27
3/27/81
24 cys NTIS T.S.

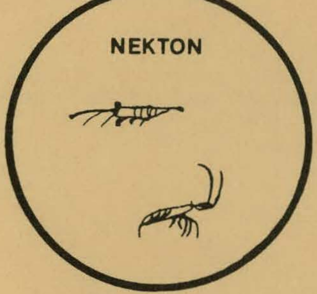
① DOE/PO/10114--2

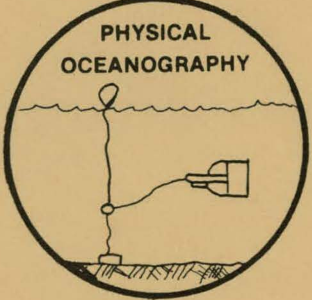
EVALUATION OF BRINE DISPOSAL

FROM THE BRYAN MOUND SITE OF THE

STRATEGIC PETROLEUM RESERVE PROGRAM

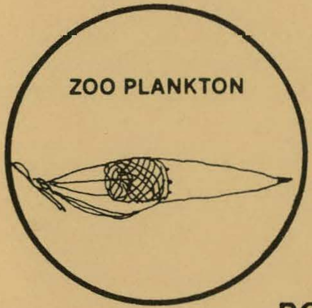
MASTER

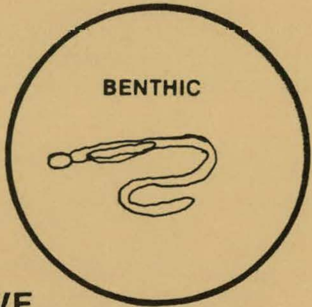




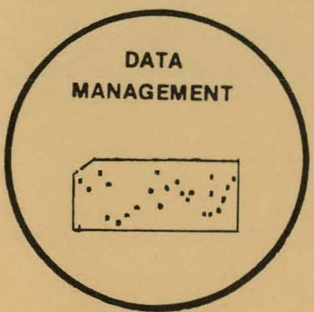
FINAL REPORT

OF

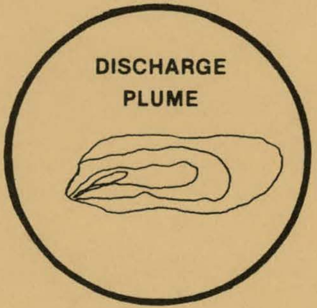




POSTDISPOSAL INTENSIVE



STUDIES



JANUARY 1981

TEXAS A & M UNIVERSITY

AND

TEXAS A & M RESEARCH FOUNDATION

CONTRACT NO. DE-FC96-79P010114

DISCLAIMER

This report has been reviewed by the Department of Energy and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Department, nor does mention of trade names or commercial products constitute endorsement of recommendation for use.

EVALUATION OF BRINE DISPOSAL FROM THE BRYAN MOUND SITE OF THE STRATEGIC PETROLEUM RESERVE PROGRAM

Final Report

Postdisposal Intensive Studies

Draft July 1980
Final January 1981

Editors

Roy W. Hann, Jr., Program Manager
Robert E. Randall, Associate Program Manager

Principal Investigators

Robert J. Case, Data Management
Mark E. Chittenden, Jr., Nekton Studies
Donald E. Harper, Jr., Benthic Studies
Francis J. Kelly, Jr., Physical Oceanography
Laurel A. Loeblich, Phytoplankton Stuides
Larry D. McKinney, Benthic Studies
Thomas J. Minello, Zooplankton Studies
E. Taisoo Park, Zooplankton Studies
Robert E. Randall, Analysis of Discharge Plume
J. Frank Slowey, Sediment and Water Quality

Texas A&M University

through

Texas A&M Research Foundation

Prepared for the Department of Energy

under Contract No. DE-FC96-79P010114

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

X

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

ACKNOWLEDGEMENTS

The program manager and the principal investigators would like to acknowledge the assistance and work of the many personnel required to complete a project of this magnitude. It is their hard work, perseverance, attention to details, long days offshore, tedious laboratory and data analysis, and endurance of low visibility diving which has made possible the presentation of the results reported in this document.

The management staff on this project are involved in purchasing, report writing, and other clerical duties which are most critical to the satisfactory performance of the technical aspects discussed in this report. The assistance of Mr. Frank Waddell in coordinating project business with the Texas A&M Research Foundation is most appreciated. Acknowledgement is given to Ms. Cindy Denton and Ms. Sylvia Dennis for their contribution in organizing and typing this report. Mr. Maurice LaMontagne is responsible for a majority of the drafting for this report and his fine work is appreciated.

The analysis of discharge plume required long hours offshore and a gread deal of tedious data recording and analysis. The assistance of Mr. Dale Berry and several student workers in these tasks is acknowledged.

Acknowledgement is given to Mr. James Cummings, assistant data manager, and to several student assistants for their invaluable data analysis assistance, data compilation and transmission of data to the Environmental Data Information Service.

The contributions of research associate Robert Salzer and graduate assistants Steve Dent, Eddie Fort, and Constance Walker to the benthic study is greatly appreciated. The assistance of numerous student workers in data analysis and volunteer diving has been invaluable. The assistance of John Machol in the laboratory and as a diver is greatly appreciated.

The assistance of research associates Joyce Schmitz, David Smith, and Allen Montgomery in the data analysis and computer programming of the physical oceanography data is most appreciated. The work of Yvaun Olsen and William Ulm in laboratory preparation and field installation of the physical oceanography instrumentation has been outstanding and greatly appreciated. Special acknowledgement and thanks are also given to Dr. David Brooks and Mr. Tom Reid of the Oceanography Department for their advice and assistance and permission to use their vercatile FESTSA and PLOTSA software packages for time-series analysis.

Special acknowledgement and thanks are given to Dr. Lela M. Jeffrey for her analysis of the sediment hydrocarbons and assistance in the preparation of the Water and Sediment Quality chapter of this report. The assistance in the collection and laboratory analysis of water and sediment quality data by research assistants Mr. Anton Vos, Mr. Craig Tautfest, Mr. Les Rice, Mr. James Martin, and Mr. Reid Dennis and to the student laboratory technicians is greatly appreciated.

The collection of the large volume of nekton data is only possible through the assistance of a sizeable field staff, and their work is most appreciated. The nekton field staff includes two research associates, Mr. John Pavela and Mr. Jeff Ross and their research assistants Messrs. Michael Burton, Tom Crawford, Douglas Devries, Paul Geohegan, Michael Murphy, Mark Rockett, Phillip Shlossman, William Slingerland, Gary Standard and Harold Yettes.

The assistance of research consultant Mr. Phillip Turk and research assistant Mr. Gerald Livingston in the collection and analysis of zooplankton data is acknowledged. In the area of phytoplankton, the assistance of Dr. Geoffrey Matthews is acknowledged.

In addition, the work of the project field personnel and the captain and crew of the university's research vessel, R/V EXCELLENCE, and other contract vessels is acknowledged. The project field coordinator is Mr. Gene Drynan and his assistance in the coordination of and participation in field activities is acknowledged. Mr. Donald Peavy is the captain of the R/V EXCELLENCE. Mr. Pete Smirch and his crews aboard the M/V PETE AND SUE and M/V TONYA AND JOE have provided support for the nekton and zooplankton cruises. Mr. Elliott Cundief of Captain Elliott's Party Boats has leased his vessels on short notice when the R/V EXCELLENCE was unavailable or the use of two vessels was necessary to meet project commitments.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

ABSTRACT

On March 10, 1980, the Department of Energy's Strategic Petroleum Reserve Program began leaching the Bryan Mound salt dome and discharging the resulting brine into the coastal waters off Freeport, Texas. During the months of March and April, a team of scientists and engineers from Texas A&M University conducted an intensive environmental study of the area surrounding the diffuser site. A pipeline has been laid from the Bryan Mound site to a location 12.5 statute miles (20 km) offshore. The last 3060 ft (933 m) of this pipeline is a 52-port diffuser through which brine can be discharged at a maximum rate of 680,000 barrels per day. Initially, 16 ports were open which permitted a maximum discharge rate of 350,000 barrels per day and a continuous brine discharge was achieved on March 13, 1980.

The purpose of this report is to describe the findings of the project team during the intensive postdisposal study period of March and April, 1980. The major areas of investigation are physical oceanography, analysis of the discharge plume, water and sediment quality, nekton, benthos, phytoplankton, zooplankton, and data management.

The physical oceanography data are presented to determine the degree to which the initial brine discharge may have altered the ambient conditions and to provide basic physical oceanographic data needed for analyses by other components of the study. The data indicate that the salinity values and their fluctuations, as recorded by current meters, are consistent with the overall physical oceanography of the area and that the brine plume was not detected by these meters during the intensive study period. Only the hydrographic data for station 34 at the diffuser show an effect

which is confined to the near-bottom measurement and indicates an increase above ambient of about 1 $^{o}/oo$.

A monitoring system is described which was used to measure the excess salinity and the areal extent of the brine plume. In March, the highest excess salinity contour was 3 $^{o}/oo$ above ambient and the greatest areal extent within the +3 $^{o}/oo$ contour was 90 acres (0.4 km^2). In April, the brine solution being discharged was greater, so the measured plumes covered a larger area and the excess concentrations were higher. On April 9, the highest excess concentration was 4 $^{o}/oo$ above ambient and the areal coverage within this contour was 31 acres (0.1 km^2). The +2 $^{o}/oo$ areal coverage was 1422 acres (5.8 km^2). On April 10, a 5 $^{o}/oo$ above ambient contour was detected which covered an area of 6 acres (0.2 km^2) and the +2 $^{o}/oo$ above ambient contour covered an area of 1828 acres (7.4 km^2). Vertical profiles measured the vertical extent of the plume and indicated that the plume was located in the bottom third of the water column.

Water and sediment sampling and laboratory analyses indicate that no significant changes resulting from brine discharge were found with the exception of salinity increases in bottom waters at the diffuser site. Fluctuations in oil and grease levels and sediment pore analyses were observed but were not attributed to brine discharge.

Nekton studies indicate that findings during the intensive postdisposal period are quite similar to findings during the predisposal period. There seemed to be little change in the nature of the abundant ichthyofauna in the diffuser area. Observations and plots of biomass volumes, counts of abundant species, and statistical analyses suggest there were no immediate obvious effects due to brine disposal.

The analysis of benthic data shows that the discharge of brine had little or no measurable effect on the benthic community near the diffuser. Minimal effects were expected in the spring when the seas are rough and the currents are strong. The effects of the brine are expected to be more detectable in late summer when seas are generally calmer and a greater possibility of stagnation occurs.

Zooplankton biomass and total zooplankton density fluctuations were observed during the intensive study, and were attributed to seasonal fluctuations rather than to brine discharge. It is concluded that the zooplankton data indicate there are no immediately obvious effects due to brine discharge. Also, the dominant species of phytoplankton and their relative abundances appeared to be unchanged from those found in the predisposal study. Brine discharge did not affect total phytoplankton abundance or chlorophyll a concentrations.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

EXECUTIVE SUMMARY

The Department of Energy began discharging brine on March 10, 1980 from the Bryan Mound site of the Strategic Petroleum Reserve Program. On March 13, 1980 continuous disposal of a nominal 230 ppt brine solution was established at a rate of 225,000 barrels per day from a multiport diffuser in 71 ft (21.6 m) of water at a distance of 12.5 statute miles (20 km) off the Freeport, Texas coast. In order to evaluate the immediate environmental effects of the discharge an intensive study was initiated by scientists and engineers from Texas A&M University, and a composite of the sampling station is shown in Figure 1.

During the intensive monitoring period, in situ physical oceanography instrumentation showed that the currents in the diffuser area were downcoast at the surface and alternating downcoast and upcoast at the bottom. The upcoast velocities were not as strong as the downcoast velocities at the bottom. Lower salinity water was associated with the downcoast flow. A salinity frontal zone persisted throughout much of the study period just inshore of the diffuser site, and the cross shelf currents, though weak, indicated that convergence/divergence often existed between the two sites.

Lower frequency salinity changes at the near bottom meter at the diffuser site were associated with changes in the longshore flow; upcoast flow increased salinity and vice versa. Higher frequency changes were associated with the cross shelf flow, probably an

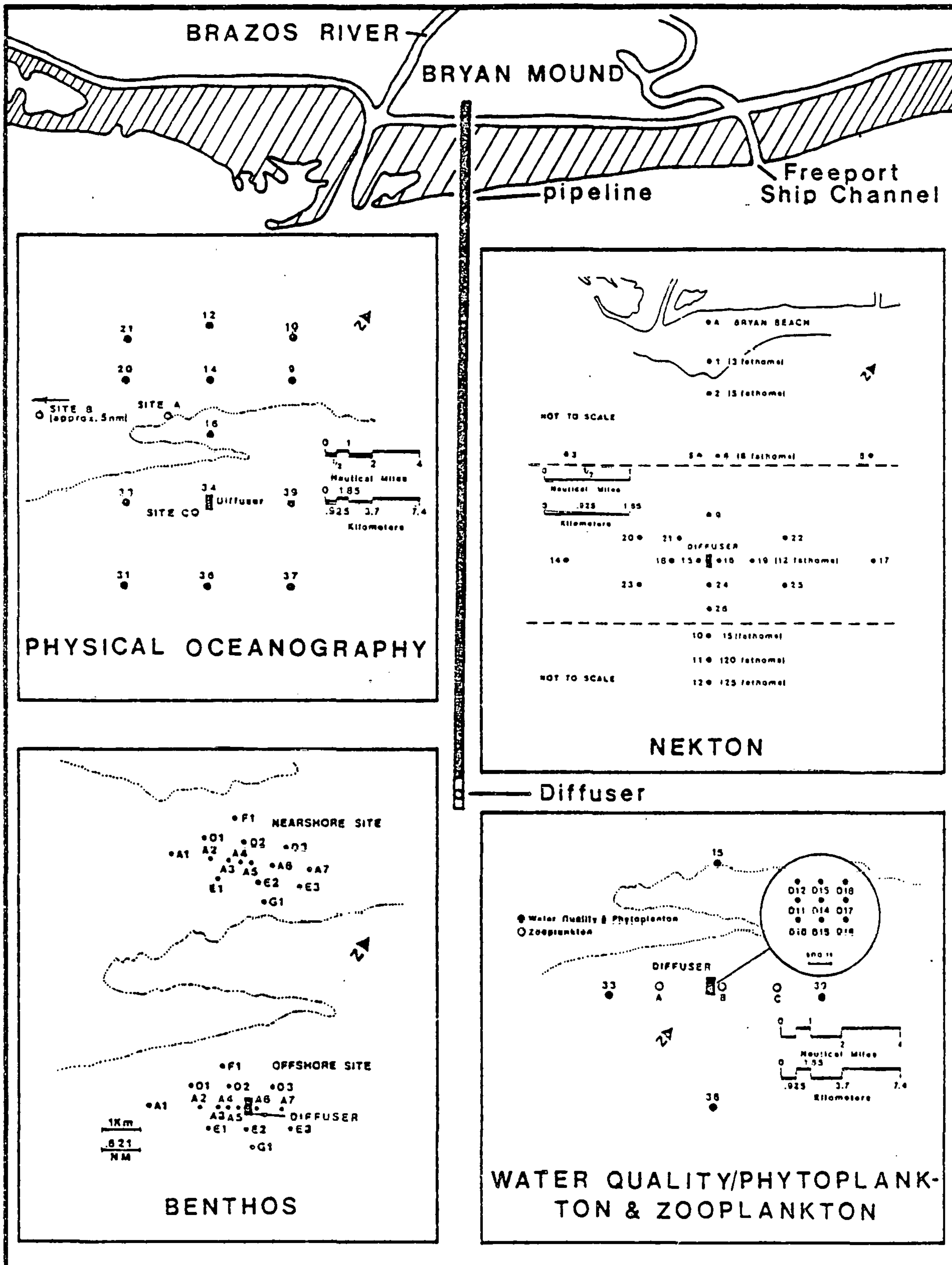


Figure 1. Composite of project sampling station locations.

indication of the shifting salinity front. The effect of the brine plume either never reached the meter at the diffuser site or lay below it. The meter is 6 ft off the bottom and 1000 ft (305 m) southwest of the offshore end of the diffuser. It is concluded that the salinity values and their fluctuations as recorded by the in situ meters are consistent with the overall physical oceaography of the area and that the brine plume was not detected by these meters during the intensive study period.

Only the hydrographic data for station 34, which is located at the diffuser show an effect from the brine discharge. This effect is confined to the near bottom measurement and indicates an increase above ambient of about 1 $^{o}/oo$.

A monitoring system is designed and assembled to measure the excess salinity and the areal extent of the brine plume. The monitoring system consists of a towing sled in which an <u>in situ</u> conductivity, temperature, and depth probe is mounted. The towing sled and probe were towed by the R/V EXCELLENCE on a predetermined search course through the expected plume area, which is called plume tracking. The probe continuously measures the salinity at a distance of 10 in (25.4 cm) off the sea floor. These data are used to construct isohalines, or constant salinity contours, of the bottom area. The resulting contour plots indicate the areal coverage of the plume and the magnitude of the excess salinity concentration. In addition, vertical salinity profiles are measured to evaluate the vertical extent of the plume.

Plume tracking was conducted on March 22, 26, 30, 31, April 9 and 10, 1980 aboard the R/V EXCELLENCE. The salinity of the water 10 inches (25.4 cm) off the bottom was recorded and used to determine contours of excess salinity above the ambient sea water salinity. In March the highest excess salinity contour was 3 $^{o}/oo$ above ambient, and it was present on all days except March 30. The largest area within the +3 $^{o}/oo$ contour was 90 acres (0.4 km^2) which occurred on March 22. The plotted 1 $^{o}/oo$ above ambient contour line was the lowest contour line plotted, and the largest area within this contour was 1/4 acres (0.7 km^2) on March 30. The average length of time required for each plume tracking operation in March was approximately five hours.

In April, the plume tracking was conducted when the brine solution was nominally 247 $^{o}/oo$ and the discharge rate was approximately 330,000 barrels/day. The measured plumes in April covered a much larger area and the excess concentrations were higher. On April 9, the highest excess concentration was 4 $^{o}/oo$ above ambient and the areal coverage within the contour was 31 acres (0.1 km^2). The lowest excess salinity contour which could be closed was +2 $^{o}/oo$ and the area within this contour was 1422 acres (5.8 km^2). One of the important natural means for dispersing the brine plume is the bottom current, and during the April 9 plume tracking period the bottom current was a low 0.06 kts (3 cm/s). Previous bottom currents in March were from 0.3 to 0.5 kts (15 to 26 cm/s). On the following day, April 10, an excess salinity contour of +5 $^{o}/oo$ was detected, and the area within this contour was 6 acres (0.02 km^2). The 4 $^{o}/oo$

above ambient contour covered 27 acres (0.1 km^2), and the 2 $^o/oo$ contour covered an area of 1828 acres (7.4 km^2).

In the nearfield, or within 100 ft (30 m) of the diffuser, vertical profiles were measured to evaluate the vertical extent of the plume. These measurements showed that the plume was located in the bottom third of the water column where the average depth is 71 ft (21.6 m). The largest measured vertical excursion of the plume was 25 ft (7.6 m) which occurred on April 10. Measurements on March 30, 31, and April 10 indicated that the vertical extent was 15 ft (4.6 m), and on April 9 it was 9 ft (2.6 m). These results generally agree with the predictions of laboratory determined empirical relationships.

Water and sediment sampling was carried out on February 29, March 25 and April 7, 1980 to evaluate the effect of brine discharge in the offshore diffuser area. Both water and sediment samples were collected at 15 stations (13 in the area of the diffuser). Results of laboratory analyses of these samples indicate that no significant changes resulting from brine discharge could be substantiated with the exception of salinity increases in bottom waters at the diffuser site in April. Sediment pore water analyses suggest slight increases over ambient for TDS and several major ions in April; however, additional analyses with time are needed before valid conclusions can be made concerning these changes.

Increased oil and grease levels in the water column on March 25 suggest they might have occurred as a result of brine discharge but high levels at control stations also indicate the oil and grease may have had another source.

On the basis of the gas chromatograms of the sediment extracts on February 29 and April 7, there is no indication that the diffuser operation caused any detectable accumulation of crude oil in the sediments, despite some variation in total or fractional concentrations.

Collections of nekton in the intensive postdisposal period of March-April were made on three night cruises and three day cruises following diffuser startup. Stations were occupied in the area near the diffuser and they corresponded to the ones occupied in the predisposal period.

Nekton compositions are summarized and described for each cruise in the intensive postdisposal period of March-April 1980 for the following areas: 1) station 9, 2) station 26, and 3) the diffuser stations (stations 14-25 inclusive as a group). The ichthyofauna in each of these three major areas was quite similar. On a given cruise, the dominant species and the more abundant species were quite similar in each area. However, there were differences in compositions related to the distinct transition from a white shrimp community to a brown shrimp community in that geographical area. There seemed to be little change in the nature of the abundant ichthyofauna in the diffuser area between the intensive postdisposal period and the March-April periods in the predisposal studies. The principal species of fishes present at the twelve diffuser stations included silver seatrout (the dominant form), shoal flounder, and gulf butterfish. The principal species of fishes at the twelve diffuser stations were silver seatrout (a dominant), Atlantic bumper (a dominant), shoal flounder, gulf butterfish, dwarf sand perch, and blackedge cusk-eel. The Penaeid shrimp fauna at the twelve diffuser stations was dominated by *Penaeus aztecus*.

Field observations in the intensive postdisposal period indicated nothing unusual at the twelve diffuser stations in terms of the behavior or appearance of the nekton in the catch and in terms of dead and dying nekton in the water. Observations and plots of biomass volumes and counts of abundant species did not suggest any obvious effects due to brine disposal.

The abundance of nine species was studied in detail using statistical analyses (Duncan's Multiple Range Test) for significant differences between stations and using "common sense" analysis to look for patterns that might be interpreted to indicate that brine disposal affected the abundance of a given species on a given cruise.

