OCS Study
MMS 98-0060

Northeastern Gulf of Mexico Chemical Oceanography and Hydrography Study between the Mississippi Delta and Tampa Bay

Annual Report: Year 1

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

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Annual Report: Year 1

Editors

Ann E. Jochens
Worth D. Nowlin, Jr.

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This report would not have been possible without the contributions of many people. Each NEGOM-COH principal investigator (PI) contributed portions of the text; many participated in the cruises and in data reduction and processing. The PIs, their affiliations, and their tasks are:

Worth D. Nowlin, Jr.	TAMU	Program Manager Co-PI for Task 3
Ann E. Jochens	TAMU	Deputy Program Manager PI for Program Management Co-PI for Task 2
Douglas C. Biggs	TAMU	Co-PI for Task 1
Norman L. Guinasso, Jr.	GERG/TAMU	Co-PI for Task 1
Matthew K. Howard	TAMU	Co-PI for Task 2
M.C. Kennicutt II	GERG/TAMU	Co-PI for Task 1 Co-PI for Task 3
Robert O. Reid	TAMU	Co-PI for Task 3

Additionally, Steven F. DiMarco, Yaorong Qian, and Christina Bernal contributed to the authorship of this report.

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Ann E. Jochens
Worth D. Nowlin, Jr.

ABSTRACT

The Northeastern Gulf of Mexico Physical Oceanography Program (NEGOM) is supported by the Minerals Management Service (MMS) of the U.S. Department of the Interior. Through a contract between MMS and the Texas A&M Research Foundation, several components of the Texas A&M University System are conducting the Chemical Oceanography and Hydrography study of NEGOM (NEGOM-COH). This report covers activities from October 1997 through June 1998. Data were collected from hydrographic and acoustic Doppler current profiler (ADCP) surveys conducted in the Gulf of Mexico over the continental shelf and upper slope between the Mississippi delta and Tampa Bay in water depths of 10 to 1000 m. Additionally, historical and concurrent data from other programs in this region were collected.

Two hydrographic/ADCP surveys, N1 and N2, were conducted with 94 and 98 hydrographic sampling stations and with 80 and 97 expendable bathythermograph stations on respective cruises. Each survey also included continuous ADCP measurements along the cruise track. At each hydrographic sampling station continuous profiles were made of conductivity, temperature, pressure, downwelling irradiance, fluorescence, and light transmission. Up to twelve water samples were taken at each station and analyzed for dissolved oxygen and six nutrients: nitrate, nitrite, phosphate, silicate, ammonium, and urea. At 51 stations on cruise N1 and 61 on N2, water samples were filtered and analyzed for phytoplankton pigments at the surface and from the chlorophyll maximum and the low light regime immediately below it. Pigments were determined using high performance liquid chromatography. At 60 stations on each cruise, water samples were filtered and analyzed for particulate matter concentrations at surface, middle, and bottom water depths and for particulate organic carbon concentrations at surface and bottom water depths. Bottle salinity was measured at every station on the first cruise and at the shallowest and deepest stations on each cross-shelf line on the second. The instrumentation as well as calibration and sampling procedures are described in this report. The collected data were subjected to stringent quality assurance/quality control procedures.

Assembly is underway of collateral data that will be of assistance in the interpretation and synthesis of the NEGOM-COH 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 and related (e.g., river discharge) data during the NEGOM-COH field years. Concurrent and historical data have been compiled from federal, state, academic, and other sources; some of these, e.g., the National Oceanographic Data Center (NODC), constitute very large data sources. Historical information compiled includes climatologies of temperature, salinity, surface waves, tides, and tidal currents. Additionally, concurrent and historical ancillary data are being obtained to aid in interpretations. Ancillary data include river discharge rates, meteorological data, and satellite fields such as sea surface height anomaly from altimetry and sea surface temperature from advanced very high resolution radiometry (AVHRR).

Selected preliminary results from the first cruise, conducted from 16-26 November 1997, are presented. Included is a description of the general circulation, which was influenced by the presence of a remnant Loop Current eddy off the western slope, by the presence of the Loop Current south of the eastern slope, and by cyclonic circulation features present over the lower

central slope and over the inner shelf. The effects of a small cyclone, located on the western shelf, on the density, temperature, salinity, dissolved oxygen, and nutrient fields are discussed. The water properties exhibited upwelling associated with this small cyclone, with indications of cross-isopycnal mixing. The general distributions of nutrients, particulates, and pigments are discussed. These distributions evidenced the influence of river discharges in the form of enhanced nutrient concentrations and particulate loadings, and higher chlorophyll *a* concentrations near riverine sources. Preliminary cross-correlations of nutrients, particulates, and pigments were computed and evaluated. Nutrients were found to be positively correlated with each other and negatively correlated with chlorophyll *a* and oxygen. Chlorophyll *a* was positively correlated with oxygen and particulate matter concentrations.

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ACRONYMS AND ABBREVIATIONS

ADCP	acoustic Doppler current profiler
AVHRR	advanced very high resolution radiometer satellite
CCAR	Colorado Center for Astrodynamics Research
CODAS	common oceanographic data access system
COTR	contracting officer's technical representative
CTD	conductivity-temperature-depth
GMT	Generic Mapping Tool software
GOM	Gulf of Mexico
GPS	global positioning system
GTS	global telecommunications stream
HPLC	high performance liquid chromatography
LATEX	Louisiana-Texas Shelf Physical Oceanography Program
LC	Loop Current
LCE	Loop Current eddy
NEGOM	Northeastern Gulf of Mexico Physical Oceanography Program
NEGOM-COH	Northeastern Gulf of Mexico Chemical Oceanography and Hydrography
MMRP	Marine Mammal Research Program at TAMU-Galveston
MMS	Minerals Management Service, U.S. Department of the Interior
NCDC	National Climate Data Center
NDBC	National Data Buoy Center
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
PAR	photosynthetically available radiation
PI	principal investigator
PM	particulate matter
POC	particulate organic carbon
QA/QC	quality assurance/quality control
RDI	RD Instruments, Inc.
RLCE	remnant Loop Current eddy
R/V	research vessel
SAIL	serial ASCII interface loop system
SOOP	Ship of Opportunity Program
SRB	NEGOM-COH scientific review board
SSHA	sea surface height anomaly
TAMU	Texas A&M University
USGS	U.S. Geological Survey
UTC	universal coordinated time
WOCE	World Ocean Circulation Experiment
XBT	expendable bathythermograph probe

1 EXECUTIVE SUMMARY

1.1 Introduction

The Minerals Management Service (MMS) of the U.S. Department of the Interior supports the Northeastern Gulf of Mexico Physical Oceanography Program (NEGOM). NEGOM is divided into six study units, one of which is the Chemical Oceanography and Hydrography study (NEGOM-COH). NEGOM-COH covers the east Louisiana-Mississippi-Alabama-west Florida continental shelf and upper slope from the Mississippi River delta to Tampa Bay in water depths of 10 to 1000 m. This report focuses on the work of NEGOM-COH during the period October 1997 through June 1998. It does not contain detailed syntheses or interpretation of data collected; that will be detailed in the Final Synthesis Report at the conclusion of the program.

The contract for NEGOM-COH was awarded to the Texas A&M Research Foundation on 30 September 1997. Through the contract, components of the Texas A&M University System, a combination of Texas institutions of higher learning and Texas state agencies dedicated to training, research, and extension, conduct the NEGOM-COH study. In addition to support from the MMS, financial backing for NEGOM-COH is provided by Texas A&M University (TAMU), a component of the System. TAMU is assisted in this program by a subcontract with Dr. Robert R. Leben of the University of Colorado.

The major objective of NEGOM-COH is to describe the spatial and temporal distribution and variation of hydrographic variables and the processes that contribute to them. The variables of interest are sea water salinity, temperature, dissolved oxygen, nutrients, particulate material, transmissivity, fluorescence, pigments, and light penetration. The objective will be met through the completion of a field program of nine hydrographic/acoustic Doppler current profiler (ADCP) cruises, one in each of the spring, summer and fall seasons over three years. The observations, together with collateral data, will be synthesized, interpreted, and reported to provide a more complete understanding of circulation and transport of properties over the study area

Program management is provided by Dr. Worth D. Nowlin, Jr., Program Manager, and Dr. Ann E. Jochens, Deputy Program Manager.

Data collection is accomplished through Task 1, Field Work and Data Collection. The co-principal investigators (PI) are: Dr. Douglas C. Biggs, Dr. Norman L. Guinasso, Jr., and Dr. M. C. Kennicutt II. This task consists of completion of hydrographic/ADCP survey work to characterize the seasonal patterns of circulation and water mass characteristics and to allow initial assessment of interannual variability and to conduct ADCP surveys on all hydrographic cruises to provide vertical profiles of currents. Two surveys were completed during this reporting period.

Data quality control and processing and acquisition of collateral data are provided under Task 2, Data Reduction/Analysis and Synthesis, with Dr. Ann E. Jochens as the PI and Dr. Matthew K. Howard as co-PI. Under this task, all field data will be processed to provide high quality data sets.

Once data have undergone quality control, the analysis phase of NEGOM-COH begins. This constitutes Task 3. Dr. Worth D. Nowlin, Jr., is PI, with Professor Robert O. Reid and Dr. M. C. Kennicutt II as Co-PIs. Under this task the scientific analyses and syntheses of the data are performed and annual reports to MMS are prepared and finalized.

A three member Scientific Review Board (SRB) was constituted to advise the Program Manager and the MMS Contracting Officer's Technical Representative (COTR). SRB members are Dr. John M. Bane, Jr., of the Department of Marine Sciences, University of North Carolina; Dr. Eileen Hofmann of the Department of Oceanography, Old Dominion University; and Dr. Stephen A. Macko of the Department of Environmental Sciences, University of Virginia. The first meeting of the SRB was on 8 December 1997 in College Station, TX. As a result of the discussions, the SRB made recommendations that lead to the development of an integrated plan for water column chemistry and particulate studies that will improve the joint study of the particulate matter, particulate organic carbon, pigment, nutrient, and oxygen measurements. Additionally, plans for future cruises will extend the shoreward end of the lines from the 20-m to the 10-m isobath to better observe the extent and possible sources of the freshwater over the inner shelf.

1.2 Field Data

Two hydrographic/ADCP survey cruises were conducted in the report period. The first, cruise N1, was conducted during 16-26 November 1997; the second, N2, during 5-16 May 1998. On the N1 and N2 cruises, respectively, 94 and 98 conductivity-temperature-depth (CTD) and bottle stations were completed, 80 and 97 expendable bathythermographs (XBT) were launched, and ADCP data were recorded continuously along track. The standard pattern of cruise track and station locations is shown in Figure 1.2.1. At each CTD/bottle station, continuous profiles were made of conductivity, temperature, dissolved oxygen, downwelling irradiance, backscatterance, fluorescence, and percent transmission. Up to 12 water samples were taken at each station and analyzed for dissolved oxygen and six nutrients: nitrate, nitrite, phosphate, silicate, urea, and ammonium. At half or more of the stations, the water samples were analyzed for phytoplankton pigments, total particulate matter, and particulate organic carbon. Bottle salinity was taken at every station on N1; these values matched well with the CTD salinity values. On N2, bottle salinities were measured only at the innermost and outermost stations of each cross-shelf line. XBT stations were taken between CTD stations to increase the resolution of the temperature data to 10 km. Near-surface temperature, salinity, and fluorescence were logged every two minutes while the ship was underway or stopped at stations. To calibrate the underway fluorescence, 181 underway water samples were analyzed for chlorophyll content on N1 and 71 on N2. After collection, the data sets were processed for compliance with quality assurance and quality control criteria.

1.3 Collateral Data

Collateral data consists of information from historical or concurrent programs in the NEGOM study area. They include both physical oceanographic data and ancillary data such as river discharge and meteorological measurements. These data are collected to augment the NEGOM-COH data set and to aid in interpretations. Historical information was compiled during the reporting period. Concurrent data were obtained from or links were

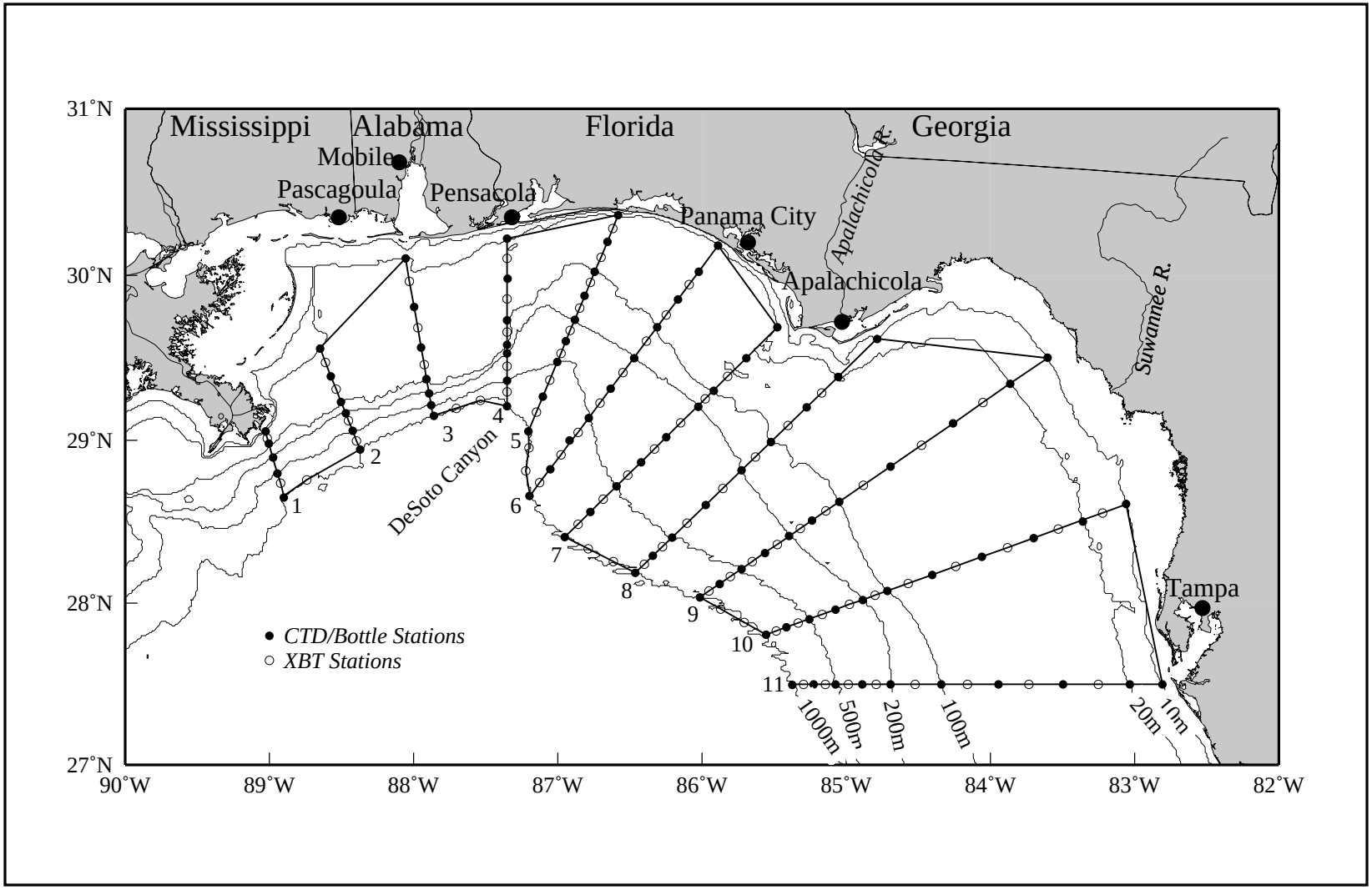


Figure 1.2.1. Standard hydrographic/ADCP cruise track and station locations. The number of each cross-shelf line is indicated at the seaward end of the line.

established to numerous other programs collecting oceanographic and ancillary data in the NEGOM-COH region, including data from other NEGOM components, satellite sea surface temperature from federal and academic sources, satellite sea surface height anomaly from the Colorado Center for Astrodynamics Research, and weather buoy data from the National Oceanic and Atmospheric Administration (NOAA).

1.4 Information Transfer

On 29-30 April 1998, MMS held a NEGOM physical oceanography information exchange meeting at the University of South Florida, Department of Marine Science, St. Petersburg, FL. At that meeting, NEGOM contractors discussed data availability and exchange. NEGOM-COH agreed to be the focal point for information regarding NEGOM data and reports.

Information on the NEGOM-COH program is provided on a publicly accessible web page on the internet. The address is http://negom.tamu.edu/negom. The web site includes information on past, current, and future NEGOM-COH activities and numerous links to other NEGOM and Gulf of Mexico-related web sites. The web site will be maintained at least through completion of the program in September 2001.

1.5 Technical Discussion

1.5.1 Introduction

This first annual report focuses on the data collection and processing activities of NEGOM-COH. Section 6 provides the discussion and examples of representative products based on the results of the first NEGOM-COH cruise, N1. No detailed syntheses of data are given, but the results of several preliminary analyses associated with interesting phenomena are presented to show examples of representative products to be provided in the final report.

1.5.2 General Circulation in November 1997

In the western part of the study area, a warm water intrusion was located off Southeast Pass of the Mississippi River and extended to the east just offshore of the 100- to 200-m isobaths into DeSoto Canyon. It was associated with a clear, strong anticyclonic remnant of a Loop Current eddy. Just east of the delta, a cooler tongue of water advected south-southeastward from the shelf into this warm intrusion. It was the western part of a large cyclone with two low centers that dominated the Mississippi/Alabama Bight and east to Cape San Blas. The warm intrusion was associated with relatively high salinity; the cool water tongue contained less saline water than adjacent waters.

Over the eastern part of the study area, there also was an intrusion of warm, relatively salty water over the slope and onto the west Florida shelf at about 28°N. This intrusion appeared related to the presence of a cyclonic eddy located off the shelf between the remnant Loop Current eddy in the west and the Loop Current that was present to the south of the eastern part of the study area. Over the eastern inner shelf, there was a large cyclone centered north of Tampa Bay.

The combination of offshore anticyclonic circulation and inner shelf cyclones resulted in maximum alongshelf currents in a downcoast (Mississippi to Tampa) direction located over the 100- to 200-m isobaths at many cross-shelf lines. The degree to which this near "shelf edge" current was dependent on the offshore existence of anticyclones versus the observed two cyclonic gyre circulation over the mid and inner shelf is a subject for study.

1.5.3 Effects of a Small Cyclone on Water Properties

During cruise N1, the small cyclone that constituted the western center of the cyclone located over the Mississippi/Alabama Bight was sampled by the stations along line 2 and bounded by the stations along lines 1 and 3. The surface waters of the small cyclone were cooler and fresher than those outside it. The near-surface temperature and salinity indicated that the small cyclone moved fresher shelf water around to the shelf edge and upper slope and saltier outer shelf/slope water to the inner shelf. The upward doming of density anomaly contours indicated upwelling of cool, salty water was occurring within this cyclone. The upwelling brought oxygen-poor, nutrient-rich waters toward the upper regions of the water column. The upward bulging of the nutrient-rich, oxygen-poor, higher salinity, cooler waters was more accentuated than that of the density, implying cross-isopycnal upwelling. The regions with nutrient enhancement from upwelling also exhibited higher relative fluorescence indicative of greater biomass.

1.5.4 Integration of Nutrients, Particulates, and Pigments

The integrated study of water column chemistry is designed to document the regional, temporal, and vertical distributions of dissolved oxygen, particulate matter, particulate organic carbon, nepheloid layers, nutrients, and phytoplankton pigments in the northeastern Gulf of Mexico. These water column properties and distributions will be evaluated in light of the major physical forcing factors and biogeochemical processes extant in the region. The goals of this work element will be accomplished through the coordinated analysis of discrete water column samples collected at varying intervals over regional transects and through the collection of continuous data by transmissometry and in situ fluorometry at each station. Seasonal variations will be assessed by collections taken three times a year over a three year period. Initial results from the first cruise illustrate the influence of various processes on water column properties.

Nutrient concentrations and distributions are the end product of a number of factors including river discharges, coastal currents and winds, upwelling, biological activity (photosynthesis), rainfall, and remineralization of organic matter. Nutrient distributions during the first cruise exhibited classical marine patterns with near surface waters (down to 100 m) depleted in nutrients due to biological uptake, deep waters enhanced in nutrients due to remineralization, and enhanced concentrations near river outflows due to the inflow of nutrient rich waters. In shallow depths the entire water column was often depleted in nutrients since the euphotic zone reached to the bottom of the water column.

Particulate matter concentrations and distributions reflect the relative input of materials from many sources including river discharges, living phytoplankton and bacteria, atmospheric deposition, resuspension of sediments, and detrital remains of organisms. In general, waters in the study area were clear. Enhanced particulate loadings were apparent near the mouths

of rivers and in some shallow water coastal areas. Mid-depth and bottom water nepheloid layers were observed near the mouths of rivers. Particulate matter concentrations ranged from 40 to 4970 $\mu g \cdot L^{-1}$ with values over 1000 $\mu g \cdot L^{-1}$ uncommon. Particulate organic carbon concentrations varid by over a factor of twenty (10 to 235 $\mu g \cdot L^{-1}$) and accounted for 25 to 100% of the particulate matter collected. Phytoplankton pigment concentrations were low and relatively uniformly distributed over the study area. Surface chlorophyll *a* concentrations ranged from 0.08 to 3.9 $\mu g \cdot L^{-1}$. The surface and chlorophyll maximum were generally similar in concentration. The depth of the chlorophyll *a* maximum varied from 10 to 70 m. Chlorophyll *a* values were highest in shallow waters and adjacent to the mouths of rivers. Phytoplankton accessory pigment concentrations were low and uniform. The dominant phytoplankton species in the area inferred from accessory pigment distributions were prymnesiophytes, pelagophytes, and cyanobacteria.

Cross-correlation of the various water column properties highlights the processes discussed above. Nutrients correlated positively with each other and negatively with chlorophyll *a* and oxygen. Chlorophyll *a* correlated positively with oxygen and particulate matter concentrations. These correlations reflect the process of photosynthesis and biomass formation. Particulates decreased with increasing salinity and chlorophyll *a* increased with decreasing salinity reflecting the riverine input of particulate and nutrient rich fresh water. As more data are collected these interactions will be more completely described and analyzed based on more complex statistical approaches.

2 INTRODUCTION

2.1 Program Overview

The Minerals Management Service (MMS) of the U.S. Department of the Interior supports the Northeastern Gulf of Mexico Physical Oceanography Program (NEGOM). NEGOM is divided into six oceanographic components of which one is the NEGOM Chemical Oceanography and Hydrography study (NEGOM-COH). The other NEGOM components are the inner shelf study, DeSoto Canyon eddy intrusion study, operational remote sensing study, NEGOM remote sensing study, and meteorology study; additionally, there is a modeling study component of NEGOM.

The contract for NEGOM-COH was awarded to the Texas A&M Research Foundation on 30 September 1997. 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 NEGOM-COH program. In addition to support from the MMS, financial backing for NEGOM-COH is provided by Texas A&M University, a component of the System. The System is assisted in this program by a subcontract with Dr. Robert R. Leben, Colorado Center for Astrodynamics Research, University of Colorado.

The NEGOM-COH study area, shown in Figure 2.1.1, encompasses the region of the northeastern Gulf bounded by 27.5°N, 89°W, the 10-m isobath, and the 1000-m isobath. This report focuses on the first nine months of the study, from contract award in September 1997 through June 1998.

2.2 Program Objectives

In its Request For Proposal, the MMS outlined three objectives for the NEGOM-COH study:

(1) To develop an effective and efficient oceanographic experimental design of research cruises in the NEGOM study area. The spatial coverage of these cruises should include the entire study area and be of sufficient frequency so as to resolve seasonal variations of chemical oceanography and hydrographic parameters. Variables to be measured include but are not limited to: seawater conductivity/salinity, temperature, depth, oxygen, nutrients, suspended particulate matter, and light transmission and light penetration.

(2) To collect the ancillary data needed to complement and analyze the measurements collected in objective 1; e.g., river discharge, fronts, jets and squirts, meteorological information, information related to the Loop Current and its associated intrusions. Also, to identify and obtain historical data sets of the variables measured in this study.

(3) To analyze the data collected in objectives 1 and 2 to describe spatial fields or distributions in the vertical and horizontal planes, temporal variations, budgets, variations, and processes (chemical, physical, or biological) which contribute to the production of the observed fields and distributions.

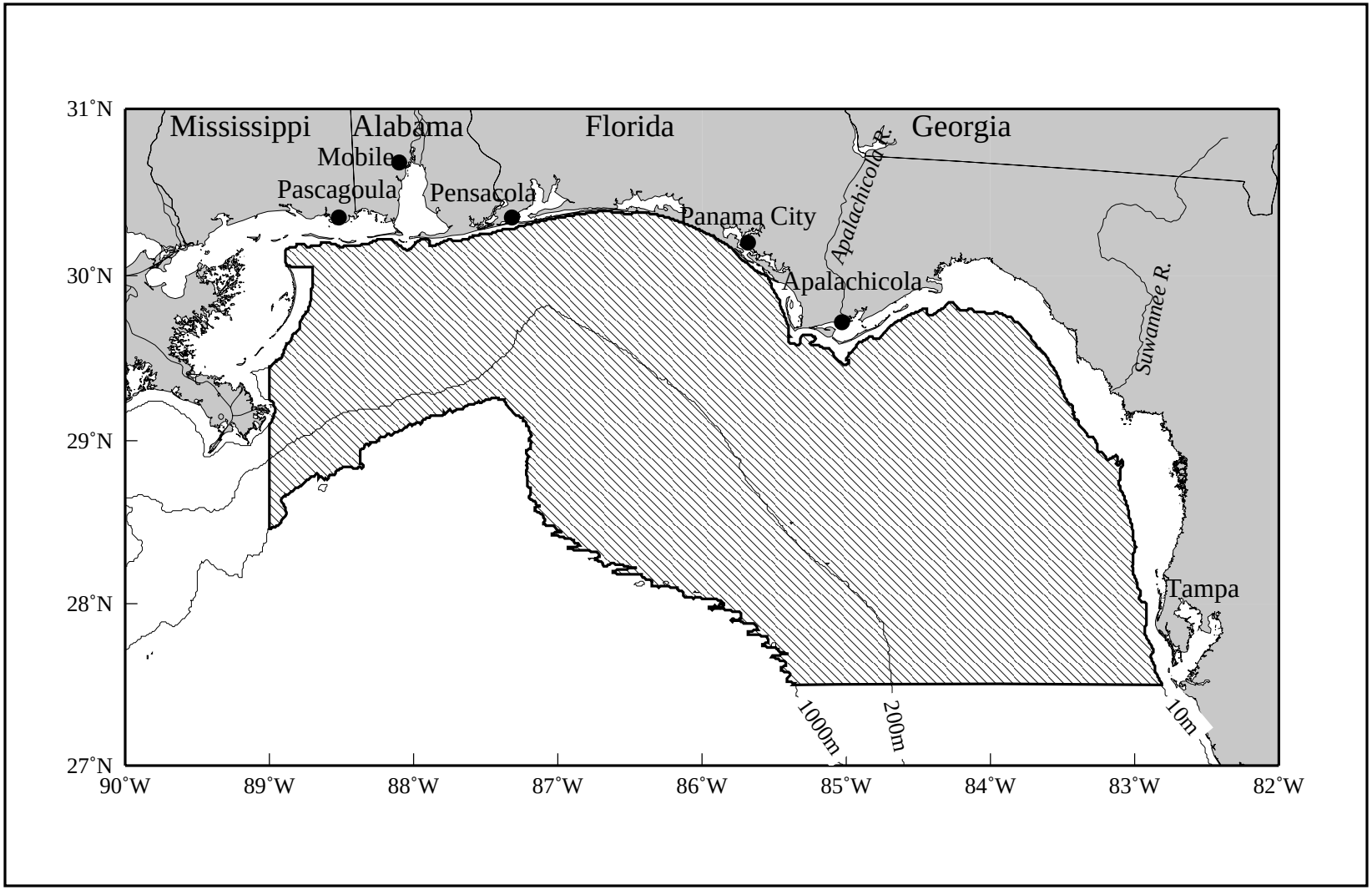


Figure 2.1.1. Study area and bathymetry of the northeastern Gulf of Mexico. Hydrography stations were located over the shelf and upper slope region within the shaded area.

A fourth objective for Texas A&M University is:

> (4) To provide a milieu in which graduate students and scientists involved with this study can use the assembled data sets to investigate the circulation and property distributions of the NEGOM study area and to educate several Ph.D. scientists, who in the process will become familiar with MMS activities and needs.

These objectives will be met through the completion of the three-year field program of observations over the northeastern Gulf of Mexico continental shelf and upper slope and the accomplishment of the tasks discussed in Section 2.3. The observations will be synthesized, interpreted, and reported to provide a better understanding of the circulation and property distributions over the shelf and upper slope, their spatial and temporal variability, and the physical and other factors responsible for them.

2.3 Program Tasks and Participants

The NEGOM-COH program consists of four tasks: a field task, a data processing task, a data synthesis task, and program management. Program management is directed by Dr. Worth D. Nowlin, Jr., Program Manager, and Dr. Ann E. Jochens, Deputy Program Manager. Data management is provided through Task 2, but with oversight by program management. Each task has Co-Principal Investigators (PI), who are responsible directly to the Program Manager for successful completion of that task.

Task 1 (Field Work and Data Collection): The Co-PIs for Task 1 are Dr. Douglas C. Biggs, Dr. Norman L. Guinasso, Jr., and Dr. Mahlon C. Kennicutt II. The goal of this task is the collection of the primary data sets that will be used in the analyses. Task 1 consists of completion of nine hydrographic/acoustic Doppler current profiling (ADCP) survey cruises over the NEGOM shelf and slope during the three field years. Cruises will be conducted in spring (April/May), summer (July/August), and fall (November). Each survey will cover 11 cross-shelf lines. Approximately 90 to 100 chemical/hydrographic stations will be occupied on each cruise. Continuous vertical profiles will be taken of conductivity, temperature, pressure, light transmission, optical backscatterance, and light penetration, as well as bottle samples for dissolved oxygen, nutrients (phosphate, silicate, nitrate and nitrite), phytoplankton pigments, particulate organic carbon, particulate matter, and salinity. Additionally, approximately 80 XBT drops will be made between the sampling stations to enhance the resolution of temperature to about 10 km. The ADCP will be operated continuously along the cruise track.

Task 2 (Data Reduction/Analysis and Synthesis): The Co-PIs for this task are Dr. Ann E. Jochens and Dr. Matthew K. Howard. The goal of this task is to provide data management and processing. Task 2 consists of the tracking of all data from its origination to final archival, quality assurance/quality control (QA/QC) processing of the data, assembly of ancillary and historical and concurrent oceanographic data sets and QA/QC of them, production of data products, and finalization and archival of the data sets and metadata.

Task 3 (Information/Data Synthesis and Technical Reports): The Co-PIs for this task are Dr. Worth D. Nowlin, Jr., Professor Robert O. Reid, and Dr. Mahlon C. Kennicutt II. The goal of this task is to analyze and synthesize the data. Task 3 consists of scientific interpretations

and comparisons to previous results, production of the Synthesis Report and Technical Reports, and preparation of scientific publications.

2.4 Overview of Cruise Schedule and Nomenclature

Two hydrographic/ADCP survey cruises were conducted in the NEGOM-COH program during the first nine months of the program. Both were conducted aboard the *R/V Gyre*. A listing of these cruises, their various designators, and their start and end dates is given in Table 2.4.1.

The NEGOM 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, G for *Gyre*, and the last two characters give the number of the ship's cruise for that year.

Table 2.4.1. Cruise identifiers and dates.

Survey No.	Start Date	End Date	NEGOM ID	Cruise ID
1	16 November 1997	26 November 1997	N1	97G14
2	5 May 1998	16 May 1998	N2	98G05

2.5 Activities of the Scientific Review Board

The NEGOM-COH Scientific Review Board (SRB) is composed of three members from the oceanographic community. Table 2.5.1 shows the members and their affiliations. The terms of reference for the SRB are:

1. Review the progress and scientific value of the study,
2. Recommend program improvements to the Program Manager and MMS Contracting Officer's Technical Representative (COTR), and
3. Provide comment on the draft synthesis report to the Program Manager and MMS COTR.

The first meeting of the SRB was on 8 December 1997. Board members were provided with background information on the MMS NEGOM Physical Oceanography Program as well as on the NEGOM-COH program, its objectives and plans, and a summary of the N1 cruise. As a result of the discussions, the SRB made recommendations that lead to the development of an integrated plan for water column chemistry and particulate studies that will improve the joint study of the particulate matter, particulate organic carbon, pigment, nutrient, and

oxygen measurements. Additionally, plans for future cruises will extend the shoreward end of the lines from the 20-m to the 10-m isobath to better observe the extent and possible sources of freshwater over the inner shelf. The SRB pointed out that with the set of measurements specified by the contract, the various budgets (heat, fresh water, other measured properties) could not be closed. They suggested adding isotopic measurements to help delineate sources of water, but acknowledged that such measurements were beyond the terms of the contract, would require additional funding, and hence were not feasible.

Table 2.5.1. Members of the NEGOM Scientific Review Board

Member	Affiliation
Dr. John M. Bane, Jr.	Department of Marine Sciences University of North Carolina
Dr. Eileen Hofmann	Department of Oceanography Old Dominion University
Dr. Stephen A. Macko	Department of Environmental Sciences University of Virginia

2.6 Report Organization

This is the first annual report of the NEGOM-COH study. It reports on the data-gathering efforts; equipment, measurement and analytical methodologies employed; results of quality control exercises and determinations; status of data archiving and data sharing with other contractors; and preliminary data analysis and results of the various data types collected. There are no extensive analyses or syntheses of the information; such will be provided in the final Synthesis Report at the conclusion of the NEGOM-COH study. Section 3 of the report details the data acquisition of the chemical oceanography, hydrography, 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 management and information transfer. Section 6 provides technical discussion of the data, with samples of data products for the various data types. All times are reported in Universal Coordinated Time (UTC) unless stated otherwise.

3 DATA ACQUISITION

3.1 Introduction

Section 3 provides an overview of the NEGOM-COH data acquisition activities. It includes a discussion of data gathering efforts on the cruises, the instrumentation, calibration, and sampling procedures, and summarizes field data collection and collateral data assembly.

3.2 General Description of Surveys

During the first nine months of the contract, two hydrographic/ADCP cruises were conducted aboard the *R/V Gyre.* A Sea-Bird SBE-911*plus* was used on each cruise. Conductivity-temperature-depth (CTD)-Rosette stations on each cruise occupied nearly identical locations. Expendable bathythermograph (XBT) probes were launched between CTD stations. Navigation data and station locations were determined using differential Global Positioning System (GPS).

Surveys consist of 11 lines of CTD and XBT stations perpendicular to the bathymetry (cross-shelf lines). Lines are numbered 1 to 11, west to east. The naming convention for cross-shelf lines is:

First and second characters:	NEGOM cruise number (N1 or N2)
Third character:	L = Line
Fourth and fifth characters:	Line number (1 through 11)
Sixth character:	S = Sequence
Seventh and eighth characters:	Sequence number of station on the line
Ninth character:	C = CTD station type; X = XBT station type

On each cross-shelf line stations are numbered sequentially from inner- to outermost, regardless of type; e.g., station N2L06S03C is the third station from the coast on line 6 and is a CTD station taken on cruise N2. Where it is clear which station type is being described, the ninth character is not included in the tables below.

In addition to cross-shelf line stations, XBTs were deployed on segments transited during the cruise between two cross-shelf lines along the 1000-m isobath. The naming convention for these stations is:

First and second characters:	NEGOM cruise number (N1 or N2)
Third character:	X = Segment between two cross-shelf lines
Fourth and fifth characters:	Starting cross-shelf line number of segment
Sixth and seventh characters:	Ending cross-shelf line number of segment
Eighth character:	Sequence number of station between lines
Ninth character:	X = XBT station type

For example, station N1X09102X is the second XBT deployed on cruise N1 between lines 9 and 10.

3.2.1 Cruise N1

The first NEGOM-COH hydrography cruise (N1) was conducted on the *R/V Gyre* from 16-26 November 1997. It was staged out of Pascagoula, MS. Dr. Douglas C. Biggs and Dr. Norman L. Guinasso, Jr., were Co-chief Scientists. Ninety-five CTD stations, including one test station located in deep water in DeSoto Canyon, were completed and 85 XBT drops were made. Figure 3.2.1 shows the locations of the CTDs and XBTs, cruise track, and line numbers. Table 3.2.1 gives station number, date, time, location, water depth, and number of bottles tripped at each CTD station. Nutrients, oxygen, and salinity were measured from every Niskin bottle sampled (Table 3.2.2). Pigments were taken at the top, chlorophyll-maximum, and at the low light regime immediately below the chlorophyll-maximum at the stations indicated in Table 3.2.2. Also at the stations shown in Table 3.2.2, total particulate matter (PM) and particulate organic carbon (POC) were measured from the top and bottom bottles and, for PM, from a middle, "clear water" bottle. Table 3.2.3 lists the location, date, time, total water depth, and probe type of the 80 XBT drops that produced usable data. Flow-through near-surface temperature, conductivity, and fluorescence were logged every 2 minutes. Surface samples were filtered and analyzed for chlorophyll *a* content to calibrate the flow-through fluorescence at 181 locations. The ADCP was operated continuously along the survey tracks in Figure 3.2.1, except when the system was shut down during long periods at a fixed location or for maintenance.

Four complementary research efforts were accommodated on N1. A marine mammal survey was conducted by Joel Ortega-Ortiz, Paco Ollevides, and Shannon Rankin, graduate students in the Marine Mammal Research Program (MMRP) at TAMU-Galveston. Survey objectives were to obtain data on the distribution and abundance of marine mammals and to compare sightings with locations of surface temperature, salinity, and fluorescence fronts. This survey collected "winter" data, which otherwise would not be available, to be used by Mr. Ortega-Ortiz in his dissertation. Twenty-five sightings, including sperm whales, bottlenose dolphins, and Atlantic spotted dolphin, were made during 49.8 hours of sea states compatible with making the observations. The volume backscatter portion of the narrow-band ADCP data was saved for use by Patrick Ressler, TAMU graduate student of Dr. Biggs, for his dissertation research. Twenty-three ARGOS-tracked drifters were launched for Dr. James M. Price of MMS. Scott Smith, graduate student of Dr. George Born and Dr. Robert Leben, Colorado Center for Astrodynamics Research (CCAR), University of Colorado, participated in the cruise as part of a training exercise to provide hands on experience in collection of *in situ* oceanographic data used to compute upper layer density, dynamic height, and geostrophic volume transport for comparison with TOPEX/Poseidon and ERS-2 radar altimetry. Further information on these complementary research programs can be obtained from the scientists involved.

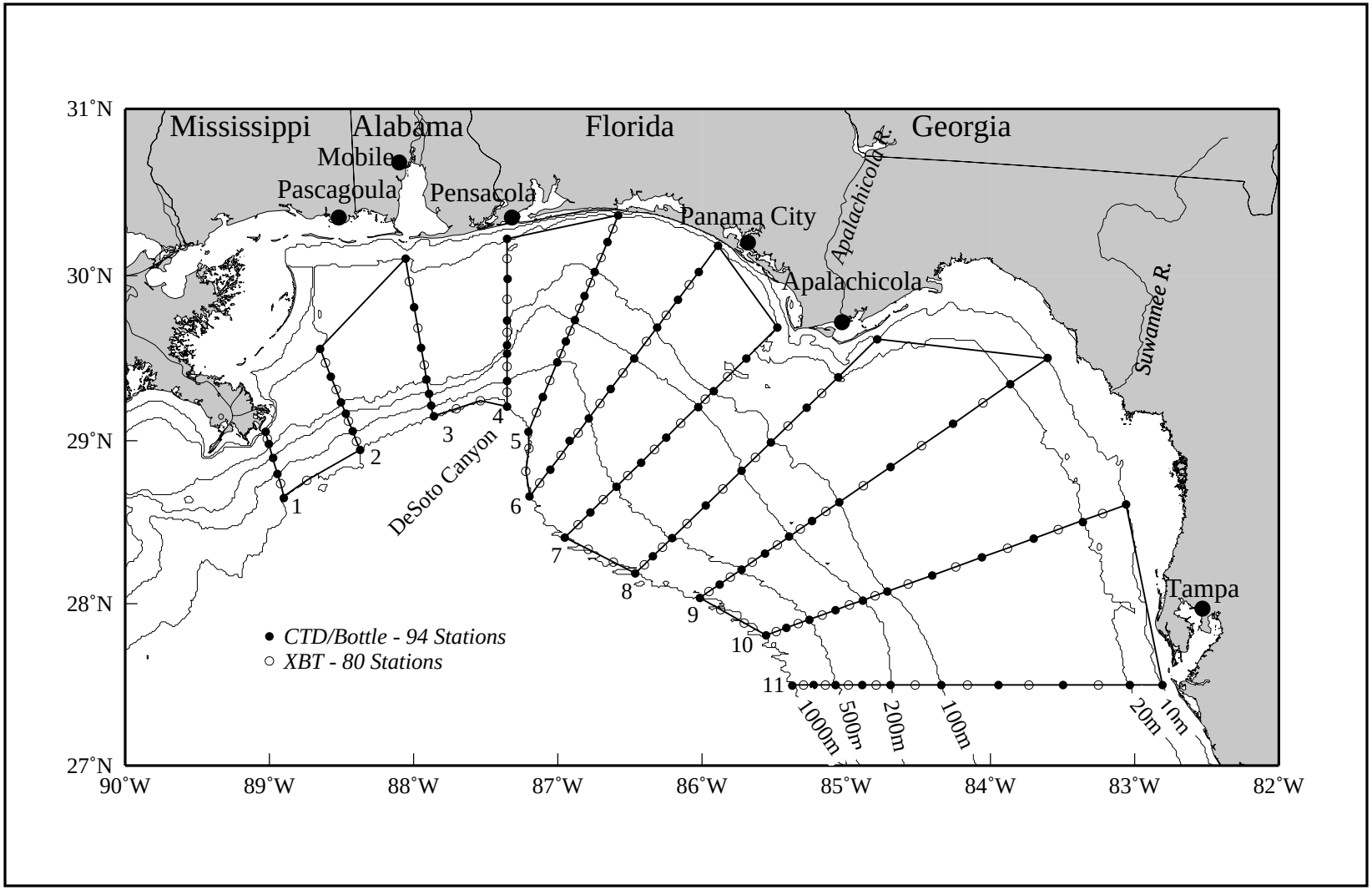


Figure 3.2.1. Station locations for cruise N1 conducted on 16-26 November 1997. Stations began with the most seaward station on line 11. The thick line shows the cruise track.

