OCS Study
MMS 95-0028

Texas-Louisiana Shelf Circulation and Transport Processes Study: Year 2, Annual Report

MMS U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

OCS Study
MMS 95-0028

Texas-Louisiana Shelf Circulation and Transport Processes Study: Year 2, Annual Report

Editors

Ann E. Jochens
Worth D. Nowlin, Jr.

Prepared under MMS Contract
14-35-0001-30509
by
Texas A&M University
College Station, Texas 77843-3146

Published by

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

New Orleans
May 1995

DISCLAIMER

This report was prepared under contract between the Minerals Management Service (MMS) and the Texas A&M Research Foundation. This report has been technically reviewed by the MMS and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Service, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. It is, however, exempt from review and compliance with MMS editorial standards.

REPORT AVAILABILITY

Extra copies of the report may be obtained from the Public Information Unit (Mail Stop 5034) at the following address:

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Regional Office
1201 Elmwood Park Boulevard
New Orleans, Louisiana 70123-2394

Attention: Public Information Unit (MS 5034)

Telephone Number: 1-800-200-4853

CITATION

Jochens, A.E. and W.D. Nowlin, Jr., eds. 1995. Texas-Louisiana Shelf Circulation and Transport Processes Study: Year 2 - Annual Report. OCS Study MMS 95-0028, U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 172 pp.

ABSTRACT

The Louisiana-Texas Shelf Physical Oceanography Program (LATEX) is supported by the Minerals Management Service of the U. S. Department of the Interior. The Texas A&M University System is conducting Study Unit A of LATEX, the Texas-Louisiana Shelf Circulation and Transport Processes Study (LATEX A). The second field year of LATEX A was April 1993 through March 1994. Data were collected from an array of current meter moorings, bottom wave recorders, meteorological buoys, drifting buoys, and hydrographic and acoustic Doppler current profiler (ADCP) surveys deployed on the Texas-Louisiana continental shelf in the Gulf of Mexico. Historical and concurrent data from other programs in this region also were collected.

The current meter array consisted of 66 current meters measuring current speed and direction, temperature, and conductivity on 27 moorings; five directional wave gauges measuring current speed and direction, temperature, and pressure; and two inverted echo sounders measuring acoustic travel time and bottom temperature and pressure. Eight meteorological buoys were installed on the shelf to measure wind speed and direction, air and sea surface temperature, and barometric pressure. Four drifting buoys were deployed and provided information on their locations and sea surface temperature via satellite. Three hydrographic/ADCP surveys were conducted with over 200 hydrographic sampling stations per survey and continuous ADCP measurements along the cruise track. At each hydrographic sampling station continuous profiles were made of conductivity, temperature, dissolved oxygen, downwelling irradiance, particle scattering, fluorescence, and beam attenuation. Up to twelve water samples were taken at each station and analyzed for six nutrients: nitrate, nitrite, phosphate, silicate, urea, and ammonium. At 100 or more stations, water samples were analyzed for dissolved oxygen, salinity, phytoplankton pigments, and surface and bottom particulate matter concentrations. Secchi disk depths were taken at each daylight station. Meteorological measurements were transmitted via the Global Telecommunications System four times a day. The instrumentation as well as calibration and sampling procedures are described in Jochens and Nowlin (1994b).

The collected data were subjected to quality control/assurance procedures as described or referenced in Jochens and Nowlin (1994b). They then were archived with the LATEX A Data Management Office and are regularly transmitted to the National Oceanographic Data Center (NODC). It should be noted that all LATEX data are still considered preliminary. Only after the field program is completed and final synthesis is well along will final data sets be submitted to the NODC. LATEX A initiated or maintained data sharing agreements with more than 20 other programs or researchers during the second field year.

Information regarding LATEX has been disseminated in various ways. To the GULF.MEX bulletin board on the electronic mail service ScienceNet of Omnet wee posted cruise plans and reports, meeting announcements, weekly drifter trajectories and meteorological summaries, and the LATEX calendar. The Defense Mapping Agency, U.S. Navy Submarine Command, and the United States Coast Guard are regularly advised regarding changes in LATEX A mooring positions and deployments. A meeting on the oceanography of the LATEX region was organized. It was well attended by representatives from LATEX A, B, and C, state and federal agencies, other concurrent research programs, and the LATEX Science Advisory Panel. The LATEX *Fortnightly News* was published bi-weekly throughout the second field year. This single sheet, two-sided newsletter was mailed to approximately 2500 addressees, giving them news and

announcements regarding the LATEX program. LATEX A scientists presented talks or papers in a variety of forms during the period covered by this report.

Assembly is underway of collateral data that will be of assistance in the interpretation/synthesis of the LATEX data. These collateral data consist of information from pertinent historical reports of physical oceanographic work in the Gulf of Mexico and from other programs collecting physical oceanographic data during the LATEX field years. Concurrent and historical data have been compiled from 15 sources; some of these, e.g., NODC, constitute very large data sources. Historical information compiled also includes climatologies of temperature, salinity, surface waves, tides and tidal currents. Model results have been gathered from models on general circulation, storm surges, and tides.

Many graphical products have been produced to aid in the quality control/assurance and in initial interpretation of the LATEX data sets. For time series collected (i.e., from meteorological buoys and moored current meters) a series of standard products for the second field year were produced and will be included in the microfiche appendix of the final report; these include monthly time series plots, current roses, and statistics. Representative samples presented here and discussed include wind fields and eddy-shelf interactions. A representative plot is presented of a trajectory for one of four drifters deployed during the second field year by LATEX A. Also shown are representative plots of wave heights and spectral periods for a case recorded during the passage of Hurricane Andrew; scales analyses from the first seven LATEX A hydrographic cruises; vertical sections of measured hydrographic properties; and geopotential anomaly distributions.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF TABLES

LIST OF TABLES (continued)

ACRONYMS AND ABBREVIATIONS

ADCP	acoustic Doppler current profiler
ARGOS	Service ARGOS
AVHRR	Advanced Very High Resolution Radiometer satellite
C-MAN	Coastal-Marine Automated Network
CTD	conductivity-temperature-depth
DMA	Defense Mapping Agency, Bethesda MD
DMT	digital magnetic tape
DSI	Defense Systems, Inc.
EHI	Evans-Hamilton, Inc.
EOF	empirical othogonal function
GDAS	Global Data Assimilation System
GMT	Generic Mapping Tool software
GMT	Greenwich Mean Time
GPS	Global Positioning System
GTS	Global Telecommunications System
HPLC	high performance liquid chromatography
ICS	ICSensors
IES	inverted echo sounder
LATEX	Louisiana-Texas Shelf Physical Oceanography Program
LATEX A	Texas-Louisiana Shelf Circulation and Transport Processes Study of LATEX (also LATEX Shelf)
LATEX B	Mississippi River Plume Hydrography Study of LATEX (also LATEX Plume)
LATEX C	Gulf of Mexico Eddy Circulation Study of LATEX (also LATEX Eddy)
LSU	Louisiana State University
MMA	Maine Maritime Academy
MMS	Minerals Management Service, U.S. Department of the Interior
M/V	motor vessel
NDBC	National Data Buoy Center
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center

ACRONYMS AND ABBREVIATIONS (continued)

NWS	National Weather Service
PBAC	particle beam attenuation coefficient
PTAT2	C-MAN station at Port Aransas TX
QA/QC	quality assurance/quality control
RCM	recording current meter
RDI	RD Instruments, Inc.
R/V	research vessel
SAIC	Science Applications International Corporation
SAP	LATEX Science Advisory Panel
SAS	statistical analysis system
SEAS	Shipboard Environmental data Acquisition System
SNL	surface nepheloid layer
SOOP	Ship of Opportunity Program
SRST2	C-MAN station at Sabine, TX
SSM	solid state memory
TAMU	Texas A&M University
TAMUG	Texas A&M University at Galveston
TIGER	Texas Institutions Gulf Ecosystem Research initiative
USCG	United States Coast Guard
USM	University of Southern Mississippi
USN	U.S. Navy Submarine Group 10, Kings Bay GA
UTC	Universal Coordinated Time
XCP	expendable current profiler
XBT	expendable bathythermograph probe
XSV	expendable sound velocity probe

ACKNOWLEDGMENTS

This report would not have been possible without the contributions of a large number of people from Texas A&M University (TAMU), Louisiana State University (LSU), Evans-Hamilton, Inc. (EHI), Maine Maritime Academy (MMA), and the University of Southern Mississippi (USM). Each LATEX A principal investigator contributed portions of the text dealing with the tasks for which he/she was responsible. The principal investigators, their affiliations, and their tasks are:

Worth D. Nowlin, Jr.	TAMU	Program Management, Tasks A-2 and A-8
Ann E. Jochens	TAMU	Program Management, Task A-8
Norman L. Guinasso, Jr.	TAMU	Data Management, Task A-5, A-7, A-10, A-11
Robert C. Hamilton	EHI	Tasks A-1 and A-12
Denis A. Wiesenburg	USM	Task A-3
Douglas C. Biggs	TAMU	Task A-4
S.A. Hsu	LSU	Task A-6
Robert O. Reid	TAMU	Task A-9

The editors were assisted greatly by the efforts and contributions of the excellent LATEX A staff at TAMU. Special thanks to Matt Howard for his writing and graphics contributions. We thank Steven DiMarco, Linwood Lee III, and Carrie Neuhard for their contributions to the writing, graphics, and data corrections for this report. We thank Debz DeFreitas, Frank Kelly, and Jodi Hughes for their help in providing information and graphics for this report. We appreciate the efforts of Yongxiang Li, Wensu Wang, Carole Current, and Hsien-Wen Chen for their work on figures and Paul Griffin for assisting as needed.

We also thank John Cochrane, a member of the LATEX Science Advisory Panel, for contributing his thoughts on upwelling on the shelf and for showing an active interest in the LATEX data set above and beyond that required of Panel members.

To all who participated on the nine LATEX A cruises during the second field year we extend our great appreciation. Special thanks go to Ken Bottom, Mark Garner, Dennis Guffy, Rick O'Neill, Mark Spears, and Eddie Webb of the Technical Support Services Group, Department of Oceanography, TAMU; Bob Albers, Roy Davis, Mike Fredericks, Jim Jobling, Chris Nugent, and John Shannon of the Geochemical and Environmental Research Group (GERG), TAMU; Paula Bontempi, graduate student in the Department of Oceanography, TAMU; Lauren Sahl of MMA; Joel Chaky, Ken Fitzgerald, and Rod Fredericks of the Coastal Studies Institute at LSU; Brian W. Blanchard of LSU; and Chuck Abbott, Jeff Cox, Doug Evans, Troy Horton, Dan Howard, Keith Kurrus, and Eric Noah of EHI. Also, EHI's land crew: Barbara Allen and Jackie Abert.

We extend our appreciation to Roger Fay of GERG for his work in coordinating logistical and onshore support for LATEX A current meter cruises. No data could be collected without outstanding work by the crew of the vessels: Thus, our thanks go to Captain Mike Field on the R/V *Gyre* and Captain Pat Sherrard on the R/V *J. W. Powell*, and to their crews. Captain Dean Letzring and Sandra Green of Marine Operations, Department of Oceanography, TAMU, offered assistance with many aspects of the LATEX cruises. Their unfailing cooperation has been invaluable and is appreciated greatly.

Thanks also to Phyllis Bonifazi, Charlene Miller, Teresa O'Brien, and team Neptune at the Texas A&M Research Foundation for helping us purchase equipment quickly, pay our bills on time, and keep our budgets in line.

Thanks to the LATEX Science Advisory Panel for stimulating discussions and ideas.

Finally, and especially, we thank Maureen Reap for her editorial work on this report and for putting together the slide set.

Ann E. Jochens
Worth D. Nowlin, Jr.

ERS-1 data were obtained from the NASA Physical Oceanography Distributed Active Archive Center at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.

1 EXECUTIVE SUMMARY

1.1 Introduction

The Minerals Management Service (MMS) of the U.S. Department of the Interior supports the Louisiana-Texas Shelf Physical Oceanography Program (LATEX). LATEX is divided into three study units: Study Unit A, Texas-Louisiana Shelf Circulation and Transport Processes (LATEX A or LATEX Shelf); Study Unit B, Mississippi River Plume Hydrography (LATEX B or LATEX Plume); and Study Unit C, Gulf of Mexico Eddy Circulation (LATEX C or LATEX Eddy). LATEX A, the largest of the three studies, covers the middle and outer Texas-Louisiana continental shelf from the Mississippi River to the Rio Grande. This report focuses on the work of LATEX A during the second field year, April 1993 through March 1994. Per the contract, this report does not contain detailed analyses or interpretation of the data collected. Information on the first field year (April 1992 through March 1993) can be found in Jochens and Nowlin (1994a, 1994b).

The contract for LATEX A was awarded to the Texas A&M Research Foundation on 30 September 1991. The Texas A&M University System, a combination of Texas institutions of higher learning and Texas state agencies dedicated to training, research, and extension, conducts the LATEX A Program. In addition to support from the MMS, financial backing for LATEX A is provided by the Texas Institute of Oceanography, the Texas Engineering Experiment Station, and Texas A&M University (TAMU), all components of the System. The System is assisted in this program by subcontracts with Evans-Hamilton, Inc. (EHI), Louisiana State University (LSU), Maine Maritime Academy (MMA), and the University of Southern Mississippi (USM).

The major objective of LATEX A is to identify key dynamical processes governing circulation, transport, and cross-shelf mixing on the Texas-Louisiana shelf. This objective will be met through the completion of a three-year field program over the Texas-Louisiana continental shelf, after which observations will be synthesized, interpreted, and reported to provide a better understanding of circulation and transport of properties over the shelf.

Program management is overseen by the Program Management Office, under Dr. Worth D. Nowlin, Jr., Program Manager, and Dr. Ann E. Jochens, Deputy Program Manager. Data collection is accomplished through six tasks in LATEX A. These are:

• Current and Meteorological Measurement Moorings (Task A-1, Mr. Robert C. Hamilton of EHI, Principal Investigator): provides a shelf-wide network of current, temperature, salinity, and meteorological time series with which to identify, characterize, and parameterize circulation processes. The moored array in year two consisted of a boundary array along the shelf edge, cross-shelf arrays for study of along-shelf transports, and two deep-water inverted echo sounders to monitor the westward passage of rings into the Texas-Louisiana shelf region. The wild card array deployed during the first field year was removed to provide a source of spare instruments for the main array.

• ARGOS-Tracked Drifting Buoys (Task A-2, Dr. Worth D. Nowlin, Jr., of TAMU, Principal Investigator): deploys sixteen drifters to study the continunity of alongshore flow. During the second field year, four drifters were deployed on the middle and outer shelf near 94°W.

• Standard Grid Hydrography (Task A-3, Dr. Denis A. Wiesenburg of TAMU (now with USM), Principal Investigator): conducts hydrographic/acoustic Doppler current profiler (ADCP) survey work to characterize the seasonal patterns of circulation and water mass characteristics and to allow initial assessment of interannual variability. Three full shelf surveys were completed during the second field year.

• Task A-4, Acoustic Doppler Current Surveys (Task A-4, Dr. Douglas C. Biggs of TAMU, Principal Investigator): conducts ADCP surveys on all hydrographic cruises to provide vertical profiles of currents. Three were conducted in the second field year.

• Collateral Data Collection (Task A-5, Dr. Norman L. Guinasso, Jr., of TAMU, Principal Investigator): consists of the assembly of data from concurrent programs in the LATEX region and from historical sources to expand the data base available for study.

• Winter Northers/Cyclogenesis (Task A-6, Dr. S.A. Hsu of LSU, Principal Investigator): consists of the deployment and maintenance of four meteorological buoys during the winter season and the study of cyclogenesis resulting from cold air outbreaks over the Texas-Louisiana shelf.

Data quality control and processing are provided under Task A-7, Data Quality Control, by the LATEX A Data Management Office at the direction of Dr. Norman L. Guinasso, Jr., Data Manager. Additionally, the Data Office oversees Task A-10, Information Transfer, under which the GULF.MEX electronic bulletin board on Omnet is maintained, and Task A-11, Public Notification, Cooperation, and Data Dissemination, under which the *LATEX Fortnightly* newsletter is published and information is provided to federal agencies and the public.

Once data have undergone quality control, the analysis phase of LATEX A begins. There are three tasks under this phase: First is the Analyses and Reports task (Task A-8, Dr. Worth D. Nowlin, Jr., and Dr. Ann E. Jochens of TAMU, Co-Principal Investigators) under which the scientific analyses and syntheses of the data are performed and annual reports to MMS are prepared and finalized. Second is the Field Measurements/Model Comparisons task (Task A-9, Professor Robert O. Reid of TAMU, Principal Investigator) which is to compare the LATEX observational data with model results; the LATEX Science Advisory Panel is supported under this task. Third is the analysis portion of Task A-6.

All government furnished equipment and capital equipment provided by MMS will be refurbished and returned to MMS under the Government Furnished Equipment/Capital Equipment task (Task A-12, Mr. Robert C. Hamilton, Principal Investigator). There was no activity under this task during the second field year.

1.2 Field Activities

1.2.1 Introduction

Six mooring cruises and three hydrographic/ADCP survey cruises were conducted in the second field year. From April 1993 through March 1994, data were collected from an array of current meter moorings, meteorological buoys, drifting buoys, and hydrographic/ADCP surveys on the Texas-Louisiana continental shelf in the Gulf of Mexico. After collection, the data sets were processed for quality assurance and quality control.

1.2.2 Moored Measurements

The current meter array consisted of 66 current meters measuring current speed and direction, temperature, and conductivity on 27 moorings; five directional wave gauges measuring current speed and direction, temperature, and pressure near the sea floor; and two inverted echo sounders measuring acoustic travel time and bottom temperature and pressure. Eight meteorological buoys, including four Task A-6 buoys, were installed on the shelf to measure wind speed and direction, air and sea surface temperature, and barometric pressure. Table 1.2.1 lists the instrumentation typically deployed on each mooring and the maintenance schedule. Figure 1.2.1 shows the locations of the moorings.

1.2.3 Drifting Buoy Measurements

Four drifting buoys were deployed during the second-year hydrographic surveys, all on the May 1993 hydrographic cruise. They were deployed along 94° W over the outer shelf near the continental shelf break (~200-m isobath). The drifter deployed at the shelf break was drawn off the shelf into Loop Current Eddy Vazquez. All drifters provided information on their locations and sea surface temperature via satellite. The mean lifetime of the four drifters was 168 days with a range of 71 to 251 days.

1.2.4 Hydrographic/ADCP Measurements

Three hydrographic/ADCP surveys were conducted with over 200 hydrographic sampling stations per survey and continuous ADCP measurements along the cruise track. Figure 1.2.2 shows a typical cruise track and station locations. At each hydrographic sampling station, continuous profiles were made of conductivity, temperature, dissolved oxygen, downwelling irradiance, particle scattering, fluorescence, and percent transmission (which gives the paricle beam attenuation coefficient). Up to 12 water samples were taken at each station and analyzed for six nutrients: nitrate, nitrite, phosphate, silicate, urea, and ammonium. At half or more of the stations, the water samples were analyzed for dissolved oxygen, salinity, phytoplankton pigments, and the surface and bottom particulate matter concentrations. Secchi disk depths were taken at each daylight station. Meteorological measurements were transmitted to the Global Telecommunications System four times daily. Several complementary research programs were conducted on each of the LATEX A hydrographic surveys.

1.3 Collateral Data

Collateral data consists of information from historical or concurrent programs on the Texas-Louisiana shelf. These data are collected to augment the LATEX A data set and to aid in interpretations. Historical information was compiled during the first field year. Concurrent data were obtained from numerous other programs collecting oceanographic data in the LATEX region during the second field year, including data from LATEX B and C and weather buoy data from NOAA.

Table 1.2.1. Typical mooring configurations.

Mooring No.	Water Depth (m)	Latitude (°N)	Longitude (°W)	Comments	Top Meter Depth	Middle Meter Depth	Bottom Meter Depth	Maintenance Interval (Day)
1	21	27°15.39'	97°14.81'	Platform	10m		19m	120
2	37	27°17.09'	96°58.81'	Platform	10m		30m	120
3	66	27°17.35'	96°44.18'	Platform	10m	30m	61m	120
4	201	27°07.76'	96°21.63'	MarkerBuoy	14m	100m	190m	120
5	199	27°27.82'	96°04.12'	MarkerBuoy	14m	100m	190m	120
6	201	27°42.59'	95°39.76'	MarkerBuoy	14m	100m	190m	120
7	199	27°50.12'	95°04.19'	MarkerBuoy	14m	100m	190m	120
8	200	27°49.47'	94°10.77'	MarkerBuoy	14m	100m	190m	120
9	200	27°48.92'	93°31.91'	MarkerBuoy	14m	100m	190m	120
10	200	27°56.07'	92°44.70'	MarkerBuoy	14m	100m	190m	120
11	200	27°50.64'	92°00.45'	MarkerBuoy	14m	100m	190m	120
12	505	27°55.76'	90°29.64'	MarkerBuoy	14m	100m	495m	180
13	200	28°03.48'	90°29.18'	MarkerBuoy	14m	100m	190m	120
14	47	28°23.74'	90°29.65'	Platform	14m	26m	42m	60
15	27	28°36.49'	90°29.53'	Platform	10m		24m	60
16	19	28°51.96'	90°29.50'	Platform	10m		17m	60
17	7	29°11.82'	91°57.89'	MetBuoy;Platform	3m		5m	60
18	22	28°57.74'	91°59.01'	Platform	10m		21m	60
19	51	28°27.92'	92°02.06'	MetBuoy;Platform	3m	21m	44m	60
20	15	29°15.67'	94°03.82'	MetBuoy;Platform	3m		13m	60
21/51	24	28°50.28'	94°04.79'	MetBuoy;Platform	10m		21m	60
22	55	28°21.39'	93°57.34'	MetBuoy;Platform	3m	20m	48m	60
23	15	28°42.77'	95°32.13'	Platform	9m		13m	60
24	30	28°32.21'	95°23.61'	Platform	11m		27m	60
25	45	28°19.33'	95°21.57'	Platform	13m	23m	38m	60
42	1540	27°07.00'	92°00.00'	IES;at sea floor			1540m	360
43	3130	25°32.52'	92°00.00'	IES;at sea floor			3130m	360
44				Removed				
45				Removed				
46				Removed				
48	200	27°58.98'	91°16.99'	MarkerBuoy	14m	100m	190m	120
49	505	27°23.13'	95°53.96'	MarkerBuoy	14m	100m	495m	180
50	20	28°52.86'	95°02.20'	MetBuoy;Platform				60
51/21	24	28°50.28'	94°04.79'	MetBuoy;Platform	10m		21m	60
52	27	28°48.18'	93°01.11'	MetBuoy;Platform				60
53	15	28°48.04'	90°57.22'	MetBuoy;Platform				60

MetBuoy = DSI Surface Meteorological Buoy; Marker Buoy = Lighted Surface Marker Buoy;
IES = Inverted Echo Sounder; blank=No instrument; Platform=Mooring loacted near permanent structure

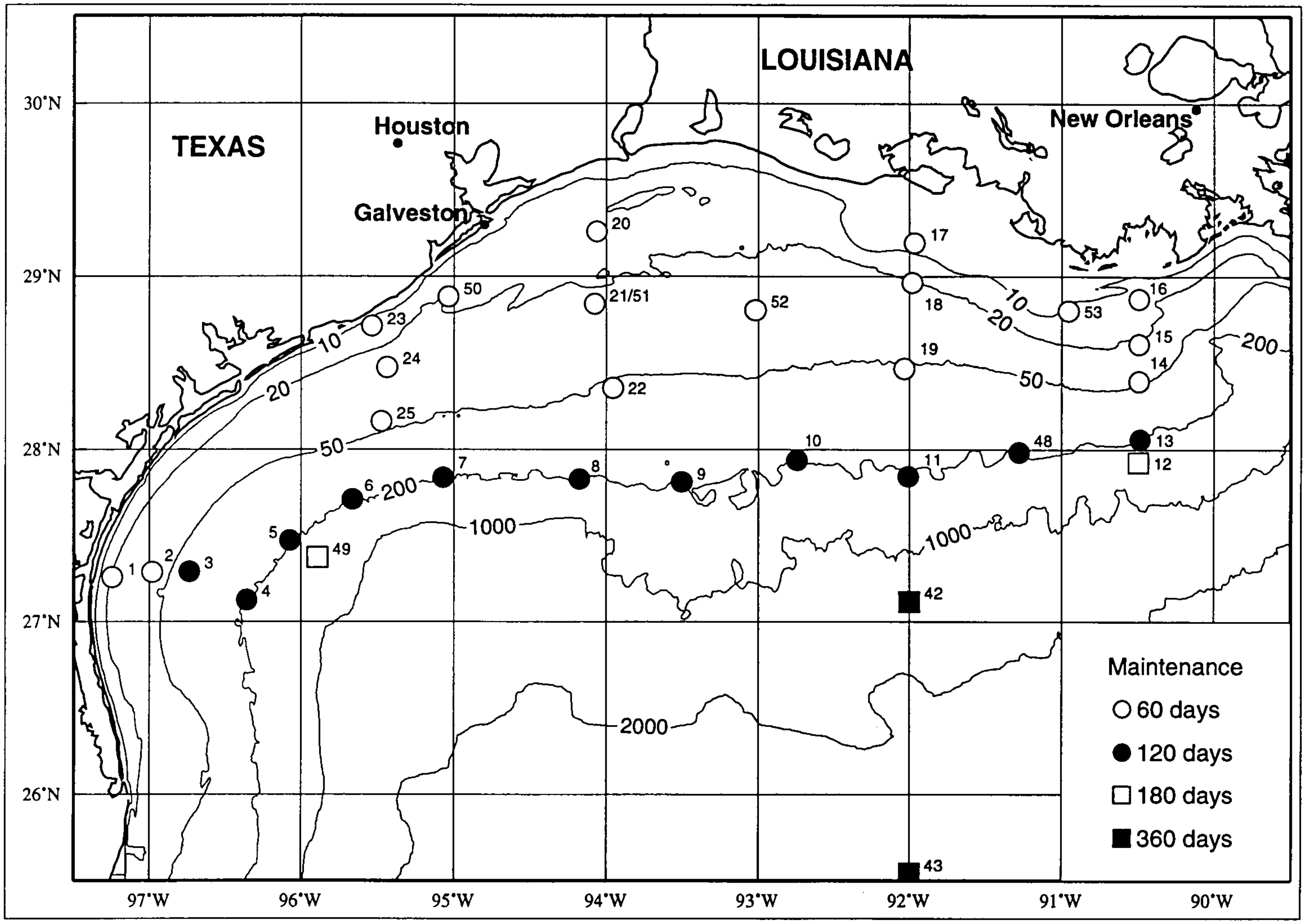


Figure 1.2.1. Moored array locations.

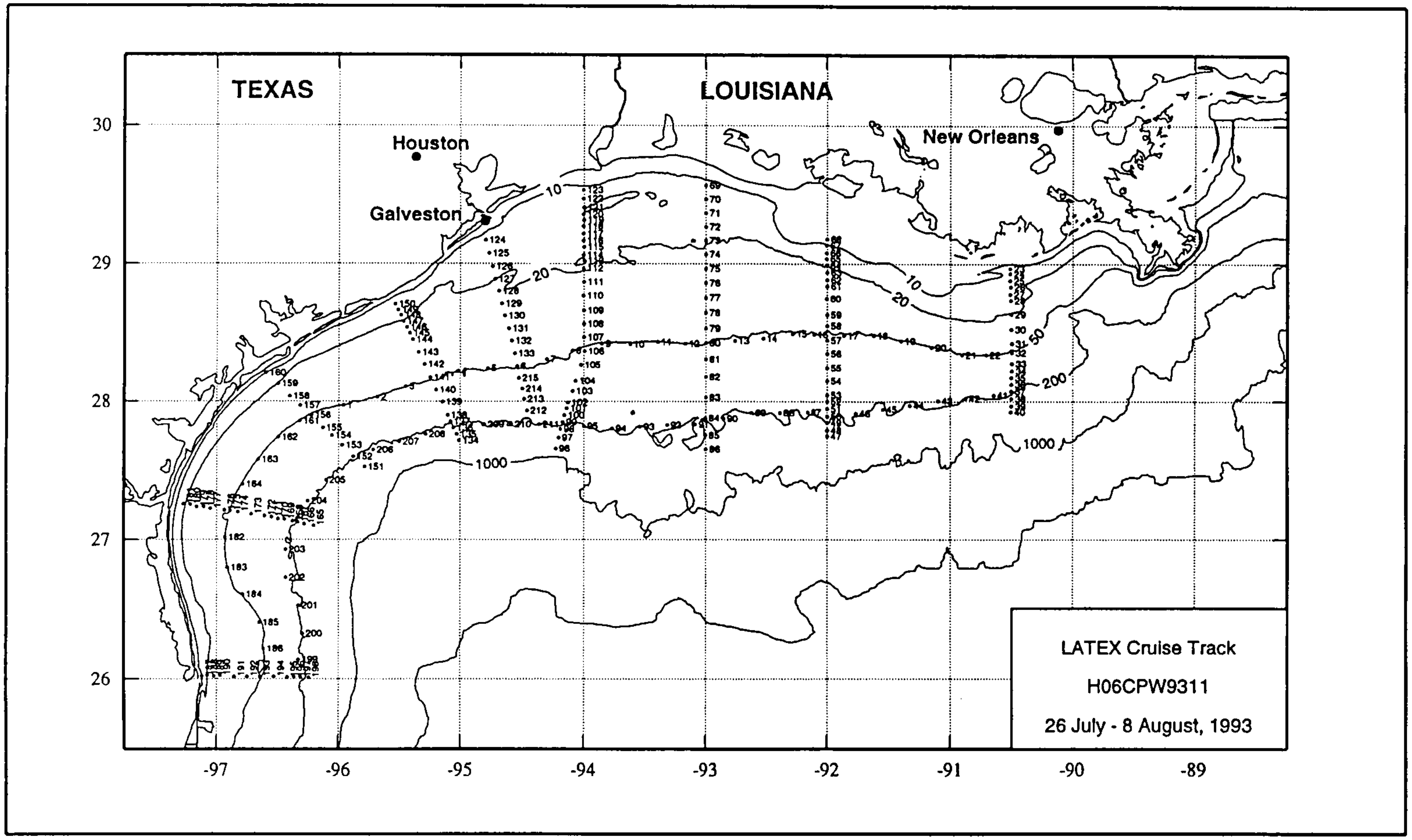


Figure 1.2.2. Typical hydrographic/ADCP cruise track and station locations.

1.4 Observations/Model Comparison

To assist with the observation/model comparisons, the LATEX Science Advisory Panel (SAP) was formed. The members of the SAP and their affiliations are: John S. Allen, Chairman (Oregon State University), John D. Cochrane (Texas A&M University, retired), Gabriel T. Csanady (Old Dominion University), Richard W. Garvine (University of Delaware), Dong-Ping Wang (SUNY - Stony Brook), Clinton D. Winant (Scripps Institution of Oceanography), and William J. Wiseman, Jr. (Louisiana State University). Members George Z. Forristall (Shell Development Company) and A.D. Kirwan (Old Dominion University) rotated off the SAP during the second field year. One meeting of the SAP was held during the second annual report year. It was held in New Orleans on 26-28 October 1993.

1.5 Technical Discussion

1.5.1 Introduction

This second annual report focuses on the data collection and processing activities of LATEX A. As required by the contract, it contains representative graphical products but no detailed analyses of the data. The results of several preliminary analyses associated with interesting phenomena, however, are presented as the vehicles for providing examples of representative products that will be provided in the final report. Section 6 of this report provides the discussion and examples of representative products. Additional examples of products can be found in the first annual report (Jochens and Nowlin 1994b). Below are given brief summaries of the preliminary results from several of the analyses presented in section 6.

1.5.2 Scales Analyses of Hydrographic Parameters

Horizontal scales of temperature, salinity, and geopotential anomaly distributions were analyzed using hydrographic data. A spatial mean reference field for each parameter, obtained using a quadratic fit, was removed from the individual LATEX A data fields to to allow study of the spatial variability at smaller (anomaly) scales. Preliminary results indicate that over the eastern and central portions of the Texas-Louisiana shelf, the cross-shelf anomaly scales for surface salinity, surface temperature, and geopotential anomaly are near 20 km. Temperature scales are somewhat shorter. In contrast, the cross-shelf anomaly scales from the western portion of the shelf (although represented by fewer realizations) range from 8 to 15 km, with averages of 8 to 14 km; again temperature scales are slightly shorter. The average alongshelf anomaly scales over the east and central shelf are 30 to 38 km, with no real difference between scales at the shelf edge (200-m isobath) and those at mid-shelf (50-m isobath). The surface salinity scales are somewhat shorter than those for temperature and geopotential anomaly.

1.5.3 Seasonal and Interannual Variability

Historical hydrographic data are being combined with LATEX A hydrographic data to study the seasonal and interannual variability of the general circulation patterns over the Texas-Louisiana Shelf. Preliminary results indicate that the distributions of temperature, salinity, and geopotential anomaly generally conform to the seasonal patterns hypothesized by Cochrane and Kelly (1986); there are, however, significant deviations, e.g., at times of anomalous river discharge.

1.5.4 Coastal Upwelling

An analysis of wind-driven coastal upwelling and related currents off south Texas was conducted using climatological monthly mean wind stresses, satellite infrared imagery, and salinity and temperature data from hydrography, current meters, and tide stations. Preliminary results indicate that data showing upcoast wind stress, cooler nearshore water temperatures, higher nearshore salinities, and upcoast currents are indicative of upwelling conditions. These conditions occur predominanly in July and August. Weaker upwelling may occur in transition periods in June and September.

1.5.5 Phenomena at the Outer Shelf Boundary

Data from hydrography, current meters, and drifters are combined, together with sea surface height anomalies from satellite altimeters (not shown), in a preliminary analysis of the effects of the anticyclonic Loop Current Eddy Vazquez (Eddy V) on the shelf circulation. The data set shows shelf water flowing across the shelf edge on the eastern flank of Eddy V and on the south flank of a cyclonic eddy located to the west of Eddy V. The data set also indicates that water from the northwest side of Eddy V was moving onto the shelf.

1.5.6 Cyclogenesis

Based on the classification scheme of Hsu (1993), there were 13 winter cyclogenesis events between November 1993 and May 1994. Typically, there are 10 cyclogenesis events per year (Johnson et al. 1984). Two of these were "meteorological bombs" with pressures at or below 1006 mb. These occurred on 13 December 1994 and 27 March 1994. The more severe winter cyclogenesis events over the LATEX region can produce wave steepness that exceeds the statistical extreme steepness value obtained by Buckley (1988) from a review of the archive of NDBC and Canadian oil rig stations.

2 INTRODUCTION

2.1 Programmatic Changes

No programmatic changes were made to the current measurement mooring program during the second field year. Because numerous current meters were lost due to fishing pressure and other problems, moorings 25 and 12 were removed during the second year so their instruments could be used as spares to keep the main array intact.

The original hydrographic sampling plan called for four cruises per year, each covering half the Texas-Louisiana shelf. During the first field year, four cruises were conducted over the eastern half of the shelf. During the second field year, the plan was modified to provide three cruises per year, each covering the full shelf. Hydrographic/ADCP surveys covering the full shelf were conducted during April/May, July/August, and November 1993, with the February 1994 cruise being eliminated. Details on the rationale for this change were provided in Jochens and Nowlin (1994b).

2.2 Overview of Cruise Schedule and Nomenclature

Six mooring cruises and three hydrographic/ADCP survey cruises were conducted in the LATEX A program during the second field year. All LATEX A cruises were conducted aboard the R/V *J.W. Powell*, the M/V *Erica Tide,* or the M/V *Seis Surveyor*. Table 2.2.1 provides a listing of these cruises, their various designators, and their start and end dates.

The MMS identifying code is the number assigned each LATEX cruise in the LATEX Calendar that is posted to GULF.MEX. This designator is deciphered as follows

First character:	M=mooring cruise; H=hydrographic/ADCP survey
Second & third characters:	LATEX A mooring cruise number, LATEX A hydrographic/ADCP survey number
Fourth character:	C=cruise
Fifth & Sixth characters:	vessel identifier (PW = R/V *J.W. Powell*; SS = M/V *Seis Surveyor*)
Seventh & eighth characters:	year of cruise
Ninth & tenth characters:	vessel cruise number

Note for cruise 10, the MMS ID for the R/V *J.W. Powell* was used, although the cruise was divided into two legs. The first leg was aboard the R/V *Powell* (M10A) to conduct the regular mooring maintenance. The second leg was aboard the M/V *Erica Tide* (M06B) to conduct maintenance on the inverted echo sounders.

The LATEX ID is the shorthand identifier used in this report. The cruise ID number is the standard cruise identifier in wide use in the oceanographic community. The first two characters give the year of the cruise, the third character gives the ship identifier (P = *Powell;* S = *Seis Surveyor*), and the last two characters give the number of the ship cruise for that year.

Table 2.2.1. Cruise identifiers and dates.

Current Mooring Maintenance Cruises

Cruise	Description	MMS ID	Start Date	End Date	LATEX ID	Cruise ID
9	120 Day Maintenance	M09CPW9307	05/18/93	05/28/93	M09	93P07
10A	60 Day Maintenance	M10CPW9310	07/13/93	07/19/93	M10A	93P10
10B	IES Maintenance	M10CPW9310	07/22/93	07/26/93	M10B	*Erica Tide*
11	120 Day Maintenance	M11CPW9312	09/21/93	10/01/93	M11	93P12
12	120 Day Maintenance	M12CPW9315	12/03/93	12/13/93	M12	93P15
13	60 Day Maintenance	M13CPW9402	02/09/94	02/16/94	M13	94P02
14	120 Day Maintenance	M14CSS9414	03/21/94	04/01/94	M14	94S13

Hydrographic Surveys

Survey	Description	MMS ID	Start Date	End Date	LATEX ID	Cruise ID
5	Full Shelf	H05CPW9306	04/25/93	05/11/93	H05	93P06
6	Full Shelf	H06CPW9311	07/25/93	08/07/93	H06	93P11
7	Full Shelf	H07CPW9314	11/06/93	11/22/93	H07	93P14

2.3 Report Organization

This is the second annual report of the LATEX A Study. It reports on the results of the second 12 months of field work in terms of data-gathering efforts, the measurement and analytical methodologies employed, quantity of data collected, the results of quality control exercises and determinations, the status of data archiving and data sharing with other contractors, standard computer-produced graphics, and comparisons between standard computer-produced graphics and any graphics provided from model simulations performed by a designated other contractor. There are no extensive analyses or syntheses of the information. Section 3 of the report details the data acquisition for the moored measurements, drifting buoy measurements, hydrographic and ADCP measurements, and collateral data assembly. Section 4 discusses data quality and analysis for the observations collected, including data processing efforts and data quality control methods and results. Section 5 summarizes the data archiving and information sharing through March 1994. Section 6 provides a technical discussion of the data, with samples of data products, from the moorings, drifters, hydrographic/ADCP surveys, and cyclogenesis study. It also provides a discussion of the model/data comparison study and the activities of the Science Advisory Panel. All times are reported in Universal Coordinated Time (UTC) unless stated otherwise. Although the data have been processed for quality control and quality assurance, they are still preliminary; users should expect that subsequent corrections will be made to all data sets prior to the final submission to the NODC in 1996.

3 DATA ACQUISITION

3.1 Introduction

Section 3 provides an overview of the LATEX A data acquisition activities. It includes a discussion of data gathering efforts from the moored current meter array, meteorological buoys, drifting buoys, hydrographic/ADCP surveys, and collateral data assembly. Six mooring maintenance cruises and three hydrographic/ADCP cruises are summarized, giving data types, data collection methods, and locations and times of data collection.

3.2 Moored Measurements

3.2.1 Mooring Maintenance Cruises

During the second year of field operations, six mooring cruises were conducted. The dates for these cruises are summarized in Table 2.2.1. Maintenance work consisted of retrieval of instruments and moorings, as necessary, check-out and refurbishment of equipment, downloading of data, and redeployment of equipment. CTD casts were taken at each mooring visited to provide calibration information for temperature and conductivity sensors and for interpretation.

Moorings in different water depths were maintained on different schedules as indicated in Table 3.2.1, which gives the mooring configurations at the beginning of the second field year. Modifications to these configurations are discussed under descriptions of each cruise. Figure 3.2.1 shows the locations of the moorings.

During the second year of operations, 66 current meters, eight meteorological buoys, five directional wave gauges, one wave meter, 17 acoustic releases, 12 transponders, and two inverted echo sounders (IES) were used. Of these instruments, 12 current meters, five surface marker buoys, one meteorological buoy, one directional wave gauge, 3 acoustic releases, 5 transponders, and one inverted echo sounder were lost permanently due to fishing activity, failure of the instrument to surface, damage beyond repair, or other difficulties such as loss due to flooding.

The following is a summary of the major events of the six current meter cruises made during the second year of field operations. All cruises on the *R/V J.W. Powell* departed from and returned to Galveston, Texas. Table 3.2.2 lists the stations visited each cruise.

3.2.1.1 Cruise M09CPW9307

The first 120-day mooring maintenance cruise (M09) of the second field year was conducted from the *R/V J.W. Powell* 18-28 May 1993. Thirty moorings were recovered and maintained. The Endeco current meters were retrimmed and reballasted. Twenty-six moorings were re-deployed. Meteorological moorings 50, 51, 52, and 53, used for the winter norther/cyclogenesis study, were removed for the hurricane season. The MiniSpec directional wave gauges at moorings 16, 17, 20, and 23 were removed for post-deployment testing. A Sea Data 635-8 wave gauge was removed from mooring 1 and installed at mooring 16. Surface marker buoys were replaced at 5, 9, and 11. The surface marker buoy at mooring 49 had washed ashore just prior to the cruise; it was replaced and maintenance was performed on the mooring. The planned reinstallation of the surface marker buoy at mooring 12 was prevented due to lack of spare marker buoys, and the

Table 3.2.1. Mooring configurations as of April 1993.

Mooring No.	Water Depth (m)	Latitude (°N)	Longitude (°W)	Comments	Top	Middle	Bottom	Release	Maintenance Interval (Day)
1	21	27°15.39'	97°14.81'	Platform	174-10m , T,C	NONE	Mini-19m, T	NONE	120
2	37	27°17.09'	96°58.81'	Platform	174-10m, T,C	NONE	174-30m, T,C	NONE	120
3	66	27°17.35'	96°44.18'	Platform	174-10m, T,C	174-30m, T,C	174-61m, T,C	397	120
4	201	27°07.76'	96°21.63'	Marker Buoy "L"	174-14m, T,C	Aand-100m, T,C	Aand-190m, T,C	397	120
5	199	27°27.82'	96°04.12'	Marker Buoy "M"	174-14m, T,C	Aand-100m, T,C	Aand-190m, T,C	397	120
6	201	27°42.59'	95°39.76'	Marker Buoy "N"	174-14m, T,C	Aand-100m, T,C	Aand-190m, T,C	397	120
7	199	27°50.12'	95°04.19'	Marker Buoy "O"	174-14m, T,C	Aand-100m, T,C	Aand-190m, T,C	397	120
8	200	27°49.47'	94°10.77'	Marker Buoy "P"	174-14m, T,C	Aand-100m, T,C	Aand-190m, T,C	397	120
9	200	27°48.92'	93°31.91'	Marker Buoy "Q"	174-14m, T,C	Aand-100m, T,C	Aand-190m, T,C	397	120
10	200	27°56.07'	92°44.70'	Marker Buoy "R"	174-14m, T,C	Aand-100m, T,C	Aand-190m, T,C	397	120
11	200	27°50.64'	92°00.45'	Marker Buoy "S"	174-14m, T,C	Aand-100m, T,C	Aand-190m, T,C	Benthos	120
12	505	27°55.76'	90°29.64'	Marker Buoy "T"	174-14m, T,C	Aand-100m, T,C	RCM-495m, T,C	Benthos	180
13	200	28°03.48'	90°29.18'	Marker Buoy "U"	174-14m, T,C	Aand-100m, T,C	Aand-190m, T,C	Benthos	120
14	47	28°23.74'	90°29.65'	Platform	174-14m, T,C	174-26m, T,C	174-42m, T,C	NONE	60
15	27	28°36.49'	90°29.53'	Platform	174-10m, T,C	NONE	174-24m, T,C	NONE	60
16	19	28°51.96'	90°29.50'	Platform	174-10m, T,C	NONE	Mini-17m, T	NONE	60
17	7	29°11.82'	91°57.89'	Platform & Met Buoy "C"=937	S4-3m, T,C	NONE	Mini-5m, T	NONE	60
18	22	28°57.74'	91°59.01'	Platform	174-10m, T,C	NONE	174-21m, T,C	NONE	60
19	51	28°27.92'	92°02.06'	Platform & Met Buoy "D"=930	S4-3m, T,C	174-21m, T,C	174-44m, T,C	397	60
20	15	29°15.67'	94°03.82'	Platform & Met Buoy "E"=931	S4-3m, T,C	NONE	Mini-13m, T	NONE	60
21/51	24	28°50.28'	94°04.79'	Platform & Met Buoy "F"=934	174-10m, T,C	NONE	174-21m, T,C	NONE	60
22	55	28°21.39'	93°57.34'	Platform & Met Buoy "G"=932	S4-3m, T,C	174-20m, T,C	174-48m, T,C	397	60
23	15	28°42.77'	95°32.13'	Platform	174-9m, T,C	NONE	Mini-13m, T	NONE	60
24	30	28°32.21'	95°23.61'	Platform	174-11m, T,C	NONE	174-27m, T,C	NONE	60
25	45	28°19.33'	95°21.57'	Platform	174-13m, T,C	174-23m, T,C	174-38m, T,C	NONEe	60
42	1540	27°07.00'	92°00.00'	At Sea Floor	NONE	NONE	IES-1540m, T	Internal	360
43	3130	25°32.52'	92°00.00'	At Sea Floor	NONE	NONE	IES-3130m, T	Internal	360
44	56			Permanently Removed					
45	200			Permanently Removed					
46	91			Permanently Removed					
47	200			Permanently Removed					
48	200	27°58.98'	91°16.99'	Marker Buoy "T"	174-14m, T,C	Aand-100m, T	Aand-190m, T	Benthos	120
49	505	27°23.13'	95°53.96'	Marker Buoy "W"	174-14m, T,C	Aand-100m, T,C	Aand-495m, T,C	Benthos	180
50	20	28°52.86'	95°02.20'	Platform & Met Buoy "H"=936	NONE	NONE	NONE	NONE	60
51/21	24	28°50.28'	94°04.79'	Platform & Met Buooy "F"=934	174-10m, T,C	NONE	174-21m, T,C	NONE	60
52	27	28°48.18'	93°01.11'	Platform & Met Buoy "I"=933	NONE	NONE	NONE	NONE	60
53	15	28°48.04'	90°57.22'	Platform & Met Buoy "J"=935	NONE	NONE	NONE	NONE	60

Met Buoy = DSI Surface Meteorological Buoy
S4 = InterOcean S4 Electromagnetic Current Meter
174 = Endeco Model 174SSM Current Meter

Aand = Aanderaa Models RCM 7 or 8
RCM = Aanderaa Models RCM 4 or 5
397 = Datasonics Model 397 Acoustic Release
Benthos = Benthos Model 865-A Acoustic Release

IES = Inverted Echo Sounder
T = Temperature Sensor
C = Conductivity Sensor (not on all instruments)

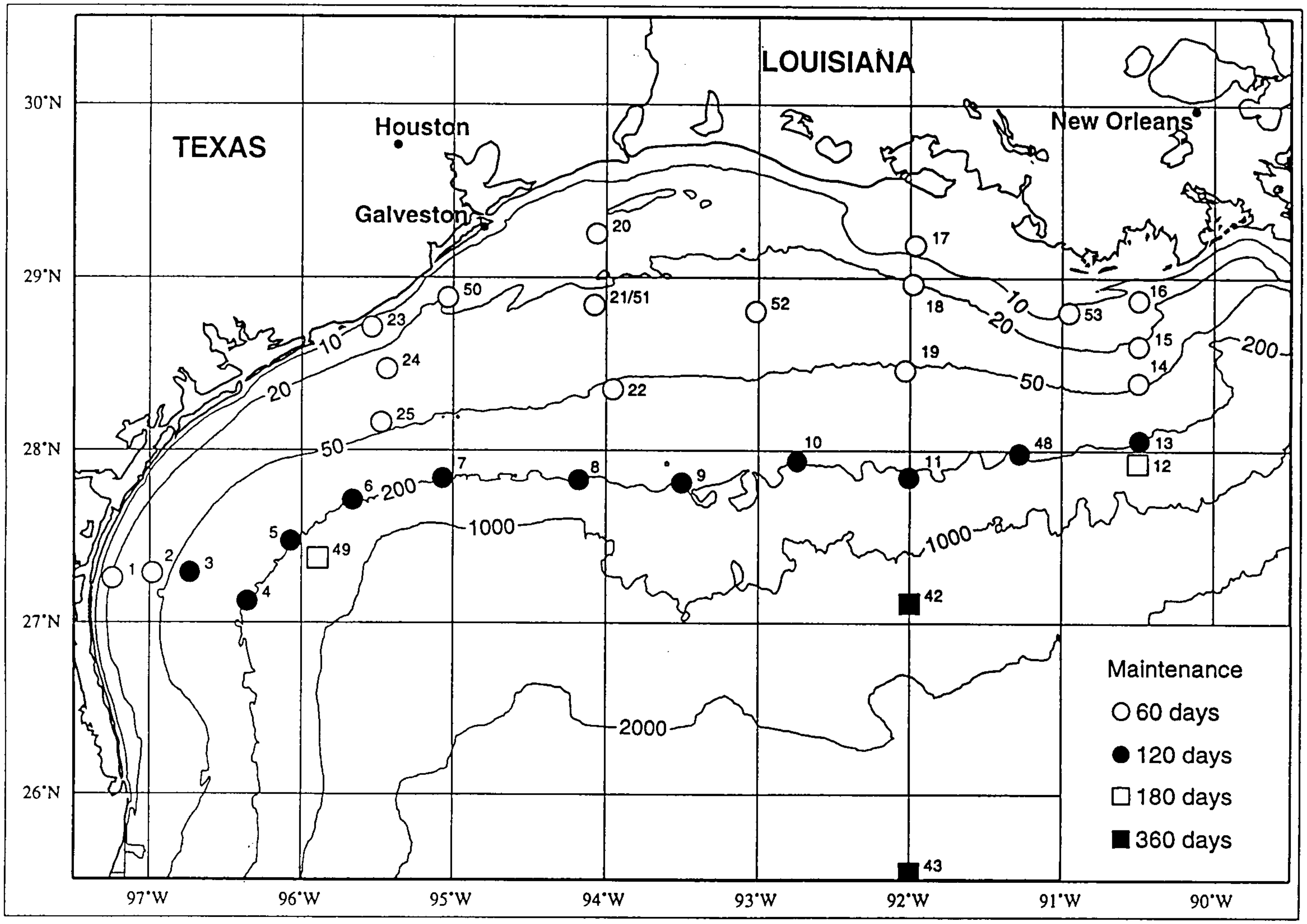


Figure 3.2.1. Mooring locations and maintenance intervals for the second field year.

Table 3.2.2. Mooring maintenance by cruise for the second field year.

Mooring No.	M09	M10	M11	M12	M13	M14
1	√		√	√		√
2	√		√	√		√
3	√		√	√		√
4	√		√	√		√
5	√		√	√		√
6	√		√	√		√
7	√		√	√		√
8	√		√	√		√
9	√		√	√		√
10	√		√	√		√
11	√	√	√	√		√
12	X	√		Remove		
13	√		√	√		√
14	√	√	√	√	√	√
15	√	√	√	√	√	√
16	√	√	√	√	√	√
17	√	√	√	√	√	√
18	√	√	√	√	√	√
19	√	√	√	√	√	√
20	√	√	√	√	√	√
21	√	√	√	√	√	√
22	√	√	√	√	√	√
23	√	√	√	√	√	√
24	√	√	√	√	√	√
25	√	√	√	Remove		
42		√				
43		Lost				
44 (Removed)						
45 (Removed)						
46 (Removed)						
47 (Removed)						
48	√		√	√		√
49	√			√		√
50	Remove			Deploy	√	√
51	Remove			Deploy	√	√
52	Remove			Deploy	√	√
53	Remove			Deploy	√	√

√ = Mooring maintenance conducted
X = Mooring visited, but left in place w/o maintenance

upper instrument on the mooring could not be checked for fouling due to poor visibility in the water. The top Endeco SSM current meter at mooring 9 was missing and presumed lost; it was replaced. Sediment traps were recovered or reinstalled at moorings 15, 16, 18, and 19 for LATEX B.

3.2.1.2 Cruise M10CPW9310

The first 60-day maintenance cruise (M10) of the second field year occurred in two legs on 13-19 July 1993 and 22-26 July 1993. The first leg was conducted aboard the *R/V J.W. Powell.* Fourteen moorings were recovered, maintained, and redeployed. Unusually strong currents were encountered at the moorings on the eastern end of the study area. New mooring wires and hardware were installed on moorings 14 through 23 not previously replaced. The Sea-Data 635-8 wave gauge was removed from mooring 16. Mooring 11, which had been retrieved by a fishing vessel prior to the cruise, was reinstalled. The surface marker buoy at mooring 12 was reinstalled. Sediment traps were recovered or reinstalled at moorings 14, 15, 16, 18, and 19 for LATEX B.

Due to scheduling constraints of the *R/V J.W. Powell*, the second leg of M10 was conducted using the *M/V Erica Tide* to recover moorings 42 and 43, which were instrumented with the inverted echo sounders. The IES at mooring 42 was retrieved and redeployed. Although it appeared to have received the release signal, the IES at mooring 43 did not surface, even after numerous attempts to trigger its release. It was not recovered. XCP profiles were taken at moorings 42 and 43. An XSV and an XBT were launched at mooring 42. Fifteen XBTs were launched at 11.1-km (6-nm) intervals between the 50-m isobath and mooring 42. Three were launched at the first location without success due to a faulty launcher that caused intermittent breaks in the wire. The launcher was repaired. Twelve XBTs returned good profiles. Ten XBTs were launched successfully at 18.5-km (10-nm) intervals between moorings 42 and 43.

Moorings 20 and 17 were visited by LSU personnel aboard the 26-ft *R/V Changes In Latitude* on August 19 and 20, 1993, respectively. The InterOcean S4 current meters and meteorological buoys were inspected for biofouling. The S4s were cleaned to remove the biofouling on the hulls and electrodes. The tower of the meteorological buoy at mooring 17 had been ripped off the buoy and was resting on top of the anchor with all instruments intact. The tower was removed

3.2.1.3 Cruise M11CPW9312

The second 120-day maintenance cruise (M11) was conducted aboard the *R/V J.W. Powell* from 21 September - 1 October 1993. Twenty-five moorings were recovered, maintained and redeployed. The five MiniSpec directional wave gauges were reinstalled at moorings 1, 16, 17, 20, and 23. Moorings 1, 16, and 20 were relocated to shallower water to enhance the collection of wave data. The new locations are shown in Table 3.2.3. New mooring wires and hardware were installed at moorings 1, 2, 16, and 20. The tower and sensors for the meteorological buoy at mooring 17 were replaced. The meteorological buoy, without its tower, and the InterOcean S4 current meter from mooring 19 were found adrift near mooring 15 by a service vessel for a nearby platform. They were retrieved from the platform owner. The remainder of mooring 19 was not recovered. Mooring 19 was replaced. The bottom current meter at mooring 22 exploded during recovery, apparently having flooded. The top current meter at mooring 18 was flooded. The top current meter at mooring 14 was missing and presumed lost. Moorings 11 and 48 were missing and presumed lost. Due to lack of spare instruments these two moorings were not redeployed. Due to corrosion from oxygen starvation on the conductivity cells, many of the Endeco current meters could not be repaired in the field. This greatly reduced the number of spare current meters available for replacing lost or malfunctioning instruments. As a result, no current meters were deployed at the top of moorings 3, 5, 7, 10, 13, 14, 23, and 25 or at the bottom of mooring 3. Sediment traps were recovered or reinstalled at moorings 14, 15, 16, 17, and 18 for LATEX B.

Table 3.2.3. New locations of moorings 1, 16, and 20.

Mooring No.	Latitude N	Longitude W	Water Depth (m)
1	27°19.41'	97°18.42'	13.3
16	28°56.36'	90°26.10'	15.9
20	29°30.03'	94°01.34'	12.4

3.2.1.4 Cruise M12CPW9315

To fill the current meter gaps left at the 200-m isobath on the previous cruise, the twelfth cruise (M12) became the third 120-day maintenance cruise. It was conducted aboard the *R/V J.W. Powell* from 3-13 December 1993. Thirty moorings were visited. Twenty-seven current meter moorings were recovered and maintained. Twenty-five were redeployed. Moorings 12 and 25 were removed from the water to provide spare equipment for the program. Moorings 11 and 48 were redeployed. The missing surface marker buoy at mooring 49 was replaced and the mooring was refurbished. Equipment remaining at the bottom at mooring 19 from the previous cruise, including two current meters, was recovered. Meteorological buoys at moorings 50, 51, 52, and 53 were redeployed. Service ARGOS transmitters were deactivated on all meteorological buoys except those at moorings 19 and 22. Sediment traps were recovered or reinstalled at moorings 15, 16, and 17 for LATEX B.

3.2.1.5 Cruise M13CPW9402

The second 60-day mooring maintenance cruise (M13) took place on the *R/V J.W. Powell* from 9-16 February 1994. Fourteen moorings were recovered, maintained, and redeployed. Poor weather made the maintenance work difficult and slow. Current meters were deployed at 11 of these moorings; five of these mooring locations were also occupied by meteorological buoys. Three moorings were occupied by meteorological buoys alone. The masts of the meteorological buoys at moorings 19, 50, and 52 had been torn off. The damage to the meteorological buoys appears to have been caused by vessels tying off to the buoys. Due to lack of spares, no meteorological buoys were deployed at moorings 51 and 52. The bottom meter at mooring 21 was flooded. A Woods Hole Instrument System Ltd PAC 2000 was installed at mooring 16, adjacent to the MiniSpec, to conduct a calibration test for the MiniSpec. Sediment traps were recovered or reinstalled at moorings 15 and 16 for LATEX B.

3.2.1.6 Cruise M14CSS9414

The fourth 120-day mooring maintenance cruise (M14) was carried out aboard the *M/V Seis Surveyor* from 21 March - 1 April 1994. Twenty-eight moorings were recovered, maintained, and redeployed. Current meters were deployed at 25 moorings; five of these also were occupied by meteorological buoys. Three moorings are occupied by meteorological buoys alone. Mooring 23 was missing, including the MiniSpec, and presumed lost. It is possible that a jack-up rig working in the area inadvertently may have destroyed the mooring, but there is no actual indication of the cause of this loss. The mooring was redeployed without a MiniSpec, due to lack of spares. The meteorological buoys at moorings 51 and 52 were redeployed. The Woods Hole Instrument System Ltd PAC 2000 was removed from mooring 16. The surface marker buoys at moorings 8, 48, and 49 were missing and were replaced. To avoid potential loss of instrumentation from seismic work being done in the area, mooring 9 was relocated to 27°48.82' N 93°32.84' W. Sediment traps were recovered or reinstalled at moorings 14, 15, 16, and 18 for LATEX B.

3.2.2 Instrumentation, Calibration, and Sampling Procedures

The calibration of all instruments and sampling procedures were performed, in general, as noted in sections 9.3 and 9.4 of Nowlin et al. (1991) and in section 2.2.2 of Jochens and Nowlin (1994b). Some variations from the procedures set out in these references occurred due to time constraints and the actual instruments used. Because of instrument loss, the current meters could not be returned to shore for major refurbishment and recalibration as frequently as originally planned. Therefore, the data from the CTD casts taken before and/or after instrument recovery and redeployment were used to assist with instrument calibrations.

3.2.3 Summary of Data Collection

The second year of deployment was from April 1993 through March 1994. Data were recovered from the moored instrumentation during mooring maintenance cruises M09 through M14. Moored instrumentation consisted of current meters collecting current speed and direction, temperature, and conductivity; meteorological buoys collecting wind speed and direction, air and sea surface temperature, and barometric pressure; MiniSpec directional wave gauges collecting current speed and direction, temperature, and pressure and inverted echo sounders collecting acoustic travel time, temperature, and pressure.

3.2.3.1 Current Meter Data

Table 3.2.2 shows moorings visited for maintenance on each cruise. Figure 3.2.2 summarizes the recovery results for the second year. In Figure 3.2.2, T stands for the top instrument, M for the middle, and B for the bottom instrument on the numbered mooring; see Table 3.2.1 for instrument types. For each current meter on each mooring, Table 3.2.4 shows the data recovery and problems during the second field year.

3.2.3.2 Wave Gauge Data

For much of the second field year, the MiniSpec instruments were removed from service for extensive testing of their ICS pressure sensors. This testing culminated in a pressure calibration at NOAA's Northwest Regional Calibration Center in Bellevue, WA, during the summer of 1993. This calibration is documented in Kelly et al. (1993) and was addressed in Jochens and Nowlin (1994b). The MiniSpecs were returned to the field in late September 1993 equipped with new ICS pressure transducers which removed the warm-up transient present during the first field year. The instruments were configured to report raw pressure counts and burst temperature so that the LATEX quadratic

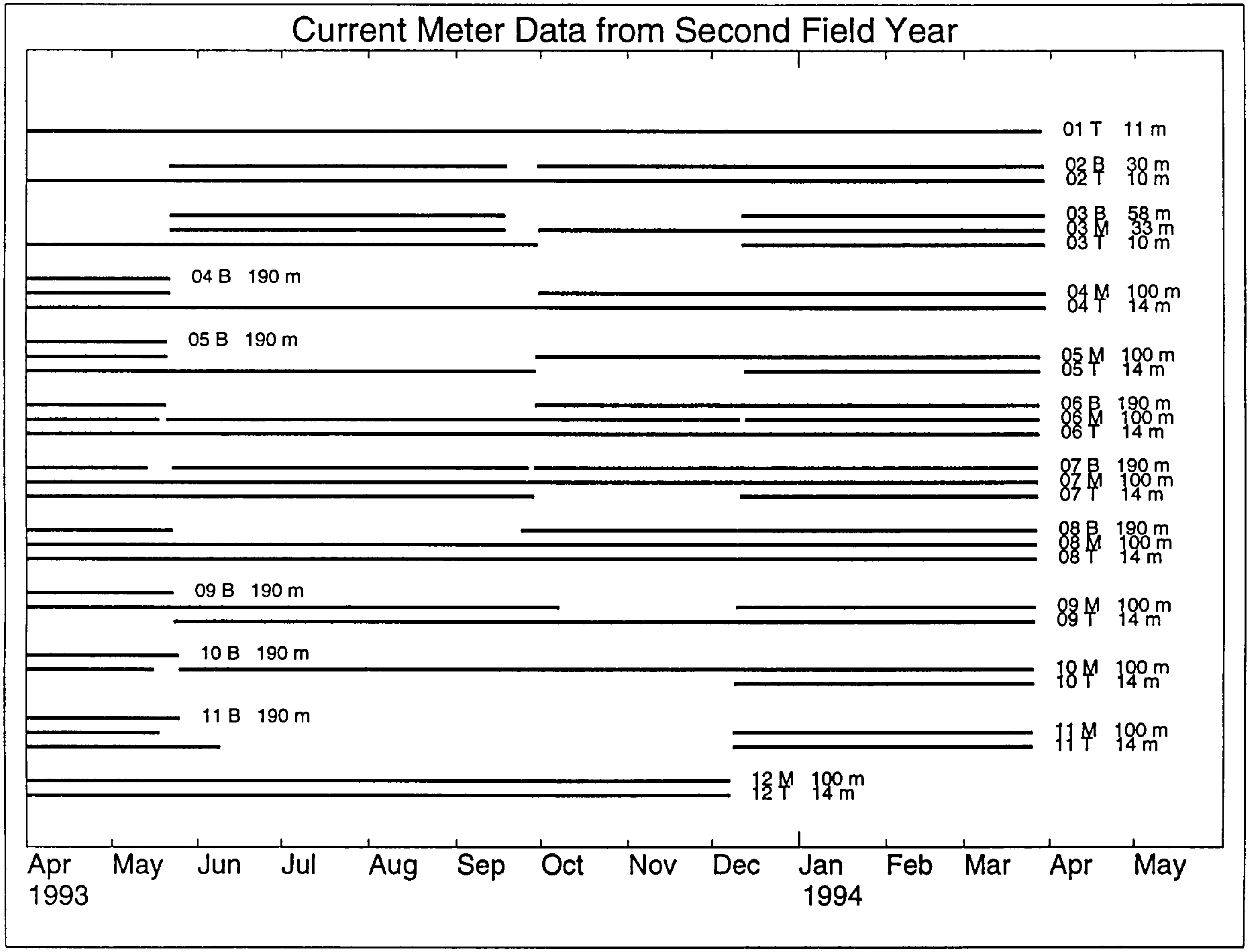


Figure 3.2.2. Current meter data recovered for the second year.