These studies have indicated that little, if any, effect on abundance of these nine species due to brine disposal was observed in the March -April 1980 period. This reinforces the field observations that brine disposal caused no obvious effects and no major dramatic lethal effects on the nekton.

The analysis of benthic data shows there is little evidence that the discharge of brine had a drastic or even measurable effect on the benthic community near the diffuser. Only the areal population data collected during the intensive period suggest a nearfield depression, and even these stations had larger populations than some of the farfield stations. It is not surprising that effects were minimal at most. This study was conducted during the spring when sea conditions are usually rough and currents strong. The turbulence and currents tend to mix the water column and rapidly carry the diluted brine away from the discharge site. The currents also tend to be variable in direction over relatively short time spans, thus the benthos in any particular patch of bottom may not have been subjected to brine for more than a few hours at a time. Another factor tending to mitigate potential impact was that the brine was not being discharged at full strength.

It is expected that the most severe effects on the benthic environment will occur in late summer when seas are generally calmer and a greater possibility of stagnation occurs. If hypoxic conditions occur with the same severity as in 1979, any effects due to brine discharge may be completely masked.

The zooplankton data from the three intensive study cruises indicate that the initiation of brine discharge in the sampling area appears to have had no immediately obvious effect on the zooplankton in the water column. Biomass and total zooplankton densities were apparently unaffected by the diffusion in the area. Some groups of zooplankton and species of copepods exhibited elevated or depressed densities following the initiation of discharge but these changes can probably be attributed to seasonal fluctuations. The continued monitoring of the zooplankton population levels will enable us to substantiate this conclusion.

An analysis of variance and Duncan's Multiple Range Test were used to examine stations variability in relation to replicate tow variability. These results indicated no consistent differences between stations after initiation of brine discharge. More postdisposal data, however, will enable us to determine with greater confidence whether the discharge of brine in the area is increasing station variability.

No new phytoplankton taxa were found in either the diffuser or the control areas during this three month period. The dominant species and their relative abundances appeared to be essentially unchanged from those found in the predisposal study. Total phytoplankton abundance and chlorophyll a concentrations did not appear to be affected by the brine discharge.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

INTRODUCTION

In March and April 1980, a team of scientists and engineers at Texas A&M University conducted an intensive environmental study of the immediate effects of discharging brine into the coastal waters off Freeport, Texas. The brine discharge is the result of leaching large storage caverns in an underground salt dome which is being used for the storage of petroleum products. The salt dome is located near Freeport, Texas, at the Bryan Mound site of the Department of Energy's Strategic Petroleum Reserve Program.

A 3 ft (0.9 m) diameter pipeline has been buried beneath the sea floor from Bryan Mound to a point 12.5 statute miles (20 km) off the Freeport, Texas coast in 71 ft (21.6 m) of water (Figure 1). The location of the end of the pipeline diffuser is latitude $28^{\circ}44'$N and longitude $95^{\circ}14.5'$W. The last 3060 ft (933 m) of the pipeline is a diffuser which consists of 52 diffuser ports which extend veritcally 6 ft (1.8 m) from the bottom, are 3 in (7.6 cm) in diameter and are 60 ft (18 m) apart. The brine pumping system was designed to discharge 200-280 $^{o}/oo$ brine at a rate of 680,000 barrels per day (1.08×10^{5} $m^{3}day^{-1}$) through 31 ports. However, during initial leaching of the caverns, it was not possible to discharge at the designed flow rate, and consequently, only 16 ports were opened initially for a maximum flow rate of 350,000 barrels per day (5.6×10^{4} $m^{3}day^{-1}$). The brine discharge began on March 10, 1980, on an intermittent basis and a continuous flow of brine was established by March 13. Since the brine discharge is more dense than the receiving waters, it falls to the bottom and spreads over the sea floor. The brine plume is diluted and advected away by the natural ocean bottom currents and turbulent diffusion.

The purpose of this report is to describe the findings of the project team during the intensive postdisposal study conducted during March and

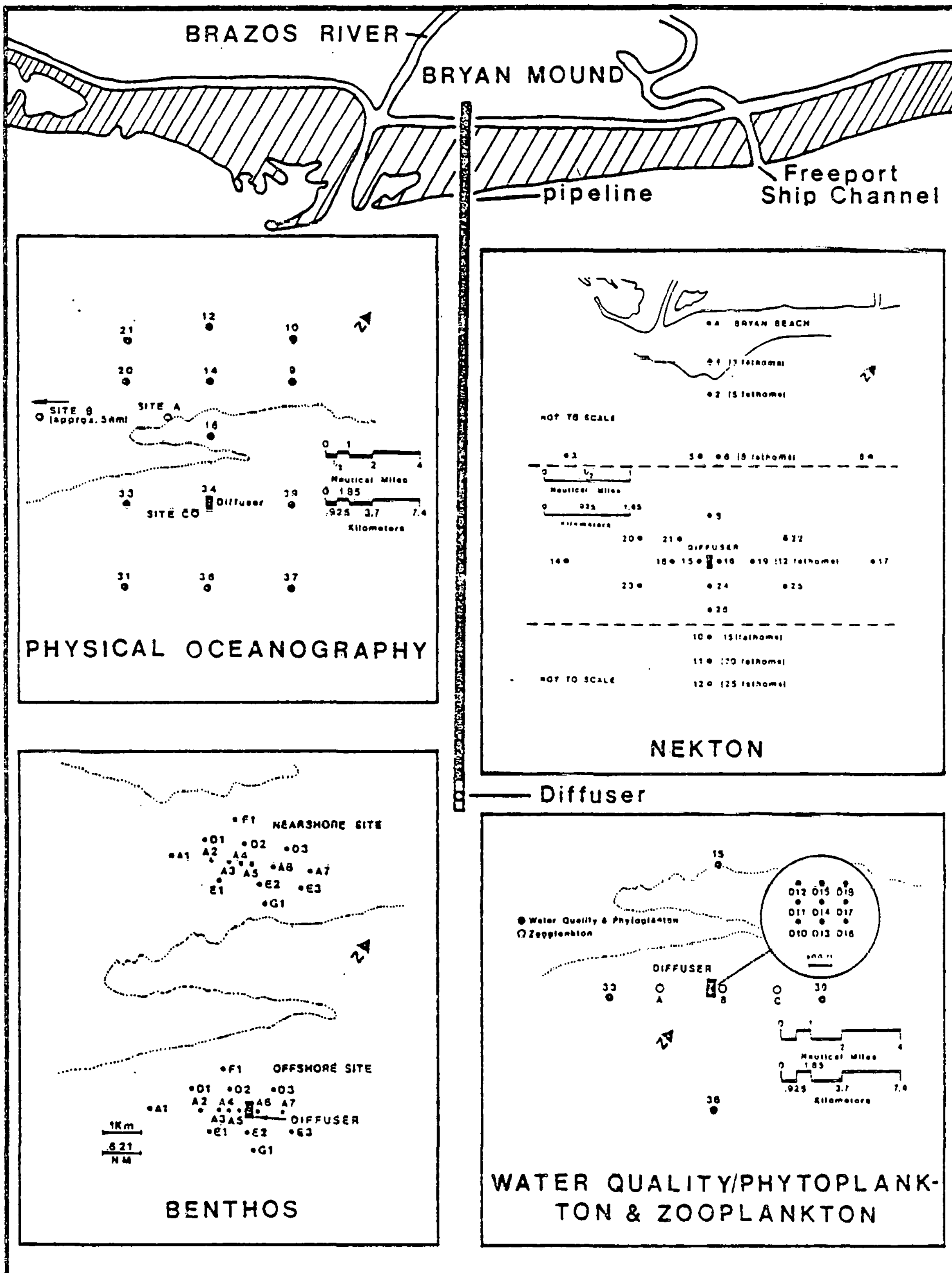


Figure 1. Composite of project sampling station locations.

April 1980. The areas of investigation are physical oceanography, analysis of the discharge plume, water and sediment quality, nekton, benthos, phytoplankton, zooplankton, and the data management. The specific objectives of this report are:

1) to describe the physical oceanographic and meteorological conditions which have been measured at the offshore diffuser site and in the surrounding waters;

2) to describe the immediate effect of brine discharge on the benthic community in the diffuser site area;

3) to discuss the immediate effect of the brine discharge on the planktonic community and the quality of the water and sediment in the vicinity of the diffuser site;

4) to describe the measurement of the areal and vertical extent of the brine plume;

5) to characterize the effect of brine discharge on the nekton community in the vicinity of the diffuser.

A detailed predisposal study was conducted by the same project team beginning in September 1977 and continuing through February 1980, and a final report (Hann and Randall, 1980) has been submitted to the Department of Energy. This 30 month study provides an unusually large baseline of data for comparison with the postdisposal results. A composite of the sampling station locations for all the project team components for both the predisposal and postdisposal studies is illustrated in Figure 1. In addition to this report, a complete data set for the predisposal and postdisposal studies has been submitted to the Environmental Data Information Service.

The meteorological and physical oceanographic data for March and April 1980 are presented to determine the degree to which the initial brine discharge may have altered the ambient conditions and to provide basic physical oceanographic data needed for the analyses by other components of the study. Discussions are restricted for the most part to the data from the instruments at the diffuser site. A special presentation is given for the current velocity, temperature and salinity time series data from the near bottom instrument on the days when plume tracking was accomplished.

The probe monitoring system used in tracking the brine plume and the procedures employed to attain the salinity contours which describe the areal coverage of the brine plume located 19 in (25.4 cm) off the bottom is described. During the intensive study period, the area extent of the plume was measured on five occasions which are referred to as plume tracks and the vestical extent of the plume near the diffuser was determined by measuring the vertical salinity profiles.

The water and sediment quality during the intensive study period consisted of a sampling cruise just prior to discharge and during the month after discharge. Water and sediment samples were collected at the stations shown in Figure 1. In addition, selected biota were collected in the diffuser area and at one control station for limited chemical analyses. These biota were analyzed for heavy metals, pesticides and polychlorinated biphenyls. Water samples were analyzed for salinity, dissolved oxygen, nutrients, major bulk ions, soluble heavy metals and estimates of organic matter, turbidity and productivity. The sediment samples were analyzed for Eh, pH, oil and grease, selected pesticides and PCBs, high molecular weight hydrocarbons and the same heavy metals as for the water samples as well as the major ions, and total dissolved solids present in the interstitial or pore waters of the sediments.

The nekton sampling cruises during the March - April 1980 postdisposal study were divided into day and night cruises with trawls made at stations 9 and 14 through 26 as shown in Figure 1. The night cruises were initiated eight days prior to continuous discharge and 12, 22, and 32 days after discharge. Day cruises were initiated at 7, 15 and 28 days after startup. The data from these cruises were used to determine the abundance, composition and diversity of the nekton during the March - April 1980 period. These results are compared with similar data collected during the March - April 1979 period in order to evaluate the immediate effect of brine discharge on the nekton community.

The benthic sampling for the intensive postdisposal study was conducted at the offshore site stations shown in Figure 1. The benthic sampling began on March 10, 1980, just prior to the start of brine discharge, and subsequent collections were made on March 20, April 3 and April 21. Areal and temporal distributions of populations and species and cluster analyses are used to evaluate the immediate effect of the brine discharge.

Zooplankton cruises were made at the stations shown in Figure 1 prior to discharge and on two occasions after the initiation of discharge. Total zooplankton biomass, population densities, and species diversity were measured and compared to results obtained during predisposal studies to determine the effect of brine discharge. Phytoplankton cruises were conducted in March, April and May of 1980, and the data were analyzed to determine if any new taxa appeared or dominant species disappeared in the diffuser area and to evaluate any changes in phytoplankton composition, abundance and diversity between the diffuser and control areas.

The data from the intensive postdisposal study has been submitted to EDIS. Also, the data from the Brine Monitoring System (BRIMS) and the on-site brine pit data are summarized in a tabular manner by the data management component in Appendix III.

The complexity of the Strategic Petroleum Reserve Program has required a multidisciplinary research effort which is coordinated by a management staff headed by Dr. Roy W. Hann, Jr., Program Manager, and Dr. Robert E. Randall, Associate Program Manager. The objectives of the management staff are to oversee the fiscal aspects of the project, act as liaison between principal investigators and sponsor, to coordinate program output such as reports and data transmittal, and to coordinate field operations. A separate unit of the management staff is the field organization located in Freeport, Texas. The field personnel are responsible for coordinating the use of the Civil Engineering Department's research vessel, R/V EXCELLENCE, and other contract vessels. In addition, the field personnel assist the principal investigators in the collection of field data. The contractural matters of the project are the responsibility of the Texas A&M Research Foundation.

This report is divided into chapters which correspond to the areas of responsibility of the principal investigators. These chapters are entitled Physical Oceanography, Analysis of the Discharge Plume, Water and Sediment Quality, Nekton, Benthos, Phytoplankton, Zooplankton and Data Management. The principal investigator for Physical Oceanography is Mr. Francis J. Kelly, who is a Research Associate in the Environmental Engineering Division of the Civil Engineering Department and a doctoral student in the Department of Oceanography. Dr. Robert E. Randall is the principal investigator for the Analysis of the Discharge Plume and he is associated with the Ocean and Hydraulics Engineering Division of the Civil Engineering Department. He also is responsible for the collection and description of the monthly hydrographic data discussed in the physical oceanography chapter. The principal investigator for Sediment and Water Quality is Dr. J. Frank Slowey of the Environmental Engineering Division of the Civil Engineering Department. Dr. Mark Chittenden is the principal investigator for the Nekton studies, and he is associated with the Wildlife and Fisheries Department. The principal investigators for the Benthos studies are Dr. Donald E. Harper and Dr. Larry D. McKinney who are associated with the Marine Science Department at Texas A&M University in Galveston. Mr. Robert J. Case is a Research Associate in the Environmental Engineering Division of the Civil Engineering Department and is a doctoral student in computer science and statistics. He is the principal investigator for the Data Management section. Dr. E. Taisoo Park and Dr. Thomas J. Minello are the principal investigators for the Zooplankton studies and they are associated with the Marine Biology Department at Texas A&M University in Galveston. The principal investigator for the Phytoplankton studies is Dr. Laurel A. Loeblich who is associated with the Marine Science Department at Texas A&M University in Galveston.

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

CHAPTER 1

PHYSICAL OCEANOGRAPHY

Francis J. Kelly, Jr.
Environmental Engineering Division
Civil Engineering Department

and

Robert E. Randall
Ocean and Hydraulic Engineering Division
Civil Engineering Department

1.1 Introduction

In this chapter the meteorological and physical oceanographic data for March and April, 1980 are presented. The objectives are to determine the degree to which the first month of brine discharge, March 10, 1980 through April 10, 1980, may have altered the ambient conditions and provide basic physical oceanographic data for the analyses of the subsequent chapters.

The hydrographic survey data collected during March and April, 1980 are discussed in section 1.2 and compared with the data collected during the same months of 1978 and 1979. The meteorological data for March and April, 1980 are presented in section 1.3 and the physical oceanographic time series data in section 1.4. Discussions are for the most part restricted to the March 10 to April 10 time period and the data from the instruments at the diffuser site. A special presentation is given for the current velocity, temperature and salinity time series data from the near bottom instrument on the days on which the brine plume was mapped.

1.2 Monthly Hydrographic Data

1.2.1 Vertical Cross Sections of Temperature, Salinity and Sigma-t

Conductivity, temperature, and depth (CTD) data have been collected for specific stations shown in Figure 1-1 at the top (1.8 m below the surface), mid-depth, and bottom (1.8 m above the bottom) for the past three years. The conductivity is converted to salinity, and it is used with the temperature to compute the density which is expressed as sigma-t. The hydrographic data were collected on bimonthly cruises aboard the University vessel, R/V EXCELLENCE, using either the Hydrolab model TC-2 or model 8000 water quality system. The description of this equipment, the data procedures, the methods of analysis of CTD data, and the calibration procedures are described in detail by Kelly and Randall (1980).

The data are displayed in the form of vertical cross sections for transects parallel to the pipeline (cross shelf) and a transect normal to the pipeline through the diffuser. The stations for the cross-shelf transect are numbers 12, 14, 16, 34, and 36. For the alongshore transect, they are 39, 34 and 33; all are shown on Figure 1-1. The vertical cross sections for March and April in 1978, 1979, and 1980 are compared to determine whether there have been any significant changes in the hydrography of the area which could be related to the discharge of brine and to demonstrate the natural short term and interannual variations which result from fresh water runoff along the Texas/Louisiana coast (Kelly and Randall, 1980).

The hydrographic conditions found on March 23, 1978 are shown in Figure 1-2. These data show a layered water column with a slight scoss shelf gradient. At the location of the diffuser (station 34), the

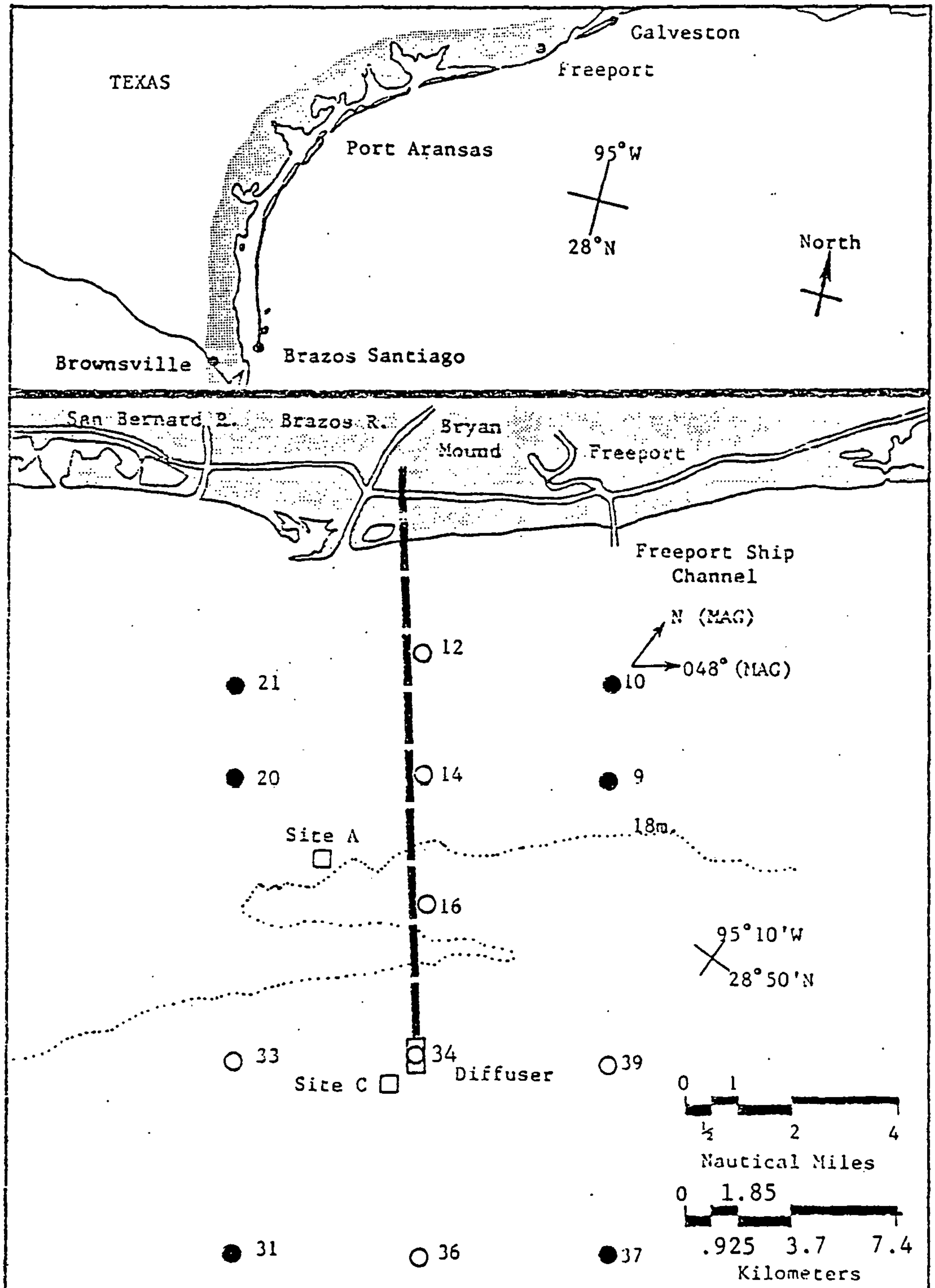


Figure 1-1. Final location of CTD measurement stations. Primary and secondary stations are indicated by ○ and ● respectively

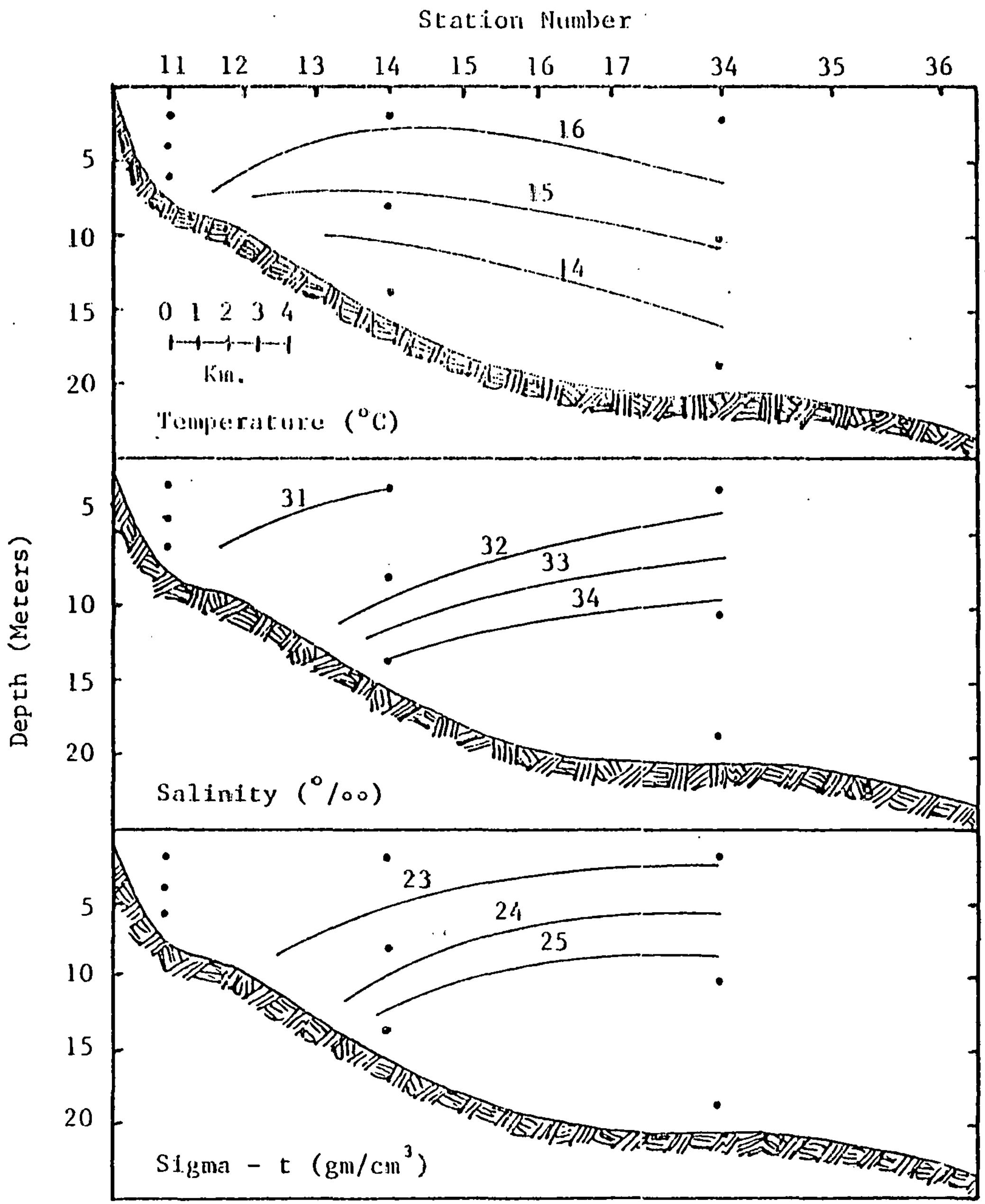


Figure 1- 2. Hydrography for cross-shelf transect offshore Freeport, Texas for March 23, 1978.

thermocline occurs near mid-depth, and the halocline and pycnocline occur between the surface and mid-depth. On April 19, 1978, the vertical cross sections, Figure 1-3, show that the stratification of the water column intensified significantly. For example, the salinity variation from top to bottom at station 34 increased from 2.8 ^{o}/oo in March to 12.3 ^{o}/oo in April, and the sitma-t variation increased from 3.8 to 10.6. The water column warmed up from 17°C to 22.4°C at the surface at station 34. The thermocline, halocline, and pycnocline occurred at approximately the same depths as in March but were much stronger in April. The alongshore variation in the hydrography is slight. The intense stratification would certainly inhibit mixing in the upper layer, but since the diffuser was designed such that the discharge should be confined to the lower layer of the water column, the stratification in the upper layer should not have a detrimental effect on the dispersion of the brine plume.

