused on the deeper [10 to 20 m (33 to 66 ft)] portions of the study area. Also, remote sensing was not able to resolvebottom features across the entire depth range of the study area, and additional deepwater ground truthing was needed to supplement aerial photographic data used for habitat mapping.

METHODS

During Cruise 1 (24 October to 1 November 1984), 1,232 km (144 mi) of seafloor between the 10- and 20-m depth contours were surveyed using a towed underwater television system. Loran-C navigational fixes and bottom type were recorded at 5-min intervals during television tows. Fifty representative Signature Control Stations were established to aid aerial photographic interpretation by providing locations of known seagrass coverage. At each station, large, floating targets were deployed and divers took quantitative photographs of the seafloor to estimate seagrass density and species composition.

Between 30 October and 15 November 1984, aerial photographs were taken along 26 north-south flight lines encompassing 2.1 million ha (5 million acres or 8,200 mi^2) of seafloor. Standard Kodak 23 cm x 23 cm (9 in. x 9 in.) color print film was used. Scale on all photographs was 1:40,000.

During Cruise 2 (19 to 27 February 1985), nine additional transects [174 km (108 mi)] were surveyed using towed divers and underwater television, and 11 of the 50 Signature Control Stations established during Cruise 1 were resampled using the same methods employed during the earlier cruise.

Aerial photographs were analyzed stereoscopically, and seagrass beds were categorized by density (dense, sparse, or patchy) as determined by interpreting "photo-signature characteristics" such as tone, color, texture, and size. Signatures of submerged seagrass beds ranged from dark blue-green offshore to light-medium brown in nearshore areas influenced by tidal fluctuations. Areas of nonvegetated sand bottom (white signature) and nonvegetated mud bottom (brown signature) were also recognized in the photographs. Live-bottom habitats characterized by hard corals, gorgonians, sponges, and other epibiota associated with low-relief rock outcrops or rock covered by a thin sand veneer could not be differentiated from surrounding seagrass beds at the 1:40,000 scale of the aerial photographs.

Six hundred photographs were interpreted and distributions of the major habitat types were outlined on clear acetate. These interpretations formed the basis for a 1:40,000 scale map of the study area. A reduced Composite Map (scale 1:25,000), which can be superimposed directly on the 1:250,000 scale MMS protraction diagrams, was produced.

RESULTS AND DISCUSSION

A total of 1.5 million ha (3.7 million acres) was mapped from the aerial imagery during the study. Mapping delineated 232,893 ha (575,479 acres) of dense seagrass beds, 498,034 ha (1,230,643 acres) of sparse seagrass beds, and 279,722 ha (691,195 acres) of patchy seagrass beds.

Study results indicate two major groupings or species associations of seagrasses in the Florida Big Bend area. An inner (nearshore) association of turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), and shoalgrass (*Halodule wrightii*) occurs in water depths of less than 9 m (30 ft). Turtle grass and manatee grass form dense beds that are easily detected in aerial photographs, and only at the southern end of the study area do the dense beds extend into Federal waters (Figure 1). Seaward of these dense seagrass beds is a zone where five seagrass species are seen--turtle grass, manatee grass, shoalgrass, and two additional species: *Halophila decipiens* and *H. engelmanni* (neither has a universally recognized common name). Farther offshore, large areas of continental shelf between approximately the 10- and 20-m depth contours support a mixed macroalgal/seagrass assemblage in which the two *Halophila* species are the only vascular plants seen. This assemblage extends beyond the 20-m depth limit of this study and is abundant to at least the 23-m (75-ft) depth contour.

Turtle grass and manatee grass are the largest seagrass species in the Big Bend area, and their blades trap sediment from the water column, thereby helping to build seagrass beds. Shoalgrass and the two species of *Halophila* are much smaller and generally are considered to be fringing or pioneer species that inhabit the margins of major seagrass beds and tolerate environmental conditions not suitable for the larger species.