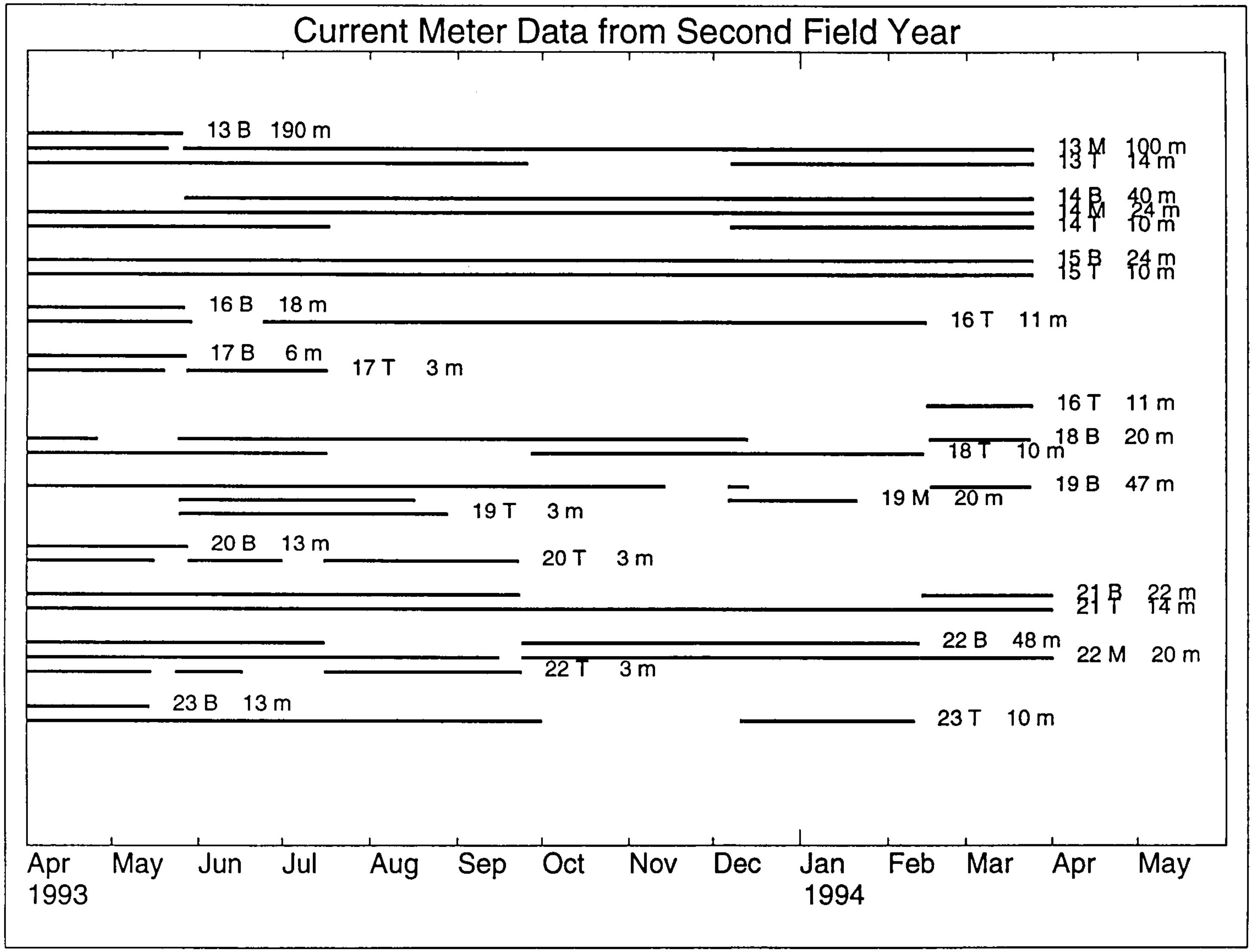


Figure 3.2.2. Current meter data recovered for the second year (continued).

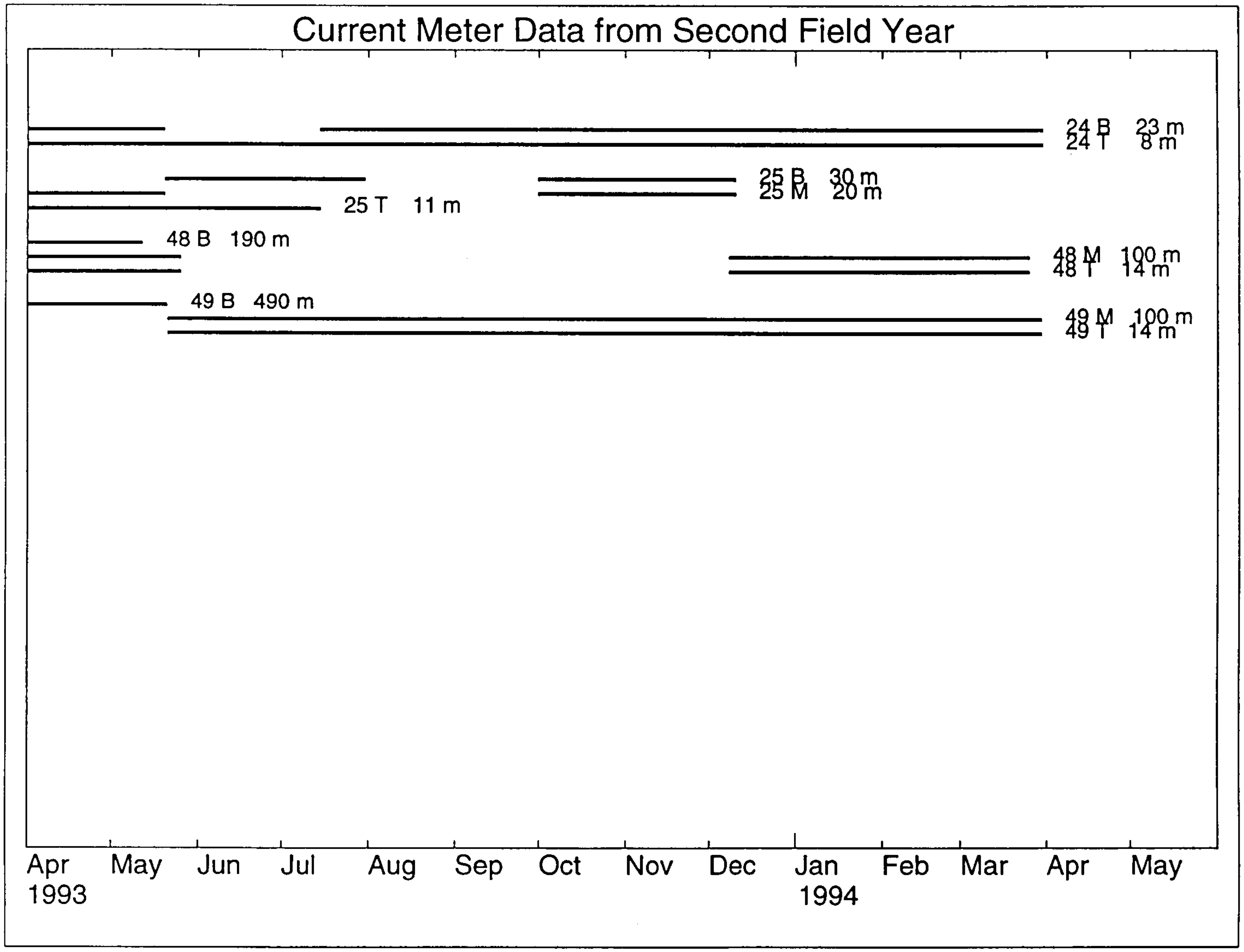


Figure 3.2.2. Current meter data recovered for the second year (continued).

Table 3.2.4. LATEX Current Meter Data April 1993 - April 1994.

Mooring	Depth	S/N	Deploy Cruise	Recover Cruise	Start Data	End Data	Exceptions
01B	11m	10093	93P12 (M11)	93P15 (M12)	09/29/1993 13:30	12/11/1993 13:00	
01B	11m	10092	93P15 (M12)	94S14 (M14)	12/11/1993 13:30	03/28/1994 13:00	K,Q,S
01T	14m	SSM241	93P04 (M08)	93P07 (M09)	03/23/1993 13:30	05/21/1993 11:30	
01T	19m	SSM239	93P07 (M09)	93P12 (M11)	05/21/1993 13:00	09/29/1993 07:00	
01T	11m	SSM240	93P12 (M11)	93P15 (M12)	09/29/1993 14:30	12/11/1993 13:30	
01T	11m	SSM250	93P15 (M12)	94S14 (M14)	12/11/1993 14:00	03/28/1994 13:00	K,Q
02B	31m	LSU008	93P07 (M09)	93P12 (M11)	05/21/1993 14:30	09/18/1993 19:25	K,N
02B	30m	LSU030	93P12 (M11)	93P15 (M12)	09/29/1993 18:30	12/11/1993 16:25	
02T	11m	SSM258	93P04 (M08)	93P07 (M09)	03/23/1993 16:30	05/21/1993 12:00	
02T	12m	SSM256	93P07 (M09)	93P12 (M11)	05/21/1993 16:30	09/29/1993 16:30	K,Q
02T	10m	SSM239	93P12 (M11)	93P15 (M12)	09/29/1993 19:00	12/11/1993 16:30	
02T	10m	SSM040	93P15 (M12)	94S14 (M14)	12/11/1993 17:00	03/29/1994 12:30	
03B	58m	DMT145	93P07 (M09)	93P12 (M11)	05/21/1993 18:30	09/18/1993 05:25	K,Q
03B	58m	LSU070	93P15 (M12)	94S14 (M14)	12/11/1993 21:00	03/29/1994 14:50	D,E
03M	33m	DMT146	93P07 (M09)	93P12 (M11)	05/21/1993 18:30	09/18/1993 08:30	
03M	32m	DMT146	93P12 (M11)	93P15 (M12)	09/30/1993 05:00	12/11/1993 18:50	
03M	33m	DMT145	93P15 (M12)	94S14 (M14)	12/11/1993 21:00	03/29/1994 14:50	K,N
03T	13m	SSM244	93P01 (M07)	93P07 (M09)	01/20/1993 01:30	05/21/1993 16:00	
03T	13m	SSM241	93P07 (M09)	93P12 (M11)	05/21/1993 19:30	09/29/1993 20:00	
03T	10m	SSM232	93P15 (M12)	94S14 (M14)	12/11/1993 22:30	03/29/1994 15:00	
04B	190m	AA10684	93P01 (M07)	93P07 (M09)	01/20/1993 07:30	05/21/1993 23:00	
04M	100m	AA10678	93P01 (M07)	93P07 (M09)	01/20/1993 07:30	05/21/1993 23:00	
04M	100m	AA10673	93P12 (M11)	93P15 (M12)	09/30/1993 02:30	12/11/1993 23:00	
04M	100m	AA9411	93P15 (M12)	94S14 (M14)	12/12/1993 02:00	03/29/1994 19:00	K,N,Q
04T	12m	SSM255	93P01 (M07)	93P07 (M09)	01/20/1993 07:30	05/21/1993 22:30	
04T	14m	SSM258	93P07 (M09)	93P12 (M11)	05/22/1993 01:00	09/29/1993 23:30	
04T	14m	SSM256	93P12 (M11)	93P15 (M12)	09/30/1993 02:00	12/11/1993 23:00	
04T	14m	SSM279	93P15 (M12)	94S14 (M14)	12/12/1993 02:00	03/29/1994 19:00	D,E
05B	190m	7106_521	93P01 (M07)	93P07 (M09)	01/20/1993 12:30	05/20/1993 21:30	I,K,M
05M	100m	AA10685	93P01 (M07)	93P07 (M09)	01/20/1993 12:00	05/20/1993 22:00	
05M	100m	AA10685	93P12 (M11)	93P15 (M12)	09/29/1993 02:30	12/12/1993 16:30	
05M	100m	AA10676	93P15 (M12)	94S14 (M14)	12/12/1993 19:30	03/27/1994 18:30	K,Q
05T	13m	SSM256	93P01 (M07)	93P07 (M09)	01/20/1993 12:30	05/20/1993 22:00	K,Q,I
05T	14m	SSM240	93P07 (M09)	93P12 (M11)	05/21/1993 01:00	09/29/1993 00:00	
05T	14m	SSM240	93P15 (M12)	94S14 (M14)	12/12/1993 19:30	03/27/1994 18:00	D,E,K
06B	190m	AA10690	93P01 (M07)	93P07 (M09)	01/19/1993 03:00	05/20/1993 12:00	A,B,K
06B	190m	AA9410	93P12 (M11)	93P15 (M12)	09/28/1993 22:30	12/12/1993 23:00	A,B,K
06B	190m	AA9121	93P15 (M12)	94S14 (M14)	12/13/1993 02:00	03/27/1994 13:00	S
06M	100m	AA10688	93P01 (M07)	93P07 (M09)	01/19/1993 03:00	05/18/1993 00:00	
06M	100m	AA10673	93P07 (M09)	93P12 (M11)	05/20/1993 15:30	09/28/1993 19:30	
06M	100m	AA10670	93P12 (M11)	93P15 (M12)	09/28/1993 22:00	12/10/1993 22:30	
06M	100m	AA10674	93P15 (M12)	94S14 (M14)	12/13/1993 02:00	03/27/1994 13:00	
06T	13m	SSM239	93P01 (M07)	93P07 (M09)	01/19/1993 03:00	05/20/1993 12:30	
06T	14m	SSM243	93P07 (M09)	93P12 (M11)	05/20/1993 15:00	09/28/1993 19:30	K,N
06T	14m	SSM255	93P12 (M11)	93P15 (M12)	09/28/1993 22:00	12/12/1993 23:00	K,Q
06T	14m	SSM256	93P15 (M12)	94S14 (M14)	12/13/1993 02:00	03/27/1994 12:30	
07B	190m	AA10175	93P01 (M07)	93P07 (M09)	01/18/1993 09:00	05/13/1993 19:00	
07B	190m	AA9410	93P07 (M09)	93P12 (M11)	05/22/1993 16:30	09/26/1993 14:00	J,S
07B	190m	AA10669	93P12 (M11)	93P15 (M12)	09/28/1993 16:00	12/10/1993 23:00	K,Q,S
07B	190m	AA10677	93P15 (M12)	94S14 (M14)	12/11/1993 02:00	03/27/1994 04:30	

Table 3.2.4. LATEX Current Meter Data April 1993 - April 1994. (continued)

Mooring	Depth	S/N	Deploy Cruise	Recover Cruise	Start Data	End Data	Exceptions
07M	100m	AA10681	93P01 (M07)	93P07 (M09)	01/18/1993 09:00	05/22/1993 13:00	B,K
07M	100m	AA10685	93P07 (M09)	93P12 (M11)	05/22/1993 16:30	09/28/1993 14:00	K,Q
07M	100m	AA10687	93P12 (M11)	93P15 (M12)	09/28/1993 16:30	12/10/1993 23:00	
07M	100m	AA10681	93P15 (M12)	94S14 (M14)	12/11/1993 02:00	03/27/1994 04:00	B,K
07T	14m	SSM253	93P01 (M07)	93P07 (M09)	01/18/1993 09:30	05/22/1993 12:00	
07T	14m	SSM255	93P07 (M09)	93P12 (M11)	05/22/1993 16:00	09/28/1993 13:30	
07T	14m	SSM235	93P15 (M12)	94S14 (M14)	12/11/1993 02:00	03/27/1994 04:00	D,E
08B	190m	AA10672	93P01 (M07)	93P07 (M09)	01/16/1993 06:00	05/22/1993 20:30	K,S
08B	190m	AA10674	93P12 (M11)	93P15 (M12)	09/23/1993 22:00	12/09/1993 19:30	A,B,K
08B	190m	AA10678	93P15 (M12)	94S14 (M14)	12/10/1993 07:00	03/26/1994 20:00	
08M	100m	AA10669	93P01 (M07)	93P07 (M09)	01/16/1993 06:00	05/22/1993 21:00	
08M	100m	AA10678	93P07 (M09)	93P12 (M11)	05/22/1993 23:00	09/23/1993 19:30	K,W
08M	100m	AA10682	93P12 (M11)	93P15 (M12)	09/23/1993 22:00	12/09/1993 19:00	
08M	100m	AA10690	93P15 (M12)	94S14 (M14)	12/10/1993 07:00	03/26/1994 20:00	K,Q,S
08T	15m	SSM233	93P01 (M07)	93P07 (M09)	01/16/1993 06:00	05/22/1993 20:00	
08T	14m	SSM244	93P07 (M09)	93P12 (M11)	05/22/1993 23:00	09/23/1993 19:00	
08T	15m	SSM040	93P12 (M11)	93P15 (M12)	09/23/1993 22:00	12/09/1993 19:00	
08T	14m	SSM242	93P15 (M12)	94S14 (M14)	12/10/1993 07:00	03/26/1994 19:30	D,E
09B	190m	AA10671	93P01 (M07)	93P07 (M09)	01/15/1993 23:30	05/23/1993 02:00	
09M	100m	AA10670	93P01 (M07)	93P07 (M09)	01/15/1993 23:00	05/23/1993 02:30	K,S
09M	100m	AA10684	93P07 (M09)	93P12 (M11)	05/23/1993 05:30	09/24/1993 12:30	K,Q,S
09M	100m	AA10677	93P12 (M11)	93P15 (M12)	09/24/1993 14:30	10/07/1993 05:45	P
09M	100m	AA10684	93P15 (M12)	94S14 (M14)	12/09/1993 16:00	03/26/1994 12:30	
09T	14m	SSM253	93P07 (M09)	93P12 (M11)	05/23/1993 05:00	09/24/1993 12:00	
09T	14m	SSM250	93P12 (M11)	93P15 (M12)	09/24/1993 15:00	12/09/1993 13:00	
09T	14m	SSM244	93P15 (M12)	94S14 (M14)	12/09/1993 16:00	03/26/1994 12:00	
10B	190m	AA10675	93P01 (M07)	93P07 (M09)	01/11/1993 09:30	05/25/1993 00:30	
10M	100m	AA10720	93P01 (M07)	93P07 (M09)	02/02/1993 00:30	05/16/1993 00:00	K,S
10M	100m	AA10669	93P07 (M09)	93P12 (M11)	05/25/1993 03:30	09/24/1993 19:30	K,Q
10M	100m	AA10678	93P12 (M11)	93P15 (M12)	09/24/1993 21:30	12/08/1993 20:00	
10M	100m	AA10689	93P15 (M12)	94S14 (M14)	12/08/1993 22:30	03/26/1994 02:30	
10T	14m	SSM042	93P15 (M12)	94S14 (M14)	12/08/1993 22:30	03/26/1994 03:00	
11B	190m	AA10689	93P01 (M07)	93P07 (M09)	01/11/1993 18:00	05/25/1993 11:30	A,B,K
11M	100m	AA10682	93P01 (M07)	93P07 (M09)	01/20/1993 00:30	05/18/1993 00:00	
11M	100m	AA10680	93P15 (M12)	94S14 (M14)	12/08/1993 09:30	03/25/1994 20:00	I,K,M
11T	14m	SSM232	93P04 (M08)	93P07 (M09)	01/11/1993 18:30	05/25/1993 11:00	
11T	14m	SSM232	93P07 (M09)	93P10 (M10)	05/25/1993 14:30	06/09/1993 00:30	K
11T	14m	SSM241	93P15 (M12)	94S14 (M14)	12/08/1993 10:00	03/25/1994 20:00	
12M	100m	AA10676	93P01 (M07)	93P10 (M10)	01/12/1993 16:00	07/18/1993 01:00	K,Q
12M	100m	AA10681	93P12 (M11)	93P15 (M12)	07/18/1993 07:00	12/07/1993 05:30	B,K
12T	14m	SSM250	93P01 (M07)	93P10 (M10)	01/12/1993 16:00	07/18/1993 01:30	
12T	14m	SSM235	93P10 (M10)	93P15 (M12)	07/18/1993 08:30	12/07/1993 05:00	K,Q,S
13B	190m	AA10674	93P01 (M07)	93P07 (M09)	01/12/1993 20:00	05/26/1993 02:00	K,Q
13M	100m	AA10679	93P01 (M07)	93P07 (M09)	01/27/1993 00:30	05/21/1993 00:30	
13M	100m	AA10670	93P07 (M09)	93P12 (M11)	05/26/1993 05:00	09/25/1993 17:00	
13M	100m	AA10676	93P12 (M11)	93P15 (M12)	09/25/1993 19:00	12/07/1993 00:30	
13M	100m	AA10679	93P15 (M12)	94S14 (M14)	12/07/1993 04:30	03/25/1994 00:00	K,N
13T	14m	SSM245	93P01 (M07)	93P07 (M09)	01/12/1993 20:00	05/26/1993 02:00	
13T	15m	SSM257	93P07 (M09)	93P12 (M11)	05/26/1993 05:00	09/25/1993 16:00	K,Q
13T	14m	SSM247	93P15 (M12)	94S14 (M14)	12/07/1993 04:00	03/25/1994 00:00	S

Table 3.2.4. LATEX Current Meter Data April 1993 - April 1994. (continued)

Mooring	Depth	S/N	Deploy Cruise	Recover Cruise	Start Data	End Data	Exceptions
14B	40m	LSU020	93P07 (M09)	93P10 (M10)	05/26/1993 19:00	07/17/1993 19:20	D,E,K
14B	40m	LSU005	93P10 (M10)	93P12 (M11)	07/17/1993 22:30	09/25/1993 20:50	D,E,K
14B	40m	DMT015	93P12 (M11)	93P15 (M12)	09/25/1993 22:30	12/06/1993 18:15	D,E,K,N,O,Q
14B	40m	LSU005	93P15 (M12)	94P02 (M13)	12/07/1993 02:00	02/14/1994 20:20	D,E
14B	40m	LSU020	94P02 (M13)	94S14 (M14)	02/15/1994 01:30	03/24/1994 21:25	D,E
14M	26m	DMT015	93P04 (M08)	93P07 (M09)	03/20/1993 20:30	05/26/1993 10:00	D,E,K,Q
14M	23m	DMT015	93P07 (M09)	93P10 (M10)	05/26/1993 19:00	07/17/1993 19:25	D,E,F,G,K
14M	23m	DMT015	93P10 (M10)	93P12 (M11)	07/17/1993 22:30	09/25/1993 20:40	D,E,K,Q
14M	20m	DMT208	93P12 (M11)	93P15 (M12)	09/25/1993 22:30	12/06/1993 17:55	
14M	24m	LSU050	93P15 (M12)	94P02 (M13)	12/06/1993 22:30	02/14/1994 19:55	D,E
14M	24m	LSU005	94P02 (M13)	94S14 (M14)	02/15/1994 01:30	03/24/1994 21:25	D,E
14T	11m	SSM235	93P04 (M08)	93P07 (M09)	03/20/1993 21:00	05/26/1993 10:30	K,Q
14T	10m	SSM245	93P07 (M09)	93P10 (M10)	05/26/1993 19:30	07/17/1993 16:30	
14T	19m	SSM039	93P15 (M12)	94P02 (M13)	12/06/1993 23:00	02/14/1994 19:30	
14T	10m	SSM258	94P02 (M13)	94S14 (M14)	02/15/1994 02:00	03/24/1994 21:00	
15B	24m	LSU005	93P04 (M08)	93P07 (M09)	03/19/1993 23:30	05/26/1993 20:30	
15B	24m	LSU005	93P07 (M09)	93P10 (M10)	05/26/1993 22:30	07/17/1993 15:30	D,E,K
15B	25m	DMT215	93P10 (M10)	93P12 (M11)	07/17/1993 17:30	09/25/1993 20:00	A,K
15B	24m	LSU005	93P12 (M11)	93P15 (M12)	09/26/1993 00:00	12/06/1993 16:00	D,E
15B	24m	DMT238	93P15 (M12)	94P02 (M13)	12/06/1993 16:00	02/14/1994 22:25	
15B	24m	LSU055	94P02 (M13)	94S14 (M14)	02/14/1994 23:00	03/24/1994 16:15	D,E
15T	10m	SSM247	93P04 (M08)	93P07 (M09)	03/20/1993 00:00	05/26/1993 20:30	I
15T	10m	SSM235	93P07 (M09)	93P10 (M10)	05/26/1993 22:30	07/17/1993 15:30	
15T	10m	SSM285	93P10 (M10)	93P12 (M11)	07/17/1993 18:00	09/25/1993 23:30	I
15T	10m	SSM257	93P12 (M11)	93P15 (M12)	09/26/1993 00:00	12/06/1993 16:00	K,N
15T	10m	SSM258	93P15 (M12)	94P02 (M13)	12/06/1993 16:30	02/14/1994 22:00	
15T	10m	SSM233	94P02 (M13)	94S14 (M14)	02/14/1994 23:30	03/24/1994 16:00	
16B	18m	10096	93P04 (M08)	93P07 (M09)	03/19/1993 20:29	05/26/1993 23:29	H
16B	18m	10096	93P04 (M08)	93P07 (M09)	03/19/1993 21:29	05/26/1993 23:29	H,J,T
16B	14m	10096	93P15 (M12)	94P02 (M13)	12/06/1993 13:30	02/14/1994 13:30	
16B	14m	10094	94P02 (M13)	94S14 (M14)	02/14/1994 18:00	03/24/1994 12:30	
16T	11m	SSM285	93P04 (M08)	93P07 (M09)	03/19/1993 19:30	05/27/1993 00:00	I
16T	11m	SSM247	93P07 (M09)	93P10 (M10)	05/27/1993 01:00	05/29/1993 12:00	
16T	11m	SSM285	93P07 (M09)	93P10 (M10)	06/23/1993 18:55	07/17/1993 11:45	P
16T	11m	SSM242	93P10 (M10)	93P12 (M11)	07/17/1993 13:30	09/26/1993 11:30	
16T	11m	SSM285	93P12 (M11)	93P15 (M12)	09/26/1993 14:30	12/06/1993 13:30	K,N,Q
16T	11m	SSM233	93P15 (M12)	94P02 (M13)	12/06/1993 14:00	02/14/1994 13:30	
16T	11m	SSM243	94P02 (M13)	94S14 (M14)	02/14/1994 15:00	03/24/1994 13:30	
17B	6m	10094	93P04 (M08)	93P07 (M09)	03/18/1993 18:00	05/27/1993 12:30	H,K,T
17B	7m	10096	93P12 (M11)	93P15 (M12)	09/27/1993 12:30	12/05/1993 13:00	K,T
17B	6m	10094	93P15 (M12)	94P02 (M13)	12/05/1993 14:30	02/13/1994 13:30	
17B	6m	10093	94P02 (M13)	94S14 (M14)	02/13/1994 14:00	03/23/1994 15:30	
17T	3m	08111788 (17)	93P04 (M08)	93P07 (M09)	03/18/1993 20:29	05/19/1993 18:59	
17T	3m	08111788 (17)	93P07 (M09)	93P10 (M10)	05/27/1993 12:40	07/16/1993 21:10	K,N
18B	19m	DMT025	93P04 (M08)	93P07 (M09)	03/18/1993 21:00	04/25/1993 23:55	D,E,K
18B	20m	DMT215	93P07 (M09)	93P10 (M10)	05/24/1993 12:50	07/16/1993 17:25	
18B	20m	LSU030	93P10 (M10)	93P12 (M11)	07/16/1993 19:30	09/26/1993 23:00	A,K
18B	20m	DMT215	93P12 (M11)	93P15 (M12)	09/27/1993 00:00	12/05/1993 18:00	
18B	20m	LSU020	93P15 (M12)	94P02 (M13)	12/05/1993 18:30	12/13/1993 14:30	D,E,K
18B	20m	LSU050	94P02 (M13)	94S14 (M14)	02/15/1994 13:30	03/23/1994 18:55	D,E

Table 3.2.4. LATEX Current Meter Data April 1993 - April 1994. (continued)

Mooring	Depth	S/N	Deploy Cruise	Recover Cruise	Start Data	End Data	Exceptions
18T	10m	SSM039	93P04 (M08)	93P07 (M09)	03/18/1993 21:30	05/24/1993 11:00	
18T	10m	SSM280	93P07 (M09)	93P10 (M10)	05/24/1993 12:30	07/16/1993 18:00	
18T	10m	SSM242	93P12 (M11)	93P15 (M12)	09/26/1993 22:30	12/05/1993 17:00	K,N,Q
18T	10m	SSM254	93P15 (M12)	94P02 (M13)	12/05/1993 18:30	02/13/1994 16:00	
19B	47m	DMT221	93P04 (M08)	93P07 (M09)	03/19/1993 04:00	05/24/1993 16:00	
19B	49m	DMT125	93P07 (M09)	93P10 (M10)	05/24/1993 19:00	07/16/1993 11:30	
19B	48m	LSU050	93P10 (M10)	93P15 (M12)	07/16/1993 15:00	11/13/1993 22:15	D,E,K
19B	47m	LSU040	93P15 (M12)	94P02 (M13)	12/06/1993 03:00	12/13/1993 21:00	D,E,K
19B	47m	LSU040	94P02 (M13)	94S14 (M14)	02/15/1994 21:00	03/23/1994 23:10	D,E
19M	18m	LSU030	93P07 (M09)	93P10 (M10)	05/24/1993 19:00	07/16/1993 11:30	K,Q,S
19M	18m	DMT238	93P10 (M10)	93P15 (M12)	07/16/1993 14:30	08/16/1993 22:30	I,J,K,S
19M	20m	LSU065	93P15 (M12)	94P02 (M13)	12/06/1993 03:00	01/20/1994 23:00	D,E,K
19T	3m	00000000 (19)	93P07 (M09)	93P10 (M10)	05/24/1993 18:40	07/16/1993 11:40	D,E,K
19T	3m	00001781 (19)	93P10 (M10)	93P12 (M11)	07/16/1993 14:36	08/28/1993 14:06	D,E,K
20B	13m	10095	93P04 (M08)	93P07 (M09)	03/17/1993 17:29	05/28/1993 00:29	J,K,T
20B	10m	10094	93P12 (M11)	93P15 (M12)	09/22/1993 18:00	12/04/1993 13:30	
20B	10m	10093	93P15 (M12)	94P02 (M13)	12/13/1993 15:00	02/12/1994 13:00	
20B	11m	10096	94P02 (M13)	94S14 (M14)	02/16/1994 18:00	03/31/1994 12:30	
20T	3m	08111779 (20)	93P04 (M08)	93P07 (M09)	03/17/1993 21:10	05/16/1993 01:40	
20T	3m	08111779 (20)	93P07 (M09)	93P10 (M10)	05/28/1993 02:10	06/30/1993 21:40	D,E,K
20T	3m	08111778 (20)	93P10 (M10)	93P12 (M11)	07/15/1993 13:24	09/22/1993 14:24	D,E,K
21B	21m	LSU030	93P04 (M08)	93P07 (M09)	03/18/1993 00:30	05/23/1993 17:00	I,M
21B	22m	DMT208	93P07 (M09)	93P10 (M10)	05/23/1993 17:30	07/15/1993 13:45	B,I,K
21B	22m	LSU010	93P10 (M10)	93P12 (M11)	07/15/1993 18:00	09/22/1993 23:05	
21B	22m	DMT208	94P02 (M13)	94S14 (M14)	02/12/1994 19:00	03/31/1994 19:30	J
21T	13m	SSM280	93P04 (M08)	93P07 (M09)	03/18/1993 00:30	05/23/1993 17:00	
21T	14m	SSM233	93P07 (M09)	93P10 (M10)	05/23/1993 17:30	07/15/1993 16:30	
21T	14m	SSM279	93P10 (M10)	93P12 (M11)	07/15/1993 19:00	09/22/1993 23:00	
21T	14m	SSM254	93P12 (M11)	93P15 (M12)	09/23/1993 00:00	12/04/1993 21:30	
21T	14m	SSM243	93P15 (M12)	94P02 (M13)	12/05/1993 01:00	02/12/1994 18:00	
21T	14m	SSM285	94P02 (M13)	94S14 (M14)	02/12/1994 19:00	03/31/1994 19:30	
22B	48m	DMT215	93P04 (M08)	93P07 (M09)	03/21/1993 23:30	05/23/1993 11:30	A,K,N
22B	48m	LSU050	93P07 (M09)	93P10 (M10)	05/23/1993 14:00	07/15/1993 22:25	
22B	48m	LSU010	93P12 (M11)	93P15 (M12)	09/23/1993 15:30	12/09/1993 23:50	K,N
22B	48m	DMT015	93P15 (M12)	94P02 (M13)	12/10/1993 02:30	02/12/1994 00:00	D,E,K
22M	20m	DMT125	93P04 (M08)	93P07 (M09)	03/21/1993 23:30	05/23/1993 11:45	C,D,E,K
22M	20m	DMT238	93P07 (M09)	93P10 (M10)	05/23/1993 14:00	07/15/1993 22:00	
22M	20m	DMT208	93P10 (M10)	93P12 (M11)	07/16/1993 00:00	09/15/1993 16:55	D,E,K
22M	20m	SSM279	93P12 (M11)	93P15 (M12)	09/23/1993 16:00	12/09/1993 23:30	
22M	20m	DMT208	93P15 (M12)	94P02 (M13)	12/10/1993 02:30	02/12/1994 00:00	
22M	20m	LSU030	94P02 (M13)	94S14 (M14)	02/12/1994 05:30	03/31/1994 23:40	
22T	3m	08111780 (22)	93P04 (M08)	93P07 (M09)	03/21/1993 23:50	05/15/1993 02:20	
22T	3m	08111781 (22)	93P07 (M09)	93P10 (M10)	05/23/1993 17:10	06/16/1993 17:40	I,K
22T	3m	08111777 (22)	93P10 (M10)	93P12 (M11)	07/15/1993 21:44	09/23/1993 14:14	
23B	13m	10092	93P04 (M08)	93P07 (M09)	03/22/1993 14:30	05/14/1993 12:30	H,K,Q,T
23B	13m	10092	93P04 (M08)	93P07 (M09)	03/22/1993 14:30	05/19/1993 12:30	H,K,Q,T
23B	14m	10092	93P12 (M11)	93P15 (M12)	10/01/1993 10:00	12/10/1993 15:00	
23B	13m	10095	93P15 (M12)	94P02 (M13)	12/10/1993 16:00	02/10/1994 14:00	
23T	10m	SSM243	93P04 (M08)	93P07 (M09)	03/22/1993 17:30	05/19/1993 15:30	D,E,K
23T	10m	SSM042	93P07 (M09)	93P10 (M10)	05/19/1993 16:30	07/14/1993 12:00	D,E,K,Q

Table 3.2.4. LATEX Current Meter Data April 1993 - April 1994. (continued)

Mooring	Depth	S/N	Deploy Cruise	Recover Cruise	Start Data	End Data	Exceptions
23T	10m	SSM247	93P10 (M10)	93P12 (M11)	07/14/1993 14:30	09/30/1993 21:00	
23T	10m	SSM257	93P15 (M12)	94P02 (M13)	12/10/1993 17:00	02/10/1994 09:00	D,E
24B	25m	DMT145	93P04 (M08)	93P07 (M09)	03/22/1993 19:30	05/19/1993 19:55	
24B	22m	LSU060	93P10 (M10)	93P12 (M11)	07/14/1993 16:00	09/30/1993 13:00	D,E,K
24B	27m	LSU060	93P12 (M11)	93P15 (M12)	10/01/1993 00:30	12/10/1993 13:55	D,E,K
24B	27m	LSU010	93P15 (M12)	94P02 (M13)	12/10/1993 17:30	02/11/1994 13:30	
24B	23m	DMT215	94P02 (M13)	94S14 (M14)	02/11/1994 14:00	03/30/1994 12:30	
24T	10m	SSM246	93P04 (M08)	93P07 (M09)	03/22/1993 20:30	05/19/1993 19:30	
24T	11m	SSM279	93P07 (M09)	93P10 (M10)	05/19/1993 20:30	07/14/1993 15:00	
24T	11m	SSM232	93P10 (M10)	93P12 (M11)	07/14/1993 16:30	09/30/1993 19:00	
24T	10m	SSM232	93P12 (M11)	93P15 (M12)	10/01/1993 01:00	12/10/1993 16:30	
24T	10m	SSM285	93P15 (M12)	94P02 (M13)	12/10/1993 18:00	02/11/1994 13:30	
24T	8m	SSM255	94P02 (M13)	94S14 (M14)	02/11/1994 14:00	03/30/1994 12:30	
25B	30m	LSU010	93P07 (M09)	93P10 (M10)	05/19/1993 22:30	07/14/1993 19:30	
25B	30m	LSU070	93P10 (M10)	93P12 (M11)	07/14/1993 20:00	07/30/1993 19:20	F,K
25B	30m	DMT145	93P12 (M11)	93P15 (M12)	09/30/1993 15:00	12/10/1993 19:20	I
25M	20m	DMT146	93P04 (M08)	93P07 (M09)	03/23/1993 00:00	05/19/1993 21:45	G
25M	20m	LSU070	93P12 (M11)	93P15 (M12)	09/30/1993 17:30	12/10/1993 19:25	D,E
25T	11m	SSM240	93P04 (M08)	93P07 (M09)	03/23/1993 00:30	05/19/1993 22:00	I,K
25T	11m	SSM242	93P07 (M09)	93P10 (M10)	05/19/1993 22:30	07/14/1993 19:30	K,O,Q
48B	190m	AA9411	93P01 (M07)	93P07 (M09)	01/12/1993 07:30	05/11/1993 23:30	
48M	100m	AA10687	93P01 (M07)	93P07 (M09)	01/12/1993 07:30	05/25/1993 18:00	
48M	100m	AA10672	93P15 (M12)	94S14 (M14)	12/08/1993 05:00	03/25/1994 14:00	
48T	14m	SSM257	93P01 (M07)	93P07 (M09)	01/12/1993 07:30	05/25/1993 18:30	S
48T	14m	SSM253	93P15 (M12)	94S14 (M14)	12/08/1993 05:00	03/25/1994 13:00	
49B	490m	AA9410	93P01 (M07)	93P07 (M09)	01/19/1993 09:30	05/20/1993 17:00	J,S
49M	100m	AA10688	93P07 (M09)	93P15 (M12)	05/20/1993 21:30	12/12/1993 05:00	
49M	100m	AA10682	93P15 (M12)	94S14 (M14)	12/12/1993 10:00	03/29/1994 23:30	
49T	14m	SSM246	93P07 (M09)	93P15 (M12)	05/20/1993 21:30	12/12/1993 06:00	A,B,K
49T	14m	SSM239	93P15 (M12)	94S14 (M14)	12/12/1993 10:00	03/30/1994 00:00	D,E

Exception Descriptions

A - No Speed Data.	K - Partial data.
B - No Direction data.	L - Temp and Cond scrambled; No data.
C - No Temperature data.	M - Temperature data suspect.
D - No Conductivity data.	N - Conductivity goes bad during deployment.
E - No Salinity Data.	O - Meter tangled in line/wire.
F - Dropped Samples.	P - Sample interval 5 minute (should be 30).
G - Bad self checks.	Q - Speed goes bad during deployment.
H - Possible 180 Abiguity in Direction.	R - Failed during deployment.
I - Conductivity and salinity suspect.	S - Speed Suspect.
J - Direction suspect.	T - Pressure data suspect.

calibration, which includes temperature effects, could be used to convert the data into engineering units. A current sensor calibration was attempted at a tow-tank facility at Bay St. Louis, MS, just prior to redeployment but the results of this calibration were suspect. Table 3.2.5 shows the data start/stop dates and in/out water dates of the five MiniSpec directional wave gauges. Figure 3.2.3 shows a timeline displaying the MiniSpec data return.

Two of the MiniSpecs, S/N's 10092 and 10096, developed chronic problems that recurred during each deployment for the rest of the second field year. The electromagnetic current sensor in S/N 10092 failed in mid-deployment three times in three deployments. The failure occurred in the U-velocity channel and resulted in a highly noisy wave spectrum from this channel; the V-velocity channel did not have this problem. The problem was discovered while analyzing the significant wave heights as measured by the pressure sensor and the velocity sensor. The current velocity field was zeroed out in the processed data set at the time at which the significant wave heights measured by the two sensors diverged.

The pressure sensor of S/N 10096 also failed inmid-deployment during each deployment of the second field year. Like the current sensor failure, the problem was discovered when analyzing and comparing the burst spectra and significant wave height. The pressure field was zeroed at the time at which the pressure-measured wave statistics diverge from the velocity statistics. Both the pressure problem of S/N 10096 and the current velocity sensor problem of S/N 10092 were brought to the attention of the manufacturer (Coastal Leasing, Inc.) and both instruments were removed from the field for servicing during the third field year. The onset of the pressure sensor failure was accompanied by a drop in battery voltage, which was investigated as the cause of this problem. The pressure sensor in S/N 10093 also failed at the end of March 1994, four days prior to recovery. This failure seemed to be isolated and did not recur.

Several of unique situations occurred during the second field year which led to MiniSpec data loss. One MiniSpec (S/N 10095) was lost some time in February or March 1994, possibly due to a jack-up rig at Mooring 23; it was never recovered. LATEX divers reported large circular holes in the ocean floor in the vicinity of this mooring. Also, during the September - December 1993 deployment, the instrument setup parameters for S/N 10095 were mistakenly left the same as those used during the Bay St. Louis current sensor calibration. The instrument, therefore, recorded every two minutes in burst mode only; 110 samples were taken at 0.5 second intervals. The instrument continued to record until the internal hard drive was filled to capacity—about 7 days total. These data are unsuitable for wave and current analysis are considered lost.

In February 1994, the LATEX Data Office scheduled a comparison study at mooring 16 between a MiniSpec (S/N 10094) and a Woods Hole Instrument Systems (WHISL)SeaPac 2100 directional wave gauge to judge the performance and accuracy of the LATEX pressure sensor calibration; the results of this study were presented in DiMarco et al. (1994). The comparison provided 38 days of directional wave data from the two instruments, which were positioned one meter above the bottom and three meters apart. The SeaPac wave gauge was equipped with a Paroscientific quartz pressure sensor, which has an order of magnitude better resolution than the MiniSpec and provided an excellent standard by which to compare the MiniSpec's performance and check its calibration. The comparison showed that the MiniSpec's ICS pressure sensor, properly calibrated, agreed closely to Paroscientific quartz sensor up to a cutoff frequency of 0.22 Hz. The rms difference of the significant wave height measured by the two sensors was

Table 3.2.5. MiniSpec directional wave gauge deployment data.

MiniSpec - Data Ranges - Second Field Year						
	Deploy.-Recov. Cruise		Pressure	Current	Temperature	
Mooring	S/N	In Water	Start Data	Start Data	Start Data	Exceptions
		Out Water	Stop Data	Stop Data	Stop Data	
	M11 - M12					
1	10093	09/29/93 13:26	09/29/93 13:30	09/29/93 13:30	09/29/93 13:30	
		12/11/93 13:25	12/11/93 13:00	12/11/93 13:00	12/11/93 13:00	
16	10095	09/26/93 13:48	09/26/93 13:48	09/26/93 13:48	09/26/93 13:48	A
		12/06/93 13:20	10/03/93 21:52	10/03/93 21:52	10/03/93 21:52	
17	10096	09/27/93 12:09	09/27/93 12:30	09/27/93 12:30	09/27/93 12:30	B
		12/05/93 13:24	10/16/93 03:00	12/05/93 13:00	12/05/93 13:00	
20	10094	09/22/93 17:54	09/22/93 18:00	09/22/93 18:00	09/22/93 18:00	
		12/04/93 14:11	12/04/93 13:30	12/04/93 13:30	12/04/93 13:30	
23	10092	09/30/93 20:56	10/01/93 10:30	10/01/93 10:30	10/01/93 10:30	C
		12/10/93 15:29	12/10/93 15:00	10/27/93 00:00	12/10/93 15:00	
	M12 - M13					
1	10092	12/11/93 13:27				
		recovered CM14				
16	10096	12/06/93 13:23	12/06/93 13:30	12/06/93 13:30	12/06/93 13:30	B
		02/14/94 13:50	12/25/93 13:30	02/14/94 13:30	02/14/94 13:30	
17	10094	12/05/93 14:03	12/05/93 14:30	12/05/93 14:30	12/05/93 14:30	
		02/13/94 13:38	02/13/94 13:30	02/13/94 13:30	02/13/94 13:30	
20	10093	12/13/93 14:53	12/13/93 15:00	12/13/93 15:00	12/13/93 15:00	
		02/12/94 13:35	02/12/94 13:00	02/12/94 13:00	02/12/94 13:00	
23	10095	12/10/93 15:30	12/10/93 16:00	12/10/93 16:00	12/10/93 16:00	
		02/10/94 14:20	02/10/94 14:00	02/10/94 14:00	02/10/94 14:00	
	M13 - M14					
1	10092	12/11/93 13:27	12/11/93 13:30	12/11/93 13:30	12/11/93 13:30	C
		03/29/94 13:40	03/28/94 13:30	12/24/93 00:00	03/28/94 13:30	
16	10094	02/14/94 13:52	02/14/94 18:00	02/14/94 18:00	02/14/94 18:00	
		03/24/94 12:58	03/24/94 12:30	03/24/94 12:30	03/24/94 12:30	
17	10093	02/13/94 13:42	02/13/94 14:00	02/13/94 14:00	02/13/94 14:00	B
		03/23/94 15:48	03/19/94 22:00	03/23/94 13:00	03/23/94 13:00	
20	10096	02/16/94 17:45	02/16/94 18:00	02/16/93 18:00	02/16/93 18:00	B
		03/31/94 13:24	03/13/94 10:00	03/31/94 12:30	03/31/94 12:30	
23	10095	02/10/93 15:30	no data	no data	no data	D
		lost	no data	no data	no data	

Exception Descriptions
A - Burst data every 2 minutes (110 samples)
B - Pressure sensor failure
C - Current sensor failure
D - instrument lost

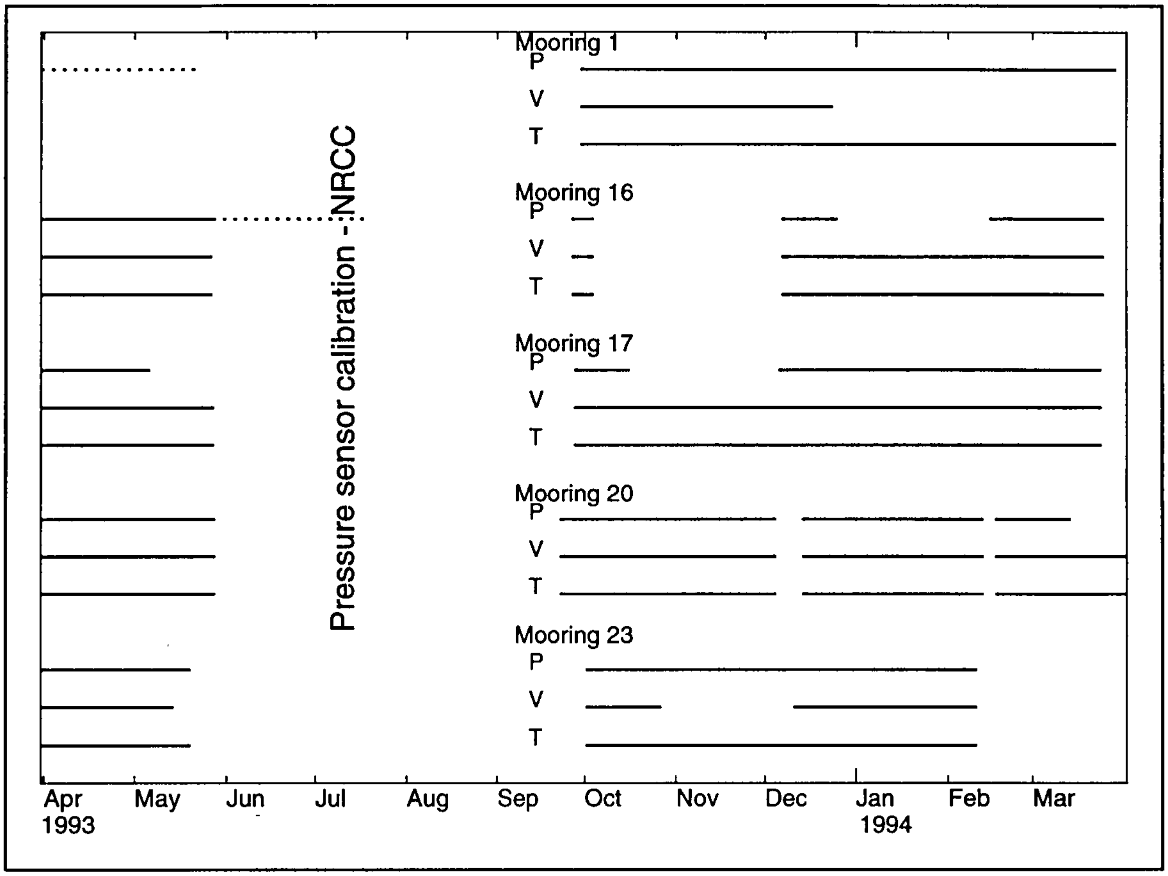


Figure 3.2.3. Timelines of data returns for five MiniSpecs at LATEX Moorings 1, 16, 17, 20, 23 during the second field year. P = pressure, V = current velocity, T = Temperature. The dotted line represents SeaData 635-8 pressure data return.

4.0 cm during the deployment period. Wave heights calculated from the SeaPac's velocity data agreed closely with the wave heights calculated from both pressure sensors, but wave heights calculated from the MiniSpec's velocity were generally lower. The principal differences between the instruments were the sensitivities of their pressure sensors, the method of determining their orientations, and the date and the amount of use since calibration.

A SeaData 635-8 Wave Gauge was deployed to replace a MiniSpec pulled from the field for service or maintenance. There were three Sea Data wave gauge deployments during the second field year. Table 3.2.6 lists the deployment and data recovery dates and provides minor corrections to times and dates for the three deployments reported in

Jochens and Nowlin (1994b). The SeaData instrument recorded only hydrostatic pressure in burst mode. A burst consisted of 1024 samples taken at 1.0-second intervals. The processing of the SeaData data was similar to the processing of the MiniSpec wave data. Computer programs were written in both FORTRAN and the PV-Wave programming language. The FORTRAN program read in blocks of raw data in units of PSIA and corrected for missing or invalid data points. Next, the PV-Wave routines converted the pressure data from PSIA to hPa, added appropriate time stamps, performed wave statistics, and provided data output.

Table 3.2.6. SeaData 635-8 wave gauge deployment data.

Mooring	Deployment Cruise	Recovery Cruise	Start Data	End Data
	M03	M04		
01	07/26/92 22:30	09/04/92 12:53	07/27/92 00:15	09/04/92 12:16
	M04	M05		
01	09/04/92 15:25	10/15/92 12:53	09/04/92 17:30	10/15/92 08:30
	M08	M09		
01	03/23/93 13:02	05/21/93 12:24	03/24/93 00:20	05/21/93 09:20
	M09	M10		
16	05/27/93 00:11	07/17/93 13:24	05/27/93 03:00	07/17/93 12:00
	M06	M07		
17	12/12/92 21:15	01/14/93 14:00	12/12/92 21:50	01/14/93 12:50
	M07	M08		
17	01/14/92 17:18	03/18/93 16:30	01/14/93 19:32	03/16/93 01:24

3.2.3.3 Meteorological Data

Internally-recorded, meteorological data collected during the second year of deployment were recovered during mooring maintenance cruises M09 through M14. Table 3.2.7 summarizes the recovery results for the second field year. Calibrations and processing of the data from the meterological buoys were completed as described in section 2.2.3.3 of Jochens and Nowlin (1994b).

During the second year, the plan called for the recovery of 36 data sets. Twenty-eight sets of varying quality were recovered. Of the eight not collected, two were due to a shortage of parts required for on-site repair. The remaining six were not collected because of dead batteries (two), a blown fuse (one), flooding in the battery compartment (one), electronics failure (one), and collision (one). Figure 3.2.4 shows data recovery timelines.

Table 3.2.7. Meteorological data recovered April 1993 - March 1994.

Mooring	Deploy Cruise	Recover Cruise	Start Data	End Data	Exceptions
17	93P04 (M08)	93P07 (M09)	03/18/1993 19:00	05/27/1993 11:00	
17	93P07 (M09)	93P10 (M10)	05/27/1993 13:00	07/16/1993 21:00	a
17	93P10 (M10)	93P12 (M11)	07/16/1993 22:45	09/27/1993 11:45	a,b,d
17	93P12 (M11)	93P15 (M12)	09/28/1993 15:00	12/06/1993 12:00	f
17	94P02 (M13)	94S14 (M14)	02/13/1994 15:45	03/23/1994 15:45	a,b
19	93P04 (M08)	93P07 (M09)	03/19/1993 05:00	05/24/1993 13:00	k
19	93P12 (M11)	93P15 (M12)	09/27/1993 20:05	12/05/1993 21:05	
19	93P15 (M12)	94P02 (M13)	12/06/1993 01:40	02/15/1994 14:40	b,d
19	94P02 (M13)	94S14 (M14)	02/15/1994 19:30	03/23/1994 22:30	
20	93P04 (M08)	93P07 (M09)	03/17/1993 21:00	05/28/1993 00:00	
20	93P07 (M09)	93P10 (M10)	05/28/1993 02:00	07/15/1993 12:00	b,j
20	93P10 (M10)	93P12 (M11)	07/15/1993 11:20	09/22/1993 10:20	b
20	93P12 (M11)	93P15 (M12)	09/22/1993 18:00	12/04/1993 13:00	
20	93P15 (M12)	94P02 (M13)	12/13/1993 17:46	02/12/1994 13:46	e
20	94P02 (M13)	94S14 (M14)	02/16/1994 21:30	03/31/1994 16:30	g,j
22	93P04 (M08)	93P07 (M09)	03/22/1993 00:00	05/23/1993 11:00	j
22	93P10 (M10)	93P12 (M11)	07/16/1993 01:45	09/23/1993 12:45	k
22	93P12 (M11)	93P15 (M12)	09/23/1993 16:30	12/09/1993 23:30	
22	93P15 (M12)	94P02 (M13)	12/10/1993 03:20	02/11/1994 22:20	i
22	94P02 (M13)	94S14 (M14)	02/12/1994 05:00	03/31/1994 23:00	
50	93P04 (M08)	93P07 (M09)	03/24/1993 14:00	05/19/1993 12:00	
50	93P15 (M12)	94P02 (M13)	12/04/1993 08:30	02/11/1994 15:30	a,d,f
50	94P02 (M13)	94S14 (M14)	02/11/1994 16:30	03/30/1994 21:30	
51	93P04 (M08)	93P07 (M09)	03/24/1993 21:00	05/23/1993 17:00	
51	93P15 (M12)	94P02 (M13)	12/04/1993 02:04	02/11/1994 18:04	
52	93P15 (M12)	94P02 (M13)	12/05/1993 06:30	02/13/1994 01:30	a,b,d
53	93P15 (M12)	94P02 (M13)	12/06/1993 08:45	02/15/1994 03:45	
53	94P02 (M13)	94S14 (M14)	02/15/1994 05:00	03/24/1994 07:00	e

Exceptions
a. Significant part of the wind direction record flagged as bad.
b. Significant part of the wind speed record flagged as bad.
c. Significant part of the pressure record flagged as bad.
d. Significant part of the air temperature record flagged as bad.
e. Entire wind direction record flagged as bad.
f. Entire wind speed record flagged as bad.
g. Entire pressure record flagged as bad.
h. Entire air temperature record flagged as bad.
i. Entire sea temperature record flagged as bad.
j. Suspect wind direction.
k. Suspect air temperature.

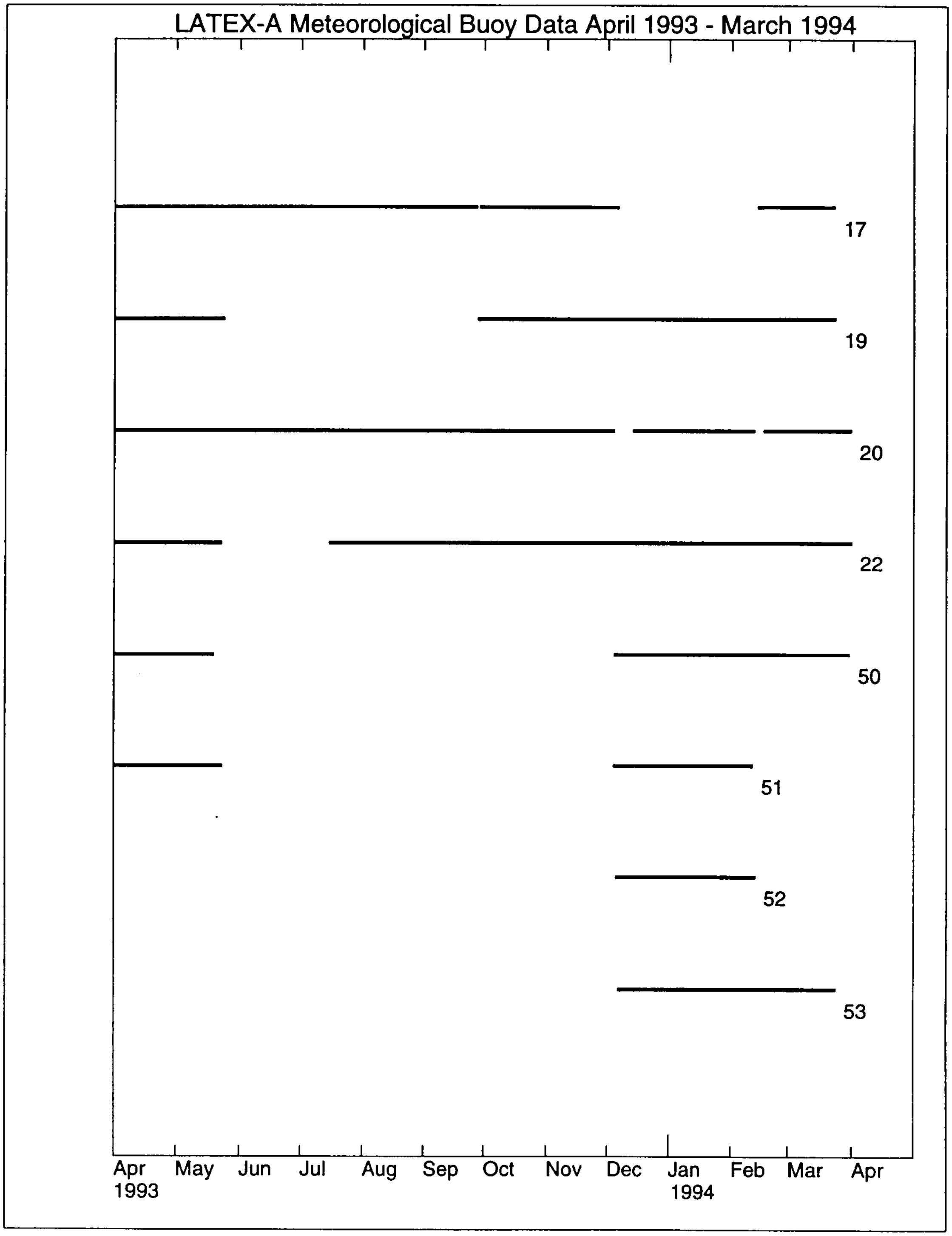


Figure 3.2.4. Meteorological buoy data recovered during the second year.

3.2.3.4 IES Data

One upward-looking inverted echo sounder (Sea Data Model 1665) was placed with an acoustic release within one meter of the sea bed in 3130 m of water depth at mooring 42 on 23 July 1992 and in 1540 m of water depth at mooring 43 on 23 July 1992. The maintenance cycle for these instruments was one year. The acoustic releases were set to release automatically 366 days after deployment. The maintenance cruise for the IES units was planned to place the vessel on-site before, during, and after the automatic trigger was to release.

The IES at mooring 43 was never recovered. During the recovery attempt there were weak acoustic communications between the deck unit and the acoustic release, but the instrument failed to surface and was declared lost. The IES at mooring 42 was recovered on 25 July 1993; however, the acoustic travel-time data, except for about six days at the beginning of the record, were unusable. Temperature and pressure data for the year-long deployment were good. After data downloading, the IES was redeployed at mooring 42

3.3 Drifting Buoy Measurements

3.3.1 Deployment Times and Locations

Four satellite-tracked drifting buoys were deployed on 2 May 1993 during hydrographic survey H05. Table 3.3.1 lists the drifting buoys by their Platform Transmitter Terminal (PTT) identification numbers along with their deployment dates and locations and associated event records.

The plan called for LATEX A drifters to be released at four locations: inshore and offshore of the coastal boundary frontal zone, mid-shelf, and over the outer shelf near the continental shelf break. Because another MMS-sponsored program, the Surface Current Lagrangian Program (SCULP), was deploying large numbers of drifting buoys over the inner and mid-shelf regions at the same time, LATEX A placed all four drifters over the region of the outer shelf. The mean lifetime of the four drifters was 168 days with a range of 71 to 251 days.

Table 3.3.1. LATEX A drifter deployment dates and disposition.