The March 12, 1979, hydrography data, Figure 1-4, show the temperature variation to be less than a degree from top to bottom at station 34. The salinity variation is 4.7 ^{o}/oo at station 34, and the halocline is located in the bottom layer. The pycnocline is likewise located in the lower layer, and the sigma-t variation is 3.8. This is similar to the previous year except that a thermocline is not present and the halocline and pycnocline lie in the bottom which would tend to somewhat inhibit mixing of a brine plume.

The hydrography data collected on April 16, 1979, and illustrated in Figure 1-5, indicate no thermal stratification but an intense, inclined salinity frontal zone inshore of station 34. At station 34, the pycnocline and halocline are located in the upper half of the water column. The variation in salinity and sigma-t at the diffuser location

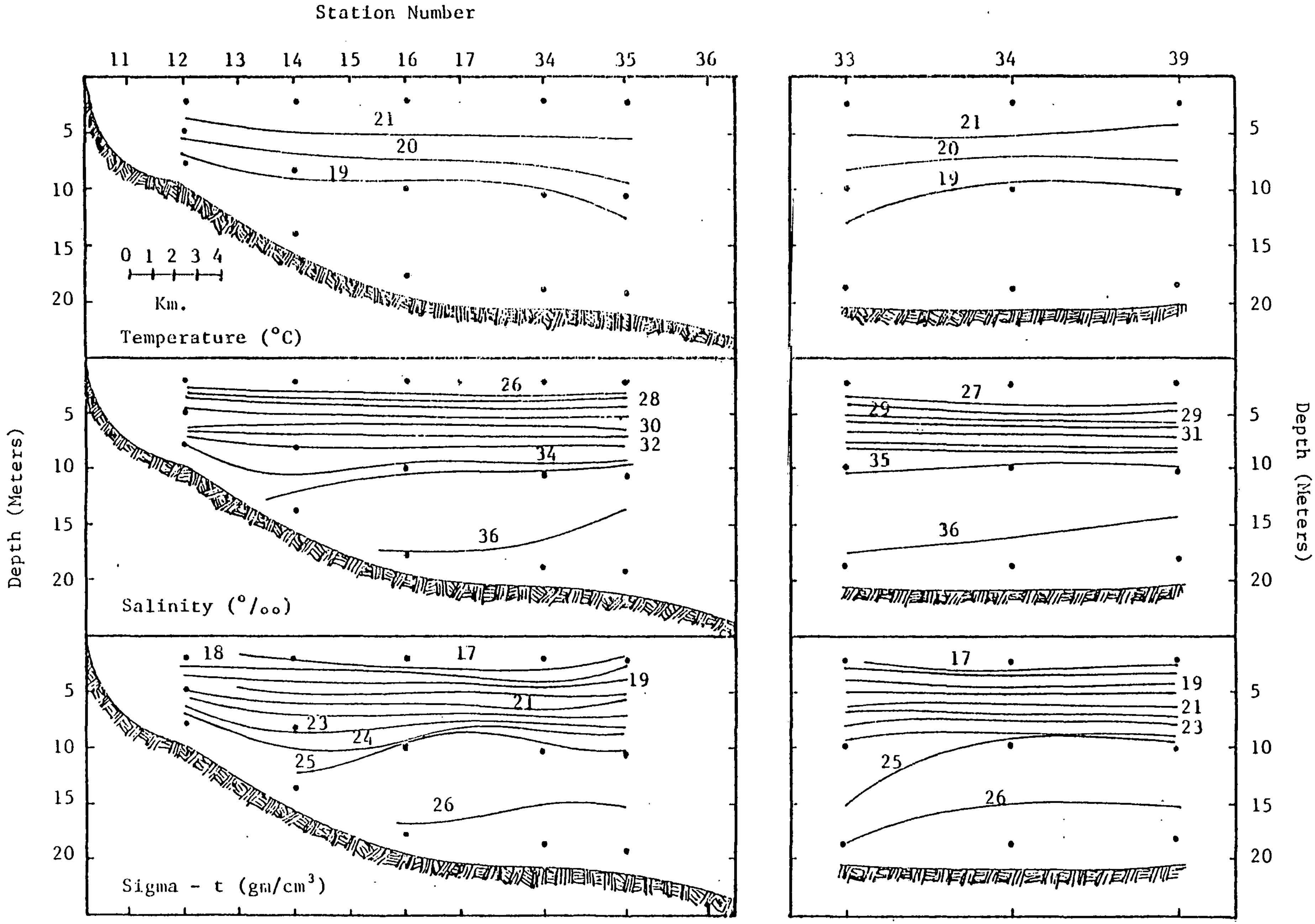


Figure 1- 3 . Hydrography for cross-shelf (left) and alongshore (right) transects offshore Freeport, Texas for April 19, 1978.

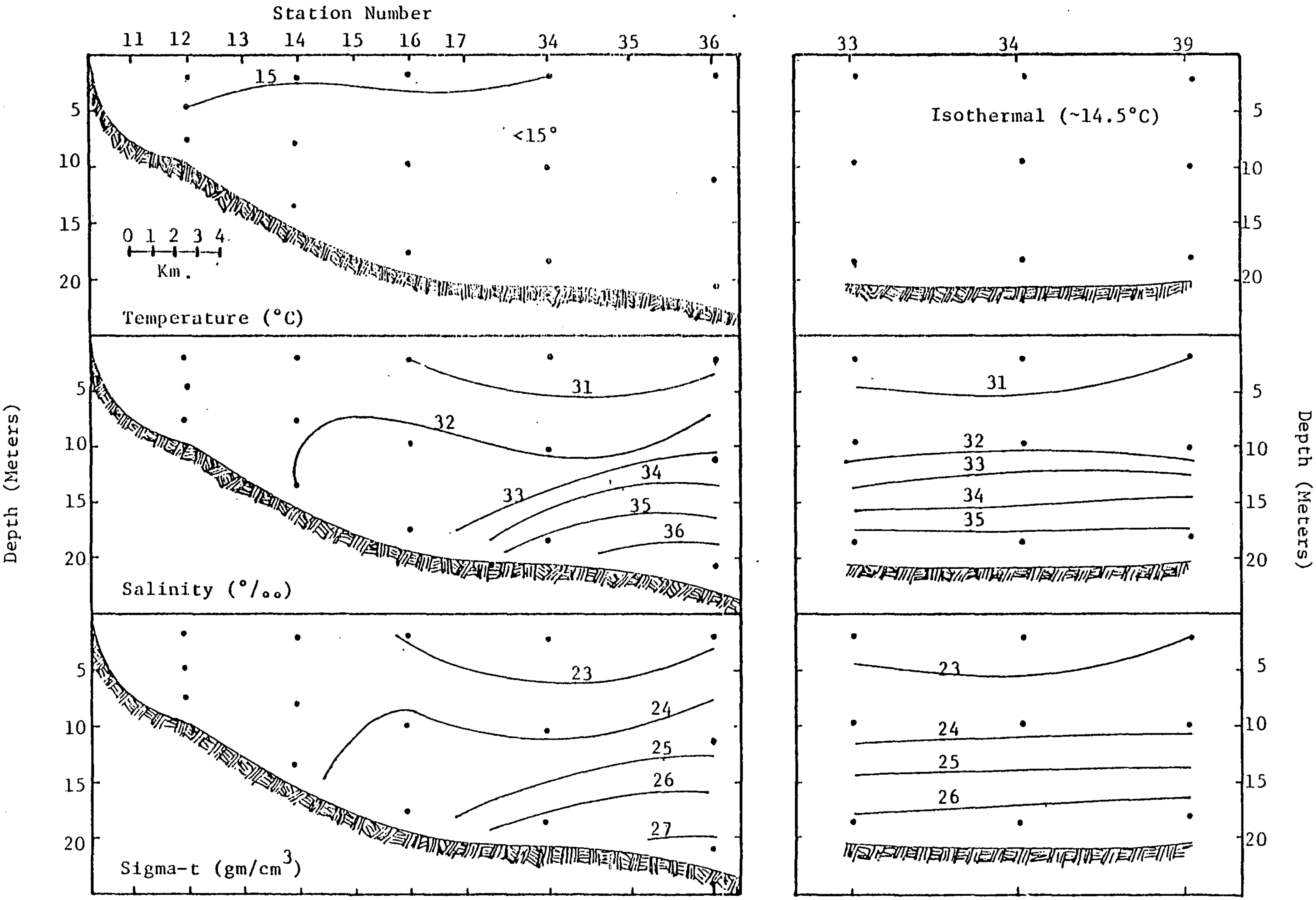


Figure 1-4 . Hydrography for cross-shelf (left) and alongshore (right) transects offshore Freeport, Texas for March 12, 1979

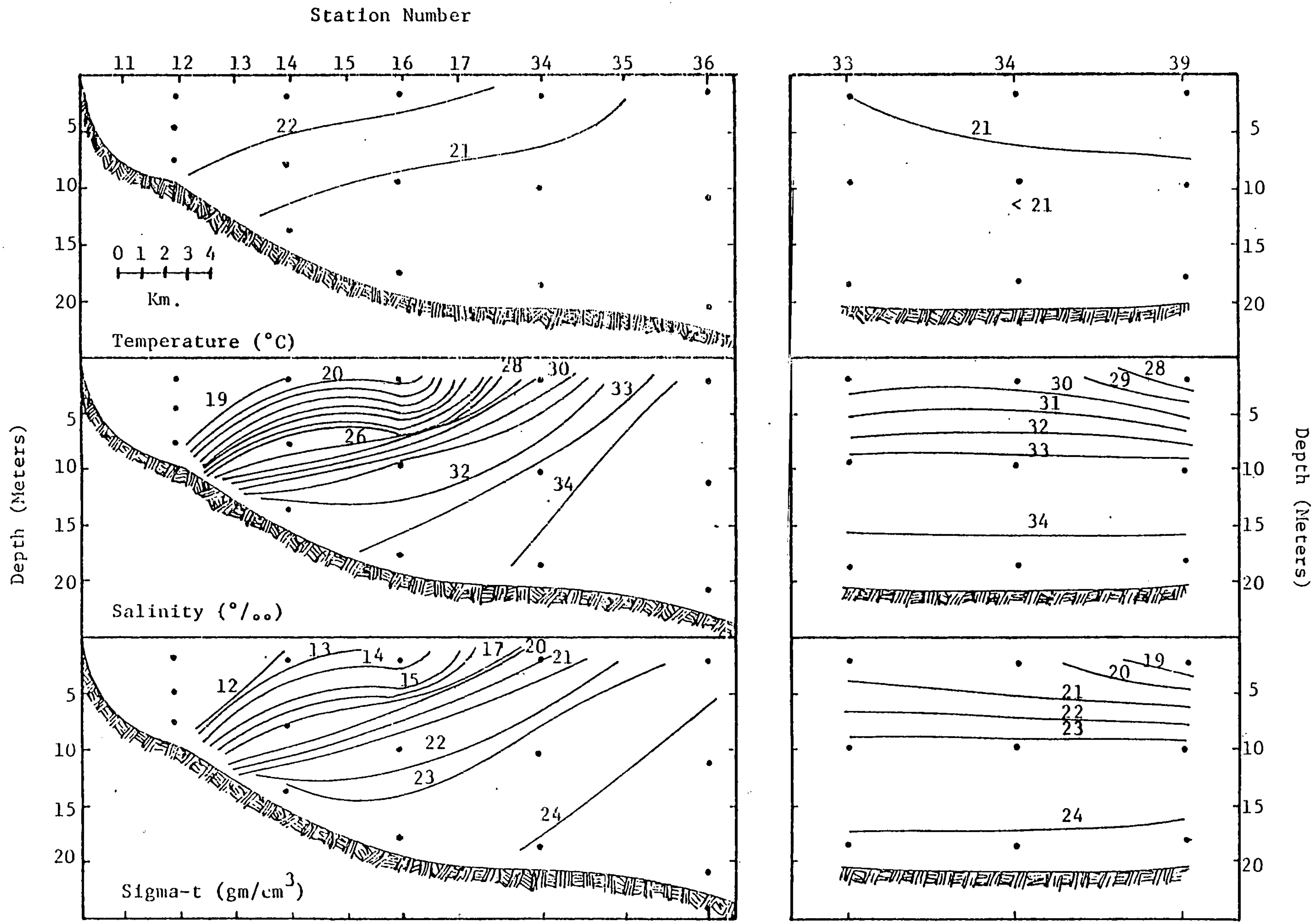


Figure 1- 5 . Hydrography for cross-shelf (left) and alongshore (right) transects offshore Freeport, Texas for April 16, 1979

(station 34) are essentially the same as in March. The variation of the data in the alongshore direction is negligible in the bottom layer.

The hydrographic conditions during March and April of 1978 and 1979 are similar in structure and magnitude, but subtle differences are observed. For example, a greater temperature difference from top to bottom existed in 1978 than in 1979, and the location of the pycnocline and halocline is in the upper layer on one occasion and the lower layer on another occasion. However, such variations are normal and are related to the amount of fresher water entering the area from the northeast as a result of runoff from the Mississippi/Atchafalaya river system as shown in detail by Kelly and Randall (1980).

On March 10, 1980, brine discharge began at a nominal rate of 225,000 barrels per day and an average concentration of 230 $^{o}/oo$. The first hydrographic survey was conducted on March 25, 1980, and the resulting vertical cross sections are shown in Figure 1-6. The data show the water column was isothermal but warmer than in 1979. The brine input is at the bottom of station 34, and it is evident in the contours of salinity and sigma-t. For example, the convex curvature of the 34 $^{o}/oo$ isohaline indicates the location of the brine source. The alongshore transects also illustrate the brine source clearly with the obvious convex curvature of the 34 $^{o}/oo$ isohaline. Although the contours indicate the brine source, the salinity concentration is not higher than that found in previous years (i.e. 35.3 $^{o}/oo$, 1978; 35.2 $^{o}/oo$, 1979). If station 39 is assumed to be the ambient salinity, then the salinity at the bottom (actual measurements are taken 6 ft (1.8 m) above the bottom) is approximately 1 $^{o}/oo$ above the ambient value. Thus, the hydrographic data

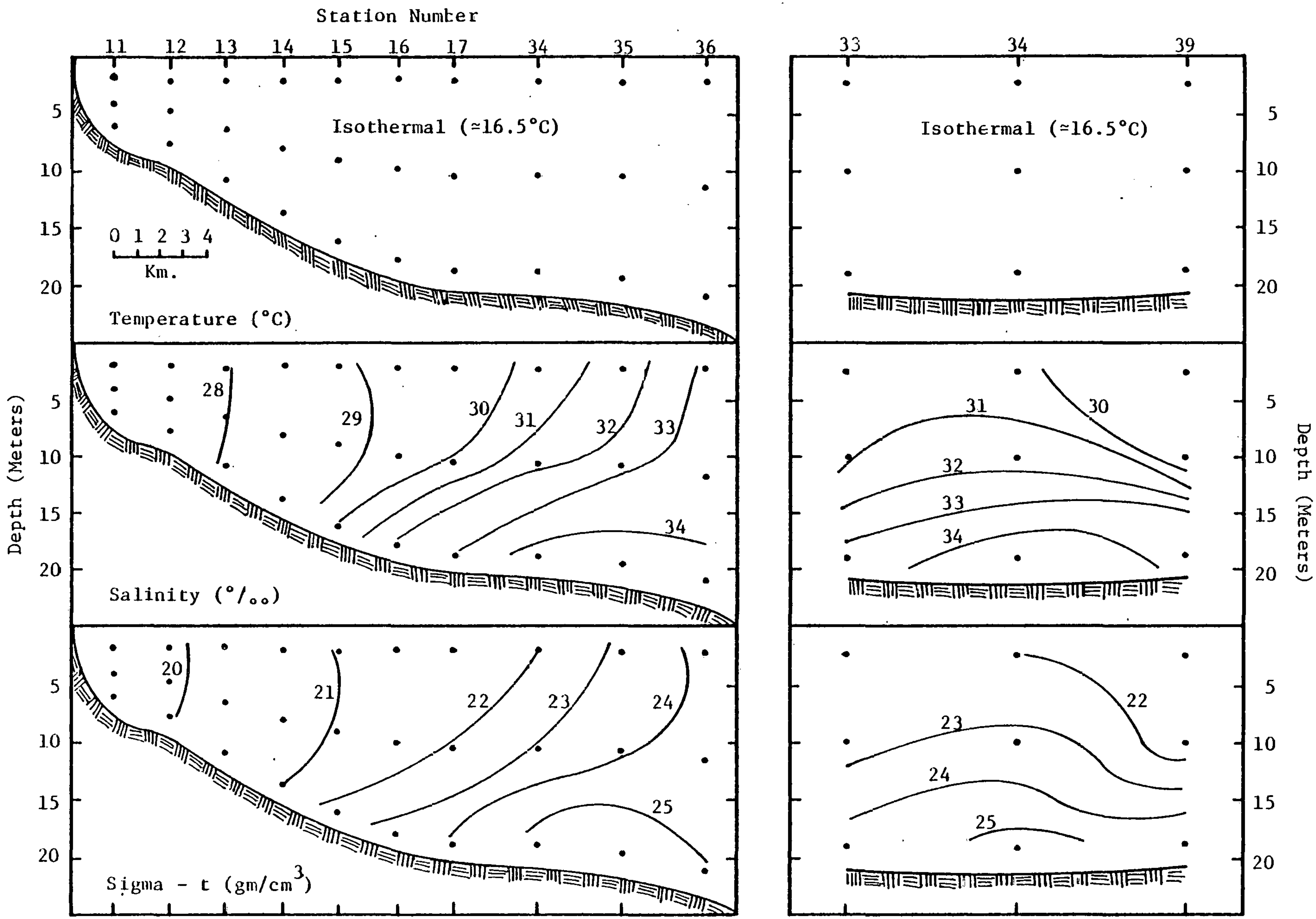


Figure 1-6. Hydrography for cross-shelf (left) and alongshore (right) transects offshore Freeport, Texas for March 25, 1980.

show that the brine source is detectable but that there is no severe increase in salinity or temperature.

The vertical cross sections for April 18, 1980 are illustrated in Figure 1-7. The temperature of the water column increased from 16.5°C to 19°C, but there was still less than 1°C change from top to bottom. The brine discharge again is evident at the bottom of station 34 as shown by the convex curvature of isohales and isopycnals. The alongshore transect indicates the brine discharge did not penetrate the water column above mid-depth. More data points are needed to determine a more accurate value for the vertical extent of the plume, and these data are discussed in Chapter 2.