Table 3.2.1. Times and locations for CTD stations on cruise N1.

Station No.	Station Name	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Depth (m)	No. of Bottles
0	N1TEST	16Nov97	1611	28.749310	87.499733	1647	12
1	N1L11S18	17Nov97	0920	27.499062	85.368767	949	12
2	N1L11S16	17Nov97	1147	27.499727	85.226730	757	12
3	N1L11S14	17Nov97	1349	27.500324	85.073318	493	11
4	N1L11S12	17Nov97	1557	27.499887	84.888229	297	10
5	N1L11S10	17Nov97	1805	27.500694	84.691330	206	9
6	N1L11S08	17Nov97	2114	27.500345	84.340424	100	6
7	N1L11S06	18Nov97	0021	27.500866	83.944221	61	3
8	N1L11S04	18Nov97	0337	27.499847	83.496735	44	3
9	N1L11S02	18Nov97	0640	27.499735	83.034538	23	3
10	N1L11S01	18Nov97	0838	27.500288	82.808937	12	3
11	N1L10S01	18Nov97	1738	28.609074	83.058212	11	3
12	N1L10S03	18Nov97	1956	28.511597	83.359871	21	3
13	N1L10S05	18Nov97	2215	28.402309	83.700462	31	3
14	N1L10S07	19Nov97	0047	28.286621	84.059288	40	3
15	N1L10S09	19Nov97	0310	28.176432	84.403107	61	5
16	N1L10S11	19Nov97	0522	28.076170	84.715126	107	6
17	N1L10S13	19Nov97	0649	28.021812	84.885231	205	9
18	N1L10S15	19Nov97	0836	27.961775	85.073166	314	11
19	N1L10S17	19Nov97	1020	27.902920	85.254539	471	12
20	N1L10S19	19Nov97	1209	27.852697	85.414169	655	12
21	N1L10S21	19Nov97	1353	27.806704	85.556236	837	12
22	N1L09S21	19Nov97	1805	28.037813	86.014305	909	12
23	N1L09S19	19Nov97	2016	28.119335	85.877815	674	11
24	N1L09S17	19Nov97	2214	28.210890	85.724861	461	10
25	N1L09S15	20Nov97	0017	28.310986	85.564545	305	10
26	N1L09S13	20Nov97	0214	28.412527	85.395920	201	7
27	N1L09S11	20Nov97	0349	28.509565	85.236115	164	9
28	N1L09S09	20Nov97	0535	28.622660	85.048500	101	8
29	N1L09S07	20Nov97	0832	28.838697	84.694351	47	6
30	N1L09S05	20Nov97	1215	29.102646	84.258354	28	4
31	N1L09S03	20Nov97	1543	29.341705	83.864616	19	4
32	N1L09S01	20Nov97	1754	29.500784	83.603439	12	4
33	N1L08S01	21Nov97	0059	29.615448	84.784798	11	2
34	N1L08S03	21Nov97	0331	29.383841	85.059967	27	4
35	N1L08S05	21Nov97	0529	29.200623	85.274353	41	4
36	N1L08S07	21Nov97	0744	28.987127	85.523590	89	7
37	N1L08S09	21Nov97	0952	28.815586	85.726204	202	12
38	N1L08S11	21Nov97	1233	28.602388	85.975792	309	12
39	N1L08S13	21Nov97	1458	28.403442	86.208382	488	12
40	N1L08S15	21Nov97	1649	28.291426	86.340813	680	12
41	N1L08S17	21Nov97	1838	28.187622	86.462677	861	12
42	N1L07S17	21Nov97	2306	28.406805	86.950111	920	12
43	N1L07S15	22Nov97	0123	28.561338	86.774948	668	12
44	N1L07S13	22Nov97	0331	28.717888	86.593620	483	12
45	N1L07S11	22Nov97	0523	28.865520	86.422989	381	12
46	N1L07S09	22Nov97	0720	29.019217	86.246567	316	12
47	N1L07S07	22Nov97	0941	29.207230	86.030098	201	12

Table 3.2.1. Times and locations for CTD stations on cruise N1. (continued)

Station No.	Station Name	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Depth (m)	No. of Bottles
48	N1L07S05	22Nov97	1120	29.301142	85.917992	89	9
49	N1L07S03	22Nov97	1332	29.500051	85.694138	32	5
50	N1L07S01	22Nov97	1532	29.687513	85.478691	20	3
51	N1L06S01	22Nov97	1935	30.179249	85.889397	21	49
52	N1L06S03	22Nov97	2100	30.021797	86.024063	32	50
53	N1L06S05	22Nov97	2231	29.855406	86.167320	46	5
54	N1L06S07	23Nov97	0007	29.686567	86.310677	100	8
55	N1L06S09	23Nov97	0204	29.499847	86.471741	204	12
56	N1L06S11	23Nov97	0405	29.314325	86.631767	383	12
57	N1L06S13	23Nov97	0604	29.136023	86.784607	495	12
58	N1L06S15	23Nov97	0813	28.982317	86.916611	612	12
59	N1L06S17	23Nov97	1007	28.823877	87.052460	769	12
60	N1L06S19	23Nov97	1208	28.660032	87.194489	988	12
61	N1L05S17	23Nov97	1558	29.054808	87.205414	999	12
62	N1L05S15	23Nov97	1830	29.266186	87.104042	722	12
63	N1L05S13	23Nov97	2044	29.477409	87.003250	467	12
64	N1L05S11	23Nov97	2213	29.602955	86.945335	267	12
65	N1L05S09	23Nov97	2337	29.730562	86.882683	197	12
66	N1L05S07	24Nov97	0106	29.876736	86.813484	150	9
67	N1L05S05	24Nov97	0230	30.021139	86.742737	106	6
68	N1L05S03	24Nov97	0406	30.203087	86.655174	29	3
69	N1L05S01	24Nov97	0528	30.362062	86.580078	21	3
70	N1L04S01	24Nov97	1000	30.222710	87.352554	18	4
71	N1L04S03	24Nov97	1151	29.979179	87.349907	30	4
72	N1L04S05	24Nov97	1352	29.727448	87.351273	76	6
73	N1L04S07	24Nov97	1512	29.581331	87.351730	96	8
74	N1L04S08	24Nov97	1557	29.528294	87.351486	215	12
75	N1L04S10	24Nov97	1758	29.363253	87.349693	530	12
76	N1L04S12	24Nov97	1941	29.206631	87.350716	972	12
77	N1L03S10	25Nov97	0004	29.148699	87.860786	1022	12
78	N1L03S09	25Nov97	0146	29.213388	87.876587	482	12
79	N1L03S08	25Nov97	0259	29.284292	87.891296	196	12
80	N1L03S07	25Nov97	0408	29.373623	87.910454	83	6
81	N1L03S05	25Nov97	0545	29.563038	87.947861	43	5
82	N1L03S03	25Nov97	0739	29.808809	87.997147	35	4
83	N1L03S01	25Nov97	1002	30.101908	88.057365	21	4
84	N1L02S01	25Nov97	1719	29.558437	88.648354	21	4
85	N1L02S03	25Nov97	1855	29.389769	88.573082	59	5
86	N1L02S05	25Nov97	2021	29.233723	88.503448	101	6
87	N1L02S06	25Nov97	2109	29.165079	88.471268	203	12
88	N1L02S08	25Nov97	2221	29.057812	88.423119	451	12
89	N1L02S10	25Nov97	2347	28.943420	88.369881	933	12
90	N1L01S07	26Nov97	0439	28.660421	88.899185	1008	12
91	N1L01S05	26Nov97	0635	28.797829	88.943611	515	12
92a	N1L01S04	26Nov97	0805	28.895662	88.975471	202	0
92	N1L01S04	26Nov97	0852	28.894756	88.974716	202	11
93	N1L01S03	26Nov97	0959	28.979004	89.003159	85	8
94	N1L01S01	26Nov97	1056	29.054827	89.027435	24	4

Table 3.2.2. Number of bottles sampled by variable on cruise N1.

Station no.	Name	Nutrients	Oxygen	Salinity	Pigments	POC*	PM*
0	N1TEST	12	12	12			
1	N1L11S18	12	12	12	3	2	3
2	N1L11S16	12	12	12			
3	N1L11S14	11	11	11	3	2	3
4	N1L11S12	10	10	10			
5	N1L11S10	9	9	9	3	2	3
6	N1L11S08	6	6	6	3	2	3
7	N1L11S06	3	3	3			
8	N1L11S04	3	3	3		2	3
9	N1L11S02	3	3	3	3	2	3
10	N1L11S01	3	3	3			
11	N1L10S01	3	3	3	3		
12	N1L10S03	3	3	3		2	3
13	N1L10S05	3	3	3	3	2	3
14	N1L10S07	3	3	3		2	3
15	N1L10S09	5	5	5	3		
16	N1L10S11	6	6	6	3	2	3
17	N1L10S13	9	9	9	3	2	3
18	N1L10S15	11	11	11			
19	N1L10S17	12	12	12	3	2	3
20	N1L10S19	12	12	12			
21	N1L10S21	12	12	12	3	2	3
22	N1L09S21	12	12	12	3	2	3
23	N1L09S19	11	11	11			
24	N1L09S17	10	10	10	3	2	3
25	N1L09S15	10	10	10			
26	N1L09S13	7	7	7	3	2	3
27	N1L09S11	9	9	9			
28	N1L09S09	8	8	8	3	2	3
29	N1L09S07	6	6	6		2	3
30	N1L09S05	4	4	4	3	2	3
31	N1L09S03	4	4	4		2	3
32	N1L09S01	4	4	4	3		
33	N1L08S01	2	2	2			
34	N1L08S03	4	4	4	3	2	3
35	N1L08S05	4	4	4			
36	N1L08S07	7	7	7	3	2	3
37	N1L08S09	12	12	12	3	2	3
38	N1L08S11	12	12	12			
39	N1L08S13	12	12	12	3	2	3
40	N1L08S15	12	12	12			
41	N1L08S17	12	12	12	3	2	3
42	N1L07S17	12	12	12		2	3
43	N1L07S15	12	12	12			
44	N1L07S13	12	12	12	11	2	3
45	N1L07S11	12	12	12			
46	N1L07S09	12	12	12			
47	N1L07S07	12	12	12	3	2	3
48	N1L07S05	9	9	9	3	2	3

Table 3.2.2. Number of bottles sampled by variable on cruise N1. (continued)

Station no.	Name	Nutrients	Oxygen	Salinity	Pigments	POC*	PM*
49	N1L07S03	5	5	5			
50	N1L07S01	3	3	3	3	2	3
51	N1L06S01	3	3	3		2	3
52	N1L06S03	4	4	4	3		
53	N1L06S05	5	5	5			
54	N1L06S07	8	8	8	3	2	3
55	N1L06S09	12	12	12	4	2	3
56	N1L06S11	12	12	12			
57	N1L06S13	12	12	12	3	2	3
58	N1L06S15	12	12	12			
59	N1L06S17	12	12	12			
60	N1L06S19	12	12	12	3	2	3
61	N1L05S17	12	12	12	3	2	3
62	N1L05S15	12	12	12			
63	N1L05S13	12	12	12	3	2	3
64	N1L05S11	12	12	12			
65	N1L05S09	12	12	12	3	2	3
66	N1L05S07	9	9	9			
67	N1L05S05	6	6	6	3	2	3
68	N1L05S03	3	3	3			
69	N1L05S01	3	3	3	3	2	3
70	N1L04S01	4	4	4	3	2	3
71	N1L04S03	4	4	4			
72	N1L04S05	6	6	6	3		
73	N1L04S07	8	8	8		2	3
74	N1L04S08	12	12	12	12	2	3
75	N1L04S10	12	12	12	3	2	3
76	N1L04S12	12	12	12		2	3
77*	N1L03S10	24	12	12	0	2	3
78	N1L03S09	12	12	12		2	3
79	N1L03S08	12	12	12	12	2	3
80	N1L03S07	6	6	6		2	3
81	N1L03S05	5	5	5	3		
82	N1L03S03	4	4	4			
83	N1L03S01	4	4	4	3	2	3
84**	N1L02S01	4	4	4	3	2	3
85**	N1L02S03	5	5	5			
86**	N1L02S05	6	6	6	6	2	3
87**	N1L02S06	12	12	12		2	3
88**	N1L02S08	12	12	12	3	2	3
89**	N1L02S10	12	12	12	3	2	3
90**	N1L01S07	12	12	12		2	3
91**	N1L01S05	12	12	12	3	2	3
92**	N1L01S04	11	11	11		2	4
93**	N1L01S03	8	8	8	3	2	4
94**	N1L01S01	4	4	4		2	3
	Total	810	798	798	183	120	182

* POC = particulate organic carbon; PM = total particulate material

** Station 77: 12 fresh and 12 frozen nutrient samples; stations 84-94: frozen nutrients.

Table 3.2.3. Launch times and locations for XBT drops on cruise N1.

Sequence No.	Station Name	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Water Depth (m)	Probe Type
1	N1L11S17	17Nov97	1105	27.499493	85.294815	815	T07
2	N1L11S15	17Nov97	1314	27.499027	85.145432	633	T07
3	N1L11S13	17Nov97	1511	27.499983	84.985245	385	T07
4	N1L11S11	17Nov97	1709	27.498884	84.790550	225	T07
5	N1L11S09	17Nov97	1949	27.499889	84.523376	140	T10
6	N1L11S07	17Nov97	2249	27.500355	84.159676	72	T10
7	N1L11S05	18Nov97	0200	27.500025	83.732841	51	T10
8	N1L11S03	18Nov97	0515	27.500177	83.249779	34	T10
9	N1L10S02	18Nov97	1857	28.547583	83.222000	19	T10
10*	N1L10S04	18Nov97	2107	28.456047	83.527962	27	T10
11	N1L10S06	18Nov97	2337	28.344082	83.882431	37	T10
12	N1L10S08	19Nov97	0204	28.226807	84.240593	50	T10
13	N1L10S10	19Nov97	0424	28.123253	84.569160	75	T10
14	N1L10S12	19Nov97	0611	28.049746	84.799347	151	T10
16	N1L10S14	19Nov97	0801	27.984003	84.999680	269	T07
17	N1L10S16	19Nov97	0942	27.931435	85.167114	397	T07
18	N1L10S18	19Nov97	1129	27.879086	85.333260	569	T07
20	N1L10S20	19Nov97	1321	27.828840	85.488350	751	T07
22	N1X09102	19Nov97	1550	27.883892	85.708656	901	T07
23	N1X09101	19Nov97	1659	27.966019	85.872101	909	T07
24	N1L09S20	19Nov97	1933	28.075527	85.951012	790	T07
25	N1L09S18	19Nov97	2134	28.165762	85.801842	562	T07
26	N1L09S16	19Nov97	2321	28.256172	85.652702	377	T07
27	N1L09S14	20Nov97	0130	28.362200	85.478935	243	T07
28	N1L09S12	20Nov97	0307	28.458967	85.318840	178	T07
29	N1L09S10	20Nov97	0451	28.568300	85.138794	131	T10
30	N1L09S08	20Nov97	0700	28.720230	84.888435	57	T10
31	N1L09S06	20Nov97	1026	28.971188	84.476280	38	T10
32	N1L09S04	20Nov97	1411	29.228071	84.051979	31	T10
33	N1L08S04	21Nov97	0433	29.288862	85.170059	32	T10
34	N1L08S06	21Nov97	0641	29.089809	85.403755	56	T10
35	N1L08S08	21Nov97	0855	28.898527	85.628120	176	T10
36	N1L08S10	21Nov97	1128	28.706642	85.854607	263	T10
37	N1L08S12	21Nov97	1405	28.492701	86.104523	378	T07
38	N1L08S14	21Nov97	1612	28.347946	86.274048	588	T07
39	N1L08S16	21Nov97	1803	28.240488	86.400391	787	T07
40	N1X07082	21Nov97	2038	28.256838	86.615105	871	T07
41	N1X07081	21Nov97	2148	28.336365	86.787109	895	T07
42	N1L07S16	22Nov97	0043	28.493979	86.849205	774	T07
43	N1L07S14	22Nov97	0245	28.639265	86.683853	567	T07
44	N1L07S12	22Nov97	0438	28.787140	86.513809	425	T07
45	N1L07S10	22Nov97	0637	28.947083	86.329826	345	T07
46	N1L07S08	22Nov97	0838	29.104445	86.149017	274	T07
48	N1L07S06	22Nov97	1044	29.252502	85.979233	161	T10
49*	N1L07S04	22Nov97	1226	29.387835	85.822762	54	T10
50	N1L06S04	22Nov97	2144	29.944937	86.090157	41	T10
51	N1L06S06	22Nov97	2326	29.761675	86.246155	67	T10
52	N1L06S08	23Nov97	0105	29.601536	86.385162	134	T10

Table 3.2.3. Launch times and locations for XBT drops on cruise N1. (continued)

Sequence No.	Station Name	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Water Depth (m)	Probe Type
53	N1L06S10	23Nov97	0312	29.410658	86.549126	291	T07
54	N1L06S12	23Nov97	0519	29.218630	86.712578	434	T07
55	N1L06S14	23Nov97	0736	29.047285	86.860748	566	T07
56	N1L06S16	23Nov97	0926	28.910133	86.979248	690	T07
57	N1L06S18	23Nov97	1128	28.740263	87.125198	871	T07
58	N1X05062	23Nov97	1407	28.812738	87.221603	984	T07
60	N1X05061	23Nov97	1509	28.953997	87.200569	975	T07
61	N1L05S16	23Nov97	1744	29.172768	87.148682	843	T07
62	N1L05S14	23Nov97	1954	29.366842	87.056137	666	T07
63	N1L05S12	23Nov97	2136	29.527746	86.978165	356	T07
64	N1L05S10	23Nov97	2306	29.670389	86.910278	220	T07
65	N1L05S08	24Nov97	0029	29.803795	86.846939	170	T10
66	N1L05S06	24Nov97	0157	29.956518	86.773941	125	T10
67	N1L05S04	24Nov97	0321	30.109041	86.700615	30	T10
68	N1L05S02	24Nov97	0447	30.282692	86.617920	29	T10
69	N1L04S02	24Nov97	1102	30.103001	87.350998	34	T10
70	N1L04S04	24Nov97	1254	29.856909	87.350563	48	T10
71	N1L04S06	24Nov97	1435	29.656986	87.350761	83	T10
72	N1L04S09	24Nov97	1703	29.449972	87.350655	353	T07
73	N1L04S11	24Nov97	1900	29.290953	87.350975	803	T07
74	N1X03042	24Nov97	2153	29.244528	87.557907	896	T07
75	N1X03041	24Nov97	2251	29.194942	87.705391	982	T07
76	N1L03S06	25Nov97	0458	29.458872	87.926964	61	T10
77	N1L03S04	25Nov97	0644	29.683958	87.969337	44	T10
78	N1L03S02	25Nov97	0859	29.963360	88.027641	35	T10
79	N1L02S02	25Nov97	1809	29.474285	88.610893	46	T10
80	N1L02S04	25Nov97	1940	29.311489	88.538147	66	T10
81	N1L02S07	25Nov97	2151	29.117830	88.450645	305	T07
82	N1L02S09	25Nov97	2318	28.995117	88.396095	757	T07
84	N1X01021	26Nov97	0320	28.757139	88.740234	955	T07
85	N1L01S06	26Nov97	0607	28.741903	88.927406	729	T07
86	N1L01S02	26Nov97	1035	29.012381	89.014755	64	T10

* Trace is suspect; data file may be removed after further evaluation.
Launches at missing sequence numbers were failures, except sequence number 59 had no XBT launch.

3.2.2 Cruise N2

The second NEGOM-COH hydrography cruise (N2) was conducted aboard the *R/V Gyre* 4-16 May 1998. It was staged out of Pascagoula, MS. Dr. Douglas C. Biggs and Dr. Norman L. Guinasso, Jr., were Co-chief Scientists. Ninety-nine CTD stations, including one test station, were completed and 107 XBT drops were made. Figure 3.2.2 shows the CTD and XBT locations and the cruise track. The test station was taken approximately at the location of the seawardmost CTD station on line 4 (N2L04S12). The cruise track starts at this location and runs along the 1000-m isobath to the seawardmost station on line 11 where

the CTD/XBT station series began. XBTs were dropped along this 1000-m track. Only the locations of the 97 successful XBT drops are shown in Figure 3.2.2.

Station number, date, time, location, water depth, and number of bottles tripped at each CTD station are shown in Table 3.2.4. Nutrients and oxygen were measured from every Niskin bottle depth sampled (Table 3.2.5). Salinity was measured at all bottles only at the most shoreward and most offshore stations (Table 3.2.5). Pigments were measured at the top bottle, the chlorophyll-maximum, and the low light regime immediately below the chlorophyll-maximum on the stations indicated in Table 3.2.5. PM and POC were measured from the top and bottom bottles and, for PM, from a middle, "clear water" bottle at the stations shown in Table 3.2.5. Because PM, POC, and pigments were sampled on the same stations and from the same depths for the surface and for bottom samples in shallow depths, two bottles were tripped at the same depth for a number of the stations. This assured adequate water was available for each sample type. Such cases are noted in Table 3.2.5. The location, date, time, total water depth, and probe type of the 97 successful XBT drops are listed in Table 3.2.6. Flow-through near-surface temperature, conductivity, and fluorescence were logged every 2 minutes. Surface samples were filtered and analyzed for chlorophyll *a* content to calibrate the flow-through fluorescence at 71 locations. The ADCP was operated continuously along the survey tracks shown in Figure 3.2.2, except when the system was shut down during long periods at a fixed location or for maintenance.

Six complementary research efforts were accommodated on cruise N2. A marine mammal survey was conducted by Joel Ortega-Ortiz with Cathy Zoller, MMRP intern, and Alberto Delgado-Estrella, graduate student from the Universidad Nacional Autonoma de Mexico. Mr. Ortega-Ortiz will use the data in his dissertation. Seventy-four sightings, including humpback whales, killer whales, pigmy killer whales, pantropical spotted dolphins, Atlantic spotted dolphins, spinner dolphins, and bottlenose dolphins, were made during 74.8 hours with reasonable sea states for observing. Plankton net tows were made at eleven stations for Rebecca Scott, graduate student of Dr. Biggs, for her thesis research on correlation of standing stocks of zooplankton and micronekton with volume backscatter from moored ADCP. Twenty-nine ARGOS-tracked drifters were launched for Dr. James M. Price of MMS. Suzanne Barth, a graduate student of Dr. Born and Dr. Leben of CCAR, participated in the cruise as part of the training exercises for students of satellite altimetry. Atmospheric sampling for hydrocarbon compounds was carried out by Dr. David Wylie, Geochemical and Environmental Research Group, TAMU, at five stations. Data will be used to examine atmospheric deposition of organic contaminants from combustion sources. Denis Nadeau and Bisman Nababan, graduate students of Dr. Frank Muller-Karger, University of South Florida, made bio-optical measurements of downwelling and sea-leaving radiance. They used a multichannel Marine Environmental Radiometer twice daily about 1000-1100 and 1400-1600 local time. The main objective was to calibrate a SeaWiFS satellite receiver to produce an algorithm for chlorophyll concentration estimates in the Gulf of Mexico using SeaWiFS satellite imagery. Further information on these complementary research programs can be obtained from the scientists involved.

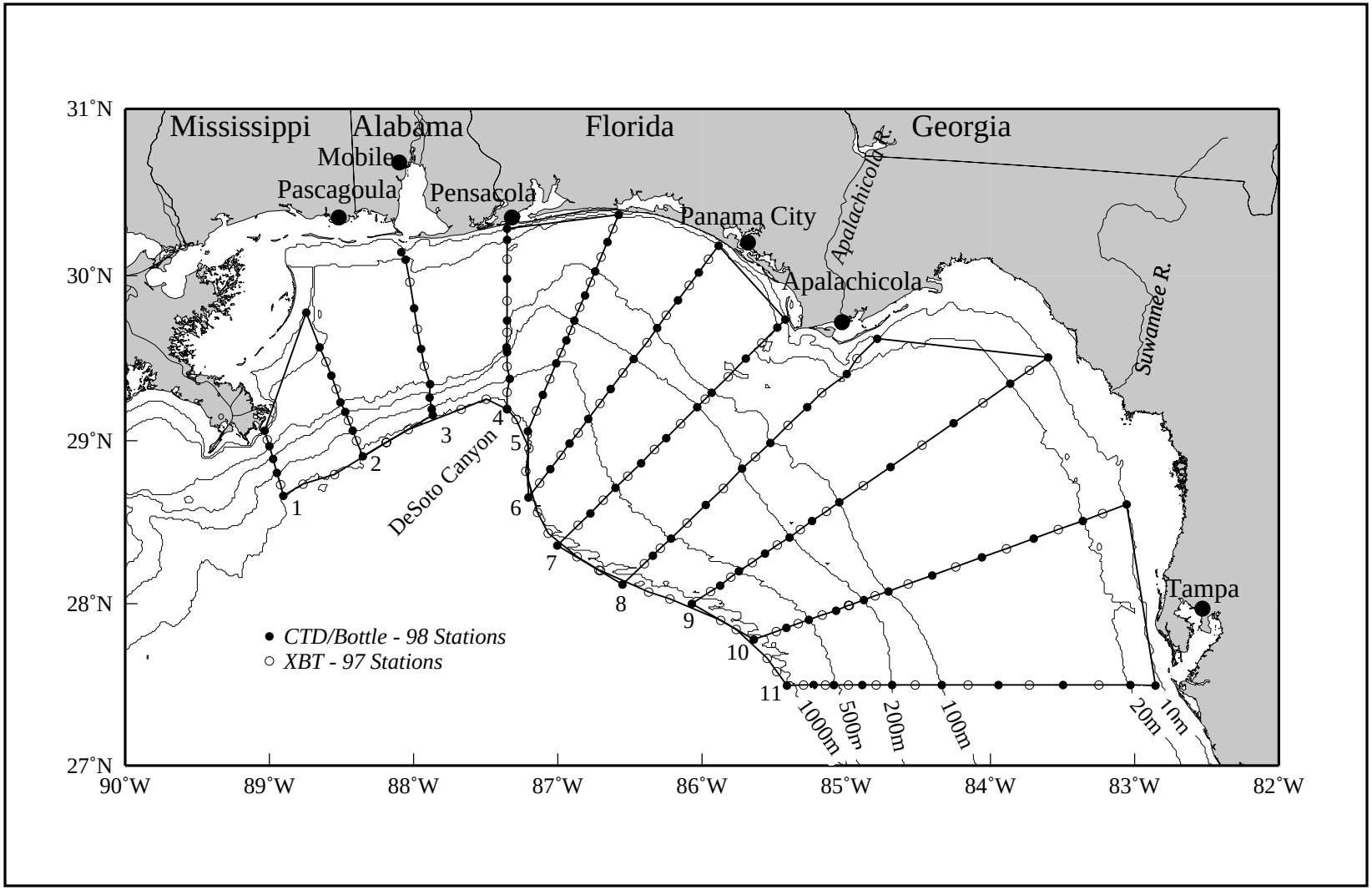


Figure 3.2.2. Station locations for cruise N2 conducted on 5-16 May 1998. CTD stations began with the most seaward station on line 11. The thick line shows the cruise track, which began at the location of the most seaward station on line 4.

Table 3.2.4. Times and positions for CTD stations on cruise N2.

Station No.	Station Name	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Depth (m)	No. of Bottles
1	N2TEST04	05May98	1033	29.194157	87.350777	994	11
2	N2L11S18	06May98	0555	27.497791	85.412880	1044	12
3	N2L11S16	06May98	0834	27.500227	85.226357	752	12
4	N2L11S14	06May98	1025	27.500427	85.083366	505	12
5	N2L11S12	06May98	1217	27.499514	84.889099	296	12
6	N2L11S10	06May98	1405	27.500841	84.682953	201	12
7	N2L11S08	06May98	1639	27.499132	84.337898	98	7
8	N2L11S06	06May98	1935	27.500950	83.943665	58	10
9	N2L11S04	06May98	2253	27.500519	83.495682	43	5
10	N2L11S02	07May98	0202	27.499531	83.030556	22	8*
11	N2L11S01	07May98	0325	27.497248	82.853844	13	4
12	N2L10S01	07May98	1137	28.609491	83.055717	10	4
13	N2L10S03	07May98	1348	28.510418	83.357506	21	4
14	N2L10S05	07May98	1617	28.400707	83.700920	31	9*
15	N2L10S07	07May98	1912	28.287144	84.059280	38	8*
16	N2L10S09	07May98	2153	28.174759	84.404205	60	8*
17	N2L10S11	08May98	0009	28.076658	84.706581	102	9*
18	N2L10S13	08May98	0142	28.023066	84.877800	200	9*
19	N2L10S15	08May98	0341	27.959328	85.071243	313	10
20	N2L10S17	08May98	0541	27.902515	85.258316	474	12
21	N2L10S19	08May98	0749	27.852917	85.413101	655	12
22	N2L10S21	08May98	1034	27.780764	85.640594	1018	12
23	N2L09S21	08May98	1454	28.001720	86.068863	1082	12
24	N2L09S19	08May98	1754	28.112453	85.874298	683	12
25	N2L09S17	08May98	1952	28.199907	85.743912	488	12
26	N2L09S15	08May98	2153	28.309742	85.562500	306	11
27	N2L09S13	08May98	2346	28.408751	85.393204	202	12
28	N2L09S11	09May98	0127	28.507963	85.235664	165	10
29	N2L09S09	09May98	0312	28.622606	85.047707	101	8
30	N2L09S07	09May98	0604	28.838682	84.694054	48	7*
31	N2L09S05	09May98	0927	29.105530	84.257202	29	5
32	N2L09S03	09May98	1230	29.345034	83.862595	21	4
33	N2L09S01	09May98	1434	29.505407	83.600090	12	4
34	N2L08S01	09May98	2151	29.619499	84.785599	10	4
35	N2L08S03	10May98	0004	29.403708	84.996696	23	8
36	N2L08S05	10May98	0236	29.204945	85.271286	38	8
37	N2L08S07	10May98	0513	28.987070	85.525444	92	6
38	N2L08S09	10May98	0721	28.828913	85.723267	200	12
39	N2L08S11	10May98	1032	28.606281	85.972855	308	12
40	N2L08S13	10May98	1338	28.401497	86.214516	498	12
41	N2L08S15	10May98	1541	28.294769	86.339844	679	12*
42	N2L08S17	10May98	1838	28.119892	86.550201	1054	12
43	N2L07S17	10May98	2248	28.358130	87.002289	1050	12
44	N2L07S15	11May98	0158	28.556288	86.773643	673	12
45	N2L07S13	11May98	0424	28.711714	86.598694	490	12
46	N2L07S11	11May98	0645	28.860792	86.422981	383	12
47	N2L07S09	11May98	0901	29.015867	86.247559	318	12
48	N2L07S07	11May98	1138	29.204786	86.031761	204	12

Table 3.2.4. Times and positions for CTD stations on cruise N2. (continued)

Station No.	Station Name	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Depth (m)	No. of Bottles
49	N2L07S05	11May98	1308	29.292496	85.931633	115	7
50	N2L07S03	11May98	1540	29.499626	85.695610	33	6
51	N2L07S01	11May98	1811	29.686098	85.478584	21	5
52	N2L07S00	11May98	1915	29.736462	85.421486	12	3
53	N2L06S01	11May98	2356	30.179028	85.885300	21	8
54	N2L06S03	12May98	0137	30.018040	86.022026	32	5
55	N2L06S05	12May98	0313	29.851822	86.165749	48	6
56	N2L06S07	12May98	0453	29.683830	86.310333	101	7
57	N2L06S09	12May98	0710	29.496716	86.474190	206	12
58	N2L06S11	12May98	0906	29.312679	86.632530	386	12
59	N2L06S13	12May98	1101	29.132362	86.787949	500	12
60	N2L06S15	12May98	1256	28.983559	86.917076	615	12
61	N2L06S17	12May98	1456	28.827246	87.052689	770	12
62	N2L06S19	12May98	1718	28.653580	87.202553	997	12
63	N2L05S17	12May98	2052	29.056959	87.209129	1002	12
64	N2L05S15	12May98	2317	29.276583	87.103600	703	12
65	N2L05S13	13May98	0129	29.469292	87.009819	482	12
66	N2L05S11	13May98	0258	29.607313	86.942505	263	12
67	N2L05S09	13May98	0418	29.729067	86.883873	197	7
68	N2L05S07	13May98	0623	29.880575	86.812157	149	7
69	N2L05S05	13May98	0748	30.025232	86.741051	103	7
70	N2L05S03	13May98	0936	30.203409	86.654869	29	4
71	N2L05S01	13May98	1103	30.365486	86.578308	19	4
72	N2L04S00	13May98	1751	30.282566	87.350700	12	4
73	N2L04S01	13May98	1833	30.216316	87.350136	24	6*
74	N2L04S03	13May98	2032	29.979082	87.350487	30	5
75	N2L04S05	13May98	2234	29.729082	87.350151	78	7
76	N2L04S07	13May98	2358	29.568317	87.355247	97	6
77	N2L04S08	14May98	0031	29.537817	87.352547	161	8
78	N2L04S10	14May98	0219	29.374399	87.333870	506	12
79	N2L04S12	14May98	0436	29.188900	87.351799	1012	12
80	N2L01S07	14May98	1531	28.661734	88.902451	1006	12
81	N2L01S05	14May98	1822	28.802917	88.947800	509	11
82	N2L01S04	14May98	1947	28.888666	88.975517	217	12
83	N2L01S03	14May98	2048	28.964649	88.998901	95	7
84	N2L01S01	14May98	2207	29.060551	89.033180	17	5*
85	N2L02S00	15May98	0259	29.777983	88.745514	16	4
86	N2L02S01	15May98	0443	29.568100	88.650299	21	5
87	N2L02S03	15May98	0613	29.394133	88.571716	59	5
88	N2L02S05	15May98	0738	29.231750	88.505684	102	8*
89	N2L02S06	15May98	0844	29.173250	88.474335	200	12
90	N2L02S08	15May98	1027	29.059032	88.421387	439	12
91	N2L02S10	15May98	1213	28.903534	88.351982	976	12
92	N2L03S10	15May98	1616	29.156134	87.866180	992	12
93	N2L03S09	15May98	1750	29.190165	87.875107	691	12
94	N2L03S08	15May98	1924	29.261368	87.890259	276	12
95	N2L03S07	15May98	2024	29.341679	87.885353	99	6
96	N2L03S05	15May98	2225	29.558205	87.947334	42	4

Table 3.2.4. Times and positions for CTD stations on cruise N2. (continued)

Station No.	Station Name	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Depth (m)	No. of Bottles
97	N2L03S03	16May98	0015	29.803570	87.996742	37	4
98	N2L03S01	16May98	0218	30.096447	88.054970	22	6
99	N2L03S00	16May98	0256	30.142124	88.085495	14	4

* samples (usually POC/PM and pigments) were split between two bottles tripped at the same depth

Table 3.2.5. Number of bottles sampled by variable on cruise N2.

Station no.	Name	Nutrients	Oxygen	Salinity	Pigments	POC*	PM*
1	N2TEST04	11	11	11			
2	N2L11S18	12	12	12	3	2	3
3	N2L11S16	12	12				
4	N2L11S14	12	12		3	2	3
5	N2L11S12	12	12				
6	N2L11S10	12	12		3	2	3
7	N2L11S08	7	7		3	2	3
8	N2L11S06	5	10				
9	N2L11S04	5	5		3	2	3
10	N2L11S02	6	6		3	2	3
11	N2L11S01	4	4	4			
12	N2L10S01	4	4	4	2		
13	N2L10S03	4	4		3	2	3
14	N2L10S05	8	8		8	2	3
15	N2L10S07	7	7			2	3
16	N2L10S09	7	7				
17	N2L10S11	8	8		3	2	3
18	N2L10S13	9	9		3	2	3
19	N2L10S15	10	10				
20	N2L10S17	12	12		3	2	3
21	N2L10S19	12	12				
22	N2L10S21	12	12	12	3	2	3
23	N2L09S21	12	12	12	3	2	3
24	N2L09S19	12	12				
25	N2L09S17	12	12		3	2	3
26	N2L09S15	11	11				
27	N2L09S13	12	12		3	2	3
28	N2L09S11	10	10				
29	N2L09S09	8	8		3	2	3
30	N2L09S07	6	6		3	2	4
31	N2L09S05	5	5		2	2	3
32	N2L09S03	4	4		2	2	3
33	N2L09S01	4	4	4			
34	N2L08S01	4	4	4			
35	N2L08S03	8	8		3	2	4
36	N2L08S05	8	8				
37	N2L08S07	6	6		3	2	3

Table 3.2.5. Number of bottles sampled by variable on cruise N2. (continued)

Station no.	Name	Nutrients	Oxygen	Salinity	Pigments	POC*	PM*
38	N2L08S09	12	12		10	2	3
39	N2L08S11	12	12				
40	N2L08S13	12	12		4	2	3
41	N2L08S15	11	11				
42	N2L08S17	12	12	12	3	2	3
43	N2L07S17	12	12	12	3	2	3
44	N2L07S15	12	12				
45	N2L07S13	12	12		3	2	3
46	N2L07S11	12	12				
47	N2L07S09	12	12				
48	N2L07S07	12	12		3	2	3
49	N2L07S05	7	7		3	2	3
50	N2L07S03	6	6		3		
51	N2L07S01	5	5		3	2	3
52	N2L07S00	3	3	3			
53	N2L06S01	8	8	8		2	3
54	N2L06S03	5	5				
55	N2L06S05	6	6				
56	N2L06S07	7	7		3	2	3
57	N2L06S09	12	12		3	2	5
58	N2L06S11	12	12				
59	N2L06S13	12	12		3	2	4
60	N2L06S15	12	12				
61	N2L06S17	12	12		3		
62	N2L06S19	12	12	12	3	2	3
63	N2L05S17	12	11	12	3	2	3
64	N2L05S15	12	12				
65	N2L05S13	12	12		3	2	3
66	N2L05S11	12	12				
67	N2L05S09	7	7		3	2	3
68	N2L05S07	7	7				
69	N2L05S05	7	7		4	2	4
70	N2L05S03	4	4				
71	N2L05S01	4	4	4	2	2	3
72	N2L04S00	4	4	4			
73	N2L04S01	5	5		3	2	3
74	N2L04S03	5	5				
75	N2L04S05	7	7				
76	N2L04S07	6	6		3	2	3
77	N2L04S08	8	8		3	2	3
78	N2L04S10	12	12		3	2	3
79	N2L04S12	12	12	12	3	2	3
80	N2L01S07	12	12	12	4	2	3
81	N2L01S05	11	11		3	2	3
82	N2L01S04	12	12		3	2	3
83	N2L01S03	7	7		3	2	3
84	N2L01S01	4	4	4	3	2	3
85	N2L02S00	4	4	4			
86	N2L02S01	5	5		3	2	3

Table 3.2.5. Number of bottles sampled by variable on cruise N2. (continued)

Station no.	Name	Nutrients	Oxygen	Salinity	Pigments	POC*	PM*
87	N2L02S03	5	5				
88	N2L02S05	6	6		4	2	3
89	N2L02S06	12	12		4	2	3
90	N2L02S08	12	12		3	2	3
91	N2L02S10	12	12	12	3	2	3
92	N2L03S10	12	12	12	3	2	3
93	N2L03S09	12	12		3	2	3
94	N2L03S08	12	12		3	2	3
95	N2L03S07	6	6		3	2	3
96	N2L03S05	4	4				
97	N2L03S03	4	4				
98	N2L03S01	6	6		3	2	3
99	N2L03S00	4	4	4			
	Total	861	865	190	196	120	186

* POC = particulate organic carbon; PM = total particulate material

Table 3.2.6. Launch times and locations for XBT drops on cruise N2.