ARGOS ID	Date and Time yymmddhhmm	Deployment Locations		Event
06938	9305020604	94°10.5'W	27°51.0'N	Deployed (active 168 days)
	9310172313	86°54.3'W	28°20.5'N	Last message (lost)
06935	9305020744	94°08.3'W	27°57.1'N	Deployed (active 184 days)
	9311021018	80°02.3'W	26°09.4'N	Last message (lost)
06937	9305021013	94°03.7'W	28°09.0'N	Deployed (active 251 days)
	9401081441	83°56.9'W	26°45.6'N	Last message (lost)
06939	9305021310	93°59.7'W	28°22.0'N	Deployed (active 71 days)
	9307121412	94°06.4W	29°19.4'N	Last message (lost)

3.3.2 Instrumentation and Sampling Procedures

A physical description of the drifting buoys, their internal instrumentation, data recovery methods, pre-deployment tasks, and bench testing were described in section 9.5 of Nowlin et al. (1991) and section 2.3.2 of Jochens and Nowlin (1994b). Beginning with the May 1993 deployment, a hand-held transmitter test unit was used immediately prior to the release of the buoys to verify that the internal transmitters were active. The release method adopted during this deployment was for two crew members to heave the unboxed drifting buoy over the side of the vessel while underway at 1-2 knots. This ensured that the drogue uncoiled well behind the vessel.

3.3.3 Summary of Data Collection

Details of the data processing steps used to process the drifting buoy data can be found in section 2.3.3 of Jochens and Nowlin (1994b). The performance and longevity of the four drifters released in May was superior to that of the previous deployments. The drifters transmitted for 71, 168, 184, and 251 days. One of the drifting buoys (06935) was captured briefly but released without communication with the LATEX Data Office. None of the drifters were returned and all are considered lost.

3.4 Hydrographic Measurements

3.4.1 Synopsis of Hydrographic Surveys

During the second field year, three hydrographic cruises were conducted over the full shelf of Texas-Louisiana west of 90.5°W. Table 2.2.1 gives the cruise dates. All cruises were aboard the *R/V J.W. Powell.* Over 200 CTD-Rosette stations were occupied on each cruise; station positions were nearly identical each time, with nine lines of stations perpendicular to the isobaths and two lines parallel to the coast along the 50-m and 200-m isobaths. No major problems were encountered during these cruises. The following is a summary of major events for each of the three cruises.

3.4.1.1 Cruise H05CPW9306

The fifth LATEX A hydrography cruise (H05) was conducted from the *R/V J. W. Powell* 25 April - 11 May 1993. Dr. Denis A. Wiesenburg was Chief Scientist. The cruise was divided into two legs. Figure 3.4.1 shows the station locations and the cruise track; Table 3.4.1 gives station number, date, time, location, water depth, and number of bottles tripped at each station. Two hundred fifteen stations were completed, three more than planned, including three located in about 1000-m water depth in the western half of the survey area within the anticyclonic Loop Current Eddy V. A representative of the National Weather Service participated on each leg to conduct LATEX weather operations. Four ARGOS-tracked drifters were deployed for Task A-2 (Table 3.4.2).

This cruise also accommodated four complementary research efforts. Three MetOcean ARGOS-tracked drifters were launched in Eddy V in cooperation with Dr. David Sheres of USM and Dr. Harry Selsor of the Naval Research Laboratory. Primary productivity measurements were made at 12 stations by Khaled Al-Abdulkader and Gaston Gonzales (students of Dr. Sayed El-Sayed, TAMU Dept. of Oceanography). Phytoplankton net hauls were taken at 11 stations and two horizontal net tows were conducted for Dr. Greta Fryxell (TAMU Dept. of Oceanography). Coccolithophorid data were collected at 15 stations for Vita Pariente (student of Dr. Stefan Gartner, TAMU Dept. of Oceanography).

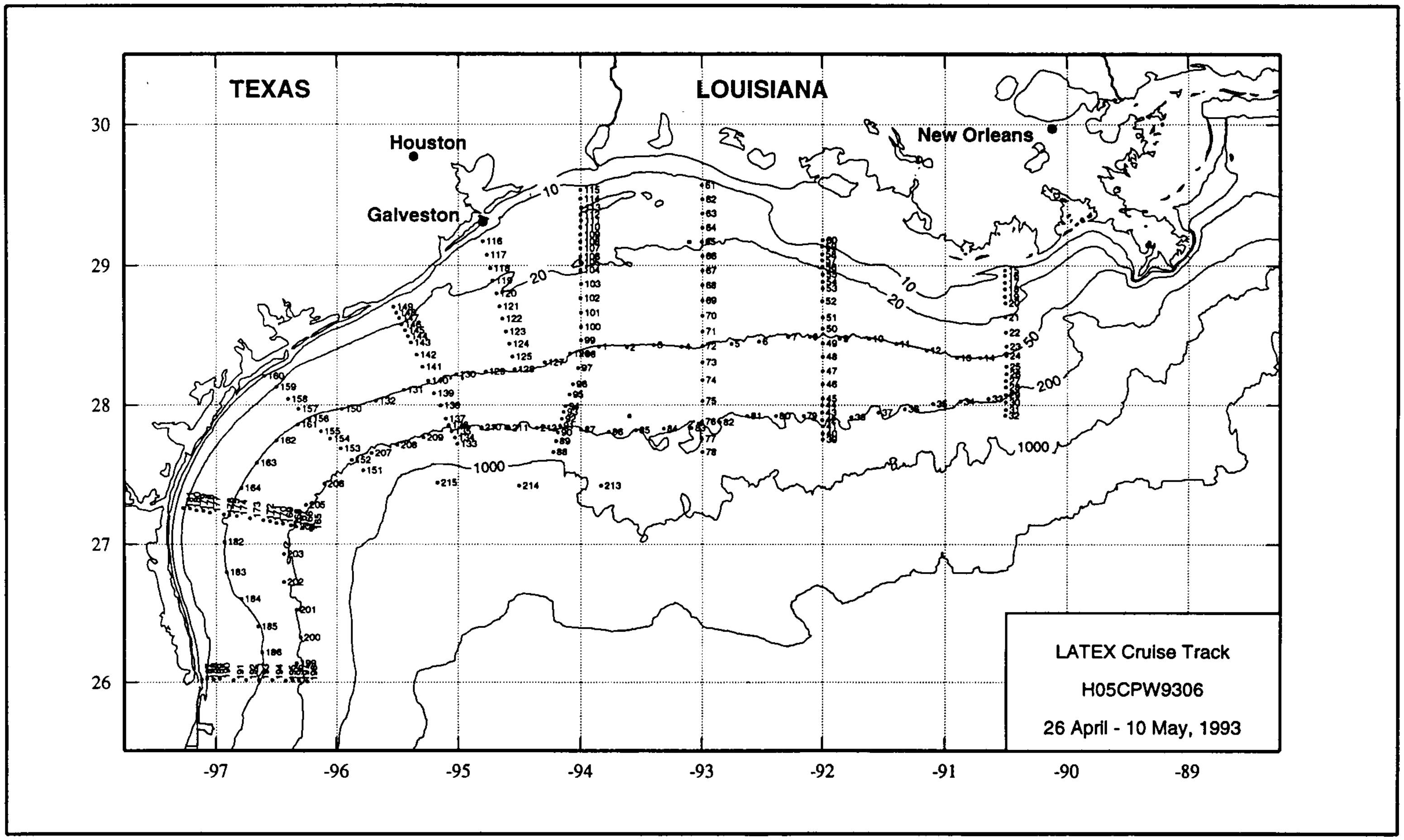


Figure 3.4.1. CTD stations and cruise track, LATEX H05.

Table 3.4.1. Station times and positions for LATEX A cruise H05.

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
1	26APR93	1938	28°25.30'	93°51.04'	48	7
2	26APR93	2145	28°25.07'	93°37.27'	48	7
3	27APR93	0005	28°25.98'	93°24.01'	47	7
4	27APR93	0150	28°25.33'	93°10.18'	47	8
5	27APR93	0446	28°26.48'	92°45.66'	50	8
6	27APR93	0632	28°27.61'	92°31.80'	50	8
7	27APR93	0807	28°29.40'	92°17.36'	50	7
8	27APR93	0920	28°29.39'	92°06.59'	49	7
9	27APR93	1129	28°28.79'	91°51.60'	50	7
10	27APR93	1310	28°28.76'	91°37.23'	51	7
11	27APR93	1501	28°26.42'	91°24.03'	49	7
12	27APR93	1709	28°23.70'	91°08.90'	48	7
13	27APR93	1923	28°20.47'	90°54.15'	49	7
14	27APR93	2056	28°20.42'	90°42.59'	47	8
15	28APR93	0127	28°58.09'	90°30.59'	10	4
16	28APR93	0156	28°55.72'	90°30.86'	12	5
17	28APR93	0234	28°52.69'	90°30.61'	16	5
18	28APR93	0304	28°49.97'	90°30.58'	16	5
19	28APR93	0336	28°46.72'	90°30.63'	16	5
20	28APR93	0405	28°43.93'	90°30.36'	16	6
21	28APR93	0455	28°37.93'	90°30.29'	19	6
22	28APR93	0552	28°31.63'	90°30.16'	36	7
23	28APR93	0653	28°25.43'	90°29.96'	44	7
24	28APR93	0734	28°21.61'	90°29.97'	48	8
25	28APR93	0825	28°16.82'	90°29.99'	60	8
26	28APR93	0903	28°13.54'	90°30.02'	75	12
27	28APR93	1000	28°10.47'	90°30.15'	92	12
28	28APR93	1049	28°07.68'	90°30.16'	115	12
29	28APR93	1153	28°04.65'	90°30.20'	147	12
30	28APR93	1302	28°01.27'	90°30.07'	251	12
31	28APR93	1411	27°57.98'	90°30.18'	435	12
32	28APR93	1510	27°55.45'	90°30.47'	496	12
33	28APR93	1655	28°02.72'	90°38.59'	162	12
34	28APR93	1845	28°01.38'	90°52.40'	187	12
35	28APR93	2037	28°00.39'	91°05.84'	134	12
36	28APR93	2236	27°58.15'	91°19.49'	264	12
37	29APR93	0022	27°56.61'	91°32.70'	223	12
38	29APR93	0202	27°54.77'	91°45.89'	167	12
39	29APR93	0410	27°44.93'	91°59.89'	491	12
40	29APR93	0538	27°47.52'	92°00.02'	389	12
41	29APR93	0656	27°50.67'	91°59.98'	196	12
42	29APR93	0821	27°53.57'	92°00.07'	166	12
43	29APR93	0934	27°56.80'	92°00.05'	98	10
44	29APR93	1058	27°59.97'	92°00.04'	118	12
45	29APR93	1156	28°02.69'	91°59.96'	103	11
46	29APR93	1348	28°08.93'	91°59.92'	81	10
47	29APR93	1524	28°14.71'	91°59.89'	67	7
48	29APR93	1727	28°21.13'	91°59.82'	59	7
49	29APR93	1812	28°26.78'	91°59.85'	57	8
50	29APR93	1921	28°33.01'	91°59.84'	43	6
51	29APR93	2006	28°37.74'	91°59.88'	38	6
52	29APR93	2109	28°44.70'	92°00.09'	32	7

Table 3.4.1. Station times and positions for LATEX A cruise H05 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
53	29APR93	2205	28°50.26'	92°00.00'	27	6
54	29APR93	2240	28°52.96'	91°59.99'	25	5
55	29APR93	2319	28°56.22'	91°59.98'	22	6
56	29APR93	2358	28°59.33'	92°00.08'	20	6
57	30APR93	0033	29°02.28'	92°00.11'	17	5
58	30APR93	0105	29°04.86'	92°00.16'	14	5
59	30APR93	0136	29°07.98'	92°00.06'	11	4
60	30APR93	0206	29°10.87'	91°59.99'	7	4
61	30APR93	0844	29°34.02'	93°00.04'	10	4
62	30APR93	0942	29°27.93'	92°59.96'	12	4
63	30APR93	1033	29°22.00'	92°59.96'	13	4
64	30APR93	1126	29°15.90'	93°00.01'	16	5
65	30APR93	1222	29°10.04'	93°00.04'	18	5
66	30APR93	1355	29°03.99'	92°59.95'	22	5
67	30APR93	1454	28°57.80'	92°59.99'	21	6
68	30APR93	1549	28°51.42'	92°59.99'	24	6
69	30APR93	1643	28°44.93'	92°59.94'	28	6
70	30APR93	1737	28°38.41'	92°59.93'	31	7
71	30APR93	1843	28°31.87'	92°59.99'	42	7
72	30APR93	1942	28°25.39'	92°59.97'	47	8
73	30APR93	2044	28°18.48'	92°59.90'	52	8
74	30APR93	2151	28°10.85'	92°59.94'	70	9
75	30APR93	2307	28°01.82'	92°59.86'	100	9
76	01MAY93	0032	27°52.85'	93°00.12'	188	12
77	01MAY93	0147	27°45.28'	93°00.16'	203	12
78	01MAY93	0252	27°39.40'	92°59.91'	316	12
79	01MAY93	0836	27°55.13'	92°09.96'	143	12
80	01MAY93	1840	27°55.13'	92°23.41'	82	9
81	01MAY93	1238	27°55.13'	92°37.47'	191	12
82	01MAY93	1455	27°52.49'	92°51.37'	216	12
83	01MAY93	1648	27°50.07'	93°05.28'	173	12
84	01MAY93	1837	27°49.86'	93°19.15'	148	12
85	01MAY93	2030	27°49.00'	93°32.57'	198	12
86	01MAY93	2227	27°48.29'	93°46.27'	187	12
87	02MAY93	0024	27°49.24'	94°00.01'	197	12
88	02MAY93	0230	27°39.63'	94°13.47'	442	12
89	02MAY93	0352	27°44.25'	94°12.21'	450	12
90	02MAY93	0450	27°47.99'	94°11.41'	266	12
91	02MAY93	0543	27°50.98'	94°10.26'	116	10
92	02MAY93	0641	27°54.14'	94°09.30'	94	10
93	02MAY93	0729	27°57.05'	94°08.32'	82	8
94	02MAY93	0809	27°59.54'	94°07.50'	79	8
95	02MAY93	0908	28°04.65'	94°05.52'	67	8
96	02MAY93	1002	28°08.96'	94°03.76'	63	8
97	02MAY93	1113	28°16.01'	94°01.30'	56	7
98	02MAY93	1257	28°21.93'	93°59.64'	50	7
99	02MAY93	1433	28°27.92'	93°59.99'	41	6
100	02MAY93	1548	28°33.80'	93°59.94'	34	6
101	02MAY93	1657	28°39.65'	93°59.93'	28	6
102	02MAY93	1806	28°46.02'	94°00.08'	23	6
103	02MAY93	1902	28°51.91'	93°59.97'	23	6
104	02MAY93	1959	28°57.93'	94°00.13'	16	5

Table 3.4.1. Station times and positions for LATEX A cruise H05 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
105	02MAY93	2040	29°01.30'	94°00.05'	18	4
106	02MAY93	2116	29°03.79'	94°00.12'	17	5
107	02MAY93	2158	29°07.34'	94°00.06'	16	5
108	02MAY93	2235	29°09.97'	94°00.07'	15	5
109	02MAY93	2313	29°13.02'	94°00.15'	13	4
110	02MAY93	2344	29°16.19'	94°00.10'	12	5
111	03MAY93	0016	29°18.97'	93°59.92'	11	5
112	03MAY93	0046	29°21.61'	94°00.12'	9	4
113	03MAY93	0118	29°24.57'	94°00.02'	9	4
114	03MAY93	0155	29°28.15'	94°00.12'	10	4
115	03MAY93	0233	29°32.05'	94°00.16'	9	5
116	03MAY93	0738	29°10.19'	94°47.98'	13	4
117	03MAY93	0827	29°04.50'	94°46.20'	16	5
118	03MAY93	0915	28°58.80'	94°44.40'	15	6
119	03MAY93	1005	28°53.40'	94°43.20'	18	5
120	03MAY93	1051	28°48.00'	94°41.41'	18	6
121	03MAY93	1137	28°42.59'	94°39.90'	24	7
122	03MAY93	1226	28°37.20'	94°38.40'	28	8
123	03MAY93	1317	28°31.80'	94°36.59'	33	8
124	03MAY93	1406	28°26.40'	94°35.12'	38	8
125	03MAY93	1455	28°21.00'	94°33.60'	41	8
126	03MAY93	1751	28°22.21'	94°05.41'	47	6
127	03MAY93	1916	28°18.59'	94°18.02'	56	6
128	03MAY93	2047	28°15.60'	94°32.41'	46	6
129	03MAY93	2219	28°14.41'	94°46.80'	46	6
130	03MAY93	2354	28°13.20'	95°01.20'	46	6
131	04MAY93	0248	28°06.62'	95°26.98'	46	6
132	05MAY93	0433	28°01.81'	95°40.79'	47	6
133	05MAY93	1400	27°43.02'	95°00.67'	500	12
134	05MAY93	1654	27°45.82'	95°01.94'	370	12
135	05MAY93	1808	27°48.55'	95°03.57'	258	12
136	05MAY93	1915	27°51.30'	95°04.92'	161	12
137	05MAY93	2005	27°54.08'	95°06.41'	106	10
138	05MAY93	2111	27°59.66'	95°09.15'	76	10
139	05MAY93	2212	28°05.03'	95°12.10'	53	8
140	05MAY93	2307	28°10.51'	95°15.01'	45	8
141	06MAY93	0003	28°16.36'	95°17.84'	37	6
142	06MAY93	0100	28°21.65'	95°20.84'	31	6
143	06MAY93	0211	28°27.00'	95°23.46'	28	6
144	06MAY93	0246	28°29.68'	95°25.05'	26	6
145	06MAY93	0322	28°32.37'	95°26.34'	23	6
146	06MAY93	0357	28°34.84'	95°28.19'	20	4
147	06MAY93	0430	28°37.44'	95°29.31'	17	4
148	06MAY93	0508	28°39.71'	95°30.82'	13	4
149	06MAY93	0555	28°42.30'	95°32.17'	13	4
150	06MAY93	1136	27°58.20'	95°57.60'	47	7
151	06MAY93	1619	27°31.50'	95°47.10'	519	12
152	06MAY93	1753	27°36.12'	95°52.68'	190	12
153	06MAY93	1903	27°41.10'	95°58.19'	100	8
154	06MAY93	2001	27°45.29'	96°03.30'	77	8
155	06MAY93	2110	27°48.60'	96°07.84'	64	6
156	06MAY93	2216	27°53.98'	96°13.50'	48	6

Table 3.4.1. Station times and positions for LATEX A cruise H05 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
157	06MAY93	2313	27°58.20'	96°18.93'	35	5
158	07MAY93	0015	28°02.39'	96°24.06'	25	5
159	07MAY93	0112	28°07.81'	96°30.01'	18	4
160	07MAY93	0207	28°12.60'	96°36.01'	8	4
161	07MAY93	0530	27°51.60'	96°19.20'	50	6
162	07MAY93	0706	27°44.40'	96°30.00'	49	6
163	07MAY93	0849	27°34.80'	96°39.61'	50	6
164	07MAY93	1025	27°24.01'	96°47.39'	50	6
165	07MAY93	1453	27°05.99'	96°12.60'	446	12
166	07MAY93	1554	27°06.88'	96°16.97'	317	12
167	07MAY93	1654	27°07.59'	96°20.21'	226	12
168	07MAY93	1741	27°08.10'	96°22.80'	185	12
169	07MAY93	1843	27°08.85'	96°26.72'	140	12
170	07MAY93	1952	27°09.10'	96°29.80'	114	10
171	07MAY93	2033	27°09.68'	96°33.14'	99	10
172	07MAY93	2112	27°10.18'	96°36.38'	90	10
173	07MAY93	2207	27°11.04'	96°42.93'	72	10
174	07MAY93	2317	27°11.92'	96°49.60'	57	8
175	07MAY93	2358	27°12.59'	96°53.39'	49	8
176	08MAY93	0035	27°12.69'	96°56.24'	43	8
177	08MAY03	0139	27°13.56'	97°03.15'	32	6
178	08MAY93	0218	27°14.30'	97°06.27'	29	6
179	08MAY93	0320	27°14.42'	97°09.58'	25	4
180	08MAY93	0350	27°15.38'	97°12.64'	22	4
181	08MAY93	0421	27°15.45'	97°16.05'	18	4
182	08MAY93	0739	27°01.00'	96°55.80'	49	6
183	08MAY93	0938	26°48.00'	96°54.61'	49	6
184	08MAY93	1136	26°36.59'	96°47.26'	50	6
185	08MAY93	1343	26°24.60'	96°39.00'	47	6
186	08MAY93	1602	26°13.22'	96°37.07'	50	6
187	08MAY93	2116	26°01.29'	97°06.98'	15	4
188	08MAY93	2149	26°01.37'	97°04.55'	21	4
189	08MAY93	2223	26°01.20'	97°01.36'	25	4
190	08MAY93	2302	26°01.50'	96°58.12'	30	4
191	09MAY93	0004	26°00.99'	96°51.44'	37	6
192	09MAY93	0103	26°00.99'	96°44.98'	44	6
193	09MAY93	0203	26°00.98'	96°38.64'	48	6
194	09MAY93	0320	26°00.97'	96°31.84'	61	6
195	09MAY93	0435	26°00.71'	96°25.26'	86	8
196	09MAY93	0523	26°00.84'	96°21.94'	121	10
197	09MAY93	0625	26°00.81'	96°18.67'	210	12
198	09MAY93	0733	26°00.60'	96°14.69'	504	12
199	09MAY93	0944	26°08.61'	96°19.94'	230	12
200	09MAY93	1133	26°19.81'	96°17.85'	245	12
201	09MAY93	1339	26°31.81'	96°19.94'	295	12
202	09MAY93	1558	26°43.78'	96°26.25'	201	12
203	09MAY93	1745	26°55.81'	96°26.25'	205	12
204	09MAY93	1939	27°07.59'	96°20.21'	220	12
205	09MAY93	2118	27°16.79'	96°15.21'	202	12
206	09MAY93	2313	27°25.79'	96°06.25'	200	12
207	10MAY93	0222	27°39.03'	95°42.68'	237	12
208	10MAY93	0412	27°42.49'	95°30.12'	304	12

Table 3.4.1. Station times and positions for LATEX A cruise H05 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
209	10MAY93	0613	27°45.68'	95°17.21'	263	12
210	10MAY93	0937	27°50.15'	94°48.57'	234	12
211	10MAY93	1128	27°50.12'	94°35.31'	272	12
212	10MAY93	1334	27°50.05'	94°21.67'	170	12
213	10MAY93	1813	27°24.95'	93°49.97'	854	0
214	10MAY93	2315	27°25.04'	94°30.03'	996	0
215	11MAY93	0404	27°26.23'	95°10.44'	1056	0

Table 3.4.2. Launch locations of LATEX A drifting buoys on cruise H05.

Station No.	Drifter No.	Day/Time (UTC)	Latitude (N)	Longitude(W)
091	6938	02 May 1993 0604	27° 51.02'	94° 10.48'
093	6935	02 May 1993 0744	27° 57.08'	94° 08.31'
096	6937	02 May 1993 1013	28° 09.02'	94° 03.74'
098	6939	02 May 1993 1310	28° 21.94'	93° 59.67'

3.4.1.2 Cruise H06CPW9311

The sixth LATEX A hydrography cruise (H06) was conducted aboard the *R/V J. W. Powell* 25 July - 7 August 1993. Dr. Lauren E. Sahl of Maine Maritime Academy was Chief Scientist. Figure 3.4.2 shows the locations of the stations occupied and the cruise track. Table 3.4.3 gives the station number, date, time (UTC), location, water depth, and number of bottles tripped at each of the stations. The survey plan called for 211 CTD stations; 215 were completed with the four extra stations located on a seaward extension of the transect offshore from Galveston.

In addition to the LATEX program work, we accommodated four complementary research efforts. Primary productivity measurements were made at eight stations by Gaston Gonzales, a student of Dr. Sayed El-Sayed (TAMU Oceanography). Plankton tows were made at 43 stations for Paula Bontempi, a graduate student of Dr. Denis Wiesenburg (Center for Marine Sciences, University of Southern Mississippi). Coccolithophorid data were collected at 18 stations for Vita Pariente, a graduate student of Dr. Stefan Gartner (TAMU Oceanography). Measurements of photosynthesis versus irradiance were made at selected stations by Xiaogang Chen, a graduate student of Dr. Steven E. Lohrenz (Center for Marine Sciences, University of Southern Mississippi).

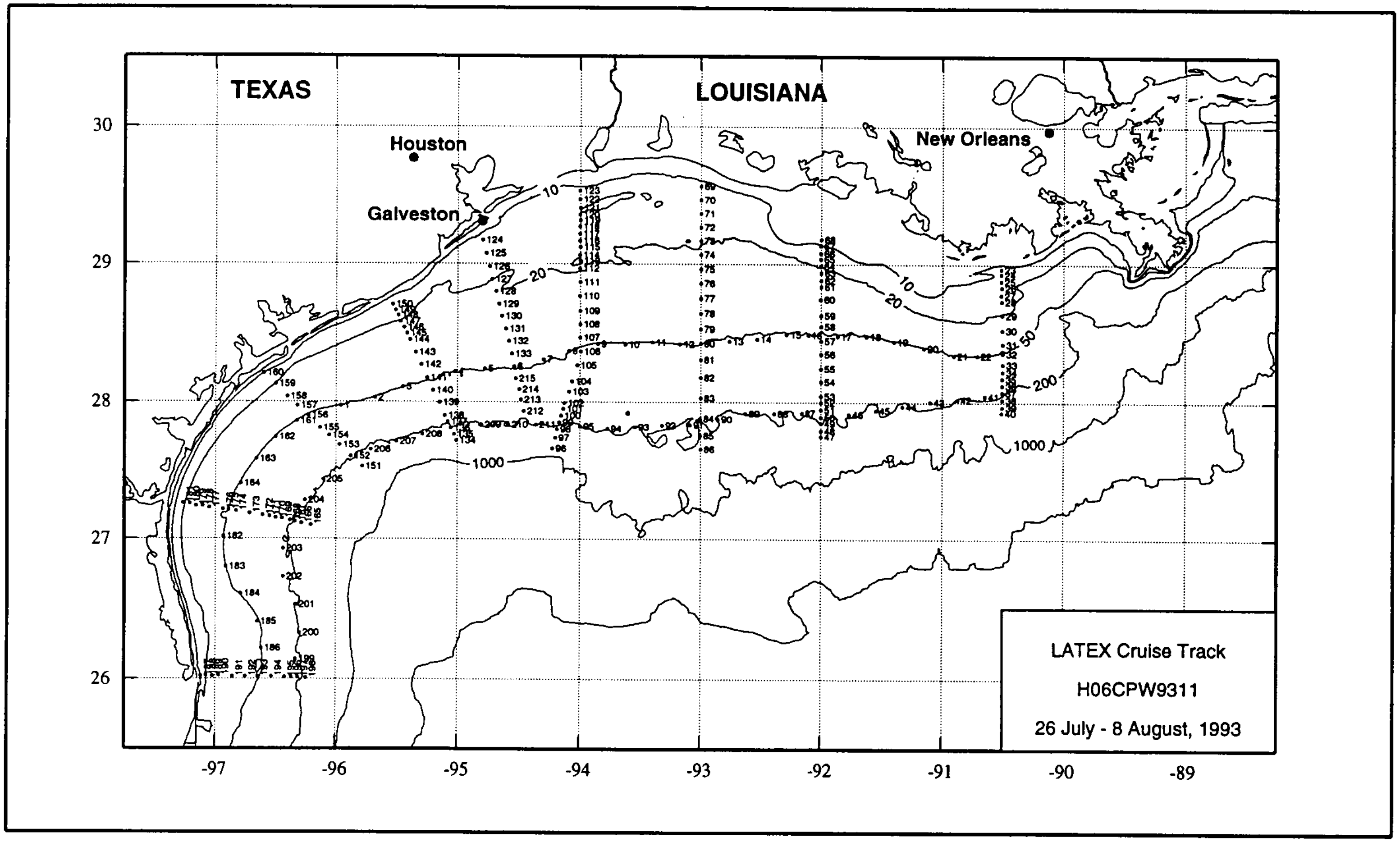


Figure 3.4.2. CTD stations and cruise track, LATEX H06.

Table 3.4.3. Station times and positions for LATEX A cruise H06.

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
1	26JUL93	1344	27°58.20'	95°57.59'	47	7
2	26JUL93	1538	28°01.80'	95°40.78'	49	6
3	26JUL93	1721	28°06.60'	95°26.96'	50	6
4	26JUL93	1957	28°13.20'	95°01.20'	49	6
5	26JUL93	2133	28°14.40'	94°46.80'	49	6
6	26JUL93	2315	28°15.59'	94°32.40'	48	6
7	27JUL93	0052	28°18.60'	94°18.01'	49	6
8	27JUL93	0228	28°22.21'	94°05.41'	49	6
9	27JUL93	0406	28°25.30'	93°51.02'	50	6
10	27JUL93	0536	28°25.06'	93°37.26'	51	6
11	27JUL93	0709	28°25.98'	93°23.98'	51	6
12	27JUL93	0837	28°25.32'	93°10.20'	51	7
13	27JUL93	1106	28°26.48'	92°45.68'	53	8
14	27JUL93	1237	28°27.62'	92°31.79'	54	8
15	27JUL93	1413	28°29.40'	92°17.36'	52	8
16	27JUL93	1524	28°29.39'	92°06.59'	52	7
17	27JUL93	1656	28°28.80'	91°51.60'	52	8
18	27JUL93	1825	28°28.76'	91°37.22'	50	7
19	27JUL93	1947	28°26.40'	91°24.02'	50	7
20	27JUL93	2133	28°23.70'	91°08.91'	50	7
21	27JUL93	2312	28°20.45'	90°54.14'	51	7
22	28JUL93	0030	28°20.41'	90°42.58'	48	7
23	28JUL93	0442	28°58.08'	90°30.60'	12	4
24	28JUL93	0525	28°55.74'	90°30.86'	14	4
25	28JUL93	0622	28°52.70'	90°30.60'	18	5
26	28JUL93	0654	28°49.97'	90°30.59'	19	5
27	28JUL93	0740	28°46.69'	90°30.62'	18	5
28	28JUL93	0815	28°43.93'	90°30.35'	18	5
29	28JUL93	0908	28°37.95'	90°30.27'	21	10
30	28JUL93	1024	28°31.63'	90°30.16'	37	7
31	28JUL93	1123	28°25.43'	90°29.96'	42	7
32	28JUL93	1221	28°21.61'	90°29.97'	48	8
33	28JUL93	1310	28°16.82'	90°29.98'	62	8
34	28JUL93	1354	28°13.54'	90°30.02'	76	12
35	28JUL93	1505	28°10.48'	90°30.13'	95	12
36	28JUL93	1546	28°07.67'	90°30.13'	118	12
37	28JUL93	1641	28°04.64'	90°30.20'	151	12
38	28JUL93	1747	28°01.28'	90°30.06'	254	12
39	28JUL93	1926	27°57.98'	90°30.17'	438	12
40	28JUL93	2009	27°55.43'	90°30.46'	499	12
41	28JUL93	2228	28°02.72'	90°38.61'	165	12
42	29JUL93	0001	28°01.35'	90°52.40'	203	12
43	29JUL93	0132	28°00.38'	91°05.83'	136	12
44	29JUL93	0302	27°58.15'	91°19.49'	266	12
45	29JUL93	0438	27°56.63'	91°32.72'	227	12
46	29JUL93	0618	27°54.78'	91°45.87'	168	12
47	29JUL93	0814	27°44.93'	91°59.90'	498	12
48	29JUL93	0927	27°47.52'	92°00.01'	391	12
49	29JUL93	1014	27°50.66'	91°59.98'	200	12
50	29JUL93	1053	27°53.58'	92°00.04'	166	12
51	29JUL93	1203	27°56.81'	92°00.05'	100	10
52	29JUL93	1304	27°59.97'	92°00.03'	121	12

Table 3.4.3. Station times and positions for LATEX A cruise H06 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
53	29JUL93	1351	28°02.69'	91°59.95'	106	11
54	29JUL93	1447	28°08.92'	91°59.90'	80	10
55	29JUL93	1541	28°14.71'	91°59.89'	62	7
56	29JUL93	1653	28°21.13'	91°59.82'	59	8
57	29JUL93	1744	28°26.78'	91°59.85'	55	8
58	29JUL93	1853	28°33.01'	91°59.83'	44	7
59	29JUL93	1941	28°37.73'	91°59.88'	40	6
60	29JUL93	2039	28°44.69'	92°00.08'	32	6
61	29JUL93	2144	28°50.26'	91°59.98'	27	6
62	29JUL93	2213	28°52.98'	92°00.01'	22	6
63	29JUL93	2251	28°56.22'	91°59.98'	22	5
64	29JUL93	2334	28°59.34'	92°00.07'	19	5
65	30JUL93	0004	29°02.29'	92°00.12'	17	5
66	30JUL93	0032	29°04.85'	92°00.16'	14	4
67	30JUL93	0110	29°07.98'	92°00.14'	10	4
68	30JUL93	0145	29°10.87'	92°00.00'	7	4
69	30JUL93	0826	29°34.02'	93°00.01'	12	4
70	30JUL93	0923	29°27.93'	92°59.95'	14	4
71	30JUL93	1023	29°22.00'	92°59.93'	16	4
72	30JUL93	1128	29°16.00'	92°59.82'	17	5
73	30JUL93	1312	29°10.04'	93°00.03'	17	5
74	30JUL93	1415	29°04.01'	92°59.97'	21	5
75	30JUL93	1510	28°57.80'	93°00.00'	21	5
76	30JUL93	1604	28°51.47'	92°59.93'	23	6
77	30JUL93	1705	28°44.93'	92°59.95'	28	7
78	30JUL93	1757	28°38.41'	92°59.93'	32	7
79	30JUL93	1850	28°31.88'	92°59.99'	41	7
80	30JUL93	1942	28°25.40'	92°59.97'	49	8
81	30JUL93	2053	28°18.48'	92°59.89'	51	8
82	30JUL93	2152	28°10.84'	92°59.98'	69	8
83	30JUL93	2314	28°01.80'	92°59.87'	105	9
84	31JUL93	0021	27°52.83'	93°00.11'	194	12
85	31JUL93	0222	27°45.28'	93°00.17'	217	12
86	31JUL93	0320	27°39.41'	92°59.93'	314	12
87	31JUL93	0858	27°55.15'	92°09.95'	145	12
88	31JUL93	1037	27°55.13'	92°23.40'	80	9
89	31JUL93	1212	27°55.13'	92°37.45'	195	12
90	31JUL93	1408	27°52.48'	92°51.37'	218	12
91	31JUL93	1551	27°50.07'	93°05.29'	173	12
92	31JUL93	1730	27°49.86'	93°19.15'	147	12
93	31JUL93	1903	27°49.00'	93°32.57'	201	12
94	31JUL93	2144	27°48.29'	93°46.27'	187	12
95	31JUL93	2317	27°49.26'	94°00.02'	201	12
96	01AUG93	0105	27°39.63'	94°13.47'	402	12
97	01AUG93	0227	27°44.25'	94°12.22'	450	12
98	01AUG93	0321	27°47.99'	94°11.44'	265	12
99	01AUG93	0410	27°50.98'	94°10.26'	118	10
100	01AUG93	0448	27°54.14'	94°09.34'	96	10
101	01AUG93	0529	27°57.06'	94°08.33'	85	8
102	01AUG93	0556	27°59.54'	94°07.49'	80	8
103	01AUG93	0643	28°04.65'	94°05.45'	69	8
104	01AUG93	0721	28°08.95'	94°03.76'	63	8

Table 3.4.3. Station times and positions for LATEX A cruise H06 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
105	01AUG93	0828	28°16.01'	94°01.29'	58	7
106	01AUG93	0914	28°21.92'	93°59.61'	52	7
107	01AUG93	1000	28°27.91'	93°59.98'	42	6
108	01AUG93	1047	28°33.80'	93°59.95'	36	5
109	01AUG93	1147	28°39.65'	93°59.93'	29	6
110	01AUG93	1242	28°46.03'	94°00.08'	25	6
111	01AUG93	1333	28°51.92'	93°59.97'	25	6
112	01AUG93	1424	28°57.93'	94°00.13'	17	5
113	01AUG93	1459	29°01.30'	94°00.05'	18	4
114	01AUG93	1528	29°03.78'	94°00.13'	18	5
115	01AUG93	1611	29°07.34'	94°00.05'	16	5
116	01AUG93	1643	29°09.97'	94°00.06'	16	5
117	01AUG93	1718	29°13.02'	94°00.15'	15	4
118	01AUG93	1750	29°16.17'	94°00.08'	13	5
119	01AUG93	1817	29°18.97'	93°59.91'	12	5
120	01AUG93	1849	29°21.62'	94°00.14'	9	4
121	01AUG93	1918	29°24.60'	94°00.03'	9	4
122	01AUG93	1954	29°28.15'	94°00.11'	12	4
123	01AUG93	2036	29°32.03'	94°00.15'	10	4
124	01AUG93	0137	29°10.21'	94°47.97'	13	4
125	02AUG93	0232	29°04.50'	94°46.18'	17	4
126	02AUG93	0317	28°58.78'	94°44.36'	17	4
127	02AUG93	0401	28°53.39'	94°43.22'	20	5
128	02AUG93	0446	28°48.00'	94°41.41'	20	5
129	02AUG93	0541	28°42.59'	94°39.89'	26	6
130	02AUG93	0633	28°37.20'	94°38.40'	30	6
131	02AUG93	0720	28°31.81'	94°36.58'	34	7
132	02AUG93	0805	28°26.40'	94°35.11'	39	7
133	02AUG93	0909	28°21.00'	94°33.59'	43	7
134	02AUG93	1451	27°43.02'	95°00.66'	500	11
135	02AUG93	1610	27°45.81'	95°01.94'	374	12
136	02AUG93	1707	27°48.55'	95°03.56'	266	12
137	02AUG93	1756	27°51.29'	95°04.89'	163	10
138	02AUG93	1846	27°54.08'	95°06.38'	108	10
139	02AUG93	1947	27°59.67'	95°09.16'	78	10
140	02AUG93	2044	28°05.04'	95°12.10'	55	7
141	02AUG93	2151	28°10.51'	95°15.02'	47	8
142	02AUG93	2246	28°16.36'	95°17.84'	38	8
143	02AUG93	2339	28°21.65'	95°20.82'	33	7
144	03AUG93	0033	28°27.01'	95°23.47'	31	6
145	03AUG93	0114	28°29.68'	95°25.04'	28	6
146	03AUG93	0143	28°32.38'	95°26.35'	25	9
147	03AUG93	0213	28°34.83'	95°28.18'	22	5
148	03AUG93	0242	28°37.42'	95°29.31'	18	4
149	03AUG93	0310	28°39.68'	95°30.79'	14	4
150	03AUG93	0340	28°42.31'	95°32.18'	14	4
151	03AUG93	1330	27°31.50'	95°47.09'	520	12
152	03AUG93	1444	27°36.12'	95°52.69'	192	12
153	03AUG93	1556	27°41.10'	95°58.21'	105	9
154	03AUG93	1653	27°45.29'	96°03.29'	80	9
155	03AUG93	1744	27°48.60'	96°07.84'	68	7
156	03AUG93	1906	27°53.97'	96°13.48'	50	6

Table 3.4.3. Station times and positions for LATEX A cruise H06 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
157	03AUG93	2005	27°58.19'	96°18.92'	36	6
158	03AUG93	2058	28°02.38'	96°24.04'	27	5
159	03AUG93	2159	28°07.81'	96°30.02'	19	4
160	03AUG93	2256	28°12.57'	96°35.98'	4	4
161	04AUG93	0154	27°51.57'	96°19.20'	49	6
162	04AUG93	0317	27°44.41'	96°29.99'	49	6
163	04AUG93	0448	27°34.79'	96°39.62'	49	6
164	04AUG93	0614	27°24.01'	96°47.40'	49	6
165	04AUG93	1015	27°05.98'	96°12.58'	445	12
166	04AUG93	1149	27°06.88'	96°16.96'	316	12
167	04AUG93	1313	27°07.59'	96°20.20'	226	12
168	04AUG93	1401	27°08.08'	96°22.77'	185	12
169	04AUG93	1450	27°08.85'	96°26.73'	140	12
170	04AUG93	1623	27°09.09'	96°29.79'	115	11
171	04AUG93	1704	27°09.68'	96°33.12'	99	10
172	04AUG93	1806	27°10.17'	96°36.35'	90	10
173	04AUG93	1907	27°11.04'	96°42.93'	72	10
174	04AUG93	2007	27°11.92'	96°49.59'	57	8
175	04AUG93	2046	27°12.58'	96°53.41'	49	8
176	04AUG93	2149	27°12.71'	96°56.23'	43	8
177	04AUG93	2253	27°13.55'	97°03.17'	32	7
178	04AUG93	2325	27°14.30'	97°06.25'	29	5
179	04AUG93	2357	27°14.39'	97°09.58'	25	5
180	05AUG93	0029	27°15.39'	97°12.64'	22	5
181	05AUG93	0106	27°15.43'	97°16.05'	18	4
182	05AUG93	0348	27°01.01'	96°55.77'	49	6
183	05AUG93	0530	26°47.98'	96°54.63'	49	6
184	05AUG93	0711	26°36.58'	96°47.26'	52	6
185	05AUG93	0855	26°24.60'	96°39.00'	48	6
186	05AUG93	1137	26°13.22'	96°37.06'	50	6
187	05AUG93	1502	26°01.30'	97°06.98'	15	4
188	05AUG93	1540	26°01.38'	97°04.53'	21	4
189	05AUG93	1612	26°01.20'	97°01.35'	25	5
190	05AUG93	1644	26°01.53'	96°58.10'	30	6
191	05AUG93	1736	26°00.99'	96°51.44'	37	6
192	05AUG93	1837	26°00.99'	96°44.98'	44	6
193	05AUG93	1924	26°00.98'	96°38.62'	49	7
194	05AUG93	2018	26°00.98'	96°31.84'	61	7
195	05AUG93	2123	26°00.71'	96°25.25'	86	9
196	05AUG93	2156	26°00.83'	96°21.94'	121	10
197	05AUG93	2248	26°00.81'	96°18.67'	210	12
198	05AUG93	2334	26°00.59'	96°14.68'	504	12
199	06AUG93	0122	26°08.63'	96°19.91'	230	12
200	06AUG93	0254	26°19.82'	96°17.81'	237	12
201	06AUG93	0430	26°31.83'	96°19.94'	272	12
202	06AUG93	0616	26°43.80'	96°26.21'	202	12
203	06AUG93	0747	26°55.83'	96°26.19'	206	12
204	06AUG93	1010	27°16.78'	96°15.20'	203	12
205	06AUG93	1140	27°25.79'	96°06.21'	206	12
206	06AUG93	1426	27°39.03'	95°42.68'	237	12
207	06AUG93	1619	27°42.50'	95°30.12'	301	12
208	06AUG93	1749	27°45.68'	95°17.19'	264	12

Table 3.4.3. Station times and positions for LATEX A cruise H06 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
209	06AUG93	2033	27°50.13'	94°48.59'	241	12
210	06AUG93	2204	27°50.12'	94°35.30'	279	12
211	06AUG93	2346	27°50.05'	94°21.68'	170	12
212	07AUG93	0056	27°56.01'	94°27.71'	106	12
213	07AUG93	0140	28°00.94'	94°29.03'	68	7
214	07AUG93	0225	28°05.46'	94°29.99'	56	6
215	07AUG93	0303	28°10.20'	94°31.51'	56	6

3.4.1.3 Cruise H07CPW9314

The seventh LATEX A hydrography cruise (H07) was conducted on the *R/V J.W. Powell* 6-22 November 1993. Figure 3.4.3 shows the location of the stations occupied and the cruise track. Ms. Carrie A. Neuhard of TAMU was Chief Scientist. Table 3.4.4 gives the station number, date, time (UTC), location, water depth, and number of bottles tripped at each of the stations. The plan called for 212 normal stations to be occupied on the Texas-Louisiana shelf and 33 additional stations along the 50-m isobath with only CTD measurements. All 212 normal stations were completed; only 23 of the CTD-only stations were completed before the Chief Scientist discontinued them due to adverse weather conditions and problems with ship operations. Stations 230 and 234 on Line 9 were sampled twice. A deep station (740 m) was added at the end of the survey for intercruise CTD comparison. A total of 238 stations were completed.

In addition to LATEX program work, three complementary research efforts were accommodated. Primary productivity measurements were taken by Gaston Gonzales a graduate student of Dr. Sayed El-Sayed (TAMU Dept. of Oceanography). Coccolithophorid data were collected at eight stations for Vita Pariente a graduate student of Dr. Stefan Gartner (TAMU Dept. of Oceanography). Measurements of photosynthesis versus irradiance were made at selected stations by Xiaogang Chen a graduate student of Steven Lohrenz (Center for Marine Science, University of Southern Mississippi).

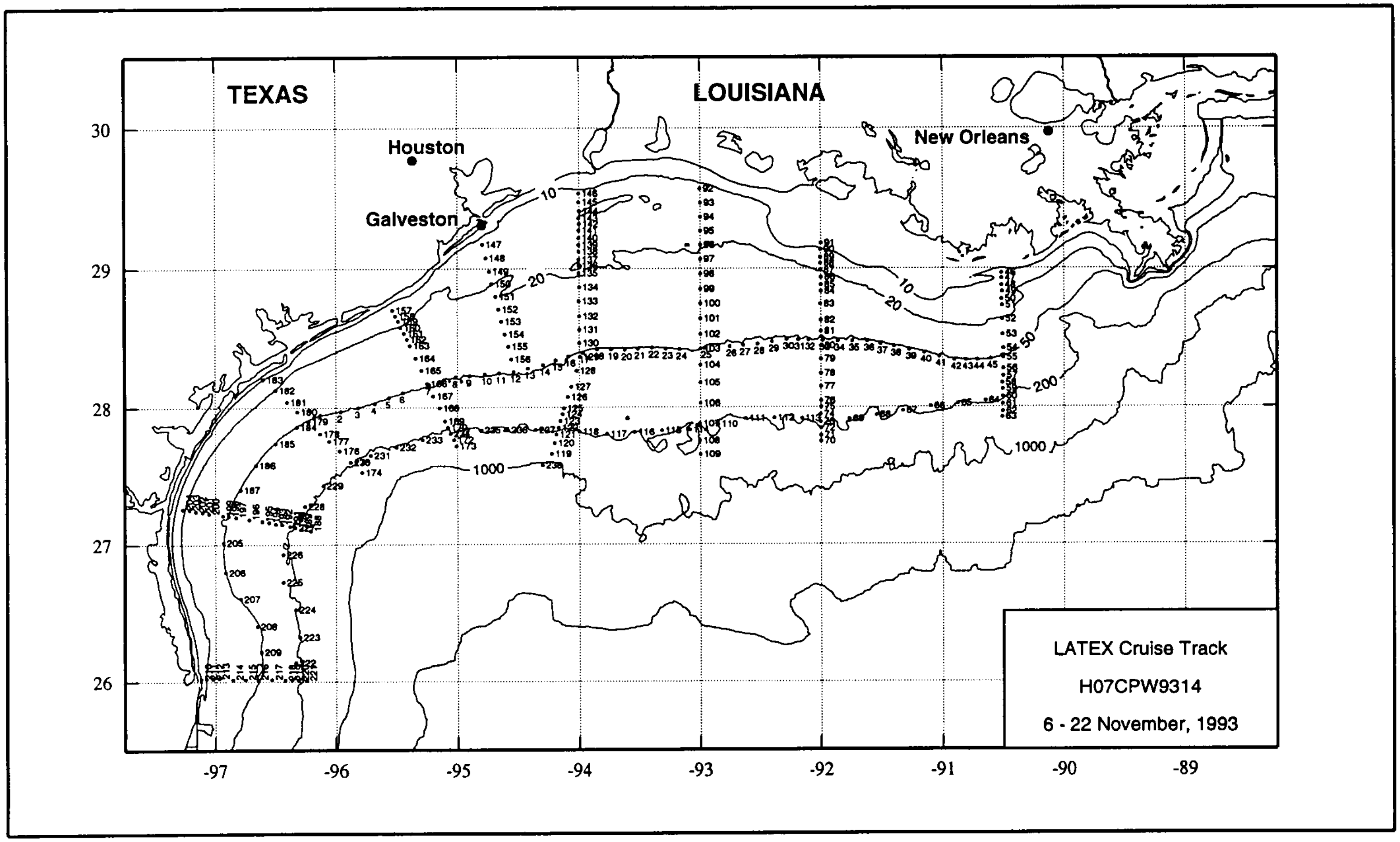


Figure 3.4.3. CTD stations and cruise track, LATEX H07.

Table 3.4.4. Station times and positions for LATEX A cruise H07.

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
1	07NOV93	1630	27°56.39'	96°10.83'	48	0
2	07NOV93	1843	27°58.19'	95°57.59'	49	7
3	07NOV93	1948	28°00.01'	95°49.18'	49	0
4	07NOV93	2046	28°01.82'	95°40.77'	49	8
5	07NOV93	2149	28°04.20'	95°33.90'	49	0
6	07NOV93	2238	28°06.62'	95°26.97'	49	7
7	08NOV93	0100	28°09.91'	95°14.07'	49	0
8	08NOV93	0217	28°13.20'	95°01.19'	49	7
9	08NOV93	0306	28°13.82'	94°54.00'	50	0
10	08NOV93	0357	28°14.41'	94°46.80'	49	7
11	08NOV93	0448	28°14.99'	94°39.60'	49	0
12	08NOV93	0538	28°15.59'	94°32.42'	49	7
13	08NOV93	0644	28°17.11'	94°25.21'	48	0
14	08NOV93	0738	28°18.57'	94°18.02'	48	7
15	08NOV93	0847	28°20.41'	94°11.73'	49	0
16	08NOV93	0935	28°22.21'	94°05.43'	49	7
17	08NOV93	1032	28°23.76'	93°58.23'	50	0
18	08NOV93	1122	28°25.30'	93°51.05'	50	7
19	08NOV93	1215	28°25.19'	93°44.16'	50	0
20	08NOV93	1304	28°25.06'	93°37.27'	51	7
21	08NOV93	1408	28°25.54'	93°30.66'	51	0
22	08NOV93	1501	28°25.96'	93°24.02'	50	7
23	08NOV93	1602	28°25.65'	93°17.11'	50	0
24	08NOV93	1658	28°25.32'	93°10.18'	50	7
25	08NOV93	1829	28°25.90'	92°57.92'	51	0
26	08NOV93	1950	28°26.48'	92°45.66'	53	6
27	08NOV93	2049	28°27.04'	92°38.74'	52	0
28	08NOV93	2143	28°27.61'	92°31.80'	53	6
29	08NOV93	2237	28°28.50'	92°24.58'	54	0
30	08NOV93	2332	28°29.40'	92°17.36'	53	7
31	09NOV93	0029	28°29.39'	92°11.98'	53	0
32	09NOV93	0115	28°29.39'	92°06.59'	52	7
33	09NOV93	0218	28°29.08'	91°59.10'	52	0
34	09NOV93	0317	28°28.79'	91°51.61'	53	7
35	09NOV93	0417	28°28.77'	91°44.42'	52	0
36	09NOV93	0513	28°28.76'	91°37.23'	51	8
37	09NOV93	0616	28°27.59'	91°30.65'	52	0
38	09NOV93	0713	28°26.43'	91°24.03'	51	7
39	09NOV93	0836	28°25.06'	91°16.48'	52	0
40	09NOV93	0937	28°23.71'	91°08.93'	51	7
41	09NOV93	1047	28°22.08'	91°01.53'	51	0
42	09NOV93	1149	28°20.47'	90°54.17'	52	7
43	09NOV93	1324	28°20.45'	90°48.38'	50	0
44	09NOV93	1430	28°20.42'	90°42.62'	50	7
45	09NOV93	1606	28°21.01'	90°36.29'	50	0
46	10NOV93	0147	28°58.11'	90°30.61'	13	4
47	10NOV93	0218	28°55.72'	90°30.86'	15	4
48	10NOV93	0310	28°52.69'	90°30.61'	19	5
49	10NOV93	0341	28°49.99'	90°30.59'	20	5
50	10NOV93	0413	28°46.72'	90°30.64'	19	4
51	10NOV93	0456	28°43.93'	90°30.36'	19	6
52	10NOV93	0623	28°37.95'	90°30.33'	22	5

Table 3.4.4. Station times and positions for LATEX A cruise H07 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
53	10NOV93	0827	28°31.63'	90°30.18'	36	6
54	10NOV93	1041	28°25.42'	90°29.97'	45	7
55	10NOV93	1152	28°21.61'	90°29.97'	50	7
56	10NOV93	1259	28°16.81'	90°30.00'	62	9
57	10NOV93	1347	28°13.53'	90°30.05'	77	9
58	10NOV93	1502	28°10.47'	90°30.30'	95	11
59	10NOV93	1553	28°07.68'	90°30.16'	118	12
60	10NOV93	1653	28°04.65'	90°30.21'	151	12
61	10NOV93	1741	28°01.26'	90°30.06'	256	12
62	10NOV93	1857	27°57.97'	90°30.14'	441	12
63	10NOV93	1950	27°55.45'	90°30.46'	503	12
64	10NOV93	2145	28°02.72'	90°38.59'	163	12
65	10NOV93	2323	28°01.39'	90°52.41'	189	12
66	11NOV93	0059	28°00.39'	91°05.83'	136	12
67	11NOV93	0232	27°58.15'	91°19.49'	267	12
68	11NOV93	0408	27°56.60'	91°32.70'	230	12
69	11NOV93	0539	27°54.77'	91°45.89'	172	12
70	11NOV93	0757	27°44.94'	91°59.90'	493	12
71	11NOV93	0938	27°47.51'	92°00.02'	396	12
72	11NOV93	1105	27°50.68'	91°59.98'	200	12
73	11NOV93	1221	27°53.54'	92°00.08'	170	12
74	11NOV93	1313	27°56.80'	92°00.07'	101	10
75	11NOV93	1409	27°59.99'	92°00.05'	123	12
76	11NOV93	1453	28°02.71'	91°59.97'	106	11
77	11NOV93	1613	28°08.94'	91°59.93'	83	10
78	11NOV93	1735	28°14.69'	91°59.89'	70	7
79	11NOV93	1902	28°21.13'	91°59.82'	62	7
80	11NOV93	1958	28°26.77'	91°59.86'	56	7
81	11NOV93	2052	28°33.01'	91°59.85'	46	6
82	11NOV93	2135	28°37.73'	91°59.88'	39	6
83	11NOV93	2231	28°44.70'	92°00.09'	33	6
84	11NOV93	2323	28°50.26'	92°00.00'	28	6
85	11NOV93	2353	28°52.96'	91°59.99'	25	5
86	12NOV93	0026	28°56.23'	91°59.98'	22	5
87	12NOV93	0058	28°59.33'	92°00.07'	20	5
88	12NOV93	0128	29°02.29'	92°00.11'	17	5
89	12NOV93	0156	29°04.87'	92°00.16'	14	5
90	12NOV93	0228	29°07.99'	92°00.06'	11	4
91	12NOV93	0255	29°10.87'	91°59.99'	7	4
92	12NOV93	0824	29°34.05'	93°00.07'	12	4
93	12NOV93	0917	29°27.93'	92°59.96'	13	4
94	12NOV93	1018	29°22.00'	92°59.97'	15	4
95	12NOV93	1116	29°15.91'	93°00.01'	17	5
96	12NOV93	1213	29°10.04'	93°00.05'	19	5
97	12NOV93	1259	29°03.98'	92°59.97'	22	5
98	12NOV93	1352	28°57.81'	92°59.99'	23	5
99	12NOV93	1448	28°51.41'	92°59.99'	26	5
100	12NOV93	1555	28°44.92'	92°59.94'	31	6
101	12NOV93	1649	28°38.41'	92°59.93'	34	7
102	12NOV93	1810	28°31.87'	92°59.98'	44	7
103	12NOV93	1911	28°25.38'	92°59.94'	50	9
104	12NOV93	2024	28°18.48'	92°59.88'	53	8

Table 3.4.4. Station times and positions for LATEX A cruise H07 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
105	12NOV93	2142	28°10.85'	92°59.92'	73	10
106	12NOV93	2315	28°01.82'	92°59.86'	102	12
107	13NOV93	0040	27°52.85'	93°00.11'	190	12
108	13NOV93	0201	27°45.27'	93°00.15'	207	12
109	13NOV93	0310	27°39.41'	92°59.91'	315	12
110	13NOV93	0504	27°52.49'	92°51.37'	217	12
111	13NOV93	0645	27°55.13'	92°37.46'	195	12
112	13NOV93	0826	27°55.14'	92°23.40'	83	9
113	13NOV93	1001	27°55.13'	92°09.94'	145	12
114	13NOV93	1500	27°50.08'	93°05.29'	176	12
115	13NOV93	1638	27°49.87'	93°19.13'	151	12
116	13NOV93	1810	27°49.00'	93°32.57'	201	12
117	13NOV93	2001	27°48.29'	93°46.23'	192	12
118	13NOV93	2153	27°49.23'	93°59.99'	199	12
119	14NOV93	0111	27°39.62'	94°13.46'	452	12
120	14NOV93	0115	27°44.25'	94°12.19'	442	12
121	14NOV93	0216	27°47.99'	94°11.40'	269	12
122	14NOV93	0302	27°50.98'	94°10.27'	121	12
123	14NOV93	0343	27°54.14'	94°09.29'	96	10
124	14NOV93	0424	27°57.05'	94°08.32'	85	9
125	14NOV93	0500	27°59.54'	94°07.51'	82	9
126	14NOV93	0549	28°04.65'	94°05.52'	70	8
127	14NOV93	0639	28°08.97'	94°03.73'	66	8
128	14NOV93	0744	28°16.02'	94°01.31'	58	7
129	14NOV93	0834	28°21.94'	93°59.64'	51	7
130	14NOV93	0930	28°27.94'	93°59.99'	43	6
131	14NOV93	1023	28°33.82'	93°59.94'	37	6
132	14NOV93	1118	28°39.64'	93°59.93'	29	6
133	14NOV93	1225	28°46.01'	94°00.09'	25	6
134	14NOV93	1315	28°51.90'	93°59.97'	25	6
135	14NOV93	1404	28°57.93'	94°00.14'	17	5
136	14NOV93	1438	29°01.31'	94°00.06'	18	4
137	14NOV93	1505	29°03.78'	94°00.14'	19	5
138	14NOV93	1539	29°07.34'	94°00.07'	18	5
139	14NOV93	1607	29°09.99'	94°00.07'	16	5
140	14NOV93	1655	29°12.99'	94°00.10'	15	5
141	14NOV93	1725	29°16.21'	94°00.10'	13	5
142	14NOV93	1753	29°18.97'	93°59.92'	13	4
143	14NOV93	1821	29°21.61'	94°00.13'	12	4
144	14NOV93	1850	29°24.57'	94°00.03'	12	4
145	14NOV93	1923	29°28.15'	94°00.13'	12	4
146	14NOV93	1956	29°32.04'	94°00.16'	12	4
147	15NOV93	0613	29°10.18'	94°47.98'	14	4
148	15NOV93	0700	29°04.50'	94°46.23'	18	4
149	15NOV93	0853	28°58.78'	94°44.41'	17	4
150	15NOV93	0936	28°53.40'	94°43.22'	20	5
151	15NOV93	1021	28°48.01'	94°41.43'	18	5
152	15NOV93	1108	28°42.58'	94°39.89'	26	6
153	15NOV93	1152	28°37.18'	94°38.41'	29	6
154	15NOV93	1246	28°31.77'	94°36.60'	34	7
155	15NOV93	1333	28°26.40'	94°35.15'	39	7
156	15NOV93	1424	28°21.00'	94°33.58'	43	7

Table 3.4.4. Station times and positions for LATEX A cruise H07 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
157	17NOV93	1001	28°42.21'	95°32.21'	16	4
158	17NOV93	1034	28°39.71'	95°30.82'	13	4
159	17NOV93	1102	28°37.45'	95°29.30'	18	4
160	17NOV93	1135	28°34.82'	95°28.19'	21	5
161	17NOV93	1215	28°32.38'	95°26.35'	26	7
162	17NOV93	1256	28°29.66'	95°25.07'	27	6
163	17NOV93	1330	28°27.00'	95°23.48'	30	6
164	17NOV93	1429	28°21.63'	95°20.86'	33	7
165	17NOV93	1522	28°16.35'	95°17.86'	38	8
166	17NOV93	1623	28°10.50'	95°15.02'	47	8
167	17NOV93	1725	28°05.03'	95°12.12'	56	7
168	17NOV93	1836	27°59.64'	95°09.11'	76	9
169	17NOV93	1925	27°54.08'	95°06.41'	108	11
170	17NOV93	2005	27°51.30'	95°04.93'	164	11
171	17NOV93	2105	27°48.55'	95°03.59'	265	11
172	17NOV93	2154	27°45.83'	95°01.96'	377	11
173	17NOV93	2241	27°43.02'	95°00.69'	508	11
174	18NOV93	0320	27°31.50'	95°47.11'	521	12
175	18NOV93	0448	27°36.12'	95°52.69'	196	12
176	18NOV93	0612	27°41.09'	95°58.19'	104	10
177	18NOV93	0813	27°45.30'	96°03.31'	80	9
178	18NOV93	0907	27°48.60'	96°07.85'	68	7
179	18NOV93	1008	27°53.98'	96°13.52'	50	6
180	18NOV93	1101	27°58.22'	96°18.93'	36	6
181	18NOV93	1153	28°02.40'	96°24.06'	27	6
182	18NOV93	1255	28°07.82'	96°30.02'	19	4
183	18NOV93	1359	28°12.62'	96°36.02'	10	4
184	18NOV93	1631	27°51.61'	96°19.21'	50	6
185	18NOV93	1753	27°44.39'	96°30.00'	50	6
186	18NOV93	1914	27°34.80'	96°39.62'	52	6
187	18NOV93	2037	27°24.01'	96°47.39'	50	6
188	19NOV93	0006	27°05.99'	96°12.59'	447	12
189	19NOV93	0102	27°06.88'	96°16.96'	316	12
190	19NOV93	0151	27°07.58'	96°20.20'	224	12
191	19NOV93	0236	27°08.10'	96°22.81'	187	12
192	19NOV93	0321	27°08.84'	96°26.72'	140	12
193	19NOV93	0403	27°09.09'	96°29.80'	114	12
194	19NOV93	0442	27°09.68'	96°33.14'	98	10
195	19NOV93	0519	27°10.17'	96°36.38'	90	10
196	19NOV93	0619	27°11.04'	96°42.92'	72	10
197	19NOV93	0718	27°11.92'	96°49.60'	57	8
198	19NOV93	0802	27°12.59'	96°53.38'	49	8
199	19NOV93	0834	27°12.69'	96°56.24'	43	8
200	19NOV93	0930	27°13.56'	97°03.13'	32	7
201	19NOV93	1004	27°14.29'	97°06.28'	29	5
202	19NOV93	1045	27°14.42'	97°09.60'	25	5
203	19NOV93	1119	27°15.38'	97°12.64'	23	5
204	19NOV93	1152	27°15.45'	97°16.05'	17	4
205	19NOV93	1405	27°01.00'	96°55.81'	48	6
206	19NOV93	1528	26°48.01'	96°54.62'	48	6
207	19NOV93	1652	26°36.59'	96°47.24'	51	6
208	19NOV93	1821	26°24.59'	96°39.00'	47	6

Table 3.4.4. Station times and positions for LATEX A cruise H07 (continued).