1.2.2 Temperature and Salinity Relationship at the Diffuser

The March and April values of temperature and salinity at the diffuser site (station 34) for the past three years are plotted on Figure 1-8. The top figure shows the relationship for the data collected near the surface (6 ft (1.8 m) below the surface). There is a general warming trend from March to April of 4-6°C in all years. The near-surface salinity decreased in April of 1978 and 1979 as a result of the spring fresh water runoff which is mainly flowing down the coast from the Mississippi/Atchafalaya river system (Kelly and Randall, 1980). In 1980, the surface salinity increased from 30.4 $^{o}/oo$ on March 25 to 32.0 and 32.4 $^{o}/oo$ on April 18 and 29, respectively. This increase in salinity is attributed to a reduced spring runoff in 1980 and not the result of the brine discharge.

At mid-depth, the increasing temperature trend from March to April is observed again in Figure 1-8. The variation in salinity is shown to be quite large (31-35.1 $^{o}/oo$). The highest salinities and greatest

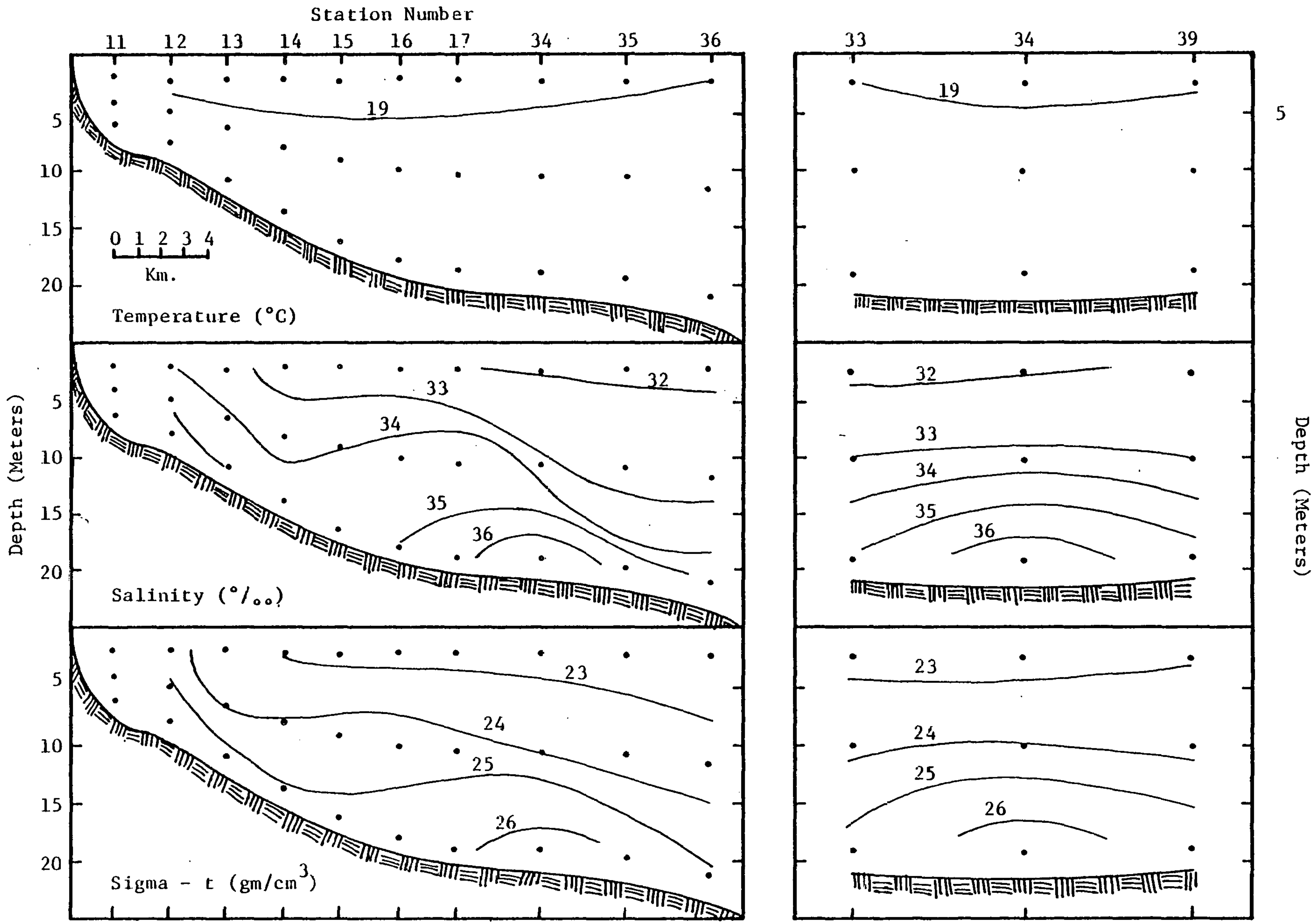


Figure 1-7. Hydrography for cross-shelf (left) and alongshore (right) transects offshore Freeport, Texas for April 18, 1980.

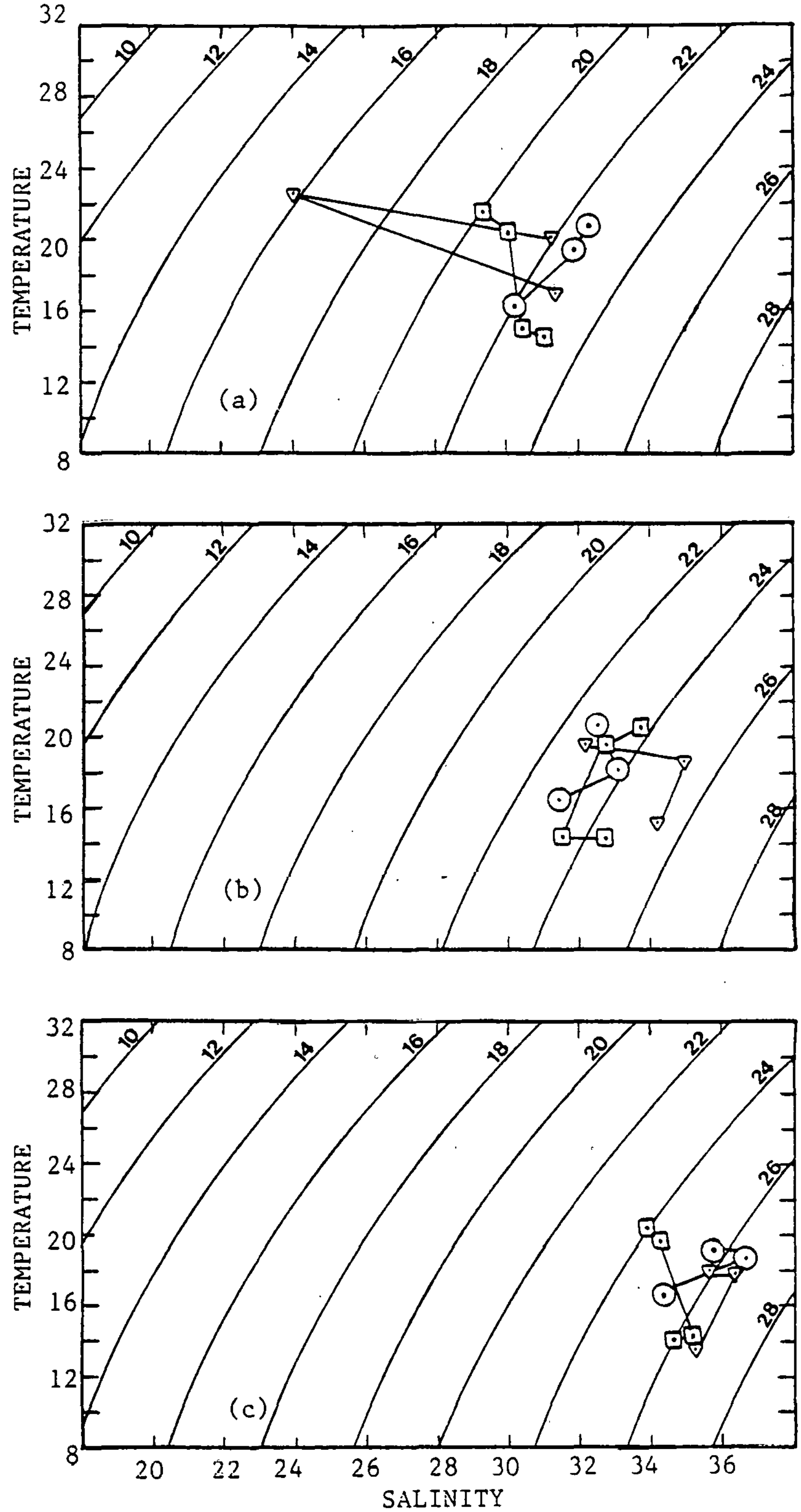


Figure 1-8. Temperature-salinity relationships for March and April data of Station 34. a) top b) middle c) bottom (△ 1978, ⊡ 1979, ⊙ 1980). Isoplethes of sigma-t are also shown.

densities occurred in March and April 1978 and not in 1980. Thus, an effect of the brine discharge on the mid-depth water was not observed in the temperature salinity relationship.

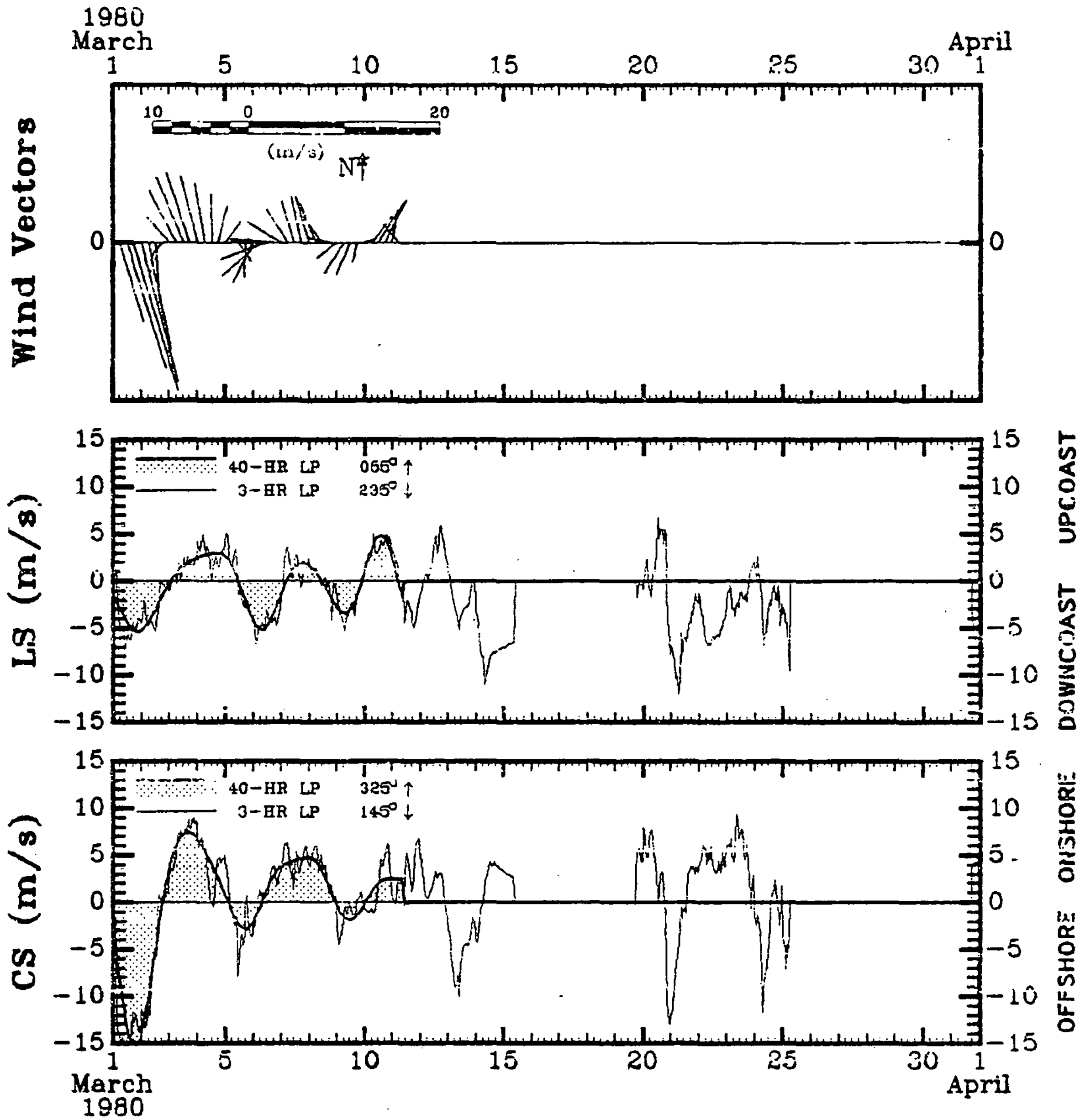
Figure 1-7 also shows the temperature salinity relationship for the bottom water. The temperature trend is similar to that in the upper layer. The salinity and density are greatest in April of 1980 which indicates an effect of the brine discharge in the bottom waters. However, the 36.7 $^{o}/oo$ salinity on April 1980 is only 0.3 $^{o}/oo$ above the value measured in April 1978, and thus the salinity increase resulting from the brine discharge has not resulted in salinities significantly in excess of previously measured values.

1.3 Meteorological Data

Meteorological data, including wind velocity, barometric pressure and air temperature, are collected in the study area by NOAA/NDBO and are provided to Texas A&M University on a monthly basis on computer compatible magnetic tapes. The sensor package is located on top of an oil company platform located about 50 meters from Site A (see Figure 1-1). Technical problems in the sensor package resulted in data gaps during March 16-19 and March 25-31. The available data have been plotted and are shown in Figures 1-9, 1-10 and 1-11. The data processing and filtering procedures are discussed in Kelly and Randall (1980). The data for March 19-25 are unfiltered because of the short record length.

All wind data are plotted and discussed in terms of the oceanographic direction convention, that is, the direction towards which the wind is blowing.

In order to augment the meteorological data, particularly during the gaps, NOAA Daily Synoptic Weather Maps were checked. They



Site A, Wind (Time is CST)

Figure 1- 9. March 1980. Wind velocity data from NOAA/NDBO meteorological package atop an oil company platform near Site A. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.

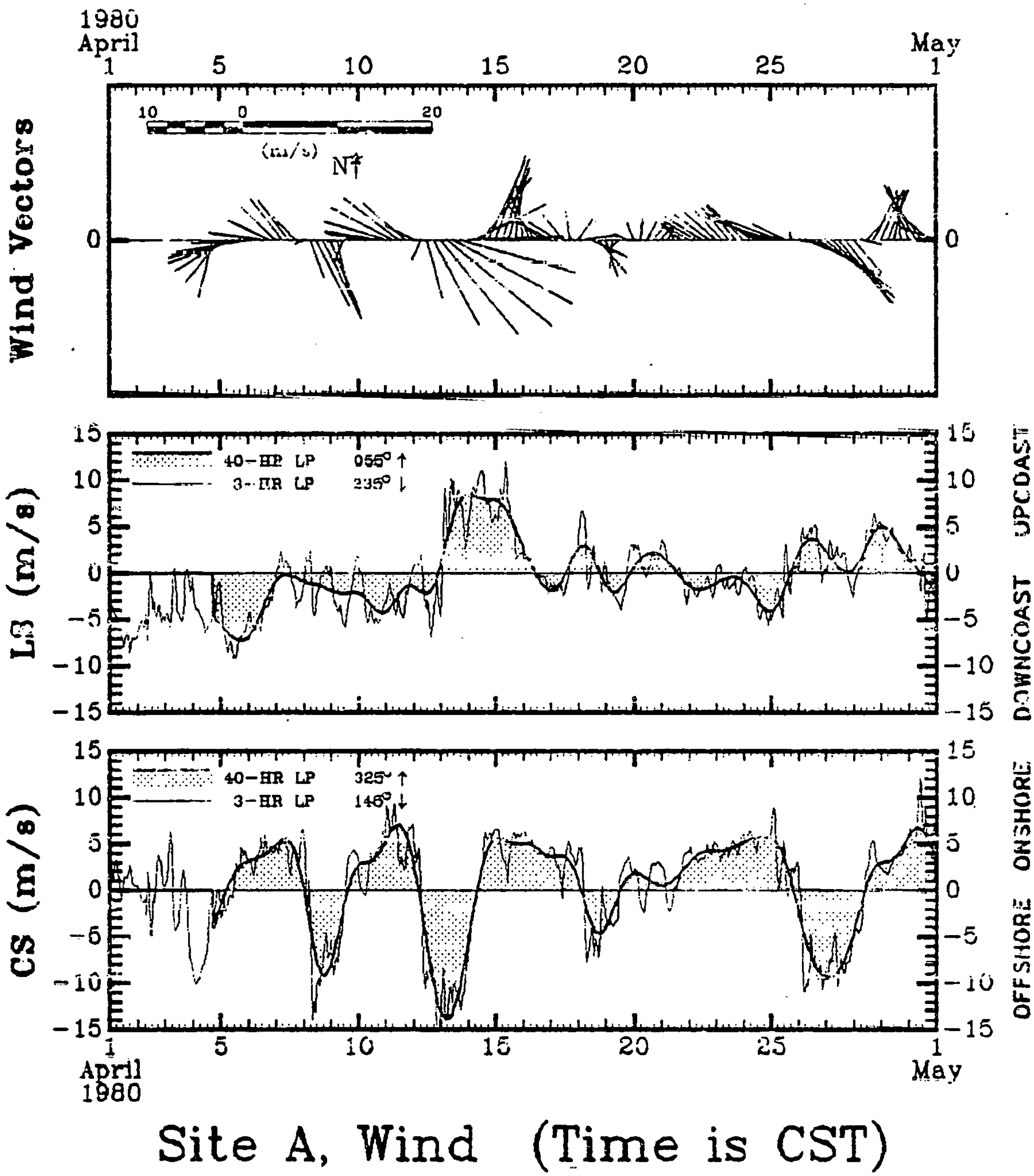
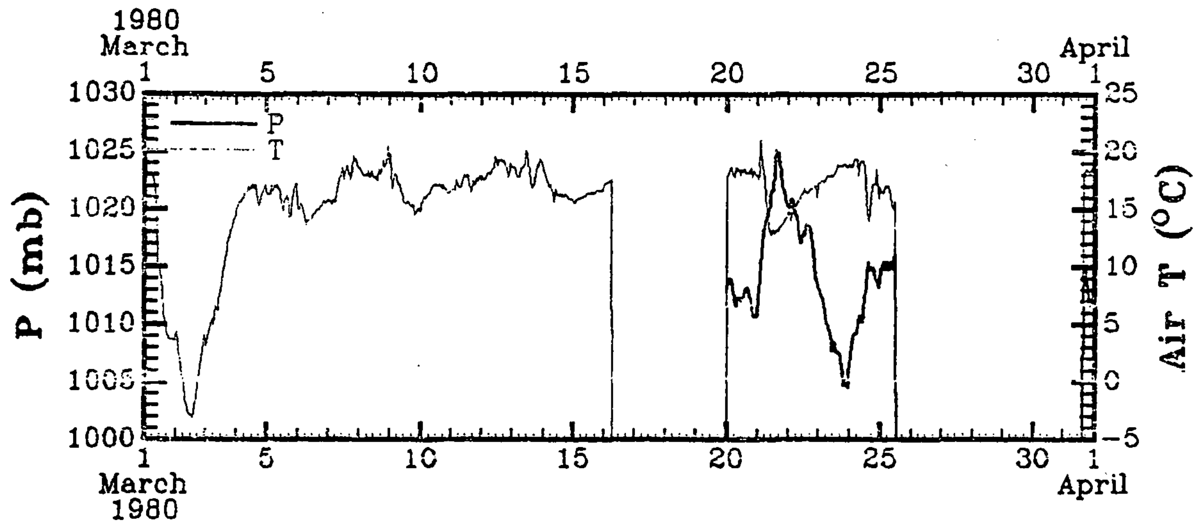
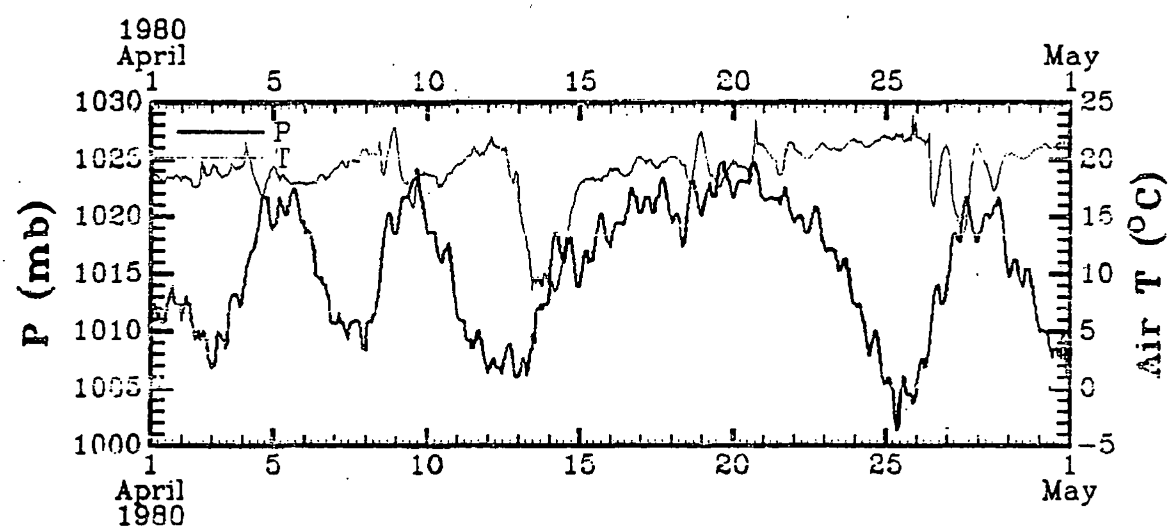


Figure 1- 10. April 1980. Wind velocity data from NOAA/NDBO meteorological package atop an oil company platform near Site A. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.