Sequence No.	Station Name	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Water Depth (m)	Probe Type
3	N2X04051	05May98	1212	29.128620	87.289169	1000	T07
4	N2X05061	05May98	1334	28.953785	87.200661	1000	T07
5	N2X05062	05May98	1431	28.811754	87.222359	1000	T07
6	N2X06071	05May98	1632	28.559881	87.142227	972	T07
7	N2X06072	05May98	1729	28.434544	87.065063	996	T07
8	N2X07081	05May98	1939	28.288822	86.867561	1048	T07
9	N2X07082	05May98	2050	28.207363	86.714798	1096	T07
10	N2X07082	05May98	2050	28.205048	86.705299	1096	T07
11	N2X08091	05May98	2259	28.072620	86.370590	1110	T07
12	N2X08092	05May98	2354	28.030655	86.222397	1113	T07
14	N2X09101	06May98	0207	27.898703	85.870850	1120	T07
15	N2X09102	06May98	0249	27.844166	85.764801	1120	T07
16	N2X10111	06May98	0431	27.666367	85.548409	1125	T07
17	N2X10112	06May98	0509	27.582741	85.483002	1125	T07
18	N2L11S17	06May98	0803	27.499844	85.294701	839	T07
19	N2L11S15	06May98	0958	27.499943	85.145775	627	T07
20	N2L11S13	06May98	1139	27.499874	84.985741	391	T07
21	N2L11S11	06May98	1323	27.500010	84.791084	233	T07
22	N2L11S09	06May98	1529	27.500008	84.523438	140	T10
23	N2L11S07	06May98	1816	27.498350	84.156151	72	T10
24	N2L11S05	06May98	2115	27.500101	83.730782	51	T10
25	N2L11S03	07May98	0040	27.500288	83.249519	34	T10
26	N2L10S02	07May98	1252	28.554228	83.223198	17	T10
27	N2L10S04	07May98	1506	28.456802	83.528625	27	T10
28	N2L10S06	07May98	1802	28.339396	83.888985	38	T10
29	N2L10S08	07May98	2044	28.228178	84.241280	50	T10
30	N2L10S10	07May98	2310	28.122593	84.569412	75	T10

Table 3.2.6. Launch times and locations for XBT drops on cruise N2. (continued)

Sequence No.	Station Name	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Water Depth (m)	Probe Type
31	N2L10S12	08May98	0103	28.049738	84.799812	150	T10
32	N2L10S14	08May98	0249	27.991741	84.976250	249	T10
34	N2L10S14	08May98	0253	27.989880	84.985458	255	T07
35	N2L10S16	08May98	0452	27.930607	85.167198	393	T07
36	N2L10S18	08May98	0704	27.877785	85.333679	569	T07
37	N2L10S20	08May98	0918	27.828842	85.486893	749	T07
39	N2L09S20	08May98	1712	28.076351	85.941666	790	T07
40	N2L09S18	08May98	1920	28.163363	85.801704	557	T07
41	N2L09S16	08May98	2108	28.253866	85.652321	376	T07
42	N2L09S14	08May98	2301	28.360712	85.478195	244	T07
43	N2L09S12	09May98	0043	28.456944	85.317741	180	T10
44	N2L09S10	09May98	0227	28.567480	85.138695	132	T10
45	N2L09S08	09May98	0439	28.724672	84.882156	52	T10
46	N2L09S06	09May98	0748	28.973032	84.475914	36	T10
47	N2L09S04	09May98	1107	29.230354	84.050789	26	T10
48	N2L09S02	09May98	1337	29.427013	83.727959	17	T10
49	N2L08S02	09May98	2310	29.499550	84.927414	15	T10
50	N2L08S04	10May98	0135	29.292414	85.169647	32	T10
51	N2L08S06	10May98	0359	29.094193	85.403236	51	T10
52	N2L08S08	10May98	0626	28.900562	85.631409	172	T10
53	N2L08S10	10May98	0911	28.708424	85.853477	258	T07
54	N2L08S12	10May98	1226	28.496836	86.103943	376	T07
58	N2L08S14	10May98	1507	28.340630	86.287918	611	T07
59	N2L08S16	10May98	1705	28.245392	86.399040	745	T07
60	N2L07S16	11May98	0105	28.481997	86.861031	783	T07
61	N2L07S14	11May98	0331	28.636078	86.683914	568	T07
62	N2L07S12	11May98	0550	28.784498	86.513985	451	T07
63	N2L07S10	11May98	0812	28.945692	86.329529	344	T07
64	N2L07S08	11May98	1029	29.102987	86.148476	270	T07
65	N2L07S06	11May98	1236	29.252228	85.978691	157	T07
67	N2L07S04	11May98	1425	29.388813	85.816895	50	T10
68	N2L07S02	11May98	1705	29.591763	85.583466	28	T10
69	N2L06S02	12May98	0049	30.098522	85.954956	26	T10
70	N2L06S04	12May98	0222	29.942291	86.090111	41	T10
71	N2L06S06	12May98	0411	29.760227	86.247231	69	T10
72	N2L06S08	12May98	0614	29.594448	86.379814	136	T10
73	N2L06S10	12May98	0820	29.409731	86.548592	290	T07
74	N2L06S12	12May98	1015	29.225357	86.707787	436	T07
75	N2L06S14	12May98	1221	29.048471	86.861053	560	T07
76	N2L06S16	12May98	1411	28.911697	86.979195	679	T07
77	N2L06S18	12May98	1630	28.742426	87.125107	860	T07
79	N2L05S16	12May98	2233	29.181368	87.149002	826	T07
80	N2L05S14	13May98	0030	29.374292	87.055565	605	T07
81	N2L05S12	13May98	0224	29.533878	86.977837	345	T07
82	N2L05S10	13May98	0348	29.671133	86.912437	221	T10
83	N2L05S08	13May98	0545	29.808580	86.846748	168	T10
84	N2L05S06	13May98	0716	29.959986	86.773613	125	T10
85	N2L05S04	13May98	0854	30.111265	86.700020	30	T10

Table 3.2.6. Launch times and locations for XBT drops on cruise N2. (continued)

Sequence No.	Station Name	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Water Depth (m)	Probe Type
86	N2L05S02	13May98	1025	30.284233	86.618217	25	T10
87	N2L04S02	13May98	1934	30.100250	87.351532	30	T10
88	N2L04S04	13May98	2138	29.848783	87.351547	48	T10
89	N2L04S06	13May98	2317	29.656384	87.350319	81	T10
90	N2L04S09	14May98	0143	29.449066	87.350632	361	T10
91	N2L04S11	14May98	0347	29.294001	87.350601	779	T07
92	N2X03042	14May98	0622	29.251232	87.494667	943	T07
93	N2X03041	14May98	0727	29.189199	87.672066	1038	T07
94	N2X02032	14May98	0940	29.065617	88.035347	1090	T07
95	N2X02031	14May98	1045	28.988701	88.189667	1043	T07
96	N2X01022	14May98	1314	28.794001	88.547729	1062	T07
97	N2X01021	14May98	1430	28.734249	88.768135	1026	T07
98	N2L01S06	14May98	1742	28.731001	88.921501	762	T07
99	N2L01S02	14May98	2142	29.005833	89.014000	52	T10
100	N2L02S02	15May98	0530	29.479017	88.605598	47	T10
101	N2L02S04	15May98	0658	29.315434	88.536285	65	T10
102	N2L02S07	15May98	0929	29.122232	88.451500	294	T07
103	N2L02S09	15May98	1128	28.999933	88.395981	725	T07
104	N2X02031	15May98	1410	28.988615	88.188202	1043	T07
105	N2L03S06	15May98	2141	29.453053	87.926567	62	T10
106	N2L03S04	15May98	2320	29.677839	87.972816	41	T10
107	N2L03S02	16May98	0120	29.961067	88.027573	32	T10

Launches at missing sequence numbers were failures.

3.3 Instrumentation, Calibration, and Sampling Procedures

Standard oceanographic instrumentation and sampling procedures were used to collect measurements on the NEGOM-COH cruises. Data taken at each station consist of five types—continuous profiles, discrete measurements, ADCP measurements, XBT profiles, and supplementary underway measurements. The equipment and data collection procedures for each are summarized below. Note: processing of filter samples from cruise N1 is completed, but filter processing from cruise N2 was in progress s of the time of this report.

3.3.1 Continuous Profiles

Continuous profiles versus pressure were made of temperature, conductivity, downwelling irradiance (with a photosynthetically available radiation (PAR) sensor), transmissivity, fluorometry, backscatterance, and, although not contractually required, dissolved oxygen. Two sets of instruments were taken on each cruise to provide back-up instrumentation. This redundancy helps assure collection of complete data sets for each parameter. No equipment failed on either cruise. The hydrographic equipment used on the cruises is given in Table 3.3.1. Sensor specifications are listed in Table 3.3.2. The altimeter allowed the CTD package to be lowered to within 1-5 meters of the sea floor.

Instruments were mounted on the Rosette frame below the Niskin water bottles and Rosette system to provide unperturbed, obstruction-free flow of water to all instruments during the downcast. The various instruments were interfaced with the CTD, which transmitted data to the Sea-Bird SBE-11 deck unit for data logging and storage. The package was lowered into the water column typically at speeds of 25 $m \cdot min^{-1}$ near the surface and 40-60 $m \cdot min^{-1}$ below about 100 m, slowing to a stop near the bottom. It was raised typically at speeds of 60 $m \cdot min^{-1}$, with slowing for stops to take water samples.

Table 3.3.1. Hydrographic equipment available on cruises N1 and N2.

Instrument	Manufacturer	Quantity
CTD system	Sea-Bird SBE-911*plus*	2
CTD deck unit	Sea-Bird SBE-11	2
Rosette system	General Oceanics 12 place	2
Rosette frame	TAMU fabrication	2
Niskin bottles	GO Lever Action, 10 liter	14
Niskin bottles	GO Standard, 10-12 liter	10
Transmissometer	25-cm SeaTech 2000 m	2
Fluorimeter	Chelsea Instruments	2
Optical backscatter sensor	SeaTech Light scattering sensor	2
PAR sensor	Biospherical QSP-200L	2
Altimeter	Datasonics PSA-900	2
Oxygen sensor	Sea-Bird SBE 13, Beckman polarographic	2

Table 3.3.2. Specifications for hydrographic continuous profiling sensors.

Sensor Description	Measurement Range	Accuracy	Resolution
Temperature	-5°C to +35°C	0.004°C	0.0003°C
Conductivity	0 to 70 $mS \cdot cm^{-1}$	0.003 $mS \cdot cm^{-1}$	0.00004 $mS \cdot cm^{-1}$
Pressure as converted to depth	0 to 6800 m	0.05% of full scale over the ambient temperature range of 0. to 25°C; 0.02% with temperature compensation installed	0.004% of full scale
PAR Downwelling Irradiance	0.01 to 100% of full sunlight		
Fluorimeter (Chelsea)	0.01-100 $\mu g \cdot L^{-1}$	±0.01 $\mu g \cdot L^{-1}$	greater of 0.01 $\mu g \cdot L^{-1}$ or ±3% over 4 decades
Transmissometer (SeaTech 2000 m)	0–100% (0–5 volts DC)	±0.5%	0.001 volts or 0.02%
Light Scattering Sensor (SeaTech)	~33 $mg \cdot L^{-1}$ (high-gain) ~100 $mg \cdot L^{-1}$ (low gain)		0.01% of full scale ~3 $\mu g \cdot L^{-1}$
Dissolved Oxygen	0 to 15 $mL \cdot L^{-1}$	0.1 $mL \cdot L^{-1}$with frequent field calibrations	0.01 $mL \cdot L^{-1}$

Conductivity, temperature, pressure: The Sea-Bird SBE-911*plus* CTD system obtained continuous profiles of temperature and conductivity with pressure. Sea-Bird model SBE 3-02/F temperature sensors and Sea-Bird model 4 conductivity sensors were used. A Paroscientific Digiquartz pressure transducer, model 410K, with temperature compensated output provided the pressure measurement. A pump on the CTD system was used to match the dynamic response of the conductivity sensor to that of the temperature sensor. All sensors had frequency outputs individually digitized in the underwater unit 24 times per second. The digitized data were transmitted from the underwater unit via a single conductor armored cable to the shipboard processor in the SBE-11 deck unit. The processor decoded the incoming data and computed sensor frequencies. The binary equivalent of these frequencies was output to a controlling compute using an IEEE-488 communication link. The computer logged the data on disk and used instrument calibration data and sensor algorithms to compute temperature, conductivity, salinity, and depth. Additionally, the audio tones from the CTD were recorded on cassette tapes which can be replayed later if problems are encountered with the digital data recording. Temperature and salinity traces were monitored in real time by the CTD operator as the package moved through the water column.

Prior to deployment, the distilled water syringe attached to the temperature sensor input was removed. After deployment, the syringe was re-attached and filled so that distilled water was in the conductivity sensor at all times to prevent it from drying out. The temperature, conductivity, and pressure sensors are returned to Sea-Bird Electronics for calibration on a regular basis. Sea-Bird's conductivity standards are based on IAPSO Standard Seawater, and othe calibrations are traceable to NIST standards. Calibrations of the conductivity and temperature sensors were performed by Sea-Bird in December 1997 and June 1998. The sensors were stable. Calibration of the Digiquartz pressure sensor was last done in January 1998 by Sea-Bird. Both pressure sensors have a long and stable calibration history.

Transmissometer and optical backscatter sensor: The CTD system was equipped with a SeaTech, Inc., 25-cm pathlength transmissometer to provide continuous profiles of percent transmission. The transmissometer lenses were cleaned every few stations using distilled water, wiped clean, and sensor readings were recorded in the CTD operator's log. The transmissometer trace was monitored in real time by the CTD operator. Additionally, continuous profiles of particle scattering were measured with a SeaTech Light Scattering Sensor. The sensor cap was removed prior to deployment and replaced after each cast.

A transmissometer sends out a beam of single wavelength light (660 nm) across a known pathlength (25 cm). The light passes through the water to the sensor at the other end of the instrument. During a CTD cast, continuous measurements of light transmission are made and recorded as voltages. The voltages are divided by 5—the maximum voltage of transmisso-meter output—and multiplied by 100 to obtain a percent transmission. There is an inverse relationship between percent transmission and total particulate matter (PM) concentration. If the water is clear, more light is able to penetrate and the percent transmission is high. If the percent transmission is low, more light is scattered/blocked, and particulates are present. Total beam attenuation coefficient is calculated using the equation:

$$\frac{V}{5} = T = e^{-cz}.$$

V is the voltage, T∗100 is the percent transmission, c is the beam attenuation coefficient in m^{-1}, and z is the optical pathlength in m (0.25 m for the transmissometer used on N1 and N2). In natural seawater, the total beam attenuation coefficient (beam c) is the sum of three separate components:

$$c = c_w + c_y + c_p.$$

The beam attenuation coefficient for seawater, c_w, is constant and set equal to 0.364 m^{-1} in particle-free water. The beam attenuation coefficient for "yellow matter," c_y, is assumed to be constant and negligible. The beam attenuation coefficient due to particles, c_p, is the component primarily responsible for changes in total beam attenuation. Therefore, beam c results are reported as beam c_p values. Beam c_p values are obtained by selecting the lowest beam c value (corresponding to the highest percent transmission), and subtracting that value from all other values. The "c min" value is then the zero value corrected for background.

Beam c_p values are assessed in relation to discrete total particulate matter concentrations using various data combinations: (1) all data; (2) data binned by station location (all 1000-m stations, all 500-m stations, etc.); and (3) data binned by depth (all surface, all bottom, all mid-water clear points). Linear regressions are then calculated to determine the most accurate method to convert continuous measurements to discrete particulate matter (PM) concentration values. See Section 6.4 for examples.

Fluorometer: Continuous profiles of fluorescence were measured using a Chelsea fluorometer. The CTD operator monitored the trace in real time throughout the cast, noting proper functioning of the instrument and identifying the depths of the chlorophyll maximum and the low light regime immediately below it for bottle sampling plans.

Downwelling irradiance: Continuous profiles of downwelling irradiance were measured using a Biospherical Instruments, Inc., Model QSP-200L irradiance-profiling sensor. While the CTD package was on deck, the sensor was covered with an opaque cap for protection. The distance between the middle of the PAR sensor and the pressure sensor on the CTD was 1.58 m.

Dissolved oxygen: Continuous profiles of dissolved oxygen were measured with a Beckman polarographic type in situ dissolved oxygen sensor, manufactured by Sensor-Medics, Inc. This oxygen probe produces an oxygen-dependent electrical current and incorporates a thermistor for determination of membrane temperature. Voltages proportional to membrane current and temperature are output by the sensor and digitized in the CTD underwater unit. Bottle dissolved oxygen data are available for calibrating the sensor data using the method of Millard (1993) and Owens and Millard (1985). The oxygen sensor was attached to a manifold on the CTD that permitted active pumping of water past the membrane. To maintain sensor stability, care was taken that the sensor membrane did not become fouled with oil or grease. Between casts, the sensor was flushed and kept filled with distilled water.

3.3.2 Discrete Measurements

Water samples for discrete measurements were collected from 10-liter Niskin bottles mounted on a General Oceanics Rosette sampler. During the upcast, the Niskin bottles were

closed electronically from the shipboard laboratory by the CTD console operator. Four to 12 bottles per station were used. Bottles were tripped at maximum CTD depth, at sea surface (~3 m), and in the chlorophyll maximum as determined from the fluorescence profile by the CTD operator. Other bottles were tripped at specific sigma-theta surfaces, when present, shown in Table 3.3.3. A number of these surfaces are associated with characteristic water masses in the Loop Current, as noted in the "Comments" column of Table 3.3.3. The CTD operator had the discretion to trip unused bottles to fill gaps in bottle spacing or to sample in interesting features in the temperature, salinity, fluorescence, or percent transmission profiles. In water depths of 200 m or more, all 12 bottles were tripped regardless of availability of sigma-theta surfaces.

Water samples were taken for nutrients (phosphate, silicate, nitrate, nitrite, ammonium, and urea) and dissolved oxygen at all stations and for PM, POC, and phytoplankton pigments at more than half of the stations (Table 3.2.2 for N1 and Table 3.2.5 for N2). On N2, the PM/POC and pigment samples were all taken from the same stations to facilitate integration and interpretation of these data sets. For salinity, samples were measured at all stations on N1 and at the innermost and offshore most stations on N2.

Water samples were drawn and processed as soon as the CTD-Rosette system was brought back on board. Samples for dissolved oxygen were drawn first, followed in order by samples for salinity, nutrients, pigments, PM, and POC. Water for complementary programs was drawn last. Analyses of dissolved oxygen, nutrients, and salinity were performed at sea, except for the last 11 stations on N1 where the nutrients were frozen and analyzed on shore. Samples for PM, POC, and phytoplankton pigments were filtered at sea, and the filters returned for final processing onshore.

Shipboard analyses were performed using a six-channel Technicon AutoAnalyzer-11 for nutrients, a Guildline Model 8400B AutoSal Laboratory salinometer for salinity, and a microWinkler system for dissolved oxygen. Specifications are given in Table 3.3.4. Filtering systems were used for PM, POC, and pigment sample collections. These samples were analyzed onshore using weight differencing for PM, measurement of material converted to CO_2 for POC, and high performance liquid chromatography (HPLC) methodologies for pigments.

Dissolved oxygen: The procedure for collecting oxygen water samples transfers seawater from a Niskin bottle to a glass flask without allowing atmospheric oxygen to be trapped in the bottle. Samples for dissolved oxygen analysis were collected in triple-rinsed, 125-mL, calibrated, glass-stoppered Erlenmeyer flasks. Oxygen samples were analyzed for dissolved oxygen using the microWinkler technique (Carpenter 1965a, 1965b), with a precision of 0.01 $mL \cdot L^{-1}$.

Nutrients: Water samples were collected from Niskin bottles in 50-mL Nalgene wide-mouth bottles, which were triple rinsed with sample water before collection. After collection, samples were refrigerated until they were analyzed. The nutrient samples were analyzed aboard the vessel, usually within a few hours after sampling. See Atlas et al. (1971), Slawyk and MacIsaac (1972), Grasshoff (1970), and Aminot and Kerovel (1982) for details on the methods used. The system was standardized by running two to four working standards of all six nutrients prior to, and after, each set of samples was analyzed. The peak height data

Table 3.3.3. Bottle tripping locations.

Trip Location	Comments
Top	generally about 3-m depth
Chlorophyll maximum	as indicated by downcast fluorescence maximum
Bottom	generally 1 to 2 m above sea floor
Available σ_θ surfaces:	
24.6	
25.4	salinity maximum in Subtropical Underwater
25.9	
26.2	
26.5	oxygen maximum in 18°C Sargasso Sea Water
26.8	
27.0	
27.15 or 27.10	oxygen minimum in Tropical Atlantic Central Water
27.45	salinity minimum in Antarctic Intermediate Water
Other bottles if available	interesting features in downcast profiles or for spacing

Table 3.3.4. Specifications for analyses of water samples.

Parameter	Range	Accuracy	Resolution
Salinity	0.005 to 42	better than ±0.002 over 24 hrs without restandardization	better than ±0.0002 at 35
Dissolved Oxygen	0.02 to 10 $mL \cdot L^{-1}$	±0.5%	±0.1%
Phosphate	0 to 3 $\mu M \cdot L^{-1}$	0.02 $\mu M \cdot L^{-1}$	0.01 $\mu M \cdot L^{-1}$
Silicate	0 to 30 $\mu M \cdot L^{-1}$	0.5 $\mu M \cdot L^{-1}$	0.1 $\mu M \cdot L^{-1}$
Nitrate	0 to 35 $\mu M \cdot L^{-1}$	0.5 $\mu M \cdot L^{-1}$	0.1 $\mu M \cdot L^{-1}$
Nitrite	0 to 2 $\mu M \cdot L^{-1}$	0.01 $\mu M \cdot L^{-1}$	0.01 $\mu M \cdot L^{-1}$
AµMonium	0 to 5 $\mu M \cdot L^{-1}$	0.05 $\mu M \cdot L^{-1}$	0.01 $\mu M \cdot L^{-1}$
Urea	0 to 5 $\mu M \cdot L^{-1}$	0.1 $\mu M \cdot L^{-1}$	0.05 $\mu M \cdot L^{-1}$

were entered into a personal computer and then were converted to nutrient concentrations in $\mu M \cdot L^{-1}$ by linear interpolation from absorbency relative to the working standards.

On cruise N1 at station 77, two nutrient samples were taken from each Niskin. One sample was analyzed aboard ship. The other was frozen until it was analyzed on shore in mid-January 1998 (see section 4.3.1 for additional information). The nutrients from stations 84 through 94 on N1 were collected, frozen, and stored until they were analyzed on shore in mid-January 1998.

Salinity: Samples for salinity analysis were collected in triple-rinsed, 250-mL glass, airtight bottles. Salinity samples were analyzed aboard ship. The salinometer system was standardized each day using Standard Sea Water from the Institute of Oceanographic Sciences, Wormley, UK. The Standard Sea Water was from batch P119 for both cruises. Salinity is reported on the practical salinity scale (Fofonoff and Millard 1983).

Total particulate matter: Prior to each cruise, 47-mm, 0.4 μm pore size polycarbonate membrane filters were numbered and weighed using an Perkin-Elmer AD-60 autobalance. Autotare and calibration sequences were conducted before each usage. The weights, as well as the filter number, date, room temperature, and percent relative humidity in the room, were recorded. A label with this information was placed in the petri dish holding the filter. Each filter was weighed at least twice to determine accuracy. If the same weight was observed twice in a row, that weight was recorded. If two different weights were observed, a third weighing was conducted. If any two of the three weights were the same, that weight was recorded. If all three weights were different, the average was recorded.

During each cruise, samples from three specified depths were taken at each of 60 CTD stations: one at the bottom, one at the surface, and one at the mid-water where the "clearest" (most free of particulate matter) water was seen. The total number of samples for each cruise was expected to be 180. Additional samples from mid-water and near-bottom nepheloid layers were occasionally collected as well. The location of the mid-water depth and determination of the presence of nepheloid layers were based on transmissometer readings recorded during the CTD downcast. Water samples were taken from Niskin bottles attached to the CTD rosette. Three liters of water were generally filtered, although at shallower stations and/or surface bottles, two liters or less usually were filtered. Depending on the transmissometer readings and proximity to the Mississippi Delta or other river outflows, less water was needed at other stations as well.

A piece of tubing was attached to the Niskin spigot. A clear, one-liter, Nalgene bottle was washed three times with a small amount of sample water before the sample was collected. Filters were positioned in the filtration apparatus and the water was filtered. For each sample, the numbers of the bottles used, the volume taken, the number of the corresponding Niskin bottle, the depth, the filter location on the six-place apparatus, the filter number, the CTD number, and the station designation were noted and recorded in a logbook. The samples were filtered and the filters then rinsed three times using a pressure rinser that contained filtered distilled water. The filter towers through which the samples were funneled were removed, and a squeeze bottle containing filtered distilled water was used to provide a final rinse around the edge of each filter. The rinsing removed salts which would otherwise give inaccurate PM weights. After rinsing, filters were returned to their respective petri

dishes and allowed to dry for a few hours in an oven under low heat. If a filter became clogged, the volume of the remaining water was measured using a graduated cylinder. That amount was subtracted from the total volume taken for the sample, and the difference was recorded as the sample volume. If the target volume of water was unavailable, the actual amount available was recorded.

After the cruise, the filters were laid out in the weighing room and allowed to acclimate. The filters were re-weighed at the same temperature and humidity as before. The new weights were recorded, and the original weights were subtracted from them. The difference in weights was the amount of particulates in the volume of water sampled. The differences were recorded. The final step was to divide the weights by the volume filtered to calculate PM concentrations in $\mu g \cdot L^{-1}$.

Particulate organic carbon: Before each cruise, 25-mm, GF-75 (approximately 0.7 μm pore size) glass fiber filters were combusted to remove any carbon/organic material that was present. Aluminum foil was also combusted for the same reason. The combustion occurred at 450°F (232°C) for 4.5 hours. The filters, which were prepared in a "boat" made of combusted aluminum foil, were completely wrapped and the foil package was placed in a large Ziploc freezer bag.

During each cruise, particulate organic carbon (POC) samples were taken in much the same manner as the PM samples. There were several differences, however: (1) samples were taken in opaque bottles to inhibit biological activity; (2) filters were not rinsed after filtration; and (3) filters, once used, were wrapped in small pieces of combusted foil. The packets were labeled with the station and depth, since the filters were not numbered. The filters were allowed to dry along with the PMs.

After each cruise, POC filters were sent to the Bermuda Station for Biological Research for analysis. The method for measuring POC was first described by Gordon (1969) and Kerambrus and Szekielda (1969) and modified by Sharp (1974). A dried, acidified sample of particulate matter was combusted at 960ºC. The organic carbon was converted to CO_2 and measured by thermal conductivity. The instrument was a Control Equipment Corporation (CEC) 240-XA Elemental Analyzer.

Phytoplankton pigment data: Phytoplankton pigment samples were collected from 51 of the 94 CTD stations deployed on cruise N1 and from 60 of 98 CTD stations on cruise N2. In most cases, every other station was sampled for phytoplankton pigments. Adjacent stations were sampled in a few cases. Three samples were collected from each station: one at the surface, one at the chlorophyll maximum, and one at the low light regime immediately below the chlorophyll maximum. On cruise N1 at several stations in DeSoto Canyon, samples were collected at several additional depths. A total of 183 samples were collected and analyzed from the first cruise.

Phytoplankton pigments are light sensitive labile compounds. Careful sample collection, processing and analysis procedures are carried out to prevent pigment compound degradation. One liter of seawater was collected in a labeled amber Nalgene bottle directly from the Niskin bottle and was immediately filtered through a 47 mm glass fiber filter (GF/F, 0.7 μm pore size, Whatman) using a low vacuum pump. The filter was wrapped in labeled

aluminum foil and stored immediately in liquid N_2 until analysis. The minimum exposure of the sample to light and sample storage in liquid N_2 minimize the degradation of pigments.

A Hewlett-Packard 1050 high performance liquid chromatography (HPLC) system consisting of an autosampler and a quaternary pump equipped with a 25 cm x 4.6 mm (i.d.), 5 μm, ODS(2) Spherisorb C_{18} column and a Waters 440 fixed-wavelength UV-Visible absorbance detector at a wavelength of 436 nm is used for phytoplankton pigment analysis. A gradient method modified from Wright et al. (1991) is used to separate and analyze pigment concentrations. The HPLC conditions used are:

100% A to 100% B from 0 to 2 min.
100% B to 25% B and 75% C from 2 to 22 min.
75% B and 25% C to 100% B from 22 to 24 min.
100% B from 24 to 25 min.
100% B to 100% A from 25 to 28 min.

Mobile phases A, B, and C are methanol/0.5M sodium acetate (8/2), acetonitrile/water (9/1), and ethyl acetate, respectively. The flow rate is 1 $mL \cdot min^{-1}$. The total analysis time is 35 minutes.

The pigment filter samples are extracted in 4 mL of acetone overnight at -20ºC using the method described by Bidigare (1991). The internal standard canthaxanthin (100 µL, 2 $\mu g \cdot mL^{-1}$ standard solution) is added to each sample at the beginning of the extraction. After mixing 200 µL of the acetone extract with 20 µL of 0.5M sodium acetate aqueous solution, 50 µL of the acetone/sodium acetate mixture is injected on the HPLC.

Pigment identification is based on the comparison of the retention times with authentic standards obtained from National Exposure Research Laboratory, Office of Research and Development, US EPA, Cincinnati, Ohio. Pigment concentration is determined based on the instrumental response of the internal standard canthaxanthin and the average response factor for each compound. The average response factor of each compound is determined from a four level calibration. An average response factor is calculated for each compound based on the multi-level calibration. The response factor is calculated by the equation:

$$RF = \frac{(A_a * C_i)}{(A_i * C_a)},$$

where RF is the analyte response factor, A_a and A_i are the analyte and internal standard peak areas, respectively, and C_a and C_i are the analyte and internal standard concentrations, respectively. An average response factor is used to calculate pigment concentrations in the samples. Pigment concentrations are reported in $\mu g \cdot L^{-1}$.

The calibration is checked for every batch of samples to verify that the predicted concentrations are within the ±25% of the known amount. If this criterion is not met, the instrument is re-calibrated. The continuing calibration standard contains β-carotene, chlorophyll *a*, and chlorophyll *b* at concentrations of 0.5 $\mu g \cdot mL^{-1}$. Chromatographic data is

collected and processed on an XChrom data system (Lab Systems, Inc., MA).

Analyses of the extract were made for the full suite of pigments using HPLC. This suite consists of chlorophyll *a*, chlorophyll c_3, chlorophyllide a, chlorophyll c_2, peridinin, 19'-butanoyloxyfucoxanthin, fucoxanthin, 19'-hexanoyloxyfucoxanthin, prasinoxanthin, violaxanthin, diadinoxanthin, alloxanthin, diatoxanthin, lutein, zeaxanthin, chlorophyll *b*, chlorophyll-a', and β-carotene.

3.3.3 Acoustic Doppler Current Profiler Measurements

The two surveys used different ADCP instruments. A 150-kHz narrow-band ADCP (S/N 355) was used during N1. A 150-kHz broad-band ADCP (S/N 1183) was used during N2. Both ADCPs were manufactured by RD Instruments, Inc., (RDI). The broad-band ADCP is the "Direct-Reading" model with a 30° convex head arrangement. The narrow-band ADCP is the "Vessel-Mount" model with a 30° concave head arrangement. The nominal maximum depth of the narrow-band ADCP is approximately 250 m, while for the broad-band ADCP it is 160 m. The maximum depth, however, is a nominal value based on typical oceanic backscatter. The actual range will vary depending on environmental conditions, including sea temperature.

Given the same setup and ADCP frequency, a broad-band ADCP generally has about 15-20% less range than a narrow-band ADCP. This is because the broad-band has a wider bandwidth that causes the signal-to-noise ratio to be lower than that of the narrow-band. However, with an improved sampling scheme and the wider bandwidth, the broad-band ADCP generally has about 5 times less standard deviation for a single ping than the narrow-band ADCP.

Both units were vessel-mounted directly onto the ship's hull. Mounting and calibration of the ADCP aboard *R/V Gyre* is described in Murphy et al. (1992). Sperry gyrocompasses on both surveys were connected to the ADCPs to provide heading information. The gyros provide a 1-to-1 output so that a 1° change in ship heading is output to the ADCP as 1°. The transducer offset for the narrow-band was set by the fixed hull alignment of the transducer heads. The offset for the broad-band was set by visually aligning the transducer head with the ship's axis.

Differential GPS fixes were used when available during both surveys. Such fixes were not available when the ship was far from a GPS base station, which is an antenna and receiver at a known location. Further, both differential and non-differential fixes are determined in either 3D or 2D mode, depending on the number of satellites visible to the GPS receiver. In the 3D mode, 4 or more satellites are visible. The 3D fix is generally more accurate than the 2D fix, and differential fixes are 1-2 orders of magnitude more accurate than non-differential fixes. Flags in the navigation string indicate whether a fix is differential or non-differential and 2D or 3D. Except as may be specifically noted, no differentiation is made between types of GPS data because differential, 3D GPS data accounted for better than 99.5% of all GPS data.

GPS navigation data were recorded by the RDI software in files separate from those containing the current profiles. The navigation and current files were merged later in

processing. The units were operated in bottom-tracking mode. The ADCPs were controlled by personal computers that also processed and logged the data. The ADCP data processing, recording, and instrument control were done with the RDI TRANSECT program. Figure 3.3.1 shows the locations of the bins with good data (see Section 4.4), giving the general track for collection of ADCP data. The data for N1 are in near final form; those for N2 are preliminary only. Table 3.3.5 shows dates of collection and quantity of raw ADCP and navigation data.

Table 3.3.5. Dates and quantity of ADCP data.

Cruise	ADCP Start (UTC)	ADCP Stop (UTC)	Acquisition Program	Quantity of Data (Mb)
N1	16 Nov 1997 04:19	26 Nov 1997 17:05	TRANSECT	210
N2	05 May 1998 00:58	16 May 1998 05:24	TRANSECT	295

The configurations recorded for each ADCP cruise are shown in Table 3.3.6. For cruise N1, the first bin depth and blank after transmit inadvertently were changed during the back-up that occurred at the inshore end of line 11. Thereafter, these values were unchanged. Thus, the first number for these two parameters covers the track from the start of the cruise to near station N1L11S01C and the second covers the remainder of the cruise. For cruise N2, periodic checks were made and recorded in the ADCP operator's log to confirm that the settings were not changed during the cruise.

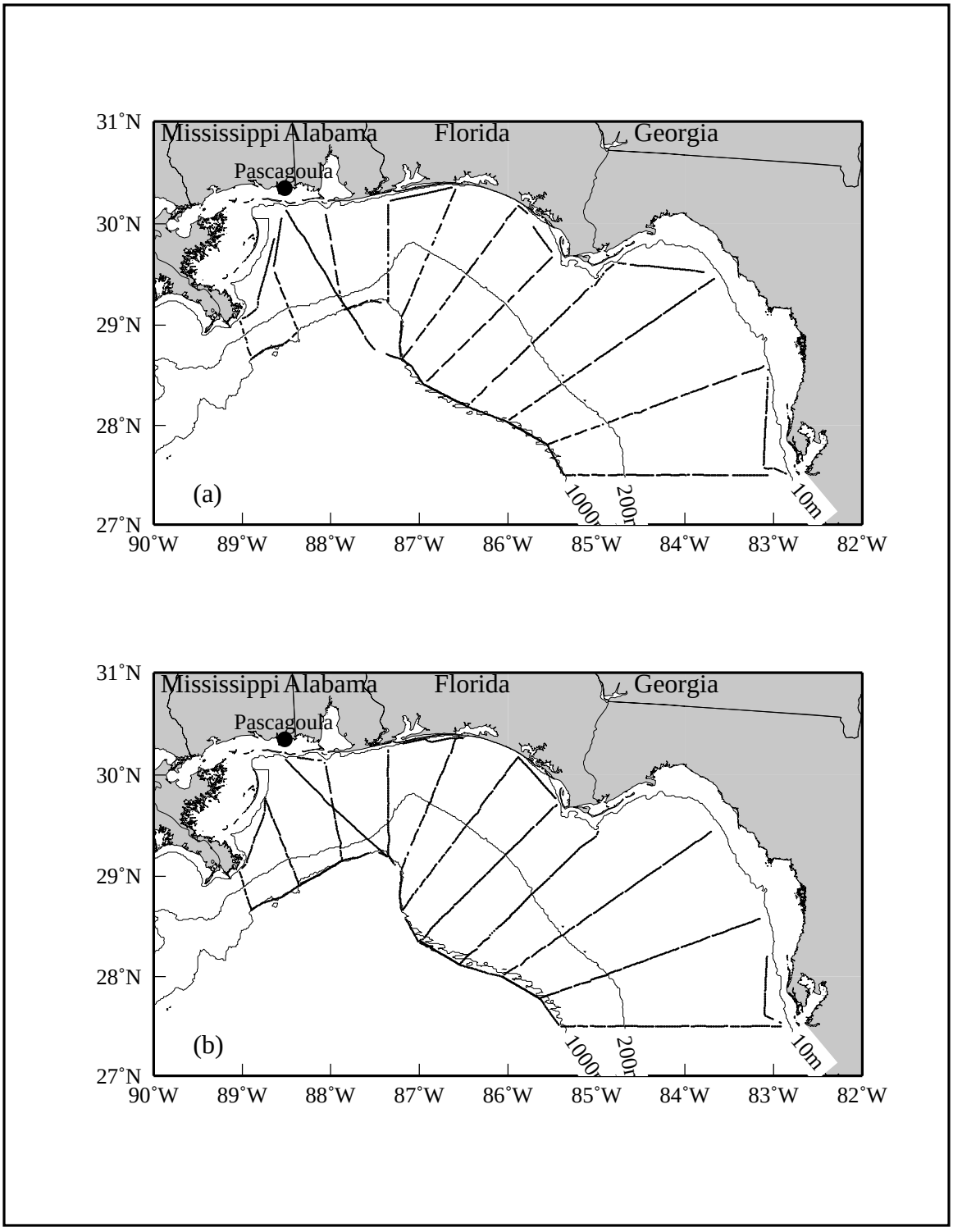


Figure 3.3.1. Ensemble ADCP locations for (a) cruise N1 quality-controlled data and (b) cruise N2 preliminary data.

Table 3.3.6 ADCP configuration summary.

Parameter	Cruise N1	Cruise N2
Instrument type	narrow-band	broad-band
Frequency (kHz)	150	150
Transducer pattern	concave	convex
Depth Cell length (m)	4	4
Number of depth cells	100	90
Time between pings (sec)	1	1
First bin depth (m)	10, 12	14
Transmit pulse length	4	4
Blank after transmit (m)	2, 4	4
Navigation type	GPS	GPS
Data recorded	raw, navigation, and averaged	raw, navigation, and averaged

3.3.4 XBT Measurements

XBT profiles were obtained using Sippican, Inc., T-7 and T-10 probes. T-7s are rated to 760 m and T-10s to 200 m. T-10s were used in water depths less then 200 m and T-7s in deeper water. The probe type for each of the XBT drops that produced usable data, as well as the drop locations, are given in Tables 3.2.3 for N1 and 3.2.6 for N2. On cruise N1, 85 XBTs were launched with 78 returning usable data and 2, noted in Table 3.2.3, returning suspect data. On cruise N2, 107 XBTs were launched with 97 returning usable data.

XBTs were deployed between CTD stations on cross-shelf lines to enhance cross-shelf thermal resolution to approximately 10 km. On cruise N1, one to two XBTs also were deployed along the 1000-m isobath on segments connecting cross-shelf sampling lines. On cruise N2, XBTs were deployed along the 1000-m isobath on the straight runs between lines 4 and 11 and between lines 4 and 1. Locations are shown in Figures 3.2.1 for N1 and 3.2.2 for N2.

XBTs were deployed from the after part of the 01 level on the ship's port side. The probes were dropped from a hand-held launcher into a tube that transported them down to deck level and over the port rail, where they fell into the sea a distance of 1.5 m. The raw data files were logged by a Sippican Mark-12 board inserted into one of the PC data loggers on board. A plot of temperature versus depth was displayed in real-time. If the wire broke prematurely before the probe reached its designated maximum depth or if the temperature versus depth signal appeared anomalous for any reason, the operator interrupted data collection and launched another XBT.

Using manufacturer's software, raw data files then were exported for storage as edited data files of temperature versus depth. Initial QA/QC of these edited files was done in near-real time by comparing XBT temperature at z = 3 m with near-surface temperature logged by the SAIL system (see section 3.3.5) and with temperature at z = 3 m measured at adjacent CTD stations.

3.3.5 Underway Measurements

Underway measurements discussed here are supplemental to the contractually required data discussed in Sections 3.3.1 through 3.3.4. They are taken only when the research vessel has the capability to collect them. Underway measurements were taken on both N1 and N2.

Near-surface temperature, conductivity, and fluorescence were logged every 2 minutes throughout both the N1 and N2 cruises with *R/V Gyre*'s Serial ASCII Interface Loop (SAIL) system. SAIL data were logged while the ship was underway as well as while it was stopped on station to carry out CTD casts and/or other station work. The raw data are better than 98% complete for the time the cruises were at sea. The only breaks in SAIL data logging during N1 are 10-15 minute periods each day about local noon when the system was backed up and data were written to another computer. Back-up down time was nominal on N2 because the SAIL data computer had been networked directly to a common server. However, there were 4 periods during N2 when navigation input problems locked the system and prevented SAIL data from being logged. These are summarized in Table 3.3.7.