Station	Date	Time (UTC)	Latitude N	Longitude W	Depth	Niskins
209	19NOV93	1937	26°13.20'	96°37.06'	51	6
210	19NOV93	2230	26°01.29'	97°06.97'	15	4
211	19NOV93	2256	26°01.37'	97°04.55'	21	5
212	19NOV93	2324	26°01.20'	97°01.35'	25	5
213	20NOV93	0011	26°01.50'	96°58.11'	30	6
214	20NOV93	0051	26°00.98'	96°51.44'	38	6
215	20NOV93	0145	26°00.97'	96°44.97'	46	6
216	20NOV93	0235	26°00.97'	96°38.62'	50	7
217	20NOV93	0326	26°00.96'	96°31.84'	60	7
218	20NOV93	0413	26°00.71'	96°25.26'	85	8
219	20NOV93	0449	26°00.83'	96°21.95'	120	10
220	20NOV93	0549	26°00.80'	96°18.66'	203	12
221	20NOV93	0712	26°00.61'	96°14.69'	504	12
222	20NOV93	1056	26°08.61'	96°19.94'	230	12
223	20NOV93	1350	26°19.80'	96°17.87'	245	12
224	20NOV93	1612	26°31.80'	96°19.95'	295	12
225	20NOV93	2106	26°43.74'	96°26.29'	204	12
226	20NOV93	2320	26°55.80'	96°26.23'	207	12
227	21NOV93	0144	27°07.59'	96°20.22'	223	12
228	21NOV93	0315	27°16.79'	96°15.21'	203	12
229	21NOV93	0500	27°25.79'	96°06.24'	203	12
230	21NOV93	0709	27°36.10'	95°52.67'	194	12
231	21NOV93	0918	27°39.04'	95°42.67'	252	12
232	21NOV93	1059	27°42.49'	95°30.12'	301	12
233	21NOV93	1237	27°45.68'	95°17.20'	266	12
234	21NOV93	1415	27°48.55'	95°03.56'	265	12
235	21NOV93	1643	27°50.15'	94°48.55'	241	12
236	21NOV93	1822	27°50.12'	94°35.29'	276	12
237	21NOV93	1959	27°50.05'	94°21.66'	173	12
238	21NOV93	2159	27°34.48'	94°18.07'	738	12

3.4.2 Instrumentation, Calibration, and Sampling Procedures

The instrumentation and sampling procedures for the hydrographic surveys were described in section 2.4.2.1 of Jochens and Nowlin (1994b). Some minor variations from the procedures set out in these references occurred due to time constraints and the actual instruments used. The only significant variation was that a Chelsea fluorimeter was used on these cruises. The Chelsea instrument has a logarithmic output which provides better fluorescence resolution in rapidly changing coastal waters.

At each cast continuous profiles with depth were taken of temperature, conductivity dissolved oxygen, transmissometry, fluorescence, optical back-scatterance, and downwelling irradiance. Routine meteorological data were collected during the cruise and were sent to the National Weather Service via the SEAS III system. Secchi disk depth readings were taken at every daylight station. Instrumentation used is shown in Table 3.4.5.

Table 3.4.5. Hydrographic equipment available on each hydrography cruise.

Instrument	Type	Quantity
CTD System + oxygen	Sea-Bird SBE-911*plus*	2
Rosette	General Oceanics 12 place	2
Rosette frame	TAMU fabrication	2
Niskin Bottles	GO Level Action, 10 liters	12
Niskin Bottles	GO Standard, 10-12 liter	12
Transmissometer	SeaTech 2000 m	2
Fluorometer	SeaTech 3000 m	1
Fluorometer	Chelsea Instruments	1
Backscatter Sensor	D&A Instruments OBS-3	2
Altimeter	Datasonics PSA-900	2
PAR Sensor	Biospherical QSP-200L	2
Secchi Disk	TAMU fabrication	2

3.4.3 Summary of Data Collection

On each hydrographic cruise, more data were collected than required by the contract. Table 3.4.6 summarizes data collected and scientific participation from the three full-shelf hydrography cruises conducted in the second year. In addition, visiting researchers on each cruise collected complementary data for use in their individual research programs. Information relative to these complementary programs is given in Table 3.4.7.

3.5 Acoustic Doppler Current Profiler Measurements (ADCP)

3.5.1 Synopsis of ADCP Surveys

Underway ADCP surveys were made on all three hydrographic surveys during the second field year. Dates are shown in Table 2.2.1. Survey tracks are shown in Figures 3.4.1 through 3.4.3. The H05 survey used the same self-contained 150-kHz RDI NarrowBand ADCP employed on LATEX A cruise H03 in the first field year. Surveys H06 and H07 used the 150-kHz RDI NarrowBand ADCP from R/V *Gyre* employed on cruise H04 in the first field year. Prior to each cruise, the ADCP was connected to a quadrapod mounting carriage that was installed in the through-ship well aboard the R/V *J.W. Powell* and aligned as described by Murphy et al. (1992).

3.5.1.1 Cruise H05CPW9306

Underway ADCP data were collected from 10:15 GMT on 26 April through 13:53 GMT on 11 May, using RDI's "TRANSECT" software. This was generally successful, although on 30 April, 3 May, and 7 May this software stuck at "checking Configuration and Data Path". There were two other periods of down time occasioned by shipboard power failures on 8 May; each was less than an hour.

Table 3.4.6. Summary of data collected and scientific participation in the LATEX A standard grid hydrography surveys in the second field year.

Description	H05 May 1993	H06 Aug. 1993	H07 Nov. 1993
Cruise Duration (days)	17	13	16
Cruise Track (km)	3680	3632	3720
Total Hydro Stations	215	215	238
CTD Stations	215	215	238
Nutrient Stations	212	215	212
Oxygen Stations	145	148	144
Salinity Stations	134	133	133
Pigment Stations	153	154	152
Particulate Stations	107	109	108
Secchi Disk Stations	105	115	97
Weather Obs	64	48	60
Nutrient Samples	1682	1704	1685
Salinity Samples	1058	1044	1054
Oxygen Samples	1129	1155	1125
Pigment Samples	1204	1211	1217
Particulate Samples	214	221	214
Total Scientific Party	23	17	20
LATEX Scientists	19	15	18
Guest Investigators	4	2	2
Graduate Students	9	4	6
Complementary Studies	4	4	3

Table 3.4.7. Complementary programs on LATEX A hydrography surveys.

Description	H05 May 1993	H06 Aug. 1993	H07 Nov. 1993
Guest Investigators	2	2	2
Phytoplankton Stations	28	61	8
Productivity Stations	12	8	9
Drifter Launches	3	0	0

3.5.1.2 Cruise H06CPW9311

At the beginning of the cruise, the ADCP deck unit had difficulty receiving heading information from the gyrocompass on the R/V *Powell*. This was corrected by 15:57 GMT on 26 July. There were no difficulties with subsequent operation, and underway ADCP data were collected from 16:18 GMT on 26 July through 10:35 GMT on 7 August.

3.5.1.3 Cruise H07CPW9314

Underway ADCP data were collected from 05:53 GMT on 7 November through 18:53 GMT on 14 November, from 09:30 GMT on 15 November through 12:30 GMT on 16 November, and from 09:56 GMT on 17 November through 05:52 GMT on 22 November. Gaps in data collection were occasioned by mid-cruise port stops. Except for data gaps when the computer hung up (8 h on 11 November and 1.5 h on 20 November), there were no major problems in data collection.

3.5.2 Instrumentation, Calibration, and Sampling Procedures

Instrumentation and sampling procedures for ADCP were described in section 9.7 of Nowlin et al. (1991) and in section 2.5 of Jochens and Nowlin (1994b). Some variations from those procedures occurred due to time constraints and the actual instruments used. Calculation of the mounting alignment error and first level and second level quality control were performed as detailed in sections 3.5.1.3 through 3.5.1.5 of Jochens and Nowlin (1994b). Most parameter settings were unchanged from those of LATEX A cruise H04; the time set between pings was changed to 0.67 seconds on H06 and H07.

3.5.3 Summary of Data Collection

The configurations recorded for each ADCP cruise are shown in Table 3.5.1. The dates of data collection are stated in section 3.5.1 above. Quantities of ADCP data collected are: 150 Mbytes on cruise H05, 293 Mbytes on H06, and 281 Mbytes on H07.

Table 3.5.1. ADCP configurations.

System Parameter	H05	H06	H07
Averaging interval (min)	5	5	5
Depth cell length (m)	4	4	4
Number of depth cells	100	100	100
Time between pings (sec)	1.75	0.67	0.67
Transmit pulse length (m)	4	4	4
Blank after transmit (m)	4	4	4
Navigation type	GPS	GPS	GPS
Data recorded	Raw data; averaged data; navigation	Raw data; averaged data; navigation	Raw data; averaged data; navigation

3.6 Collateral Data

The assembly of collateral data consists of the collection of information from other programs that are collecting physical oceanographic data on the Texas-Louisiana shelf during the LATEX field years and from pertinent historical reports. These data will be used to assist in the analysis of the LATEX A data set and in the development of the final synthesis report. The collateral data assembly has followed the plan given in Nowlin et al. (1991). This section summarizes the progress made in assembling (1) a bibliography on the physical oceanography of the Gulf of Mexico, (2) the physical oceanographic data collected over the Texas-Louisiana shelf by non-LATEX programs during the LATEX field years (the concurrent data), and (3) the historical data from the Gulf of Mexico that may be pertinent to the analysis and synthesis of the LATEX and concurrent data sets.

3.6.1 Bibliography

The LATEX Gulf of Mexico bibliography continues to be maintained and augmented. It contains 687 entries related to the physical and hydrographic characteristics of the Gulf. Notice of the availability of the bibliography was posted twice in this report year to the GULF.MEX bulletin board and is promoted in every issue of the *LATEX Fortnightly*. Ninety-eight copies of the bibliography were distributed in the second year of the program in response to requests from the public. Four individuals requested and received diskette versions.

3.6.2 Concurrent Data Collection

LATEX A has established links with other programs that are collecting data on the physical oceanography of the Texas-Louisiana shelf and adjacent waters during the LATEX field years. Many of these data sets have been obtained through data sharing agreements that limit further distribution of the data. The major data sets obtained in the second field year are briefly described in Table 3.6.1. Those obtained in the first field year are described in Table 2.6.1 of Jochens and Nowlin (1994b).

3.6.3 Historical Data Collection

As part of the collateral data assembly, LATEX A acquired available historical data from the Gulf of Mexico that could be useful in interpreting the LATEX data sets. These were discussed in section 2.6.3 of Jochens and Nowlin (1994b). Additional data sets obtained are included in Table 3.6.1.

Table 3.6.1. Collateral data assembled.

Entity	Description of Data Obtained
LATEX B LSU	Preliminary Data from cruise P932 AVHRR images posted to GULF.MEX April 1993 through March 1994
LATEX C SAIC	XBT and drifter data posted to GULF.MEX April 1993 through March 1994
TIGER/SOOP TAMU	Tech. Report 93-04-T, TAMU Oceanography 10 May 1993 Hydrographic data reports 1988-1993 for SOOP data in the LATEX region Technical Report 94-01-T, TAMU Oceanography 17 January 1994 Hydrographic data from continental shelf & slope of the NW Gulf of Mexico
NOAA-NWS-GTS	Surface land and sea weather observations, waves from fixed sites and from the Volunteer Observing Ships program in and around the Gulf of Mexico 4/92-3/94 extracted from the Global Telecommunications System
NOAA-NDBC	Wave data transmitted over the GTS, April 1993 through March 1994 NDBC moored data base for the Atlantic and Gulf of Mexico
Conrad Blucher Institute	Coastal water level data for Gulf of Mexico stations for April 1993 through March 1994
NECOP	Agreement and password to provide access to their data base (all data)
NOAA COASTWATCH	Approximately 2500 AVHHR sea surface temperature images
Army Corps of Engineers	Daily discharge of the Atchafalaya River at Simmesport, Louisiana and Mississippi River at Tarbert Landing, MS (April 1993 - March 1994)
USGS	For Texas and Louisiana rivers: •All USGS data for water year 1992 (9/1991-9/1992) •Preliminary data for water year 1993 (9/1992 -9/1993) •All USGS data for Texas rivers, October 1989 - September 1991
NOAA-NOS	Gulf of Mexico tidal hourly heights for 1991 and 1992
NOAA-NWS-NMC	Final Analysis Cycle Gridded Flux Data archive 4 times daily 2/93-3/94 3-hourly surface weather maps, April 1993 - March 1994 Daily weather map: weekly series, April 1993 - March 1994
GULFCET TAMUG	Hydrographic and XBT data from GULFCET cruises 01 through 07
NOAA-SEAMAP	Temperature and salinity data from SEAMAP Gulf of Mexico cruises
JPL	Satellite-derived multi-channel sea surface temperature and phytoplankton pigment concentration data (5 CD ROMs)

4 DATA QUALITY ASSURANCE AND CONTROL

4.1 Introduction

Section 4 provides a discussion of the data processing efforts and quality assurance/quality control (QA/QC) methods for each type of data and a summary of the results of the QA/QC processing. The data processing was conducted in accordance with the procedures set out in section 9 of Nowlin et al. (1991) and section 3 of Jochens and Nowlin (1994b).

Data QA/QC and preliminary analyses are performed by the LATEX A Data Office. The primary responsibility for QA/QC and analysis of different types of data are handled by different individuals in the Data Office as shown in Table 4.1.1.

Table 4.1.1. Personnel performing QA/QC.

Individual	Data Type
Dr. Norman L. Guinasso, Jr.	Hydrographic data
Dr. Matthew K. Howard	Meteorological data & Drifter data
Dr. Steven F. DiMarco	Directional wave data
Mr. Linwood L. Lee III	Current meter data
Mr. Frank J. Kelly, Jr.	ADCP data

In general, data sets are grouped by the name of the cruise on which the data are recovered. Data are processed into engineering units and stored in hierarchical directories on hard disks. Preliminary data products are produced, examined, and obvious errors corrected. The preliminary data products then are given to other principal investigators for examination. These investigators inform the Data Office of further corrections. After all corrections are made the data are transferred to a distribution directory where investigators can have access to the data set.

4.2 Moored Measurements

The QA/QC processing procedures for the current meter, wave gauge, and meteorological data sets were discussed in sections 3.2.1, 3.2.2, and 3.2.4, respectively, of Jochens and Nowlin (1994b).

The first retrieval of data from the IES instruments was completed on mooring cruise M10 in July 1993. The IES on mooring 43 was never recovered. The IES on mooring 42 was recovered but the acoustic travel-time data were unusable with the exception of a few days at the start of the record. The data at the start of the record is not useful for analyses because it is so short and during most of that time the instrument and electronics were still equilibrating to the ambient pressure and temperature. The temperature and pressure records were good. The entire data set—acoustic travel-time, temperature, and pressure, along with the calibration coefficients for the thermistor and Paroscientific pressure sensor—were sent to Earl F. Childers, a technician at Woods Hole Instrument Systems, Ltd. (WHISL), the authorized service provider, for processing. Mr. Childers is very familiar with the instrument and the software for processing the resulting data and graciously processed the data for LATEX. He could not, however, offer any insight to the failure of the instrument to collect good acoustic data.

4.3 Drifting Buoy Measurements

The methodology for data analysis and QA/QC for the drifting buoys is provided in Nowlin et al. (1991) and in section 2.3 of Jochens and Nowlin (1994b). A summary of times of operation is given in Table 3.3.1, and an example trajectory is given in section 6.5. Drifter trajectories were posted to the GULF.MEX electronic bulletin board on a weekly basis.

4.4 Hydrographic Measurements

Hydrographic data were processed following methodologies described in section 3.4 of Jochens and Nowlin (1994b) with the following exception: During cruises H06 and H07, duplicate phytoplankton pigment samples were collected, filtered, and analyzed for chlorophyll a and phaeophytin using a Turner Model 10 Fluorometer. The methods of Smith et al. (1981) were followed for these analyses. Prior to analysis, sample collection, filtration, and storage processes were handled in the same manner as filters collected for HPLC. Similar to chlorophyll a measurements made by HPLC, data acquired using the Turner 10 Model fluorometer was validated by comparing chlorophyll a measurements with *in situ* fluorometric measurements on the CTD package. Fluorometric data versus chlorophyll a bottle data were plotted over each other using the procedures described in Jochens and Nowlin (1994b) for chlorophyll a measured by HPLC. To further validate the chlorophyll a data collected using the Turner fluorometer, duplicate filters from selected stations were analyzed on the HPLC system. Chlorophyll a values determined on both systems were plotted on top of each other. When discrepancies are detected, stations are flagged for further examination.

In their section 3.4.4, Jochens and Nowlin (1994b) reported the participation of the TAMU Department of Oceanography's Technical Support Services Group in an international intercalibration experiment sponsored by Quality Assurance of Information for Marine Environmental Monitoring in Europe (QUASIMEME). LATEX samples were among those evaluated. Results of the nutrient intercalibration experiment were published in a confidential report. Nutrient concentrations submitted by TAMU were found to be in very good agreement with actual nitrate, nitrite, phosphate, and ammonia concentrations.

4.5 Acoustic Doppler Current Profiler Measurements

The QA/QC processing procedures for the ADCP data sets were discussed in section 3.5 of Jochens and Nowlin (1994b). During the second year of field work, the TRANSECT software developed by RD Instruments was used to record both raw and averaged data. The initial QA/QC processing for H06 and H07 was routine and the data quality was good. Due to the downtime described in section 3.5.1.1 of this report, the processing of the H05 ADCP data required additional work. The resulting data set also was of good quality. Work continues on the subjective second level QA/QC, described in section 3.5.15 of Jochens and Nowlin (1994b).

5 DATA MANAGEMENT AND INFORMATION TRANSFER

5.1 Introduction

Section 5 gives an overview of data archival and sharing activities and of information transfer activities of LATEX A, including summaries of data archived at the National Oceanographic Data Center (NODC) and data provided to others. A summary of information transfer activities implemented is provided, including postings to GULF.MEX electronic bulletin board, issuance of public notices and notices to fishermen, publication of the bi-weekly newsletter, *LATEX Fortnightly,* and organization of LATEX meetings.

5.2 Data Archival

The NODC project identification code for LATEX A data is 0212. Data collected from current meter moorings (Table 3.2.4), wave gauges (Tables 3.2.5 and 3.2.6), meteorological buoys (Table 3.2.7) on mooring cruises M09 through M14, CTD and other continuous profile data and bottle nutrients, oxygen, and salinity data collected on hydrographic surveys H05 thorugh H07 have been submitted to NODC. Due to poor data return from the inverted echo sounder, the pressure and temperature data require further QA/QC. Drifting buoy data were posted to GULF.MEX. ADCP data collected during the hydrographic surveys are undergoing additional QA/QC. Analyses of filters for pigments and total suspended particulates from cruises H05 through H07 have been completed. The results are undergoing QA/QC processing.

5.3 Data Sharing

There has been substantial interest in the LATEX A data set. A data sharing agreement was formulated to allow interested scientists outside the LATEX/MMS community to use portions of the data set while protecting the interests of the LATEX A scientists in the use of these data. Data provided were those that had been submitted to NODC. Table 5.3.1 provides a summary of the data provided by LATEX A to others during the second field year.

Table 5.3.1. LATEX A data shared with others.

Name	Data Description	Date Sent
George Forristall Shell Dev. Corp.	current meter data from initial cruises	April 1993
Eric Noah EHI	current meter and wind data in area and time of LATEX B October 1992 cruise	June 1993
Michael Dowgiallo NOAA	surface temperature and salinity data from H06 comparison of these with same from H02	July 1993
John Cortinas NSSL	corrected met buoy data	August 1993

Table 5.3.1. LATEX A data shared with others (continued).

Name	Data Description	Date Sent
Marie Neuman LSU	CMAN and MOMS meteorological data from April 1992 through September 1993	September 1993
Glen Wheless ODU	current meter and met data from mooring 22 for October 1992 to March 1993	October 1993
William Wiseman LSU	meteorological buoy data from April 1992 through March 1993	October 1993
Susan Brown UTMSI	selected CTD data from H01 through H04	October 1993
D. Lopez-Veneroni TAMU	chlorophyll a data from H01	October 1993
K. Al-Abdulkader TAMU	selected bottle data from H01 through H04	October 1993
Tom Lee RSMAS	meteorological data from NDBC buoys 42001 and 42007 for January through October 1993	November 1993
Giulietta Fargion TAMUG-GulfCet	CTD, nutrient, and oxygen data from H01 through H04	November 1993
James Herring Dynalysis	NMC archive flux data	November 1993
Richard Patchen Dynalysis	time history of the mooring locations	November 1993
Nan Walker LSU	accuracy and precision specifications for the current meters	November 1993
Murray Brown MMS	selected meteorological and current meter data	November 1993
John Lundberg UT	sea surface temperature and CTD data from H01, H02, and H03	December 1993
Glen Wheless ODU	additional current meter and met data from mooring 22	December 1993
David Brooks TAMU	historical Mississippi and Atchafalaya river flow data	January 1994
John Heideman & Wilson Lamb EXXON	Hurricane Andrew wave data from mooring 16	February 1994
John Hubertz COE-WES	NMC gridded flux data from September through December 1993	February 1994
John Hubertz COE-WES	NMC gridded flux data from March 1993	March 1994
Doug Evans EHI	current meter data from moorings 12 through 19 and met buoy data from moorings 17 and 19 for August through October 1992	March 1994
David Sheres USM	wind, wave, current data from moorings 15, 17, and 23 for March through May 1993	March 1994
Giulietta Fargion TAMUG-GulfCet	CTD and bottle data from H05	March 1994

5.4 Information Sharing

5.4.1 GULF.MEX Bulletin Board

LATEX A maintains the GULF.MEX bulletin board on ScienceNet of Omnet, a commercial electronic mail service. GULF.MEX received approximately 500 postings in this second year. Approximately 70% of the postings consisted of drifter tracks, frontal analysis, and OPCplot postings; 20% were field study reports; and 10% provided general information. LATEX A posts to GULF.MEX all cruise plans and reports, meeting announcements, weekly drifter trajectories, weekly meteorological summaries, the LATEX calendar, and other selected information relative to LATEX A.

5.4.2 Public Notices

Whenever there is a substantial change in the position of a mooring located away from offshore platforms, LATEX A advises the United States Coast Guard (USCG), the Defense Mapping Agency (DMA), and the U.S. Navy Submarine Command (USN). One change in position was reported during the second field year: buoy E at mooring 20 was reported to the USCG and the DMA and USN were copied 9 September 1993. Other reports were made to the USCG to notify of them of off-station marker buoys (8 April, 26 April, 6 July, 8 July, 12 October 1993, and 9 March 1994), redeployment or status reports (6 July, 30 July, and 13 October 1993; DMA and USN copied), and discontinued buoys (1 April 1993; DMA and USN copied).

5.4.3 LATEX Meetings

LATEX A organized one meeting on the oceanography of the Texas-Louisiana continental shelf. The third general meeting (LATEX III) was held in New Orleans, 27-28 October 1993. The Science Advisory Panel (SAP) met 26-28 October. Program descriptions were presented by the program managers of LATEX A, B, and C, and by principals of the MMS-sponsored modeling efforts and other collateral programs. Science presentations focused on the topics of remote sensing and hydrography (27 October) and shelf kinematics and processes (28 October). Table 5.4.1 shows the agenda for this meeting.

5.4.3 The *LATEX Fortnightly*

The *LATEX Fortnightly News* is sent to approximately 2500 addresses by bulk mail. Twice during the period 1 October 1993 - 30 September 1994, address correction flags were added to the front of the newsletter to determine the number of publications not being delivered for various reasons. This resulted in the removal of approximately 200 addresses due to inability to contact or lack of information on the addressees. Tables 5.4.2 and 5.4.3 provide a listing of all issues published during the second field year.

Table 5.4.1. Agenda for LATEX III meeting of October 1993.

Description	Speaker
October 26, 1993	
Welcome and general remarks	M. Brown
Opening statements	R. O. Reid
Review of LATEX Plume	S. Murray
Review of LATEX Shelf	W. Nowlin
Review of LATEX C	T. Berger
Review of TIGER	D. Biggs
Review of shelf modeling study	J. Herring
Review of Gulf modeling study	L. Kantha
Discussion	Speakers and SAP
October 27, 1993	
First Session: Remote Sensing and Hydrography	
Data assimilation in local circulation model	K. Thompson
Salinity, density, and geopotential distributions during LATEX A hydrographic cruises	J. Cochrane
Variations in non-conservative properties over the LATEX shelf	D. Wiesenburg
Seasonal variations of hydrographic characteristics in the LATEX coastal plume	S. Murray
TOPEX & ERS-1 analysis in the Gulf of Mexico	G. Born
The effects of coastal processes on ocean color measurement in the Gulf of Mexico	R. Gould
Aspects of circulation in the NW Gulf of Mexico during 1993	L. Rouse
Second Session: Reviews of selected collateral efforts	
The NOAA coastal ocean program Nutrient Enhanced Coastal Ocean Productivity (NECOP) Program: an overview	D. Atwood
Surface current & Lagrangian drifter program	P. Niiler
Gulf Offshore Satellite Applications Program	N. Guinasso
GulfCet hydrography cruises, April 1992 - August 1993	G. Fargion
NE Gulf study sorkshop	A. Clarke
NOAA's activities in the Gulf of Mexico	J. Lamkin
SEAMAP	D. Donaldson
Oil spill risk analysis program	G. Wheless
Estuaries modeling in the Gulf of Mexico	M. Inoue
Paleocirculation	M. Inoue
Historical oil industry eddy surveys (EJIP)	K. Schaudt
October 28, 1993	
Third Session: Kinematics and Processes	
Numerical simulation of warm core and secondary eddies in the western Gulf of Mexico	D. Dietrich
Hydro/drifter data at the shelf edge	P. Hamilton
ADCP observations of shelf edge currents	F. Kelly
Issues in modeling continental shelf flow fields	J. Allen
Wind-driven circulation in Bay of Campeche; distinct patterns of western Gulf circulation	R. O. Reid
Near-inertial oscillation over the Texas-Louisiana shelf	C. Chen
Variability in the velocity structure of the LATEX coastal current	S. Murray

Table 5.4.2. Volume 2 *LATEX Fortnightly News,* 12 April - 20 December 1993.

Volume 2:	Date:	Title(s):
Iss. 8	4/12/93	Inertial Currents (story) MMS Reports Available (story) Correction (story) LATEX Mooring 14/East-West Current (figure) Winds from 25 March - 8 April 1993 (back map)
Iss. 9	4/26/93	The Blizzard of 1993 (story) Blizzard Storm Track (back map)
Iss. 10	5/10/93	May is a Busy Month for Field Work in the GOM (story) LATEX-C May Surveys (story) Mooring Service Cruise (story) GulfCet Spring Survey (story) Winds from 26 April - 10 May 1993 (back map)
Iss. 11	5/24/93	ADCP Currents for Cruise 92C (story) ADCP Currents (figure) Winds from 10 May - 24 May 1993 (back map)
Iss. 12	6/7/93	LATEX Assists Kids with Drift Bottles (story) Ninth Mooring Cruise Completed (story) Winds from 25 May - 7 June 1993 (back map)
Iss. 13	6/21/93	SOOP and Whoppers (story) Depth of Isotherms/June 2-3 1993 (figure) XBT Station Track and Drifter Trajectories (figure) Winds from 7 June - 20 June 1993 (back map)
Iss. 14	7/5/93	Second Field Activity Completed for GOOMEX (story) GOOMEX Study Sites (figure) Winds from 21 June - 4 July 1993 (back map)
Iss. 15	7/19/93	Humidity Data Flows Through GTS (story) VOS Reporting Locations June 1993 (figure) Relative Humidity at VOS Locations (figure) Winds from 5 July - 18 July 1993 (back map)
Iss. 16	8/2/93	Sixth LATEX A Hydrography Cruise Underway in Gulf (story) Oceanographic Charting Software for the World's Seas (story) Winds from 19 July - 27 July 1993 (back map)
Iss. 17	8/16/93	LATEXans Research Raging River Runoff (story) Surface Salinity July-August 1993 (figure) Winds from 28 July - 15 August 1993 (back map)
Iss. 18	8/30/93	ONR Adds Plankton Study to LATEX (story) Winds from 16 August - 29 August 1993 (back map)
Iss. 19	9/13/93	LSU Scientists Describe 1993 Hypoxia (story) Winds from 29 August - 12 September 1993 (back map)
Iss. 20	9/27/93	LUMCON Scientists Describe 1993 Hypoxia (story) Current Meter Service Cruise Underway (story) Winds from 13 September - 26 September 1993 (back map)

Table 5.4.2. Volume 2 *LATEX Fortnightly News*, 12 April - 20 December 1993 (continued).

Volume 2:	Date:	Title(s):
Iss. 21	10/11/93	LATEX III Meeting October 26-28, 1993 (story) Directions to MMS Regional Offices for the LATEX III Meeting (back story) Information about Hotel Accommodations (back story)
Iss. 22	10/25/93	Surface Current and Lagrangian-Drift Program (SCULP) (story) SCULP Drifters July-Sept 1993 (figure) Winds from 11 October - 24 October 1993 (back map)
Iss. 23	11/8/93	Seventh LATEX-A Hydrographic Cruise Underway in Gulf (story) LATEX III is a Success (story) Winds from 25 October - 7 November 1993 (back map)
Iss. 24	11/22/93	Loop Current Eddy Shedding Cycle 1981 through 1993 (story) Winds from 8 November - 21 November 1993 (back map)
Iss. 25	12/6/93	Loop Current Eddies (story) Most GTS Reporting of LATEX Data to Stop (story) Loop Current Eddies (figure) Winds from 22 November - 6 December 1993 (back map)
Iss. 26	12/20/93	LATEX Talks Given at MMS Meeting (story) Seventh LATEX A Survey Completed (story) LATEX Mooring Cruise Returns (story) Winds from 6 December - 20 December 1993 (back map)

Table 5.4.4. Volume 3 *LATEX Fortnightly News*, 1 January - 28 March 1994.

Volume 3:	Date:	Title(s):
Iss. 1	1/3/94	Ocean Sciences 1994 A LATEX Jamboree (story) Winds from 20 December - 3 January 1994 (back map)
Iss. 2	1/17/94	Numerical Model Reproduces Small-Scale Features of Gulf Circulation (story) Top Level Temperature from DieCAST Model (maps)
Iss. 3	1/31/94	Story of Texas and the Sea on Display at the Texas Maritime Museum (story) LATEX Mooring Service Cruise (story) Winds from 17 January - 30 January 1994 (back map)
Iss. 4	2/14/94	LATEX Measures Large Waves During Hurricane Andrew (story) Significant Wave Height - Hurricane Andrew (figure) Winds from 1 February - 14 February 1994 (back map)
Iss. 5	2/28/94	USM Scientists Study Phytoplankton Production on LATEX Hydro Cruises (story) Winds from 14 February - 27 February 1994 (back map)
Iss. 6	3/14/94	Net-/Nano-/Picoplankton Contributions to Primary Productivity on the LATEX Shelf (story) Winds from 28 February - 13 March 1994 (back map)
Iss. 7	3/28/94	Dissolved Organic Nitrogen Studies in LATEX (story) Information Highway Used to Send LATEX Data to NODC (story) Winds from 14 March - 27 March 1994 (back map)

6 TECHNICAL DISCUSSION

6.1 Introduction

Section 6 provides a brief technical discussion of early results of the data collection from the second field year as the vehicle for providing a representative selection of standard computer-produced graphics. Additional graphical products will be contained in the microfiche packet that will accompany the Final Report, which will be completed in 1996. Included in the discussion are representations of time series from the moored measurements, drifting buoy trajectories, plots of hydrographic properties, and preliminary plots of ADCP-measured currents. The preliminary results of the second year of the cyclogenesis study are presented. A comparison is made of observed currents with those simulated by a simple barotropic wind-driven model. The activities of the LATEX Science Advisory Panel are described.

Although the data shown in this section have received quality control and assessment, they are still preliminary; users should expect that subsequent corrections will be made to the data sets prior to the final submission to the NODC. THIS SAME CAVEAT APPLIES TO ALL DATA REPORTED IN THIS DOCUMENT.

6.2 Scales Analyses for the LATEX Shelf Based on Hydrographic Observations

One important result of the LATEX Program will be a description of the spatial and temporal scales of energetic variability over the Texas-Louisiana continental shelf. Y. Li, W. Nowlin, and R. Reid are completing an analysis of the spatial scales based on hydrographic observations. In particular, this analysis examines horizontal scales of temperature, salinity, and geopotential anomaly distributions.

Our procedure is to identify, describe, and remove reference fields corresponding to the shelf-wide patterns of density and circulation. We have examined both Fourier and polynomial representations of the reference fields, including terms of order necessary to include the major large-scale variability as determined by applying an F-test. The results for individual May cruises were compared to the mean May fields based on multiple cruises described in section 6.3. The May mean reference fields are fit reasonably well by a quadratic in cross-shelf direction or in along-shelf direction for half the shelf length. (A higher order is necessary to represent the along-shelf variability of the mean or individual fields when full shelf length is considered.) After removing the reference fields, the remaining anomaly fields are analyzed to describe the scales of the smaller scale variability over the LATEX region.

The variability from a spatial mean of the reference fields obtained by fitting quadratics to data from individual May cruises agreed well with those of the May mean fields. Moreover, the length scales and associated variability of the anomaly fields (determined by use of both autocorrelations and structure functions) of individual and mean May data agreed well. Therefore, we have decided to remove reference fields from all individual LATEX A cruises using quadratic fits.

Figure 6.2.1 shows 3-m salinity observed at each station on cross-shelf transect 4 (approximately 94° W) during the May 1992 LATEX A hydrographic cruise and 3-m salinity from the mean May field interpolated to the May 1992 station positions. The shelf-scale shape of both individual and mean fields are seen to be quite similar—a quadratic with cross-shelf variation in salinity of near 10. Removing the mean field from the May 1992 cruise yields an anomaly field that can be used to describe the smaller energetic spatial scales of variability. Figures 6.2.2 and 6.2.3 show the autocorrelation coefficients and structure function, respectively, as functions of cross-shelf separation for the anomaly field. The first zero crossing of the autocorrelation function is approximately 25 km; the structure function indicates the magnitude of cross-shelf variability in the salinity anomaly to be about 1.3. Also indicated in Figure 6.2.3 is that the measurements are not adequate to resolve smaller scale variability in surface salinity of amplitudes 0.5 or less. Note that the magnitude of variability of this anomaly field is almost an order of magnitude less than that of the background or reference field removed.

Table 6.2.1 gives spatial scales of anomaly fields for most of the LATEX A hydrographic cruises. Transects 2, 4, and 7 are cross-shelf, located at 92° W, 94° W, and 27.4° N respectively; transects 9 and 10 are along the 200-m and 50-m isobaths respectively (values for the eastern shelf from 90.5° W to 94° W). All scale values are based on first zero crossings of autocorrelation coefficients of anomaly fields after background quadratic fits were removed. Salinity and temperature values were observed at 3 m; the geopotential anomaly is for 3 db relative to 70 db, calculated as described in section 6.3.

Over the eastern and central portions of the Texas-Louisiana shelf, the cross-shelf anomaly scales for surface salinity, surface temperature, and geopotential anomaly all average to values near 20 km. Temperature scales seem slightly less. By contrast, the cross-shelf anomaly scales at transect 7 (although represented by fewer realizations) range from 8 to 15 km with averages of 8 to 14 km—again, temperature scales are slightly shorter.

The average of along-shelf anomaly scales over the east-central shelf are 30 to 38 km. There seems to be no real difference between scales at the shelf edge (transect 9) and those at mid-shelf (transect 10). The surface salinity scales are somewhat shorter than those for temperature and geopotential anomaly, which seem equal.

It is important to note that our LATEX hydrographic station spacing on cross-shelf transects normally varied from 10 km at mid-shelf to 5 km at inner and outer shelf locations, and our along-shelf hydrographic station spacing was normally 20 km. On one cruise, however, we decreased the station spacing to 10 km along-shelf. Usable underway surface temperture and salinity measurements were obtained on many cruises. We have examined the data from the 10-km along-shelf stations and thermosalinograph surface data at 1-km separations for cross-shelf transects. These examinations showed no significant differences in spatial scales from those given in Table 6.2.1. Thus, it seems unlikely that significant variability is present in spatial scales shorter than indicated by Table 6.2.1 but missed in our analysis because of the LATEX A sampling intervals.

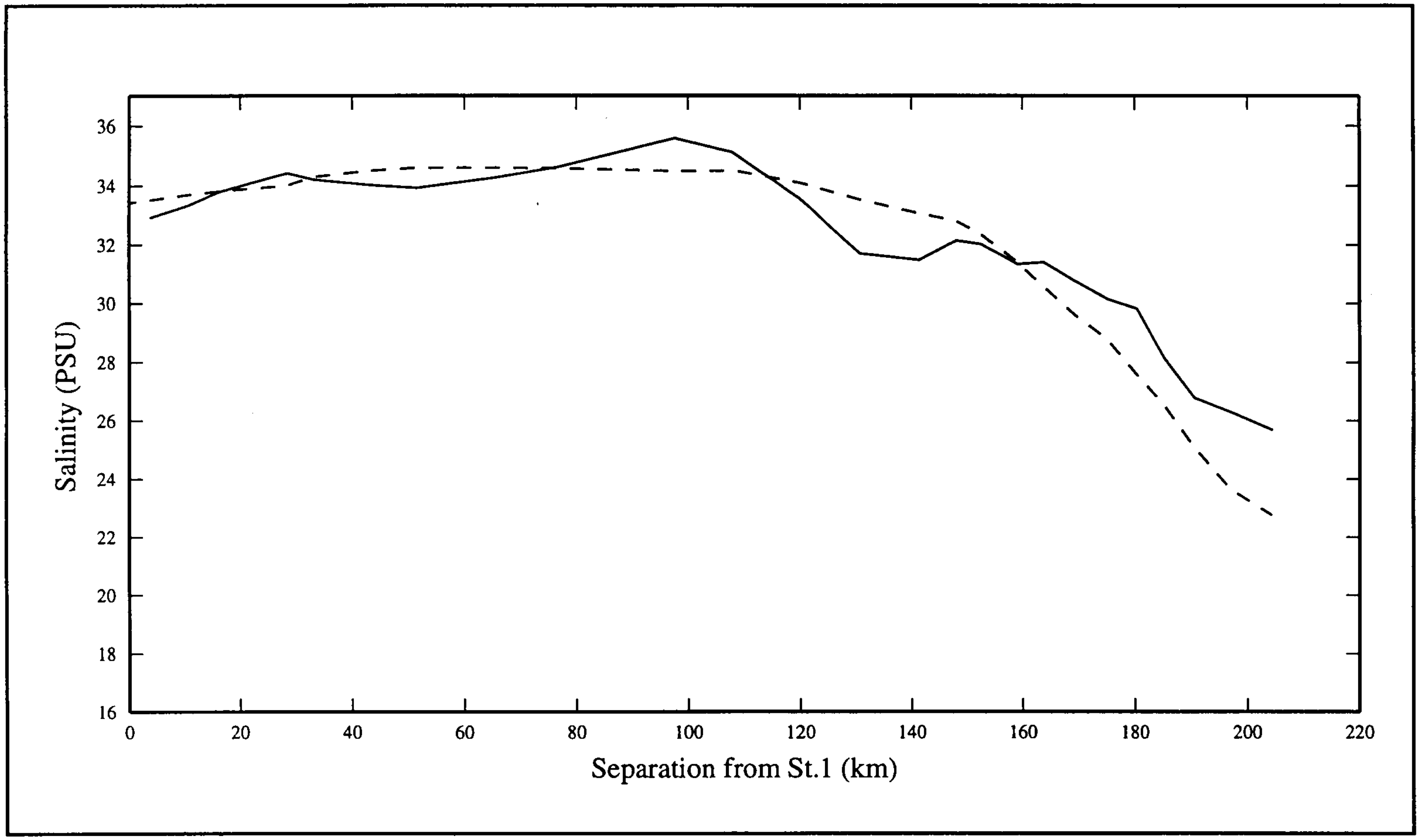


Figure 6.2.1. (—) 3-m salinity observed at each station on cross-shelf transect 4 (94°W) during LATEX May 1992 hydrographic cruise H01; (---) 3-m salinity from mean May field interpolated to May 1992 station positions.

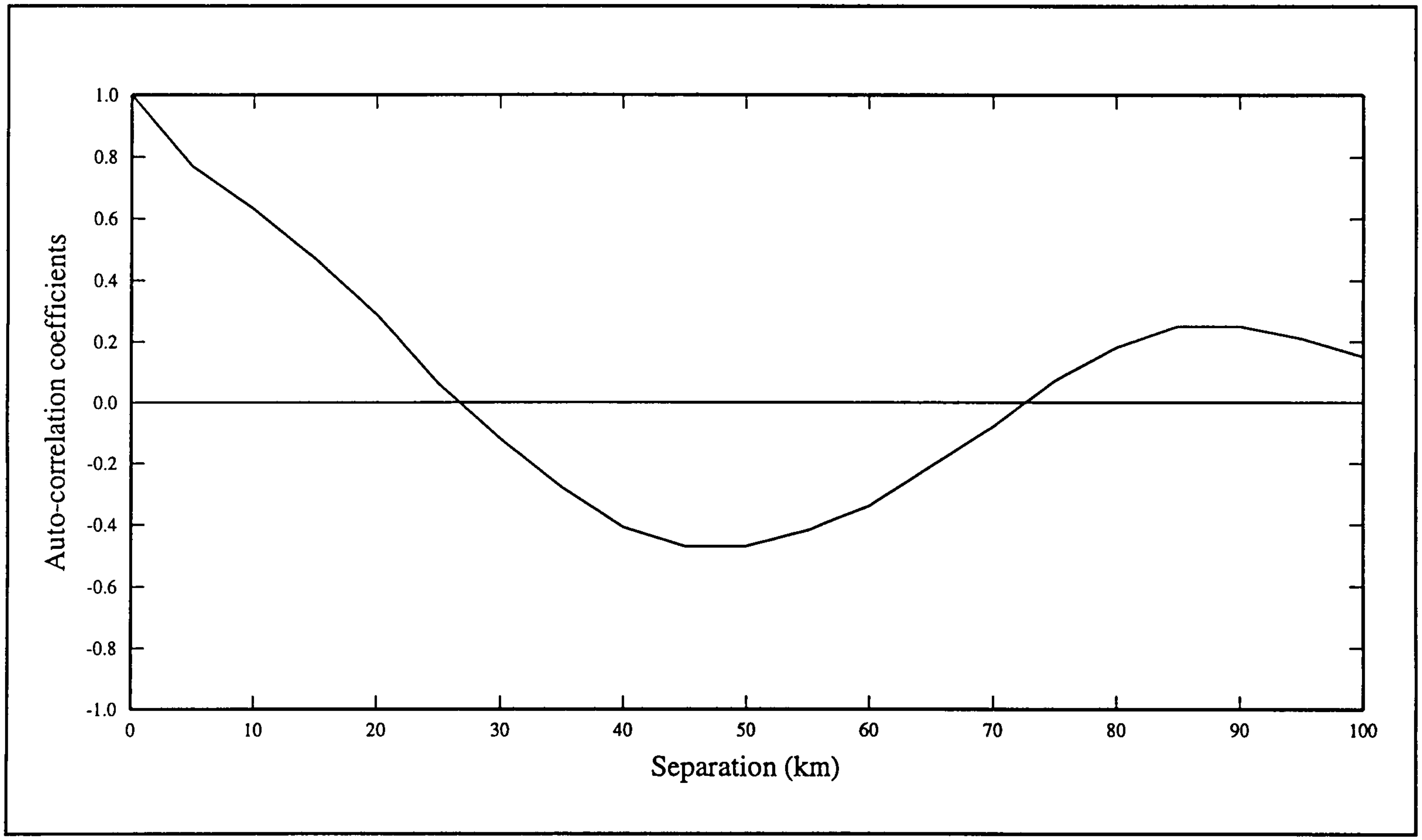


Figure 6.2.2. Autocorrelation function for difference between May 1992 and mean May 3-m salinities as funcion of cross-shelf separation.

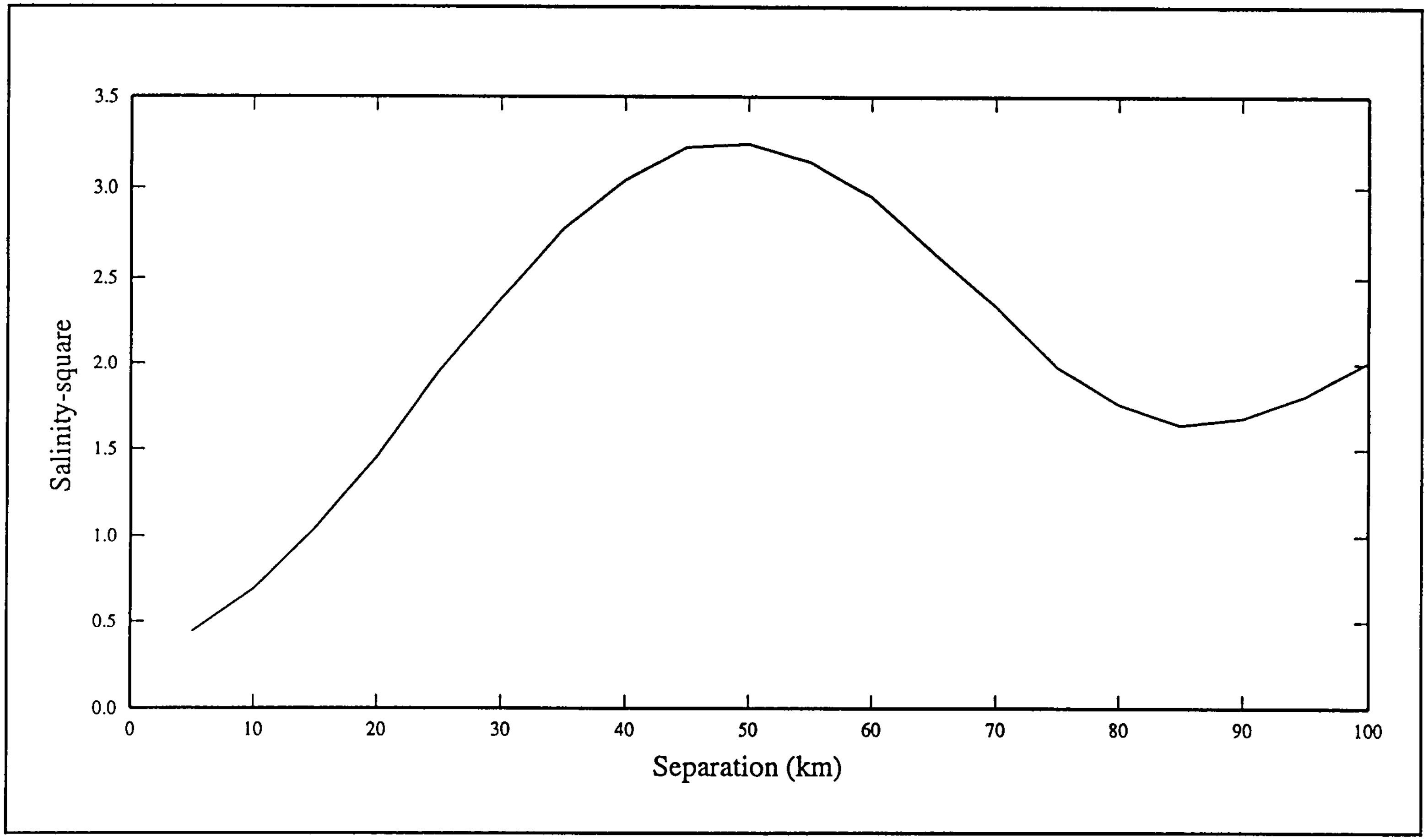


Figure 6.2.3. Structure function as for Figure 6.2.2.

Table 6.2.1. Spatial scales of anomaly field of selected transects and variables as described in the text.

	Salinity						Geopotential Anomaly						Temperature					
Transect	2	4	7	10E	10W	9	2	4	7	10E	10W	9	2	4	7	10E	10W	9
LATEX - H01	20.5	17		30		23	23	24		64		38	18	15		18		36
LATEX - H02	18	20		37		19	7	21		38		36	14.5	14.5		32		38
LATEX - H03	27	28		38		41	24	18		28		50	23	16		46		50
LATEX - H04	15	24		35		30	24	23		44		36	22	21		27		23
LATEX - H05	18	30.5	14.5	31		37.5	15	28	10	37		33	11	28.5	10.5	30		45
LATEX - H06	16	32.5	13	26		32	22	20	17	36		37	16	9	9	26		43
LATEX - H07	11.5	19.5	15	26		22	18.5	17.5	14.5	20		38	23	22	8.5	26		35
Mean	18	22	14	31	38	30	20	21.5	14	35	40	38	17	18	9	30	31	37
# of Cruises	7	7	3	7	3	7	7	7	3	7	3	7	7	7	33	7	3	7

6.3. Seasonal and Interannual Variability over the Texas-Louisiana Continental Shelf

As described in Jochens and Nowlin (1994b), we are pursuing a study of the general circulation patterns (and property distributions) over the Texas-Louisiana continental shelf based on combining historical and LATEX hydrographic data. We began last year by examining all pre-LATEX hydrographic cruises over the region and selecting some 60 cruises that either covered most of the shelf or constituted intensive repeats over a portion thereof. We then examined distributions of temperature (T), salinity (S), and geopotential anomaly (surface relative to 70 db, after the approach of Csanady (1981)) to assess in a general way whether these patterns conform to the seasonal patterns hypothesized by Cochrane and Kelly (1986). Indeed, they generally do, although there are significant deviations, e.g., at times of anomalous river discharge. We also examined for the same purpose the LATEX A hydrographic cruises; as discussed in Jochens and Nowlin (1994b), the conformation is good.

During the past year we have composited LATEX and historical data for two distinctly different seasons (according to Cochrane and Kelly 1986): for May, when the shelf is dominated by a large cyclonic circulation with relatively fresh water flowing downcoast (west and southwest) in the surface layers of the nearshore portion of the gyre; and for August, when the cyclonic gyre has been disrupted by the annual shift in the wind regime. These two seasons were chosen for initial examination because they characterize the typical shelf-wide patterns, ignoring atypical patterns generated by extreme events, e.g., hurricanes.

Mean May and August patterns of 3 db relative to 70 db geopotential anomaly are shown in Figures 6.3.1 and 6.3.2. These were constructed by gridding data from 9 and 8 cruises, respectively, using the objective analysis package incorporated in GMT (Generic Mapping Tools) software. The objective analysis package in GMT is based on an extension of the minimum curvature method of gridding described by Smith and Wessel (1990). Gridded values were obtained at 15-minute separations in latitude and longitude. Then we began a cruise-by-cruise comparison of the LATEX A May and August patterns (geopotential anomaly and 3-m salinity) with the corresponding mean patterns. We constructed gridded fields from the individual LATEX cruise data in the same manner, using GMT. An example is shown in Figure 6.3.3 for LATEX A May cruise H05. For a quantitative comparison we constructed difference fields between the individual fields and the corresponding mean field (shown in Figure 6.3.4 for cruise H05). This difference was compared to the field of standard deviations for the mean field obtained by differencing that field from the individual fields from which it was constructed (shown in Figure 6.3.5 for the May mean field of geopotential anomaly).

If the difference field of individual cruise data from the mean field (e.g., Figure 6.3.4) was larger than the standard deviation field (e.g., Figure 6.3.5), we judged that the individual field evidenced a significant interannual difference from the mean. For those cases we have begun to examine the differences in synoptic wind fields and river discharge histories for the individual cruises as compared with the longer term wind and river discharge patterns. In this manner we expect to be able to describe and understand the underlying mechanisms responsible for changes in shelf-wide circulation and property distributions. We have a draft manuscript of results. During the next two years, we will complete this study and submit a manuscript for publication that will constitute a portion of our final LATEX A synthesis.

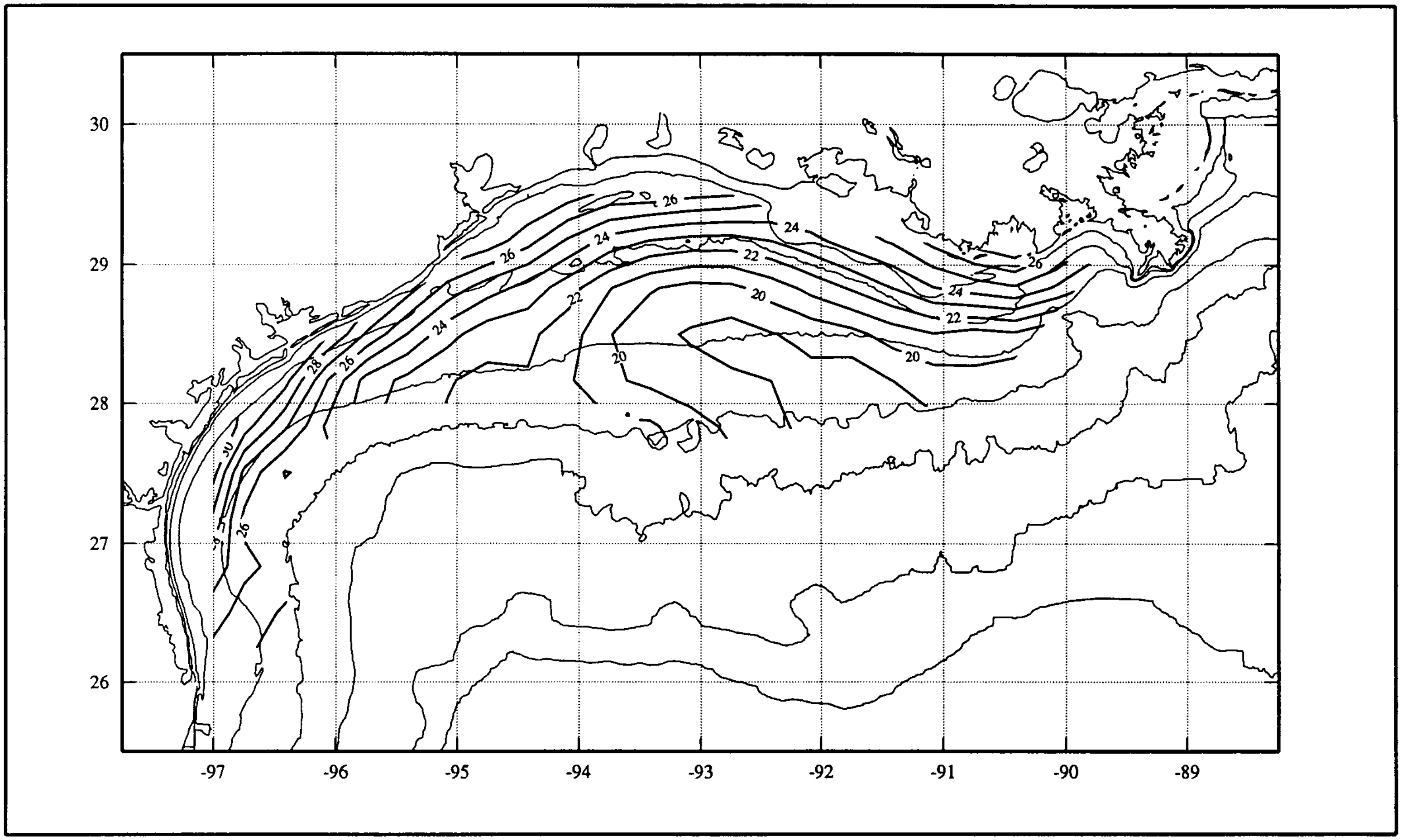


Figure 6.3.1. Average geopotential anomaly at sea surface relative to 70 db for nine May cruises.

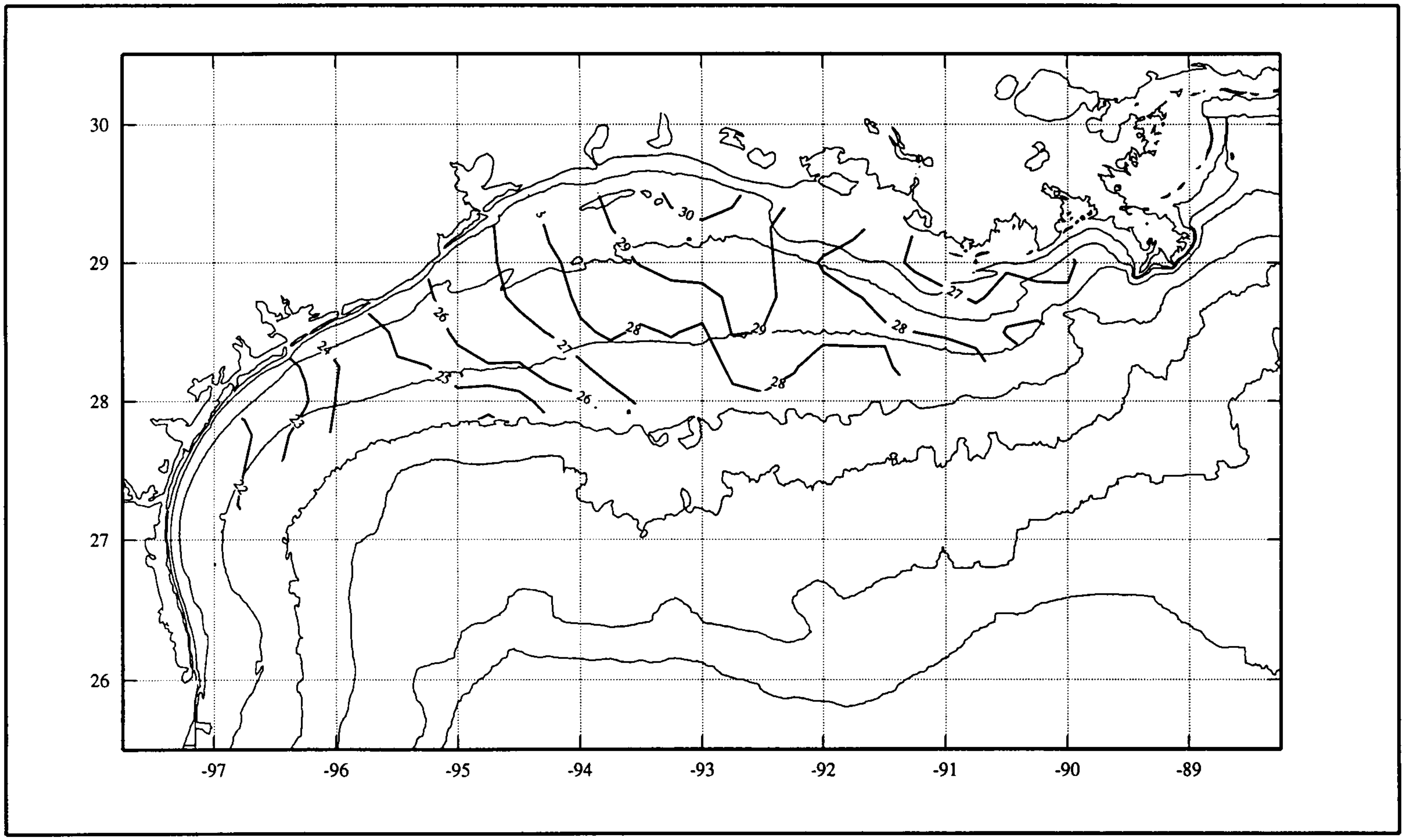


Figure 6.3.2. Average geopotential anomaly at sea surface relative to 70 db for eight July-August cruises.

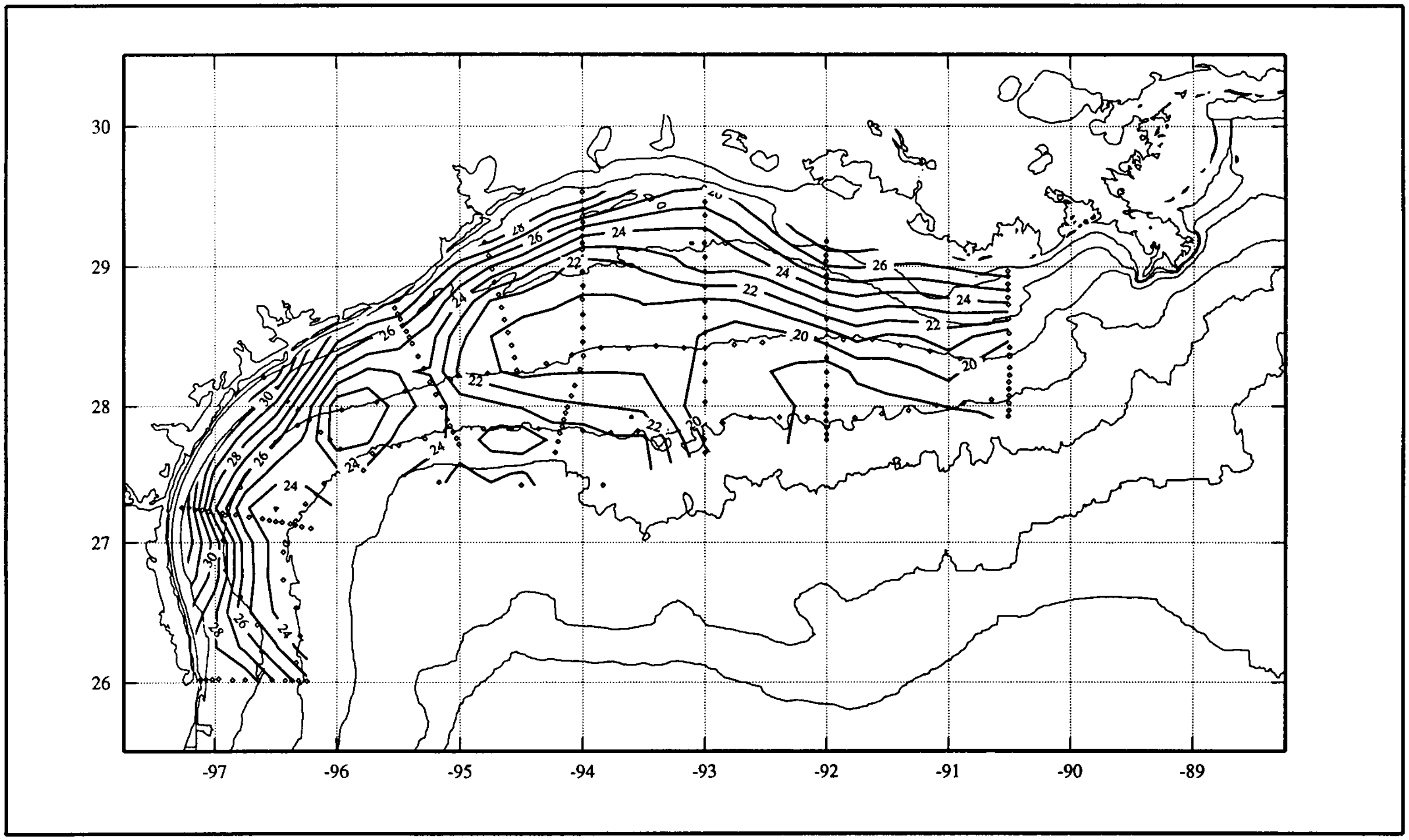


Figure 6.3.3. Geopotential anomaly at sea surface relative to 70 db for LATEX H05 cruise (26 April - 10 May 1993).