Site A,Air Temp,Press (CST)



Site A,Air Temp,Press (CST)

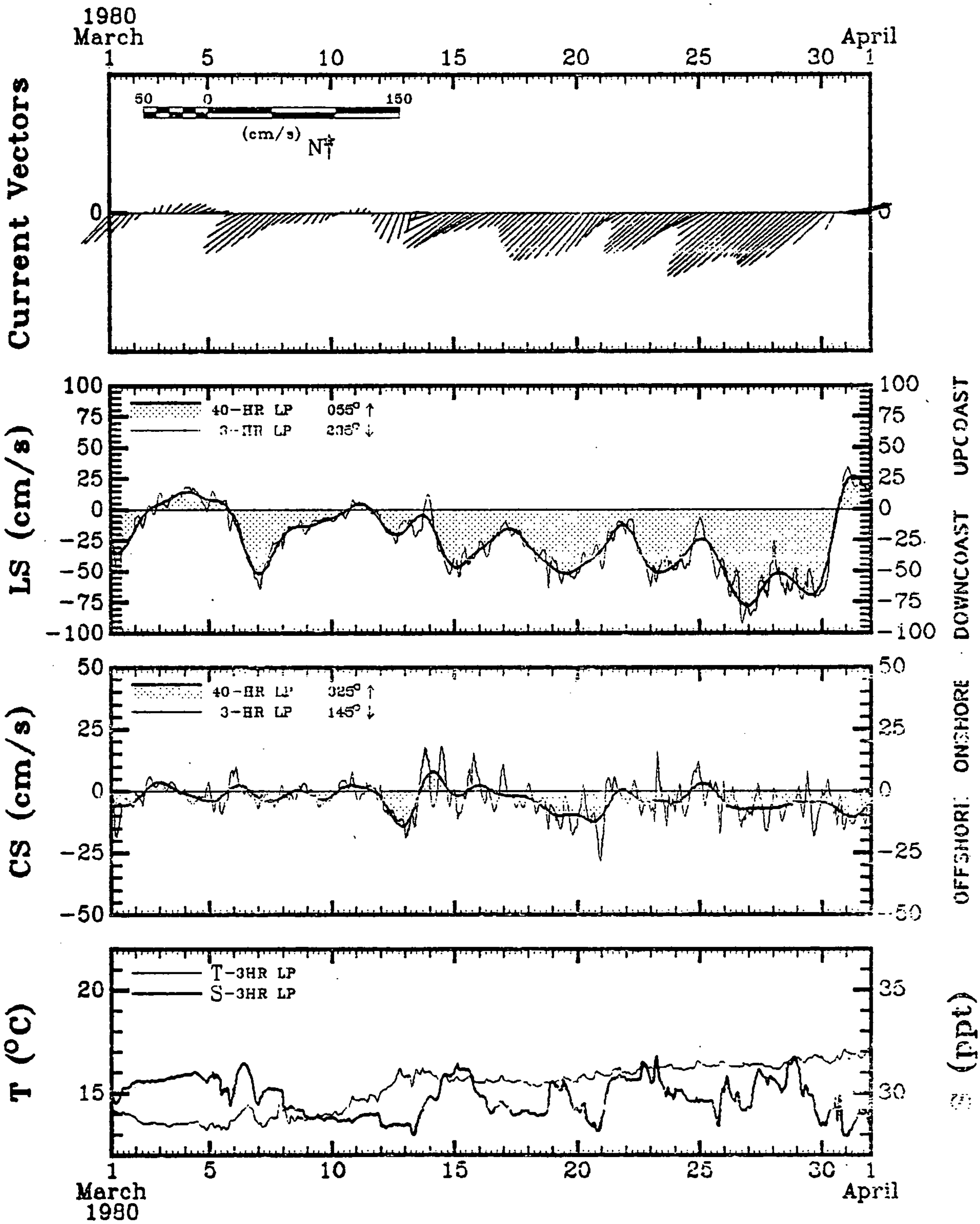
Figure 1- 11. March and April 1980. Air temperature and barometric pressure from NOAA/NDBO meteorological package atop an oil company platform near Site A. Data are unfiltered hourly values.

indicate that cold fronts moved off the Texas coast on the following dates: March 1, 6, 9, 13, 18, 21, 24, 28, and April 4, 8, 12, 18, and 26. The wind velocity data in Figures 1-9 and 1-10 are consistent with these dates and indicate shifts from winds out of the southeast to winds out of the northwest. There are corresponding drops in barometric pressure and air temperature (Figure 1-11). However, the temperature drops are not large except after the passage of fronts on March 1 and April 12. (The Daily Synoptic Maps indicate that the decreases in air temperature associated with the frontal passages during the data gaps were not large.) Thus strong cold air outbreaks, which can cause deep convective mixing, did not occur during the first month of brine discharge.

1.4 Physical Oceanographic Time-Series Data

The current velocity, temperature and salinity time series data from Site A and Site C (see Figure 1-1) are presented in Figures 1-12 through 1-23. Figure 1-1 shows the location of Site C in relation to the diffuser. The distance between them is about 300 m. The "top" current meter is located about 3.6 m below the surface, "middle" at mid-depth, and "bottom" 1.8 m above the bottom at each site. The water depth is 18.9 m at Site A and 21.9 m at Site C. A description of the current meters and the configuration of the mooring line is given in Kelly and Randall (1980).

In Figures 1-12 through 1-23, note that the alongshore scale is twice the cross-shelf scale for the top and middle meters but equal to the cross-shelf scale for the bottom meters. The alongshore current velocity component is parallel to the local orientation of the coastline (055°T - 145°T) and the cross-shelf component is approximately



Site A, Top (CST)

Figure 1- 12. March 1980 current velocity, temperature and salinity time-series data from the near-surface instrument at Site A. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.

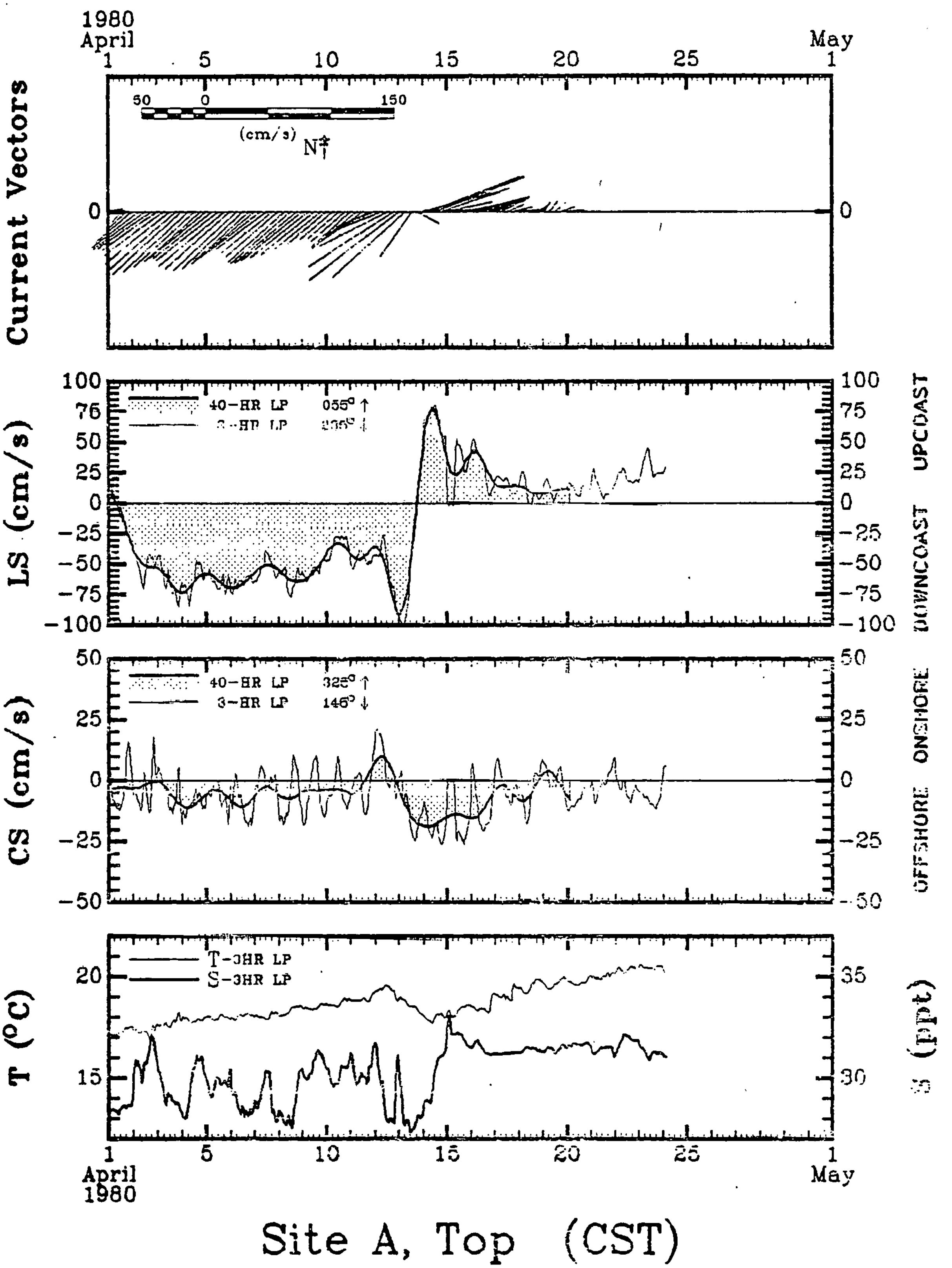


Figure 1-13. April 1980 current velocity, temperature and salinity time-series data from the near-surface instrument at Site A. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.

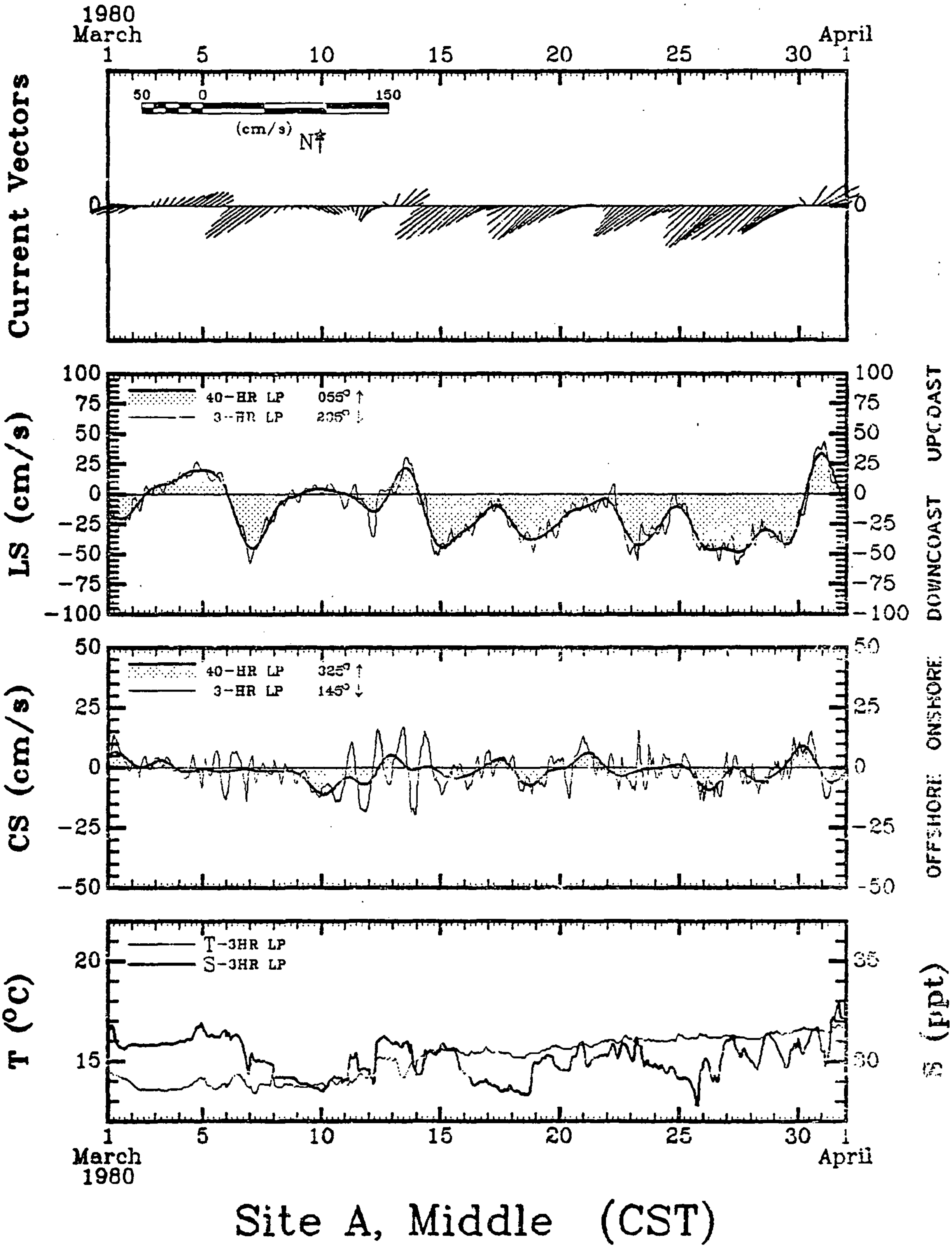


Figure 1-14. March 1980 current velocity, temperature and salinity time-series data from the mid-depth instrument at Site A. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.

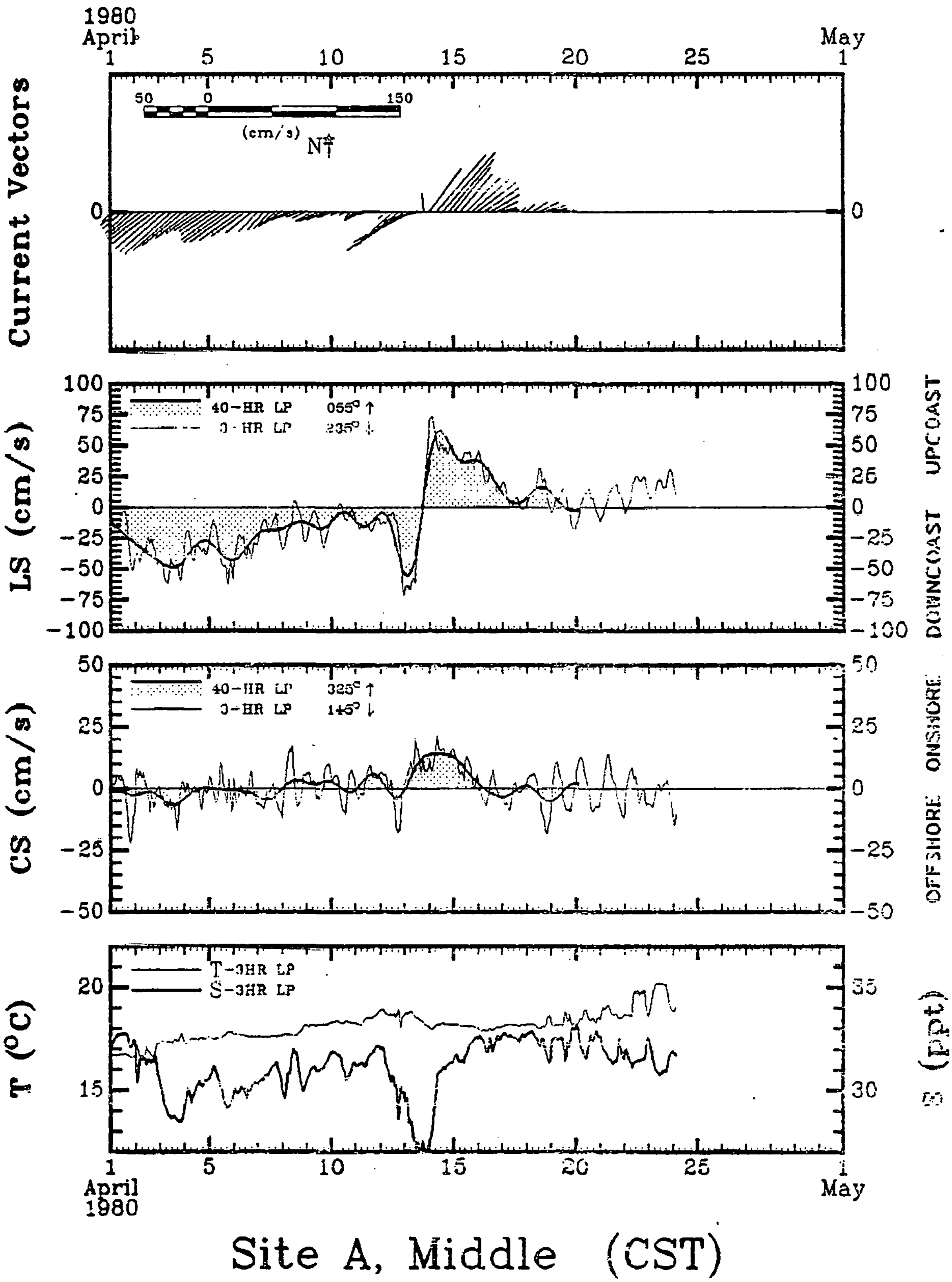


Figure 1-15. April 1980 current velocity, temperature and salinity time-series data from the mid-depth instrument at Site A. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.

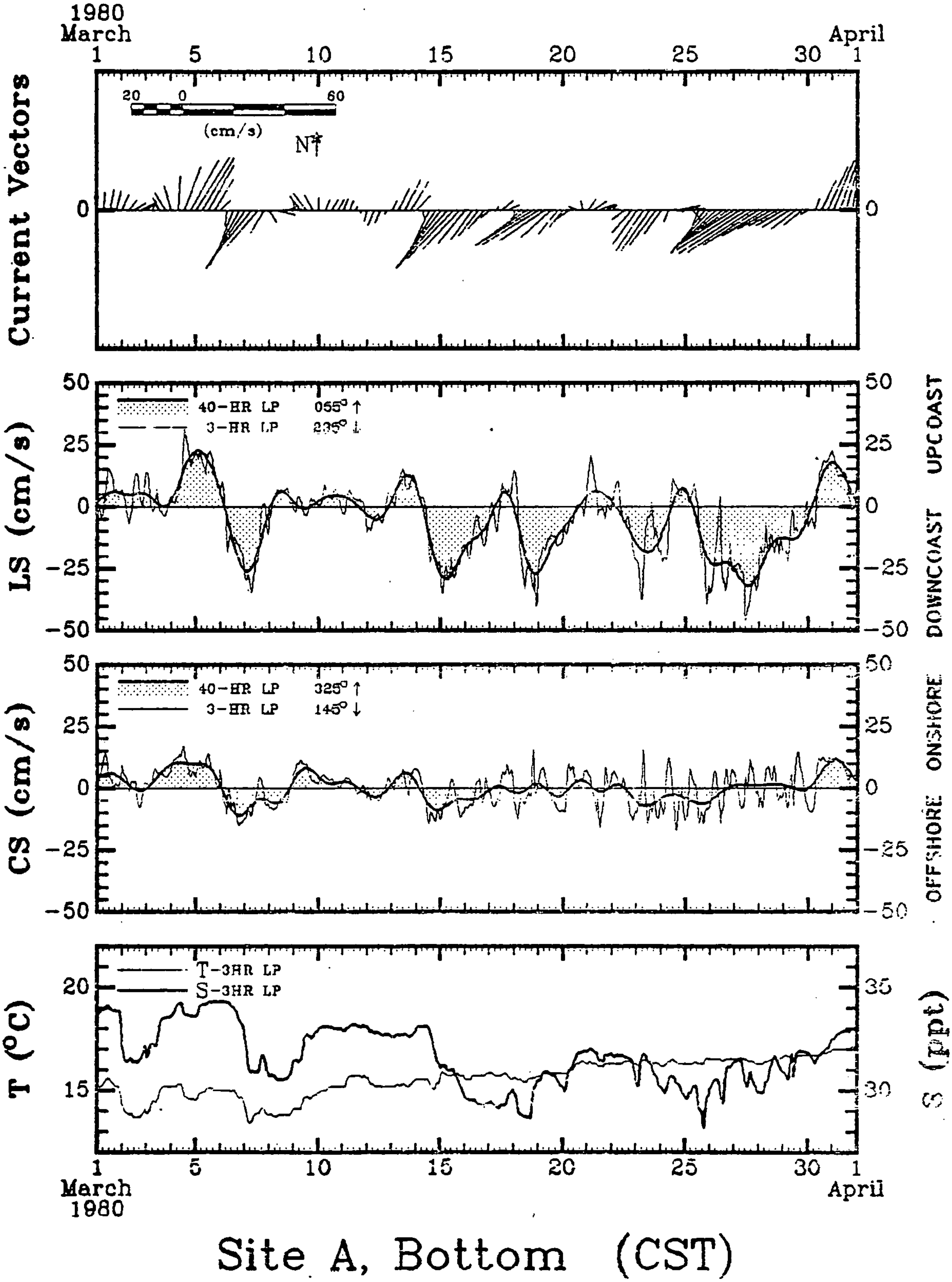


Figure 1- 16. March 1980 current velocity temperature and salinity time-series data from the near-bottom instrument at Site A. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.