Temperature and conductivity were measured by Sea-Bird sensors in a sampling stream that was pumped at a rate of 20 $L \cdot min^{-1}$ from a hull depth of 3 m into the main laboratory through a debubbler and mixing chamber of 20-liter volume; the water in the mixing chamber had a residence time of about one minute. This pumped flow was reduced from 20 $L \cdot min^{-1}$ to 1 $L \cdot min^{-1}$ using garden hoses connected by adjustable ball valves to a "Y" splitter valve leading off the debubbler. This 1 $L \cdot min^{-1}$ flow was shunted to the temperature and conductivity sensors and to a continuous-flow Turner Designs model 10 fluorometer.

Raw fluorescence data were calibrated against extracted chlorophyll measured in 1-liter samples drawn several times per day from the pumped sampling stream. Calibration followed standard methods given by Parsons et al. (1985). A total of 181 calibration samples were taken on N1 and 71 on N2. Sample locations are shown in Figure 3.3.2. For each cruise, separate algorithms were used for high and low chlorophyll regimes. Every second or third day the inflow to the flow-through fluorometer was shut down for 4-6 minutes, during which time the internal cuvette was bleached by the addition of full-strength commercial chlorine bleach as a precaution against growth of algae by biofouling on the quartz sides of the internal cuvette.

Table 3.3.7 Hiatus periods (no logging) during collection of underway data.

Date	Begin Hiatus (UTC)	End Hiatus (UTC)	Comments
	NEGOM-COH Cruise N1		
16 Nov 1997	18:03	18:14	
17 Nov 1997	16:03	16:14	
18 Nov 1997	18:10	18:16	
19 Nov 1997	16:49	17:08	
20 Nov 1997	18:23	18:35	
21 Nov 1997	16:56	17:04	
22 Nov 1997	16:43	17:11	
23 Nov 1997	16:58	17:11	
24 Nov 1997	16:44	16:50	
25 Nov 1997	17:56	18:08	
	NEGOM-COH Cruise N2		
05 May 1998	19:32	22:00	
06 May 1998	14:24	14:50	
07 May 1998	07:02	07:21	missing nav input to SAIL
08 May 1998	22:03	22:28	
09 May 1998	23:04	00:40	missing fluorescence data
13 May 1998	12:53	18:02	
14 May 1998	09:44	10:46	
14 May 1998	11:39	14:14	

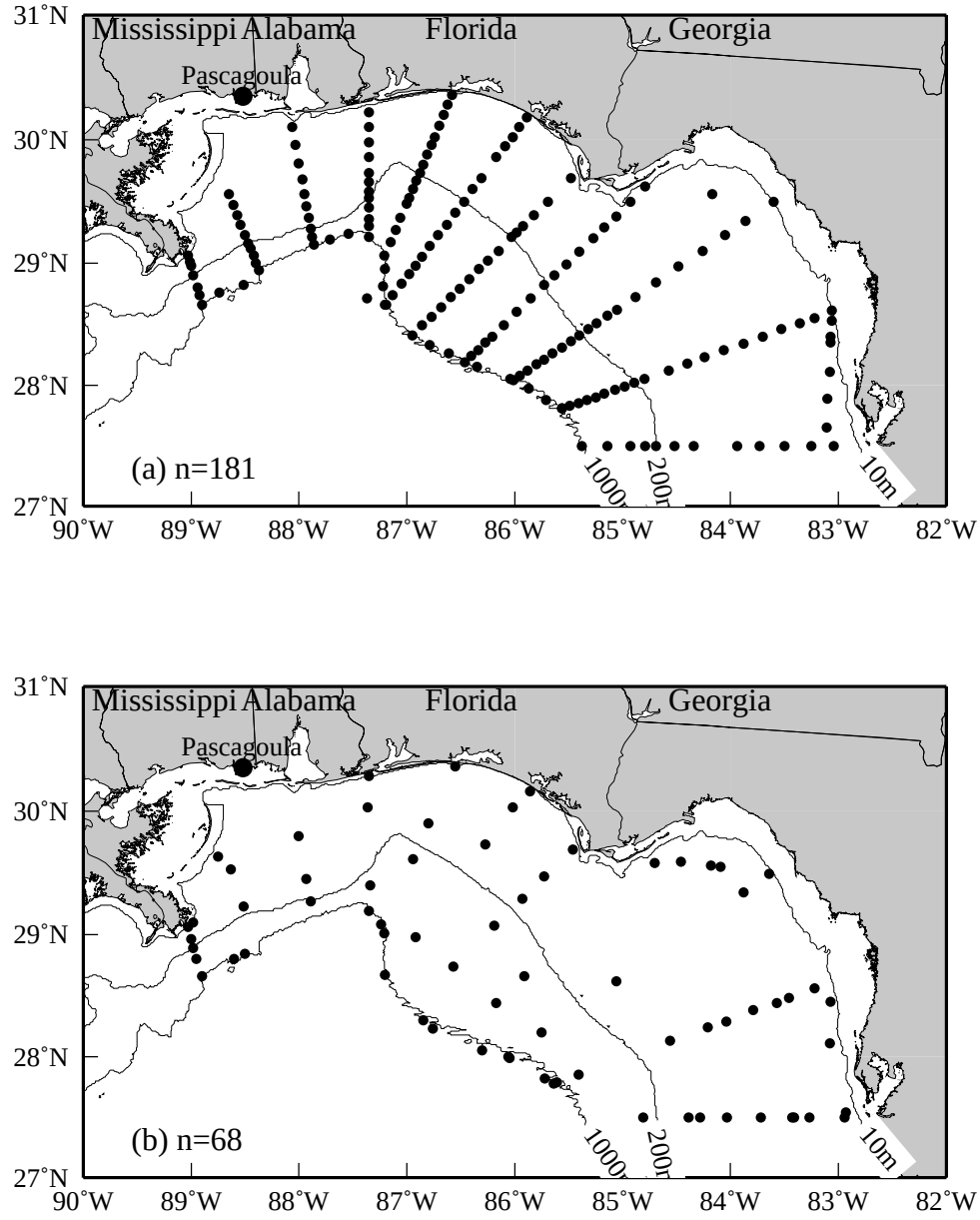


Figure 3.3.2. Locations of discrete samples filtered for calibration at sea of flow-through fluorometer data on (a) cruise N1 and (b) cruise N2.

3.4 Summary of Field Data Collected

Table 3.4.1 summarizes data collected and scientific participation from the cruises N1 and N2. Test stations are not included in this tabulation. In addition, visiting researchers on each cruise collected complementary data for their own programs; see Table 3.4.2 and Section 3.2.

Table 3.4.1. Summary of data collection, excluding samples from test stations, and scientific participation on NEGOM-COH cruises.

Description	N1 (11/97)	N2 (5/98)
Cruise duration (days)	11	11
Cruise track (km)	3283	3380
Total hydrographic stations, including test station	95	99
CTD stations, excluding test stations	94	98
Nutrient stations, excluding frozen nutrient stations*	83	98
Frozen nutrient stations*	12	0
Oxygen stations	94	98
Salinity stations	94	22
Pigment stations	51	61
Particulate matter stations	60	60
Particulate organic carbon stations	60	60
Surface chlorophyll stations	181	71
XBT drops (successful/total)	80/85	97/107
Nutrient samples, excluding frozen samples	688	850
Frozen nutrient samples	110	0
Oxygen samples	786	854
Salinity samples	786	179
Pigment samples	183	196
Particulate matter samples	182	186
Particulate organic carbon samples	120	120
Surface chlorophyll samples	181	71
Underway surface temperature and conductivity logging	2 min	2 min
Underway surface fluorescence logging	2 min	2 min
Total scientific party	23	24
NEGOM-COH scientists	15	15
Guest investigators on board	4	7
Students (graduate and undergraduate)	10	10
Complementary studies	4	6

* Station 77 is included in both nutrient station counts for N1 because both frozen and non-frozen samples were analyzed from this station.

Table 3.4.2. Complementary programs on NEGOM-COH hydrography surveys.

Description	N1 Nov 1997	N2 May 1998
Guest investigators on board or on shore	6	9
Drifter launches	23	29
Marine mammal watchers	3	3
Altimeter-in situ data trainees	1	1
Bio-optical stations	0	18
Atmospheric chemistry stations	0	5
ADCP volume backscatter study	1	0
Plankton net tow stations	0	11

3.5 Summary of Historical and Concurrent Data Assembly

Historical and concurrent data sets were identified and assembled. The present holdings from the major sources of these data are given in Table 3.5.1.

Concurrent data include collateral and ancillary data sets. Collateral data consist of information from other programs collecting physical data on the northeastern Gulf of Mexico shelf and upper slope during the NEGOM field years. Many of these are involved with the other components of NEGOM or other MMS-sponsored programs such as MAMES III and GULFCET. NEGOM-COH has established links with the concurrent programs listed in Table 3.5.1. Additionally, links have been established with a number of programs that are involved in the collection and processing of satellite data, including sea surface height anomaly (SSHA) from satellite altimeter, sea surface temperature from satellite Advanced Very High Resolution Radiometer (AVHRR) sensors, and ocean color from the SeaWiFS satellite. Concurrent collateral data will be acquired during the program as they become available.

Ancillary data consist of hydrologic, meteorological, and related data sets; e.g., river discharge, surface wind speed and direction, air temperature, surface barometric pressure, frontal passages, and sea level. These data will assist in the analysis of the NEGOM-COH data set and in development of the synthesis report. Concurrent ancillary data will be acquired as they become available.

The data assembly also includes the acquisition of available historical data from the Gulf of Mexico that could be useful in interpreting the NEGOM data sets. This includes hydrographic station data, record-length river discharges, current meter measurements, drifter tracks, sea level data, SSHA fields, AVHRR images, and meteorological data. Many of these have been acquired, as indicated in Table 3.5.1.

Table 3.5.1. Historical and concurrent data assembled.

Data Type	Sources	Holdings/Comments
Hydrographic: temperature, salinity or conductivity, dissolved oxygen, and nutrients versus depth or pressure	National Oceanographic Data Center (NODC)	All NODC holdings for northern Gulf of Mexico 1900-1994
	Texas A&M University (TAMU)	Data from most historical cruises in Gulf of Mexico from 1935 to 1994
	DeSoto Canyon Study (MMS-sponsored)	link established
	Inner Shelf Study (MMS-sponsored)	link established
	MAMES III (MMS-sponsored)	link established
	GULFCET (MMS-sponsored)	link established; have 1992-1993 data
	TIGER/SOOP (part MMS-sponsored)	1988-present
	NOAA Nutrient Enhanced Coastal Ocean Productivity Program (NECOP)	link established; have data for several 1992 and 1993 cruises
	NOAA SEAMAP	paper reports
	NOAA climatologies	paper reports
Current meter measurements: current speed and direction, temperature, salinity, and pressure	NODC	All NODC holdings for northern Gulf of Mexico 1977-1994
	TAMU	All data collected by TAMU scientists, including MAMES studies
	DeSoto Canyon Study (MMS-sponsored)	link established; have data reports
	Inner Shelf Study (MMS-sponsored)	link established
Drifting buoys : locations and sea surface temperature with time	MMS SCULP	1.5-hourly-locations
	LATEX A, LATEX C	6-hourly locations, includes data in north east Gulf of Mexico
	Concurrent MMS	link established
	Historical MMS studies	reports; selected data
ADCP: current profiles	TAMU	electronic
	DeSoto Canyon	link established
XBT, AXBT, MBT: temperature with depth	NODC	NODC holdings for northern Gulf of Mexico 1900-1990
	TAMU, including TIGER/SOOP	various historical to present
	Historical MMS studies	reports; selected data

Table 3.5.1. Historical and concurrent data assembled. (continued)

Data Type	Sources	Holdings/Comments
River discharge: Mississippi-Atchafalaya R. Mississippi, Alabama, and Florida rivers	Army Corps of Engineers, USGS, & EarthInfo	full record length; links established to acquire concurrent data as available
Coastal sea level and tide data	NOAA National Ocean Service	various electronic data
Wave data: directional waves, significant wave height, spectra	NODC	From moorings in northern Gulf of Mexico 1973-1996; link established for concurrent data
Meteorological: wind speed & direction, sea level barometric pressure & air temperature, sea surface temperature, dew point, relative humidity	TAMU	various
	National Climate Data Center (NCDC) & EarthInfo	Hourly airport weather observations (beginning of record-present available)
	Global Telecommunications Stream (GTS)	Hourly airport weather observations; extracting north Gulf of Mexico sites since 1992
	NOAA Coastal-Marine Automated Network	1973-present
	NASA-JPL-PODAAC	ERS-1 &- 2 scatterometer winds (1992 to present)
	NCDC	*Daily Weather Maps* (1992 to present)
Satellite Altimeter: sea surface height anomaly in time	Colorado Center for Astrodynamics Research	link established; have 1992-1997 SSHA fields
Satellite AVHRR: sea surface temperature	NEGOM Remote Sensing: USGS	link established
	Johns-Hopkins	link established; selected images from 1997 & 1998
	NOAA-COASTWATCH	images from 1992-present
Ocean Color (SeaWiFS)	NEGOM Remote Sensing: University of South Florida	link established

4 DATA QUALITY ASSURANCE AND QUALITY CONTROL

4.1 Introduction

Section 4 provides a discussion of 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 for the first nine months of the program. Initial data QA/QC are performed at sea and on shore by Task 1 personnel who collect the data sets. Digital data are processed into engineering units and stored in hierarchical directories on hard disks. Filter samples undergo laboratory analysis, with attendant QA/QC; final results are entered into electronic format by the laboratory analysts and checked. Data then are turned over to the Task 2 team for additional QA/QC, preparation of data products, and eventual data archival. Preliminary data products are produced, examined, and obvious errors corrected. After correction, the preliminary data are transferred to a distribution directory where NEGOM investigators have access to the data sets. These investigators, particularly those in the NEGOM-COH program, are asked to inform the Task 2 team of any problems identified. The Task 2 team investigates any problems, conducts secondary QA/QC of the data, and makes corrections to data sets as appropriate. The QA/QC process continues throughout the program, with corrections noted in file headers.

4.2 Continuous Profile Data

All continuous profile data are processed through the CTD data acquisition software, SEASOFT Version 4.232 (see Sea-Bird Electronics, Inc., at http://www.seabird.com), to produce a clean set of 0.5-m, bin-averaged data. The configuration files used in this processing contain the instrument calibration values. The software includes steps to:

1. Convert raw data to engineering units,
2. Separate the upcast from the downcast data,
3. Edit loops in the data,
4. Mark/remove wild data points,
5. Correct conductivity for thermal mass effects,
6. Low-pass filter the data,
7. Correct data for pressure reversals,
8. Average data into 0.5-m depth bins,
9. Compute potential temperature, salinity, and potential density using algorithms in Fofonoff and Millard (1983), and
10. Compute an average value for each parameter during bottle tripping.

These steps constitute the primary QA/QC of the continuous data sets. After processing with Sea-Bird software, the bin-averaged data for each station are stored in files with a 12 character filename. The first eight characters of the filename follow the station naming convention (Section 3.2) and the final four characters give the Sea-Bird extension, ".cnv".

In secondary QA/QC processing of continuous data, the *.cnv files are processed to check for out-of-range data, inversions, and gaps. The salinity, temperature, and sigma-theta are checked to be sure the values fall within reasonable ranges. Depths are checked to make sure

they are monotonically descending. Problems identified are corrected in the *.cnv files by linear interpolation across gaps or by replacing bad data with "-999.00" or similar bad data flag; a note on the correction is included in the file header. The latitude, longitude, date and time (in UTC), and total water depth included in the header are checked and corrected as necessary.

Individual station plots of the continuous sensor data are prepared and inspected to identify spurious data points. Selected vertical sections of continuous variables, using the Generic Mapping Tools (GMT) software (Wessel and Smith 1991, 1995), are produced along each cross-shelf line and inspected for spurious data points. Problems are identified as suspect in the header of the *.cnv file, corrected by linear interpolation, or replaced with the "-999.00" bad data flag.

Temperature and salinity: After primary QA/QC processing, composite plots of temperature versus salinity for cruises N1 and N2 showed reasonable results (Figure 4.2.1 for N1 and Figure 4.2.2 for N2). Note the seasonal differences for temperatures higher than 18°C.

Downwelling irradiance: Prior to contouring, the downwelling irradiance data are converted to percent of surface irradiance (I_o) by normalizing the 0.5-m bin values by the value of the surface irradiance and multiplying by 100. The surface value was taken as the maximum of the top five bins. Night time stations occasionally recorded non-zero downwelling irradiance; this resulted from ship lighting. The user should note these data have not been removed from the data sets.

Percent transmission: During collection, profiles of percent transmission are monitored in real time by the CTD operator to determine if the instrument is functioning properly. A malfunctioning sensor is fixed or replaced during the cruise. Any problems are noted in the CTD operator log. The glass cover plates over the source and sensor ends of the transmissometer are cleaned periodically with distilled water and a Chemwipe. The clear (air) path voltage is recorded by the CTD operator prior to each cast. If this voltage is not sufficiently high (about 4.9 v), the operator requires the cover plates to be re-cleaned. During the cast, the voltage was recorded every 0.41667 s (24 Hz). During post processing, measurements made when the CTD is moving less than a minimum velocity or moving upward due to ship roll are removed. The remaining data are averaged into 0.5 m depth bins. The data are scaled by the clear air path voltages and converted into percent transmission.

4.3 Discrete Measurements

4.3.1 Nutrients, Oxygen, and Salinity

The bottle salinity, nutrient, and dissolved oxygen data are provided to Task 2 personnel upon return of the ship to port. The data collected are compared against an inventory of expected data collection and discrepancies are investigated. Major sources of discrepancies include breakage of sample bottles, malfunction of processing equipment, or change of sampling plan at sea. The individual bottle data are merged with the location and total water depth data into a bottle data file for each cruise. The data are checked to confirm there are no loss of data and no incorrectly entered data. When the averaged continuous sensor data for the bottle trip times become available, they are merged with the bottle data and checked.

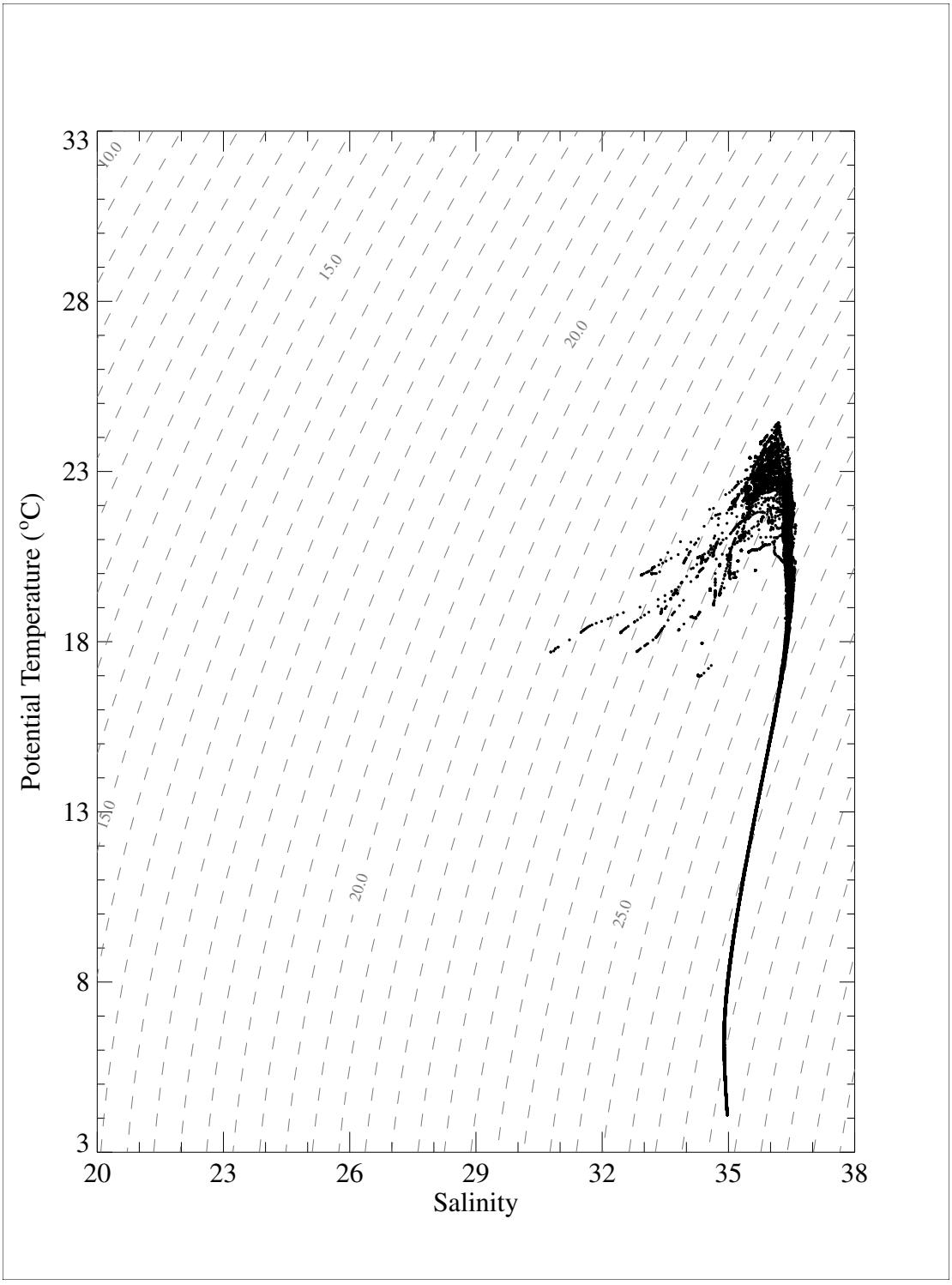
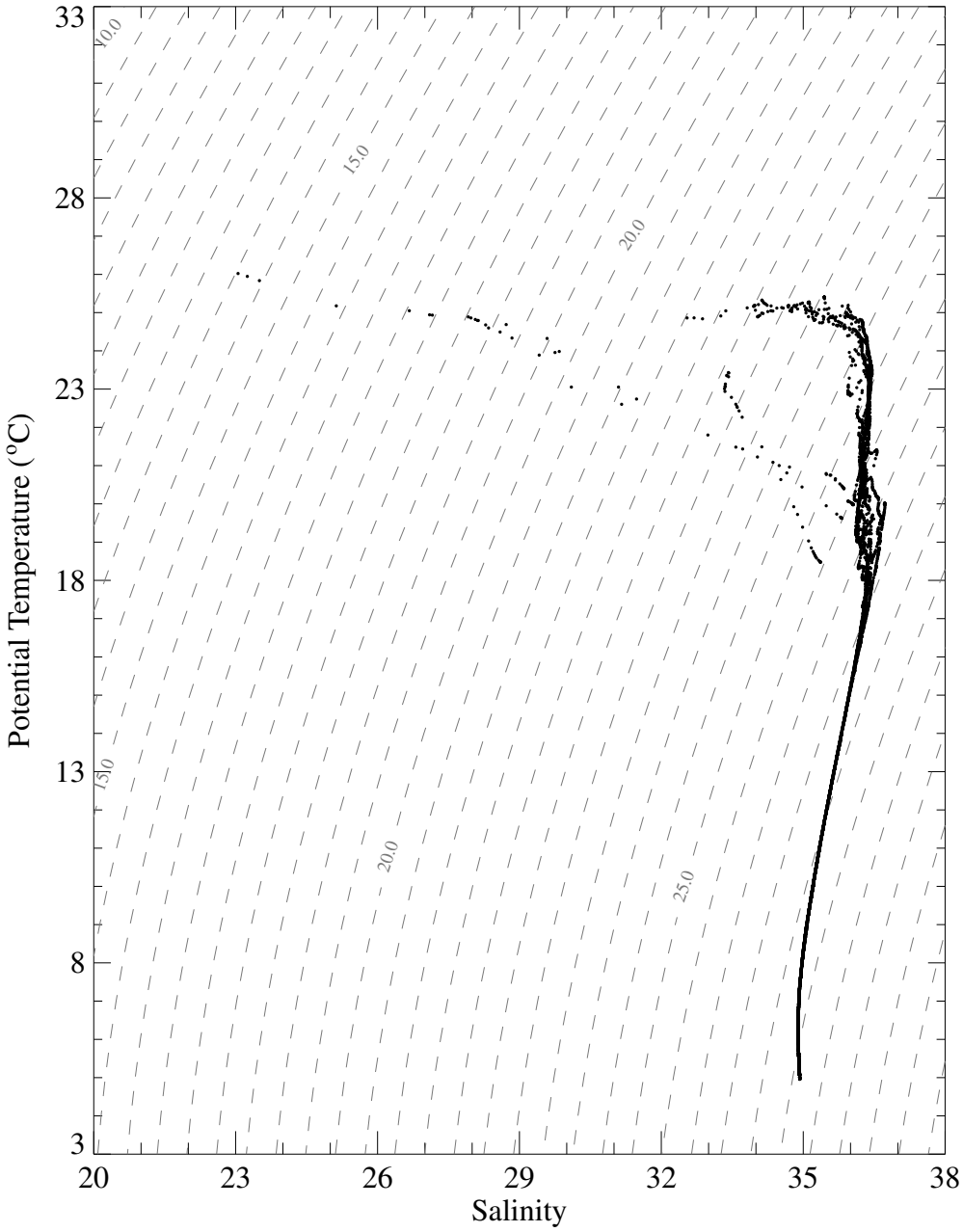


Figure 4.2.1. Composite potential temperature-salinity diagram for stations from NEGOM-COH cruise N1, 16-26 November 1997.


Potential Temperature (°C)
33
28
23
18
13
8
3
20
23
26
29
32
35
38
Salinity
10.0
15.0
20.0
15.0
20.0
25.0

The pressure sensor is 1 m below the mid-point of the Niskin bottles; so a bottle depth is computed as the pressure-derived depth minus 1. The bottle depths entered for the bottle data at the time of sampling are compared to those computed from the pressure. Discrepancies of more than 1 m are investigated and a best bottle depth is determined. For N1 and N2, the few discrepancies were resolved by using the depth computed from the pressure. The merged data set provides a link between the bottle data and the continuous profile data sets, although users should beware of possible hysteresis effects in the continuous profiling sensors.

Bottle data are plotted versus sigma-theta and examined for spurious results. Vertical sections and selected property-property plots also are made and inspected. Obvious problems in the data are corrected after visual inspection. All changes or suspect data are noted in the header. Bad data are replaced with the flag,"-9.0".

Nutrients: On cruise N1 at station 77, two nutrient samples were taken from each Niskin bottle. One sample, here called the "fresh" sample, was analyzed aboard ship; the other was frozen until it was analyzed on shore. A comparison between the frozen and fresh samples for the six nutrients on station 77 is shown in Figure 4.3.1. In considering the quality of the frozen nutrients for stations 84 through 94, the station 77 comparisons suggest that frozen phosphate, silicate, nitrate, and nitrite concentrations are reliable, but that the frozen ammonium and urea concentrations may be in error. Note that pairs above the line drawn on each figure indicate the frozen concentration is greater than the fresh; those below the line are less.

Bottle salinity: Bottle salinity was taken at all stations on cruise N1. The comparison between the bottle salinity and the CTD salinity at the time of the bottle trip, given in Figure 4.3.2, shows excellent agreement. The biggest differences are at stations with large vertical salinity gradients. Based on these results, the bottle salinity sampling was reduced to the innermost and outermost stations of each line. The bottle and CTD salinities for N2 show similar results, but with fewer samples.

Dissolved oxygen: The plot of dissolved oxygen concentration versus sigma-theta for cruise N1 (Figure 4.3.3) shows dissolved oxygen concentrations behaved as expected, with most variability in the less dense upper water and a tight relationship in the denser deep water. Note that the groupings fall especially on specific σ_θ values due to the sampling procedure (Table 3.3.3).

4.3.2 Particulate Material and Particulate Organic Carbon

For particulate matter (PM) measurements, blanks were prepared at every other station. The filters used for this purpose were weighed before the cruise and all pertinent data recorded. The blanks were rinsed in the same manner as the sample filters—the only difference being no seawater was filtered through them. The filters were removed, placed in petri dishes, and dried. After the cruise, the blanks were re-weighed along with the sample filters at the appropriate temperature and humidity. The pre-cruise weights were subtracted from the post-cruise weights, and differences recorded. Any outliers were removed and the remaining weight differences were averaged. The average weight was the blank correction and was subtracted from all of the sample filters. Corrected sample filter weights were also recorded.

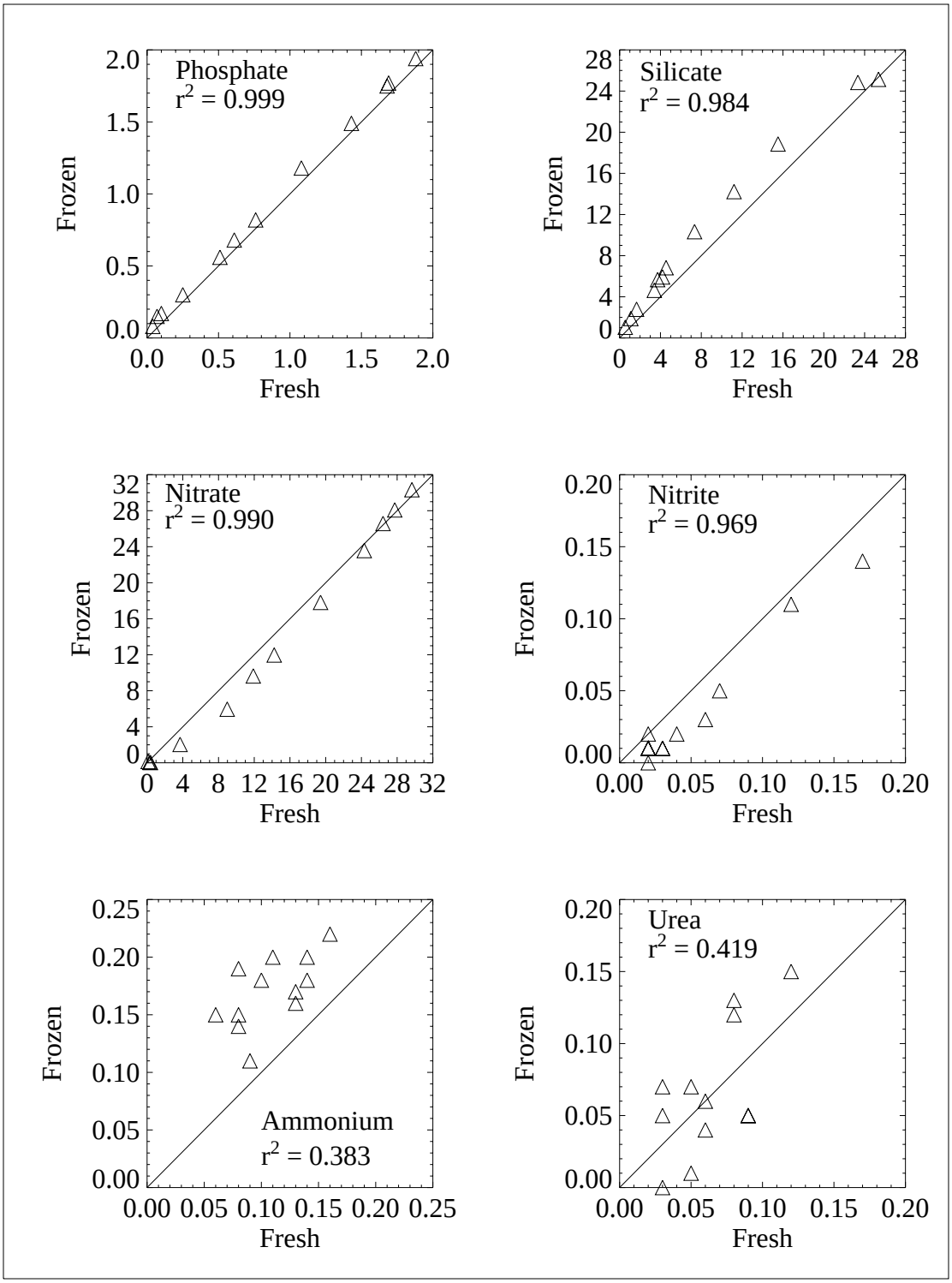


Figure 4.3.1. Frozen versus fresh nutrient concentrations ($\mu M \cdot L^{-1}$) from station 77 on NEGOM cruise N1 (November 1997). There are 12 pairs each.

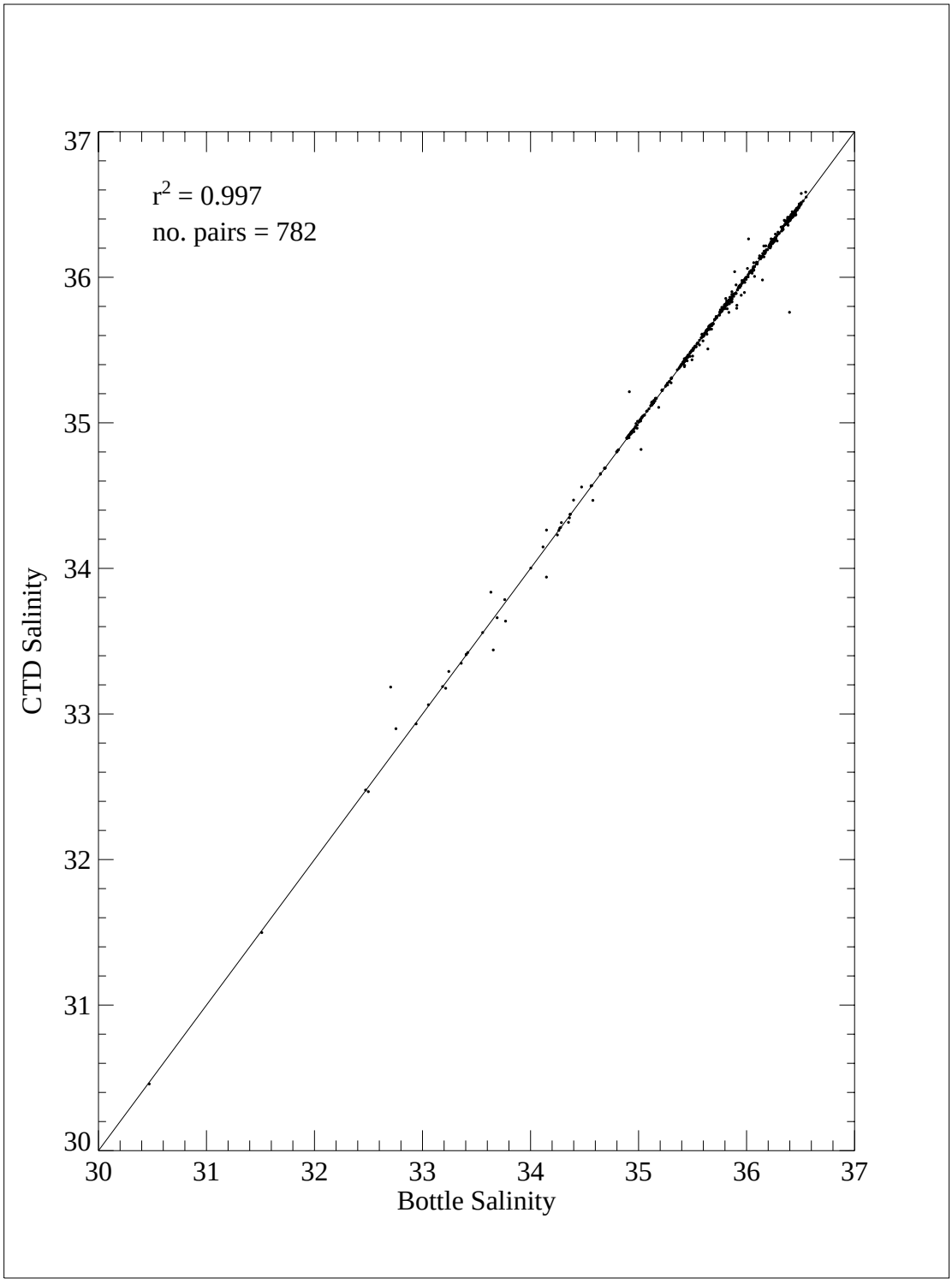


Figure 4.3.2. Ensemble upcast CTD salinity versus bottle salinity for stations from NEGOM-COH cruise N1, 16-26 November 1997.

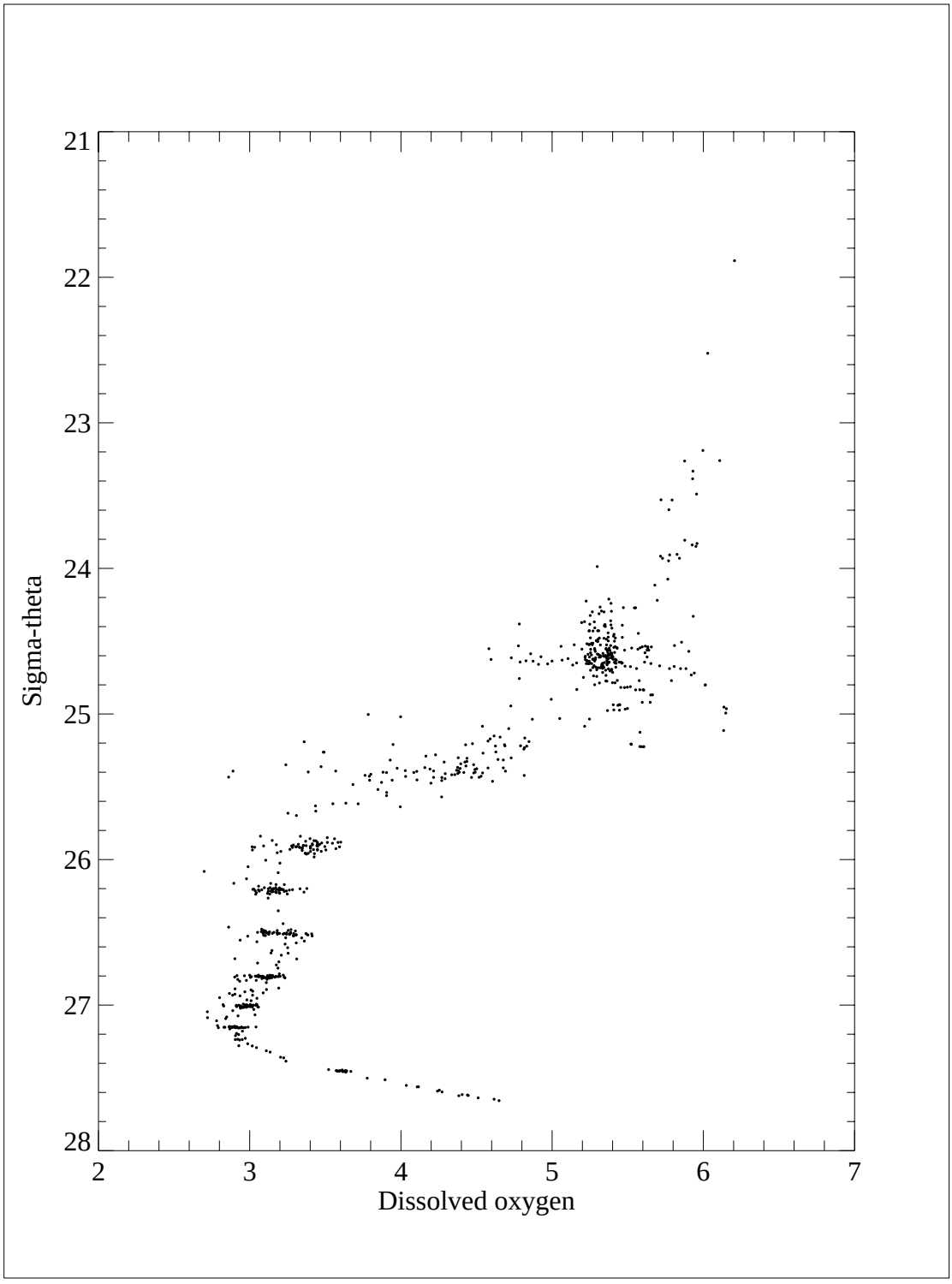


Figure 4.3.3. Dissolved oxygen ($mL \cdot L^{-1}$) versus upcast sigma-theta ($kg \cdot m^{-3}$) for NEGOM cruise N1, 16-26 November 1997.

For particulate organic carbon (POC), unused, combusted filters were wrapped in foil in the same manner as the sample filters and labeled as blanks. These blanks were included in the shipment to the Bermuda Station for Biological Research and a blank correction was applied to the POC concentrations. Acetanilide standards and blanks were measured prior to each analytical batch. Standards were usually between 0.25 and 2.0 mg.

After laboratory analysis of the PM and POC filters, the data were inspected and plotted. These data then were merged into the bottle data file for the cruise; merged data were checked to confirm there were no loss of data and no incorrect entry of data.

4.3.3 Phytoplankton Pigments

Phytoplankton pigments are light sensitive labile compounds. Careful sample processing and analysis procedures were practiced in order to minimize pigment degradation during processing (see Section 3.3.2 for discussion of QC measures taken during laboratory analysis). Additionally, each batch of samples extracted and analyzed included a procedural blank. The procedural blank consists of a blank filter and the necessary glassware and solvents. Each is processed the same way as the filtered samples. All procedural blanks from cruise N1 were demonstrated to be free of pigment compounds.

After laboratory analysis of the pigment filters, the data are inspected and corrected as necessary. Data are next placed into a pigment data file, which then is merged with the other bottle data. Merged data are checked to confirm there was no loss or incorrect entry of data.