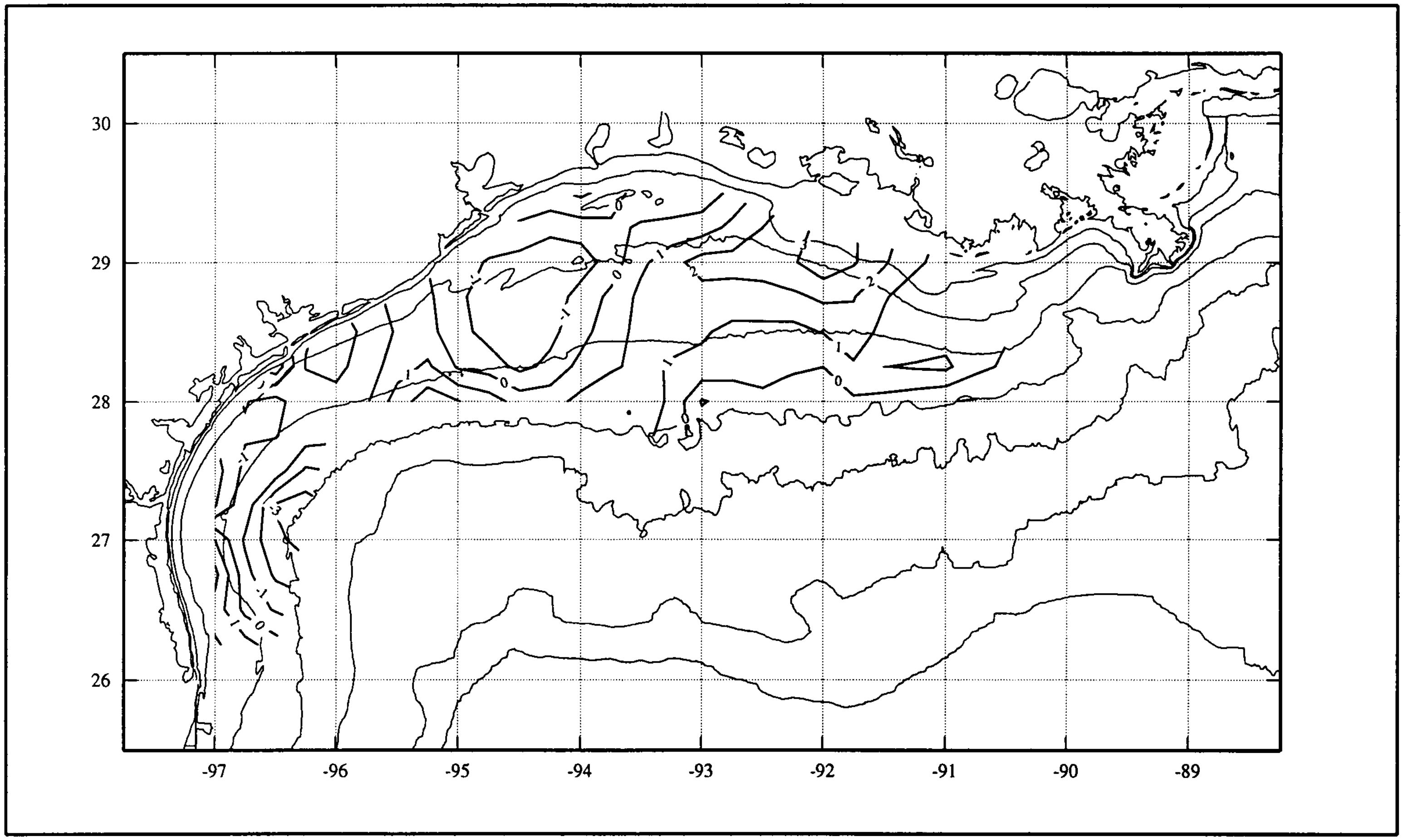


Figure 6.3.4. Differences of geopotential anomalies at sea surface relative to 70 db for LATEX H05 cruise (26 April - 10 May 1993).

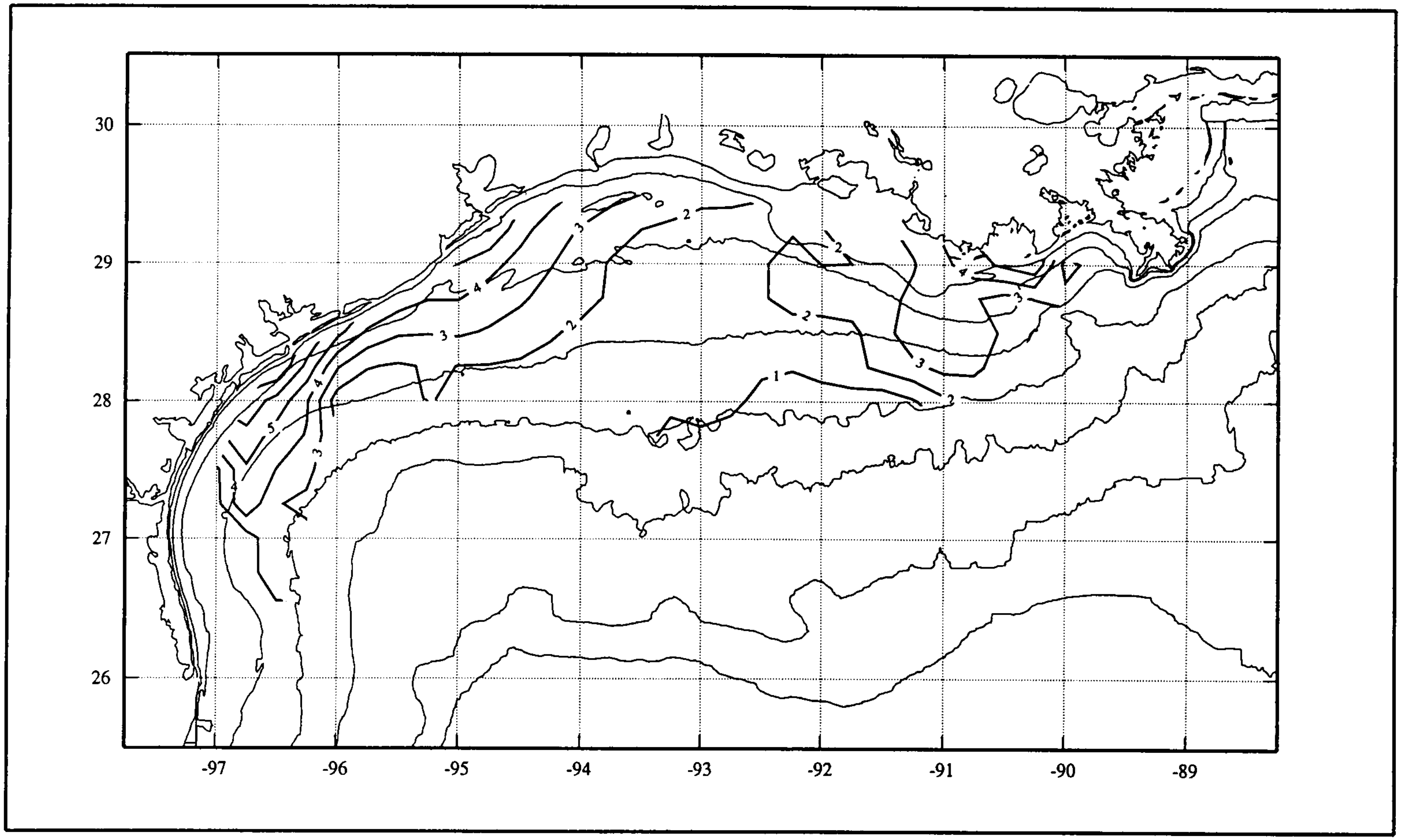


Figure 6.3.5. Standard deviation of geopotential anomaly at sea surface relative to 70 db for nine May cruises.

6.4 Coastal Upwelling and Related Currents in Spring and Summer off South Texas

In this section we report on a preliminary analysis to describe and explain the wind-driven coastal upwelling and related currents off south Texas (Cochrane et al. 1995). Figure 6.4.1 shows the annual progression of monthly mean wind stress in 2° quadrangles along the western boundary coast of the Gulf of Mexico from 20°-30° N, based on Hellerman and Rosenstein (1983). Along the coast, the zonal component of the means is predominantly westward throughout the year, exclusively so north of about 24° N. The meridional component undergoes an annual cycle, being northward April through August and southward October - March. In March and September north of 20° N, the stress is almost westward. Since the alongshore component of stress provides the primary driving force for coastal upwelling, it may be seen from Figure 6.4.1 that the mean stress is favorable for upwelling along much of the coast from April through August.

The NOAA/NOS/OPC Oceanographic Features Analyses (NOAA 1994) of infrared imagery indicate that upwelling is present along the western boundary coast of the Gulf of Mexico at least from 21° N to 29° N. Figure 6.4.2 shows an example of an analysis for the Gulf of Mexico. The twice weekly analyses from 1992-1994 have been used in this study. Browsing through these analyses makes clear that particularly cool spots are often found in places where the coastline is oriented more nearly parallel to the mean wind stress direction, e.g., north of the mouth of the Rio Grande.

For a more precise evaluation of the prevalence of reduced coastal temperature, we have determined the number of days in which a band with temperature at least 2°C below that of the adjacent open Gulf extended at least 4° of latitude along the coast. Table 6.4.1 gives the results for June, July, August, and September in terms of relative frequencies; the 3-year means for months not listed are lower. July shows the highest incidence. August has the defined conditions for more than half the days analyzed. The July maximum and the high August value are not surprising in view of the strong upcoast mean stress in those months. September's relatively small incidence agrees with the low upcoast mean for that month. On the other hand, the low incidence of coastal cool bands for April, May, and June seems inconsistent with the strong upcoast stresses in the long-term mean given in Figure 6.4.1, a paradox still awaiting resolution.

Near-surface hydrographic data, while not as extensive in time or space as infrared imagery, provides a closer view of temperature and includes salinity. For April through September, nearly all the presently available data of this kind south of 28° N are from off the coast of south Texas. Readily available inner shelf data are from (1) the southernmost GUS III monthly stations for 1963-1965 (Temple et al., 1977), (2) the tide station at Brazos Santiago, which is exposed to the Gulf, for 1958-1971 (U.S. Dept. of Commerce, 1973), (3) the top current meters (10-14 m depth) of LATEX A moorings 1 and 2 for 1992-1993, and (4) inner shelf stations of LATEX A hydrographic cruises in May and August of 1993 and 1994. Information for the outer shelf, slope, and open Gulf is based on Etter and Cochrane's (1975) discussion of Texas-Louisiana Shelf water temperatures. Figure 6.4.3 shows the locations where the above data were obtained.

Figure 6.4.4 shows monthly means of temperature for April through October for each of the above data sources except the LATEX A hydrographic data. The April, May, and June means for the inner shelf sources are higher or about the same as the outer shelf-open Gulf means (Etter and Cochrane 1975); they do not suggest upwelling. The July and August means, however, fall considerably below the outer shelf-open Gulf mean—nearly 3°C in July when a secondary temperature minimum is indicated; upwelling surely is present. The September means for inner shelf sources are close to that for the outer shelf-open Gulf sources, suggesting insignificant upwelling. For October, the lower inner shelf means seem to be due to the more rapid autumnal cooling there.

The relations between the inner shelf and the outer shelf-open Gulf temperature means from July through October seem quite compatible with the mean stresses for those months (Figure 6.4.1). However, the absence of upwelling indicated by the temperature means in April through June is in conflict with the upcoast alongshore stress component that implies to upwelling. The low mean salinity in the inner shelf data for April and May also is in conflict with the alongshore stress (Figure 6.4.4(b)). Thus, the near-shore hydrography leads to the same conclusion as the Oceanographic Features Analyses of infrared imagery: paradox for the April - May period, but good agreement with wind stress in July - August.

Figure 6.4.5 shows the shallowest CTD temperatures (1-3 m depth) for the western portion of the Texas-Louisiana Shelf during the period 2-7 August 1993 and 1994. In both years, a band of cool water extended north along the coast to about 28° N from a coldest spot (temperature near 26 C) at the most inshore station of the line along 26° N. The tonguelike form of the band suggests northward flow.

Figure 6.4.6 gives the distributions for the same region of shallowest CTD salinities for 3-11 May and 2-8 August 1993. In May, the shallowest CTD salinity was generally less than 32, and in August it was generally above 36. Similar salinities were encountered in early May and early August of 1994. Thus, the near-surface salinities in both years show the same change as the mean salinities (Figure 6.4.4(b)) for the inner shelf sources. Consequently, they lead to the same situation for May, little or no upwelling and downcoast current in disagreement with an upcoast component of the long-term mean wind stress.

Looking beneath the sea surface one finds that off south Texas the slope of the isopycnals changes from predominantly downward toward the coast in early May 1993 to predominantly upward in early August. A similar change between May and August was found in 1994. The May slope data in both years indicate against upwelling and for downcoast geostrophic flow; the August slope data in both years indicate the opposite. As an example of the change, Figure 6.4.7 provides the topographies of the $\sigma_\theta = 25.0$ surface for May and August. In August, somewhat north of where the lowest surface temperature was encountered, the surface is considerably shallower than in May. The topography illustrates clearly that the onshore rise in isopycnals has a three-dimensional form with a downslope to the north and east of the crest. To illustrate further the vertical structure for early May and early August, vertical sections of σ_θ based on measurements made in 1993 along Line 7 are shown in Figure 6.4.8.

The geopotential anomaly of 3 over 400 decibars (1 db = 10 kPa) for the early May 1993 and August 1993 observations is shown in Figure 6.4.9. In May, the indicated geostrophic velocity is directed downcoast, while in August it is upcoast. The change in direction is the same in 1994. The downcoast flow in May is to be expected in the absence of upwelling; the upcoast flow in August is consistent with upwelling.

Further information regarding the mean currents on the south Texas shelf is supplied by records for the period April through September from the top current meters (10-14 m depth) of LATEX moorings 1, 2, and 3 (Figure 6.4.3). Records with some gaps exist and have been processed for 1992 and 1993. Records for 1994 have been processed only through 27 July. Table 6.4.2 provides mean alongshore components for six-week periods. Means are given for each year so far as data are available. Although the variability of the currents is so great that confidence limits can be expected to be wide, the current records represent the only direct measurements available.

From 8 April - 19 May, the alongshore component was downcoast in all years and had the only downcoast mean taken over the three years. The downcoast direction agrees with the evidence of the inner shelf temperatures and salinities for April and May in indicating that upwelling is not dominant in this period. From 20 May - 30 June, the multi-year mean is upcoast but quite small. This indicates that the period is a plausible time for transition to the higher positive means for 1 July - 11 August. For the latter period no disagreement exists between the upwelling condition, upcoast current, and upcoast mean stress. Finally, the relatively small mean from 12 August - 23 September (no 1994 data) indicates that this period is at least a plausible time for transition to mean downcoast flow accompanying mean downcoast wind stress.

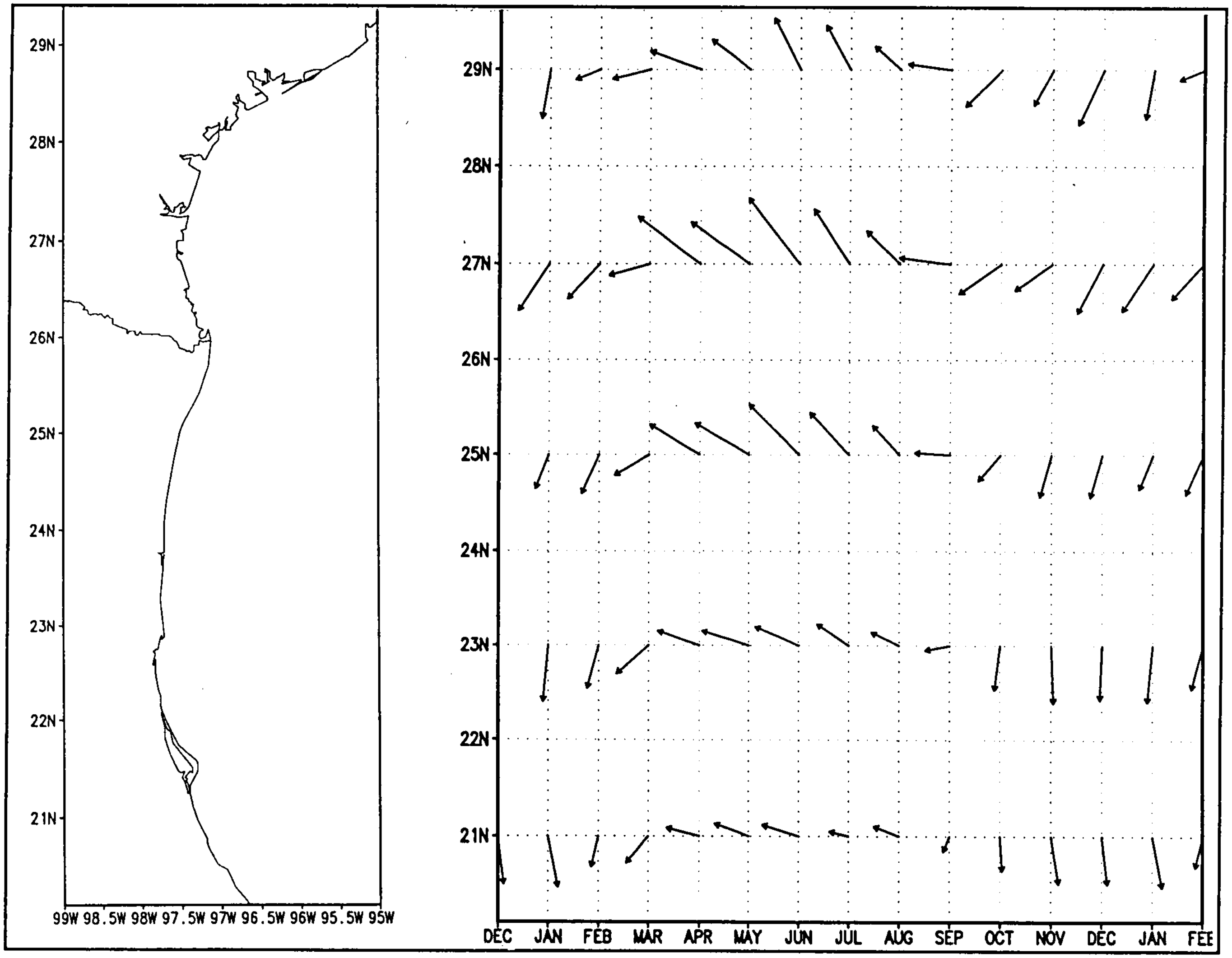
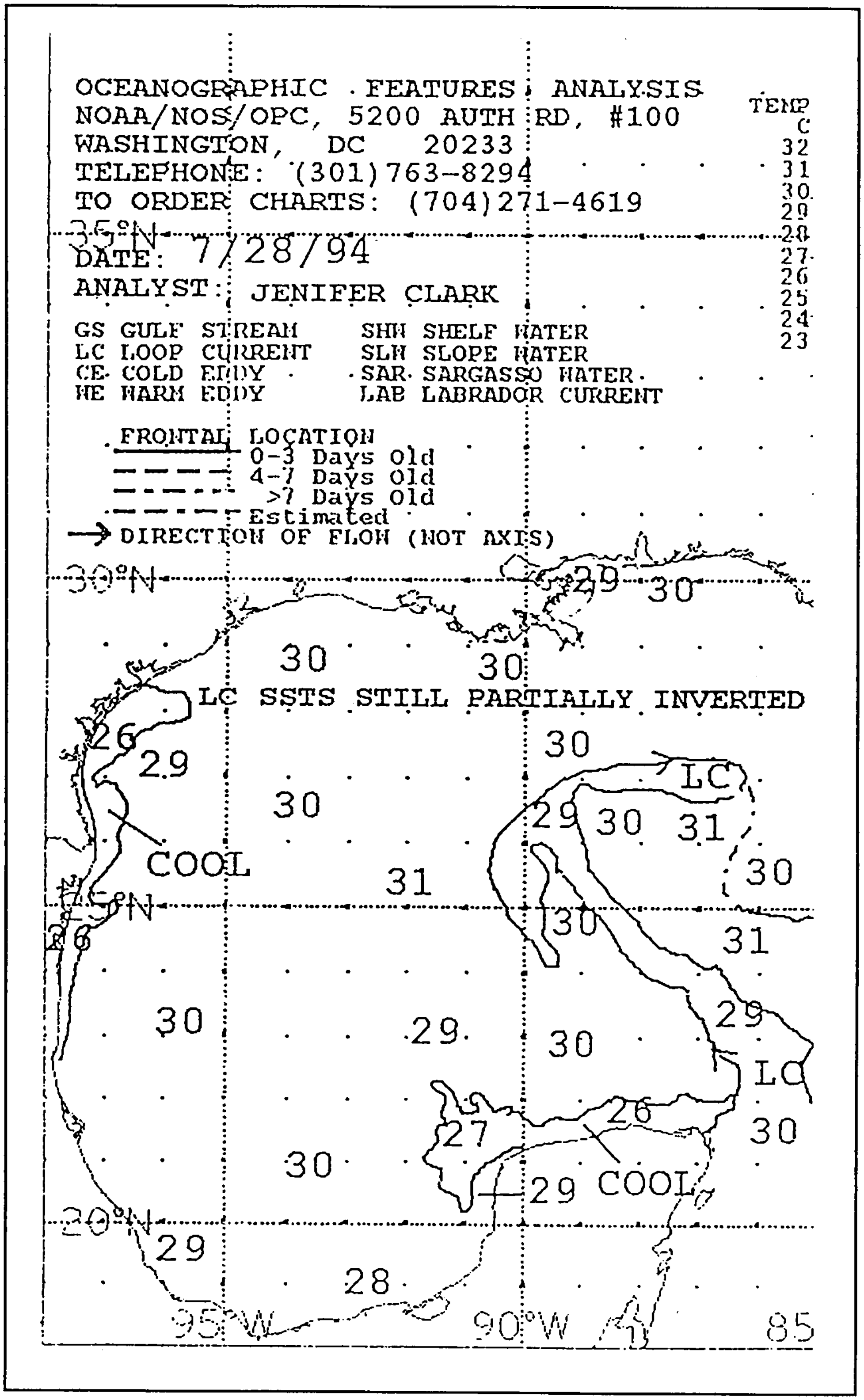


Figure 6.4.1. Climatic monthly mean wind stress for 2° squares along the western boundary of the Gulf of Mexico between 20° and 30° N.



6.4.2. Example of NOAA/NOS/OPC Oceanographic Features Analysis showing the cool band along the western boundary of the Gulf.

Table 6.4.1. Relative frequency of coastal cool bands that are cooler by 2° C or more than the adjacent open Gulf and extend 4° or more in latitude along the western boundary.

	June	July	Aug	Sep
1992	0.33	0.78	0.33	<0.11
1993	<0.11	0.89	0.44	0.22
1994	0.33	0.89	0.89	0.44
Mean	0.22	0.85	0.56	0.22

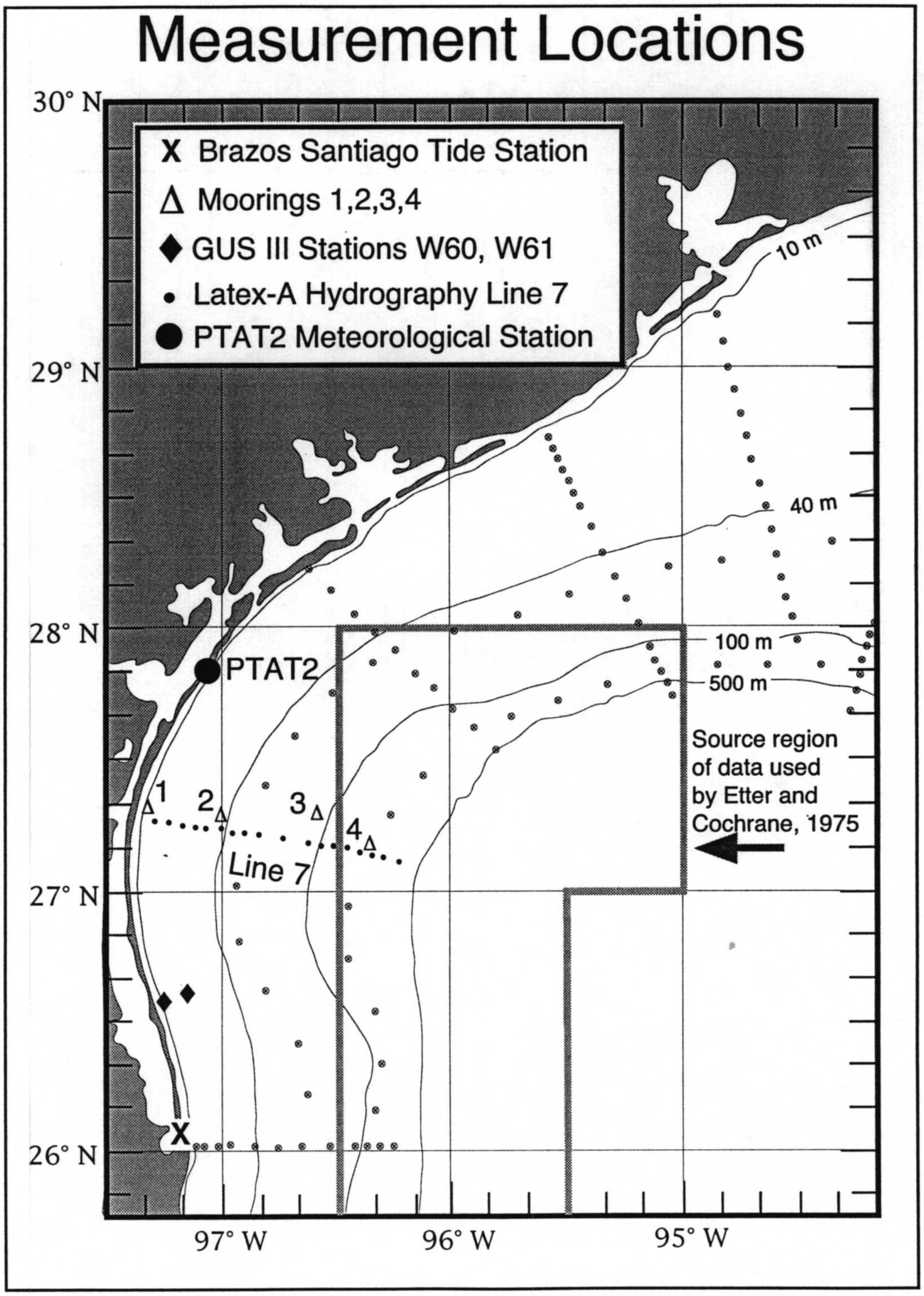


Figure 6.4.3. Locations of measurement stations discussed in the text.

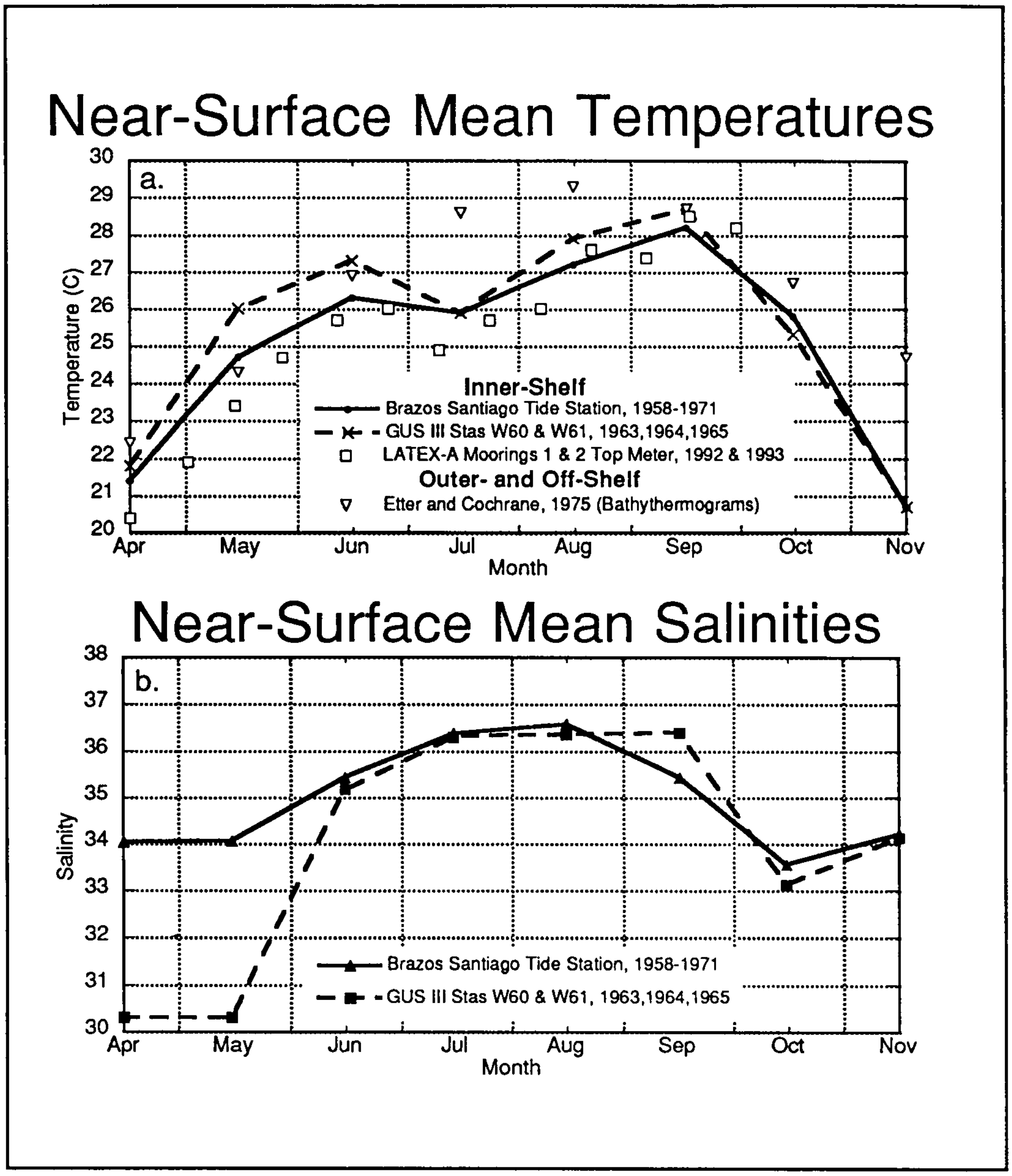


Figure 6.4.4. Monthly or fortnightly means of (a) near-surface temperature for inner shelf and outer or off-shelf locations, and (b) near-surface salinity for inner shelf locations.

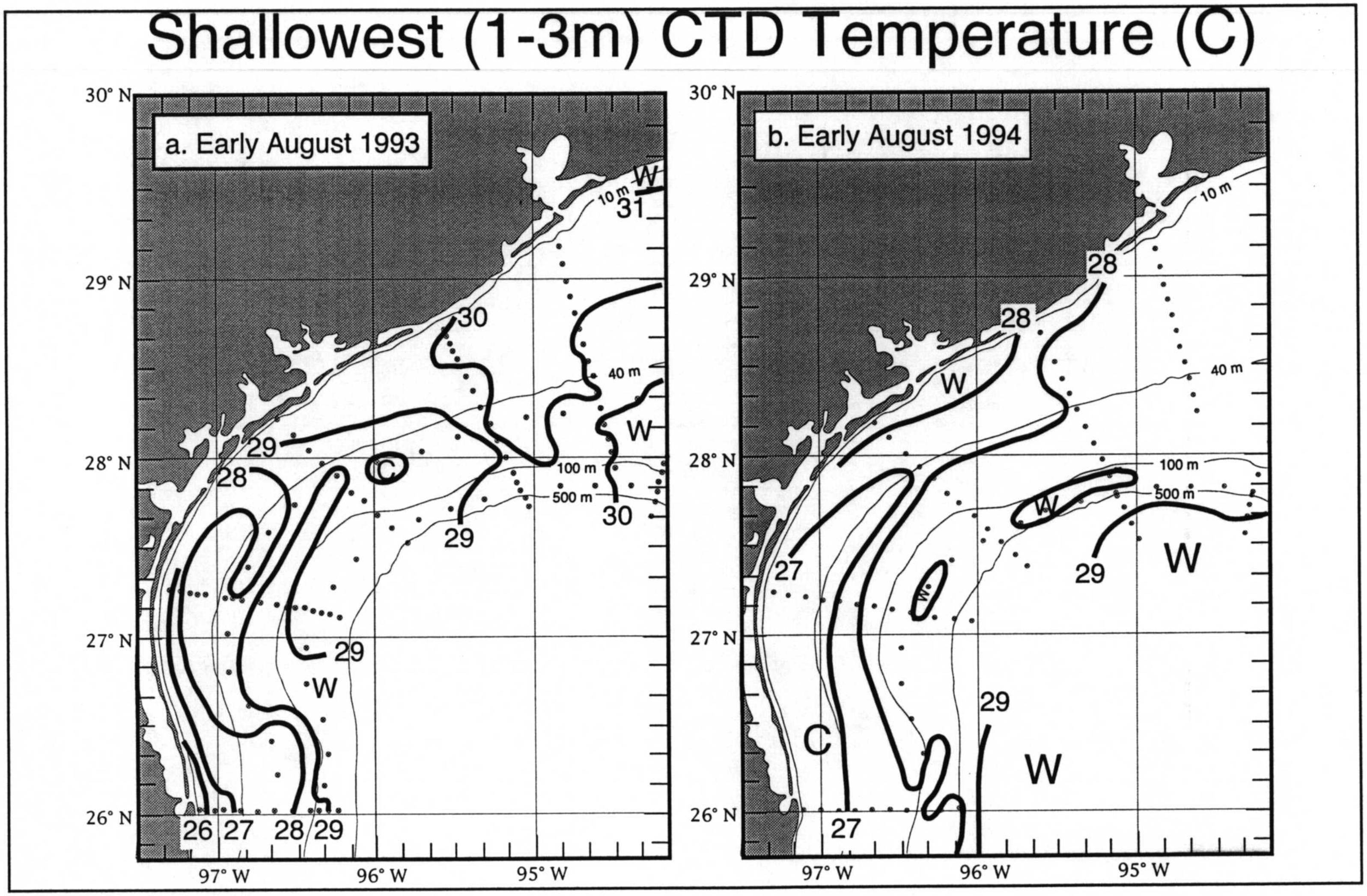


Figure 6.4.5. Shallowest (1-3 m) CTD temperatures measured in (a) early August 1993 and (b) early August 1994.

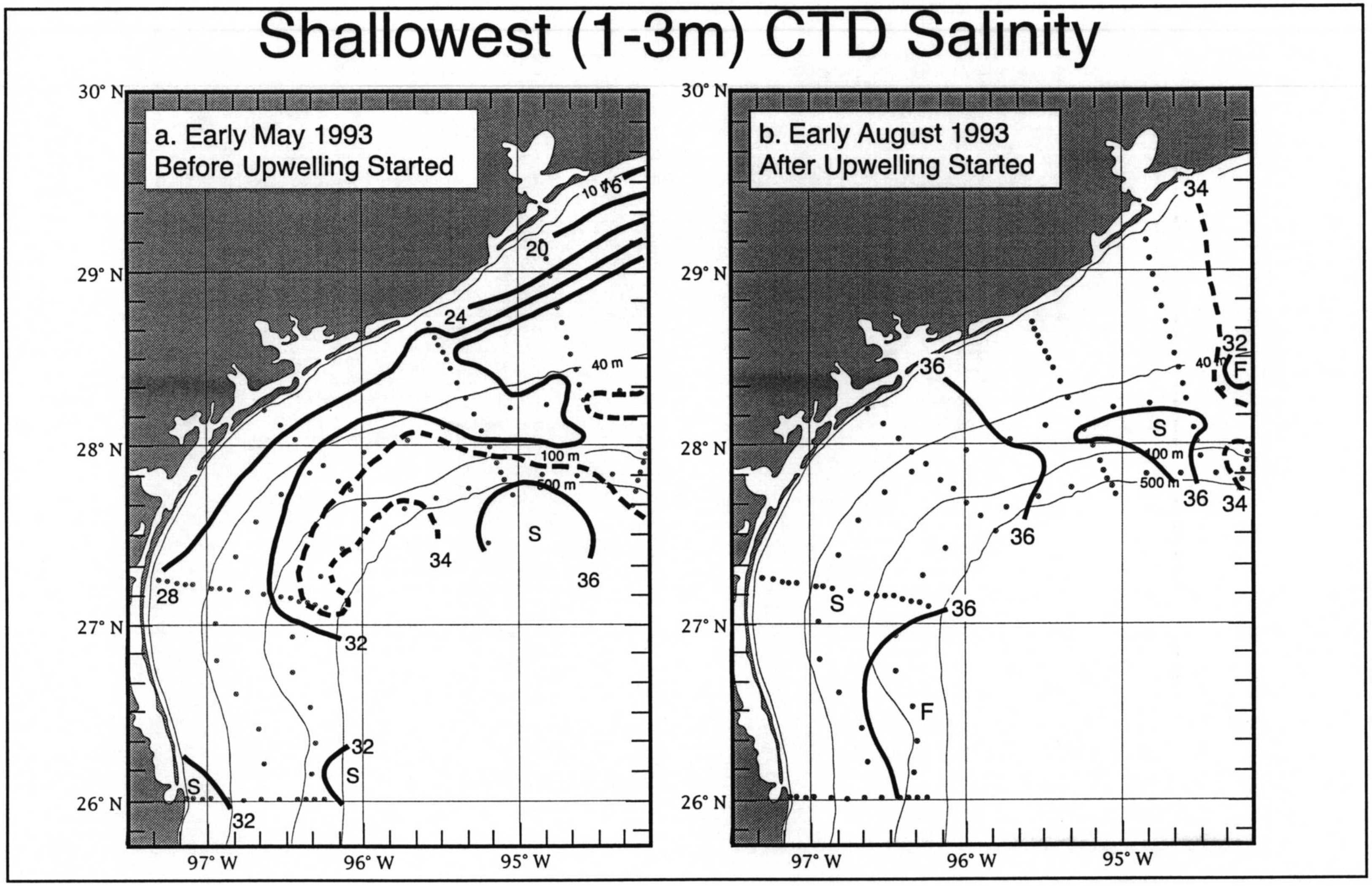


Figure 6.4.6. Shallowest (1-3 m) CTD salinities measured in (a) early May 1993 and (b) early August 1993.

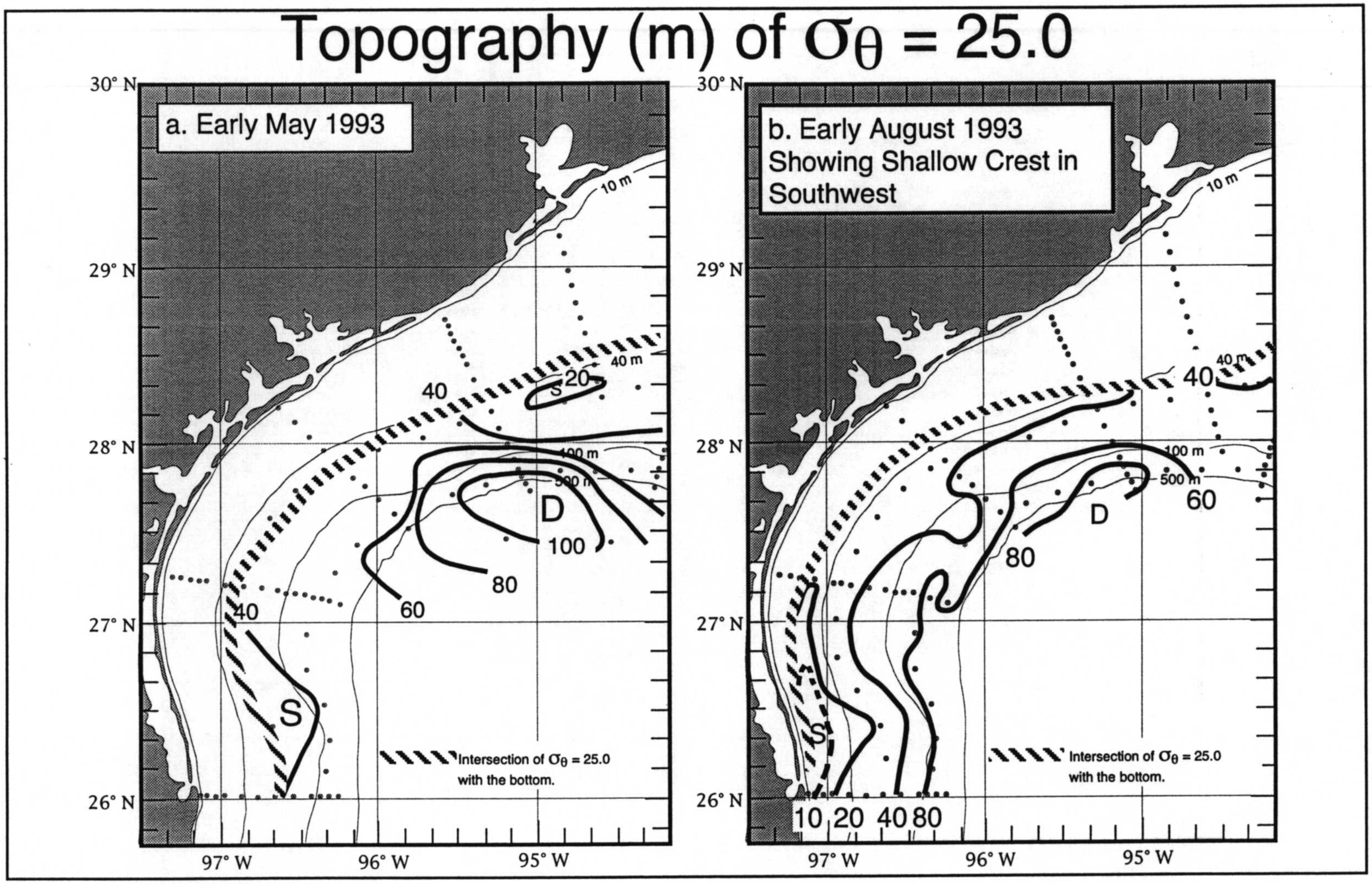


Figure 6.4.7. Topography of the $\sigma_\theta = 25.0$ surface based on measurements made in (a) early May 1993 and (b) early August 1993.

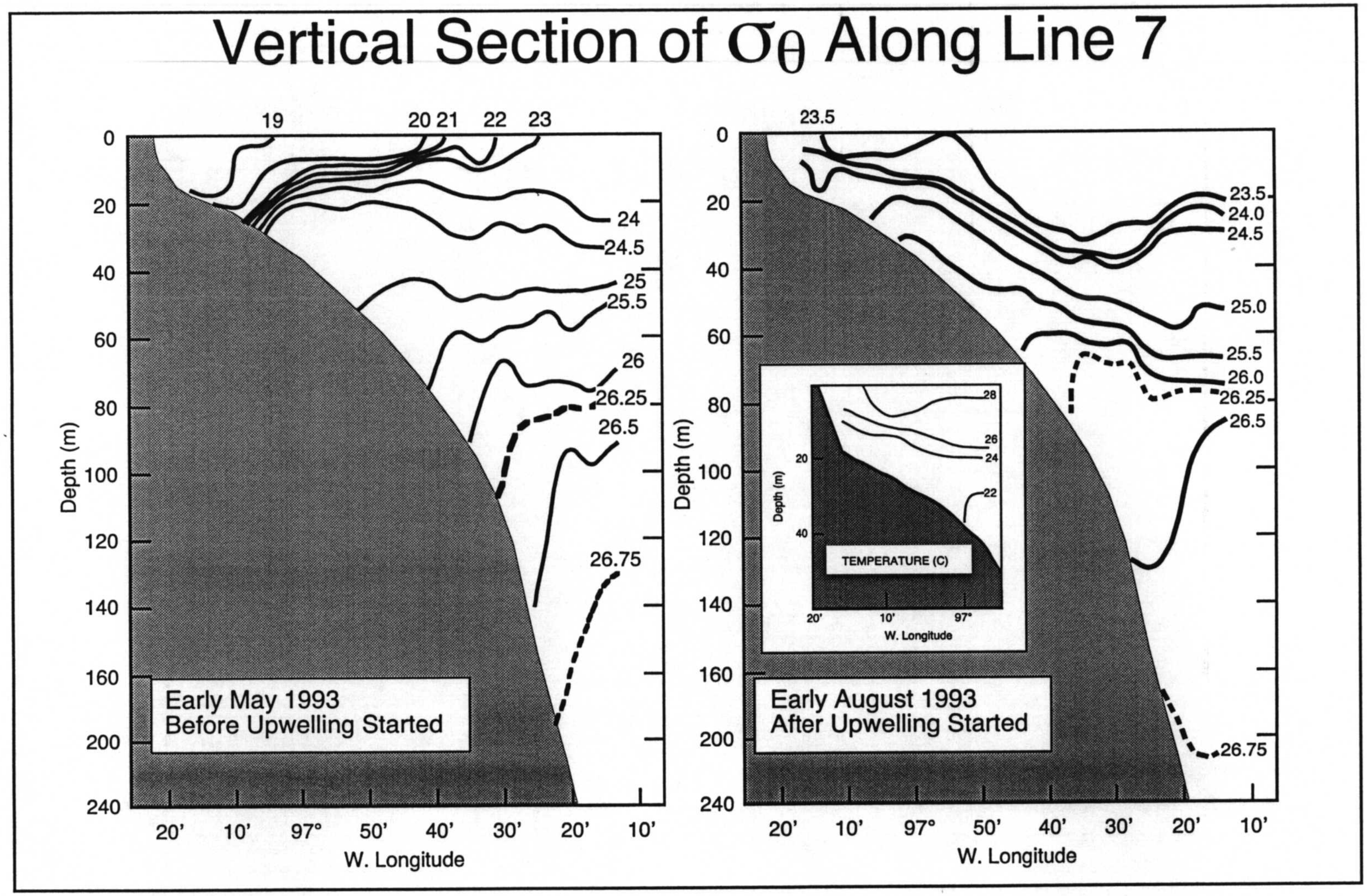


Figure 6.4.8. Vertical section of σ_θ along line 7 made in (a) early May 1993 and (b) early August 1993.

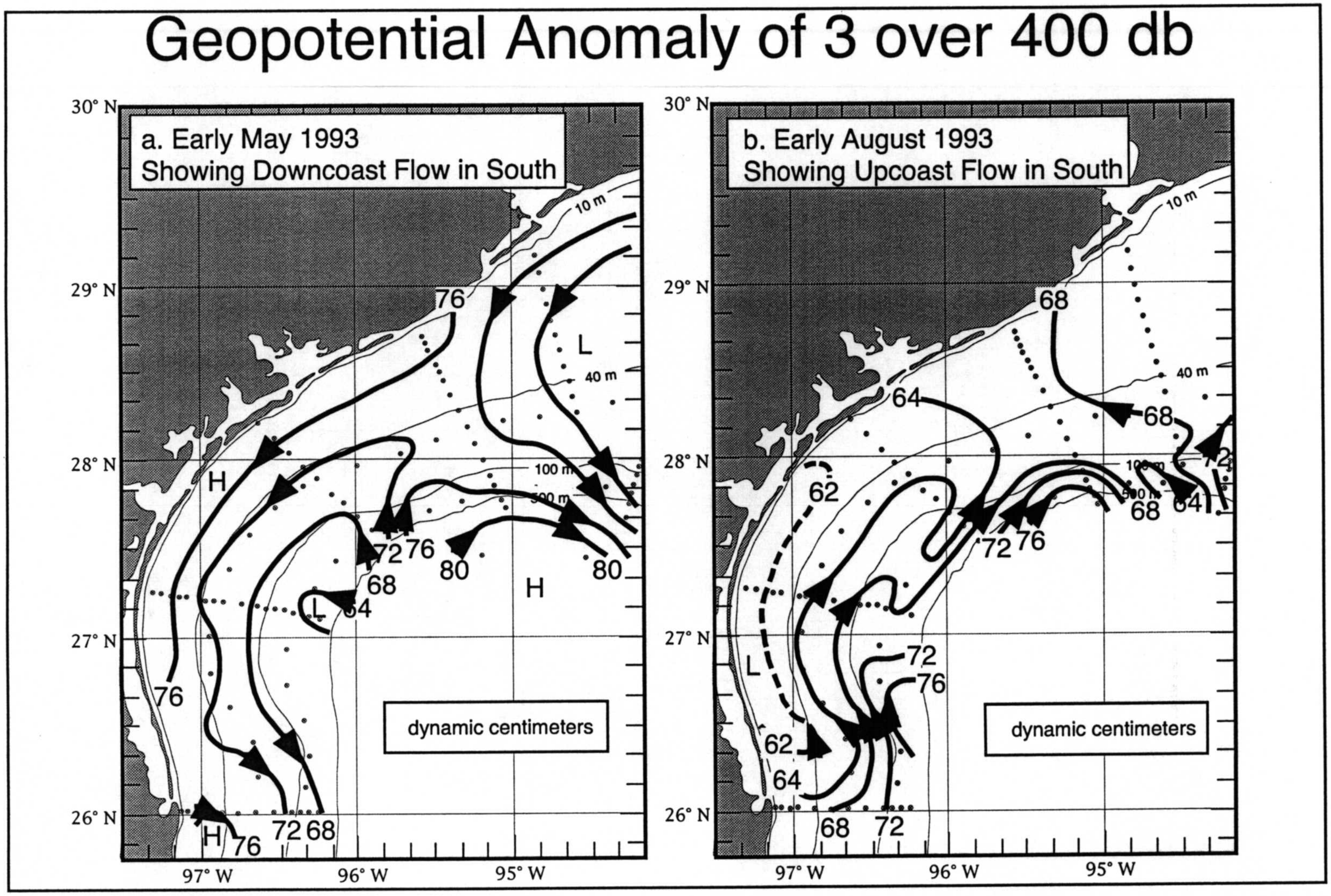


Figure 6.4.9. Geopotential anomaly of 3 over 400 db based on measurements made in (a) early May 1993 and (b) early August 1993.

Table 6.4.2. Six-week means of the alongshore component of currents at top current meters (10-14 m depth) of moorings 1, 2 and 3 combined ($cm \cdot s^{-1}$).

	1992	1993	1994	Mean
08 Apr - 19 May	-0.65	-1.08	-8.09	-3.27
20 May - 30 Jun	$<5.52>_3$	-4.44	2.57	1.22
01 Jul - 11 Aug	$<4.80>_3$	$<4.76>_2$	6.72*	5.43
12 Aug - 23 Sep	-5.11	$<5.62>_2$	-	0.26

< > Indicates that a six-week mean for one of the moorings is missing. The subscript indicates which mooring was missing.

* Indicates that the records ended with 27 July.

All entries in the table have been given equal weight in computing the multiyear means.

6.5 Phenomena at the Outer Shelf Boundary

Phenomena at the outer shelf boundary are being studied using hydrographic, current meter, and drifter data, as well as collateral data such as AVHRR and altimetric fields from satellites. One such phenomenon observed with the LATEX A data set was the anticyclonic Loop Current eddy, Eddy Vazquez (Eddy V). Satellite altimeter data from the TOPEX/POSEIDON mission, not shown here, provided important information in developing the history of this eddy (Jochens et al. 1994).

In summer 1992, Eddy V was observed in the Gulf of Mexico, adjacent to the Texas-Louisiana Shelf (e.g., Jochens and Nowlin 1994b). During the fall and winter of 1992, Eddy V migrated along the base of the north slope into the northwestern corner of the Gulf. Eddy V spun down during December 1992 through February 1993, probably through interaction with another anticyclonic Loop Current eddy, Eddy Unchained (Eddy U), located in the southwestern Gulf (Jochens et al. 1995). By the end of February, the two eddies were separated completely. In March and April 1993, Eddy V and Eddy U interacted again. By May, Eddy V again separated from Eddy U. Each of these interactions weakened Eddy V, which dissipated in summer 1993, perhaps as early as June.

The LATEX A hydrographic survey H05 provided observations of Eddy V adjacent to the shelf in early May 1993 and of a cyclonic eddy at the shelf edge to the west of Eddy V. Figure 6.5.1 shows the geopotential anomaly of 3 db with respect to 200 db; station numbers are provided in Figure 3.4.1. The northern portion of Eddy V is apparent as the high in geopotential anomaly at about 27.5°N 95°W. The cyclonic eddy adjacent to Eddy V is apparent as a low in geopotential anomaly at about 27.3°N 96.3°W. Eddy V and the cyclonic eddy can be identified in the contour section of potential temperature taken along the 200-m isobath between approximately 97° and 94° W (Figure 6.5.2). Eddy V is seen approximately between stations 207 and 211, and the cyclonic eddy is seen between stations 202 and 206. Note that the cyclonic eddy has no expression in the upper 100 m.

Figure 6.5.3 provides examples of potential temperature-salinity diagrams for hydrographic stations influenced by Eddy V (208, 136, and 91) and the cyclonic eddy (168). Station 208 has a salinity maximum greater than 36.5 at temperatures around 20 C; this is indicative of the Subtropical Underwater that occurs in Loop Current eddies and suggests that water from Eddy V is found near the outer shelf. Stations 136 and 91, located progressively east of station 208, show an erosion of the salinity maximum present at station 208. Station 91 shows the influence of fresher shelf waters, suggesting that shelf water is flowing off the shelf at the eastern edge of Eddy V; based on the temperature-salinity diagram, the offshelf flow of freshwater extended to depths near 50 m. By comparison, station 168 is located within the cyclonic eddy.

Current meter data from along the 200-m isobath show flow at approximately 12-m water depths consistent with the local flow indicated by the geopotential anomaly map. Figure 3.2.1 shows the locations of moorings 4, 6, 7, and 8 discussed in this section. Figure 6.5.4 shows the data from mooring 4, which in early May was located in the region of southward flow for the cyclonic eddy. Hydrographic station 168 is located next to this mooring. Figure 6.5.5 shows the data from mooring 6, which was heavily influenced by Eddy V. It shows northward flow in early May, which, coupled with the Subtropical Underwater signature from the adjacent hydrographic station 208, suggests that water from the eddy was being moved onto the shelf. Figures 6.5.6 and 6.5.7 show data from moorings 7 and 8, respectively. These moorings are next to hydrographic stations 136 and 91, respectively. Mooring 7, located in the region of high geopotential anomaly, shows strong eastward flow indicative of influence by Eddy V. Mooring 8, located at the eastern edge of the region of high geopotential anomaly, shows weaker flows varying from east to southeast. This, coupled with the potential temperature-salinity diagram for station 91, indicates flow off the shelf.

LATEX A drifter 06938 was deployed at 27°51.02' N, 94°10.48' W on 2 May 1993 at the 200-m isobath near station 91 and mooring 8. It immediately was drawn off the shelf into the east flank of Eddy V, confirming an exchange of shelf water (Figure 6.5.8). It circulated anticyclonically throughout May, confirming the separation of Eddy V and Eddy U. The circuits of the drifter moved progressively westward, showing that Eddy V was translating westward during this time. In early June, the trajectory of the drifter changed to a cyclonic loop as it was drawn into a cyclonic eddy that had been to the southeast of Eddy V. Satellite altimeter data showed that this cyclonic feature had moved northwest into portions of the Eddy V region, suggesting that Eddy V had become disorganized and may have dissipated in June 1993 (Jochens et al. 1994).

The presence of Eddy V at the edge of the shelf and the cyclonic eddy to its west may have been factors in driving an offshore cross-shelf flow on the south Texas shelf. The cross-shelf flow can be seen in Figure 6.5.9 showing the salinity distribution at the sea surface from cruise H05 in May 1993. Between Corpus Christi and Brownsville, water with salinities less than 31 extended across the shelf. The surface salinities suggest that Eddy V spilled a tongue of higher salinity water onto the shelf near 95° W, and drew lower salinity water off the shelf farther east.

This cross-shelf flow affected particle and nutrient distributions on the outer shelf (Sahl et al. 1994). The waters of the offshore flow were low in temperature, nutrients, and density, as well as salinity, and, as shown in Figure 6.5.10, high in particle beam attenuation coefficient (PBAC). The tongue of water from Eddy V that spilled onto the shelf had lower PBAC and higher temperature, nutrients, and density, as well as salinity, than adjacent shelf waters.

The primary impact of this cross-shelf flow on particles was to transport a surface nepheloid layer (SNL) across the shelf. Cruise line 7 was the cross-shelf line closest to the axis of the cross-shelf flow. A vertical section of PBAC along this line illustrates the change in the SNL across the shelf (Figure 6.5.11). From mid-shelf to slope waters, the thickness of the SNL decreased from 25 m to 2.5 m. The particle concentration also decreased from the middle to the outer shelf.

The structure of the SNL suggests that some of the particles contained in it were eroded from the sea floor. On the middle shelf, the SNL had a PBAC maximum located close to the base of the SNL. This structure would be created by the transport of a bottom nepheloid layer from the inner shelf into deeper water. Preliminary analysis of PBAC and fluorimetry data indicate that some, but not all, of the particles carried in the SNL were phytoplankton.

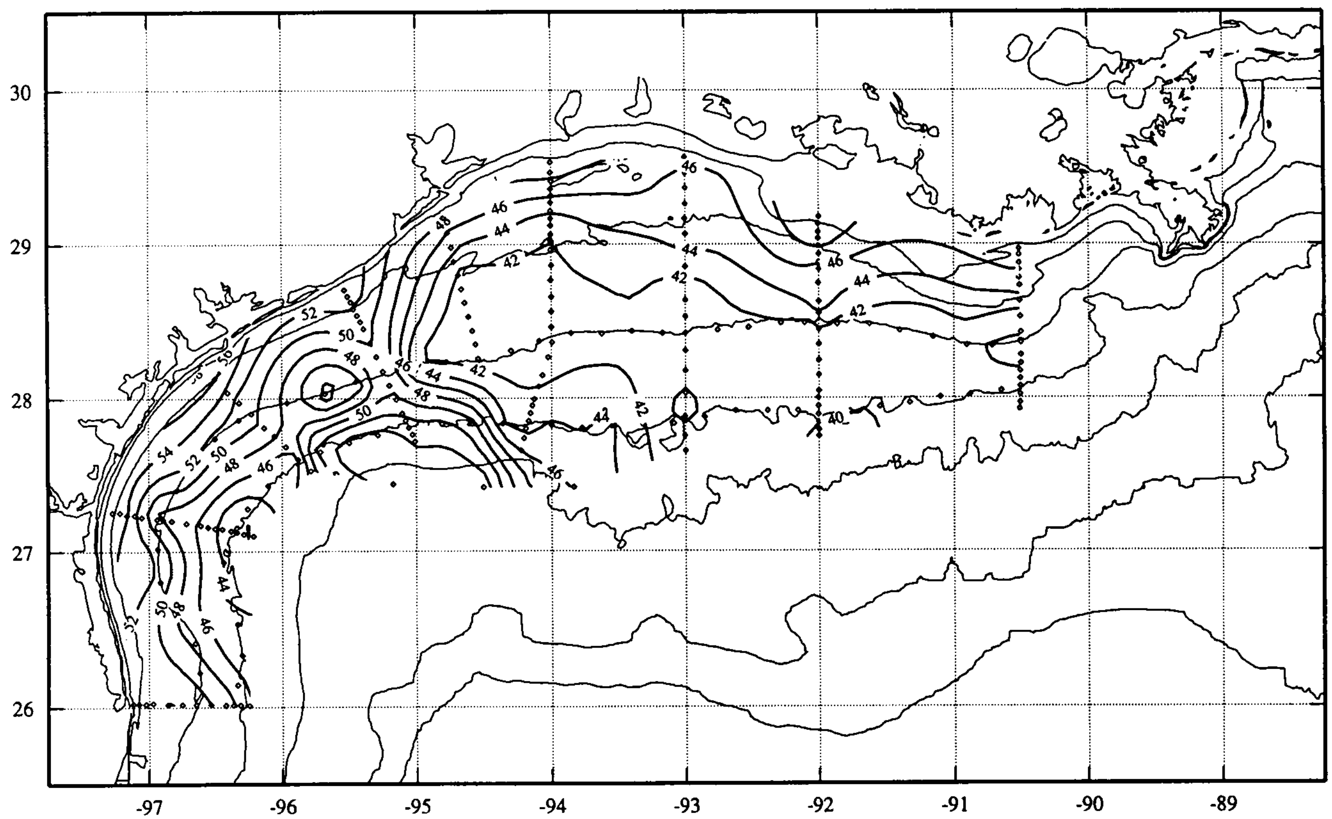


Figure 6.5.1. Geopotential anomaly of 3 db relative to 200 db for the LATEX H05 cruise, May 1993.

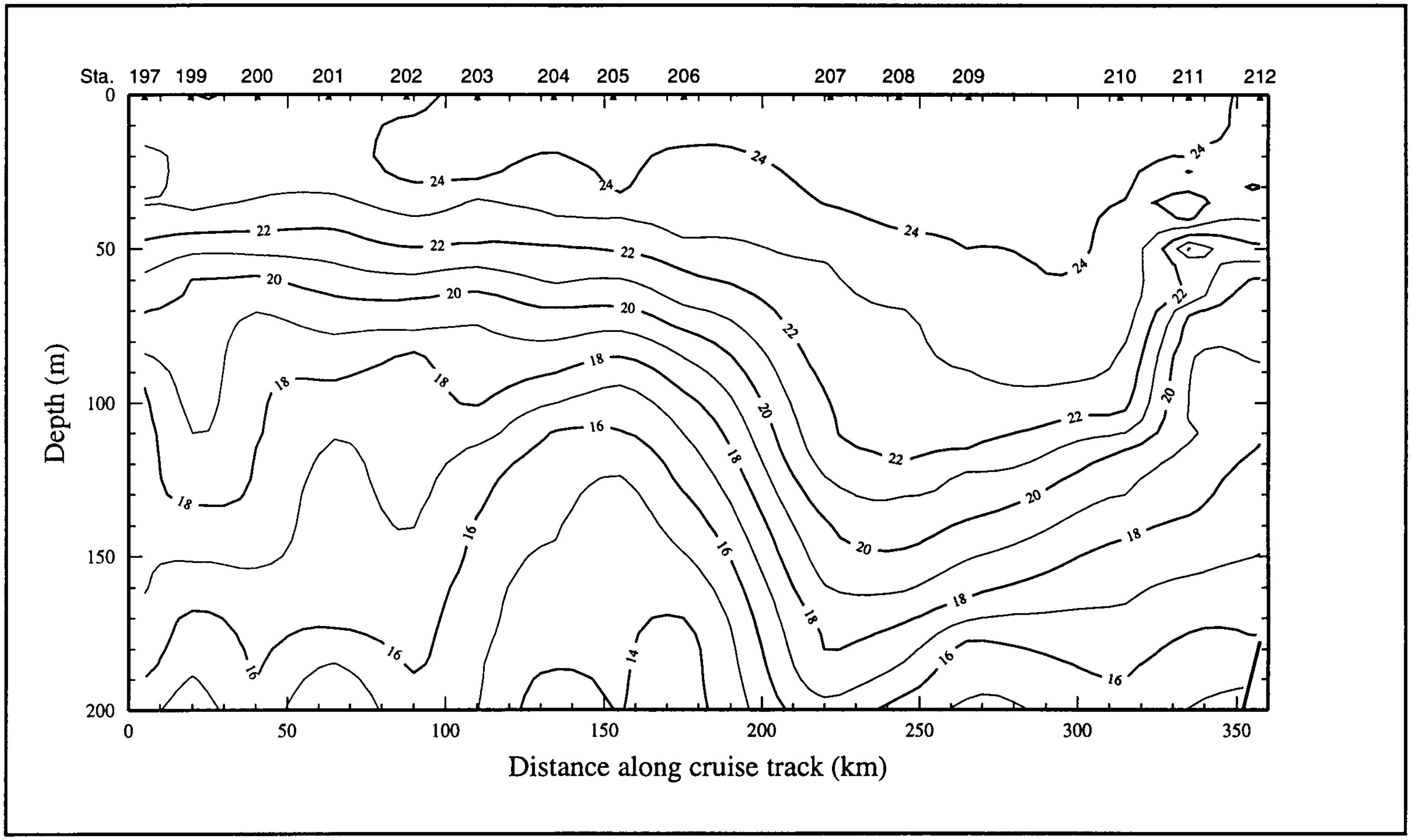


Figure 6.5.2. Vertical section of potential temperature along the 200-m isobath for the LATEX H05 cruise, May 1993.