The unique aspect of seagrass communities in the Florida Big Bend area is the extended nature of the deeper, fringing zone dominated by *H. decipiens*, *H. engelmanni*, and various macroalgal species. Ground-truthing data indicate that macroalgae account for an average of 21% of total blade density seen here. Ground-truthing data also indicate approximately 44% of the area mapped on the basis of aerial photographs as sparse or patchy seagrass beds consisting of live-bottom habitats that could not be differentiated from seagrass beds in the aerial imagery.

In addition to the spatial zonation patterns of seagrasses noted in this study, seasonal variability in seagrass bed density and species composition was evident, especially in the sparse offshore beds. At most offshore Signature Control Stations sampled during Cruise 2 (February), blade densities were 50% to 90% lower than those noted during Cruise 1 (October to November), and *H. decipiens* had disappeared. *Halophila engelmanni* persisted during the interim between cruises, but many instances of wave stress and uprooting were evident during Curise 2. Temperature, light, and wave action are likely to be important variables influencing both spatial and seasonal abundance patterns in the seagrass beds.

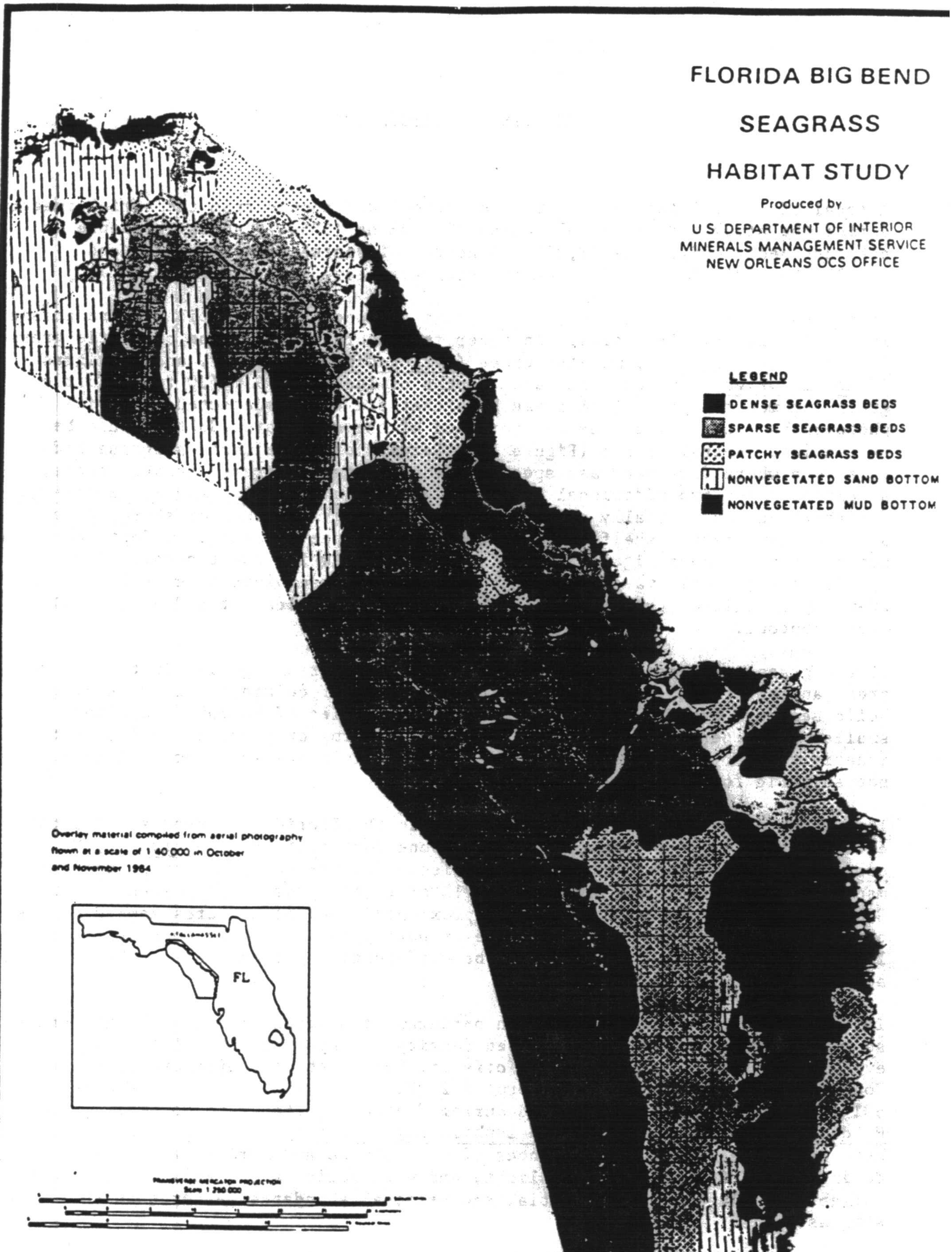


FIGURE 1. FLORIDA BIG BEND SEAGRASS HABITAT STUDY COMPOSITE MAP BASED ON AERIAL PLUS GROUND TRUTHING DATA (PHOTOGRAPHIC REDUCTION).

The ecology of deepwater seagrass/algal beds in the Florida Big Bend area has not been studied, but these habitats could play important roles in this productive environment. Future studies should focus on primary productivity, influential environmental variables, and associated flora and fauna of Big Bend area seagrass beds. Very little is known about the ecology of *Halophila*. Although wave action are important variables influencing both spatial and seasonal abundance a great deal more information is needed on the individual species needs and interrelationships among species.

HURRICANE EFFECTS

As a follow-up to the existing seagrass mapping contract, an evaluation of the effects of the passage of hurricanes Elena, Juan, and Kate is planned during the summer of 1986. Reports on masses of seagrass washing ashore have indicated that extensive damage was done to the study area. A reconnaissance of previously mapped areas is planned to characterize hurricane effects and changes in mapped information.