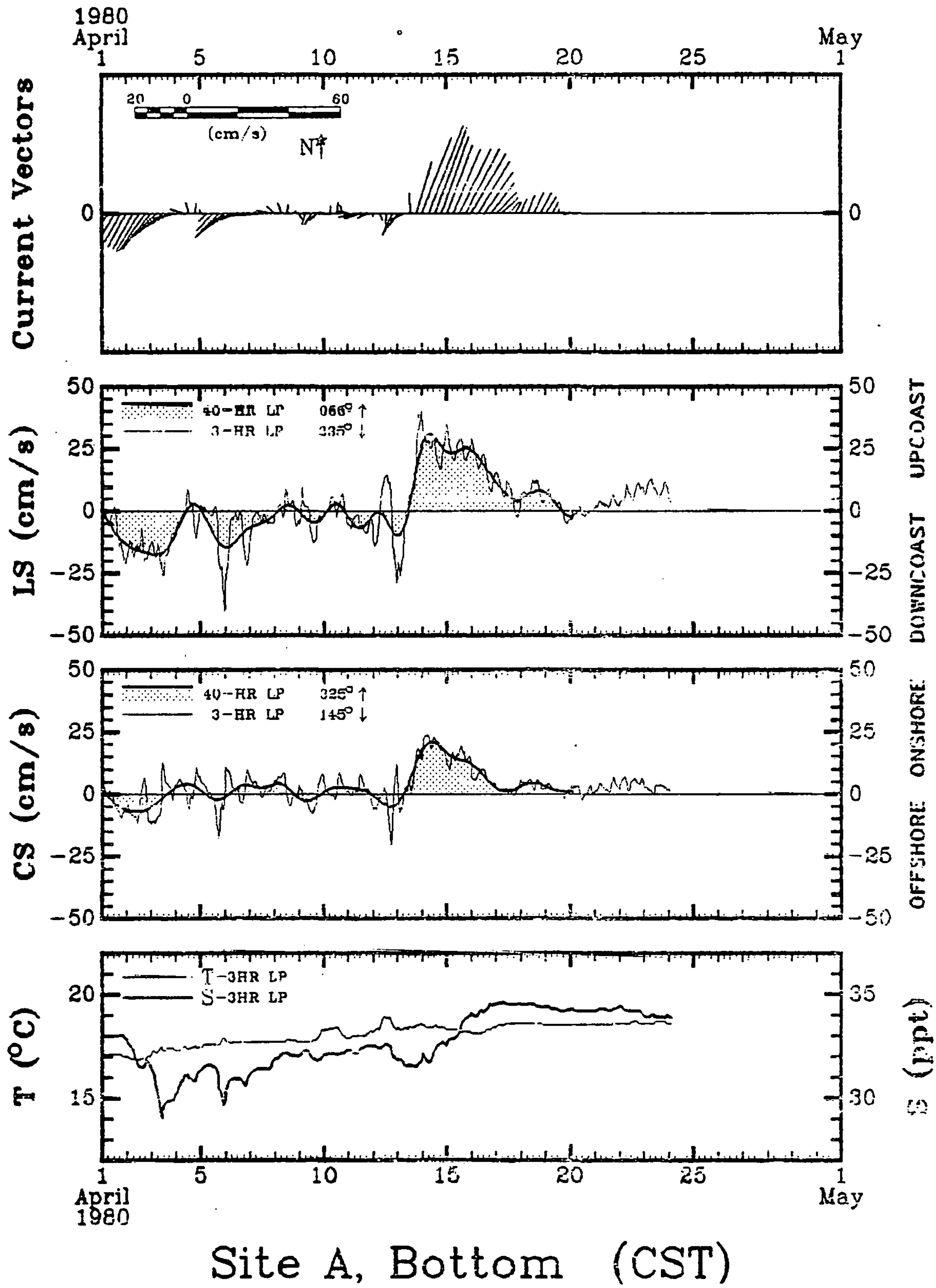


Figure 1- 17. April 1980 current velocity, temperature and salinity time-series data from the near-bottom instrument at Site A. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.

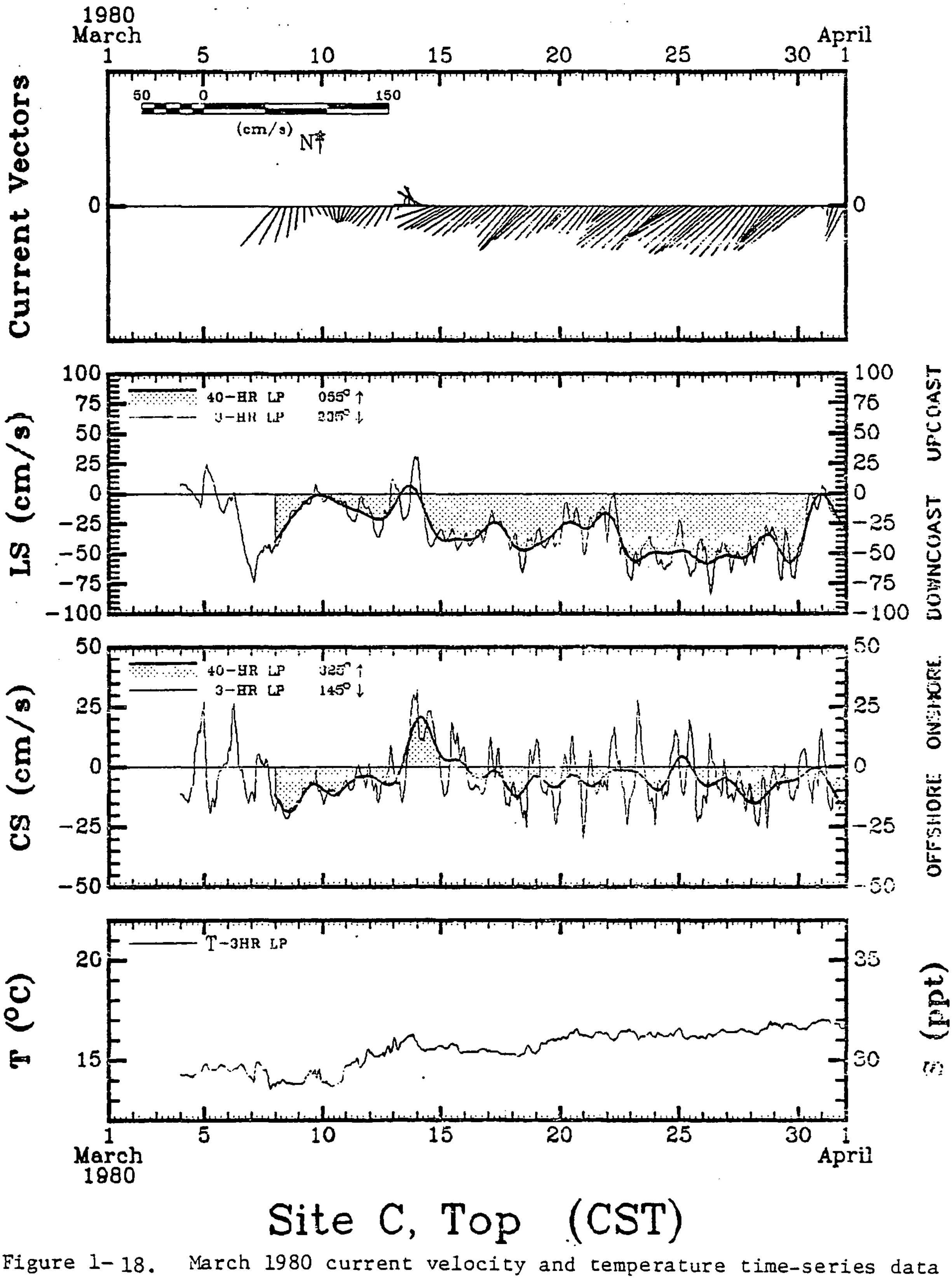
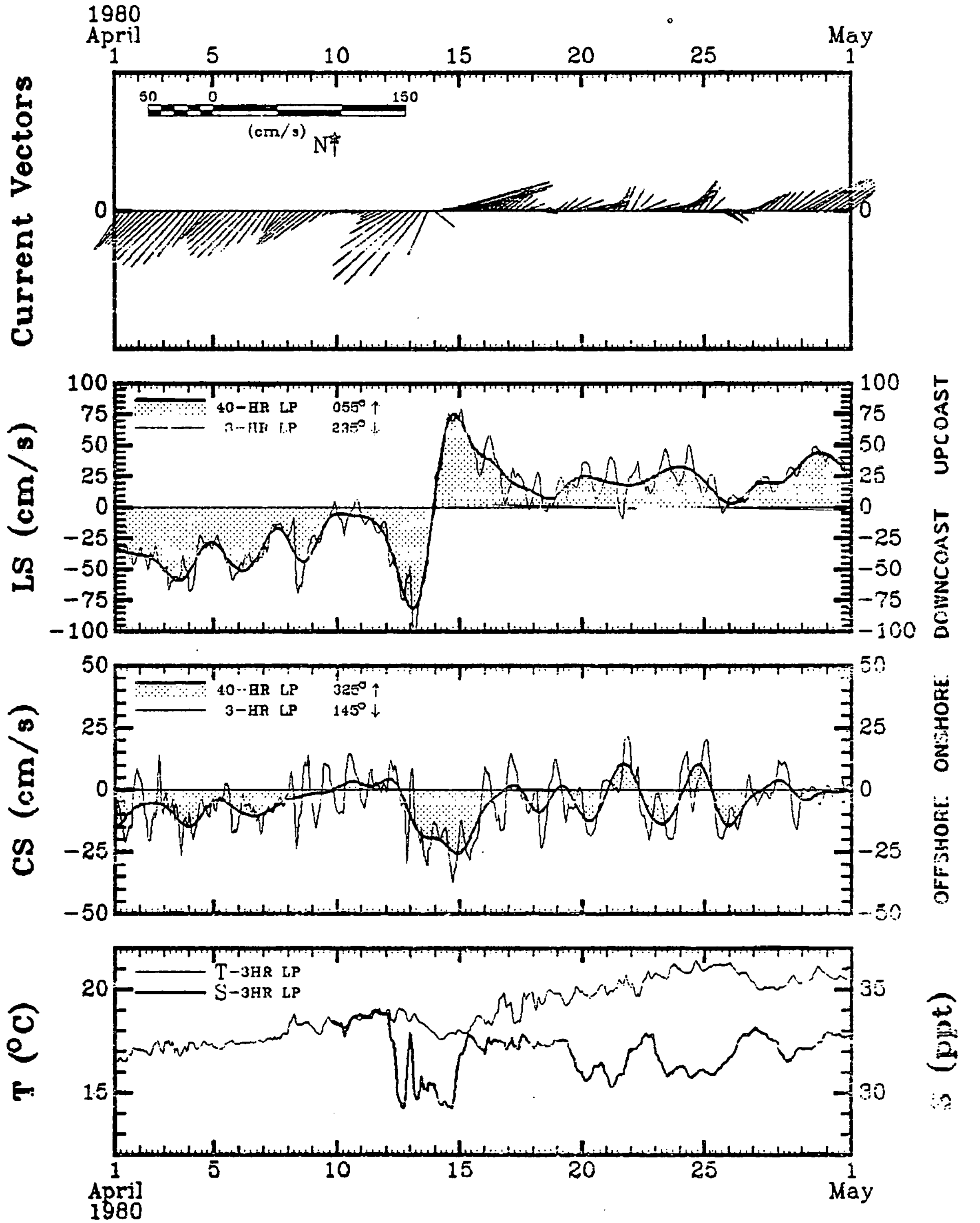


Figure 1- 18. March 1980 current velocity and temperature time-series data from the near-surface instrument at Site C. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.



Site C, Top (CST)

Figure 1-19. April 1980 current velocity, temperature and salinity time-series data from the near-surface instrument at Site C. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.

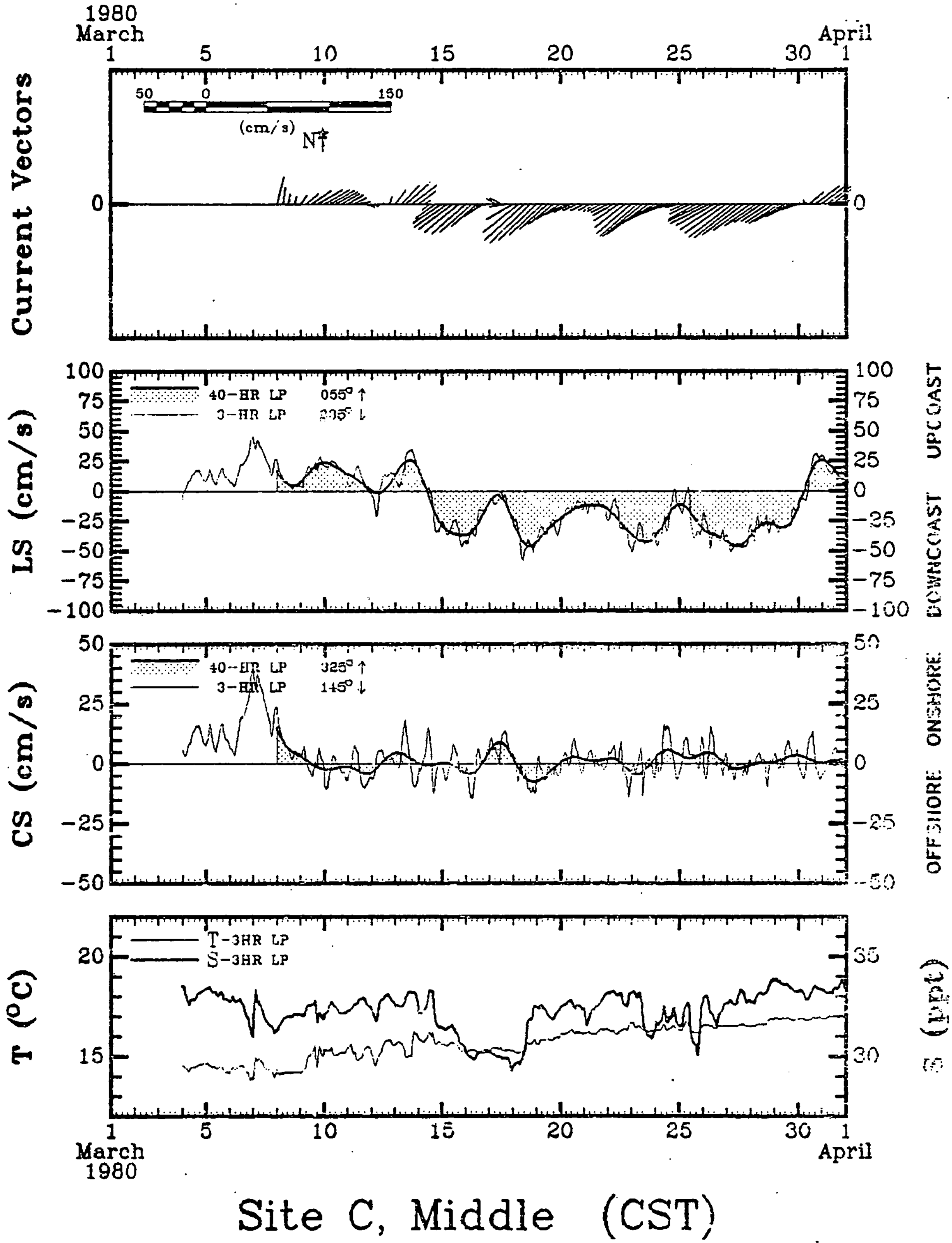
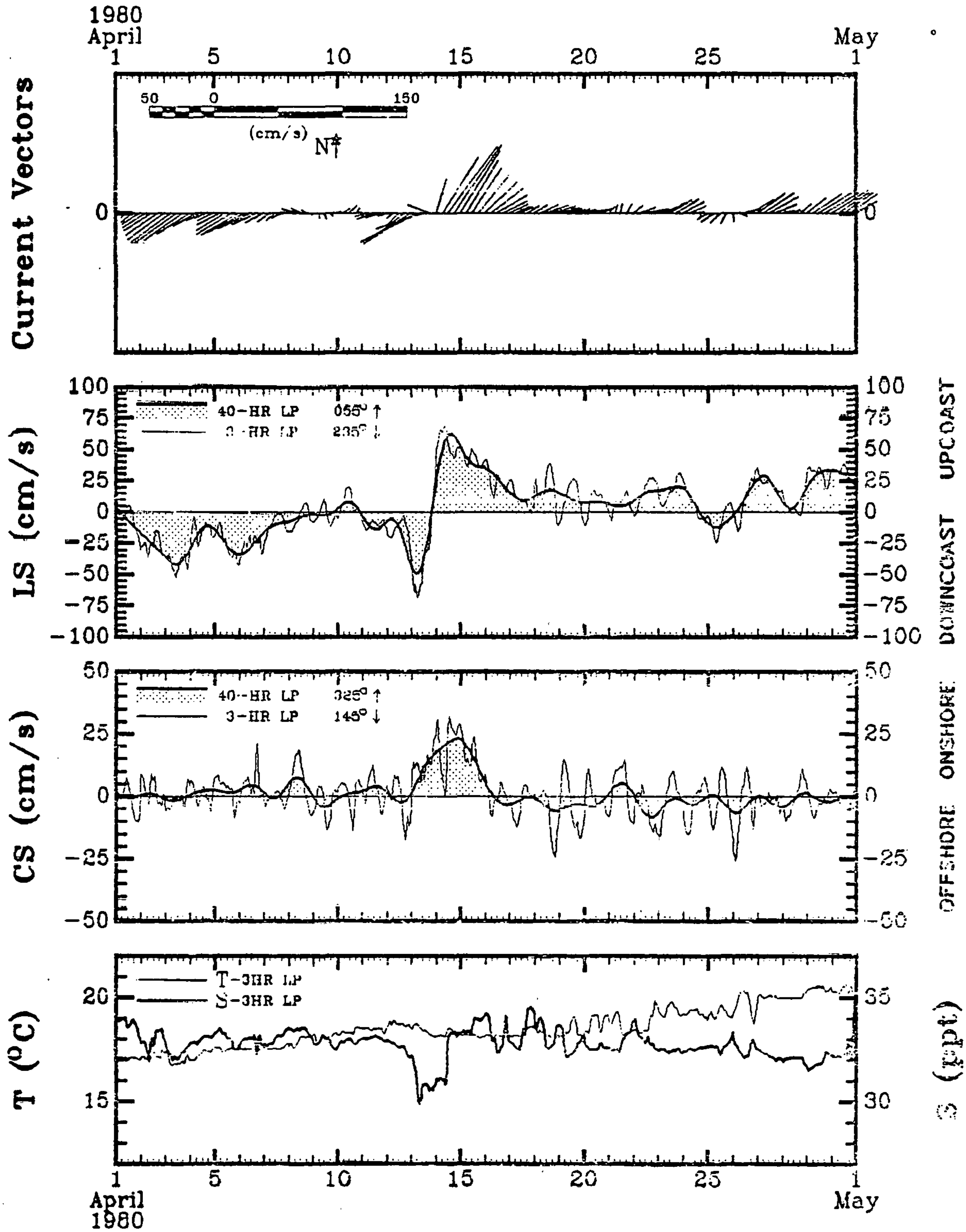


Figure 1- 20. March 1980 current velocity, temperature and salinity time-series data from the mid-depth instrument at Site C. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.



Site C, Middle (CST)

Figure 1- 21. April 1980 current velocity, temperature and salinity time-series data from the mid-depth instrument at Site C. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.