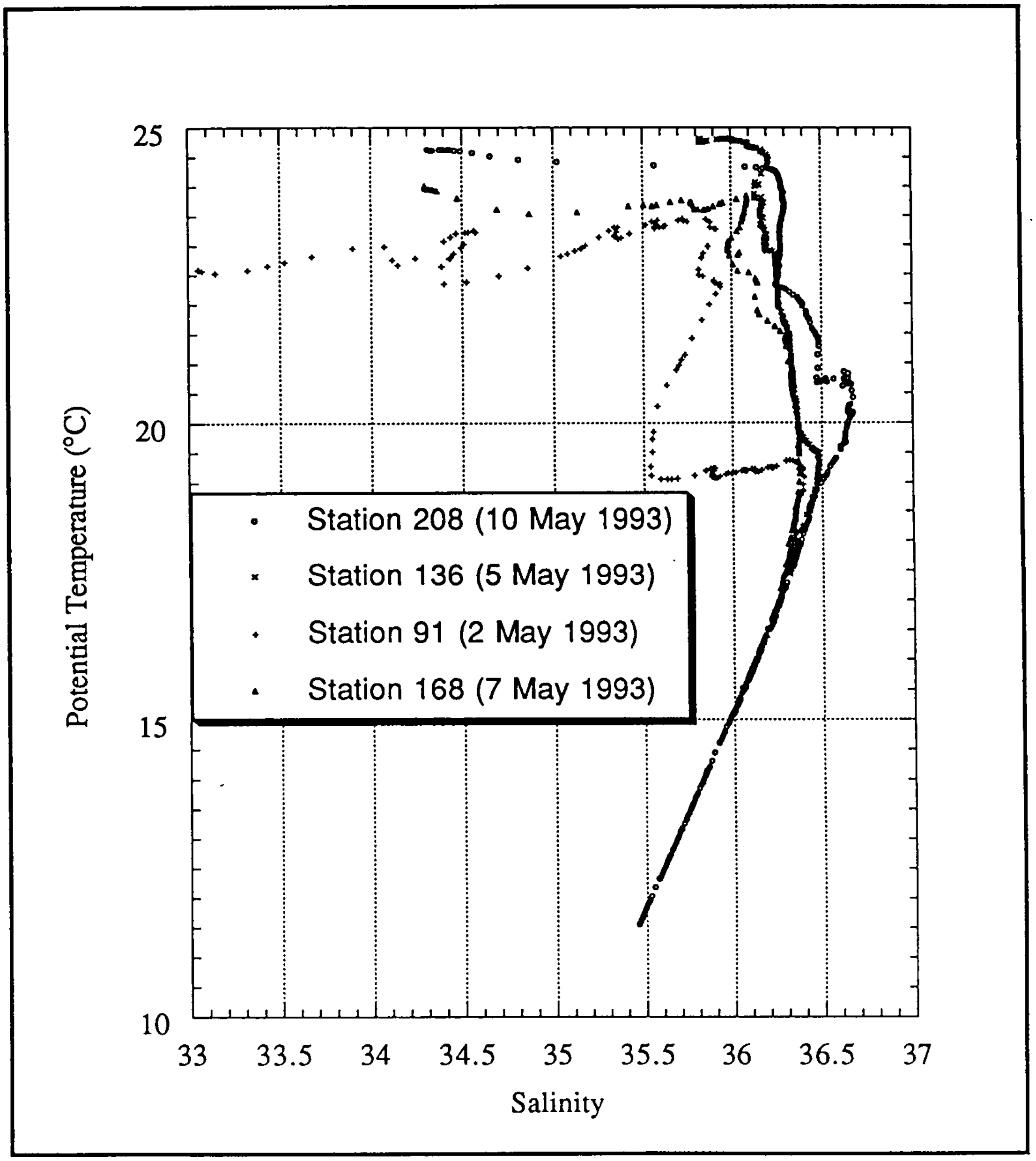


Figure 6.5.3. Potential temperature - salinity diagrams for stations 91, 136, 168, and 208, located in the western half of the LATEX Shelf along the 200-m isobath.

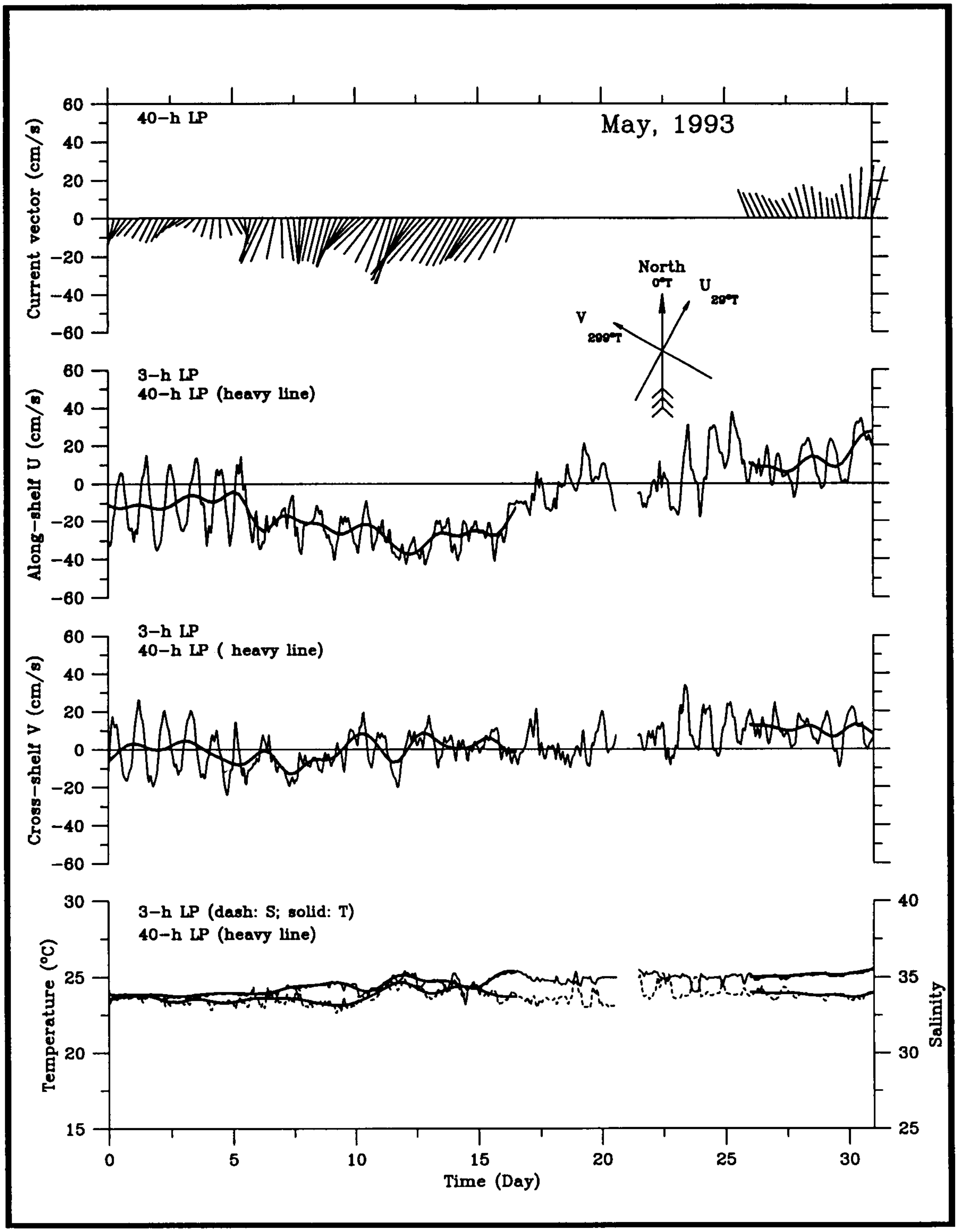


Figure 6.5.4. Monthly plot of current velocity, temperature, and salinity for mooring 4 at 12 m for May 1993.

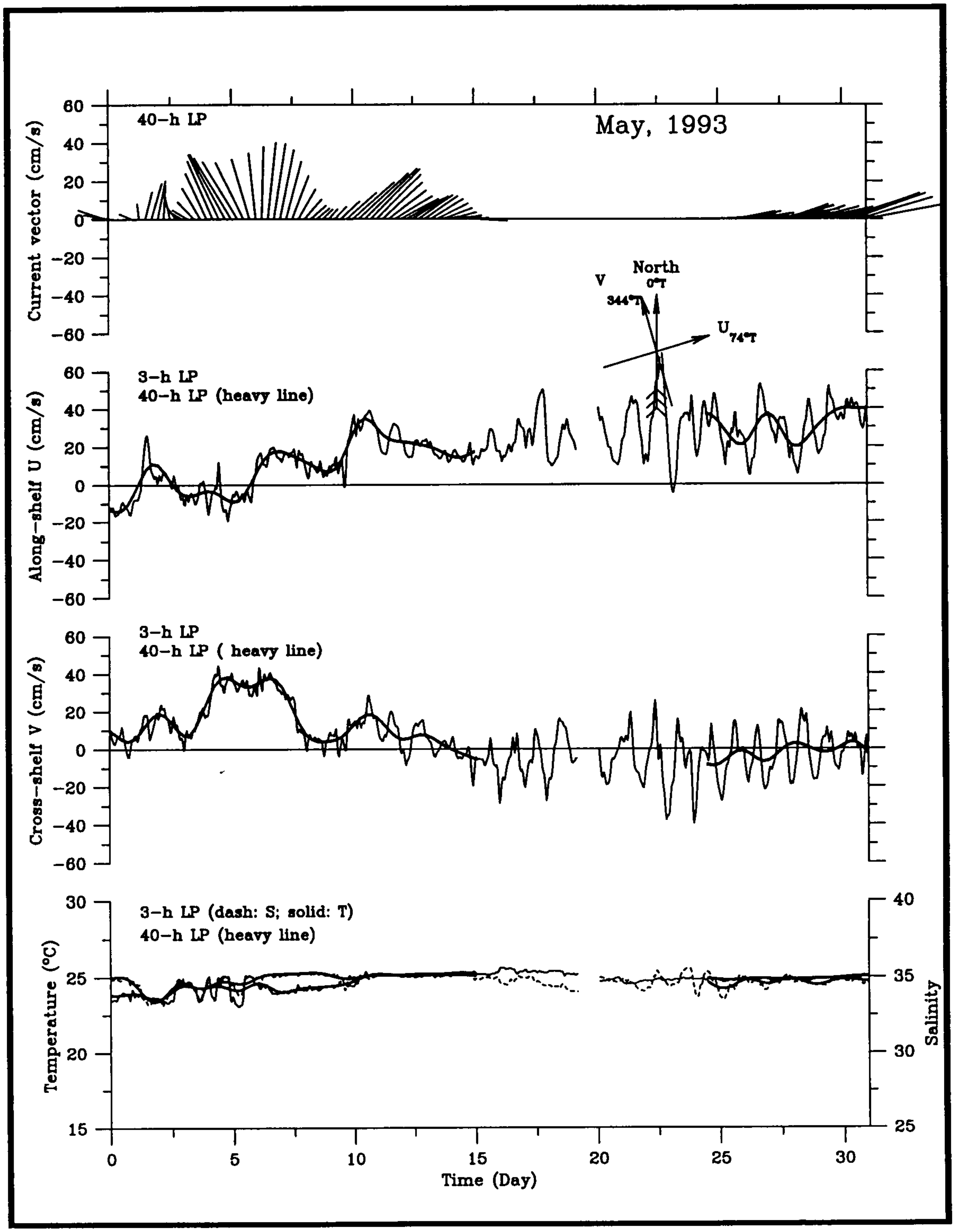


Figure 6.5.5. Monthly plot of current velocity, temperature, and salinity for mooring 6 at 13 m for May 1993.

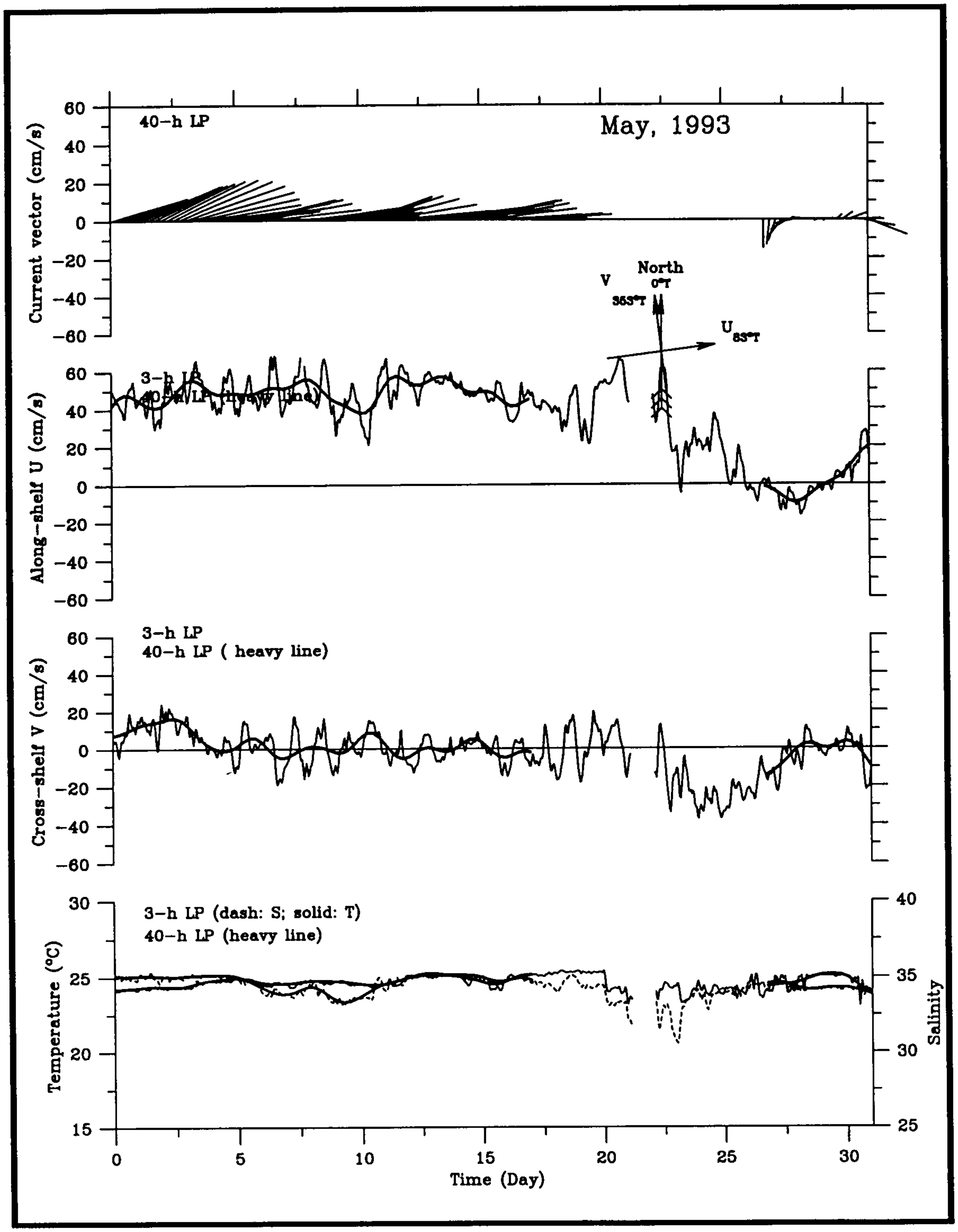


Figure 6.5.6. Monthly plot of current velocity, temperature, and salinity for mooring 7 at 14 m for May 1993.

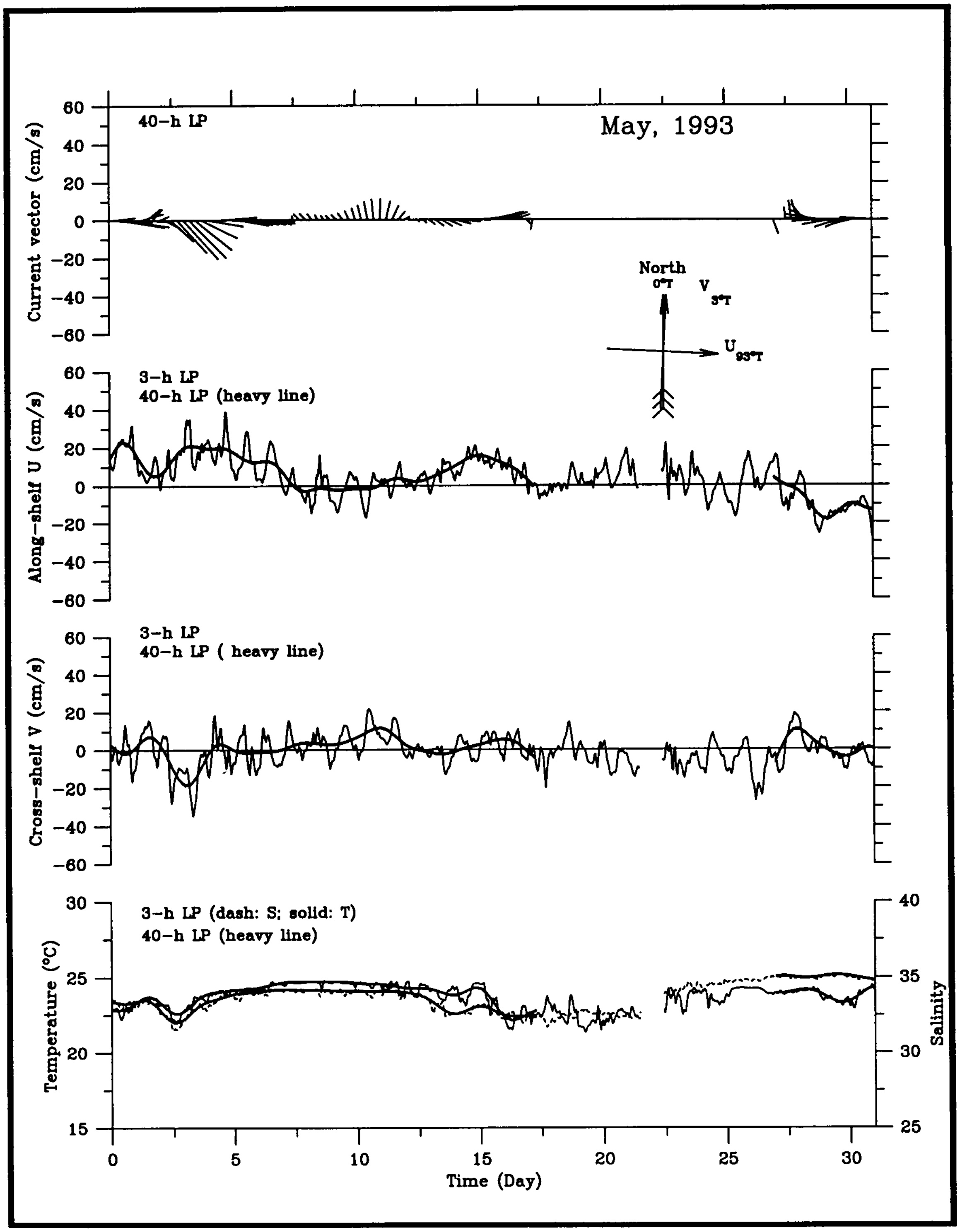


Figure 6.5.7. Monthly plot of current velocity, temperature, and salinity for mooring 8 at 15 m for May 1993.

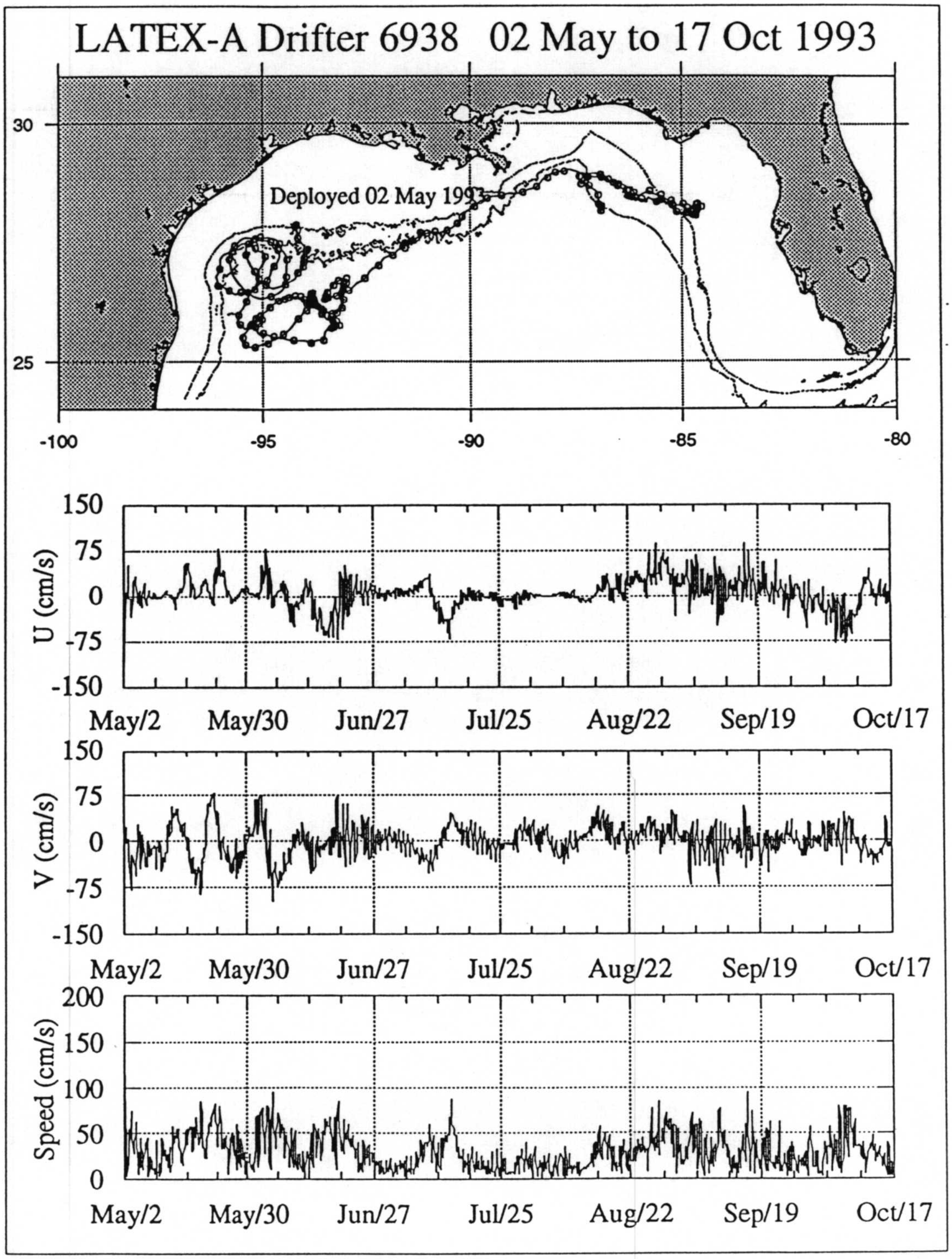


Figure 6.5.8. Trajectory of drifter 6938, May to October 1993, with U (east) and V (north) velocity components and speed. Circles in the trajectory trace represent the drifter's position at midnight each day. The record is 168 days long.

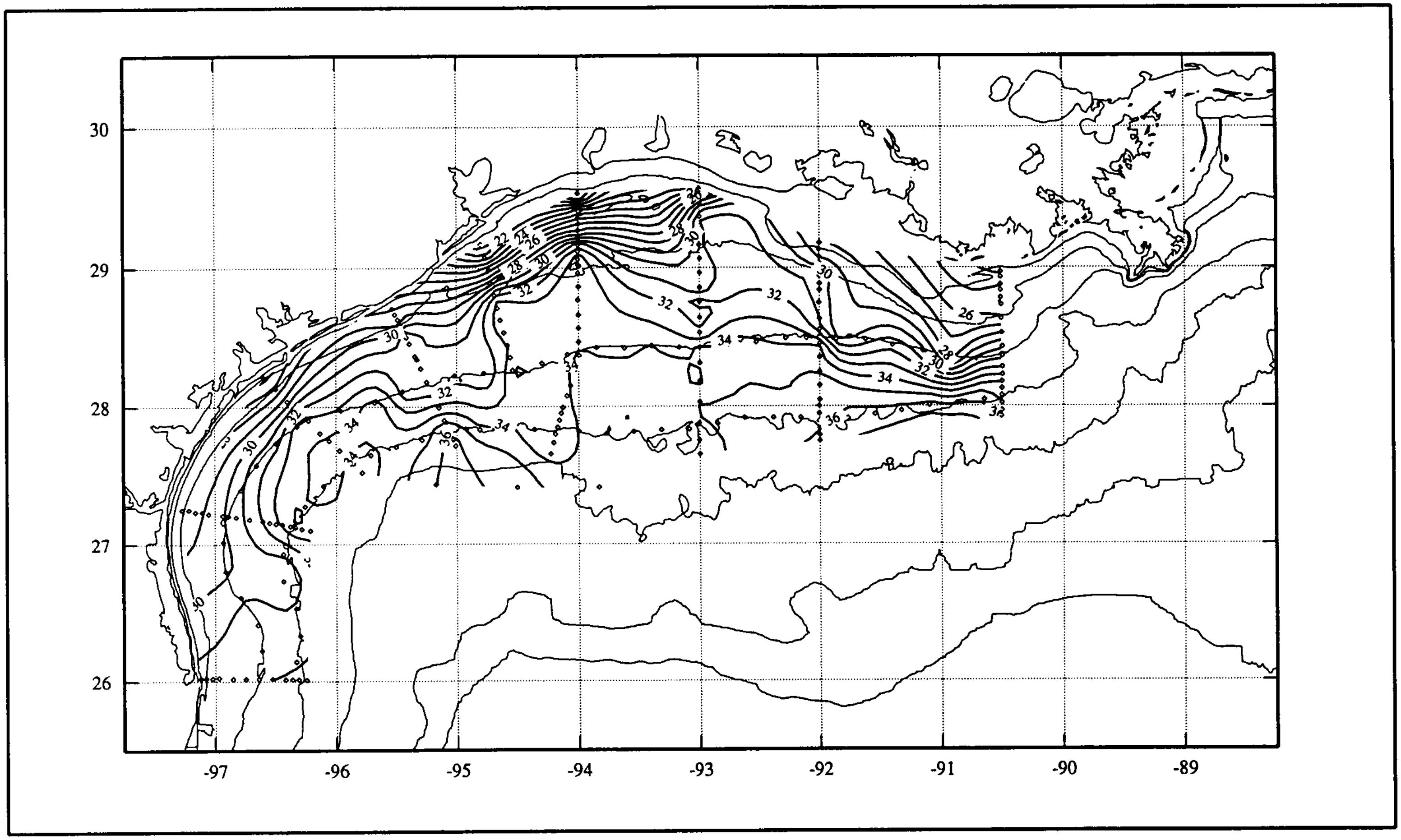


Figure 6.5.9. Salinity at 3 m depth for the LATEX H05 cruise, May 1993.

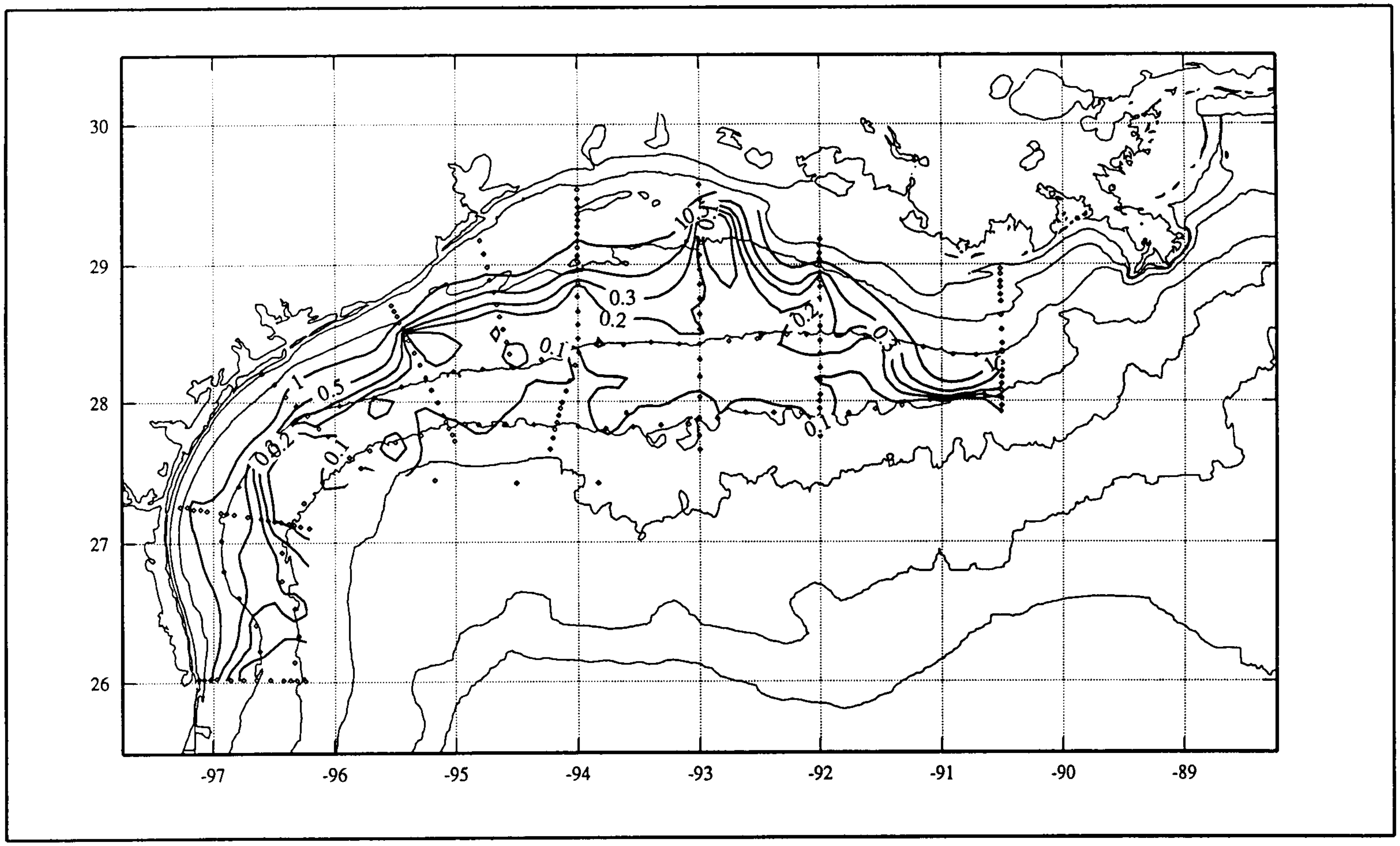


Figure 6.5.10. Distribution of particle beam attenuation coefficient (m^{-1}) at 2 m depth for the LATEX H05 cruise, May 1993.

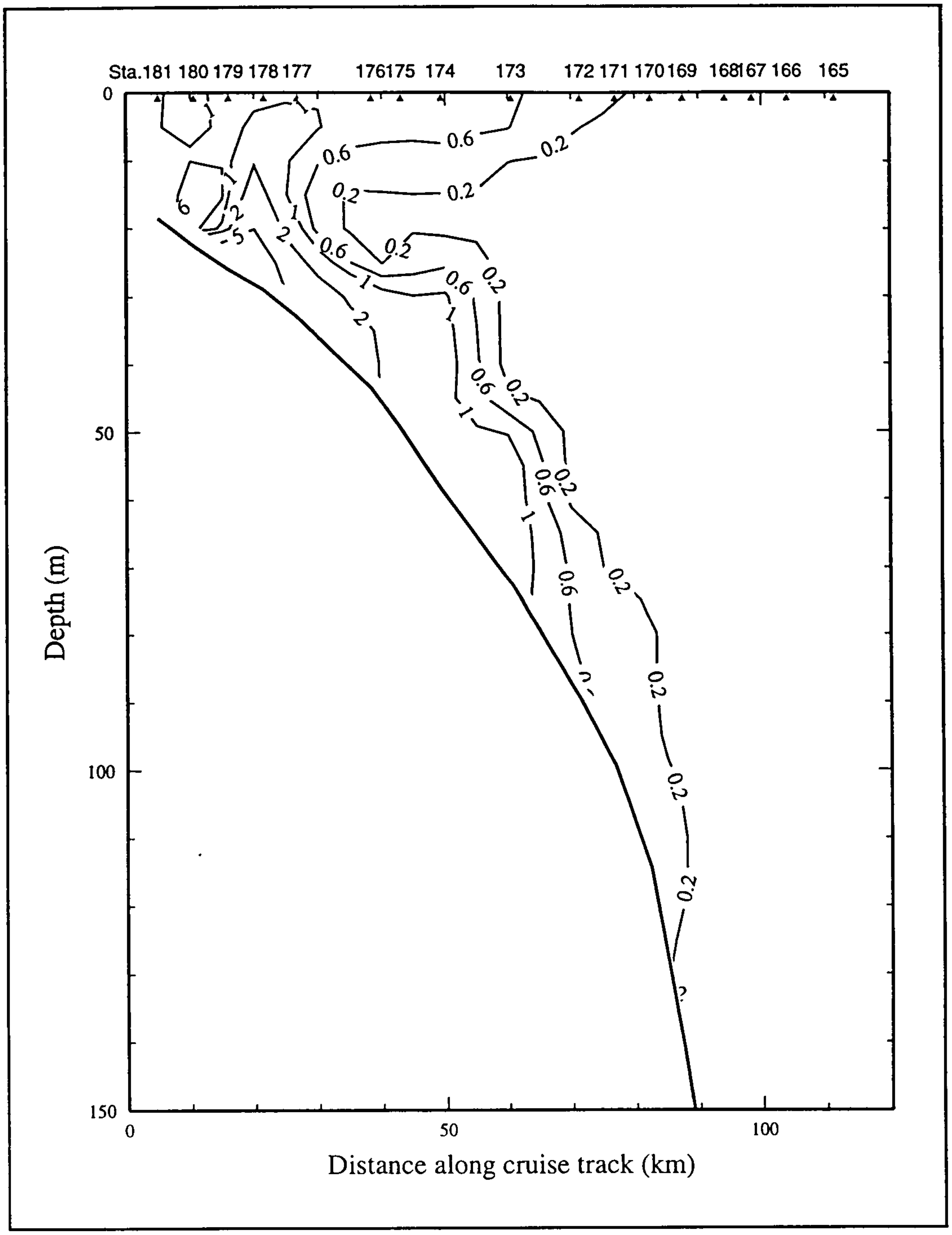


Figure 6.5.11. Vertical section of particle beam attenuation coefficient (m^{-1}) along transect 7 for the LATEX H05 cruise, May 1993.

6.6 Analysis of Wind Fields over Texas-Louisiana Shelf

Surface winds significantly influence the ocean environment of the Texas-Louisiana Shelf. Wind stress serves as a primary driving force affecting the pattern of shelf circulation, while evaporation and surface heat flux related to wind modify the distributions of water properties and thus the vertical stability. The wind fields over this region display a marked seasonal march (Hastenrath 1968). During summer, the atmospheric circulation over the region is dominated by the western end of the North Atlantic Anticyclone and the downstream portion of the trades (Elliott 1979); winds are northwestward and relatively weak compared with those in other seasons. In fall and winter, the polar front moves to the south, generating a series of intense cold fronts that pass over the shelf region; winds are dominated by westward or southwestward components.

Cochrane and Kelly (1986) showed a clear seasonal pattern of ocean circulation in this region. They indicated the dominant feature of the shelf circulation is a cyclonic gyre elongated along the shelf. The inshore limb of the gyre is a coastal current. West of 92.5° W, the coastal current is driven primarily by the along-shore component of wind stress. They stated "... the western or southern end of the gyre migrates seasonally with the direction of the prevailing wind, reaching south of the Rio Grande mouth in fall and [off] Cameron in July. The gyre is normally absent in July, but reappears in August-September when a down-coast wind component develops." The coherence between shelf circulation and wind stress has been examined by others; e.g., Lewis and Reid (1985) studied the response of the coastal current off the Texas coast to the local wind in the summer and fall of 1978 and the winter of 1979. Their results showed that in fall and winter, the current is driven by local wind forcing; in summer, it is driven by a combination of local wind plus non-locally generated shelf wave phenomena due to weak local wind.

In addition to the seasonal variation, wind fields have large spatial and temporal variability at periods of a few days to a few weeks. Extreme events, such as hurricanes, frontal passages, cyclogenesis, and severe cold-air outbreaks, often occur over the LATEX shelf. Such extreme events affect the circulation and water mass distributions over the shelf. Accurate, high-resolution wind fields are needed for the study of such effects.

To date, there have been several compilations of wind stress fields over the Gulf of Mexico, including the Texas-Louisiana shelf; e.g., Elliott (1979) calculated seasonally averaged wind stress fields for the Gulf of Mexico with 1°-grid resolution using historical ship data through 1972; Rhodes et al. (1985) calculated corrected geostrophic winds for the period 1967-1982 using surface pressure analysis with 280- to 300-km grid resolution and 12-hour temporal resolution.

The National Meteorological Center (NMC) analyzes the global surface wind fields with 1° spatial resolution and 6-hour temporal intervals using their Global Data Assimilation System (GDAS). GDAS consists of several parts, including the processing of observed data, objective analysis, initialization, numerical forecasting, and post-processing (Kanamitsu 1989). The NMC analyzed fields differ from fields produced by analyzing observed data alone. The regional NMC analyzed surface wind field for 0600 UTC on 4 November 1992 is shown in Figure 6.6.1.

From April 1992 through November 1994, the LATEX meteorological buoys provided data over the mid Texas-Louisiana Shelf, measuring hourly sea level pressure, sea surface wind speed and direction, sea surface temperature, and surface air temperature. In addition, there were seven National Data Buoy Center (NDBC) buoys and nine Coastal-Marine Automated Network (C-MAN) buoys operative in the area. Four land weather stations along the coast were chosen to supplement the buoy stations. The locations of all twenty-eight stations are shown in Figure 6.6.2; on the shelf, the mean separation of observations was about 0.8°.

Directed by Professors R.O. Reid and W.D. Nowlin, Ms. Wensu Wang, a Ph.D. student, is analyzing selected surface meteorological fields for the LATEX region and field period. Gridded values will be obtained at 0.5° spatial resolution over the Texas-Louisiana shelf and adjacent regions by using all observed data from the 28 stations. The principal objectives of this research are:

1) To produce time series, probably at 3-hour intervals, of surface meteorological fields for selected episodic atmospheric events over the Texas-Louisiana Shelf. These might include hurricane Andrew, cyclogenesis of a major storm, and frontal passages. This work also will serve to examine the effectiveness of selected distinct objective analysis procedures by comparing analyzed fields with those obtained by subjective analyses using the same data.

2) To apply the chosen objective analysis procedures to produce seasonal patterns of 10-m wind and pressure, surface wind stress, and perhaps wind stress curl, SST, and surface air temperature for the LATEX shelf during the field period.

Winds were measured at different heights during the LATEX field period: LATEX buoys measured them at 3.6 m; some NDBC buoys measured at 5 m, others at 10 m; measurement heights at C-MAN buoys varied from station to station. To be compared and used as surface wind, the observed wind must be adjusted to a common height, usually to 10 m. The shape of the vertical wind profile over the sea depends on the aerodynamic surface roughness length and the air stability in the marine boundary layer (Smith 1988). Surface roughness is a function of wind speed. Stability depends on the temperature difference between air and sea and wind speed as well. Using empirical formulae, the wind profile can be calculated if the wind, surface sea and air temperature, and humidity are given at the height of observation. A number of variants of these empirical formulae are in use. Among the adjustment methods, those of Smith (1988), Liu et al. (1979), and Large and Pond (1981) are commonly used. These published empirical formulations have been compared over a broad range of temperatures, winds, and stability; a preferred algorithm has been selected. Based on examination of surface humidity measured on Voluntary Observing Ships (VOS) and at platforms over the LATEX area, a mean humidity was estimated for use in the algorithms.

The surface meteorological fields are measured at irregularly distributed stations over the shelf and adjacent regions. However, for many purposes it is necessary to use regularly arrayed data sets. This is true for contouring fields of these variables or for their use as the boundary conditions in numerical model of shelf circulation.

There are various methods of gridding the data. The basic principle is to estimate the value at a grid point from a weighted average of nearby observed data. The simplest methods, such as that of Barnes (1964, 1973), use a known function of distance as the weighting function. This method is commonly used for mesoscale analysis in meteorology (Koch et al. 1983) and it is in the General Meteorological Data Assimilation, Analysis, and Display (GEMPAK) software package. Another method is the "minimum curvature" method (Smith and Wessel 1990). A modification of this method is used in the Generic Mapping Tool (GMT) software, a package commonly employed in oceanography. A third method is statistical interpolation (SI) based on an estimation theory known as optimal estimation and used in meteorological data analysis (Gandin 1963). It was first applied in oceanographic analysis by Bretherton et al. (1976).

A set of wind events were selected and subjectively analyzed fields prepared. Using the same data sets, three objective analysis methods were used to prepare corresponding fields: GMT, GEMPAK, and the SI method. These results were compared to one another and to the subjectively analyzed fields. The comparisons showed that the SI method has distinct advantages; this method was chosen to analyze the surface meteorological fields. At this stage of our analysis, we are estimating covariances for the meteorological fields for which we intend to produce gridded and contoured fields.

For the month of November 1992, observed winds at each station (Figure 6.6.2) for 6-hr intervals were corrected to 10 m and components were averaged. Then the SI method was applied to obtain gridded fields of components, which were combined to produce the mean 10-m wind field shown in Figure 6.6.3. For contrast, we show in Figure 6.6.4 the 10-m wind field produced by the same objective method for 0600 UTC on 4 November 1992 during a major cyclogenesis event. Figure 6.6.4 should be compared with the NMC wind field for the same time shown in Figure 6.6.1.

We show another comparison between our analyzed 10-m wind field at 1700 UTC on 7 November 1992 (Figure 6.6.5) and the NMC analyzed field for the same time (Figure 6.6.6). One major difference in those fields is the trend toward decreased speed and southward winds over the far western shelf in our analysis. For comparison, we show (Figure 6.6.7) the wind field for that western region at the same time as derived from the scatterometer data from ERS-1 (Freilich and Dunbar 1994). This ERS-1 field agrees more closely with our analysis.

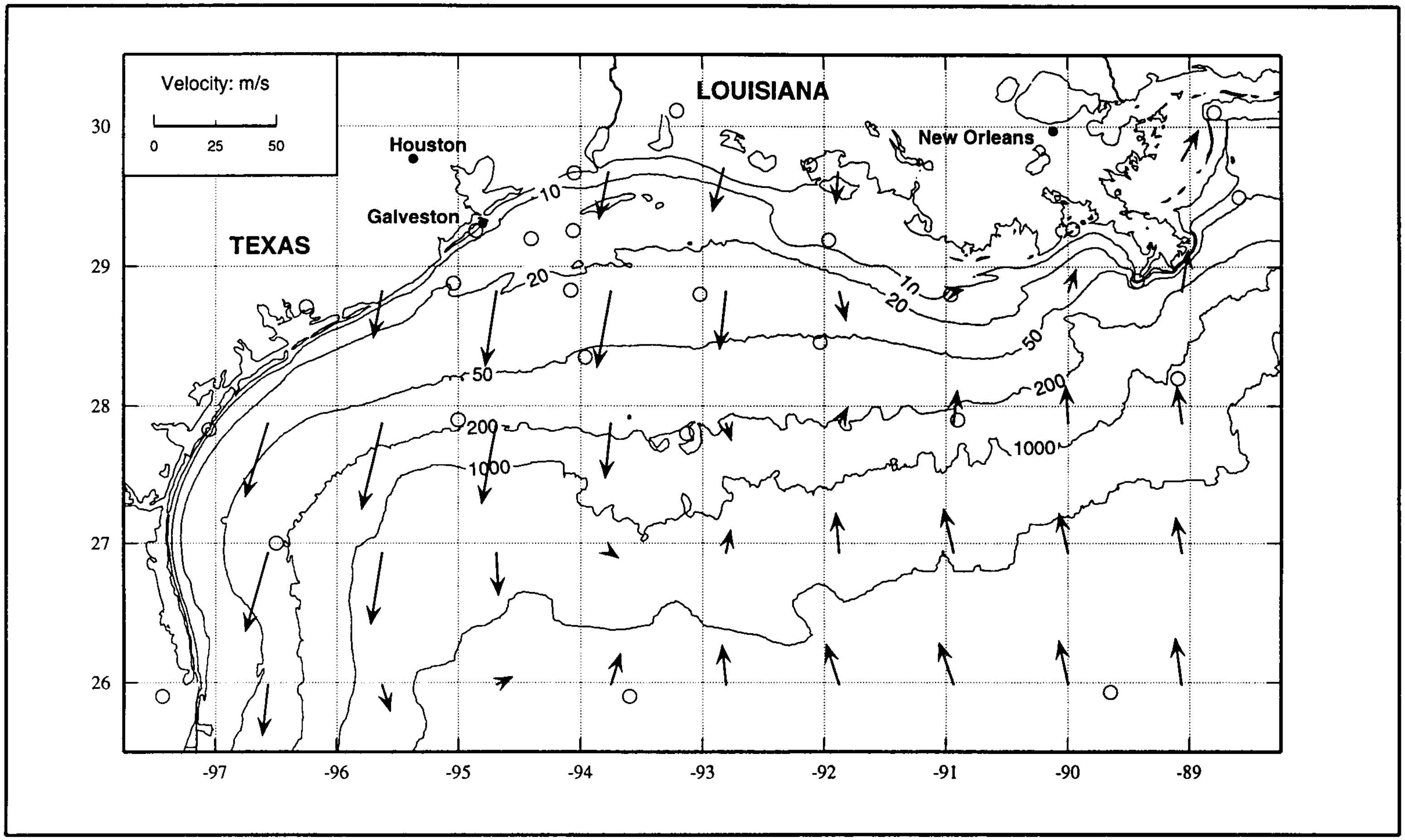


Figure 6.6.1. National Meteorological Center analyzed wind field at 0600 UTC on 4 November 1992.

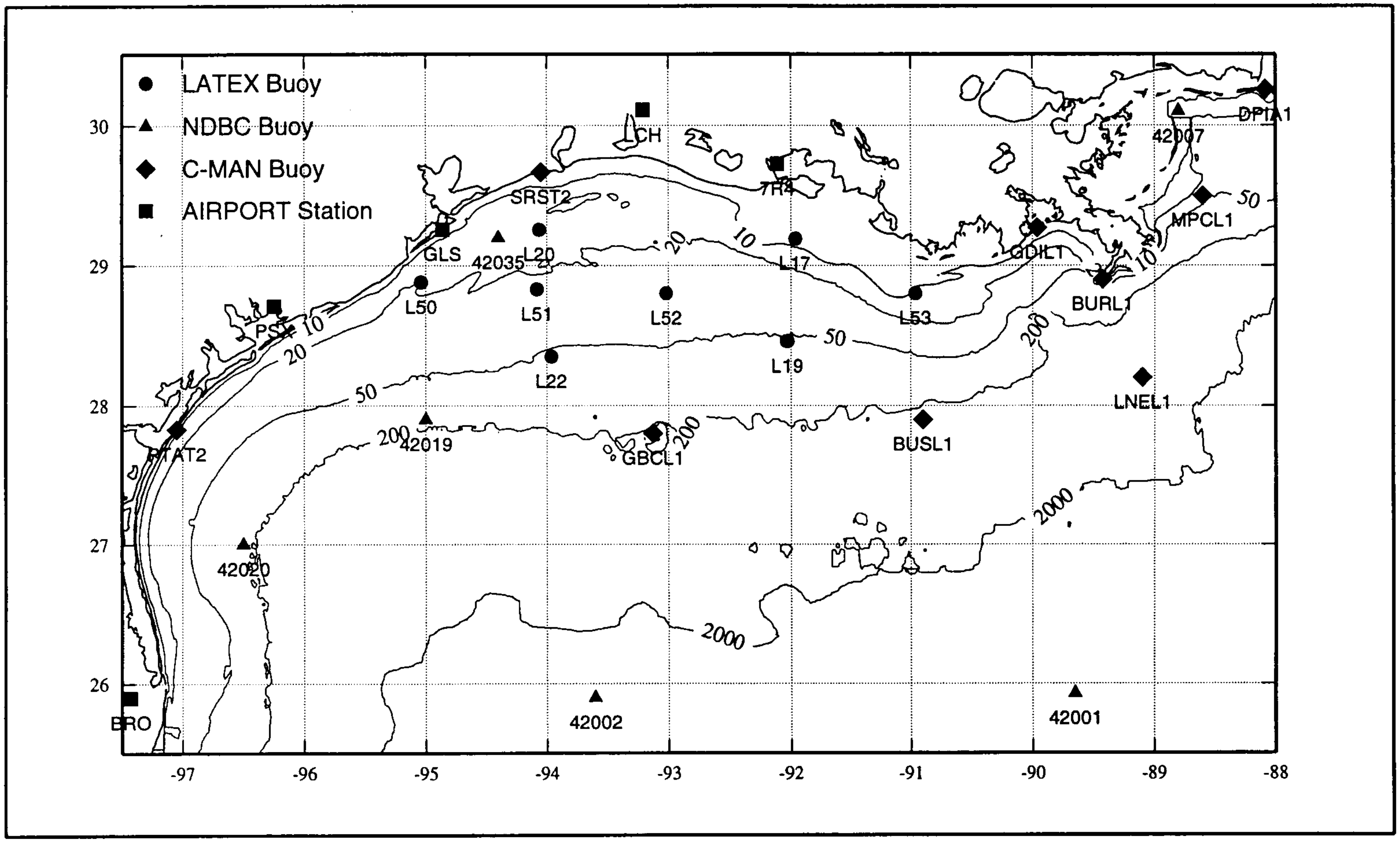


Figure 6.6.2. The distribution of observing stations used in analysis of surface meteorological variables.

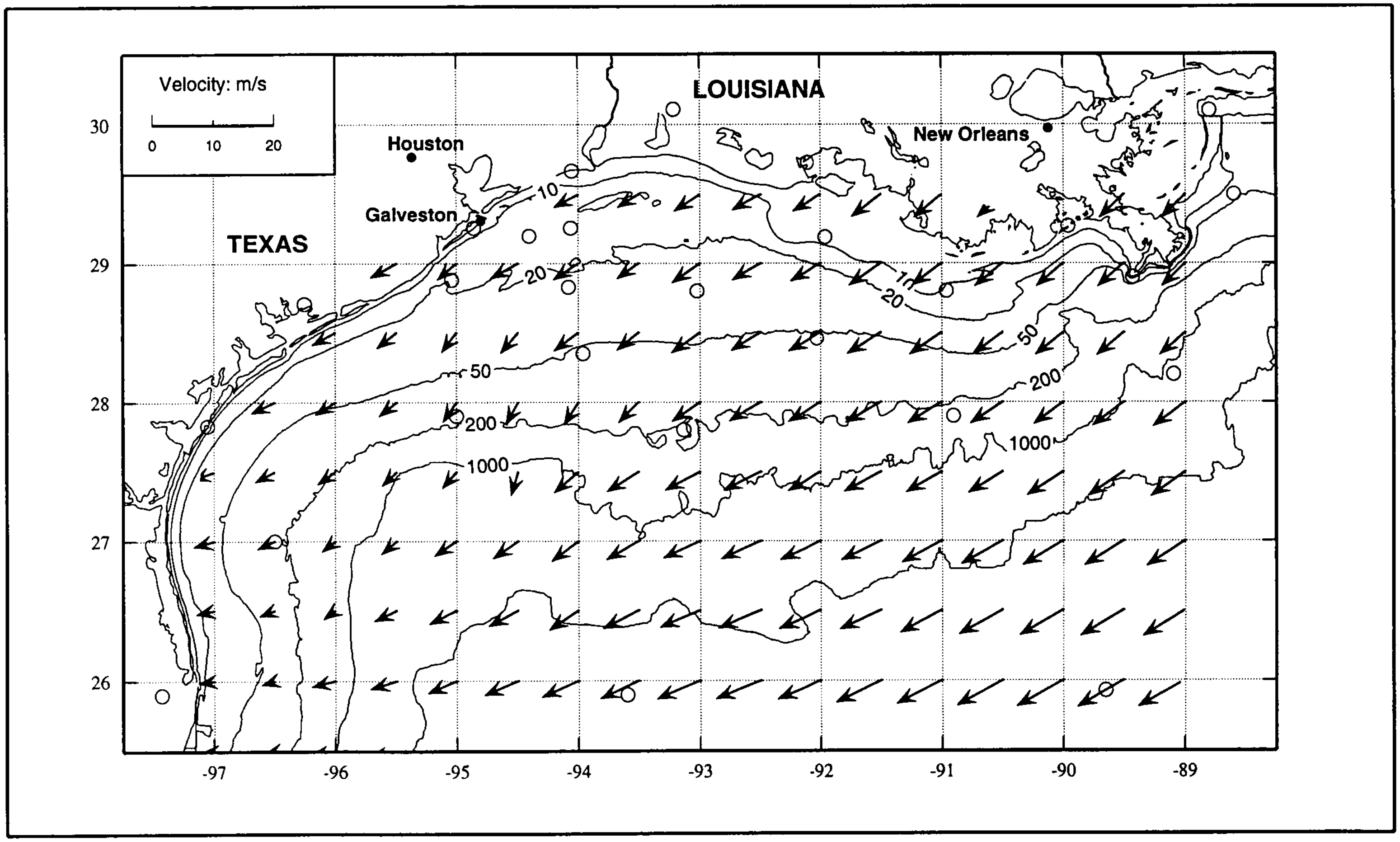


Figure 6.6.3. Mean 10-m wind field for November 1992.

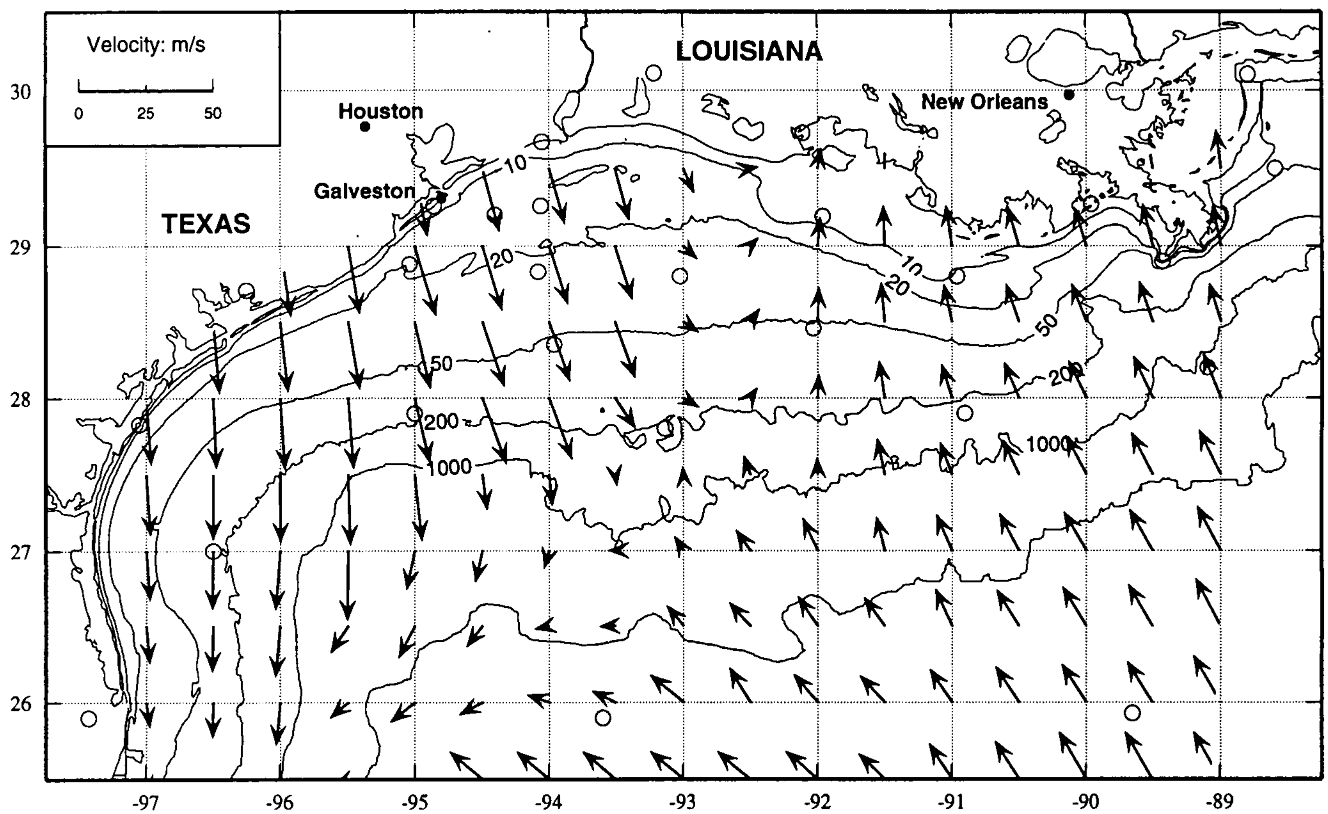


Figure 6.6.4. 10-m wind field at 0600 UTC on 4 November 1992.

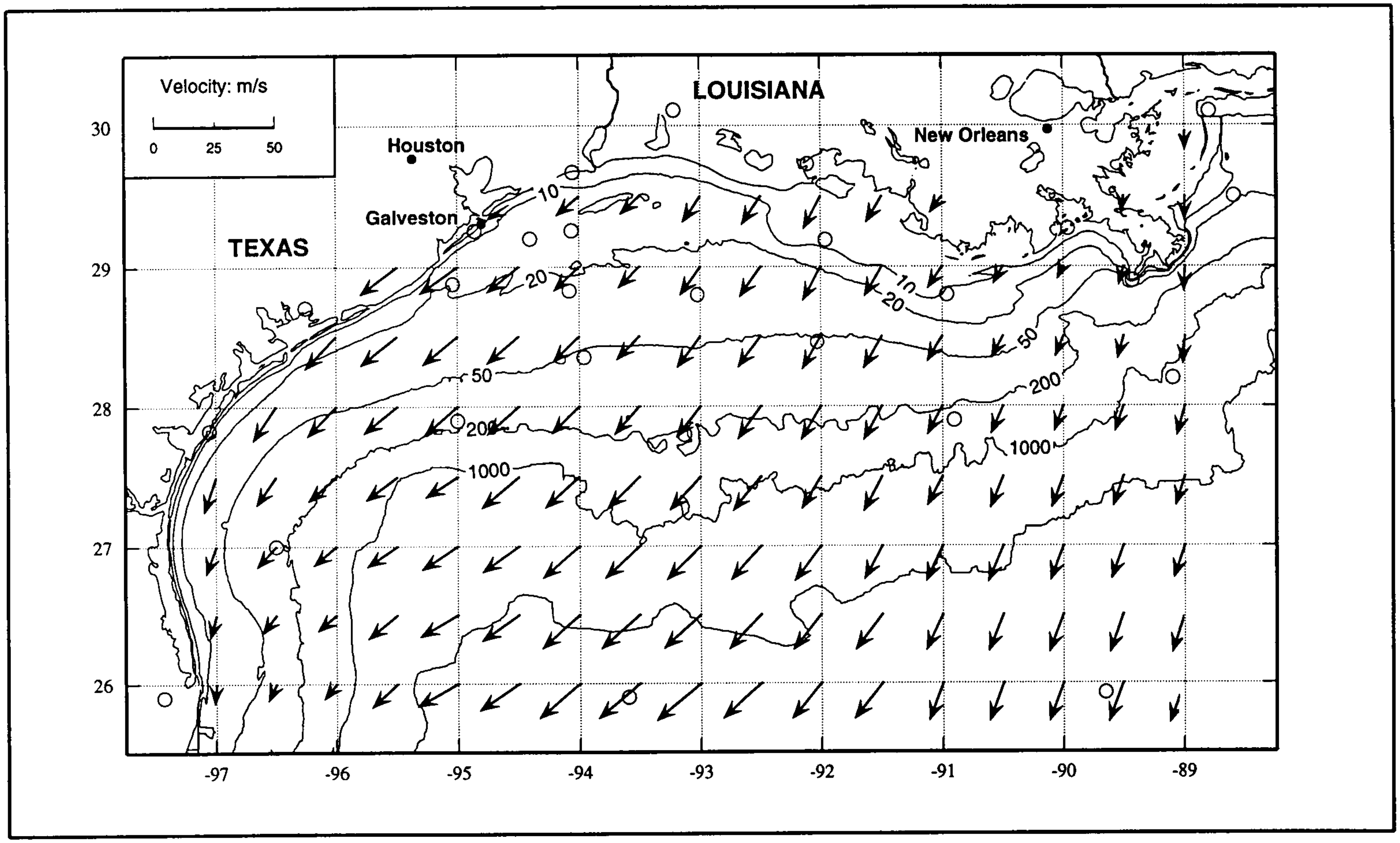


Figure 6.6.5. Wind field at 1700 UTC, 7 November 1992.