4.4 Acoustic Doppler Current Profiler Measurements

4.4.1 TRANSECT Software

During N1 and N2, ADCP data were recorded using the TRANSECT software developed by RDI. Both the raw and averaged current velocity data are recorded in binary format on a personal computer while at sea. The averaged current data are produced by binning the raw binary data into the standard averaging interval of 5 minute ensembles (called the ensemble length). If necessary, the raw current velocity data may be re-processed after the cruise with modified parameters (ensemble length, bin number, etc.), allowing some flexibility in the initial processing step. TRANSECT also logs the GPS navigation data to a separate file in ASCII format for future merging with the current velocity data. The navigation data are read from a serial port and are marked with the raw ADCP ensemble number and computer time. Several navigation fixes per ensemble are recorded. ASCII files containing the averaged data are created during the post-processing by replaying the data in the lab and saving the data to disk. This step also is performed on a PC using the RDI program NBPLBK or BBPLBK, for narrow-band and broad-band data, respectively.

4.4.2 ADCP QA/QC Processing

After collection and converting the averaged files to ASCII format, the QA/QC processing of the resulting data continues on UNIX workstations using a combination of FORTRAN, PV-WAVE, and GMT computer codes. The QA/QC processing of the ADCP data is complex and requires several levels to merge navigation data, determine absolute ship

velocity with respect to the GPS fixes, calculate current velocity, and remove outliers and suspicious data. The QA/QC processing can be separated into four parts: (1) merging of navigation data, (2) rejection of data due to external factors, (3) rejection due to internal factors, and (4) systematic visual examination of vertical and horizontal plots of current velocity. The final step in the processing is the production of ASCII data files containing the processed data and associated metadata and horizontal, vertical, and gridded plots of the quality-controlled data.

Merging of navigation data: Because the built-in clock on the ADCP is subject to drift, the GPS navigation stream must be merged with the ADCP position data to obtain an accurate time and location of each ensemble. This step is extremely important because it provides the reference from which to estimate the average ship velocity during a given segment. The ship velocity is subtracted from the raw ADCP measurements to obtain the current velocity. The ADCP operated in bottom-track mode to give an estimate of ship velocity while in shallow water. The bottom-tracking is implemented using separate pings from water profiling and generally has 50% greater range than water profiling. When the ship is in deep water, i.e., depths greater than 400 m, the ADCP often has difficulty acquiring an accurate estimate of the total water depth. Therefore, the GPS ship velocity is used for the calculation of current velocity in deep water while bottom-track velocity is used in shallow water.

The subset of the data having both bottom-track and navigation velocities is used to perform a calibration of the ADCP after the manner of Joyce (1989). The errors are of two types: sensitivity and alignment. Sensitivity errors arise because the orientation of the acoustic beam is not correct due to factors such as nonzero trim to the transducer and ship, small errors in the beam geometry, or over-all system bias. The alignment errors are caused by misalignment between the reference frames of the ADCP and the ship gyro. Joyce (1989) notes that these two types of errors arise from independent sources and produce errors approximately orthogonal. The misalignment induces an error in the velocity component perpendicular to the ship that is linearly related to the ship speed, while the sensitivity errors occur in the ship-parallel component, again in linear proportion to ship speed. The mean alignment error is typically one to two degrees for the *R/V Gyre*, i.e., viewing the ship from above, the data are rotated clockwise by this angle. The mean sensitivity error is typically 1.00 to 1.04, so the data are scaled up by this value. Complex regression statistics for the bottom-track versus GPS navigation velocities and the average GPS ship speed are summarized in Table 4.4.1.

In Table 4.4.1, b_m is the regression modulus and is a measure of the gain or bias between the two vector sets, α is the offset angle between the two data sets, and ρ^2 is the coherence parameter, which measures the amount of variance in the GPS-determined velocities accounted for by the bottom-track-determined velocities ($\rho^2 = 1.0$ for perfect coherence). Compared with the *R/V Gyre* sensitivity error and mean alignment error, Table 4.4.1 shows the regression modulus and angle fall within typical values for the *R/V Gyre*. Bender and Kelly (1997) also give a more detailed description of the estimation of the regression angle, modulus, and coherence.

Two GPS navigation strings are separately written to the navigation file and provide redundancy and assurance that the GPS fix data are retained throughout the cruise. Both navigation strings are based on the raw navigation stream from the GPS and contain identical

information. Either navigation string may be used for the ship velocity calculation. The program GERGNAV translates the raw stream into ASCII strings and places them into an output buffer where they are read into the TRANSECT program and written to the ADCP navigation file. During QA/QC processing, the navigation strings are formatted into a common format prior to running the navigation merging routines. This is to prevent data dropout due to the disruption of one of the GPS strings from external reasons. Rarely, both data streams are disrupted and no GPS data are available for QA/QC processing. ADCP ensembles occurring during this disrupted period are discarded.

Table 4.4.1. Complex regression statistics for GPS velocity versus bottom-track velocity on cruise N1.

Description	Statistic
Number of stations for misalignment angle	1947
Sample size actually used	10741
Clockwise regression angle (α)	-1.466°
Regression modulus (b_m)	1.004284
Coherence parameter (ρ^2)	0.9609
Average GPS ship speed ($cm \cdot s^{-1}$)	458.6

External factors: After the navigation data are merged with the ADCP data, the data are inspected for problems external to the data. These external factors include:

1. No navigation data for a given ensemble,
2. Bottom track depth too shallow for any good data,
3. Slow ship speed (speed < 100 $cm \cdot s^{-1}$),
4. Fast ship speed (speed > 650 $cm \cdot s^{-1}$), and
5. The percent good pings for the first bin is less than 30%.

Data not passing the stipulated requirements for each factor are rejected and removed from the database. Those that pass are corrected as described below and reformatted into a more manageable and efficient format. A summary of the results of this step is given in Table 4.4.2.

Further, the bottom 15% of the vertical profile is rejected as unreliable due to improper echo return near bottom. Therefore, the deepest usable bin number is readjusted during this step of processing. If the adjusted bottom depth is less than the first bin depth, the segment is discarded. Processing software for this stage was composed largely in FORTRAN.

Table 4.4.2. Cruise N1 ADCP data segments and rejections due to external factors.

Description	Number
Total number of segments	2927
Segments rejected for no navigation	104
Segments rejected for bottom-track depth too shallow	50
Segments rejected for slow ship speed (< 100 $cm \cdot s^{-1}$)	484
Segments rejected for fast ship speed (> 650 $cm \cdot s^{-1}$)	0
Segments rejected for first bin percent good less than 30	1
Total usable segments	2288

Internal Factors: After data are removed from the ADCP database due to external reasons, the remaining data are examined for internal problems. Internal data problems are intrinsic and mainly include outliers. Outliers are determined using basic statistics and are identified by estimating the standard deviation and mean of each velocity component for the entire cruise at a given depth level. The entire segment is rejected when any velocity component at any depth is greater than three standard deviations from the average value. This procedure removes many of the grossly anomalous velocity vectors in the ADCP data. Velocity fields also are replaced by a no data flag, "-999.99", if the percent good field falls below 30. During N1, approximately 80 segments (3.5% of the usable data) were rejected at this level. The processing software for this stage was composed mostly in PV-WAVE command language.

Visual inspection: The above-described QA/QC processing steps mainly are objective and based on constraints of the physical system. In the next processing step, vertical profiles showing along- and cross-transect velocities and horizontal maps at a given level are produced, analyzed, and inspected to identify suspect and questionable data. Suspect data are evaluated and then are left as is, flagged as suspect, or rejected entirely and replaced with the no data flag. Viewing such plots allows the data to be examined in context and marks the beginning of the data analysis phase as processes and features become evident. Note that this step is the most subjective and, therefore, the most labor intensive part of the QA/QC. By its nature, this step is considered to be fine tuning of the dataset since all the gross outliers have been removed previously. Approximately 30-50 segments (out of order 2000) are removed during this step of post-processing. Most of the plots produced during this stage of processing use the contouring, gridding, and mapping capabilities of the Generic Mapping Tools (GMT) Software System (Wessel and Smith 1995).

After all quality control steps are performed, the data are formatted into an ASCII data file for distribution to MMS and NODC. The files include metadata with cruise identifiers, instrument type, FORTRAN formatting instructions, and program contacts. In addition,

special problems and important processing information unique to the cruise are included in the metadata. This information begins with "$NEGOM VERSION" and represents a history of the processing done on that file. The information is crucial to the proper interpretation of the data. It is recommended that the user become familiar with all such information prior to analysis and interpretation. Following the metadata are the data which are listed by ensemble with the date, latitude, and longitude of the beginning and end of each ensemble followed by the GPS ship velocity and bottom-track depth. The current velocity by depth is then given with the signal intensity of each transducer and the percent good pings.

For N2, the Common Oceanographic Data Access System (CODAS) ADCP Processing System of the University of Hawaii was down-loaded and installed for direct comparison with the in-house ADCP processing codes. CODAS has become the standard processing system for the World Ocean Circulation Experiment (WOCE) and provides valuable insight and guidance for processing the NEGOM ADCP data. CODAS will be used as alternative processing only for broad-band ADCP data. The processing of N2 ADCP data are currently underway.

4.4.3 Collection Problems

Two ADCP configuration files were used during the N1 cruise. The configuration file sets the data collection parameters for the instrument while it is in operation. For a consistent and high quality dataset, it is imperative that only one configuration file be used per cruise and that the same configuration file be used for each cruise. The first N1 configuration file used a blank after transmit of 4 meters, a top bin at 12 m depth, and a bottom depth bin of 204 m. This configuration file was used from the beginning of the cruise to the shoreward end of Line 11, south of Tampa, FL. After the first backup and restore procedure was done, a second configuration file was inadvertently installed and subsequently used until the end of the cruise. This file had a 2-meter blank after transmit, a top depth bin at 10 m, and maximum depth bin of 350 m. RDI recommends a blank after transmit of 4 m to prevent sidelobe contamination of the top 3-5 depth bins with noise. For this reason, the N1 ADCP metadata will contain a flag recommending that the top 3-5 depth bins be used with caution. Depth bins from the two datasets are offset by 2 m, which complicates the processing and interpretation of these data.

No significant collection problems have been encountered during the early processing stages of the N2 ADCP data set. A configuration file with a 4-m blank beyond transmit was used throughout the cruise.

During N1, a backup/restore procedure lasting from 0.5 to 0.75 hr was required whenever an IOMEGA zip disk, which recorded the raw, averaged, and navigation data, became full. This operation was usually performed during the inner-shelf, along-shore transects, i.e., in shallow water, to minimize ADCP data loss. The backup/restore operation was performed, the old disk removed, labeled, and a new disk inserted. During N2, a PC containing two zip drives was used for the ADCP collection, and was configured to automatically record to the next available drive when a disk became full. This effectively eliminated instrument down time during backup/restore operations. This method will continue on future cruises.

4.5 XBT Profile Data

In waters shallower than the probe's depth capability, the probe continues to collect data after impacting the sea bed. Data collected after bottom impact are removed from the record. Traces are examined for outliers. Outliers are replaced by linear interpolation for gaps of a few points or with the flag value -999.00 for larger gaps. Traces that are bad in their entirety are eliminated. Drop rate corrections, such as that of Singer (1990), have not been applied to the traces because the algorithms for these corrections continue to evolve and are easily applied by the user. Of the 85 XBTs deployed on cruise N1, 78 produced usable data and two, N1L10S04X and N1L07S04X, produced traces that are suspect and may be eliminated from the data set after further evaluation. Of the 107 XBTs on N2, 97 produced usable data. Station locations are shown in Table 3.2.3 for N1 and Table 3.2.6 for N2.

4.6 Underway Measurements

On both N1 and N2, chlorophyll computed from the flow-through fluorescence agreed with the extracted chlorophyll to $\pm 0.05\ \mu g \cdot L^{-1}$ or better in low chlorophyll, bio-optical Type II environments, and to $\pm 0.2\ \mu g \cdot L^{-1}$ or better in high chlorophyll, bio-optical Type I environments. Figures 4.6.1 and 4.6.2 summarize these calibration data. In general, chlorophyll was inversely correlated with salinity; locally low salinity water usually had locally high chlorophyll, and vice versa. One or more high chlorophyll-low salinity fronts were encountered over the inner shelf on most of the 11 lines. How these compared in location among lines on N1 is summarized by Figure 4.6.3 and on N2 by Figure 4.6.4.

4.7 Collateral Data

The level of QA/QC applied to collateral data is dependent on the source of the data and the QA/QC applied by that source. It is done on a case-by-case basis in the course of using the data for analysis purposes.

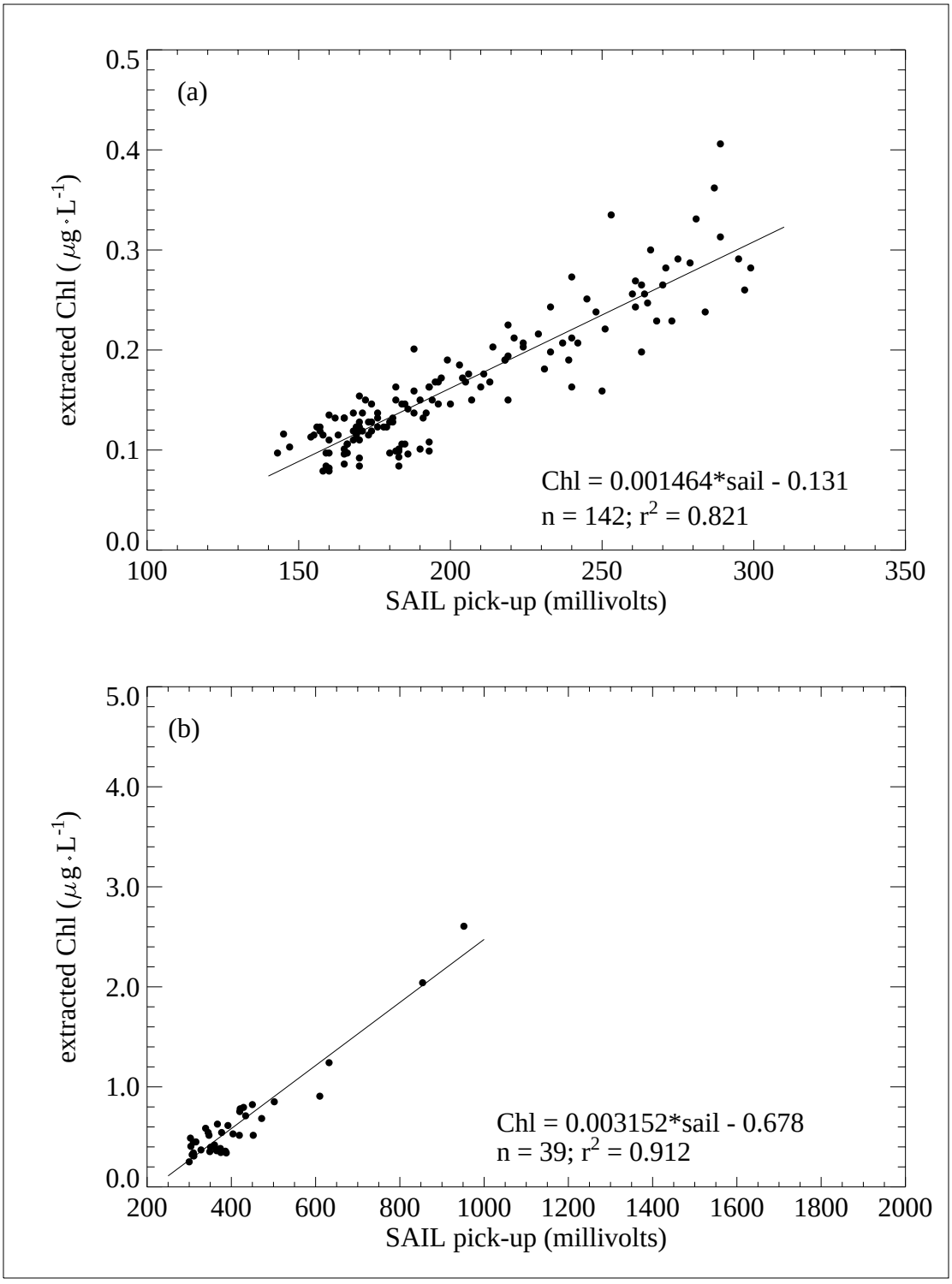


Figure 4.6.1. Flow-through fluorometer calibration for (a) Type 2 (low chlorophyll) water and (b) Type 1 (high chlorophyll) water on NEGOM cruise N1 (November 1997).

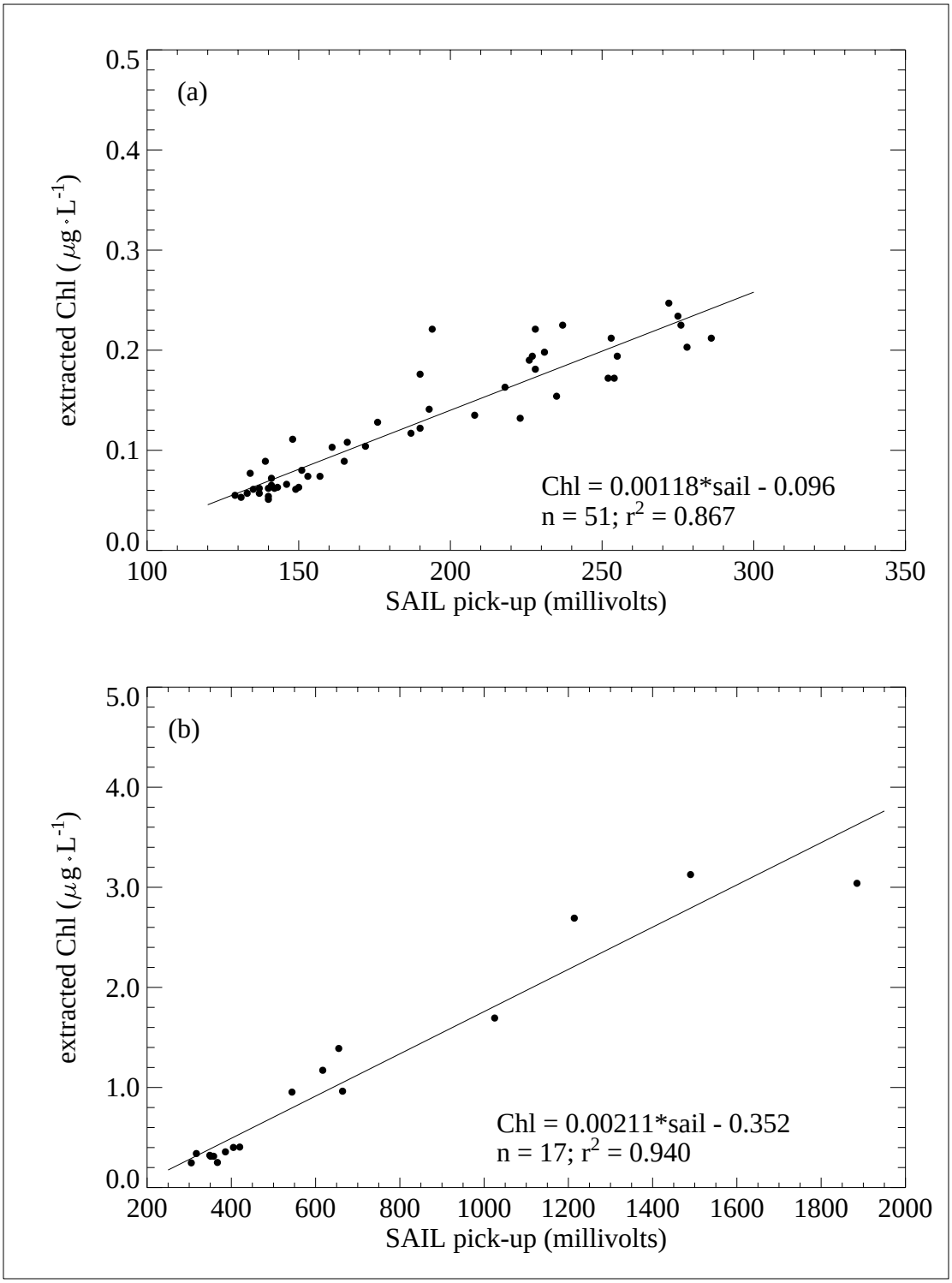


Figure 4.6.2. Flow-through fluorometer calibration for (a) Type 2 (low chlorophyll) water and (b) Type 1 (high chlorophyll) water on NEGOM cruise N2 (May 1998).

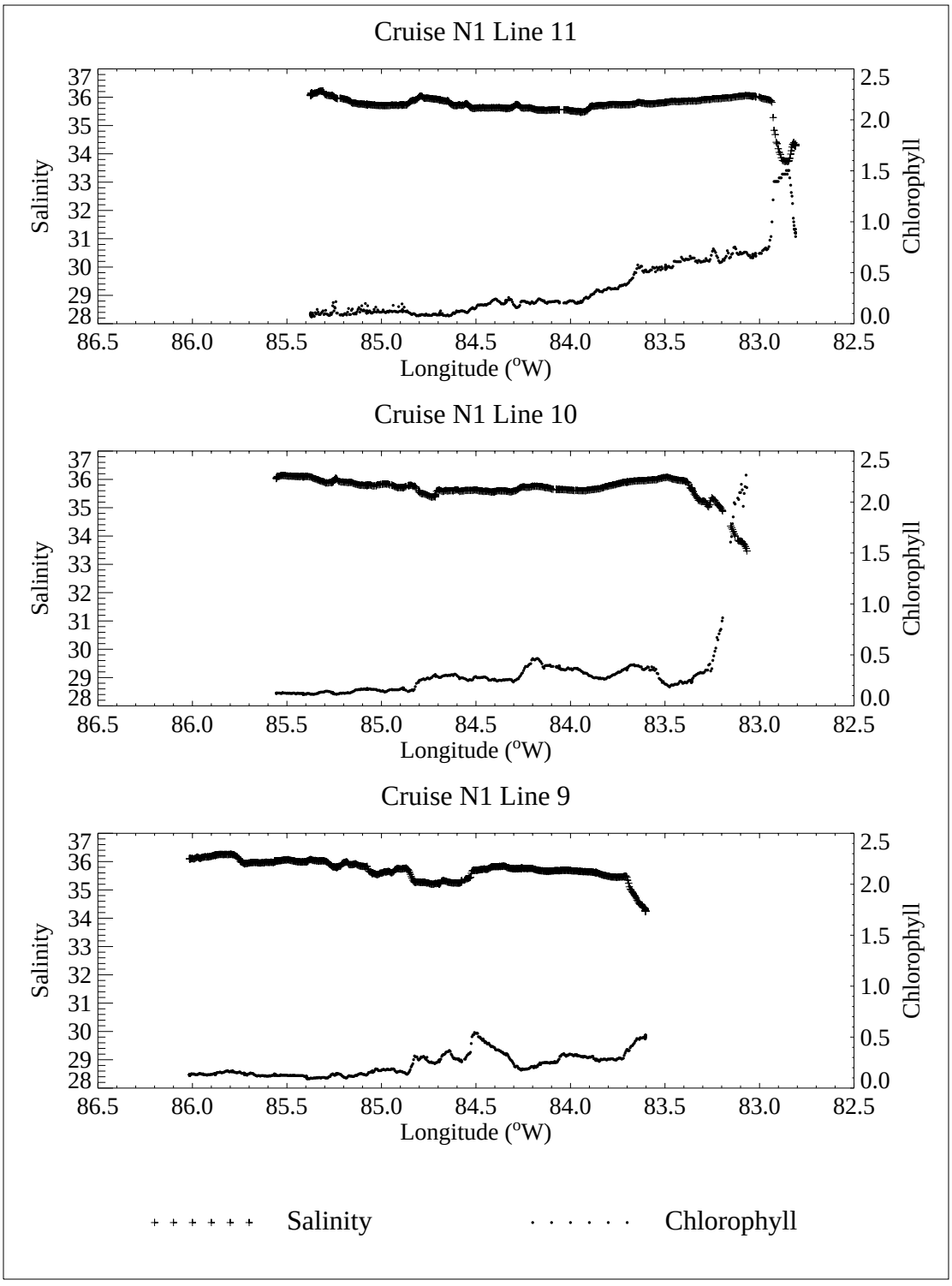


Figure 4.6.3. Flow-through salinity and chlorophyll ($\mu g \cdot L^{-1}$) for the three southeast transects on NEGOM cruise N1 (November 1997). Each line runs approximately from the 1000-m isobath (westernmost data) to the 10-m isobath (easternmost data).

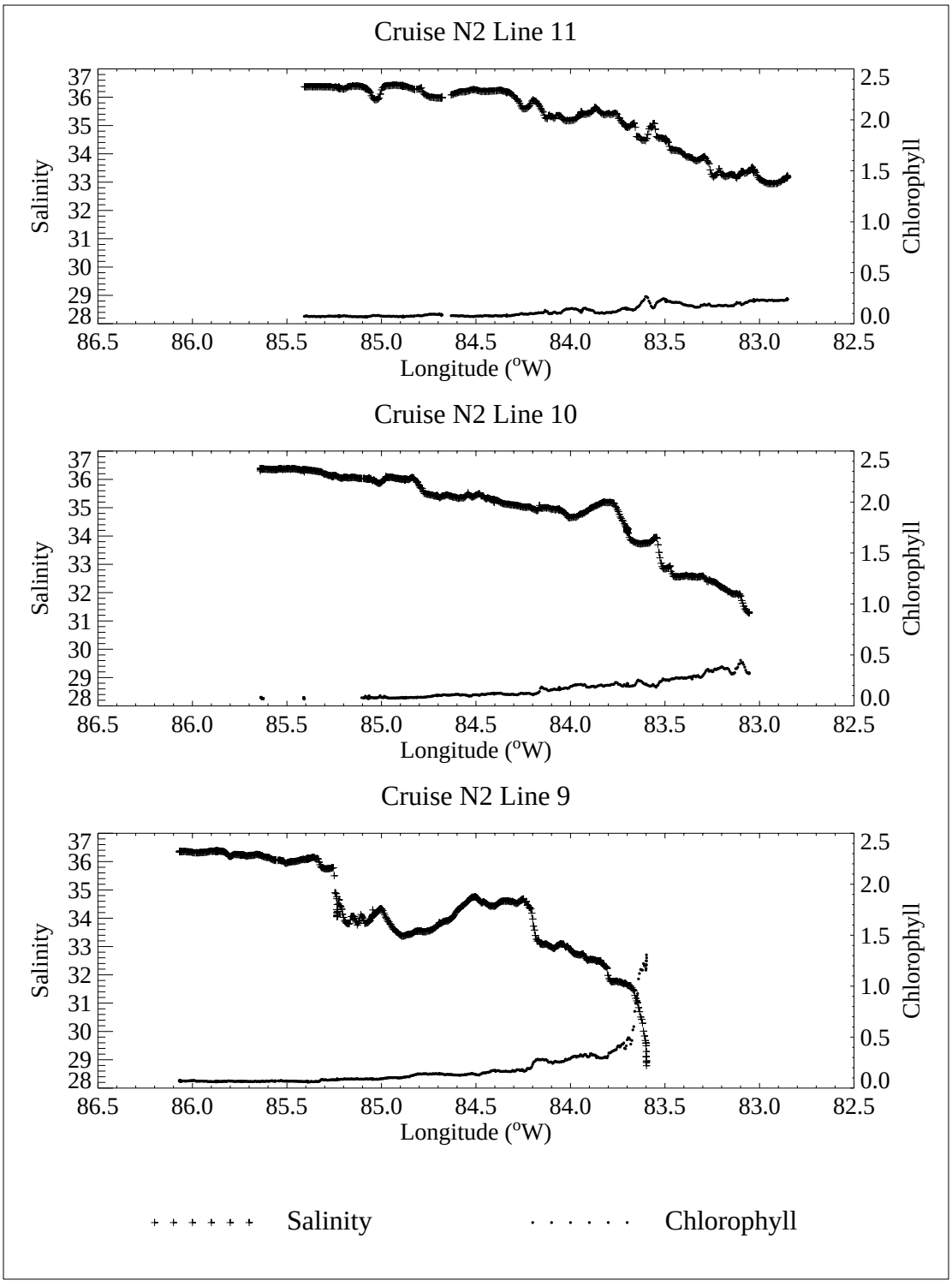


Figure 4.6.4. Flow-through salinity and chlorophyll ($\mu g \cdot L^{-1}$) for the three southeast transects on NEGOM cruise N2 (May 1998). Each line runs approximately from the 1000-m isobath (westernmost data) to the 10-m isobath (easternmost data).

5 INFORMATION TRANSFER

5.1 Introduction

This section gives an overview of information transfer and data sharing activities of NEGOM-COH. An MMS NEGOM physical oceanography information exchange meeting was held on 29-30 April 1998 at the University of South Florida, Department of Marine Science, St. Petersburg, FL. At that meeting, the MMS NEGOM contractors discussed data availability and exchanges. A major conclusion was that preliminary data should be shared freely between the contractors within about one month of data collection; final data are submitted to MMS and NODC. NEGOM-COH agreed to provide a NEGOM web site (see Section 5.2 below) and a password protected ftp site for preliminary NEGOM data to facilitate NEGOM data exchanges. NEGOM-COH further agreed to receive and post on the web site a data inventory from the other NEGOM participants and a list, provided by the MMS Contracting Officer's Technical Representative, of NEGOM and NEGOM-related reports with contact sources.

5.2 Information Transfer

Information on the NEGOM-COH program is provided on a publicly accessible web page on the internet. The address is

http://negom.tamu.edu/negom

The web site includes information on past, current, and future NEGOM-COH activities and numerous links to other NEGOM and Gulf of Mexico-related web sites. The NEGOM-COH activities include a summary of the program, postings of cruise station locations and maps as planned and as executed, selected AVHRR and/or altimeter sea surface height anomaly images relevant to cruise periods, and contour plots of selected hydrographic parameters from completed cruises. Two listings are posted on the web site: a data catalog of historical and current data held by NEGOM participants with links to their sites and a record of NEGOM and NEGOM-related reports and publications prepared by or for MMS with a contact source. Links are provided to the web sites of all other NEGOM components and to the MMS Active Environmental Studies Offshore Florida web page. Links also are provided to sources of various ancillary data sets, such as river discharge, as well as to other programs and institutions studying the oceanography of the northeast Gulf of Mexico. The NEGOM-COH web site will be maintained at least through completion of the program in September 2001.

5.3 Data Sharing

Data sharing is accomplished through two means. First, participants in other MMS contracts can download NEGOM-COH data sets from the web site through password protected venues. These data may have had limited quality control processing and so are restricted. MMS NEGOM contractors were provided a password for access to NEGOM-COH data. Second, a data sharing agreement was formulated to allow interested scientists outside the NEGOM/MMS community to use subsets of processed data while protecting the interests

of MMS and the NEGOM-COH scientists in the use of these data. Requests for subsets of the data are made to the NEGOM-COH Program Manager. No data requests requiring a data sharing agreement were recieved during the first nine months of the program.

6 TECHNICAL DISCUSSION

6.1 Introduction

Section 6 provides a brief technical discussion of preliminary results of the data collection from cruise N1. Detailed syntheses and interpretations will be included in the Final Synthesis Report for this project. Sequential numbers for CTD/bottle stations on N1 are shown in Figure 6.1.1. These numbers appear in several of the graphics. 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 prior to the conclusion of the project. This same caveat applies to all data reported in this document.

A preliminary description of the general circulation during cruise N1 is presented in section 6.2, effects of a small cyclone on water properties in section 6.3, and nutrients, particulate matter, and phytoplankton pigment distributions in section 6.4.

6.2 General Circulation in November 1997

Figure 6.2.1 (upper panel) shows average SST from AVHRR for 24-30 November 1997 and the temperature field at 5-m depth observed on N1 during 16-27 November. Considering the time mismatch, agreement is relatively good. Off Southeast Pass is seen a warm feature that extends to the east just offshore of the 100- to 200-m isobaths into DeSoto Canyon. East of the delta, a cooler tongue of water appears to be advecting south-southeastward from the shelf into this warm intrusion. Another intrusion of warm water over the slope and onto the west Florida Shelf appears near 28°N. South of 27.5°N very warm surface water appears across the shelf to the 10- or 20-m isobath. There is a marked cross-shelf temperature gradient over the inner shelf with inshore temperatures less than 18°C.

In Figure 6.2.1 (lower panel) are shown 5-m isohalines superimposed on the same satellite SST field shown in the upper panel. The warm water intrusions off Southeast Pass and over the shelf of DeSoto Canyon appear as regions of relatively high salinity. Between them, centered about 29.2°N and 88.4°W, is a distinct low salinity feature with values less than 33, corresponding to the cooler water advecting offshore along the eastern edge of the delta. The warm water at and south of 28°N on the west Florida Shelf is relatively salty. The warm intrusion onto the slope and shelf near 28°N, 85.5°W is clearly seen in the salinity and satellite SST patterns. Nearshore salinities are less than 33 from the Mississippi River to east of Mobile Bay. Salinities are less than 34 from Tampa northward to the bend.

The 800 db level was selected as the reference level for a surface geopotential anomaly map based on N1 hydrography (Figure 6.2.2 upper panel). Clear, strong anticyclonic features are associated with the warm intrusions off Southeast Pass and into DeSoto Canyon as well as near 28°N over the west Florida slope and shelf. A weak cyclonic feature is seen over the slope between the latter two anticyclonic intrusions.

A large cyclone with two low centers dominates the region of the Mississippi/Alabama Bight and east to Cape San Blas. Another strong cyclonic feature is present over the shelf north of Tampa Bay; its center is over the inner shelf.

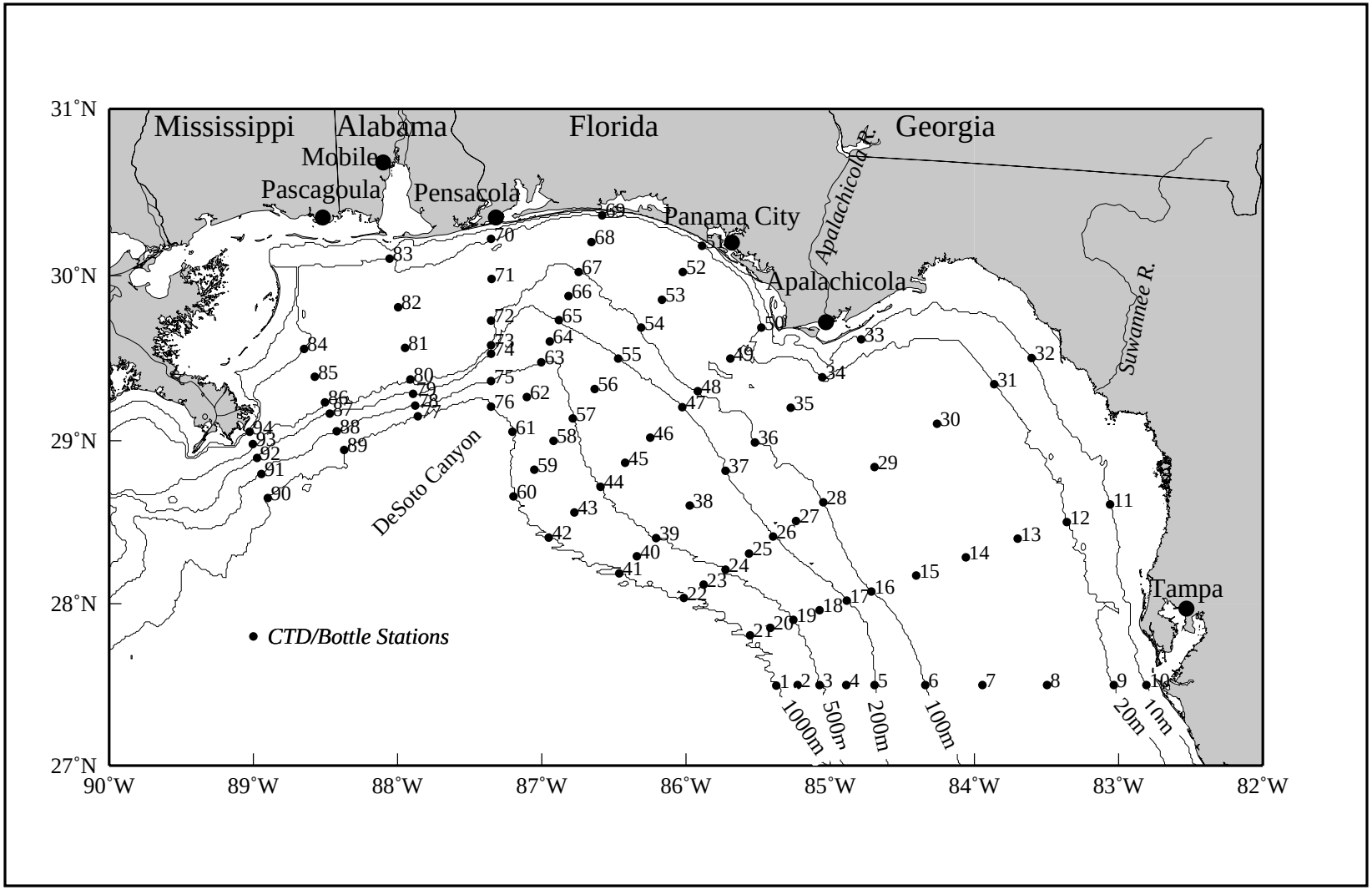


Figure 6.1.1. Station numbers for CTD stations on cruise N1 conducted on 16-26 November 1997.

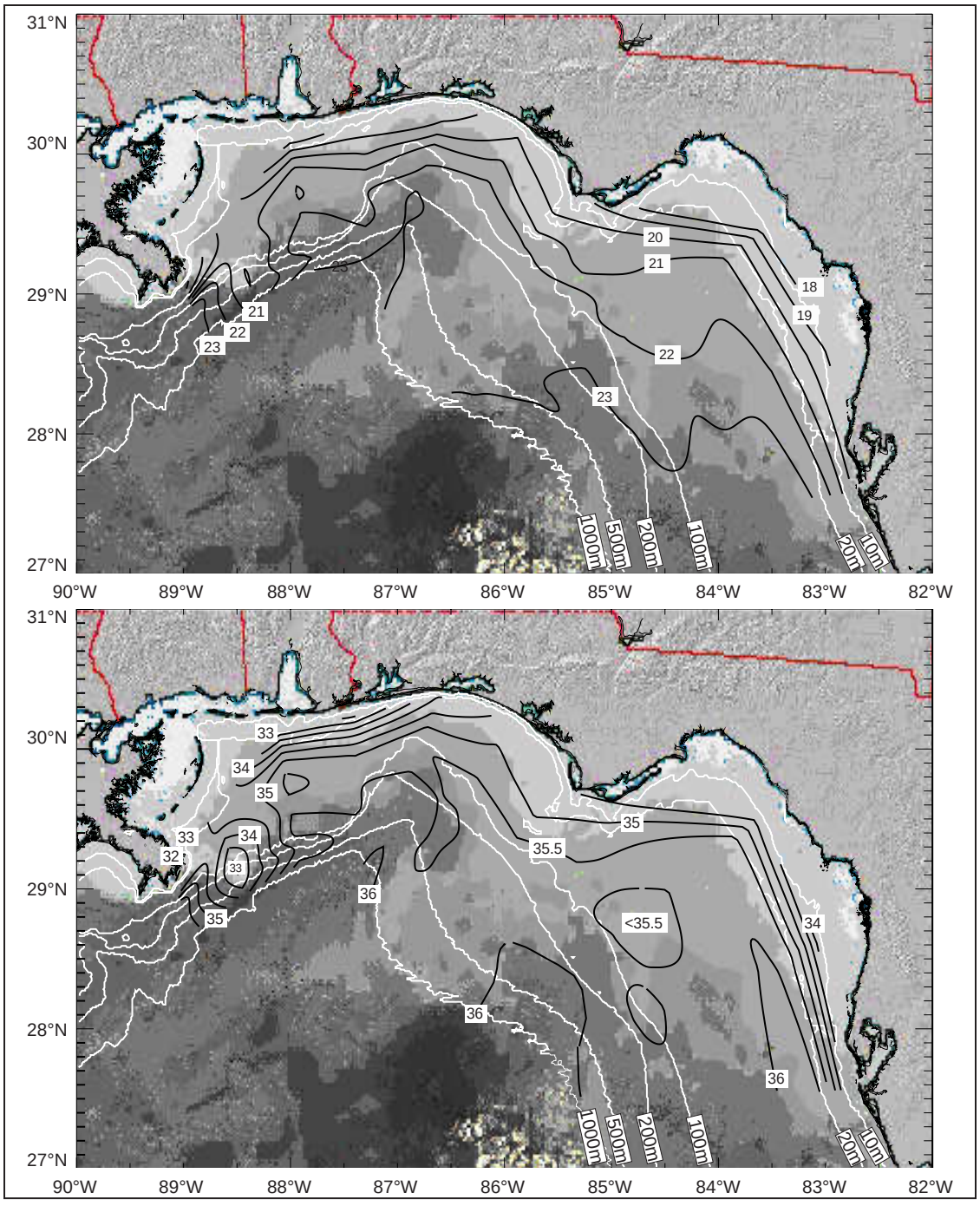


Figure 6.2.1. Sea surface temperature from AVHRR averaged for 24-30 November 1997 with isotherms (upper panel: °C) and ioshalines (lower panel) at the 5-m depth from cruise N1, 16-26 November 1997. Warm water is in the darker greys; cold water in the lighter.