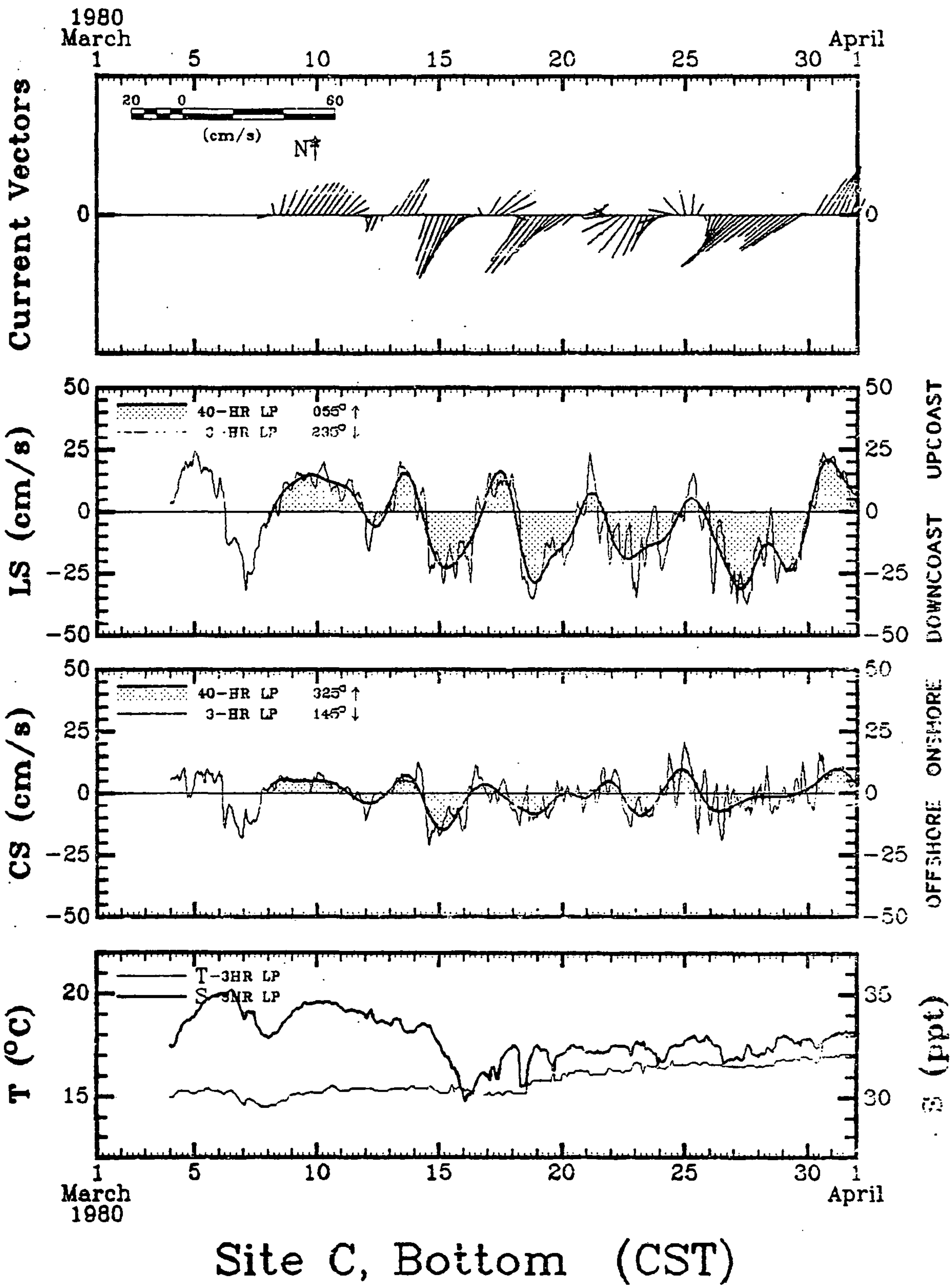
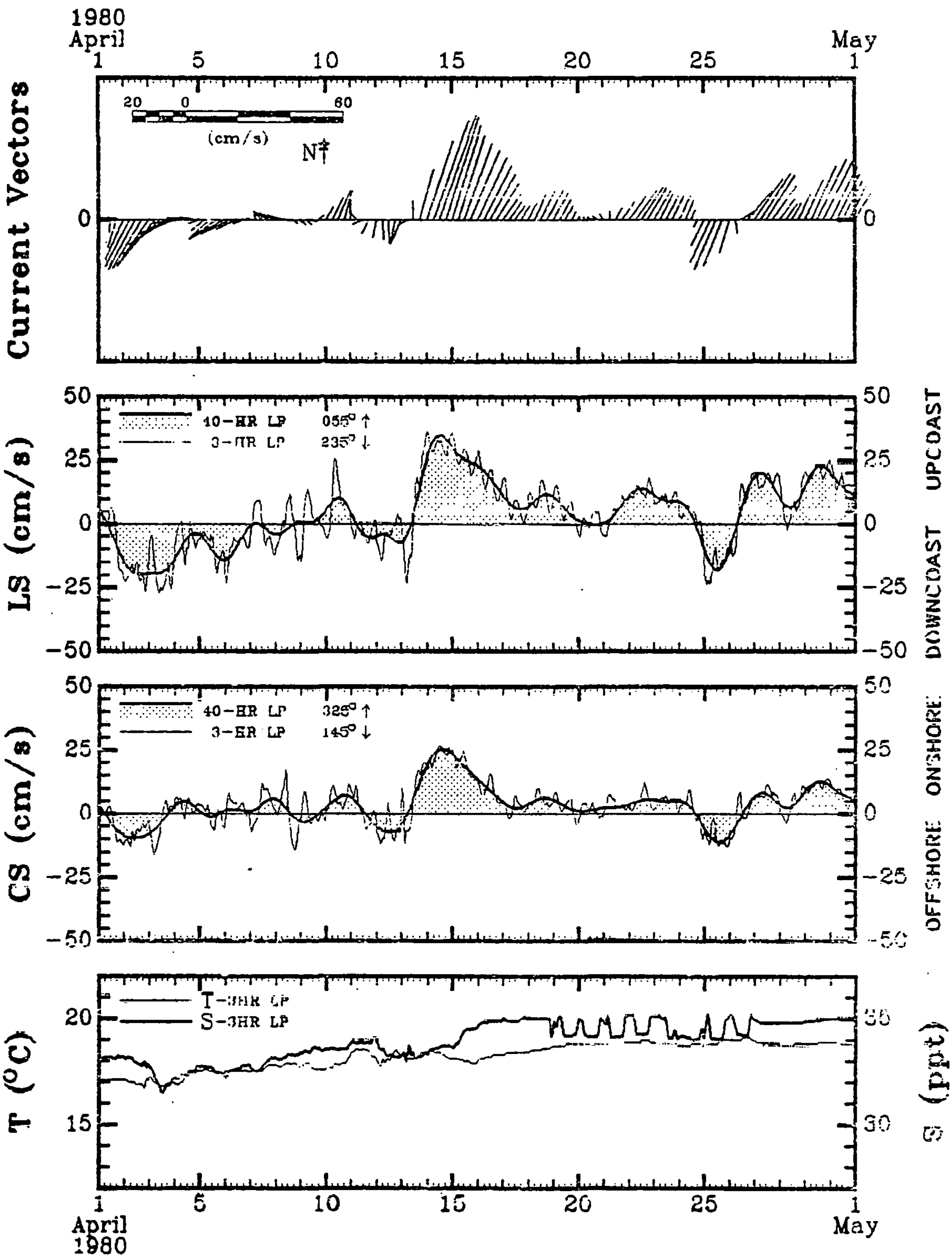


Figure 1- 22. March 1980 current velocity, temperature, and salinity time-series data from the near-bottom instrument at Site C. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.



Site C, Bottom (CST)

Figure 1- 23. April 1980 current velocity, temperature and salinity time-series data from the near-bottom instrument at Site C. For the stick plot, the x-axis is oriented W-E and the y-axis N-S, and the sticks are constructed from 40-hour low-passed data.

parallel to the diffuser pipe which tends 144°T in an offshore direction.

Salinity data are not available from the top meter at Site C from March 3 to April 9 because of a small leak in the conductivity sensor. The current velocity and temperature data from that instrument were not affected. The salinity data from the bottom meter at Site C had a systematic drift from March 3 to April 9 which was removed. In addition to the manufacturer's calibration checks, the temperature and salinity calibration constants of each meter are checked before and after deployment. Also, the temperature and salinity data from each meter are compared with periodic hydrographic station data collected near the meter and salinity samples collected at the time of deployment and recovery of the meters. Based on these checks, it is believed that the temperature data in Figure 1-13 through 1-23 are accurate to $\pm$ 0.2°C and the salinity data to $\pm$ 0.5 ^{o}/oo. The precision is 0.1°C for temperature and 0.14 ^{o}/oo for salinity.

The subsequent discussion refers to the period March 10 through April 10 in Figures 1-12 through 1-23.

In the near-surface layer, the 40-hour, low-passed surface currents were mostly directed downcoast (235°T) with a small offshore component. Site A had slightly stronger alongshore currents than Site C but weaker cross-shelf currents as evidenced by the 3-hour, low-passed data. The data clearly imply that a zone of convergence/divergence existed between the two sites, which would be consistent with the weak frontal zone indicated in the vertical section of hydrographic data for March 25, 1980. Near-surface salinity data for Site A show variations of up to 4 ^{o}/oo in two days and in general appear to be correlated in a complex way with both alongshore and cross-shelf currents: low-frequency changes in salinity are related to shifts in the alongshore component of current while higher frequency changes are related to shifts in the cross-shelf component. There is a gradual warming trend in the temperature data. Short period fluctuations in temperature are typically less than 1°C in amplitude, and the cross-shelf gradient is less than 0.5°C in the near-surface layer.

At mid-depth, the currents are still predominantly downcoast at both sites but more similar in magnitude. A comparison of the stick plots for the top and mid-depth meters for each site indicates a moderate degree of vertical shear. At mid-depth, cross-shelf currents are slightly smaller than at the top and almost zero on the average. The salinity variations at Site A, mid-depth, are quite similar to salinity variations at Site A, top, but the salinity values are slightly greater at mid-depth. The cross-shelf salinity difference at mid-depth between Sites A and C is on the order of 3 $^{o}/oo$ throughout most of the intensive study period. Both sites have a similar pattern of variation. This is further evidence that a salinity frontal zone existed between the two sites. The magnitude of temporal variations of temperature is greater than at the top, probably indicating the presence of a thermocline, and there is a slight (0.25°C) cross-shelf temperature gradient.

The data from the bottom meters, particularly that of Site C, hold the most interest. Both sites have periods of downcoast flow of up to one-half knot alternating with periods of weaker upcoast flow. Cross-shelf flow at the two sites is similar in direction at low frequencies, but a comparison of values at any instant indicates differences of up to 10 cm/s in magnitude. Salinity at the bottom at Site C follows the same pattern of variation as at the bottom at Site A but is about 2 $^{o}/oo$

higher on the average. As before, the higher frequency fluctuations appear to be correlated with those of the cross-shelf current. The indication, as at mid-depth, is that a salinity front existed between the two stations much of the time. The salinity data from the bottom meter at Site C are consistent with the overall salinity pattern indicated by the other meters and the hydrographic survey of March 25. Site C is located about 300 m downcoast of the diffuser pipe. Salinity increases appear to be correlated with a shift in the flow towards upcoast, which is towards the diffuser. The current meter at Site C is nominally about 6 ft (1.8 m) off the bottom, and the available evidence indicates that the brine plume, during the intensive study period, was confined to a region below this depth except in the immediate vicinity of the diffuser (see Chapter 2). It is concluded that salinity from the diffuser was not detected by the near-bottom meter at Site C.

There appears to be a significant component of the current in the tidal frequencies and local inertial frequency. Therefore, the 3- to 40-hour pandpass data from the bottom meter at Site C are shown in Figures 1-24 and 1-25. The currents in this frequency range are often significant -- up to 20 cm/s. The brine plume orientation apparently responds rapidly to changes in current velocity (C. Burroughs, personal communications), and thus this figure may be of interest to those involved in plume modeling and tracking.

To further aid in the plume tracking analysis in Chapter 2, the hourly data (from the 3-hour low-pass filter) for the bottom meter of Site C have been plotted for each day of plume tracking: March 22, 26, 30, 31, April 9, 10. (See Figures 1-26 through 1-31). The plots are similar in format to those of Figures 1-12 to 1-23 and use the same

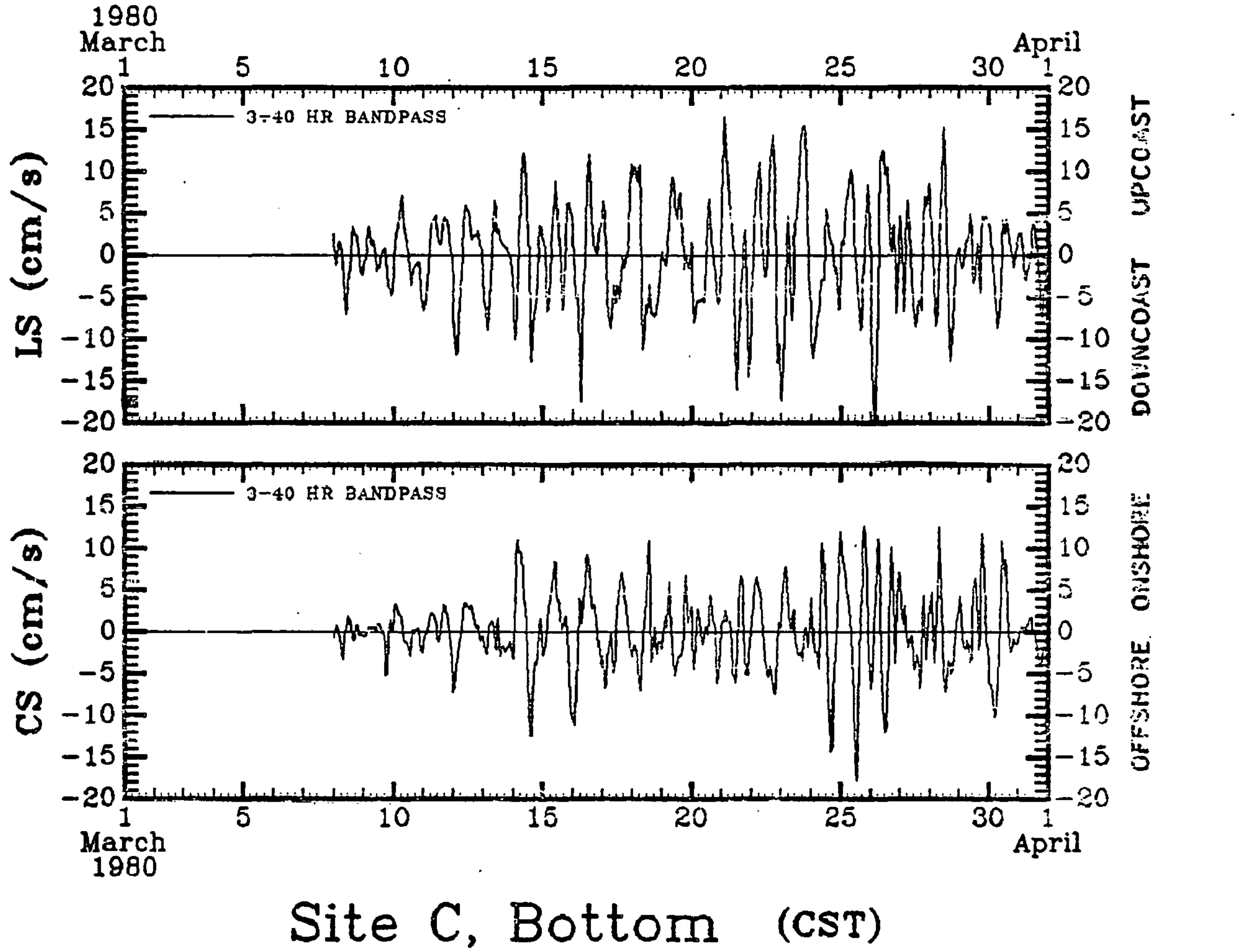


Figure 1-24. March 1980. 3-40 hour bandpass filtered current velocity data from the near bottom instrument at Site C.

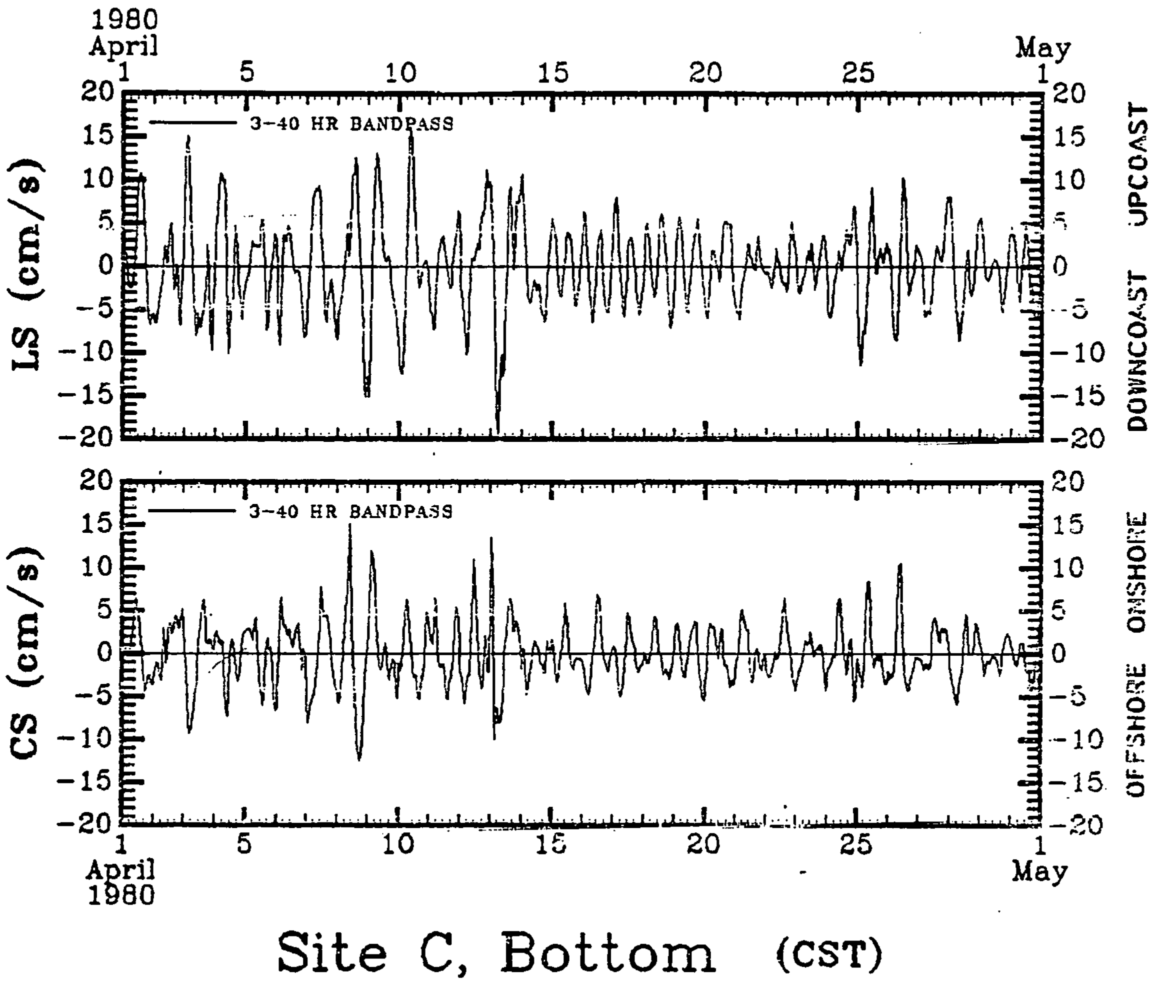


Figure 1- 25. April 1980. 3-40 hour bandpass filtered current velocity data from the near bottom instrument at Site C.

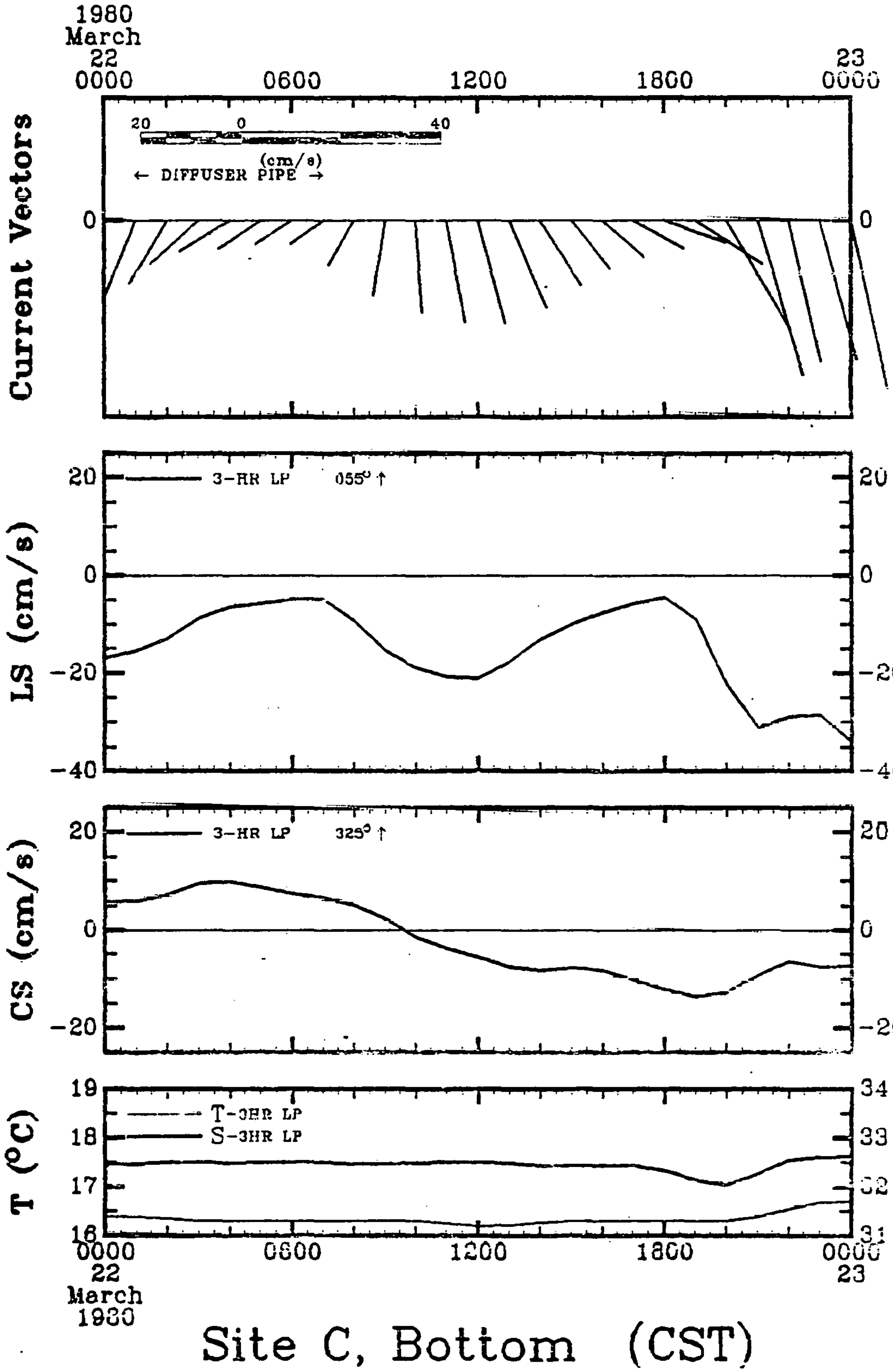


Figure 1- 26. March 22, 1980. Hourly current velocity, temperature and salinity time-series data from the near-bottom instrument at Site C (diffuser site). The x-axis of the stick plot is parallel to the diffuser (325°T-145°T) and the sticks are constructed from 3-hour low-passed data.