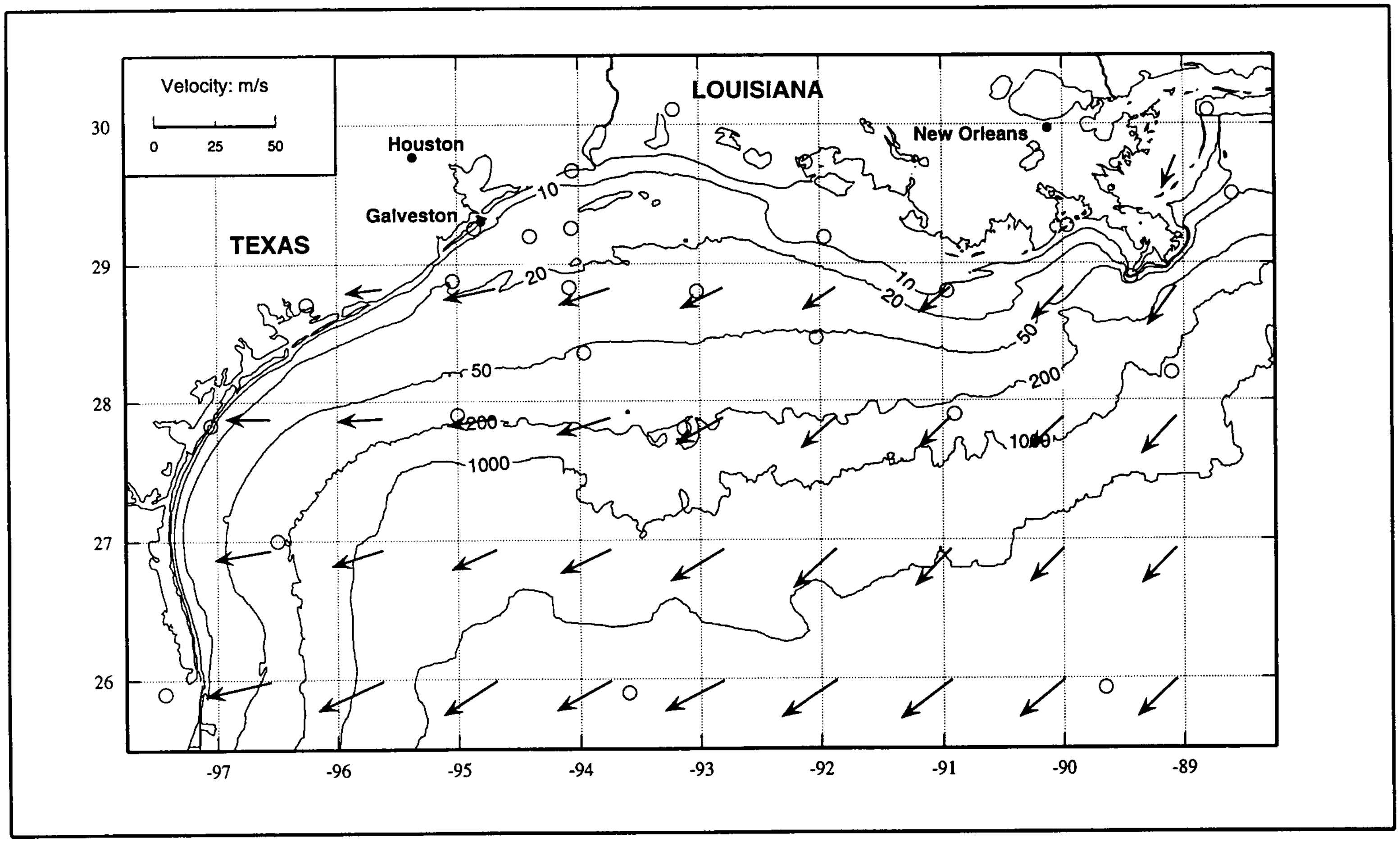


Figure 6.6.6. NMC analyzed wind field at 1700 UTC, 7 November 1992.

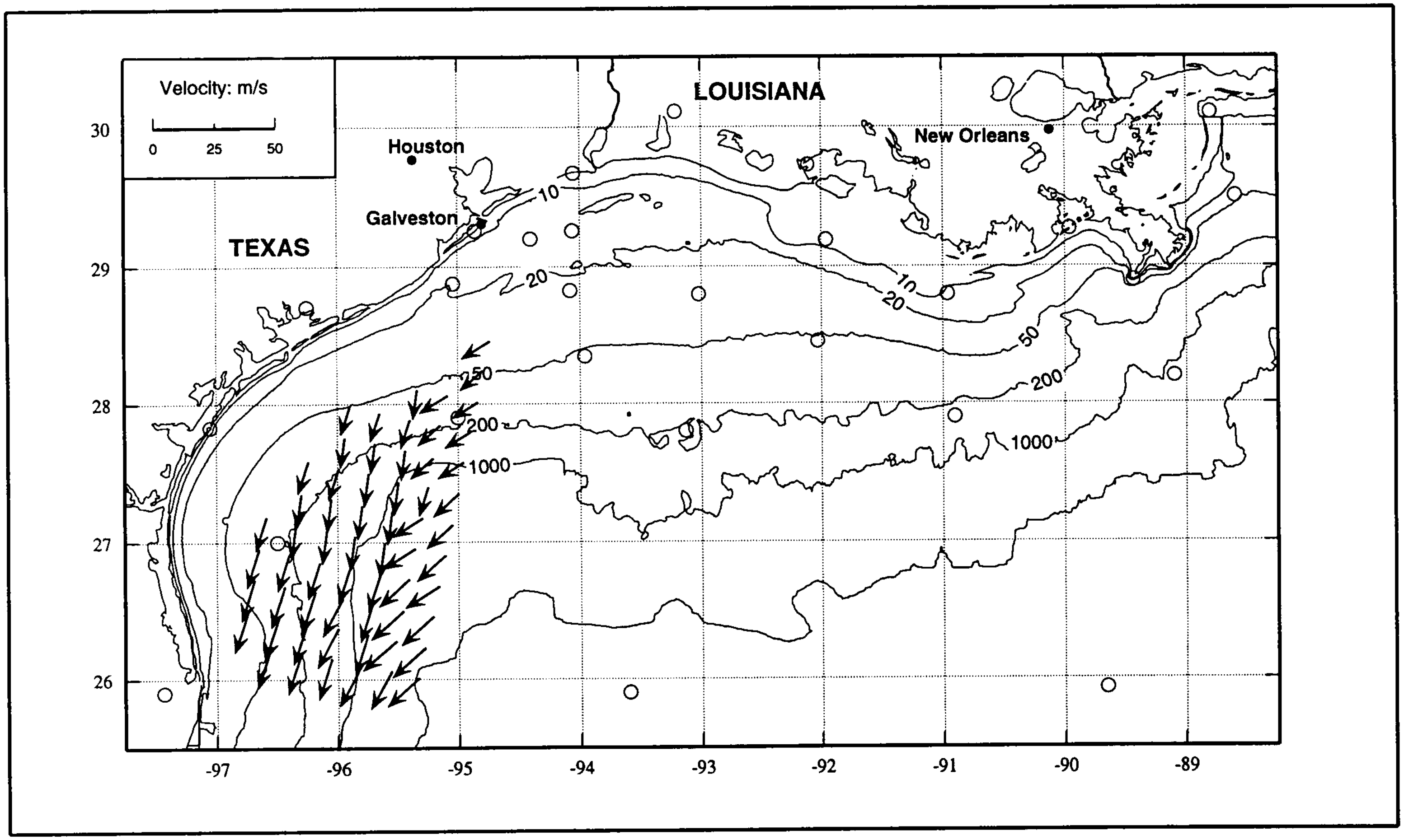


Figure 6.6.7. ERS-1 wind field at 1700 UTC, 7 November 1992.

6.7 Summary of Cyclogenesis Study

Cyclogenesis is defined as any development or strengthening of cyclonic circulation in the atmosphere. The term is applied here to the development of low-pressure systems over the northwestern Gulf of Mexico. Between 1972 and 1982 an average of 10.4 winter cyclones developed each year over the LATEX region. Of these, 5.5 cyclones per year developed central pressures at or below 1010 mb. The 1983 winter season (November to March, inclusive) was by far a more active cyclone season for the Gulf than during the preceding 11-year period. A total of 26 surface cyclones affected the region. Of these, 21 attained central pressures at or below 1010 mb; five of these cyclones were "meteorological bombs", i.e., the pressure drop exceeded 0.5 mb per hour, or 12 mb for a 24-hour period, at latitudes of approximately 28° N.

From November 1993 through May 1994, there were 13 winter cyclogeneses over the LATEX region (Table 6.7.1). The 1994 winter season (November to March, inclusive) had nine cyclogeneses, which was close to the average ten discussed above. Of these, five attained central pressures of or below 1010 mb or at least Class 2 in Hsu's classification (1993), and two were "meteorological bombs" (13 December 1993 and 27 March 1994).

At LATEX mooring/buoy station 22 (Figure 6.7.1) between 22Z (UTC) on 12 December and 06Z on 13 December 1993, the atmospheric pressure dropped from 1012.8 mb to 1003.95 mb, an 8.8 mb decrease in eight hours (Figure 6.7.2), indicating the development of a meteorological bomb during this period. This characteristic was widespread over the LATEX region, as shown for NDBC buoys 42002, 42019, 42020, and 42035, as well as C-MAN station PTAT2. The wind speed increased from around 5 ms^{-1} in the morning hours of 12 December to over 14 ms^{-1} twenty-four hours later (Figure 6.7.3). Note that the precipitous decrease in wind speed around 12Z on 13 December at both PTAT2 and NDBC buoy 42020 occurred about six hours later than the pressure minimum, indicating that the center of this cyclogenesis was located in the south LATEX region between PTAT2 and buoy 42020.

The development of significant wave height (H_s), at buoys 42002, 42020, and 42035 are shown in Figure 6.7.4. At buoy 42020, H_s increased approximately 3 m within 24 hours. Because cyclogenesis was initiated in the vicinity of that buoy, H_s increased more rapidly there than at 42002 and 42035.

Wave steepness is defined as the ratio of wave height to wave length. From linear wave theory, the steepness is $H_s/gT_p^2 = k$, where H_s is the significant wave height, g is gravity, T_p the dominant wave period, and k is assumed to be a constant for a given wave condition (e.g., Gilhousen 1993). Buckley (1988) reviewed the entire archive of the NDBC for all stations and Canadian oil rig observations and obtained an extreme steepness value of k = 0.00776. Gilhousen (1993), using NDBC buoys 42019 and 42020, plotted a chart with the vertical axis as H_s in meters and the horizontal axis as T_p in seconds for the "Storm of the Century" on 12 March 1993 over the LATEX region. His results show that some measurements were located to the left of Buckley's Extreme Steepness Curve, indicating phenomenal wave growth and confirming the presence of strong winds and a rapidly deepening storm. According to Gilhousen (1993), these steep waves also portend the type of widespread maritime calamity that followed, where the U.S. Coast Guard conducted 111 search and rescue efforts from Texas to Appalachee Bay related to these storm effects.

Figure 6.7.5 provides added evidence to show that winter cyclogenesis over the LATEX region can produce a wave steepness that exceeds the statistical extreme steepness value obtained by Buckley (1988). Because the storm on 13 December 1993 was only moderate, it is very surprising to see that so many measurements exceeded the Buckley limit. We checked the data at NDBC 42035 and found no case in which the waves were under either shoaling or fully-developed conditions, indicating more steep waves existed in the shallower water (≈ 20 m) for 42035 than at the deeper water (≈ 200 m) along the shelf break at 42020. More studies on this subject and its effect on the drag coefficient formulation for shallower waters induced by winter cyclogenesis are recommended.

The wind stress or the flux of momentum at the sea surface affects nearly all aspects of air-sea interactions, including the growth of surface gravity waves, the generation of surface currents, and the development of the mixed layer. Wind stress, τ, is often estimated by $\tau = \rho C_d U_{10}^2$, where ρ is the air density, C_d the drag coefficient, and U_{10} the wind speed at 10 m above the mean sea surface. Since τ is directly proportional to C_d, it is crucial to get as accurate a formulation as possible.

Because published equations of C_d varied greatly in the literature, a proper C_d formulation for the LATEX region was needed. Since C_d is related to the aerodynamic roughness length, Z_0, which in turn is related to the wind waves, any C_d formulation must include the wave parameters (Hsu 1994a). Most recently, Donelan et al. (1993) proposed a formulation in which Z_0 is directly proportional to the significant wave height and inversely proportional to the 2.6 power of the wave age. Therefore, C_d can be estimated from both wind and wave data. During an extreme winter cyclogenesis period in March 1993 (the "Storm of the Century"), simultaneous measurements of wind and waves were made in the LATEX region. The results are shown in Figures 6.7.6 and 6.7.7. While the variation of C_d with U_{10} along the shelf break was published in Hsu (1994b) as shown in Figure 6.7.6, its variation over the deep Gulf is shown in Figure 6.7.7. Figure 6.7.8 shows the comparisons of both equations of C_d over the northwest Gulf of Mexico and other areas. It can be seen that over the LATEX region, the closest popular formulation is that of Wu (1982), whereas usage of both open ocean (e.g., Large and Pond 1981) and lake environment (Donelan 1982) formulations can lead to large errors.

Table 6.7.1. Winter cyclogenesis over the northwestern Gulf of Mexico from November 1993 through May 1994.

Year	Month	Day	Intensity*
1993	November	9	1
	December	13	3
	December	19	1
	December	22	2
1994	January	11	1
	February	5	1
	February	10	2
	March	1	2
	March	27	4
	April	19	1
	April	22	2
	May	2	1
	May	14	2

* The intensity classification is based on Hsu (1993). The data source is "Daily Weather Maps", published weekly by NOAA.

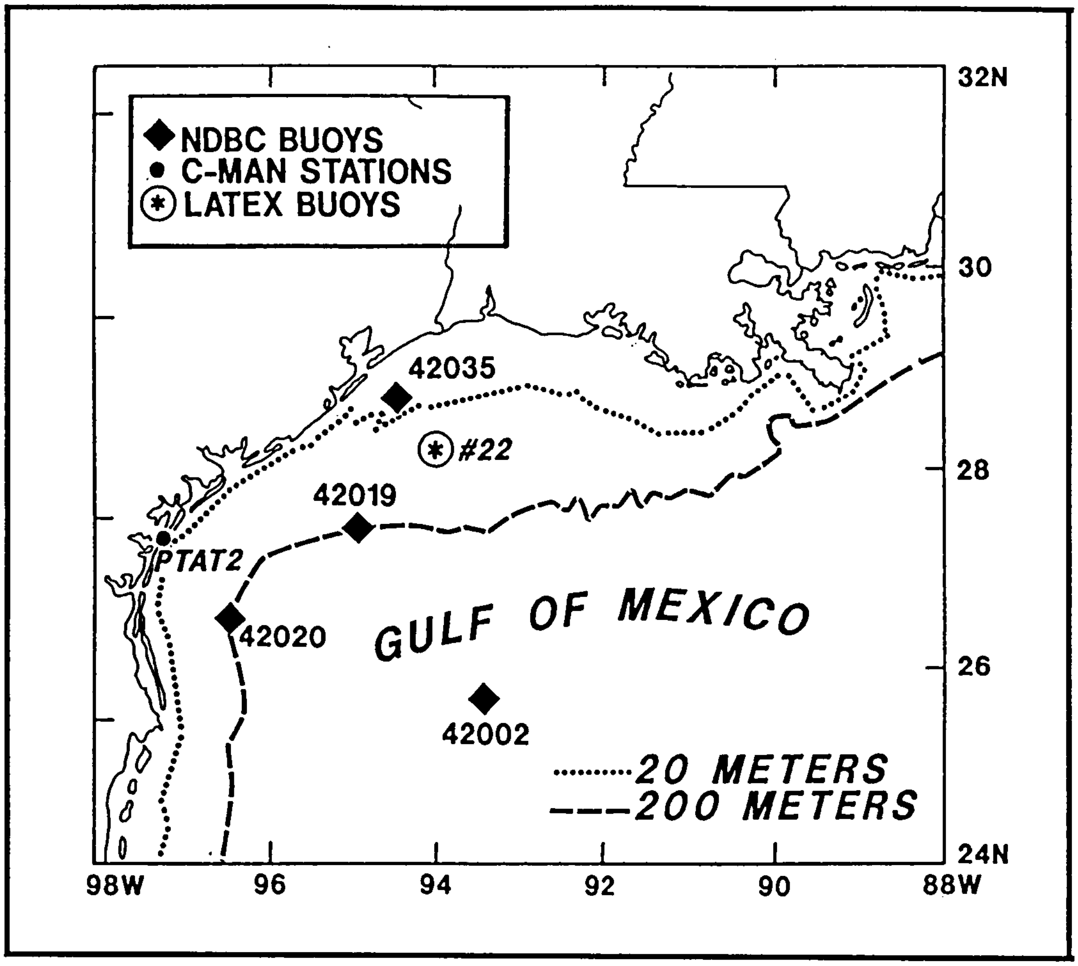


Figure 6.7.1. Locations for the winter cyclogenesis case study, 12-14 December 1993.

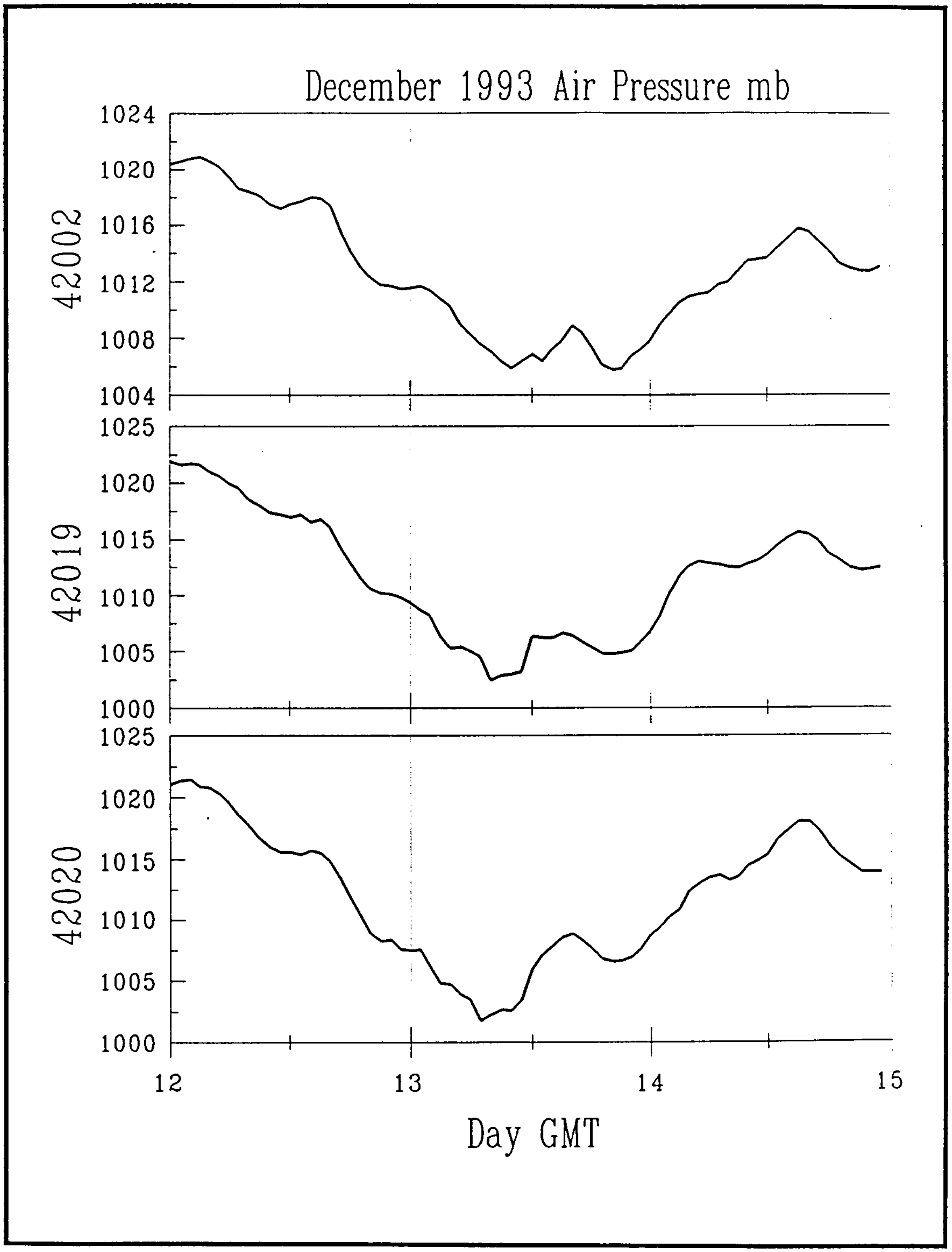


Figure 6.7.2. Characteristics of atmospheric pressure over the LATEX region during the winter cyclogenesis case of 12-14 December 1993.

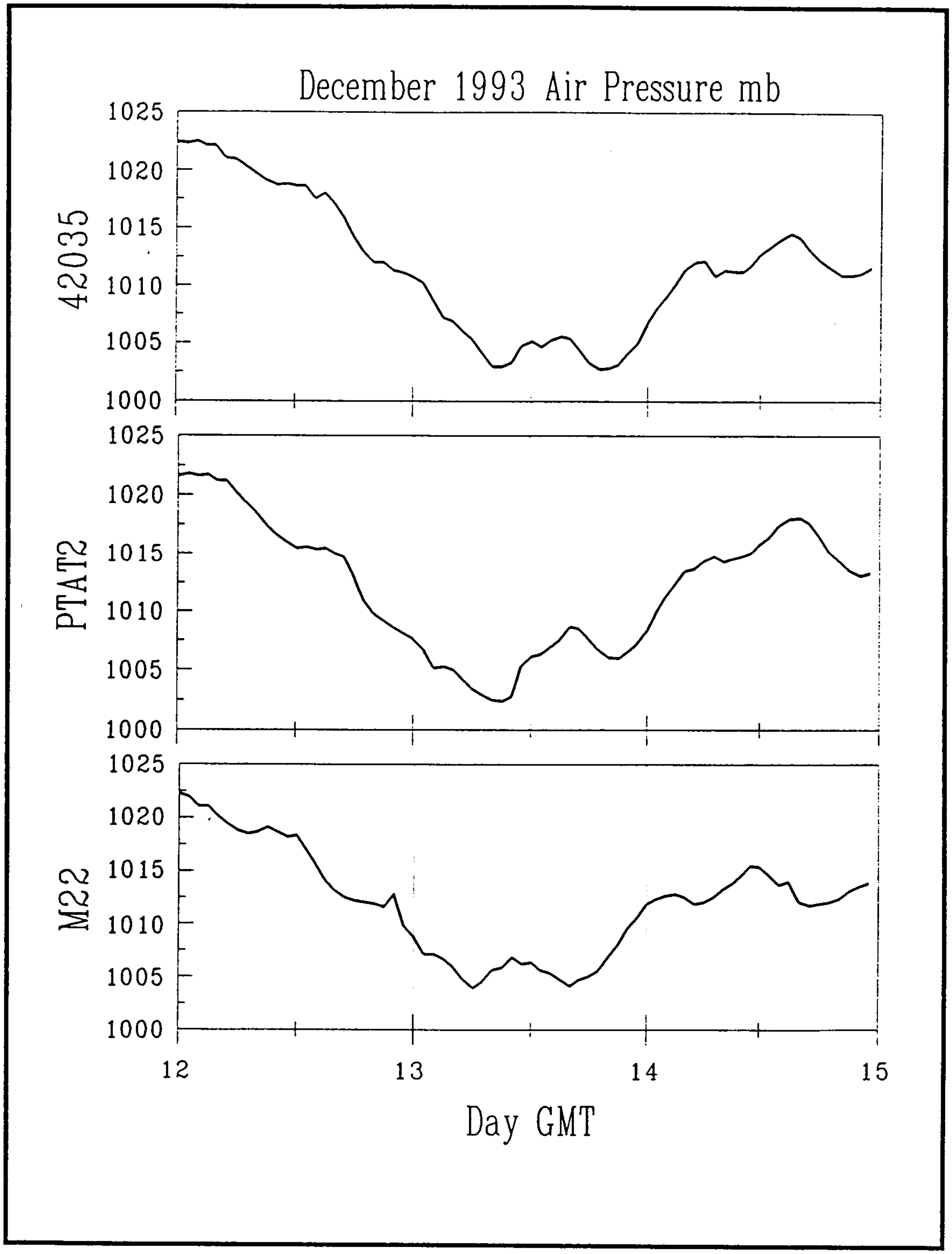


Figure 6.7.2. Characteristics of atmospheric pressure over the LATEX region during the winter cyclogenesis case of 12-14 December 1993 (continued).

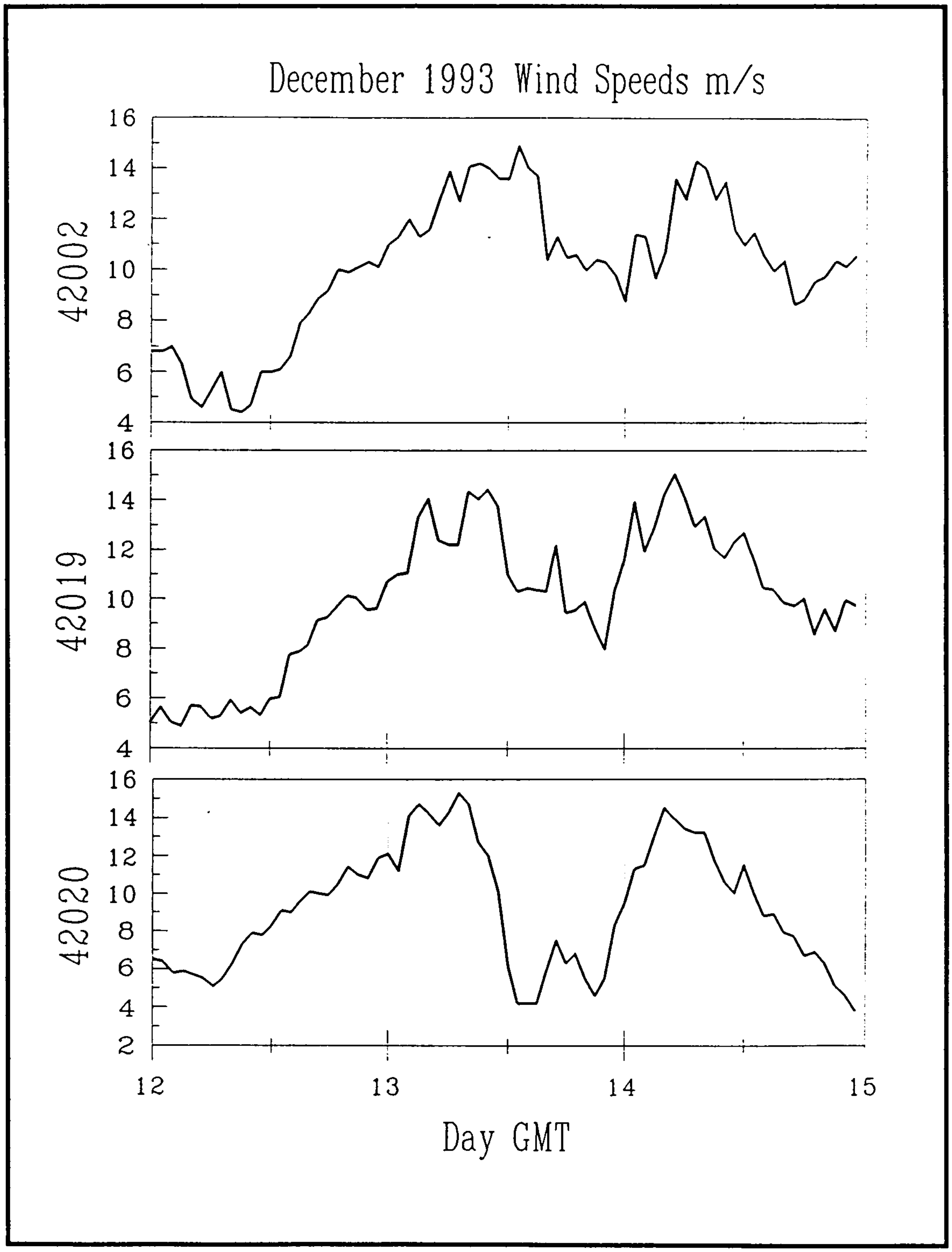


Figure 6.7.3. Characteristics of wind speeds over the LATEX region during the winter cyclogenesis case of 12-14 December 1993.

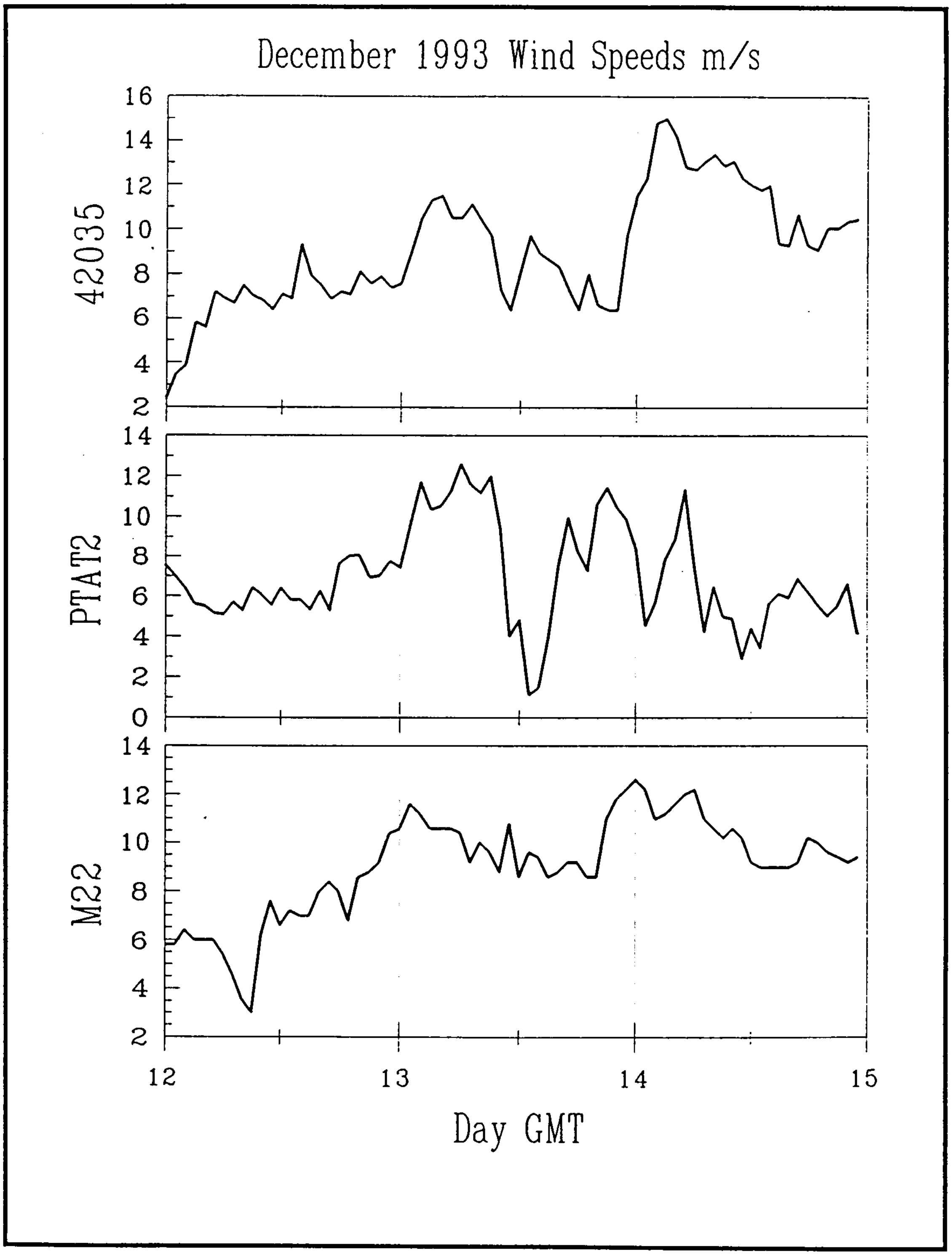


Figure 6.7.3. Characteristics of wind speeds over the LATEX region during the winter cyclogenesis case of 12-14 December 1993 (continued).

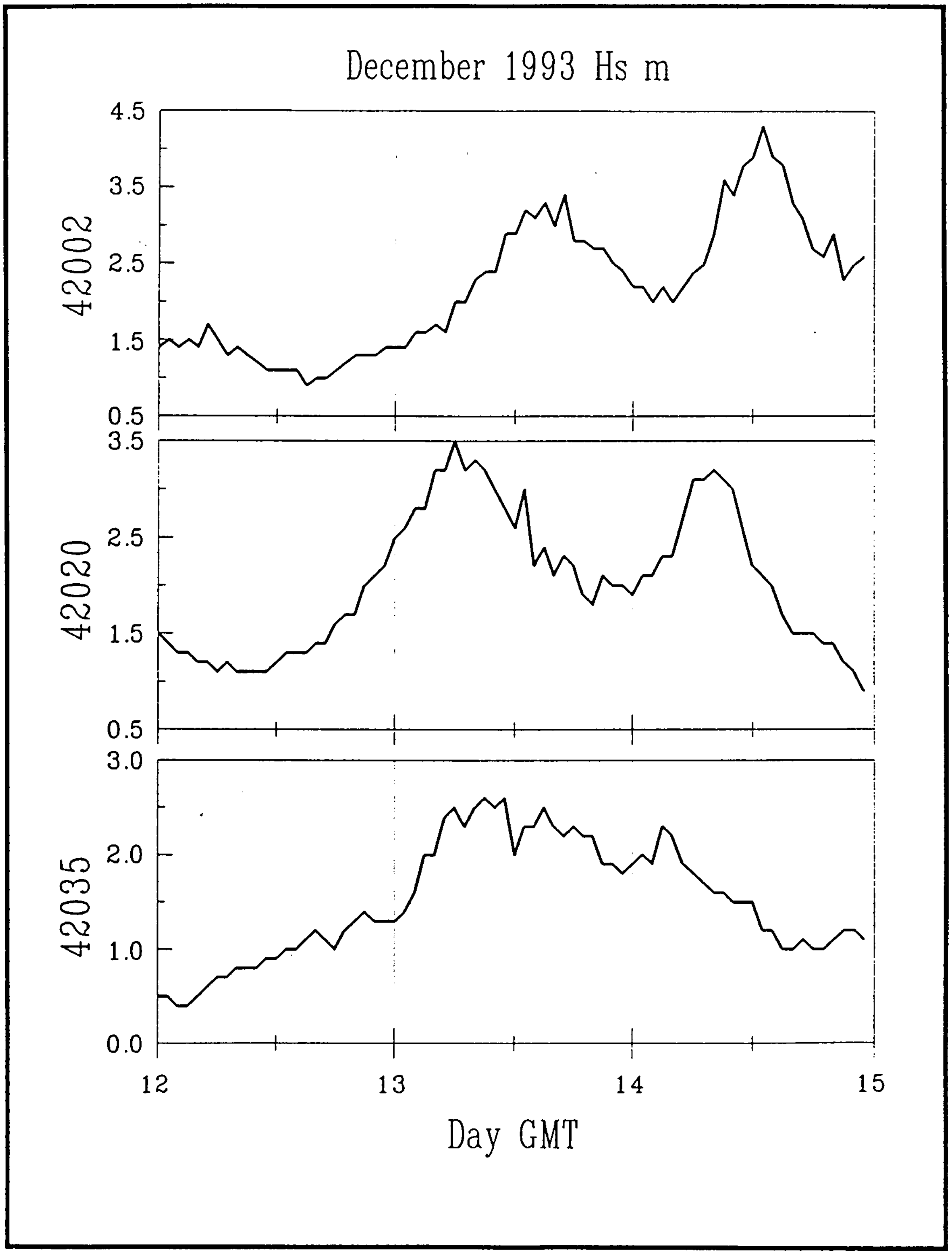


Figure 6.7.4. Characteristics of H_s over the LATEX region during the winter cyclogenesis case of 12-14 December 1993.

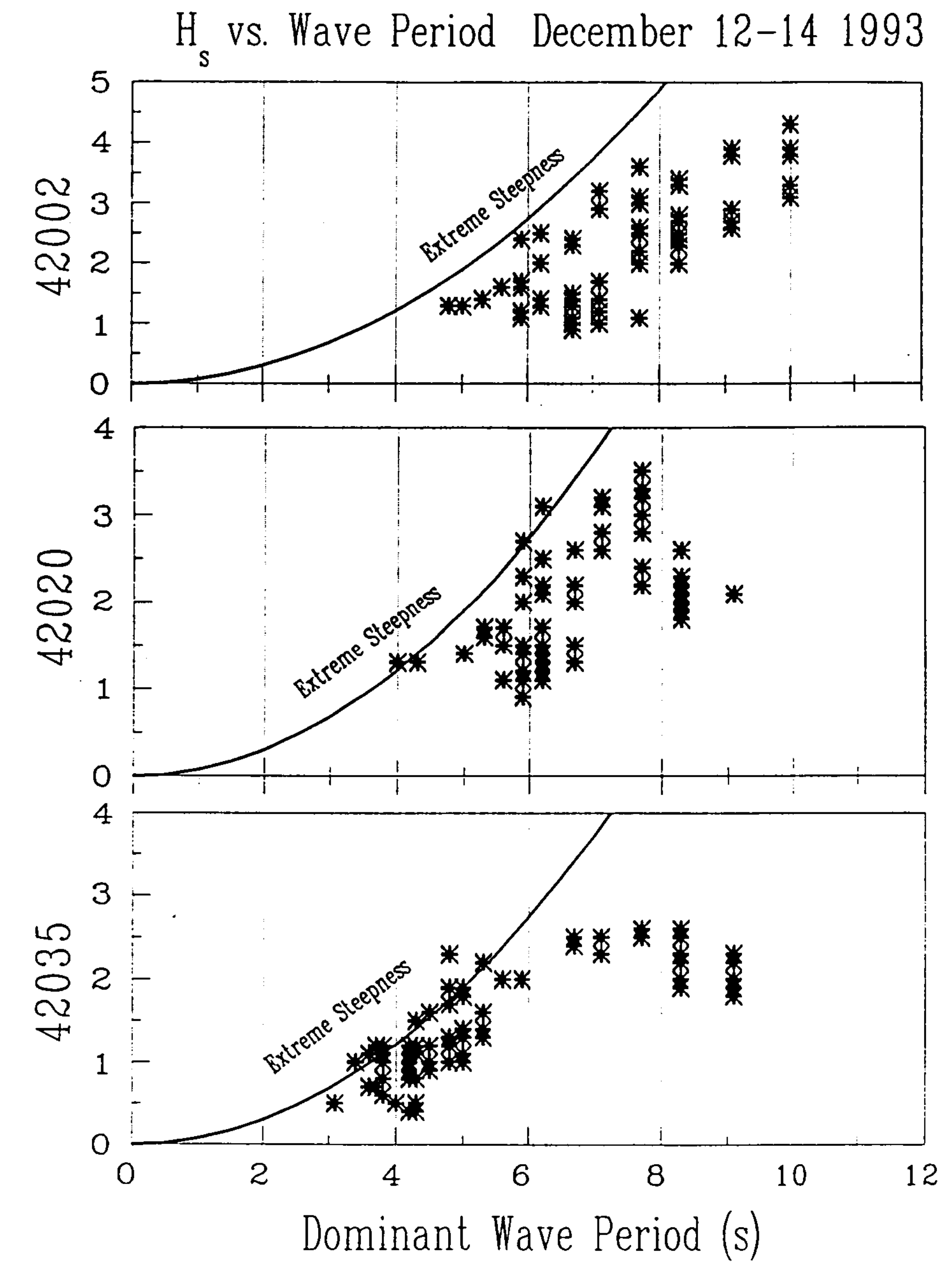


Figure 6.7.5. Measurements of H_s and T_p from NDBC buoys #42002, #42020, and #42035 during the cyclogenesis period 12-14 December 1993.

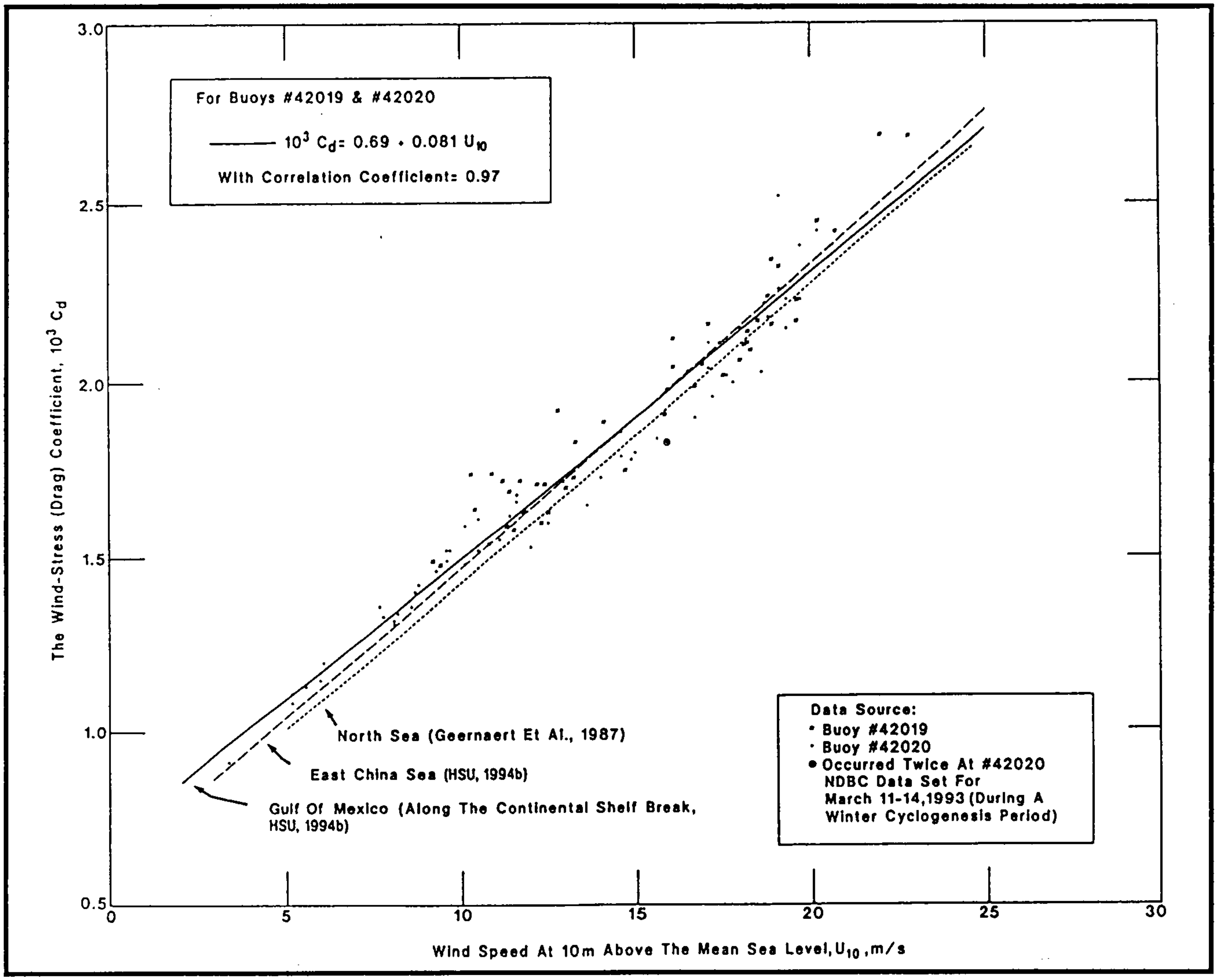


Figure 6.7.6. A relationship between C_d and U_{10} based on the wind-wave interaction method for the LATEX region and its comparison to the North Sea and East China Sea.

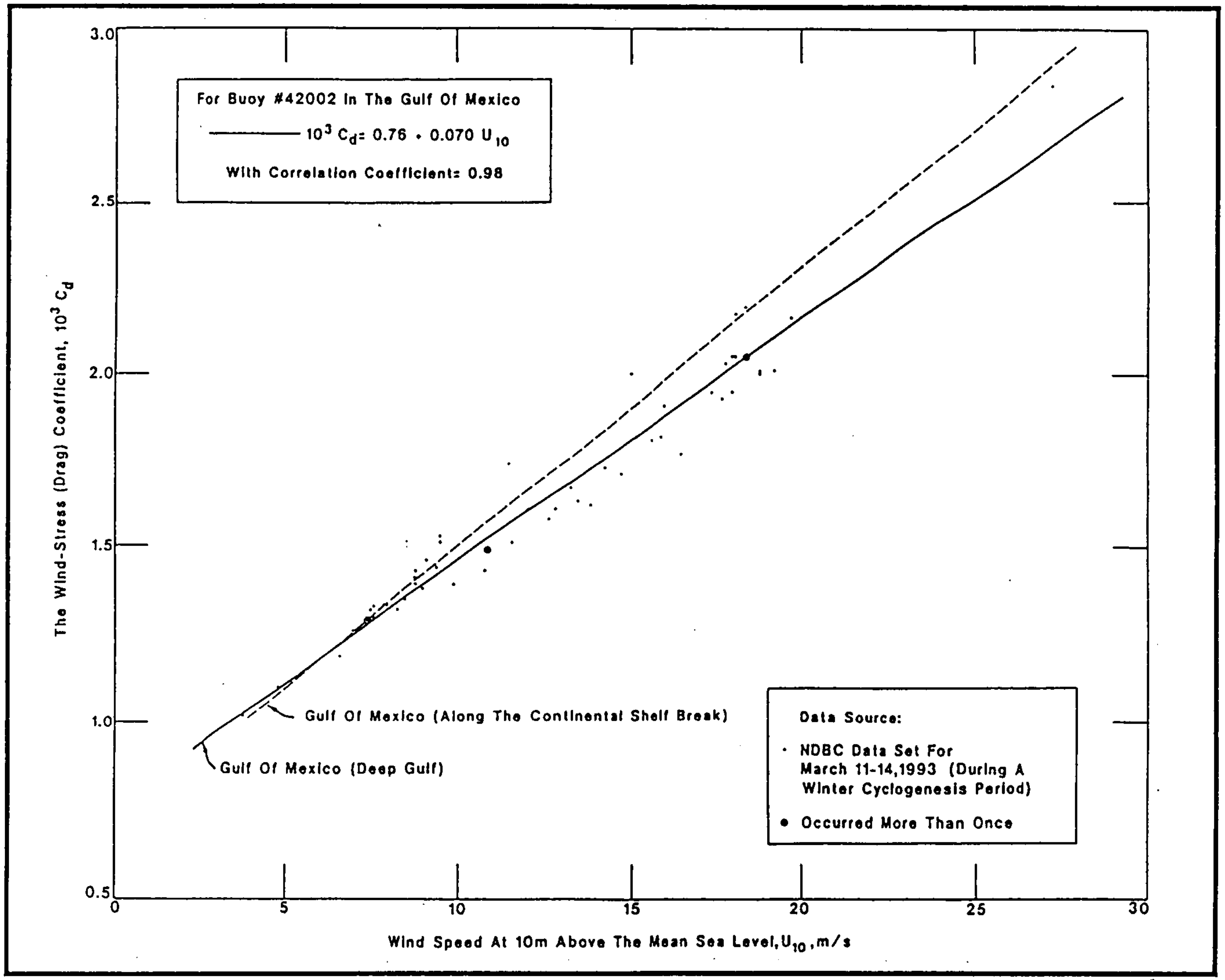


Figure 6.7.7. A relationship between C_d and U_{10} based on the wind-wave interaction method for the LATEX region.

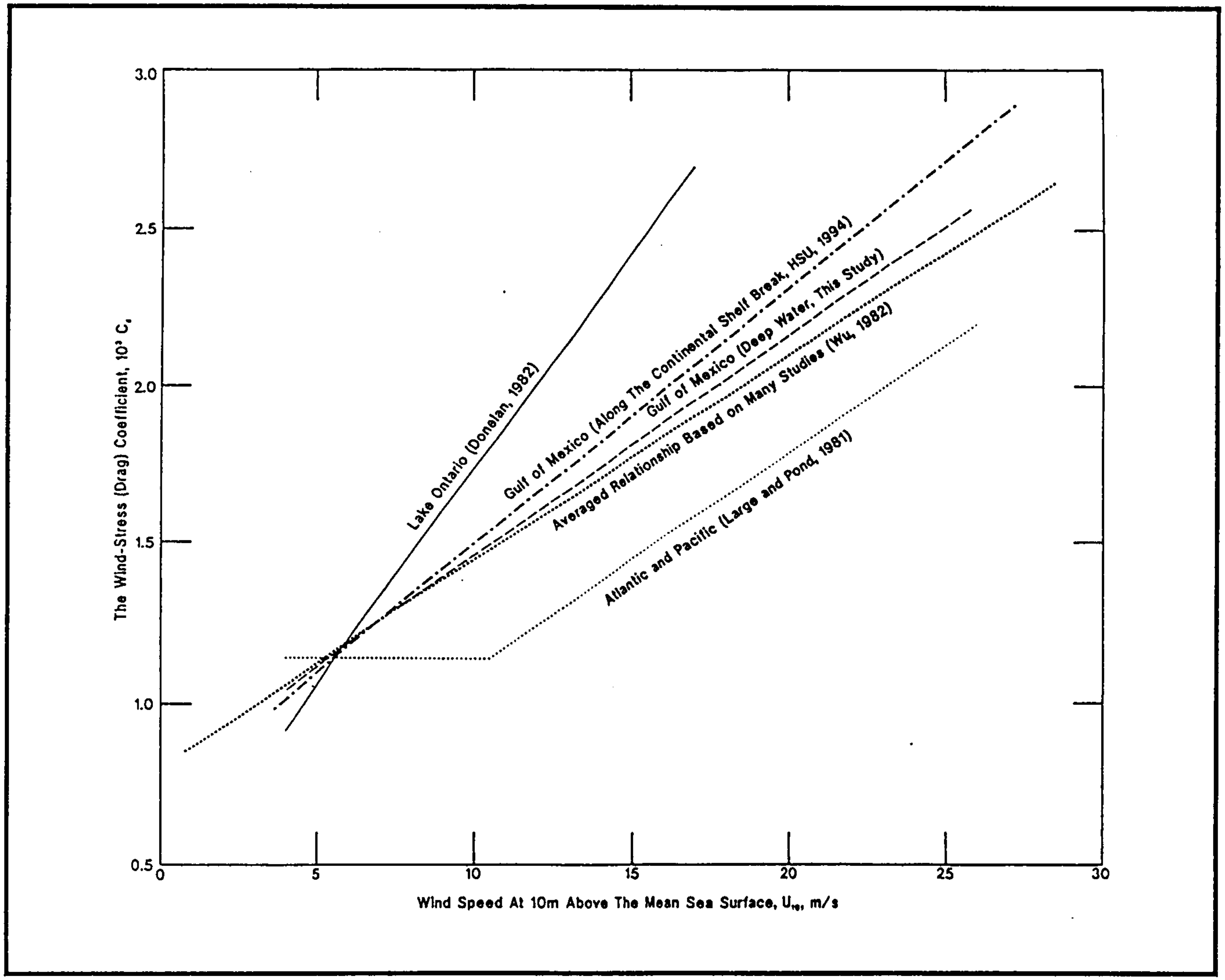


Figure 6.7.8. A comparison of C_d formulations over the LATEX region and others published in the literature.

6.8 Summary of LATEX Wave Observations during Hurricane Andrew

On 24 August 1992, the LATEX program had four bottom-mounted wave gauges in the northwestern Gulf of Mexico as Hurricane Andrew moved westward across the southern tip of Florida (Figure 6.8.1). As the storm entered open water in the eastern Gulf, this relatively small but intense Category 4 hurricane followed a northwesterly arc and made landfall on the south-central Louisiana coast near Cypremort Point, LA, on 26 August 1992. The easternmost wave gauge was located at mooring 16, within 30 km of Andrew's eye as the hurricane crossed the eastern edge of the Texas-Louisiana Shelf.

The wave gauges deployed during the hurricane's passing were three Coastal Leasing, Inc. (CLI) MiniSpec directional wave gauges at moorings 16, 20, and 23, and one SeaData 635-8 non-directional wave gauge at mooring 1. All four gauges were mounted approximately one meter above the bottom and recorded hydrostatic pressure; the MiniSpecs also recorded current velocity and temperature.

As Andrew traveled westward across the west Florida shelf into the deeper eastern Gulf, the hurricane quickly generated fast-moving long period waves that propagated westward and reached the Texas-Louisiana Shelf (DiMarco et al. 1995). Long period waves, i.e., waves of period 10 seconds and greater, are rare in the Gulf of Mexico for all but the most extreme weather events. Such long period waves are of particular interest because larger orbital velocity added to mean flow can resuspend sediments at much greater depths than under normal conditions. Arriving several hours before the storm's eye, the long period waves first reached the easternmost mooring 16. Although considerable distances from the storm center, the wave gauges at the more western locations also recorded longer period waves.

The significant wave heights (H_s) at each LATEX mooring during the 48-hour period, centered on the time of highest waves at mooring 16, are shown in Figure 6.8.2. The most striking feature is the peak height of 9.09 m at mooring 16 at approximately the time the eye was closest to this location. The maximum wave heights observed at moorings 20, 23, and 1 occurred when long period waves represented a large percentage of spectral energy, i.e., at 2:00Z, 3:00Z, and 9:00Z on 26 August, respectively. The waves traversed broad shelf regions before arriving at moorings 23 and 20. Wave heights were lower at these locations than at mooring 1 even though the distances traveled were shorter. The phasing of the H_s peaks at each mooring indicates that the long period swell generated by the hurricane propagated westward in agreement with linear wave theory. Further, by knowing the arrival times at each location of the long period waves and the wave celerity, one can extrapolate back to the location at which they were generated. This analysis obtained a generation zone in the southeastern Gulf of Mexico that extended from 26.2° N, 85.0° W to a point on the edge of the west Florida shelf around 25.8° N, 83.1° W. If waves had been generated at locations east or west of this range, they could not have arrived at the LATEX wave gauges at the observed times.

The frequency of the peak spectral value for each wave burst is shown as a function of time in Figure 6.8.3. Early in the 24-hour period preceding Andrew, the spectra at moorings 20, 23, and 1 were generally dominated by locally generated high-frequency waves. Peak frequency dropped abruptly as the swell created by Andrew reached each mooring. The dramatic shift to low frequency was accompanied by a rise in the wave height at each mooring (Figure 6.8.2). After the shift, peak frequency increased gradually with time because of the frequency dependent celerity of the waves. In a few cases, the wave spectra became multi-modal and showed peaks at both high and low frequencies.

In constructing the curves of Figure 6.8.3 for the case of a multi-modal spectra, we chose the peak whose frequency corresponded to swell and had a period greater than eight seconds, thus focusing on energy derived from the distant storm. The phasing of the arrival times of the long period waves is evident in this figure, with the waves arriving earlier at the eastern moorings.

The spectral contour plot in Figure 6.8.4 shows that when Andrew made its closest approach to mooring 16 the spectrum was multi-modal and exhibited significant energy density at higher frequencies (>0.15 Hz). This figure also shows the evolution of the correlation between significant wave height and the spectral distribution of wave energy. At mooring 16, long period waves outran the storm center by several hours. The storm advanced at a speed of 14 km per hour while in the deep eastern Gulf (Stone et al. 1993). Low frequency waves continued to contribute to the energy spectra after the eye passed (after 6:00Z on 26 August). During the eight-hour period when the storm center was closest to mooring 16 (20:00Z on 25 August to 4:00Z on 26 August), the spectra had considerable energy in the high frequency range (0.15-0.22 Hz). For example, at 1:00Z on 26 August, the spectrum consisted of locally generated wind waves and swell generated by the storm in the deeper Gulf. The spectra at mooring 16 were fundamentally different than the spectra recorded at the three other moorings, where the wave energy due to the hurricane was present only as swell.

Because of its bi-modal structure, the spectra recorded at mooring 16 deserves special attention. This structure differs from many observations in deeper water of hurricane spectra that are characterized by a modified JONSWAP type distribution having a single low-frequency peak (Ochi 1994). Two major factors probably contributed to the significant energy involved in the frequency range (>0.15 Hz) of the spectrum of mooring 16 when Andrew approached. The wave spectrum essentially represents a resultant wave field of a steep and narrow-banded long period wave train propagating to mooring 16 from earlier Andrew wave generation, superposed by a locally generated long period wave field when Andrew passed nearby mooring 16. In addition, a significant portion of wave energy in the higher frequency range (0.14-0.17 Hz) results from second-order sum-frequency nonlinear effects of the steep long wave train (Longuet-Higgins and Stewart 1960; Zhang et al. 1992). The nonlinear effects became more significant in this shallow (20 m) area because of the large spectral peak at low frequency and because the significant wave height approached half the water depth. A specific study to quantify the nonlinear wave effects in the high frequency range of the Hurricane Andrew data is underway.

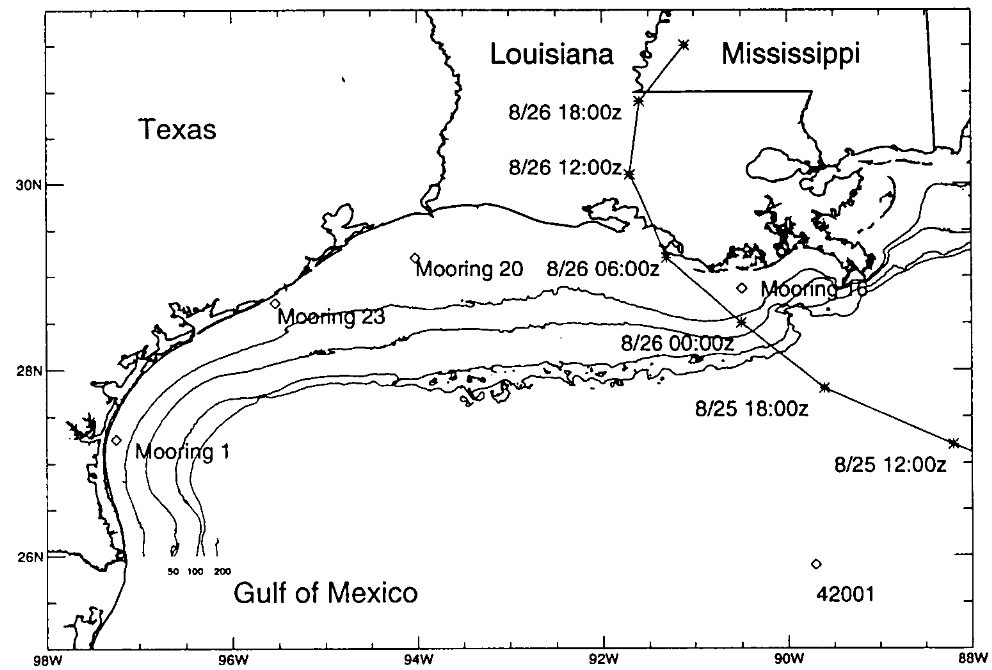


Figure 6.8.1. Map of the northwestern Gulf showing 50-, 100-, and 200-m isobaths, Hurricane Andrew storm track, and LATEX wave gauge and NDBC buoy locations.

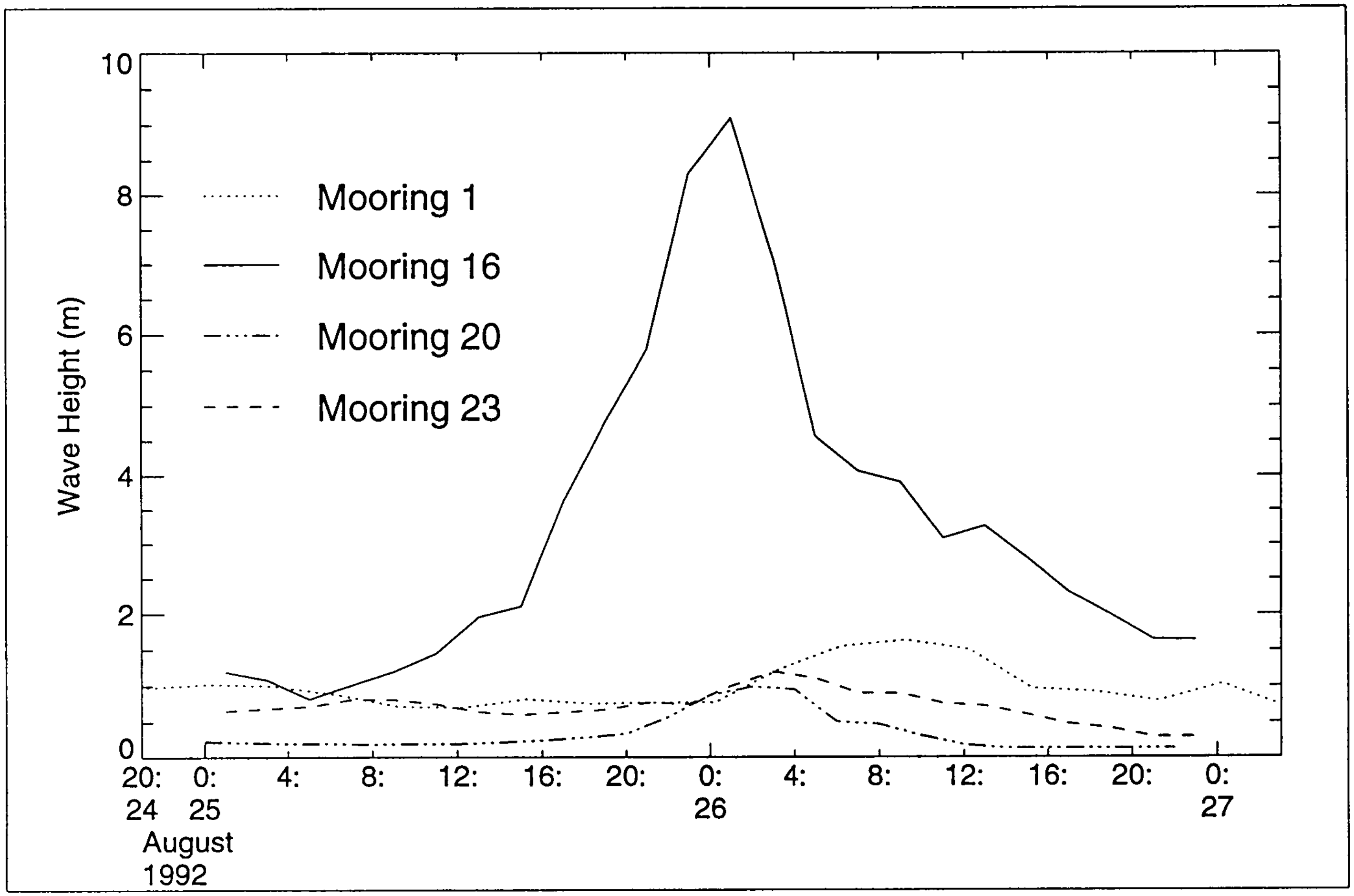


Figure 6.8.2. H_s measured at LATEX moorings 1, 16, 20, and 23 during Hurricane Andrew.