ITEM 3

LIST OF REGISTERED ATTENDEES

Minerals Management Services
Ternary Meeting
March, 1986

Lloyd F. Baehr Jr., U.S. Army Corps Engineers, NOLA

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

William R. Bryant, Texas A&M

Steve Chustz, La. Dept. of Natural Resources

Gary Couret, DNR/CMD

Larry Danek, ESE

Rick Dawson, National Park Service

Kevin O. Fisher, La. Offshore Terminal Authority

Asher B. Grimes, USCG

John Hitdlebaugh, Chevron Environmental Division
935 Gravier, New Orleans, LA 70112

Patricia Ice, Texaco

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

Mahlon C. Kennicutt, Texas A&M University, Oceanography Division
College Station, TX 77843

Tim Killeen, La. Dept. of Natural Resources

Charles Lamphear, REMA, Inc.

David J. LeBlanc, Texaco

Dianne Lindstedt, Louisiana Geological Survey

Bethlyn McCloskey, MMS, RTWG
5113 Bissonet Drive, Metairie, LA 70003

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

Scott Mettee, Alabama Geological Survey
420 Hackberry Lane, Tuscalousa, AL 35486

Frank Monteferrante, La. Dept. Natural Resource

Allan Mueller, U.S. Fish & Wildlife Service, Ecological Services
17629 El Camino Real, #229, Houston, TX 77058

Tom Oliver, Gulf Ocean Salvages

Willis Pequegnant, LGL Ecological Research Associates
1410 Cavitt Street, Bryan, TX 77801

Tom Randolph, Shell Offshore Frontier Division
P.O. Box 61011, New Orleans, LA 70161

Richard Rezak, Texas A&M University Department of Oceanography
College Station, TX 77843

Murice Rinckel, OCS Representative Florida

A. P. Rosenberg, Dept. of Navy (DOD)

Ian Rosman, LGL Ecological Research Associates
1410 Cavitt St., Bryan, TX 77801

Marilyn Scholz, University of Southern Mississippi
Gulf Park, Long Beach, MS 39560

Harty C. Van, Jr., AMOCO

Evans Waddell, Science Applications International Corporation
4900 Water's Edge Dr., Raleigh, NC 27606

Alan Wallcraft, Jaycor
NORDA Code 323, NSTL Station, MS 39576

E.G. Wermund, Texas Bureau of Economic Geology
Box X, University Station, Austin, TX 78713

Karen Wicker, Coastal Environments, Inc.

In addition, many local MMS personnel attended the presentation, but are not listed above.

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.