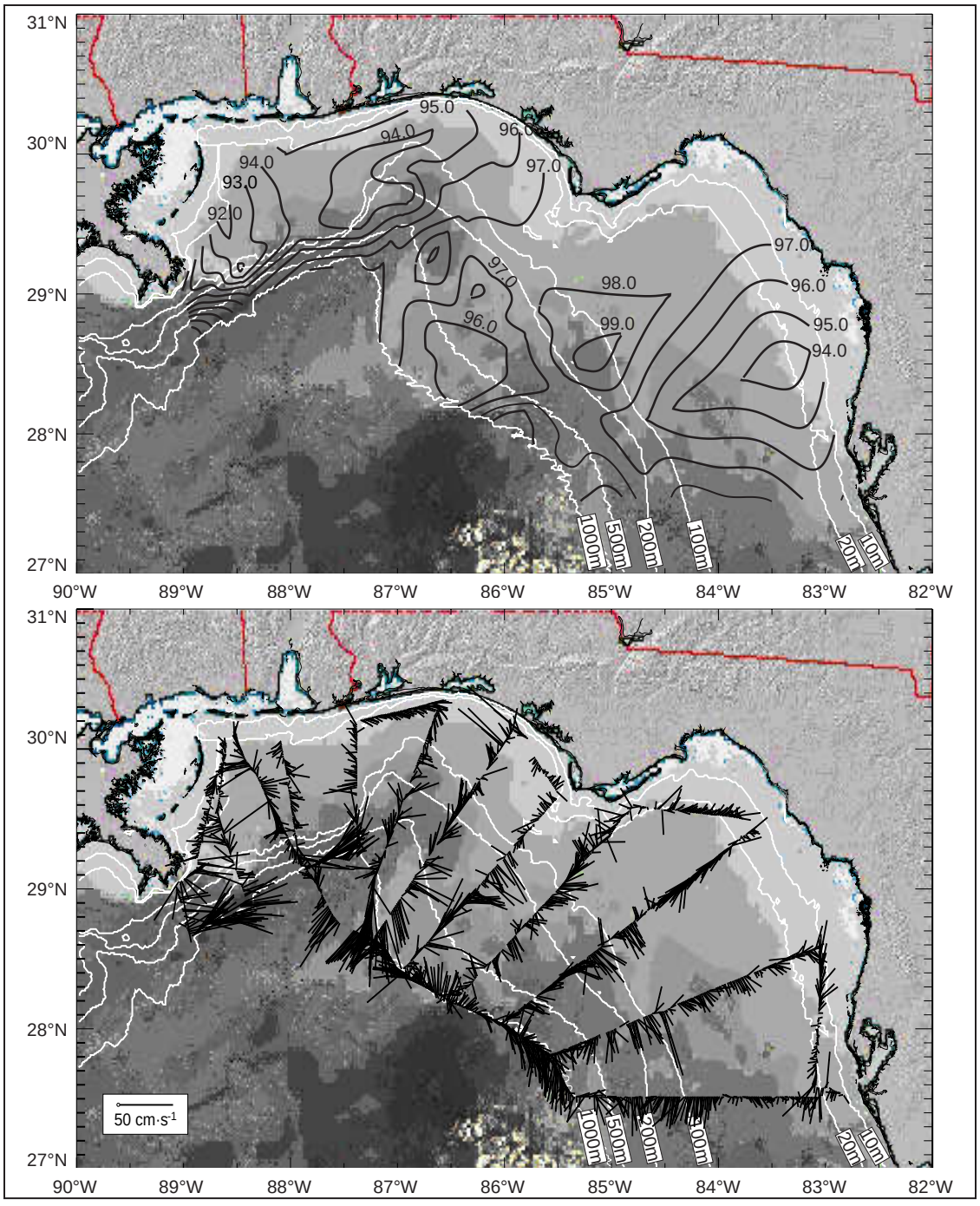


Figure 6.2.2. Sea surface temperature from AVHRR averaged for 24-30 November 1997 with the geopotential anomaly of 3 db relative to 800 db (upper: dyn cm) and the ADCP-measured currents at the 10/12-m depth (lower panel: $cm \cdot s^{-1}$) from cruise N1, 16-26 November 1997. Warm water is in the darker greys; cold water in the lighter.

Shipboard ADCP measurements during N1 yielded the field of currents at 10-12 m shown in Figure 6.2.2 (lower panel). Strong currents are seen in the two major anticyclonic, warm, salty intrusions over the slope/shelf edge. The western center of the cyclone over the Mississippi/Alabama/Florida shelf west of Apalachicola is clearly seen in the ADCP field. This circulation is responsible for the southeastward advection of cooler, fresher water along the delta. The eastern center of this large cyclonic feature is not as well defined by ADCP measurements, except for its eastern flank. The large cyclone centered over the inner shelf north of Tampa Bay also is seen in the ADCP field.

The combination of offshore anticyclonic circulation and inner shelf cyclones results in maximum alongshelf currents in a downcoast (Mississippi to Tampa) direction located over the 100- to 200-m isobaths at many cross-shelf lines. The degree to which this near "shelf edge" current is dependent on the offshore existence of anticyclones versus the observed two cyclonic gyre circulation over the mid and inner shelf is yet to be determined.

Sea surface height anomaly from satellite altimeter data are useful in identifying circulation features seaward from the shelf edge (Jochens 1997). In particular, the anticyclonically circulating Loop Current and its associated Loop Current eddies appear as highs in sea surface height anomaly. Cyclonically circulating eddies appear as lows. These high and low regions are consistent with dynamic topography.

The sea surface height anomaly field for 16-26 November 1997 is shown for the study area in the upper panel of Figure 6.2.3. This representation clearly shows a remnant Loop Current eddy responsible for the anticyclonic offshore circulation features and intrusions of warm, salty water across the western slope and onto the shelf at and west of the delta. The eddy is centered southeast of Southeast Pass. It is elongated to extend into the DeSoto Canyon; a secondary extension is to the southeast and then more eastward resulting in warm, salty water near 28°N over the slope.

The larger view of the eastern Gulf, given in the lower panel of Figure 6.2.3, shows the northern extent of the Loop Current on 16-26 November from sea surface height anomaly. Between the Loop Current and the eddy remnant off Southeast Pass is a strong cyclonic eddy. Though it is located well off the northeast shelf, it may still have had considerable influence in contributing to the northward advection of warm, salty water along its eastern edge. The confluence of that northward flow with the southward flow of the eddy near DeSoto Canyon may have contributed to the warm intrusion over the outer shelf near 28°N.

6.3 Effects of a Small Cyclone on Water Properties

Line 2 of cruise N1 crossed approximately through the middle of the western center of the cyclone located over the Mississippi/Alabama Bight (Figure 6.2.2). The surface waters within the cyclone were cooler and fresher than adjacent waters (Figure 6.2.1). The data collected along line 2 together with data from adjacent lines 1 and 3 show the effects of this small cyclone on the water properties.

The density anomaly, σ_θ, calculated from the CTD data, for the upper 200 m along lines 1, 2, and 3 is shown in Figure 6.3.1. The σ_θ contours for line 1 (left panel) show no evidence of the small cyclone; however, effects of Mississippi River discharge are seen in the lower

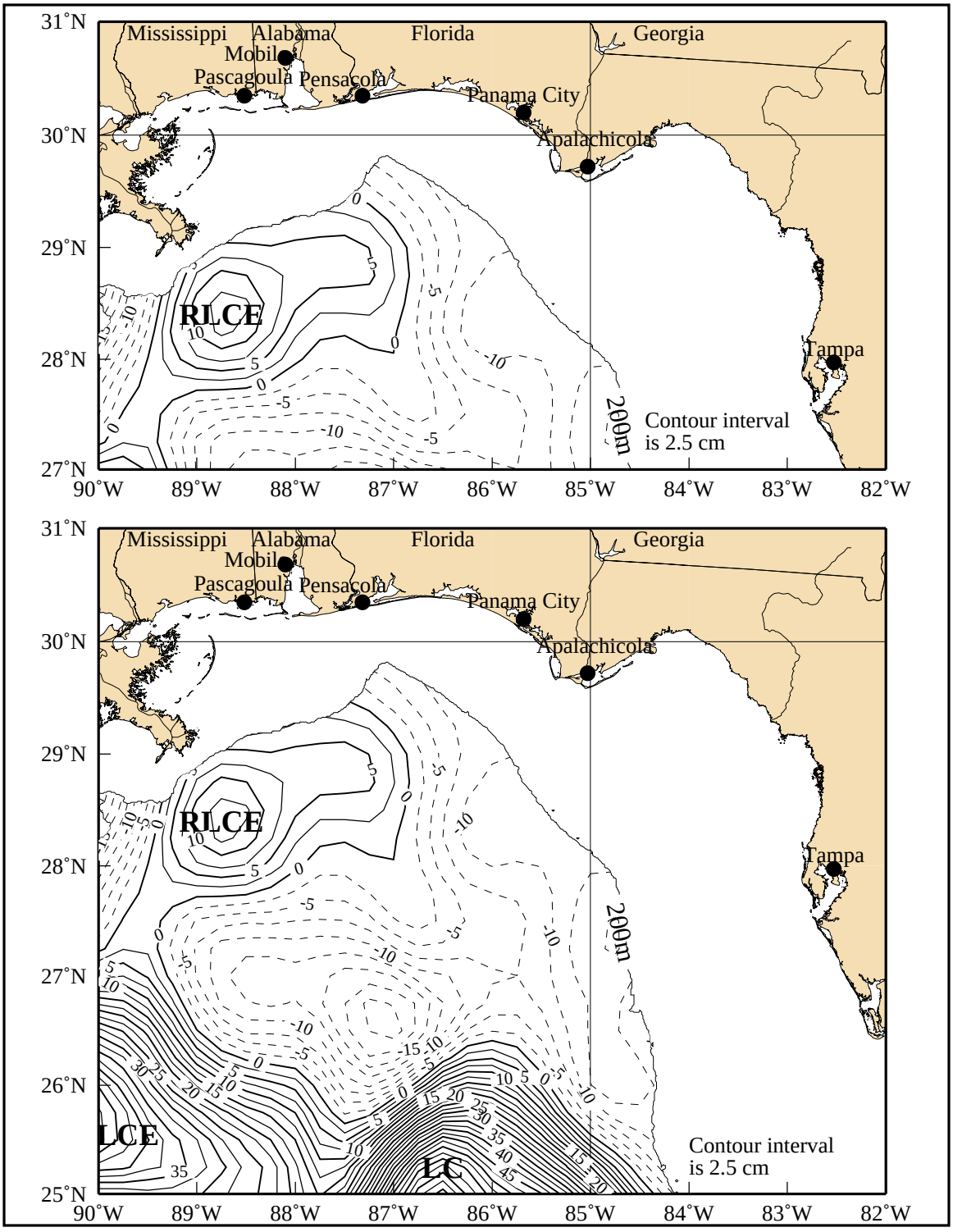


Figure 6.2.3 Mean sea surface height anomaly from satellite altimeter data for 16-26 November 1997 showing NEGOM study area (upper) and extended region (lower). LC means Loop Current; (LCE) means Loop Current Eddy; and RLCE means remnant LCE. [Data from Dr. Robert R. Leben, CCAR.]

densities (< 23 kg·m^{-3}) associated with stations 93 and 94. Along line 2, the σ_θ contours show the clear presence of the cyclone, with denser waters doming in the center at stations 86 and 87 (middle panel). The effects of the cyclone extend below 100 m. The pooling of fresher, less dense water in the center of the cyclone can be seen above the 20-m depth. On line 3, the σ_θ contours show very little influence from the cyclone (right panel).

Potential temperature and salinity from the CTD data, as well as the bottle oxygen concentrations, along line 2 are given in Figure 6.3.2. The potential temperature contours show cooler water upwelled from depth (left panel). Contours in the upper 50 m show interleaving of warmer water from offshelf with cooler nearshore water. The oxygen contours show upwelling of oxygen-poor deep water in the cyclone center (right panel). Salinity contours show upwelling of saltier deep water in the center of the cyclonic circulation (middle panel). The salinities in the upper 30-40 m show the cyclone has moved fresher shelf water to the shelf edge and slope and saltier outer shelf/slope water to the inner shelf; this also can be seen in the 5-m isohalines shown in Figure 6.2.1.

Nitrate, phosphate, and relative fluorescence along line 2 are shown in the left, middle, and right panels, respectively, of Figure 6.3.3. The nutrient concentrations for a given depth at stations 86 and 87, in the center of the cyclone, are higher than those of adjacent stations. The nutrient enrichment at these stations is from upwelling of nutrient-rich deeper waters. The silicate contours (not shown) are similar to those of phosphate. Note that the upward bulging of the nutrient-rich, oxygen-poor, and higher salinity waters is more accentuated than that of the density, thus implying cross-isopycnal upwelling.

Along line 1, there is no upwelling of nutrient-rich waters (left and middle panels in Figure 6.3.4). The waters in the upper 100 m over the outer shelf are poor in nutrients, while those in the upper 50-m over the inner shelf exhibit some nutrient enrichment associated with river discharge. Along line 3 (not shown), the upper waters across the shelf are nutrient poor, although there is some nutrient enrichment between the 25- and 50-m depths over the outer shelf.

In the upper 60 m of the water column, the relative fluorescence for lines 2 and 1, shown respectively in the right panels of Figures 6.3.3 and 6.3.4, is higher in regions with higher nutrient concentrations. The contours reflect the two different nutrient source regions: the cyclone for line 2 (e.g., stations 86 and 87) and the riverine influence for line 1 (e.g., stations 92-94). Below the photic zone, the relative fluorescence is minimal, as expected.

The cyclonic circulation associated with the small cyclone created a region of upwelling nutrients. This contributed to the higher relative fluorescence, suggestive of greater biomass, seen in the upper waters of line 2 as contrasted with those of lines 1 and 3.

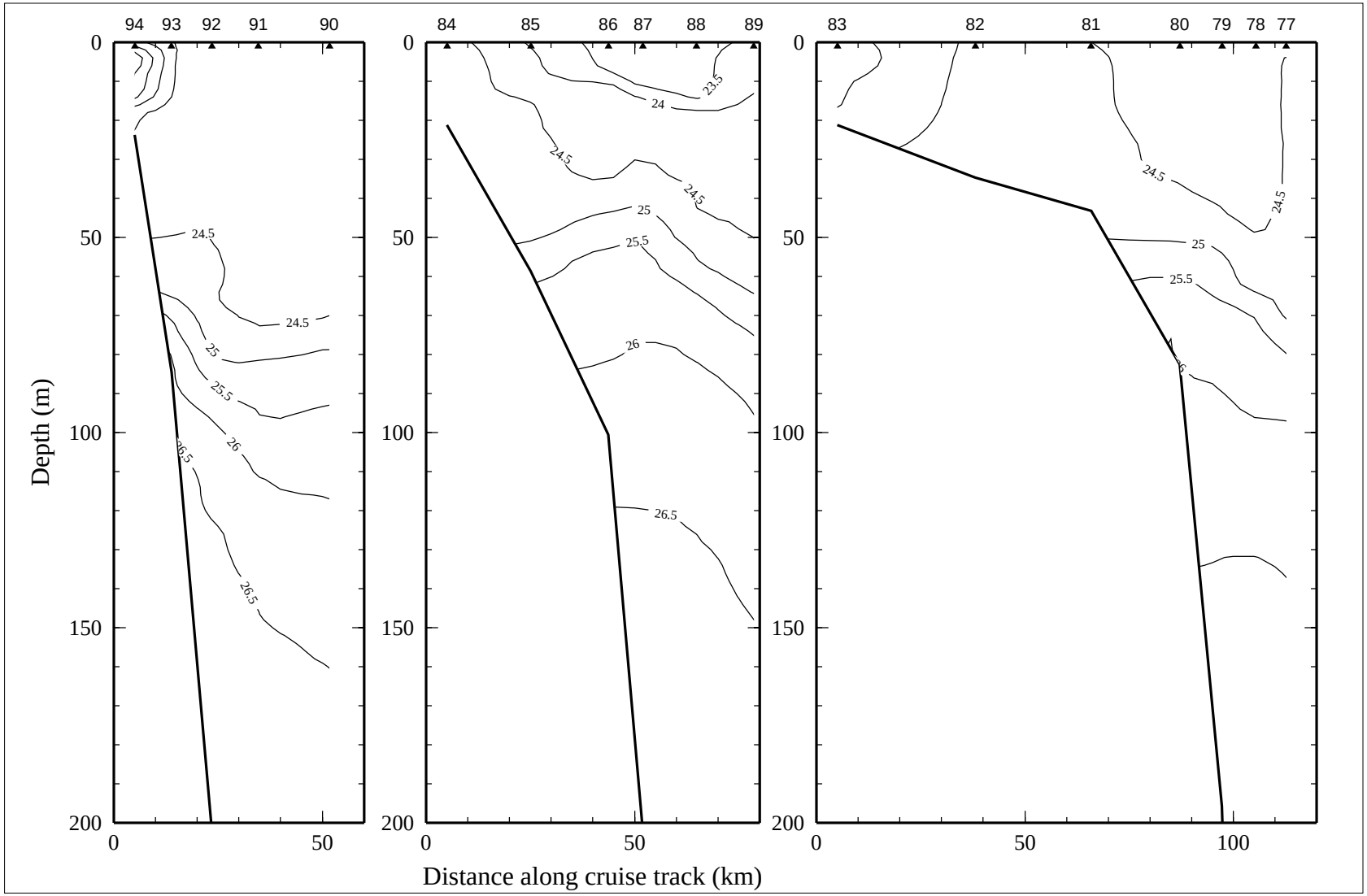


Figure 6.3.1 Density anomaly (σ_θ, kg·m^{-3}) on lines 1 (left), 2 (middle), and 3 (right) on NEGOM Cruise N1 (November 1997).

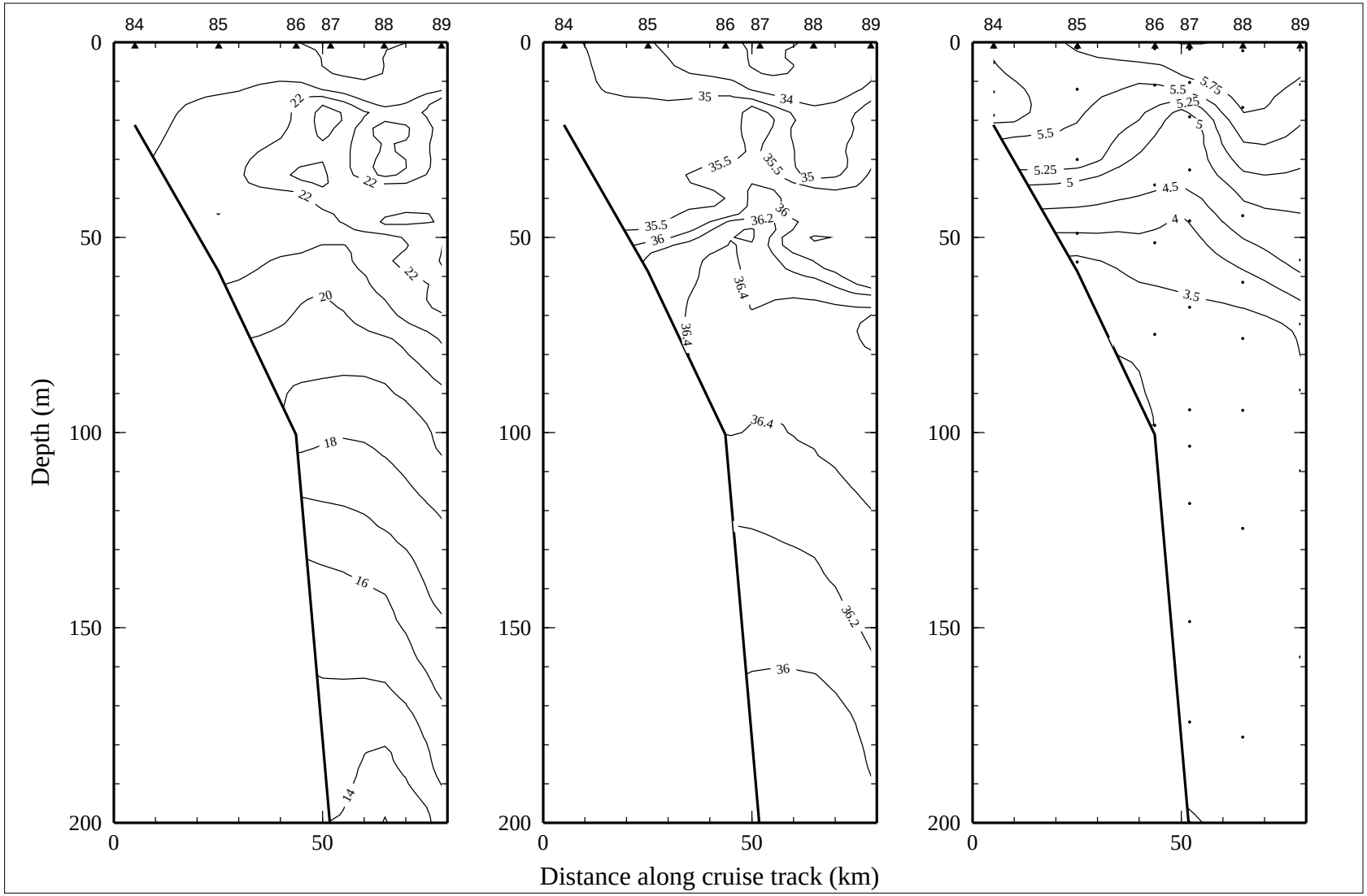


Figure 6.3.2 Potential temperature (˚C; left), salinity (middle), and dissolved oxygen (mL·L^{-1}; right) on Line 2 of Cruise N1.

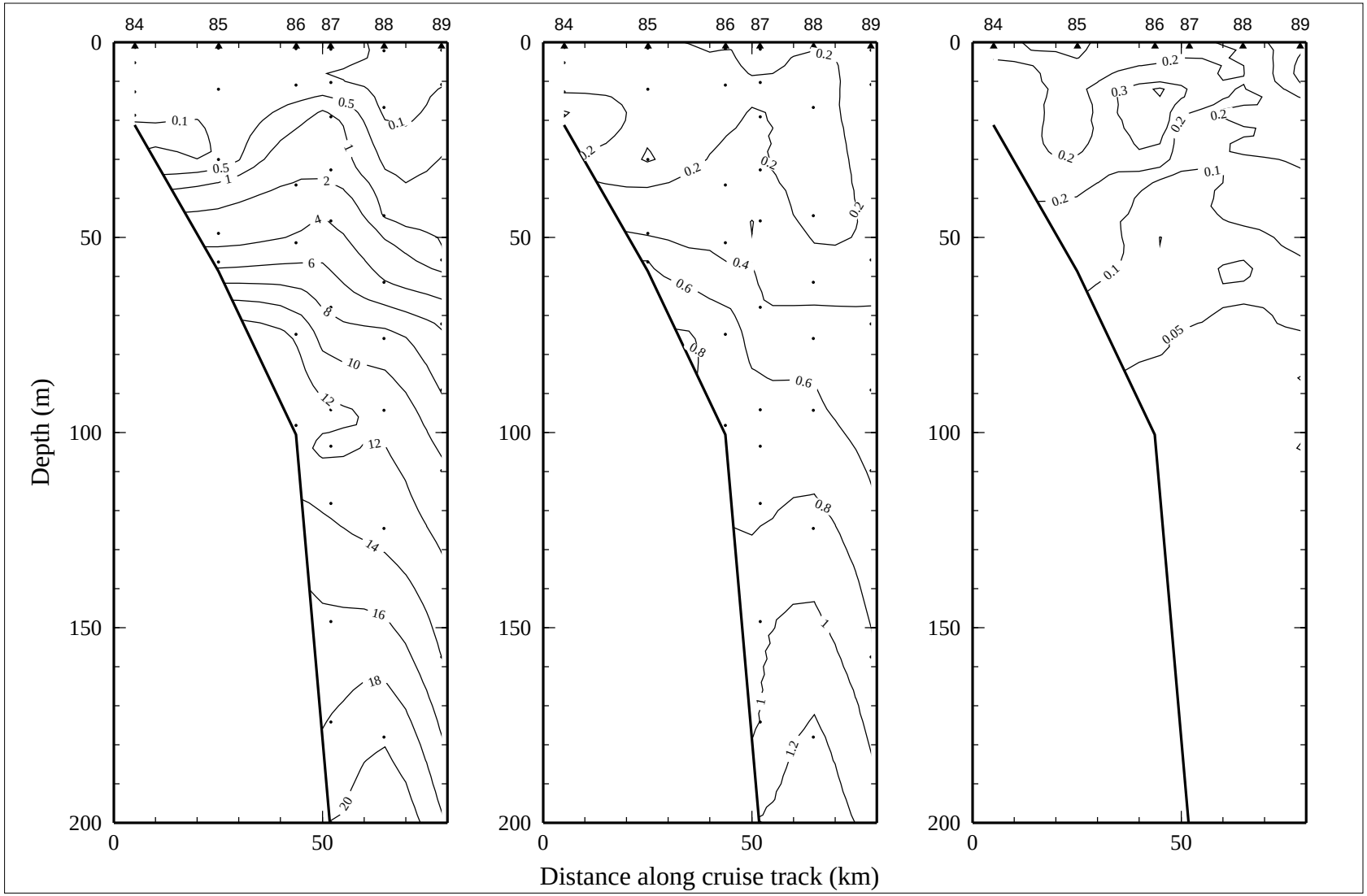


Figure 6.3.3 Nitrate (μM·L^{-1}; left), phosphate (μM·L^{-1}; middle), and relative fluorescence (right) on Line 2 of Cruise N1.

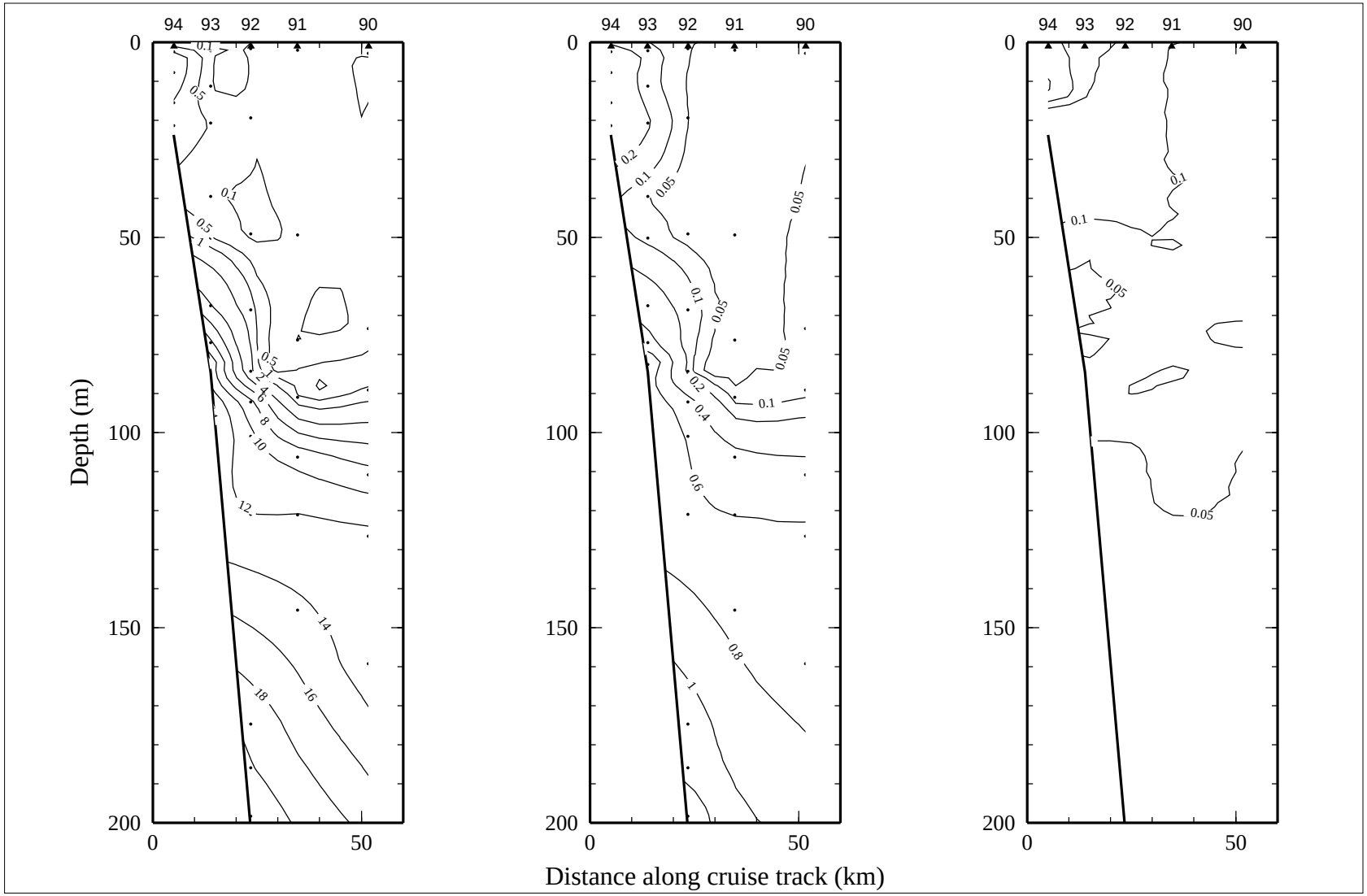


Figure 6.3.4 Nitrate (μM·L^{-1}; left), phosphate (μM·L^{-1}; middle), and relative fluorescence (right) on Line 1 of Cruise N1.

6.4 Nutrient, Particulate Matter, and Phytoplankton Pigment Distributions

6.4.1 Nutrient Distributions

Nutrient concentrations over the northeastern shelf of the Gulf of Mexico are controlled by a combination of biogeochemical and physical processes. Processes effecting nutrient concentrations are river discharges, coastal currents and winds, upwelling, biological activity, and rainfall. In near-bottom waters, remineralization of organic matter can lead to elevated levels of nutrients. Excess or enhanced nutrient levels can contribute to oxygen depletion and plankton blooms. Nutrient rich waters are often recognized in the plumes of the dominant northern Gulf of Mexico river systems. This dynamic interaction of potential sources and sinks results in seasonal and geographic variations in nutrient distributions. For example, in the northwestern Gulf of Mexico phosphorous and silicate distributions are biologically controlled while nitrate distributions are influenced by large riverine inputs. The nutrients studies are designed to describe spatial, seasonal, and interannual variations in nutrient distributions and to examine nutrient distributions with regard to water column stability, river discharge, wind field, and circulation patterns.

The nutrients measured include phosphate, nitrate, nitrite, silicate, ammonium, and urea. During the first cruise, the concentrations of phosphate, nitrite, ammonium, and urea were low; ranging from below the detection limit to a high of 2 $\mu M \cdot L^{-1}$. The concentrations of nitrate and silicate ranged from below the detection limit to 30 $\mu M \cdot L^{-1}$. Nutrient concentrations in nearshore surface waters were low, ranging from below detection limit to less than 0.2 $\mu M \cdot L^{-1}$ for all nutrients, except those stations along transect 1 (Figures 6.4.1 through 6.4.3). The nearshore surface water along transect 1, near the Mississippi River, exhibited high nutrient concentrations, particularly silicate. Surface waters at the innermost station had silicate and nitrate concentrations of 12.6 and 1.5 $\mu M \cdot L^{-1}$, respectively, whereas bottom waters had silicate and nitrate concentrations of 5.4 and 0.7 $\mu M \cdot L^{-1}$, respectively. Enhanced nutrient levels were a common feature at the mouths of rivers.

In general, nutrient concentrations are higher in bottom waters than surface waters. On the outer continental shelf differences in nutrient concentrations between surface water and bottom waters were substantial (Figures 6.4.4 through 6.4.6, sections along line 6, illustrate nutrient distributions). The concentrations of nitrate and silicate increased from below the detection limit in surface waters to 20-30 $\mu M \cdot L^{-1}$ in the deep waters over the continental slope. Waters as deep as 70 m tended to be nutrient-poor, with nutrient concentrations far below those of deep waters. An abrupt increase in nutrient concentration (particularly for phosphate, nitrate, and silicate) occurred typically between 70 and 100 m water depth. This vertical structure develops as a result of fixation of nutrients into biomass by phytoplankton in the euphotic zone and remineralization of organic matter in deeper waters and sediments.

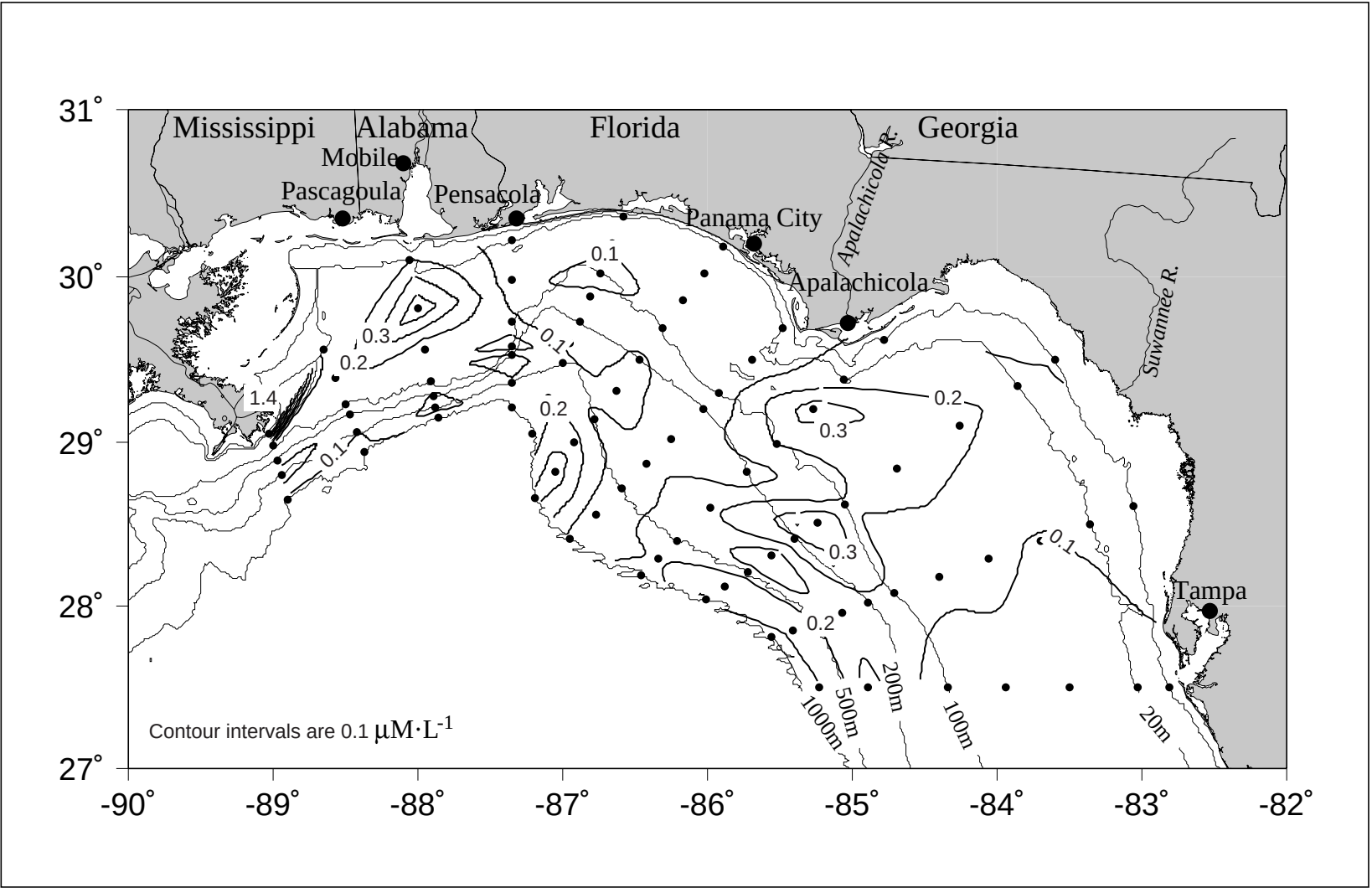


Figure 6.4.1. Near-surface (~5 m) nitrate concentration ($\mu M \cdot L^{-1}$) from cruise N1, 16-26 November 1997.

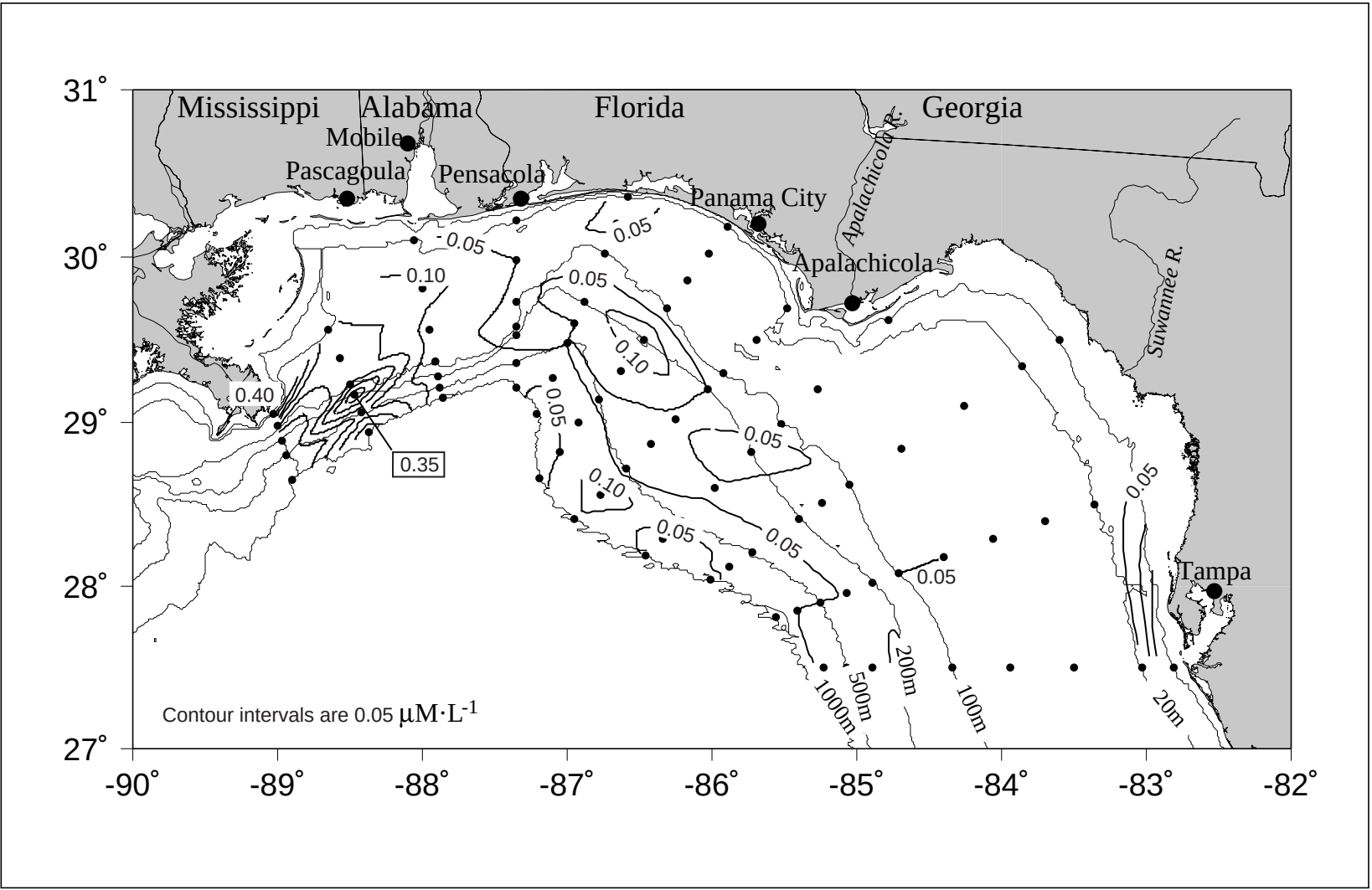


Figure 6.4.2. Near-surface (~5 m) phosphate concentration ($\mu M \cdot L^{-1}$) from cruise N1, 16-26 November 1997.