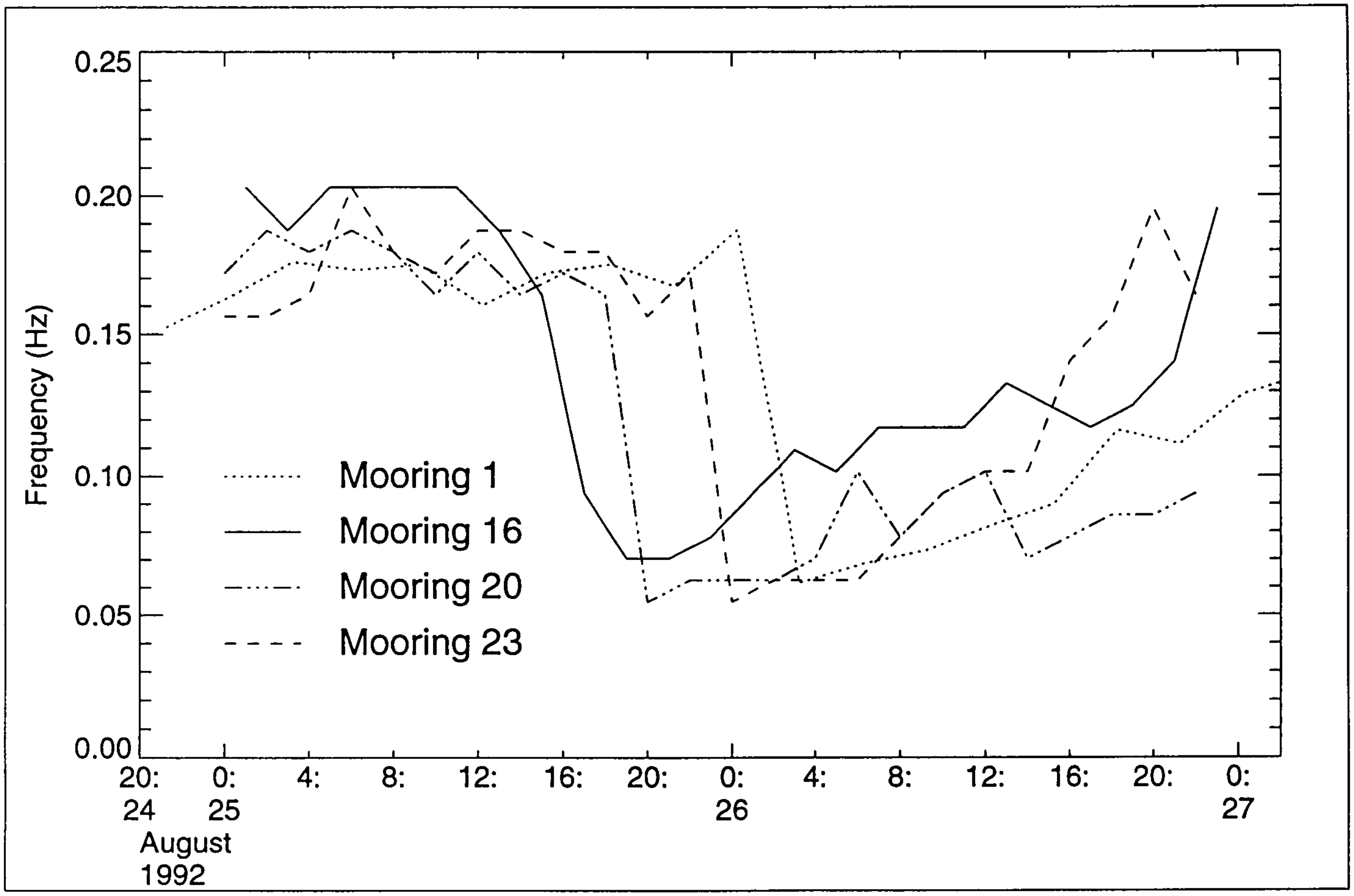


Figure 6.8.3. Spectral peak periods at LATEX moorings 1, 16, 20, and 23 during Hurricane Andrew.

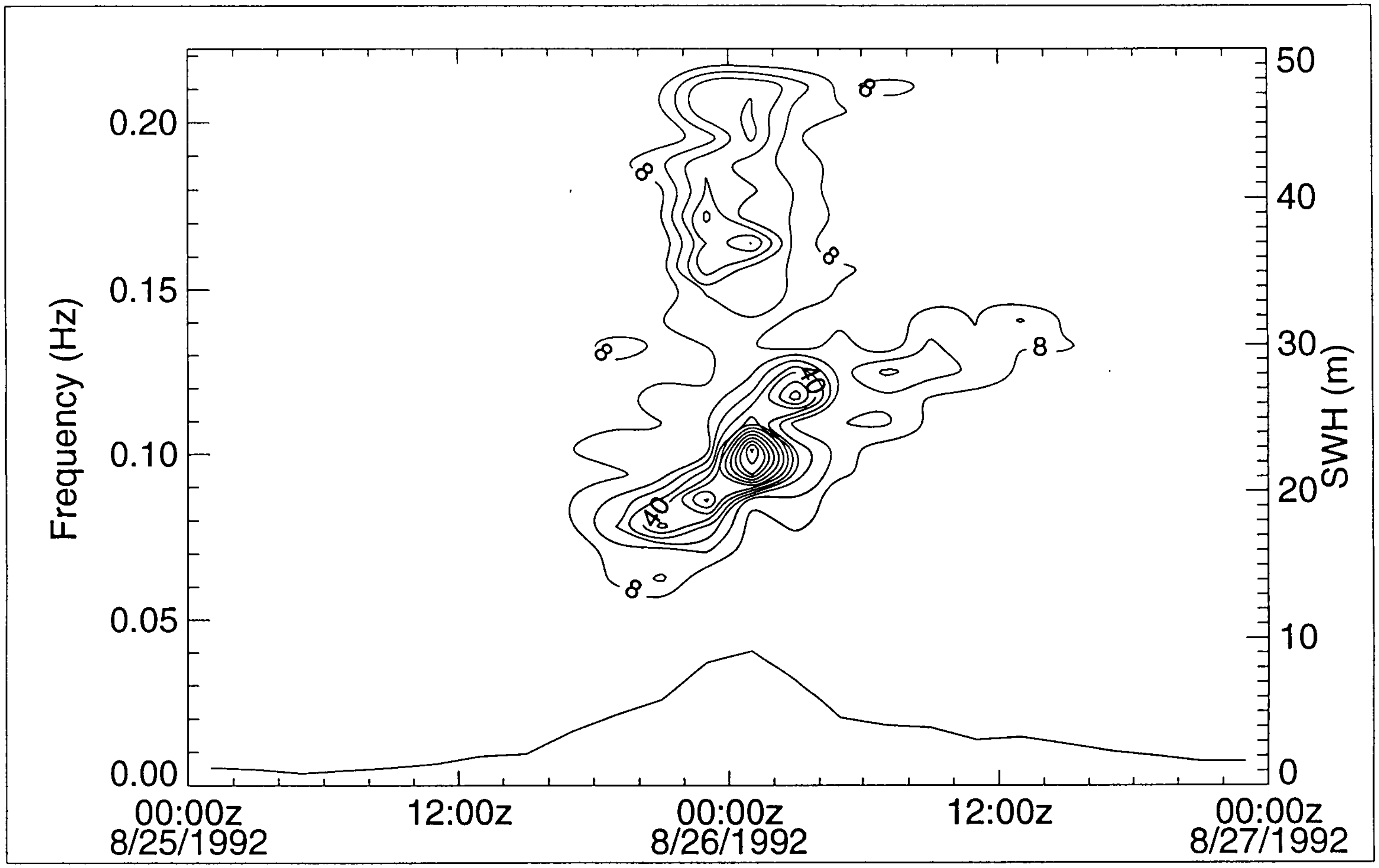


Figure 6.8.4. Contour plot of energy density versus time with significant wave height (SWH) superimposed at mooring 16.

6.9 Acoustic Doppler Current Profiler Measurements

Some of the limitations in the use of ADCP data on the Texas-Louisiana Shelf have been discussed in Jochens and Nowlin (1994b). The most serious of these is that the velocity vectors, such as that shown in Figure 6.9.1 for cruise H06, do not represent a synoptic pattern of near-surface current. Based on the moored current meter data, considerable variability of the flow is known to occur at periods less than the two-week period required for the shelf-wide hydrographic cruise. Much of this variability is caused by winds on the inner and mid-shelf (see section 6.11), which tend to produce a nearly barotropic response for depths of 50 m or less. The ADCP measures this response which is not readily detected in the CTD measurements.

One of the primary uses of ADCP is in assessing the vertical profiles of current, since the measurements over the water column at any given location do give a synoptic pattern with resolution superior to that provided by the current meter moorings. As part of his dissertation research, H-W. Chen has carried out analyses of the dominant vertical structures of current for selected ADCP cruises, of which H06 is one. The method of treating the velocity vector as a complex number allows evaluation of vector empirical orthogonal functions (EOFs) as first employed by Kundu and Allen (1976).

Figure 6.9.2 shows the locations of ADCP transects AB along the 50-m isobath and transects CD, EF, and GH along the 200-m isobath during cruise H06. Dates, time-intervals, and number of ADCP vertical profiles along each of these transects are given in Table 6.9.1. Complex EOF modes were computed from the complex covariance matrix formed by summing contributions over all profiles along the nominal 50-m transect AB. Vertical levels were restricted to those having a common range for all profiles. The resulting first, second, and third dominant modes are shown as vector stick plots in Figure 6.9.3 for each four meters in the depth range 10 to 38 m below the surface. The percent of the total variance (kinetic energy) explained by each of these modes is shown at the top of each profile. Similar EOF computations were carried out for the transects along the 200-m isobath for a common depth range of 10 to 106 m. The resulting EOF modes based on combining covariance contributions from all three sections are shown in Figure 6.9.4.

The dominant empirical structures in each case are nearly unidirectional profiles that characterize about 68 and 85 percent of the kinetic energy along the 50-m and 200-m transects, respectively. The second and third modes, which contain one and two null vectors respectively, contribute much less to the kinetic energy. Representation of the currents in terms of the first few modes can provide a spatially filtered version of the flow across the transect.

One of the objectives of Chen's research is to compare the vertical shear derived from the ADCP data with the vertical shear derived from the temperature and salinity data using the "thermal wind" (geostrophic shear) relation. The use of EOF mode representation of profiles may be helpful in that task.

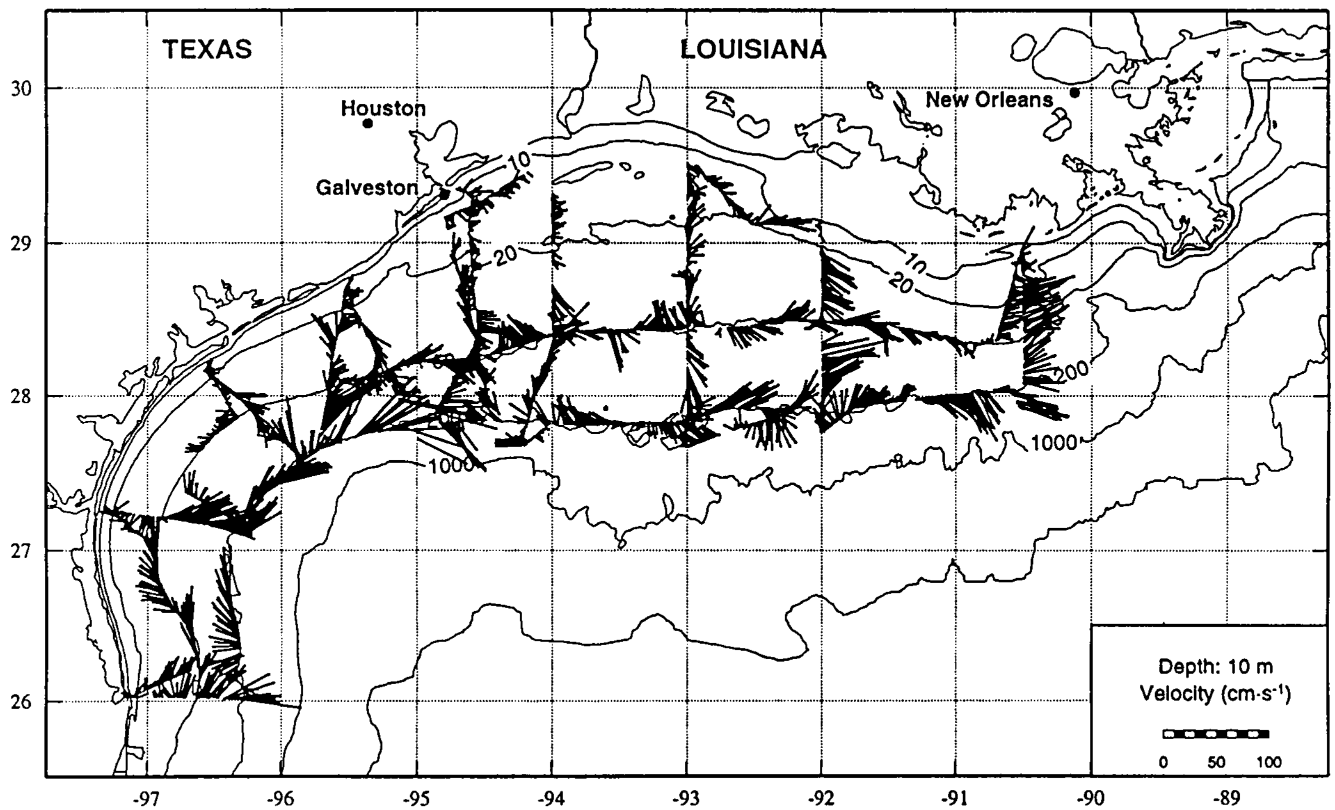


Figure 6.9.1. Vector stick plots of currents at 10 m, measured by ADCP during cruise H06, 25 July - 7 August 1993.

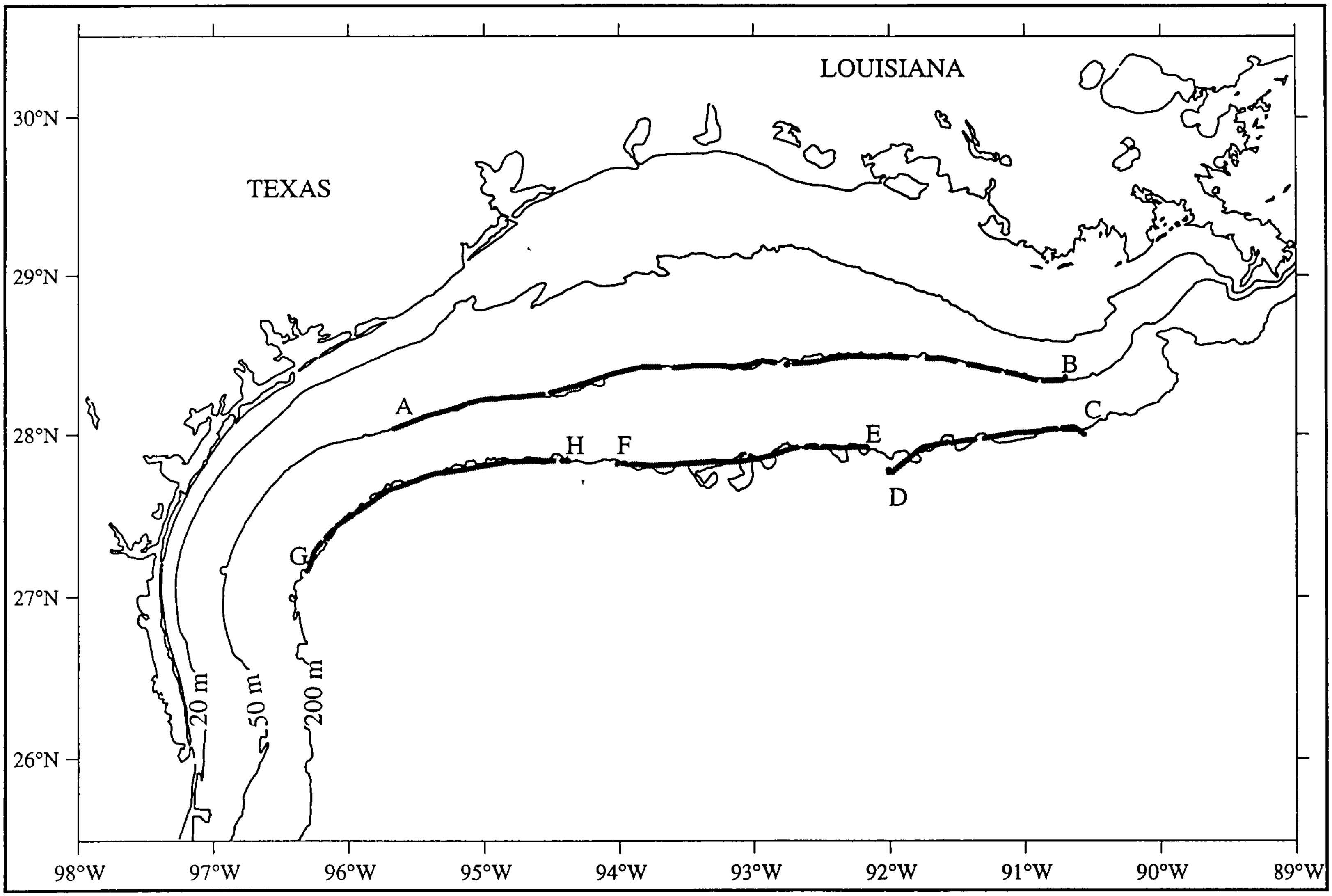


Figure 6.9.2. Transects along the 50-m and 200-m isobaths along which ADCP data from cruise H06 were employed to evaluate empirical othogonal profiles of current.

Table 6.9.1. Dates, time-intervals and number of ADCP vertical profiles along the 50-m and 200-m isobaths during the LATEX cruise H06.

	Decimal Day	Date and Time	Length of Time (hr)	No. of Locations
A	207.666100	Jul 26 15:59:11		
B	209.035394	Jul 28 00:50:58	32.86	269
C	209.912454	Jul 28 21:53:56		
D	210.383692	Jul 29 09:12:31	11.31	86
E	212.369271	Jul 31 08:51:45		
F	212.985833	Jul 31 23:39:36	14.80	103
G	218.391076	Aug 6 09:23:09		
H	218.982928	Aug 6 23:35:25	14.20	121

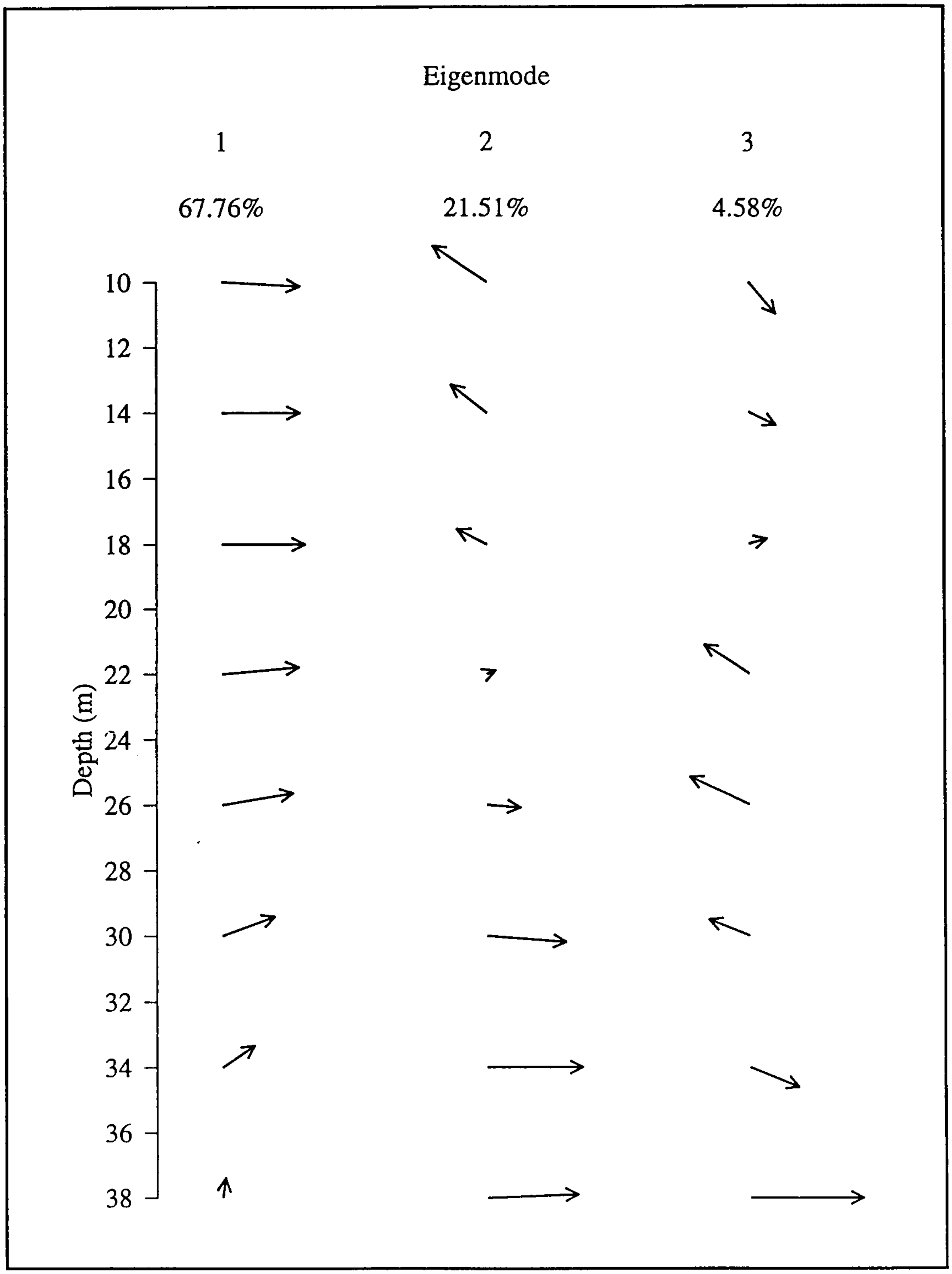


Figure 6.9.3. The first three EOFs derived from ADCP data along the 50-m transect of cruise H06.

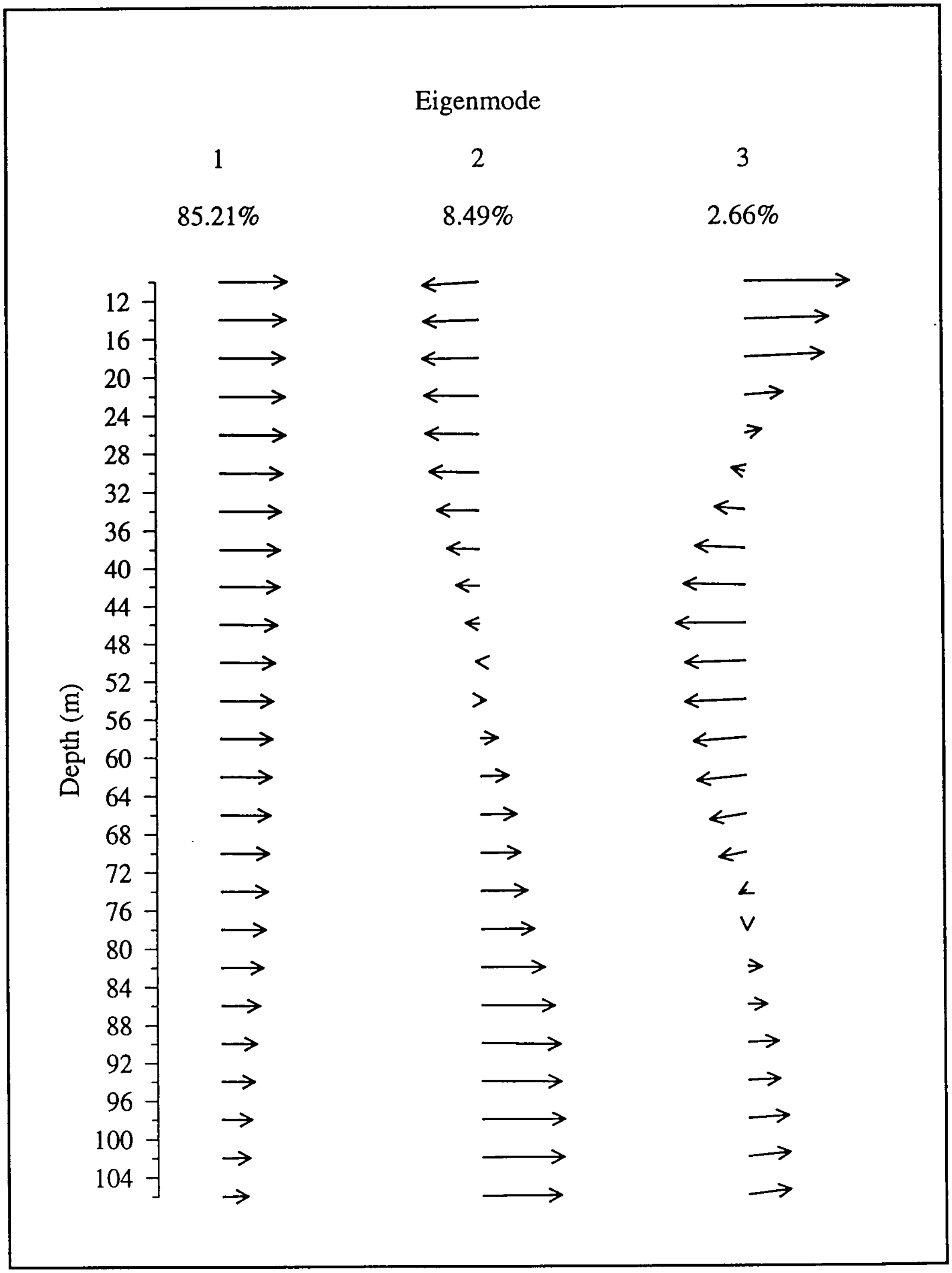


Figure 6.9.4. The first three EOFs derived from ADCP data along the 200-m transect of cruise H06.

6.10 Maximum Currents

The MMS wishes to determine the maximum likely distance that spilled oil over the Texas-Louisiana shelf could move in a 48-hour period. To assist in this assessment, the maximum speeds and associated directions measured at the upper instruments were determined from the second-year records of each of the LATEX A moorings. These maxima were selected from the 40-hour, low-passed current records that will be included in the microfiche packet that will accompany the Final Report. Table 6.10.1 gives mooring number, location, instrument depth, maximum speed, direction, and date for each current meter site measured over the Texas-Louisiana shelf. The types of instruments used at each location are given in section 3.2.

For the second LATEX field year, the table shows that the maximum low-passed currents, at a nominal 10-m depth, range from about 29 to 86 $cm \cdot s^{-1}$, directions vary around the compass, and maxima occur around the calendar. This may make interpretation of these results difficult. Additionally, instruments did not record at all locations year round due to instrument losses, malfunctions, lack of spares, and removal of moorings. Moreover, these records often contain several relative speed maxima of similar values (for an example, see section 5.2.1 in Jochens and Nowlin, 1994b).

Table 6.10.1. Maximum speeds and corresponding directions observed in 40-hr low-passed current record from each LATEX A mooring during the second field year.

Mooring	Latitude N	Longitude W	Depth (m)	S_{max} ($cm.s^{-1}$)	Dir_{max} (°T)	Date
1	27° 15.39'	97° 14.81'	19	86	196	20 June 1993
2	27° 17.09'	96° 58.81'	10	81	204	10 Nov. 1993
3	27° 17.35'	96° 44.18'	13	69	222	13 Mar. 1993
4	27° 07.76'	96° 21.63'	12	77	358	13 Feb. 1993
5	27° 27.82'	96° 04.12'	14	64	63	12 Aug. 1993
6	27° 42.59'	95° 39.85'	13	83	94	15 Feb. 1993
7	27° 50.12'	95° 04.19'	14	83	99	4 Aug. 1993
8	27° 49.47'	94° 10.77'	15	61	144	10 Mar. 1993
9	27° 48.92'	93° 31.91'	14	51	94	6 Jan. 1994
10	27° 56.07'	92° 44.70'	14	39	88	8 Mar. 1994
11	27° 50.64'	92° 00.45'	14	32	29	17 Jan. 1994
12	27° 55.76'	90° 29.64'	14	68	103	27 Oct. 1993
13	28° 03.48'	90° 29.18'	15	54	87	17 Aug. 1993
14	28° 23.74'	90° 29.65'	19	42	262	8 Jan. 1994
15	28° 36.49'	90° 29.53'	10	59	80	7 Aug. 1993
16	28° 51.96'	90° 29.50'	11	52	268	8 Oct. 1993
17	29° 11.82'	91° 57.89'	3	62	304	20 June 1993
18	28° 57.74'	91° 59.01'	10	69	271	8 Apr. 1993
19	28° 27.92'	92° 02.06'	3	52	309	11 Aug. 1993
20	29° 15.67'	94° 03.82'	3	73	12	13 Sept. 1993
21	28° 50.28'	94° 04.79'	14	46	264	19 June 1993
22	28° 21.39'	93° 57.34'	3	59	22	20 July 1993
23	28° 42.77'	95° 32.13'	10	72	246	19 June 1993
24	28° 32.21'	95° 23.61'	10	83	240	9 Nov. 1993
25	28° 19.33'	95° 21.57'	11	36	87	2 Apr. 1993
44	Removed					
45	Removed					
46	Removed					
47	Removed					
48	27° 58.98'	91° 16.99'	14	42	85	7 Jan. 1994
49	27° 23.13'	95° 53.96'	14	29	240	2 Mar. 1994

6.11 Observations/Model Comparison

A perception emerging from the LATEX A hydrographic and current meter measurements is that the energetic variable circulation on the inner shelf (< 50 m water depth) at frequencies within the weather band (about 0.05 to 0.3 cycles/day) is locally wind-induced barotropic motion. This variability is superimposed on a much more stable but less energetic baroclinic circulation over the whole shelf that varies seasonally, as in the Cochrane and Kelly (1986) schema, and whose patterns can be quantified from the hydrographic data. Even casual inspection of wind and current records for the inner LATEX shelf shows a remarkable consistency between reversals in direction of the longshore current and reversals in direction of the longshore wind during weather events.

Wind-driven currents on the west Florida shelf have been quantifed by Mitchum and Sturges (1982) and modeled by Mitchum and Clarke (1986). We (R.O. Reid and C.L. Current) have employed a simple barotropic wind-driven model similar to that of Mitchum and Clarke in a pilot experiment for the Texas-Louisiana shelf. The weather event of 11-14 March 1993 was selected for this test. It has some unique features first recognized by Lee et al. (1994).

The model/data comparison discussed below should be considered more as a model/data assimilation experiment because from it we deduce a field of bottom friction characterization that produces a reasonably optimum match of simulated and observed (40-hr low passed) currents, using measured winds to estimate the (40-hr low passed) wind stress evolution.

The model used is a generalization of the simple barotropic shelf model of Gill and Schumann (1974) in which the field of flow is represented as a linear combination of cross-shelf structure functions, whose amplitudes are predicted versus longshore position and time for specified longshore wind stress. Bottom friction is included as parameterized by Clarke and Brink (1985) and implemented in a manner similar to Mitchum and Clarke (1986). The primary dynamical constraints of the model are that it is barotropic and the horizontal volume transport non-divergent. The latter implies that a stream function exists whose horizontal gradient (divided by local depth) gives the current. The subsurface pressure anomaly (SSP) can also be related to the stream function since the longshore flow is very nearly geostrophic. Another constraint is that the scale of variation alongshore is considered large compared to the cross-shore scale.

In the present application of the model, the bathymetry is approximated by a simple exponential form as employed by Buchwald and Adams (1968) and Gill and Schumann (1974) but with an offshore scale parameter that depends on alongshore position. Using this approximation, the rms error in the offshore distance of a given isobath is about 6% of the offshore distance to the 200-m isobath. The domain of the model is from the coast (taken as the 6.2-m isobath) to the 200-m isobath (Figure 3.2.1). The Mississippi Delta is replaced by a wall extending fully across the shelf, so it and the coastal wall are streamlines of flow. The model extends along the coast to about 26° N, at which there is no constraint on the flow. At the seaward boundary (200-m isobath) the flow is allowed to pass across, but the longshore flow is considered zero, a constraint that clearly limits the model application to wind-driven inner shelf response. Vital geometrical parameters that are specified versus longshore position are the distance from the 6.2-m "shore" to the 200-m isobath (which varies from 80 km to 220 km) and the direction of the alongshore orientation of the 6.2-m "shoreline."

Following Mitchum and Clarke (1986) and others, the resisting bottom stress divided by water density (T_b) is taken proportional to the depth-averaged flow (V):

$$T_b = rV \qquad (1)$$

where r has dimensions of speed. The value of r depends, among other factors, on background high frequency currents due to surface waves as discussed by Clarke and Brink (1985). As such, r depends on offshore distance and surface wave energy level. In the present model application, we take

$$r = r_0(1-y/L) \qquad (2)$$

where y is offshore distance, L is the local distance to the 200-m isobath, and r_0 is the nearshore value of r. The dependency of L on longshore position is known. The value of r_0 for the coastal region east of 96.5° W is allowed to differ from the coastal region southwest of 96.5° W (Figure 3.2.1). We will refer to these two regions as the upcoast and downcoast regions, respectively. The values of r_0 for these regions are selected in the optimal tuning of the model.

The March 1993 storm was formed by cyclogenesis in the northwest Gulf, and at 1200h on 12 March was centered near 27° N and 95.5° W. It intensified as it propagated eastward to 90° W, then northeastward, later producing very severe weather along the eastern seaboard. The average eastward propagation speed from 95.5° W to 91° W was 20.6 ms^{-1} based on the National Weather Service analyses.

Wind records at LATEX meteorological moorings 50 and 53 were used to estimate wind stress; time series of speed and direction are shown as Figures 5.6.11 and 5.6.12 of Jochens and Nowlin (1994b). Locations of these moorings are given here in Figure 3.2.1. The methodology of Smith (1988) was employed to estimate wind stress from the observed wind velocity at a mast height of 3.6 m above the sea surface. The drag coefficient (for neutral stability) based on wind speed W at 3.6 m was taken as:

$$c_d = 0.80+0.081W. \qquad (3)$$

The east and north components of wind stress were calculated for the period 9-16 March 1993 for moorings 50 and 53 and then smoothed with a 40-hr low pass filter. The resulting filtered stress components are shown for a three-day window in Figure 6.11.1. These plots indicate very similar east and north components at the two inner shelf locations but with a time lag of about 5 hours and an intensification in stress magnitude from about 0.3 Pa at mooring 50 to 0.5 Pa at mooring 53.

In the model runs, the east and north components of wind stress over the shelf domain are taken as:

$$\tau_e = G(\lambda')F_e(t')$$
$$\tau_n = G(\lambda')F_n(t') \qquad (4)$$

in which λ' is west longitude from mooring 53 and t' is $t+\lambda'/\omega$, where ω is the eastward angular speed (0.75 deg/hr) of the storm. The functions F_e and F_n are those shown in Figure 6.11.1. for mooring 53, and G is a gain factor relative to mooring 53 taken as an exponential whose e-folding scale is consistent with a gain of 0.60 for mooring 50 relative to mooring 53.

The model forcing employs the local longshore component of the wind stress. In the early stages of the storm, the direction of the stress is toward the west and rotates cyclonically toward the south and southeast in the later stages on 14 March. This sequence causes the maximum downcoast longshore stress to propagate downcoast with time; i.e., we should expect the maximum downcoast flow in the southwest part of the shelf to lag behind that at the central and east shelf—even though the storm is moving to the east.

Observed currents for moorings 1, 23, and 18 were selected as representative of near coast conditions at downcoast, midcoast, and upcoast locations (Figure 3.2.1). The depths at these locations lie between about 15 to 22 m. The upper current meter at these locations is about 10 m below the surface, and hence, at about mid-depth. We regard this, therefore, as an estimate of the depth-averaged current. The only midshelf mooring having data at mid-depth (and, in fact, at top, middle, and bottom) spanning the March 1993 storm event is mooring 25, at a depth of about 40 m (Figure 3.2.1). In comparing the measured and simulated current, it is important to bear in mind that the model simulation provides only the depth-averaged or barotropic part of the current.

The current meter records at moorings 1, 23, 18, and 25 were smoothed with a 40-hr low pass filter, and the longshore component of the estimated depth-averaged current was obtained for each. Plots of the estimated depth-averaged longshore current from measurements at the three near coastal moorings are shown in the top panel of Figure 6.11.2, while that for mooring 25 is shown with mooring 23 in Figure 6.11.3. The sign convention for longshore flow is such that positive is upcoast (toward the Mississippi delta), while negative is downcoast (toward the Rio Grande). This is consistent with the monthly current plots.

The simulated depth-averaged longshore current from the model is shown in lower panels in Figures 6.11.2 and 6.11.3 to facilitate direct comparison. The values of r_0 employed in the simulated runs shown here are 2.4×10^{-4} ms^{-1} and 3.7×10^{-4} ms^{-1} for the upcoast and downcoast domains, respectively. These provided the optimal simulation of range and phase of current variability shown for the common three day time window in these figures.

Figure 6.11.2 shows that there is over 12 hours lag of the energetic downcoast flow at mooring 1 compared with that at mooring 23 in the measurements and this is mimicked quite well in the model simulation. Mooring 18, which is well upcoast from mooring 23, is less energetic but nearly in phase with mooring 23. This is simulated reasonably well by the model, but one notes some phase error.

Comparison of mooring 25 with 23 (Figure 6.11.3) indicates a decay and phase lag in the observations. The lag is mimicked well in the simulation, but the offshore decay of the simulated flow is more pronounced.

In the simulations, the initial current for a given mooring was taken as that of the observations at 1200h on 11 March 1993. The effect of initial condition produces a transient that dies away exponentially in time, leaving purely forced motion after about two e-folding times. For the upcoast region, the model e-folding decay time is about 26 hours, but only 17 hours for the downcoast region.

Not shown here are the observed near surface currents at moorings 24 and 25 or at moorings 2 and 3. These currents reach magnitudes comparable to and even larger than those nearer the coast. This suggests that a significant vertical shear exists at these moorings. Indeed, for mooring 25, the speed at the time of maximum downcoast flow varies from about 0.2 ms^{-1} near the bottom to about 0.7 ms^{-1} near the surface and is directed downcoast at all three levels.

Caveats: The observation/model comparisons shown in Figures 6.11.2 and 6.11.3 look almost too good to be true. Recall, however, that we have in effect fit the dynamics to the data for these selected moorings and for this very short (3-day) event. The fitting for this event involved tuning the bottom friction parameter r_0 for two regions of the shelf, assuming that the wind stress field derived from two meteorological moorings is adequate.

A nagging feature of the simulations, not mentioned earlier, is that in the downcoast region (moorings 1, 2, 3), the computed response for moorings 2 and 3 showed an unreasonably large time lag compared with the longshore current measured at the near surface meters. Possible reasons for this discrepancy between simulation and observations are: improper parameterization of friction versus y in this region; inaccurate time sequence of wind stress for this region (taken essentially as that at mooring 50); improper account of the effect of coastal curvature in the model; or perhaps there is a large phase difference between the depth-averaged and surface current for this region of the shelf.

The above questions require further follow-on data/assimilation experiments. This, together with confirmation of the bottom friction parameterization and tuning over many more weather events, is one of several objectives of C.L. Current in her proposed dissertation research.

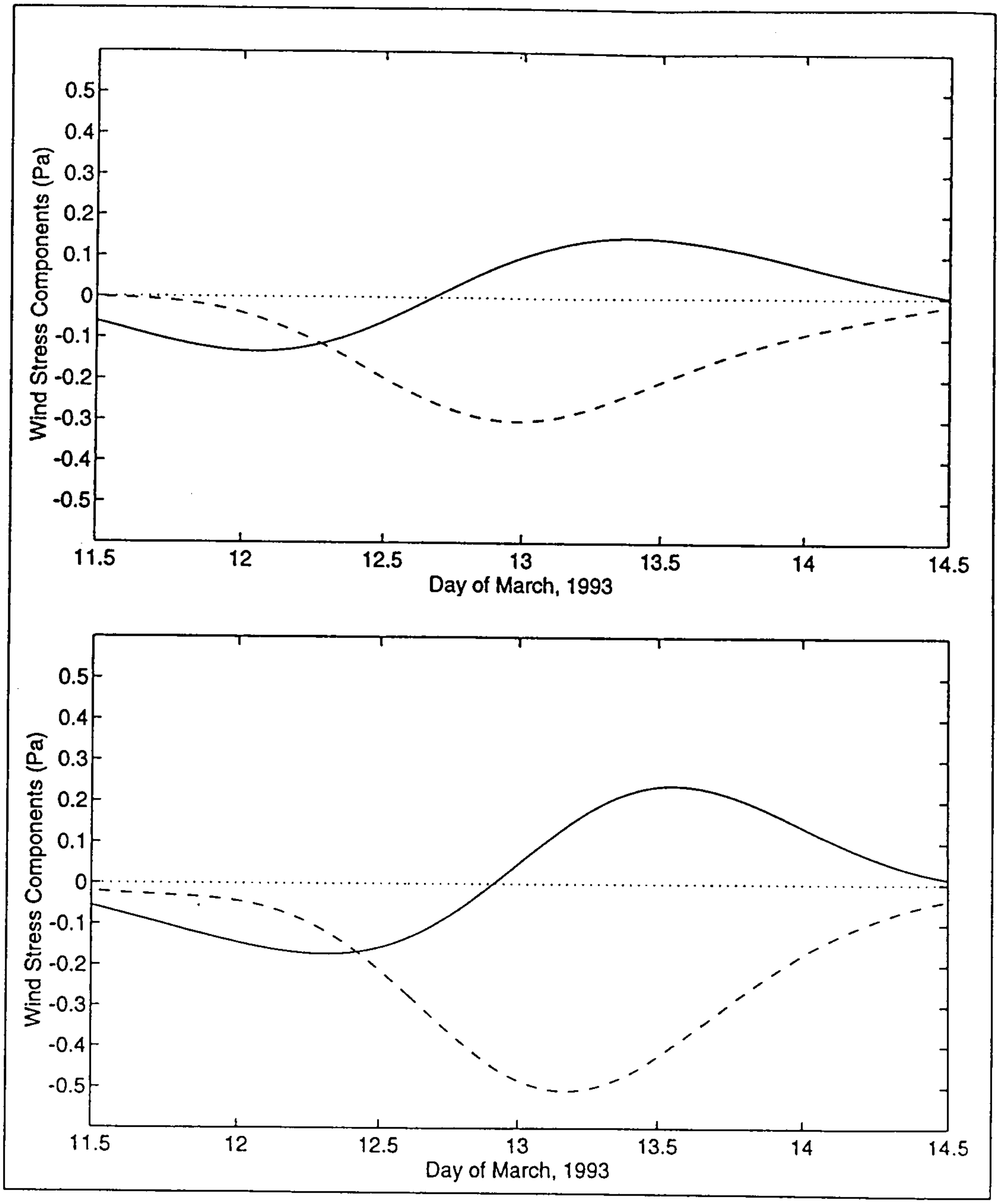


Figure 6.11.1. Eastward (—) and northward (---) 40-hr low pass wind stress components from moorings 50 (upper panel) and 53 (lower panel) for the three-day March 1993 storm. Upcoast is positive.

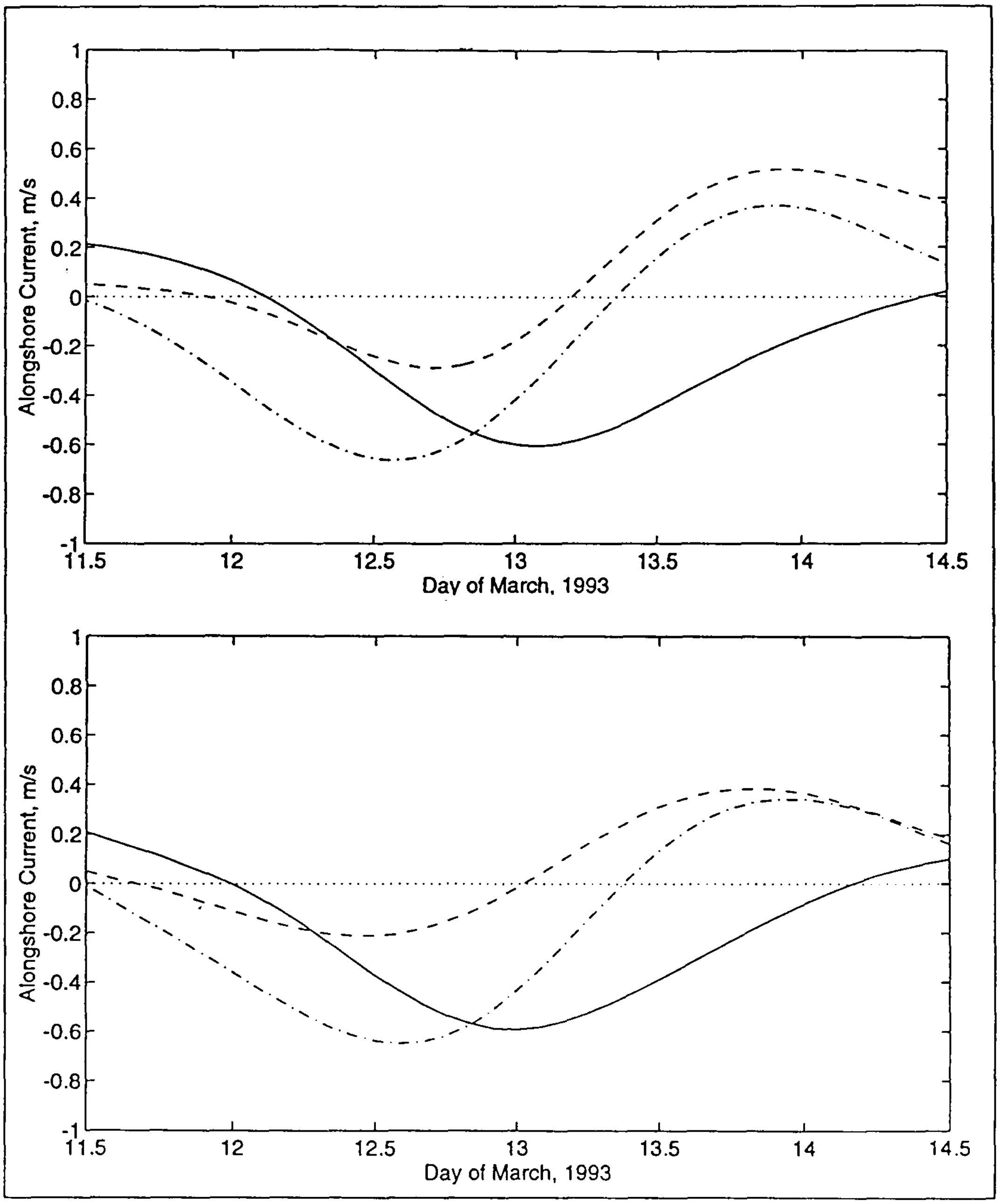


Figure 6.11.2. Observed 40-hr low pass (upper panel) and simulated (lower panel) longshore currents for moorings 1 (—), 18 (---), and 23 (-·-) for the three-day March 1993 storm. Upcoast is positive.

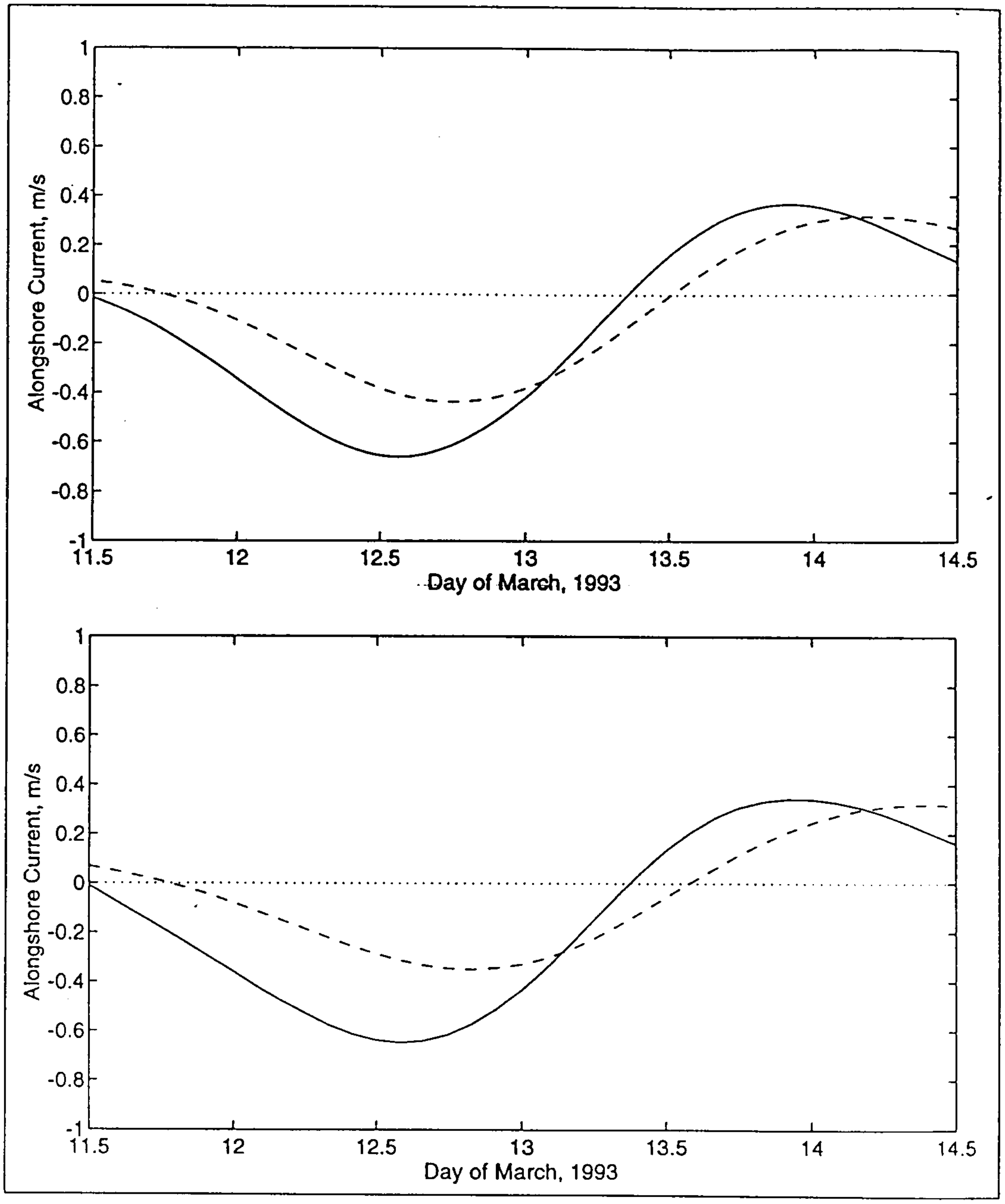


Figure 6.11.3. Observed 40-hr low pass (upper panel) and simulated (lower panel) longshore currents for moorings 23 (—) and 25 (---) for the three-day March 1993 storm. Upcoast is positive.

6.12 LATEX Science Advisory Panel

During this year, both George Forristall (Chairman) and Denny Kirwan (member) resigned from the LATEX Science Advisory Panel because of changes in their situations. With the concurrence of LATEX B and C program managers and the MMS COTR, John Allen was asked, and agreed, to assume the chair and Gabriel Csanady and Richard Garvine were appointed as new Panel members. The members of the SAP and their affiliations are listed in Table 6.12.1.

October 26-28, 1993, Panel members attended the LATEX III Meeting at MMS Regional Headquarters in New Orleans. They reviewed the LATEX Program and prepared draft recommendations which were circulated to the program managers.

Table 6.12.1. Members of the LATEX Science Advisory Panel from 1 April 1993 through 31 March 1994.

Member	Affiliation
John S. Allen, Chairman	Oregon State University
John D. Cochrane	Texas A&M University, retired
Gabriel T. Csanady	Old Dominion University
Richard W. Garvine	University of Delaware
Dong-Ping Wang	SUNY - Stony Brook
Clinton D. Winant	Scripps Institution of Oceanography
William J. Wiseman, Jr.	Louisiana State University

7 REFERENCES

Barnes, S.L. 1964. A technique for maximizing details in numerical weather map analysis. J. Appl. Meteor., 3:396-409.

Barnes, S.L. 1973. Mesoscale objective analysis using weighted time-series observations. NOAA Tech. Memo. ERL NSSL-62, National Severe Storms Lab., Norman, OK. 60 pp.

Bretherton, F.P., R.E. Davis, and C.B. Fandry. 1976. A technique for objective analysis and design of oceanographic experiments applied to MODE-73. Deep-Sea Res. 23:559-582.

Buchwald, V.T. and J.K. Adams. 1968. The propagation of continental shelf waves. Proc. Roy. Soc. Lond. A305:235-250.

Buckley, W.H. 1988. Extreme and climatic wave spectra for use in structure design of ships. Naval Engineers Jour. 100(5):36-57.

Clarke, A.J. and K.H. Brink. 1985. The response of stratified, frictional flow of shelf and slope waters to fluctuating large-scale, low frequency wind forcing. J. Phys. Oceanogr. 15:439-453.

Cochrane, J.D., M.K. Howard, and L.L. Lee III. 1995. Coastal upwelling and related currents in the western Gulf of Mexico. Poster. AGU Circulation of the Intra-Americas Seas Meeting, January 1995, San Juan, Puerto Rico.

Cochrane, J.D. and F.J. Kelly. 1986. Low-frequency circulation on the Texas-Louisiana continental shelf. J. Geophys. Res. 91:10645-10659.

Csanady, G.T. 1981. Circulation in the coastal ocean, pp. 101-183. In Advances in Geophysics, Vol. 23. Academic Press, New York.

DiMarco, S.F., F.J. Kelly, E.F. Childress, and D.G. Aubry. 1994. Field comparison study of two directional wave gauges (one ICS solid state, the other Paroscientific quartz). MTS 94 Conference Proceedings. Marine Technology Society, Washington, D.C. pp. 32-38.

DiMarco, S.F., F.J. Kelly, J. Zhang, and N.L. Guinasso, Jr. 1995. Directional wave spectra on the Louisiana-Texas Shelf during Hurricane Andrew. J. Coastal Research. In press.

Donelan, M.A. 1982. The dependence on the aerodynamic drag coefficient on wave parameters. In First International Conference on Meteorology and Air-Sea Interaction of the Coastal Zone. Amercian Meteorol. Soc., Boston, MA. 381-387.

Donelan, M.A., F.W. Dobson, S.D. Smith, and R.J. Anderson. 1993. On the dependence of sea surface roughness on wave development. J. Phys. Oceanogr. 23:2143-2149.

Elliott, B.A. 1979. Anticyclonic rings and the energetics of the Gulf of Mexico. Ph.D. Dissertation, Texas A&M University, College Station, TX. 188 pp.

Etter, P.C., and J.D. Cochrane. 1975. Water temperature on the Texas-Louisiana Shelf. Texas A&M Univ., Sea Grant Program, Mar. Adv. Bull. SG 75-604. 22 pp.

Freilich, M., and S. Dunbar. 1994. ERS-1 scatterometer data products. 4 mm tape medium. NASA JPL, California Inst. of Tech., Pasadena, CA.

Gandin, L.S. 1963. Objective analysis of meteorological fields. Israel Program for Scientific Translations, Jerusalem. 242 pp.

Geernaert, G.L., S.E. Larsen, and F. Hansen. 1987. Measurements of the wind stress, heat flux, and turbulence intensity during storm conditions over the North Sea. J. Geophys. Res. 92(C12):13127-13139.

Gilhousen, D.B. 1993. Buoy wave extremes. Mariners Weather Log. 37(4):33-34.

Gill, A.E. and E.H. Schumann. 1974. The generation of long shelf waves by the wind. J. Phys. Oceanogr. 4:83-90.

Hastenrath, S. 1968. A contribution to the wind conditions over the Caribbean Sea and Gulf of Mexico. Tellus. 1:163-178.

Hellerman, S., and M. Rosenstein. 1983. Normal monthly wind stress over the world ocean and error estimates. J. Phys. Oceanogr. 13:1093-1104.

Hsu, S.A. 1993. The Gulf of Mexico—a breeding ground for winter storms. Mariners Weather Log. 37(2):4-11.

Hsu, S.A. 1994a. A verification of two shear velocity equations for the wind-wave interaction in a lake environment. Boundary-Layer Meteorol. 71:205-209.

Hsu, S.A. 1994b. On the incorporation of wave characteristics into drag coefficient formulation at sea. Preprint: Second International Conference on Air-Sea Interaction and Meteorology and Oceanography of the Coastal Zone, September 1994, Lisbon, Portugal. American Meteorol. Soc., Boston, MA. 237-238.

Jochens, A.E, G.S. Fargion, R.R. Leben, and P. Hamilton. 1994. Observations on the fate of Eddy V, March - June 1994. Spring 1994 Meeting, American Geophysical Union, Baltimore, MD. Abstract: Eos, Transactions 75(16):212.

Jochens, A.E, G.S. Fargion, and R.R. Leben. 1995. Observations on the fate of Loop Current Eddy Vazquez in the Gulf of Mexico. In preparation.

Jochens, A.E., and W.D. Nowlin, Jr., eds. 1994a. Texas-Louisiana Shelf Circulation and Transport Processes Study: Year 1, Annual Report. Volume I: Executive Summary. OCS Study MMS 94-0030, U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 33 pp.

Jochens, A.E., and W.D. Nowlin, Jr., eds. 1994b. Texas-Louisiana Shelf Circulation and Transport Processes Study: Year 1, Annual Report. Volume II: Technical Summary. OCS Study MMS 94-0030, U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 207 pp.

Johnson, G.A., E.A. Meindl, E.B. Mortimer, and J.S. Lynch. 1984. Features associated with repeated strong cyclogenesis in the western Gulf of Mexico during the winter of 1982-83. In Postprints, Third Conference on Meteorology of the Coastal Zone, pp. 110-117. Amer. Meteorol. Soc., Boston, MA.

Kanamitsu, M. 1989. Description of the NMC Global Data Assimilation and Forecast system. Weather and Forecasting. 4:335-342.

Kelly, F.J., S.F. DiMarco, N.L. Guinasso, Jr., R.C. Hamilton, and K.A. Kurrus. 1993. Calibration and performance of the pressure and temperature sensors in the Coastal Leasing, Inc., MiniSpec directional wave gauge. Texas A&M Univ., Dept. of Ocn. Tech. Rep., Ref. No. 93-07-T. 63 pp.

Koch, S.E., M. DesJardins, and P.J. Kocin. 1983. An interactive Barnes objective map analysis scheme for use with satellite and conventional data. J. Climate Appl. Meteor. 22:1487-1503.

Kundu, P.K., and J.S. Allen. 1976. Some three-dimensional characteristics of low-frequency curent fluctuations near the Oregon coast. J. Phys. Oceanogr. 6:181-199.

Large, W.G. and S. Pond. 1981. Open ocean momentum flux measurements in moderate to strong winds. J. Phys. Oceanogr. 11:324-336.

Lee, L.L. III, F.J. Kelly, and M.K. Howard. 1994. The response of the Texas-Louisiana shelf waters to an impulsive wind event. 1994 Ocean Sciences Meeting, American Geophysical Union, San Diego, CA. Abstract: EOS, Transactions 75(3):65.

Lewis, J.K. and R.O. Reid. 1985. Local wind forcing of a coastal sea at subinertial frequencies. J. Geophys. Res. 90:935-944.

Liu, W.T., K.B. Katsaros, and J.A. Businger. 1979. Bulk parameterization of air-sea exchanges of heat and water vapor including the molecular constraints at the interface. J. Atmos. Sci. 36:1722-1735.

Longuet-Higgins, M.S. and R.W. Stewart. 1960. Changes in the form of short gravity waves on long waves and tidal currents. J. Fluid Mechanics. 8:565-583.

Mitchum, G.T. and A.J. Clarke. 1986. The frictional nearshore response to forcing by synoptic scale winds. J. Phys. Oceanogr. 16:934-946

Mitchum, G.T. and W. Sturges. 1982. Wind-driven currents of the west Florida shelf. J. Phys. Oceanogr. 12:1310-1317.

Murphy, D.J., D.C. Biggs, and M.L. Cooke. 1992. Mounting and calibrating an acoustic Doppler current profiler. MTS Jour. 26(3):34-38.

NOAA. 1994. Oceanographic Features Analysis, southern panel. National Ocean Service, Washington, D.C.

Nowlin, W.D., Jr., A.E. Jochens, N.L. Guinasso, Jr., D.A. Wiesenburg, R.O. Reid, S.A. Hsu, and R.C. Hamilton. 1991. Louisiana/Texas Shelf Physical Oceanography Program Task A (A Technical Proposal). Texas A&M University, Department of Oceanography. Ref. No. 93-06-T. College Station, TX. 196 pp.

Ochi, M.K. 1994. On hurricane-generated seas, pp. 374-387. In O.T. Magoon and J. Michael Hemsley, eds. Ocean Wave Measurement and Analysis. ASCE, New York.

Rhodes, R.C., A.J. Wallcraft, and J.D. Thompson. 1985. Navy-corrected geostrophic wind set for the Gulf of Mexico. J. Phys. Oceanogr. 16:483-504.

Sahl, L.E., W.J. Merrell, and D.A.Wiesenburg. 1994. The impact of an offshore squirt on particle and nutrient distributions in the Gulf of Mexico. American Geophysical Union. Abstract: Supplement to Eos Transactions 75(44):339.

Smith, R.C., K.S. Baker, and P. Dustan. 1981. Fluorometric techniques for measurement of oceanic chlorophyll in the support of remote sensing. Scripps Institute of Oceanography, La Jolla, CA. Ref. 81-17, 14 pp.

Smith, S. 1988. Coefficients for sea surface wind stress, heat flux, and wind profiles as a function of wind speed and temperature. J. Geophys. Res. 93:15467-15472.

Smith, W.H.F. and P. Wessel. 1990. Gridding with continuous curvature splines in tension. Geophysics. 55:293-305.

Stone, G.W., J.M. Grymes, III, K.D. Robbins, S.G. Underwood, G.D. Steyer, and R.A. Muller. 1993. A chronologic overview of climatological and hydrological aspects associated with Hurricane Andrew and its morphological effects along the Louisiana coast, U.S.A. Shore and Beach. 61(2):2-12.

Temple, R.F., D.L. Harrington, and J.A. Martin. 1977. Monthly temperature and salinity measurements of continental shelf waters in the western Gulf of Mexico, 1963-1965. NOAA Tech. Rep. SSRF-707. 29 pp.

U.S. Dept. of Commerce. 1973. Surface water temperature and density—Atlantic Coast, North and South America. NOAA/NOS Publ. 31-1. 109 pp.

Wu, J. 1982. Wind-stress coefficients over sea surface from breeze to hurricane. J. Geophys. Res. 87(C12):9704-9706.

Zhang, J., R.E. Randall, and C.A. Spell. 1992. Component wave interactions and irregular wave kinematics. J. Waterway, Port, Coastal, and Ocean Engineering. 118(4):401-416.

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 **Royalty Management Program** 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.