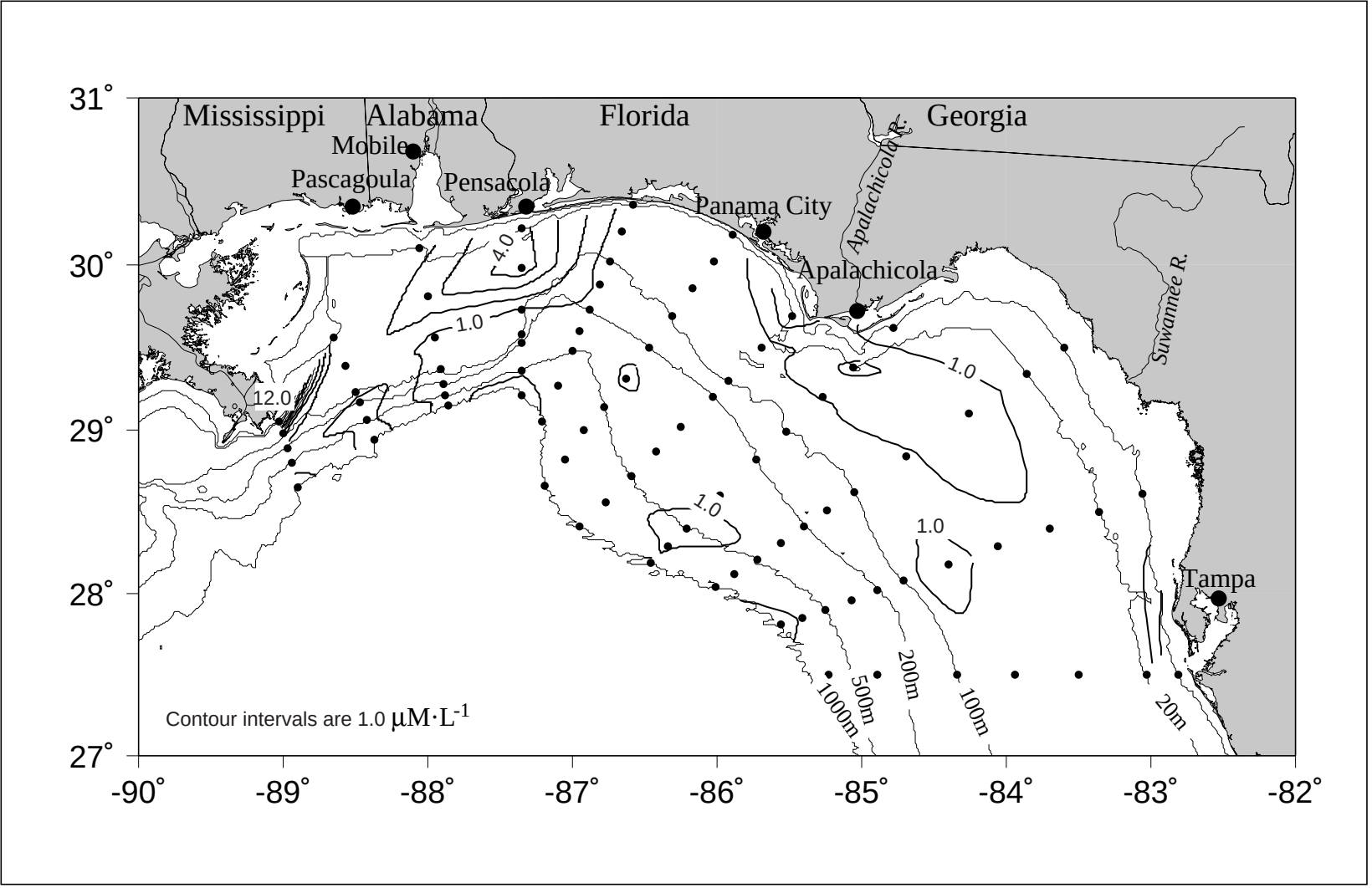


Figure 6.4.3. Near-surface (~5 m) silicate concentration (μM·L^{-1}) from cruise N1, 16-26 November 1997.

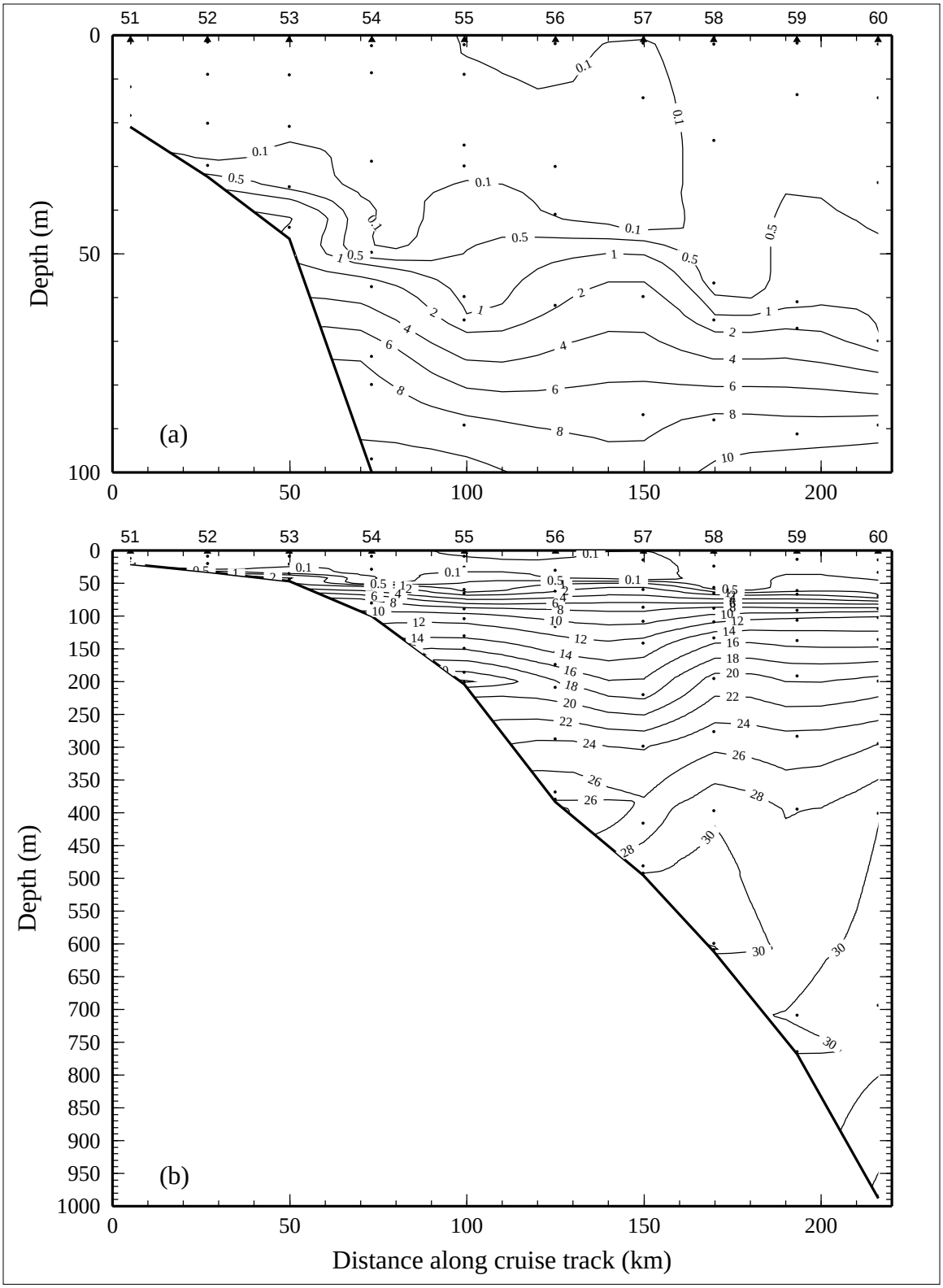


Figure 6.4.4. Nitrate ($\mu M \cdot L^{-1}$) along Line 6 of NEGOM Cruise N1 for the (a) upper layer and (b) full water column.

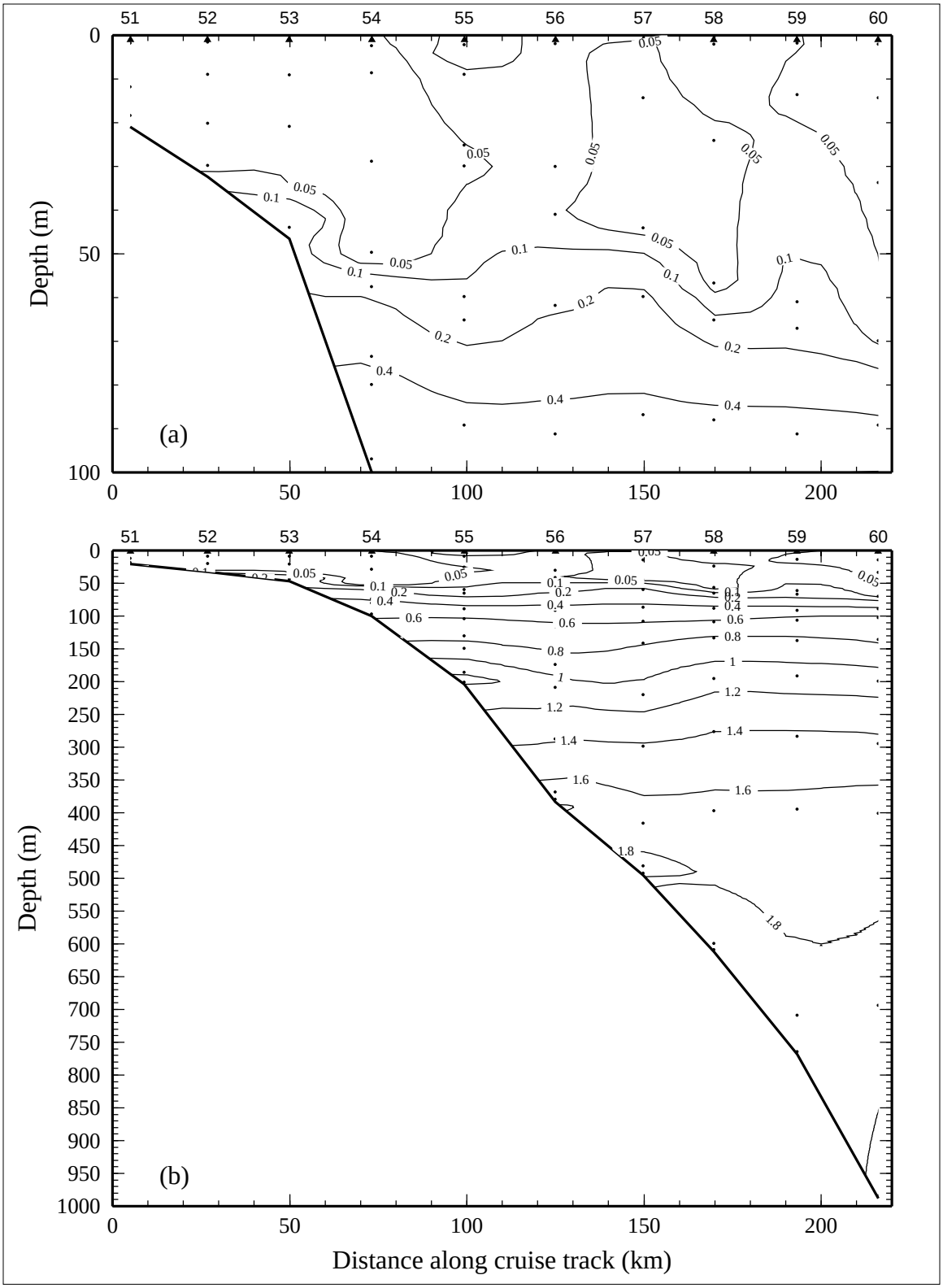


Figure 6.4.5. Phosphate ($\mu M \cdot L^{-1}$) along Line 6 of NEGOM Cruise N1 for the (a) upper layer and (b) full water column.

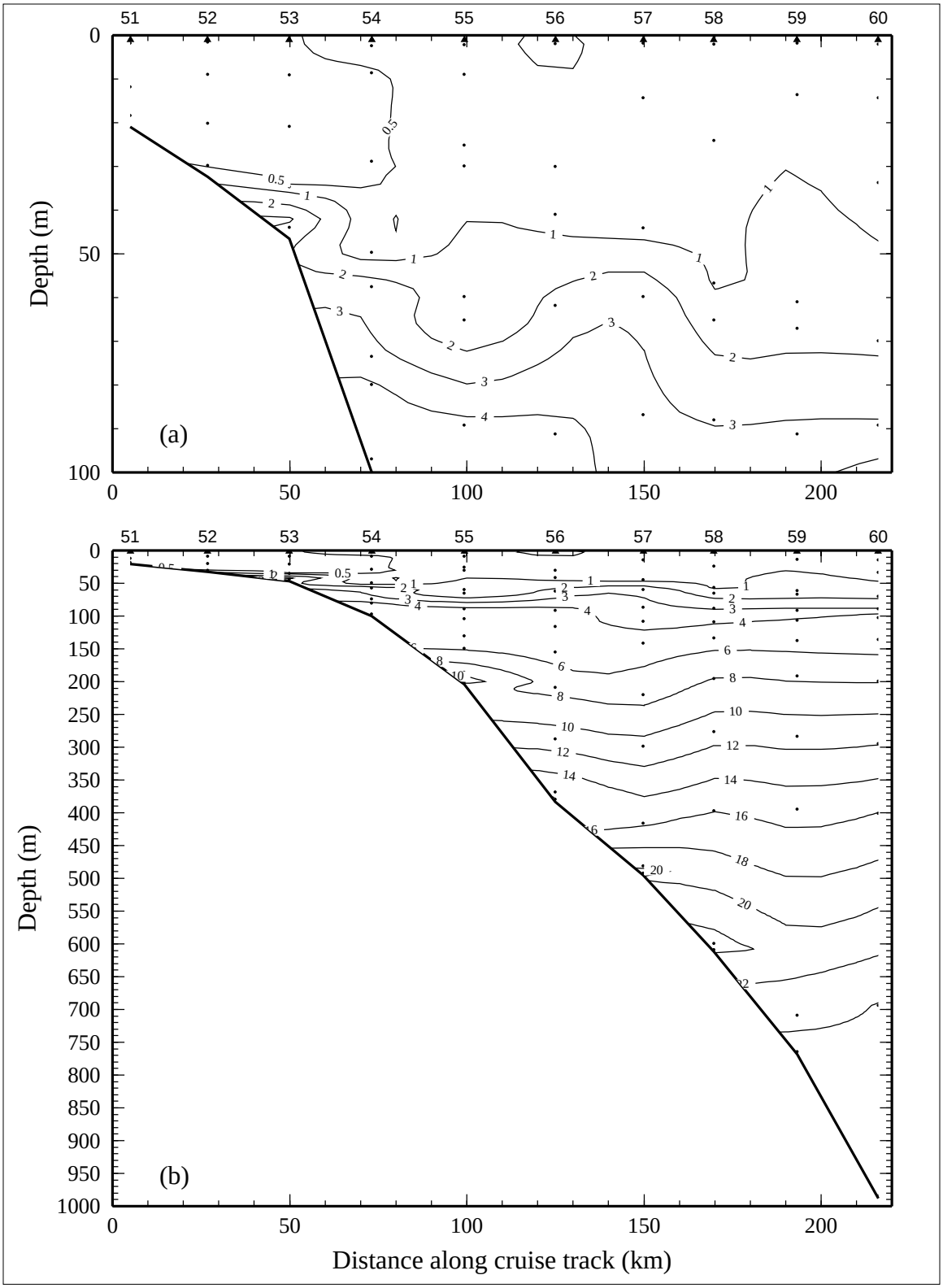


Figure 6.4.6. Silicate ($\mu M \cdot L^{-1}$) along Line 6 of NEGOM Cruise N1 for the (a) upper layer and (b) full water column.

6.4.2 Particulate Matter Distributions

Particulate matter in the world oceans is derived from a variety of sources including river discharges, living phytoplankton and bacteria, atmospheric deposition, and detrital remains of organisms. Particulate matter is organic as well as inorganic and contains living biological organisms resulting in a complex biogeochemical cycle. The living portion of particulate matter interacts with water column chemistry through the uptake of nutrients to form biomass, production of oxygen during photosynthesis, and chemical reactions related to excretion of waste products and decay of organic detritus. To adequately describe and understand water column chemistry and particulate matter distributions and variations, these interactions must be considered.

Particulate matter distributions in the study area are described in terms of particulate matter (PM), particulate organic carbon (POC), and light transmission. Vertically continuous estimates of particulate concentrations are provided by transmissometry. This provides a rapid determination of the horizontal and vertical distribution of particles and an assessment of temporal (seasonal and interannual) variability over the three-year observation period. In the open ocean most particles are biological organisms and associated detritus. However in near-shore regions, riverine sources of inorganic materials and terrestrially sourced organic matter can be significant. In the open ocean, particulates detected via beam attenuation (c_p), are believed to be primarily due to particle sizes less than 20 micron in diameter and represent a range of organisms including heterotrophic bacteria, prokaryotic prochlorophytes, cyanobacteria, eukaryotic picoplankton and smaller nanoplankton. Beam transmission is converted to a total beam attenuation coefficient (c), where $c = c_w + c_p + c_y$ (w = seawater, y = yellow dissolved organic matter, and p = particles). Seawater attenuation is constant and the contribution of yellow dissolved organic matter at the light wavelengths utilized is generally considered to be minimal. In coastal waters, this second assumption may or may not be true. Based on these assumptions, particle concentrations can be estimated from transmissometry readings. These water column properties can be used to understand the origins of nepheloid layers. Particulate distributions and temporal variations are to be evaluated in the context of the physical processes that operate within the study area.

Transmissometry values during cruise N1 varied from 35% to 93%. Values were lowest close to the Mississippi River. The majority of stations exhibited transmittance of 70% or more. Most stations showed constant transmission values of 90% or greater with little or no vertical structure evident (Figure 6.4.7 shows an example from line 6). It was anticipated that transmission profiles in the vicinity of DeSoto Canyon (lines 4, 5, and 6) might reveal mid-depth nepheloid layers, but except for a slight minimum in transmission at 50-200 m water depth and at the 1000-m station (lines 4 and 5), no significant particle layers were detected there during N1. Mid-depth and bottom water nepheloid layers were observed along lines 1 and 2, and to a lesser extent line 3, indicating outflow from the Mississippi River. The shallowest stations along lines 7, 8, 10, and 11 had transmission of approximately 70%, most likely due to outflow from the Apalachicola and Suwannee Rivers.

Particulate matter (PM) concentrations and beam c_p values from cruise N1 were well correlated (Figure 6.4.8); an equation was obtained to estimate PM concentrations from beam c_p values from transmissometer data. Values under 1000 $\mu g \cdot L^{-1}$ were used to determine the equation. Data were binned based on location and depth; all 1000-m stations, all 500-m

stations, all 200-m stations, all 100-m stations, all mid-shelf (between 100 m and 20 m) stations, all 20-m stations, all surface points, all mid-water points, and all bottom points. Data in the last three bins were also divided into three depth groups—station water depths shallower than 100 m, depths between 100-200 m, and depths below 200 m (Figure 6.4.9). In all cases, good correlations between the parameters were obtained.

Surface, mid-depth, and bottom water PM concentrations ranged respectively from 40.0 to 2410.9, 18.5 to 1784.3, and 20.7 to 4967.1 $\mu g \cdot L^{-1}$. Concentrations in excess of 1000 $\mu g \cdot L^{-1}$ were uncommon. Highest PM concentrations occurred closest to river outflow, in particular at the Mississippi Delta (Figures 6.4.10 through 6.4.12). Particulate organic carbon (POC) concentrations at the surface and near bottom ranged from 26.5 to 235.5 and from 9.4 to 211.9 $\mu g \cdot L^{-1}$, respectively (Figures 6.4.13 and 6.4.14). POC generally increased as water depth decreased. PM, POC, and beam c_p distributions were compared (Figures 6.4.15 and 6.4.16). The ratio of POC to PM ranged from 0.025 to 1.06, suggesting a mixed origin of inorganic detritus and phytoplankton biomass or remains. No simple relationship between these parameters was apparent based on this limited dataset.

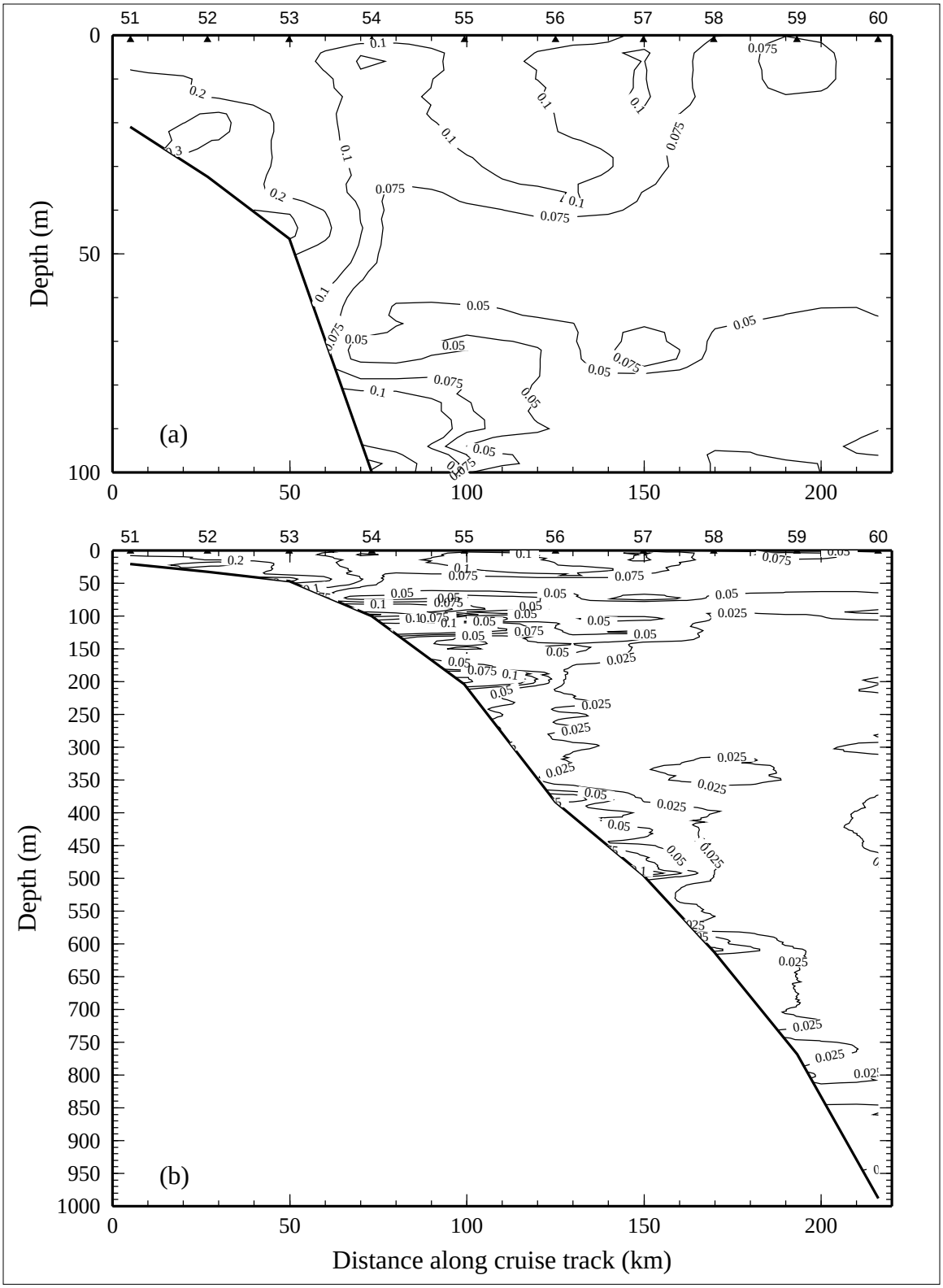


Figure 6.4.7. Beam c_p (m^{-1}) along Line 6 of NEGOM Cruise N1 for the (a) upper layer and (b) full water column.

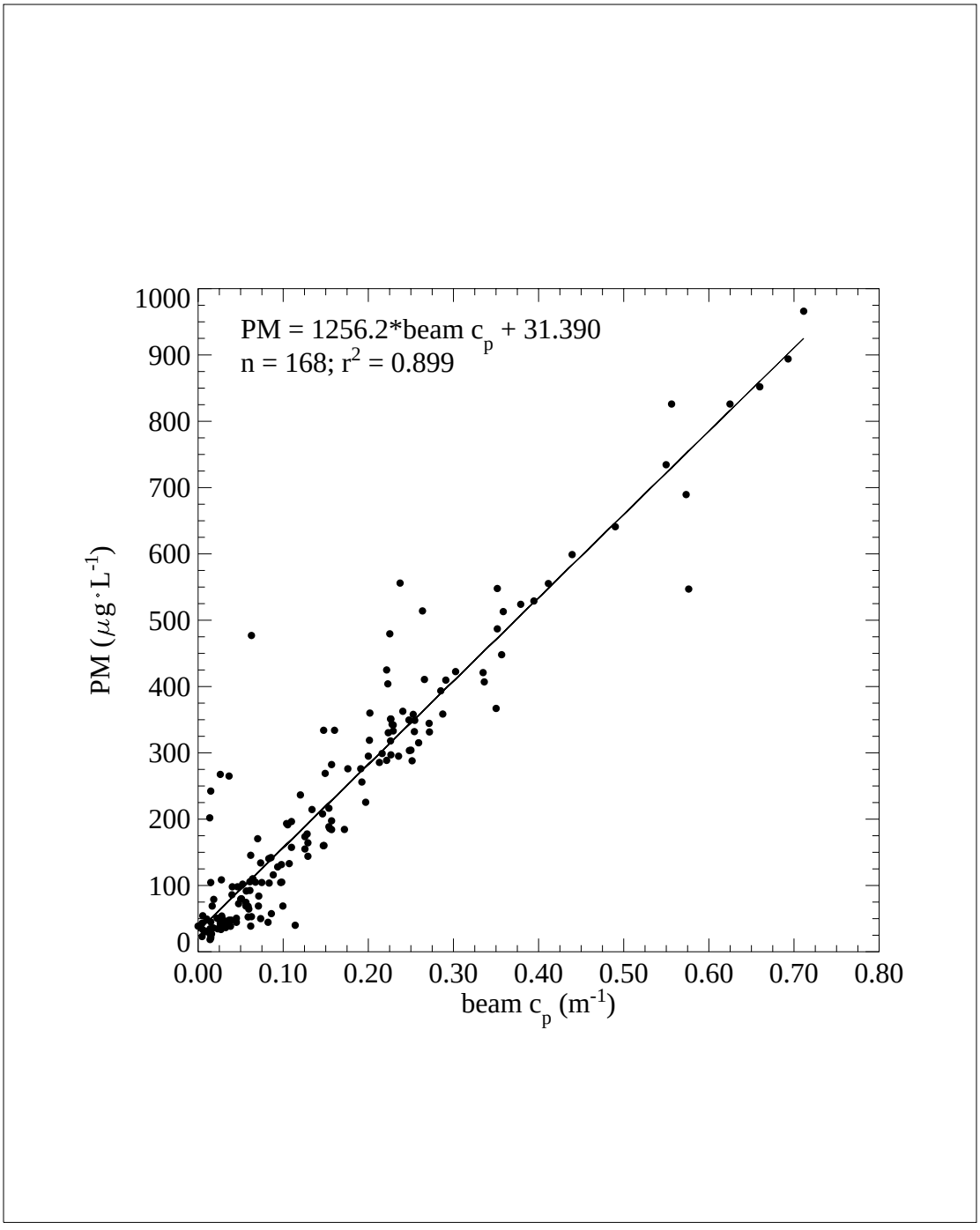


Figure 6.4.8. Correlation of particulate matter concentration (PM) and beam c_p on cruise N1, November 1997.

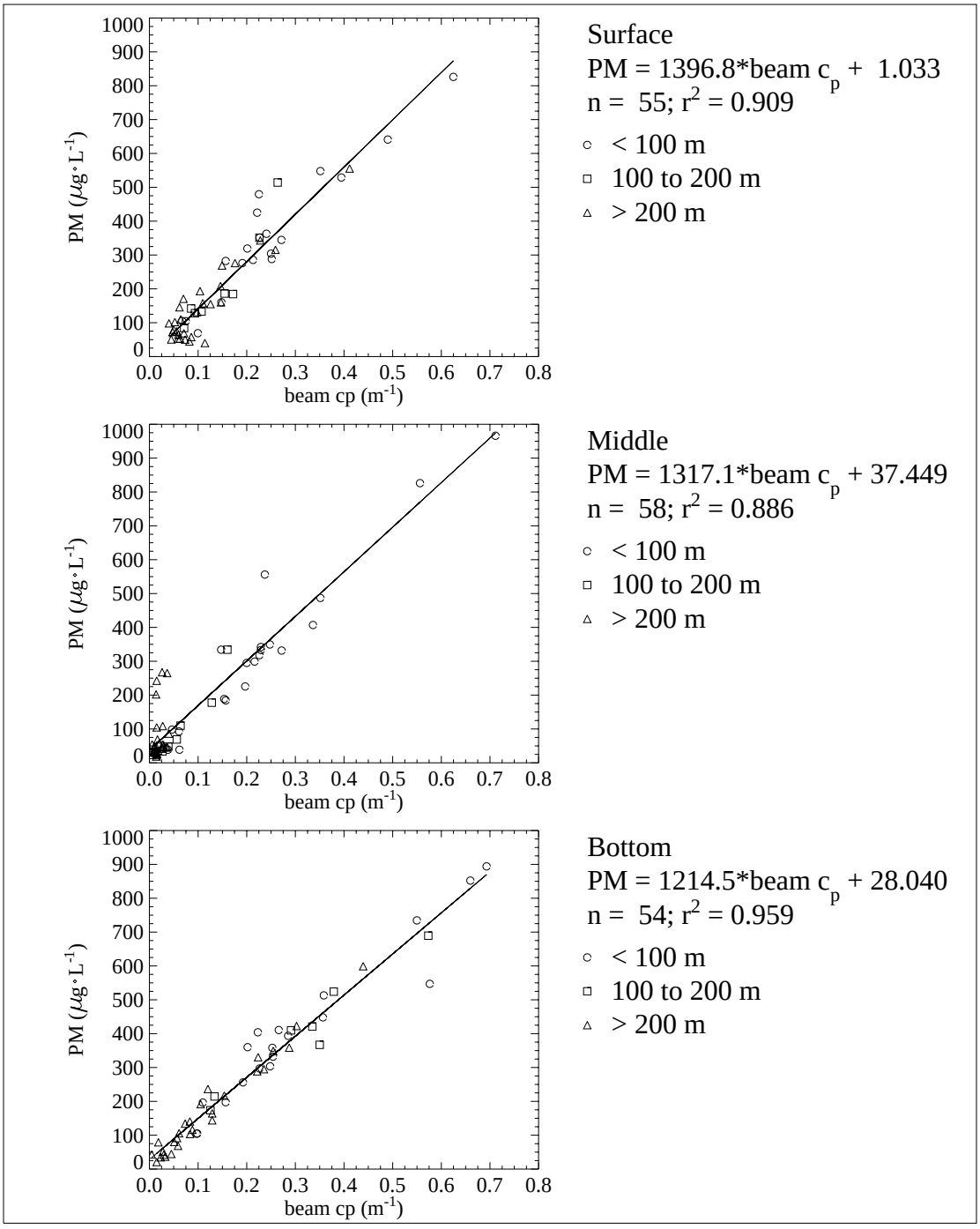


Figure 6.4.9. Correlation of particulate matter concentration (PM) and beam c_p on cruise N1, November 1997, by depth bins.

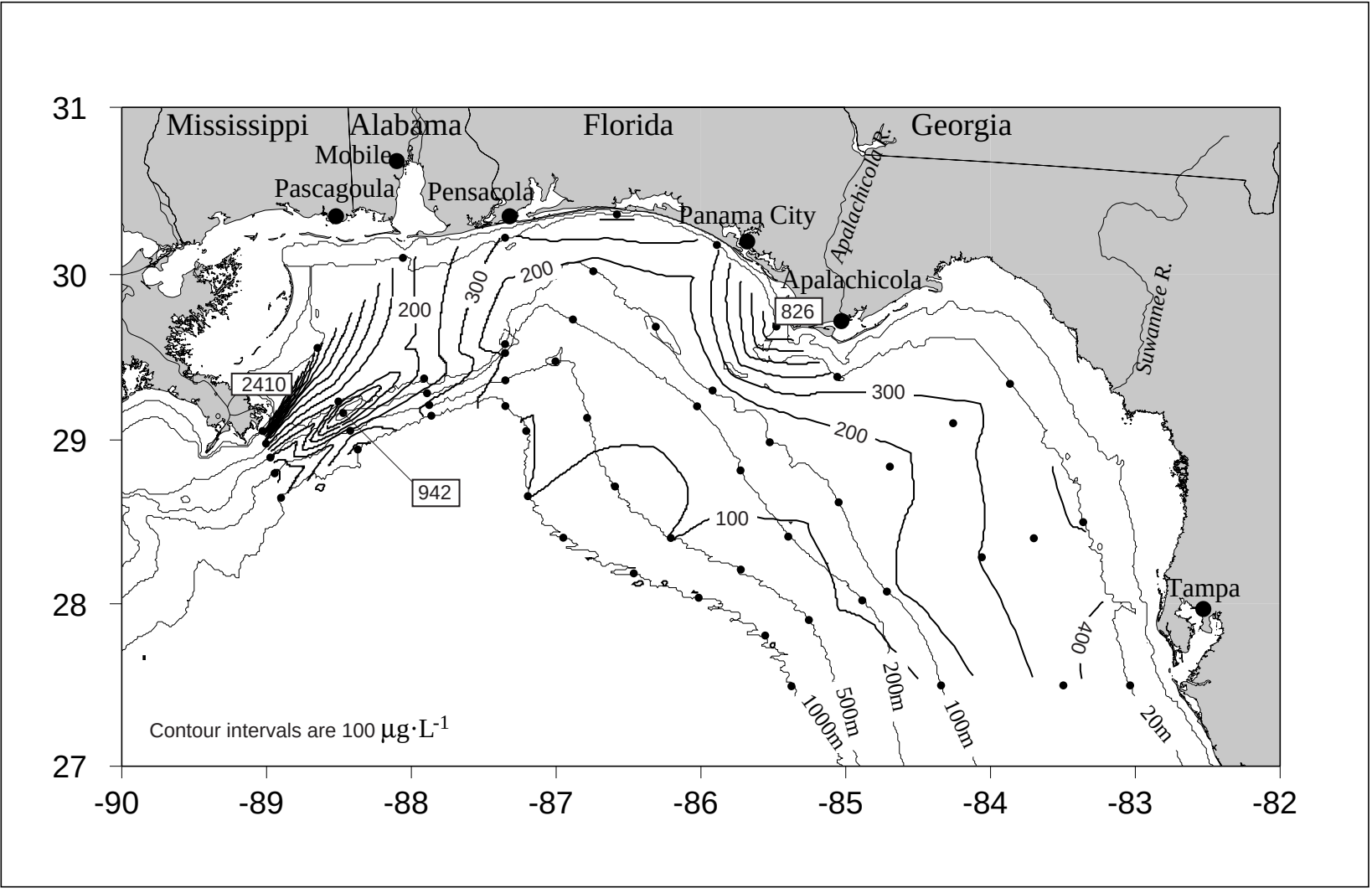


Figure 6.4.10. Near-surface (~5 m) particulate matter concentration ($\mu g \cdot L^{-1}$) from cruise N1, 16-26 November 1997.

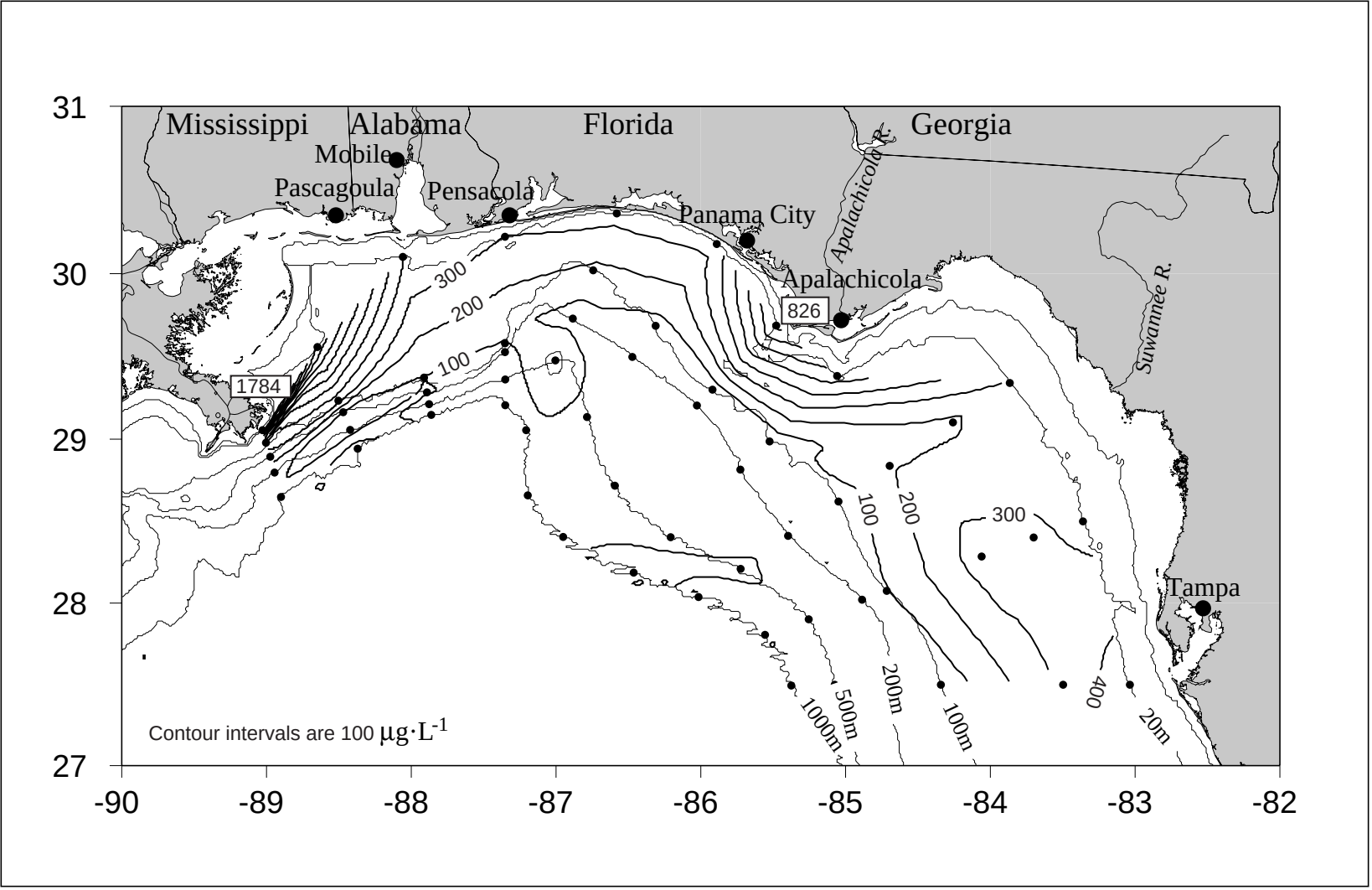


Figure 6.4.11. Mid-depth particulate matter concentration ($\mu g \cdot L^{-1}$) from cruise N1, 16-26 November 1997.

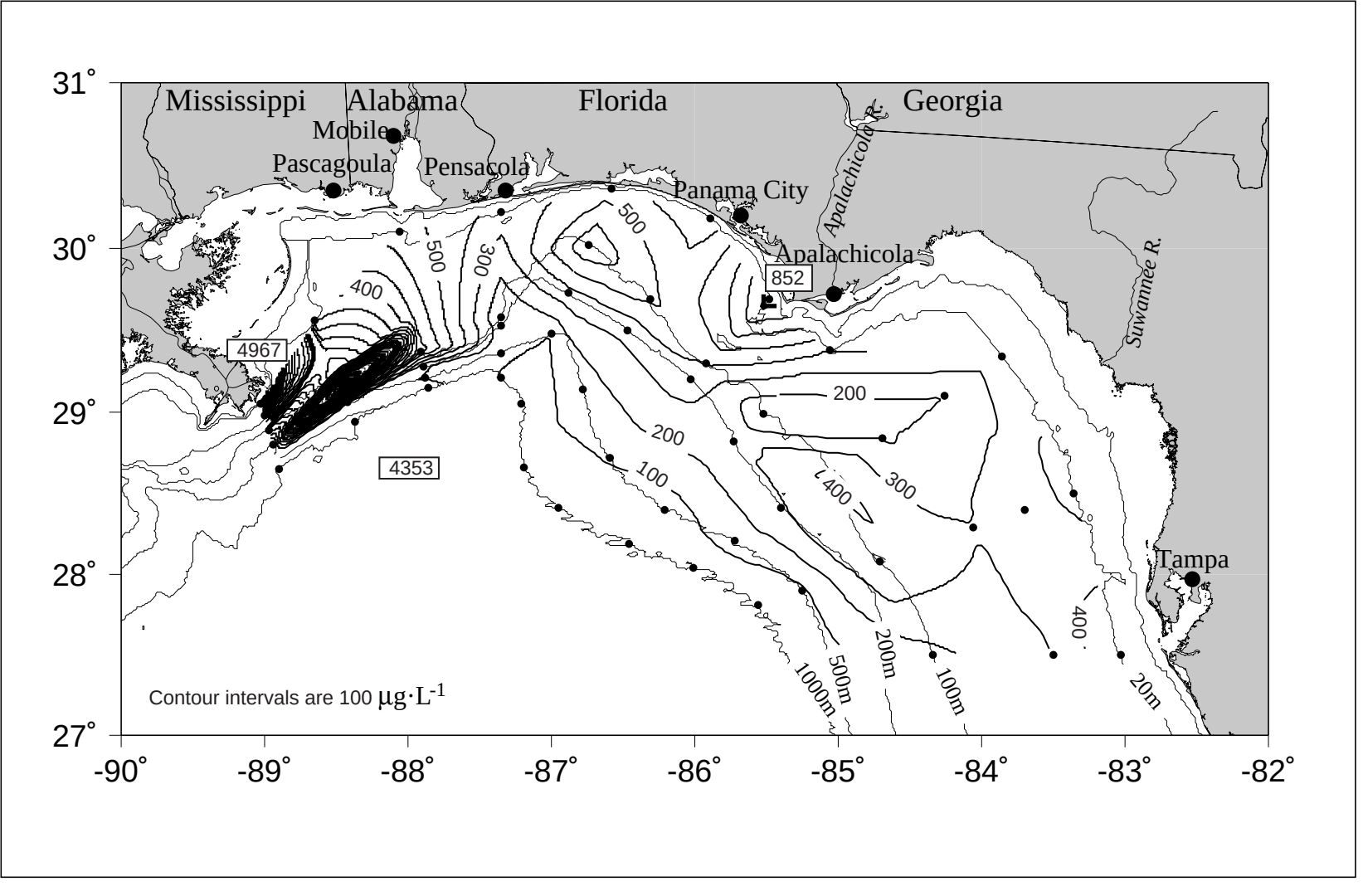


Figure 6.4.12. Near-bottom particulate matter concentration (μg·L^{-1}) from cruise N1, 16-26 November 1997.

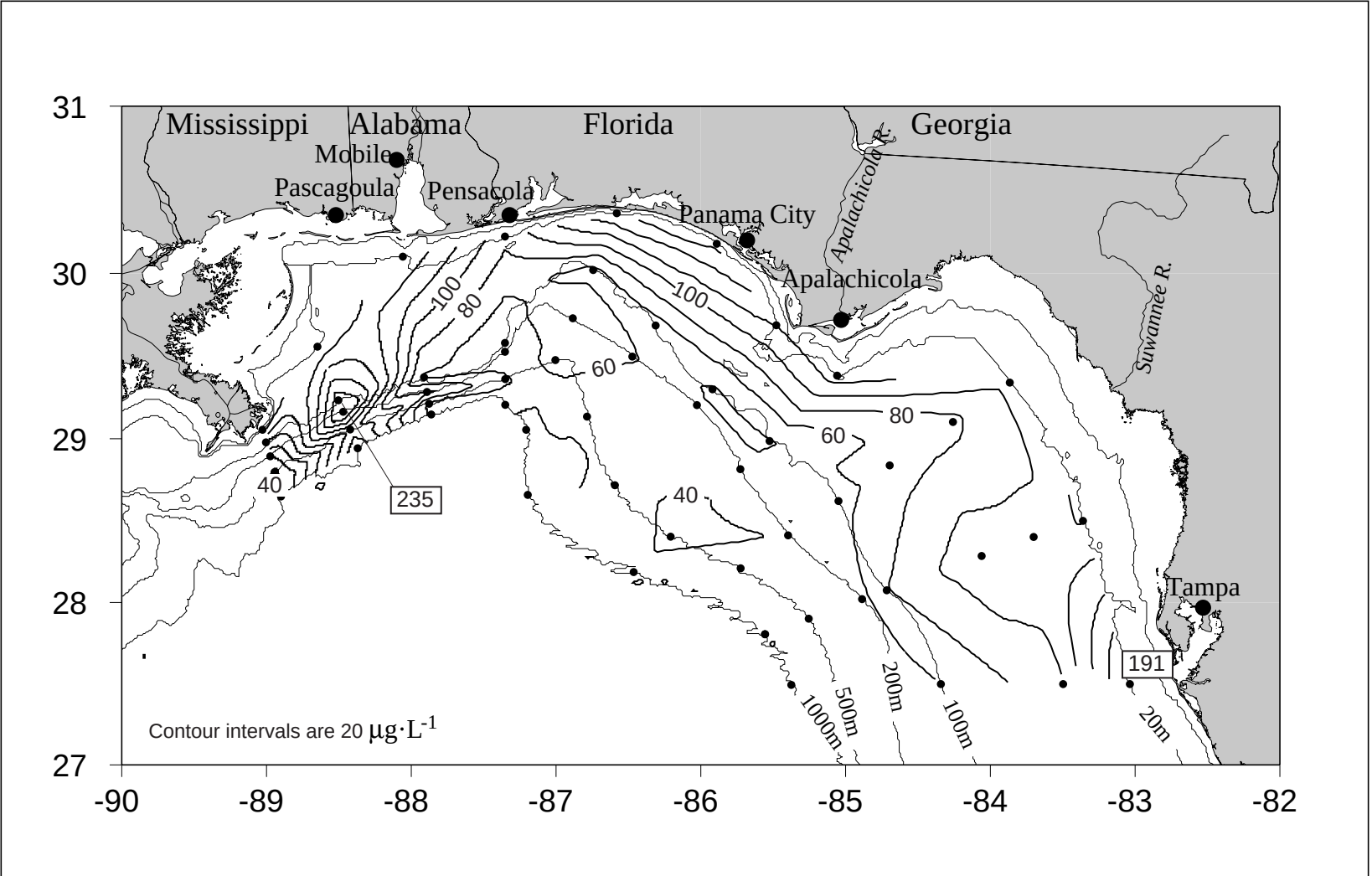


Figure 6.4.13. Near-surface (~5 m) particulate organic concentration (µg·L^{-1}) from cruise N1, 16-26 November 1997.

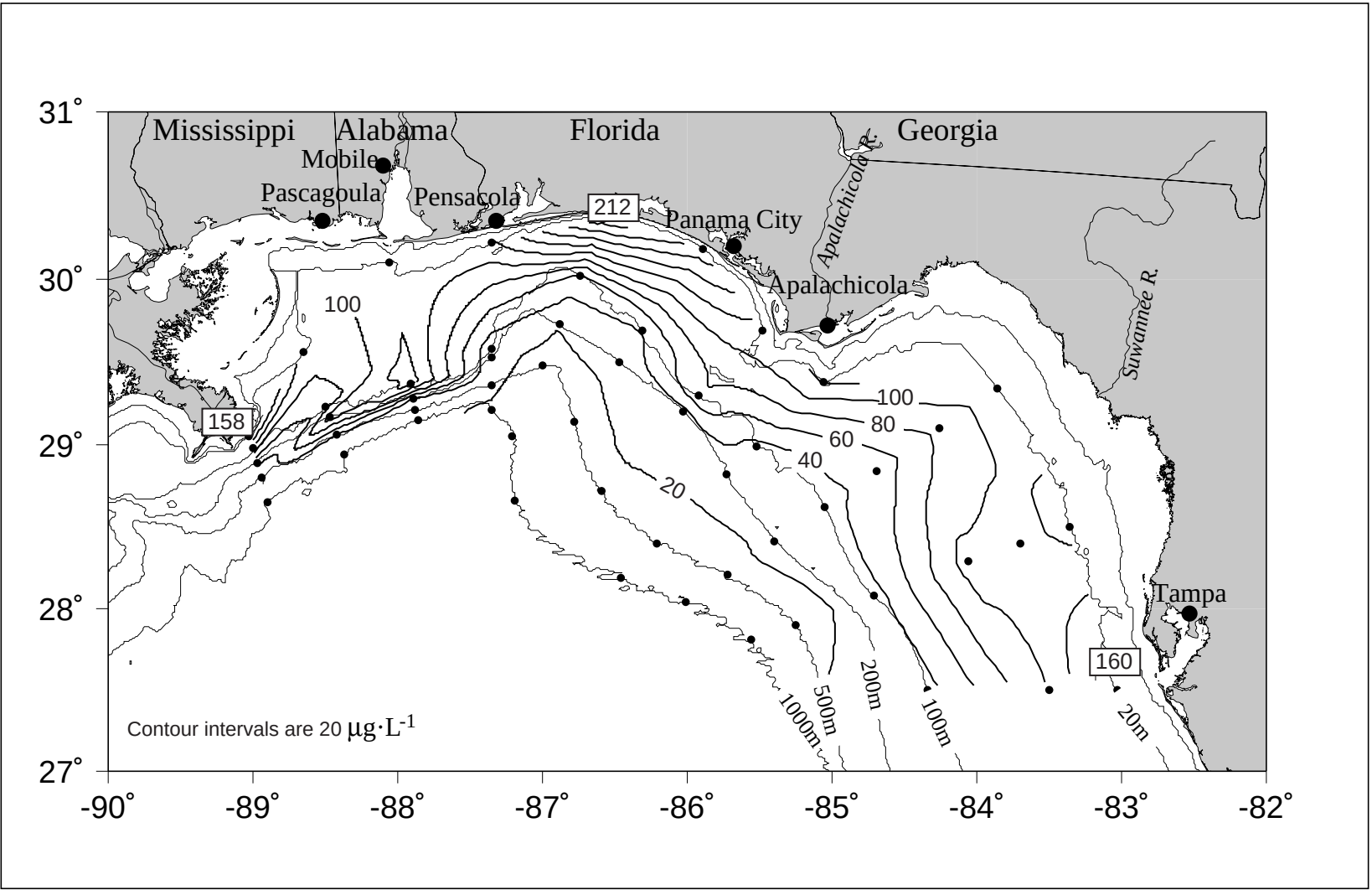


Figure 6.4.14. Near-bottom particulate organic carbon concentration ($\mu g \cdot L^{-1}$) from cruise N1, 16-26 November 1997.

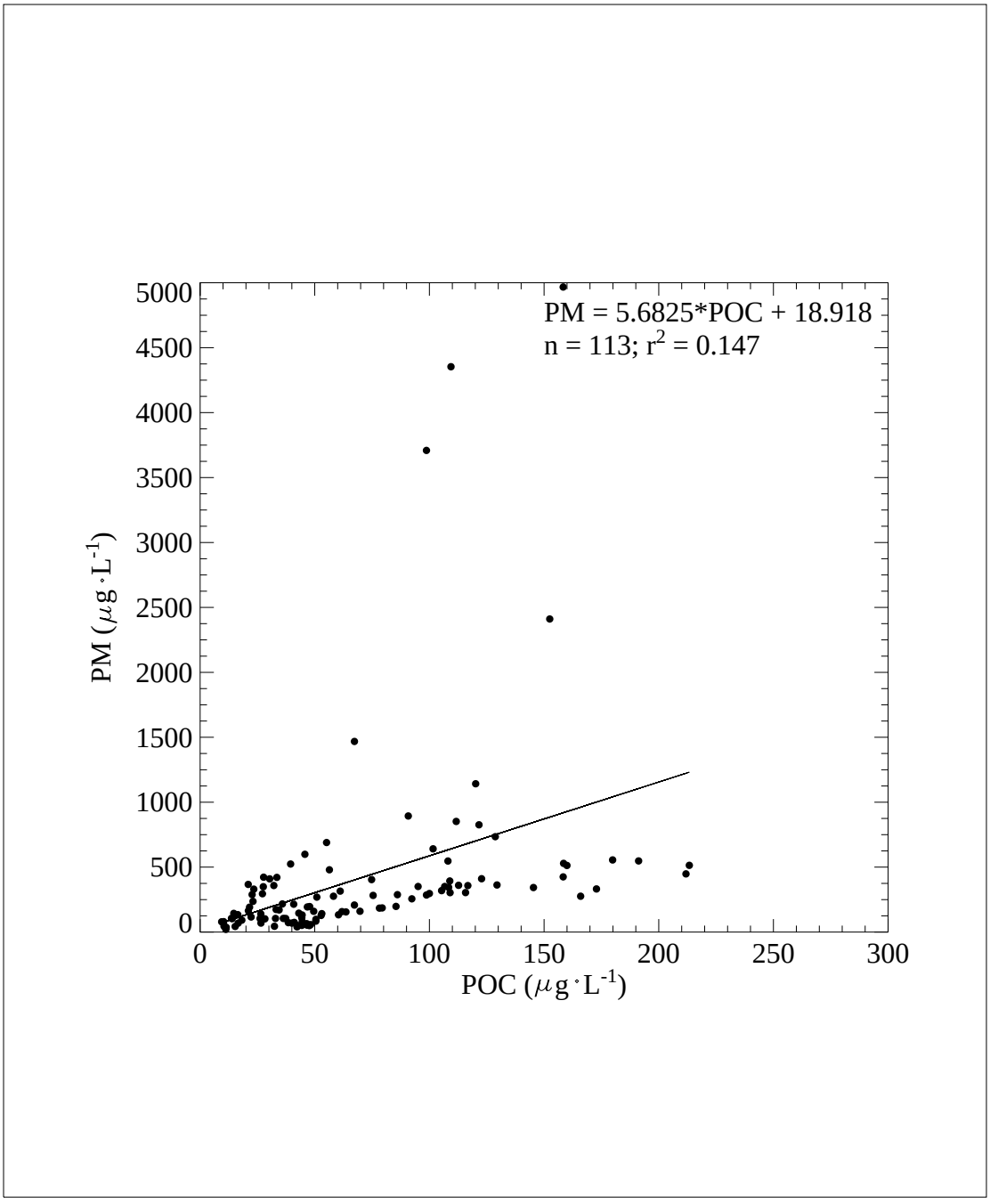


Figure 6.4.15. Correlation of particulate matter concentration (PM) and particulate organic carbon (POC) on cruise N1, November 1997. POC data are preliminary. No outliers have been removed.

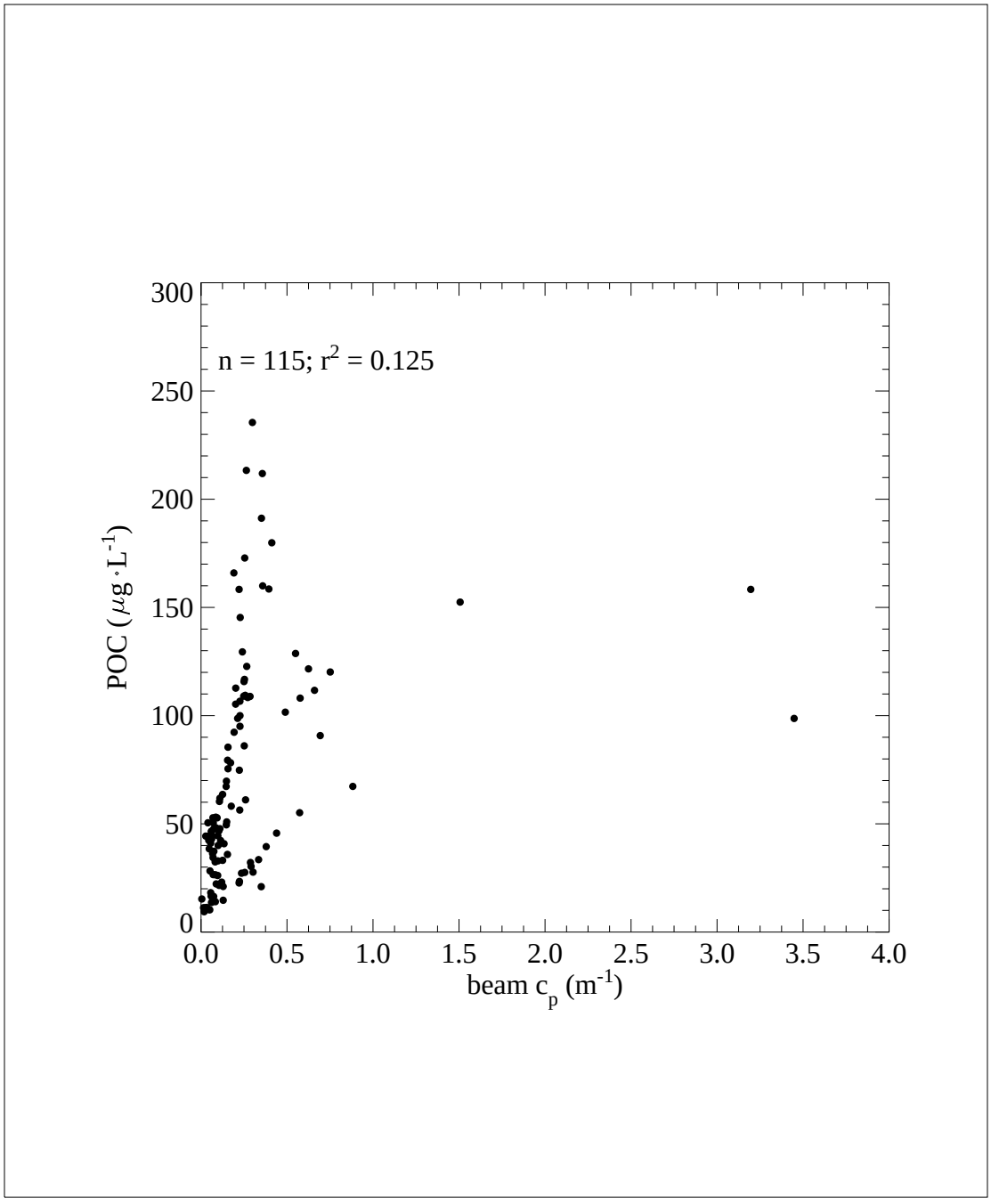


Figure 6.4.16. Correlation of particulate organic carbon (POC) and beam c_p on cruise N1, November 1997. POC data are preliminary. No outliers have been removed.

6.4.3 Phytoplankton Pigment Distributions

Chlorophyll and carotenoid pigment distributions are used to infer spatial and temporal variations in phytoplankton biomass and taxonomic composition. Phytoplankton exert an important influence on water column properties. Phytoplankton are an important source of particulates, they produce oxygen during photosynthesis, and they fix water column nutrients into biomass. The composition of pigments in particulates provides insight into the relative abundance of algal groups (Table 6.4.1). Pigment composition can also be used to determine the amount of algal biomass due to specific taxa (Table 6.4.2). Variations in phytoplankton biomass and community composition are an important factor influencing particulate, dissolved oxygen, and nutrient distributions. The plant pigment studies are designed to describe the spatial, seasonal, and interannual variations in phytoplankton pigment and major phytoplankton group distributions; calibrate *in vivo* fluorescence measurements; and examine phytoplankton pigment and major phytoplankton group distributions with regard to water column stability, river discharge, wind field, and circulation patterns.

Surface chlorophyll *a* concentrations determined by HPLC agreed well with discrete on-board fluorometry measurements (Figure 6.4.17). Although the response of the on-board fluorometer is semiquantitative, it is a rapid, sensitive, and convenient technique of mapping surface chlorophyll distributions and phytoplankton abundance. Chlorophyll *a* concentrations determined by HPLC varied from 0.08 to 3.9 $\mu g \cdot L^{-1}$ for the surface water samples and from 0.08 to 2.8 $\mu g \cdot L^{-1}$ at the chlorophyll maximum (depth varied) with most concentrations in the range of 0.2 to 0.9 $\mu g \cdot L^{-1}$ for surface water and the chlorophyll maximum depth (Figure 6.4.18). Chlorophyll *a* concentrations were highest for samples collected at the surface nearshore and off river mouths. The concentration of chlorophyll *a* was, in general, similar for the surface and the chlorophyll maximum at most locations. The depth of the chlorophyll maximum varied from 10-70 m. Chlorophyll *a* concentration decreased to below detection limit deep in the water column on the outer shelf. Chlorophyll *a* concentration in samples collected on the outer shelf were lower than nearshore areas, ranging from 0.5 to 5 $\mu g \cdot L^{-1}$. Three regional chlorophyll *a* maxima along transects 1 and 2 near the Mississippi River delta, transects 6 and 7 near Panama City and Apalachicola, and the nearshore region of transect 10 are apparent (Figure 6.4.18). Along transect 10, a few high chlorophyll concentrations were observed in shallow waters. The region of lowest chlorophyll *a* concentrations occurs on the outer shelf along transects 6 and 7.

The equation for predicting chlorophyll *a* from *in situ* fluorometry data was generated by a least squares method (Figure 6.4.19). The linear regression model set chlorophyll *a* as the dependent variable and fluorescence as the independent variable. Data from the continuous observations (fluorometry) and the discrete observations (chlorophyll *a*) were paired by line, station, and Niskin bottle depth and number. Further pairing was done between the datasets by matching the sigma-t values. This calibration is used to complete the matrix of bottle cast data for statistical analysis.

Accessory pigment compositions were relatively simple and uniform throughout the study area. Major pigments commonly detected during N1 were chlorophylls *a*, *b*, c_2, and c_3; β-carotene; fucoxanthin; 19'-butanoyloxyfucoxanthin and 19'-hexanoyloxyfucoxanthin; and zeaxanthin. Concentrations of major accessory pigments (the fucoxanthins, zeaxanthin, and chlorophyll c_2 and c_3) were low, ranging from 0.3 $\mu g \cdot L^{-1}$ to less than 0.01 $\mu g \cdot L^{-1}$.

Table 6.4.1. Summary of photosynthetic pigment distributions among marine phytoplankton. Chlorophyll and carotenoid pigments in bold are diagnostic markers (after Andersen et al. 1996).

Algal Group	Major Pigments Present
Prochlorophytes	**Divinyl chlorophylls *a* and *b***, monovinyl chlorophyll *b*, zeaxanthin, α-carotene, chlorophyll *c*-like pigment.
Cyanobacteria	Monovinyl chlorophyll *a*, zeaxanthin, β-carotene, phycoerythrin, phycocyanin, allophycocyanin.
Diatoms	Monovinyl chlorophyll *a*, chlorophylls c_1 and c_2, **fucoxanthin+diadinoxanthin**, diatoxanthin, β-carotene.
Prymnesiophytes	Monovinyl chlorophyll *a*, chlorophylls c_1+c_2 or c_2+c_3, **19'-hexanoyloxyfucoxanthin**, fucoxanthin, diadinoxanthin, diatoxanthin, β-carotene.
Pelagophytes	Monovinyl chlorophyll *a*, chlorophylls c_2 and c_3, **19'-butanoyloxyfucoxanthin**, diatoxanthin fucoxanthin, diadinoxanthin, β-carotene.
Chrysophytes	Monovinyl chlorophyll *a*, chlorophylls c_1 and c_2, **fucoxanthin+violaxanthin**, β-carotene.
Cryptophytes	Monovinyl chlorophyll *a*, chlorophyll c_2, **alloxanthin**, phycoerythrin or phycocyanin, crocoxanthin, monadoxanthin, α-carotene.
Dinoflagellates	Monovinyl chlorophyll *a*, chlorophyll c_2, **peridinin***, dinoxanthin, diadinoxanthin, diatoxanthin, β-carotene.
Prasinophytes	Monovinyl chlorophylls *a* and *b*, **prasinoxanthin†**, chlorophyll *c*-like pigments (Mg, 3, 8, DVPa_5), zeaxanthin, neoxanthin, violaxanthin, α- and β-carotene.
Chlorophytes	Monovinyl chlorophylls *a* and *b*, **lutein**, neoxanthin, violaxanthin, antheraxanthin, zeaxanthin, α- and β-carotene.

*Some species possess fucoxanthin-related pigments instead of peridinin.
†Some species possess futein (e.g., *Pyramimonas*), siphonein or siphonaxanthin instead of prasinoxanthin.

Table 6.4.2. Pigment algorithms used for partitioning chlorophyll *a* biomass among the major phytoplankton groups (Letelier et al. 1993).

Algal Group	Equation
Prochlorophytes	$[\text{Chl } a]_{pro} = [\text{divinyl chlorophyll } a]$
Prymnesiophytes	$[\text{Chl } a]_{prym} = 1.3 \times [19'\text{-hex}]_{prym}$
Pelagophytes	$[\text{Chl } a]_{pel} = 0.9 \times [19'\text{-but}]_{pel}$
Dinoflagellates	$[\text{Chl } a]_{dino} = 1.5 \times [\text{peridinin}]$
Diatoms	$[\text{Chl } a]_{diat} = 0.8\,([\text{fucox}]-(0.02[19'\text{hex}]_{prym}+0.14[19'\text{-but}]_{pel}))$
Other algae	$[\text{Chl } a]_{others} = [\text{Chl } a]_{total}-[\text{Chl } a]_{pro+prym+pel+dino+diat}$ where, $([19'\text{hex}]_{prym} = (P/(P-C))\bullet([19'\text{-hex}]_{total}-([19'\text{-but}]_{total}\bullet C))$ $[19'\text{-but}]_{pel} = (P/(P-c))\bullet([19'\text{-but}]_{total}-([19'\text{hex}]_{total}\bullet 1/P))$ $P = [19'\text{-hex}]_{prym}/[19'\text{-but}]_{prym} = 54.27$ $C = [19'\text{-hex}]_{pel}/[19'\text{-but}]_{pel} = 0.14$
Eukaryotic photoautotrophs	$[\text{Chl } a]_{euk} = [\text{Chl } a]_{pyrm+pel+dino+diat}$
Prokaryotic photoautotrophs	$[\text{Chl } a]_{prok} = [\text{Chl } a]_{prok} = [\text{Chl } a]_{total}-[\text{Chl } a]_{Euk}$

Peridinin, violaxanthin, diadinoxanthin, diatoxanthin, and alloxanthin were only detected in trace amounts (generally < 0.02 $\mu g \cdot L^{-1}$) in only a few samples. Concentrations of accessory pigments such as chlorophylls c_2 and c_3, chlorophyll *b*, 19'-butanyoloxyfucoxanthin,19'-hexanoyloxyfucoxanthin, fucoxanthin, and zeaxanthin, relative to chlorophyll *a* concentrations, showed little spatial variation on the first cruise. The ratios of chlorophyll *b* and β-carotene to chlorophyll *a* ranged from 0.1 to 0.5. Fucoxanthin, 19'-butanoyloxyfucoxanthin, and 19'-hexanoyloxyfucoxanthin ratios to chlorophyll *a* were in the range of 0.05 to 0.23. The low concentrations of all the phytoplankton pigments and the relatively simple and uniform distributions of the accessory pigments indicated that the composition of the phytoplankton community was simple. The dominant species inferred from the accessory pigment compositions were prymnesiophytes, pelagophytes, and cyanobacteria. Other types of phytoplankton were not important contributors to the biomass.

6.4.4 Integration of Water Column Property Distributions

Integration of the observed distributions can elucidate the relative importance of biogeochemical processes in producing variations in nutrients, particulate matter, and phytoplankton pigment concentrations. The water column chemistry and particulate studies are designed to: (1) examine the relationship between dissolved oxygen, PM, POC, nepheloid layers, nutrients, phytoplankton pigments, and plankton community structure; (2) determine the origins of PM, POC, and nepheloid layers; and (3) estimate the importance of physical and biogeochemical processes in determining the observed distributions and variations.

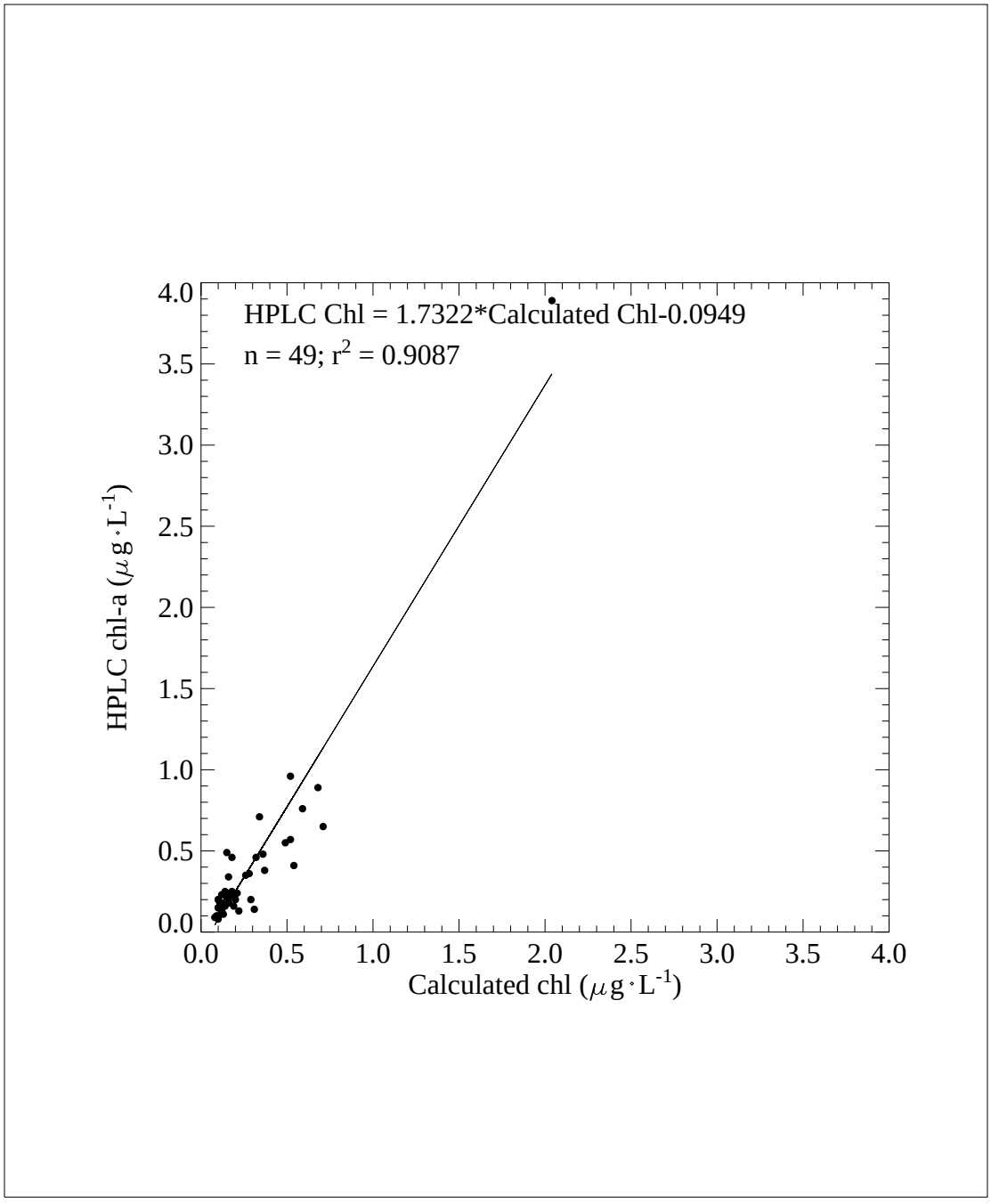


Figure 6.4.17. Correlation of chlorophyll *a* determined by HPLC and the response of *in vivo* fluorometry from surface seawater samples on cruise N1. The response of the *in vivo* fluorometry includes chlorophyll *b*, *c* , and other fluorescent compounds.

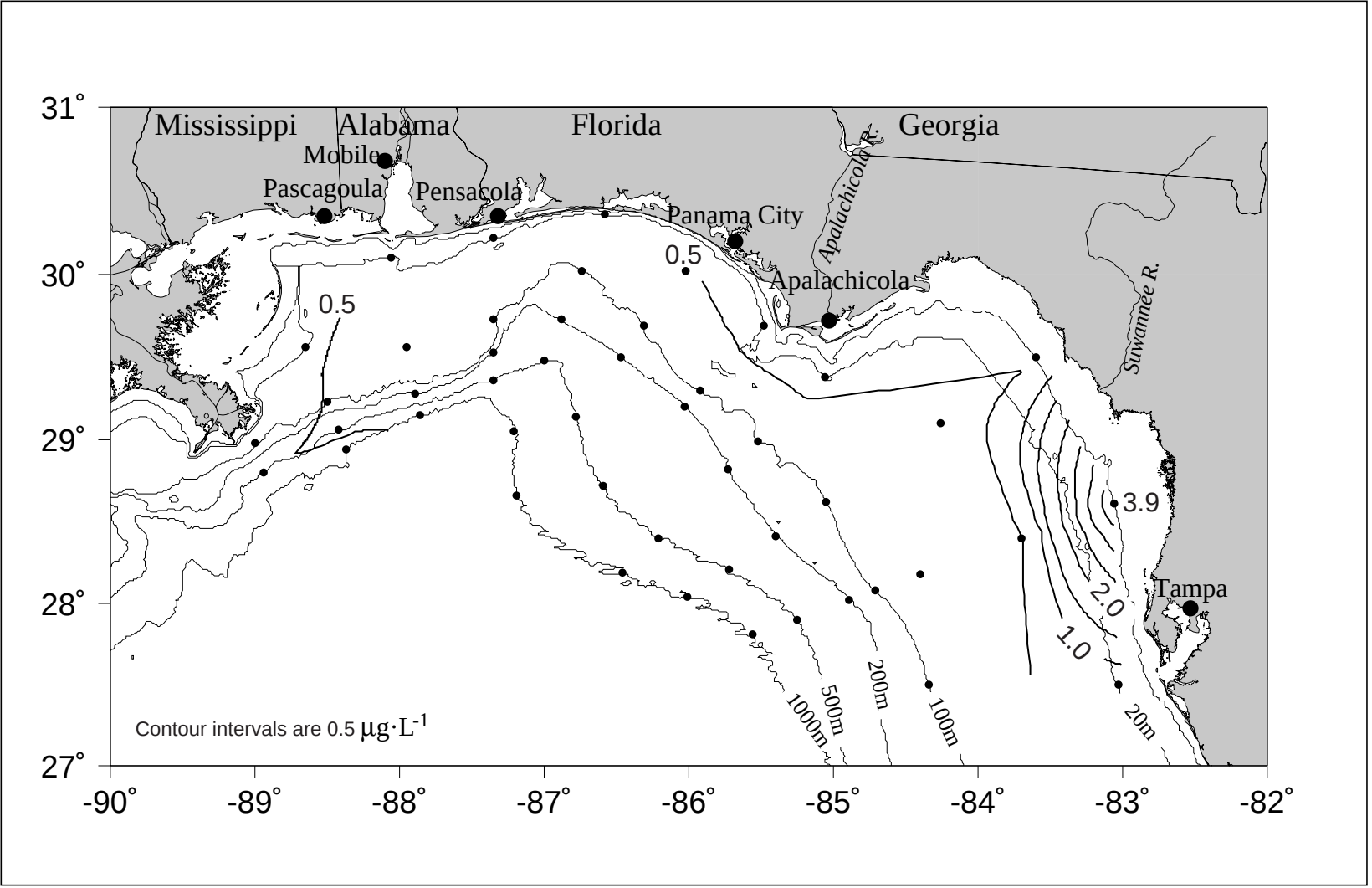


Figure 6.4.18. Chlorophyll *a* concentration (µg·L^{-1}) at the surface (1-3m) from cruise N1, 16-26 November 1997.

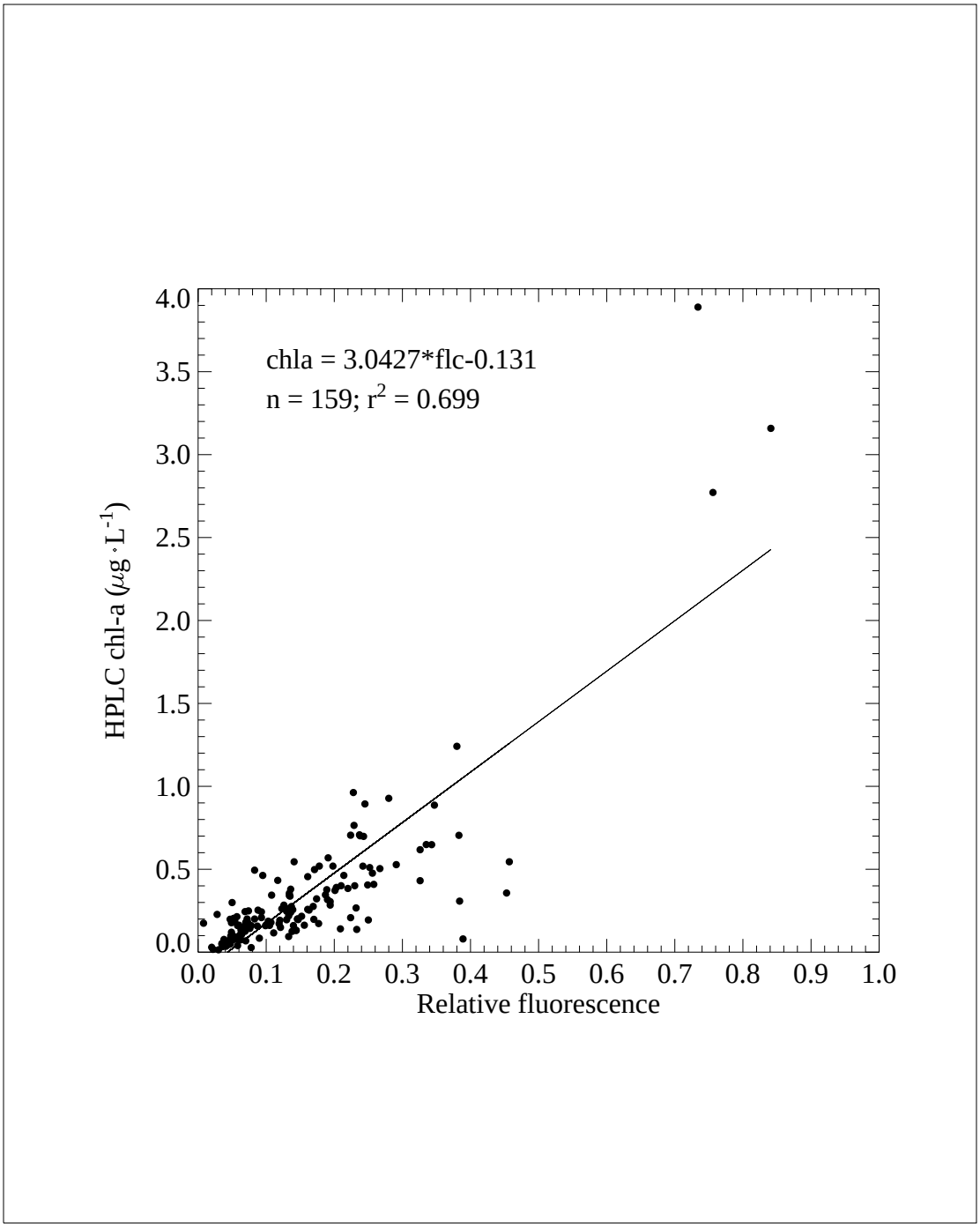


Figure 6.4.19. Calibration curve comparing HPLC chlorophyll *a* (chla) concentrations and continuous fluorescence (flc) measurements, based on cruise N1 data.

In general, most properties of particulate matter measured during cruise N1 were vertically and horizontally uniform in distribution with a few notable exceptions related to riverine inputs. As an initial approach, water column characteristics were cross-correlated. Correlation coefficients were calculated between several of the continuous and discrete variables. If one variable has a linear relationship with another, then the coefficient is 1 if they are directly related or -1 if the variables are negatively related. A correlation of 0 indicates that the variables have no linear predictive ability between them. Several expected trends are apparent from the correlation matrix (Table 6.4.3). Nutrients such as nitrate, phosphate, and silicate are significantly correlated amongst themselves as expected due to the influence of a common biological removal process, photosynthesis. Chlorophyll *a* concentrations are negatively correlated with nutrients as expected also due to fixation of nutrients during photosynthesis. Chlorophyll *a* concentrations are positively correlated with oxygen, a by-product of photosynthesis. Chlorophyll *a* concentrations are negatively correlated with salinity indicative of riverine input of nutrients in conjunction with an influx of freshwater. Nutrients are negatively correlated with oxygen concentrations confirming a photosynthetic linkage. Light transmission negatively correlated with chlorophyll *a* and dissolved oxygen as expected. An increase in photosynthesis increases particles and decreases light transmission. Transmission also increased with increasing salinity indicating the influence of particle-containing freshwater inputs from riverine systems. As more data become available, further correlations, principal component analysis, univariate analyses, and multivariate analyses will be used to better define the interactions among the various properties.

Table 6.4.3. Cross-correlation of various water column properties.

	Chlorophyll *a*	Salinity	Dissolved O_2	Phosphate	Nitrate	Nitrite	Silicate	Ammonium	Urea	Transmission
Chlorophyll *a*	1.000 0.000									
Salinity	-0.0189 0.8089	1.0000 0.0000								
Dissolved O_2	0.2265 0.0033	0.8262 0.0001	1.0000 0.0000							
Phosphate	-0.2256 0.0034	0.0187 0.8107	-0.4144 0.0001	1.0000 0.0000						
Nitrate	-0.2609 0.0007	0.0858 0.2705	-0.3819 0.0001	0.9580 0.0001	1.0000 0.0000					
Nitrite	-0.0694 0.3726	0.0690 0.3755	-0.0908 0.2434	0.0440 0.5725	-0.0033 0.9664	1.0000 0.0000				
Silicate	-0.2132 0.0057	-0.0163 0.8343	-0.3662 0.0001	0.8435 0.0001	0.7924 0.0001	0.1261 0.1043	1.0000 0.0000			
Ammonium	0.1066 0.1702	-01639 0.0343	0.0199 0.7991	-0.0876 0.2602	-0.1892 0.0143	0.0366 0.6384	0.0126 0.8715	1.0000 0.0000		
Urea	-0.0568 0.4660	-0.0143 0.8548	-0.0453 0.5613	0.0199 0.7989	-0.0148 0.8492	0.1033 0.1839	-0.0163 0.8341	0.2600 0.0007	1.0000 0.0000	
Transmission	-0.6842 0.0001	0.0457 0.5573	-0.2049 0.0079	0.0928 0.2331	0.1846 0.0170	0.0781 0.3159	-0.0189 0.8083	-0.3655 0.0001	0.0193 0.8042	1.0000 0.0000

Pearson Correlation Coefficients/Prob > |R| under Ho: Rho = 0 / N = 161

7 LITERATURE CITED

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The Department of the Interior Mission

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

The Minerals Management Service Mission

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

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

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