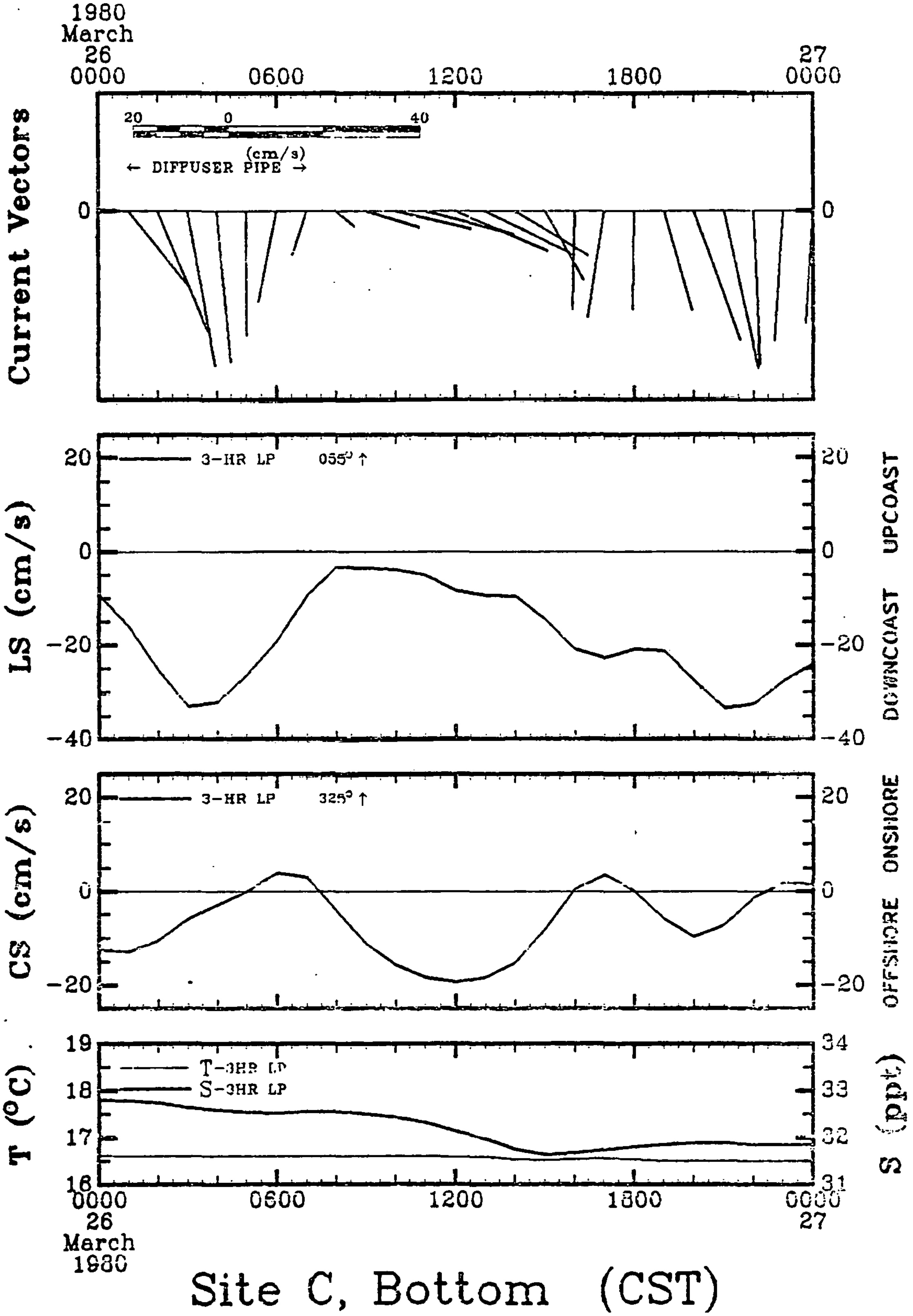


Figure 1-77. March 26, 1980. Hourly current velocity, temperature and salinity time-series data from the near-bottom instrument at Site C (diffuser site). The x-axis of the stick plot is parallel to the diffuser (325°T-145°T) and the sticks are constructed from 3-hour low-passed data.

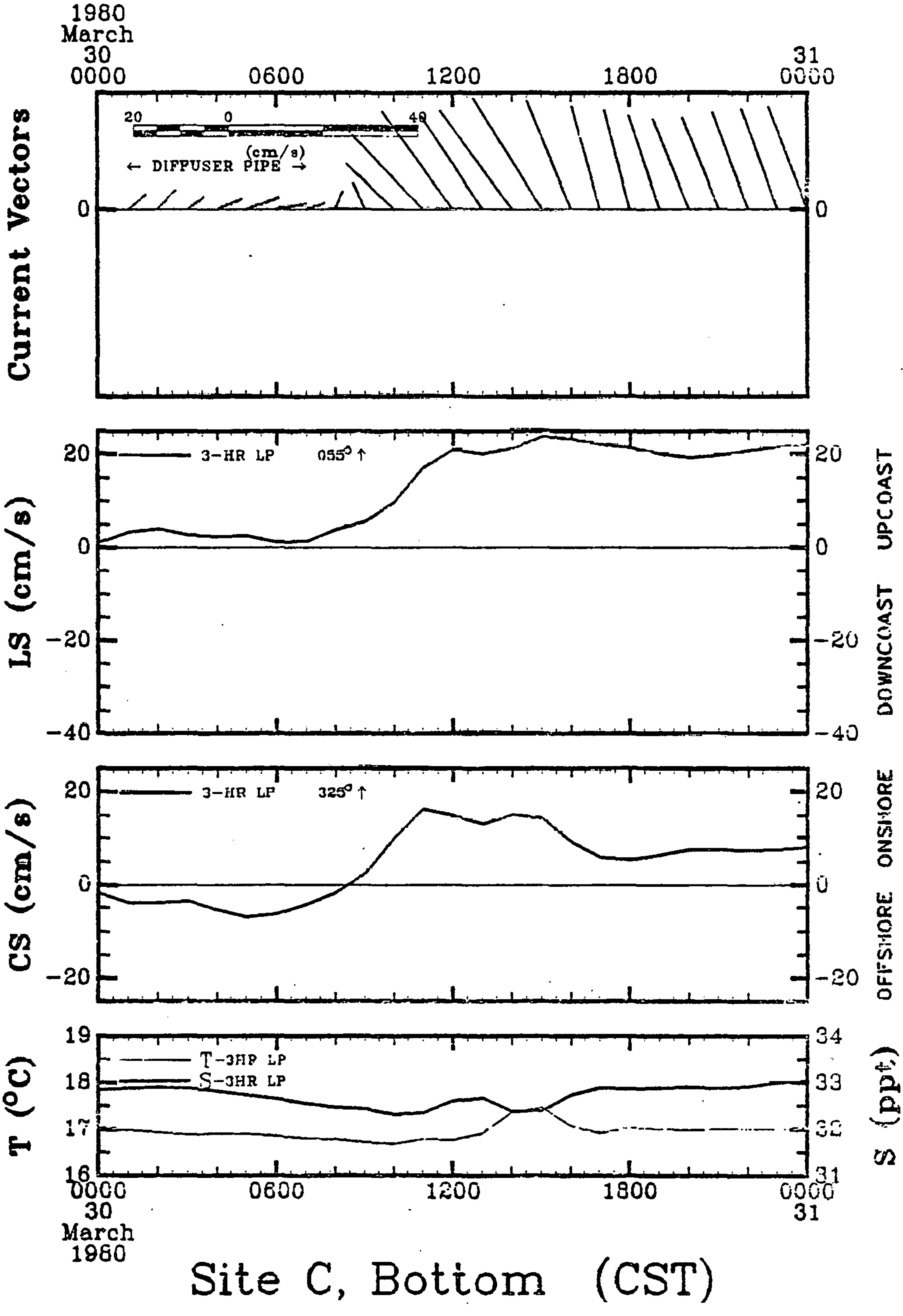
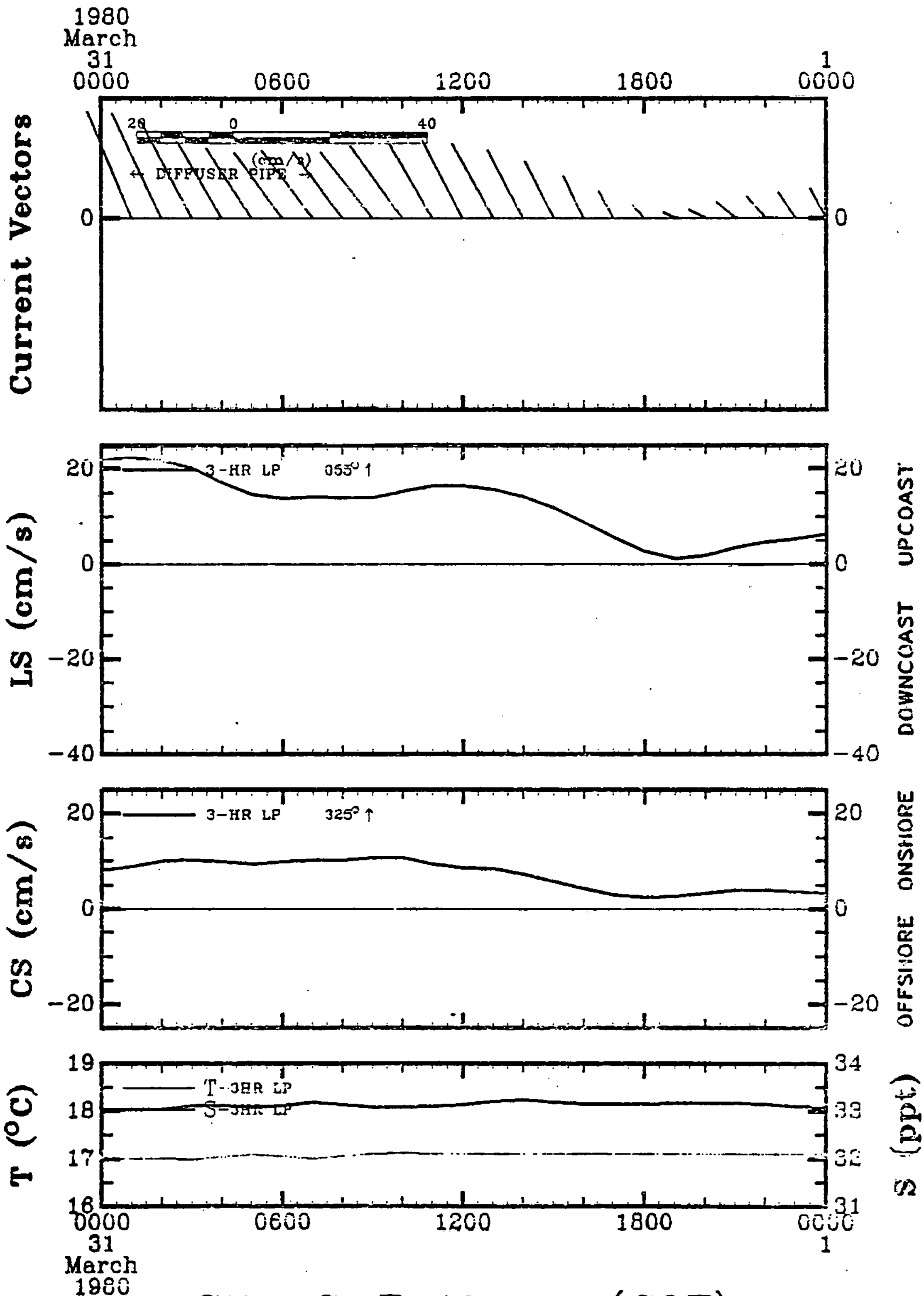


Figure 1- 28. March 30, 1980. Hourly current velocity, temperature and salinity time-series data from the near-bottom instrument at Site C (diffuser site). The x-axis of the stick plot is parallel to the diffuser ($325^{\circ}T$-$145^{\circ}T$) and the sticks are constructed from 3-hour low-passed data.



Site C, Bottom (CST)

Figure 1- 29. March 31, 1980. Hourly current velocity, temperature and salinity time-series data from the near-bottom instrument at Site C (diffuser site). The x-axis of the stick plot is parallel to the diffuser (325°T-145°T) and the sticks are constructed from 3-hour low-passed data.

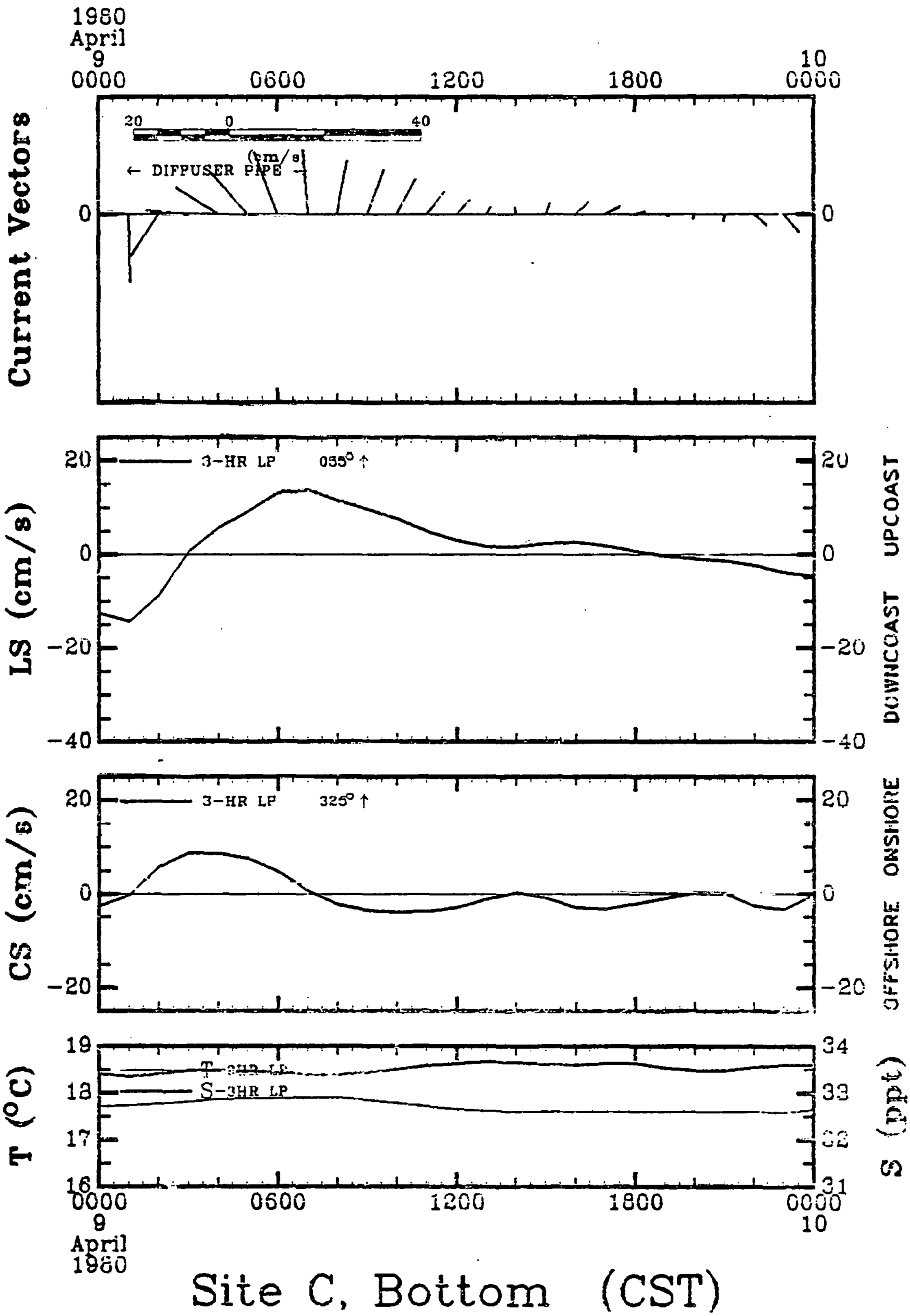


Figure 1- 30. April 9, 1980. Hourly current velocity, temperature and salinity time-series data from the near-bottom instrument at Site C (diffuser site). The x-axis of the stick plot is parallel to the diffuser (325°T-145°T) and the sticks are constructed from 3-hour low-passed data.

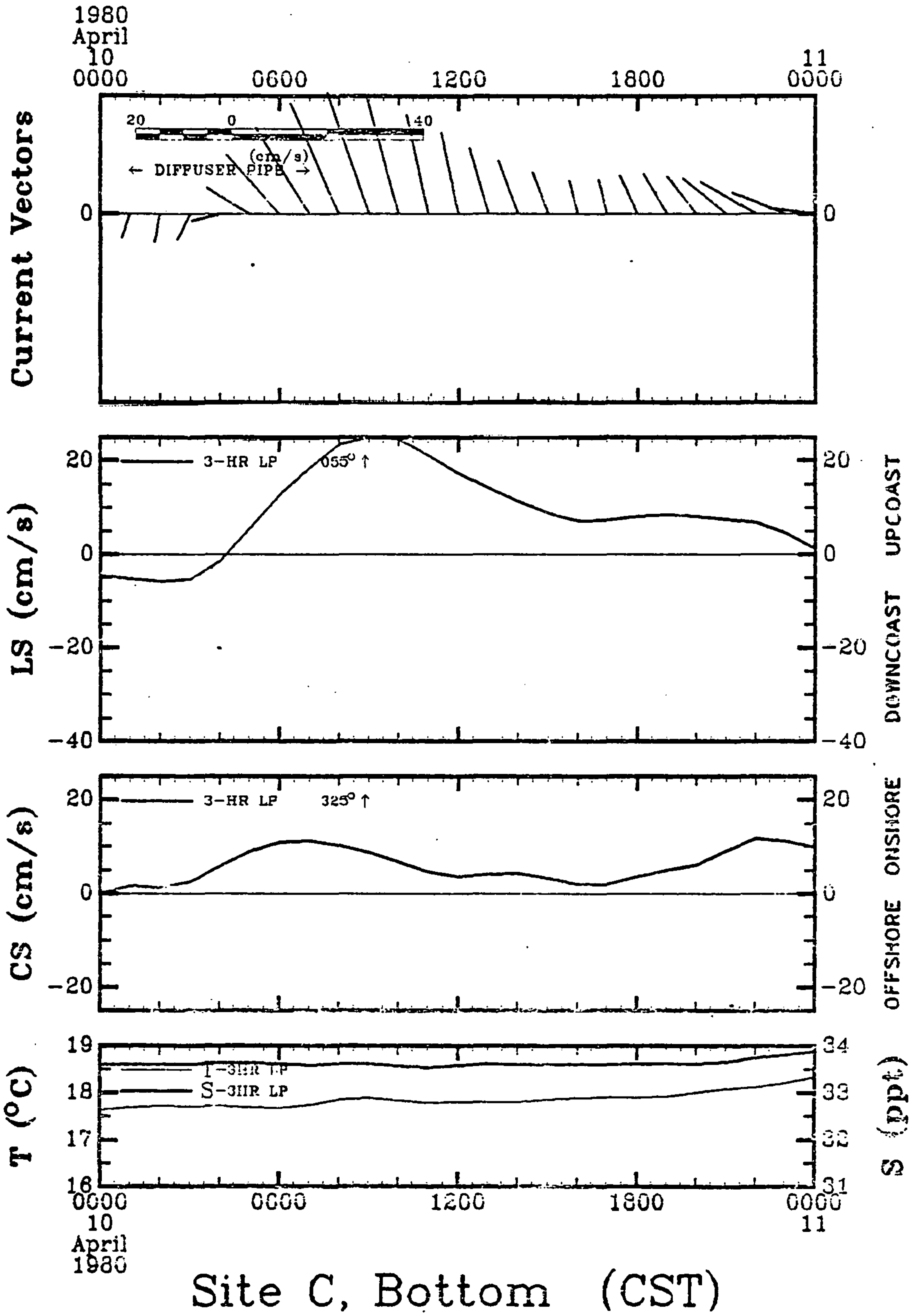


Figure 1- 31. April 10, 1980. Hourly current velocity, temperature, and salinity time-series data from the near-bottom instrument at Site C (diffuser site). The x-axis of the stick plot is parallel to the diffuser (325°T-145°T) and the sticks are constructed from 3-hour low-passed data.

data, but the axes have been re-scaled. In the stick plot, the x-axis is now parallel to the diffuser. The data show, again, that higher salinity is associated with upcoast flow and that short period changes are associated with cross-shelf fluctuations. They also indicate that there is a few hours phase lag between cross-shelf current fluctuations and salinity fluctuations. No unusual salinity values or changes are detected in these six daily plots.

1.5 Conclusions

During the intensive monitoring period, March 10 through April 10, currents were downcoast at the surface and alternated between downcoast and upcoast at the bottom. At the bottom, the upcoast velocities were not as strong as the downcoast velocities. Lower salinity water was associated with the downcoast flow and vice versa. A salinity frontal zone persisted throughout much of the study period between Sites A and C, and the cross-shelf current data indicate that a region of weak convergence/divergence often existed between the two sites.

Lower-frequency salinity changes at the near-bottom meter at Site C were associated with changes in the alongshore flow; upcoast flow increased salinity and vice versa. Higher frequency changes were associated with the cross-shelf flow, probably an indication of the shifting salinity front. The effect of the brine plume either never reached the meter at Site C or lay below it (the meter is 1.8 m off the bottom). It is concluded that salinity values and their fluctuations as recorded by the *in situ* meters at Sites A and C are consistent with the overall physical oceanography of the area and that the brine plume was not detected by these meters during the intensive study period.

Only the hydrographic data for station 34, which is located at the diffuser, show an effect from the diffuser. This effect is confined to the near bottom measurement and indicates an increase above ambient of about 1 $^{o}/oo$.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

CHAPTER 2

ANALYSIS OF THE DISCHARGE PLUME

Robert E. Randall
Ocean and Hydraulic Engineering Division
Civil Engineering Department

2.1 Introduction

On March 13, 1980, the Strategic Petroleum Reserve Program initiated the continuous discharge of brine solution through a multiport diffuser which is located 12.5 statute miles (20 kilometers) off the Freeport, Texas coast at a water depth of 71 feet (22 meters). A monitoring plan by DOE (1979) called for the _in situ_ measurement of the plume resulting from the brine discharge to determine the maximum concentration and its areal extent. The purpose of this chapter is to describe the results of the measurement of the plume during the intensive study period immediately following the initial discharge. The monitoring plan called for the plume to be tracked daily after the third day of discharge for five consecutive days. Following which, the plume was to be tracked once a week for the following three weeks. These plans were altered considerably by the interference of bad weather, but it was possible to track the plume on March 22, 26, 30, 31, April 9 and 10.

The brine solution is being leached from on-land salt domes located at Bryan Mound near Freeport, Texas and initially pumped to a brine pit for storage just before being pumped to the Gulf of Mexico. As illustrated in Figure 2-1 a submerged pipeline which has a diameter of 3 ft (.9 m) has been constructed in a trench out to the discharge area. The last 3060 ft (933 m) of the pipeline is called the diffuser which has rigid pipes extend-

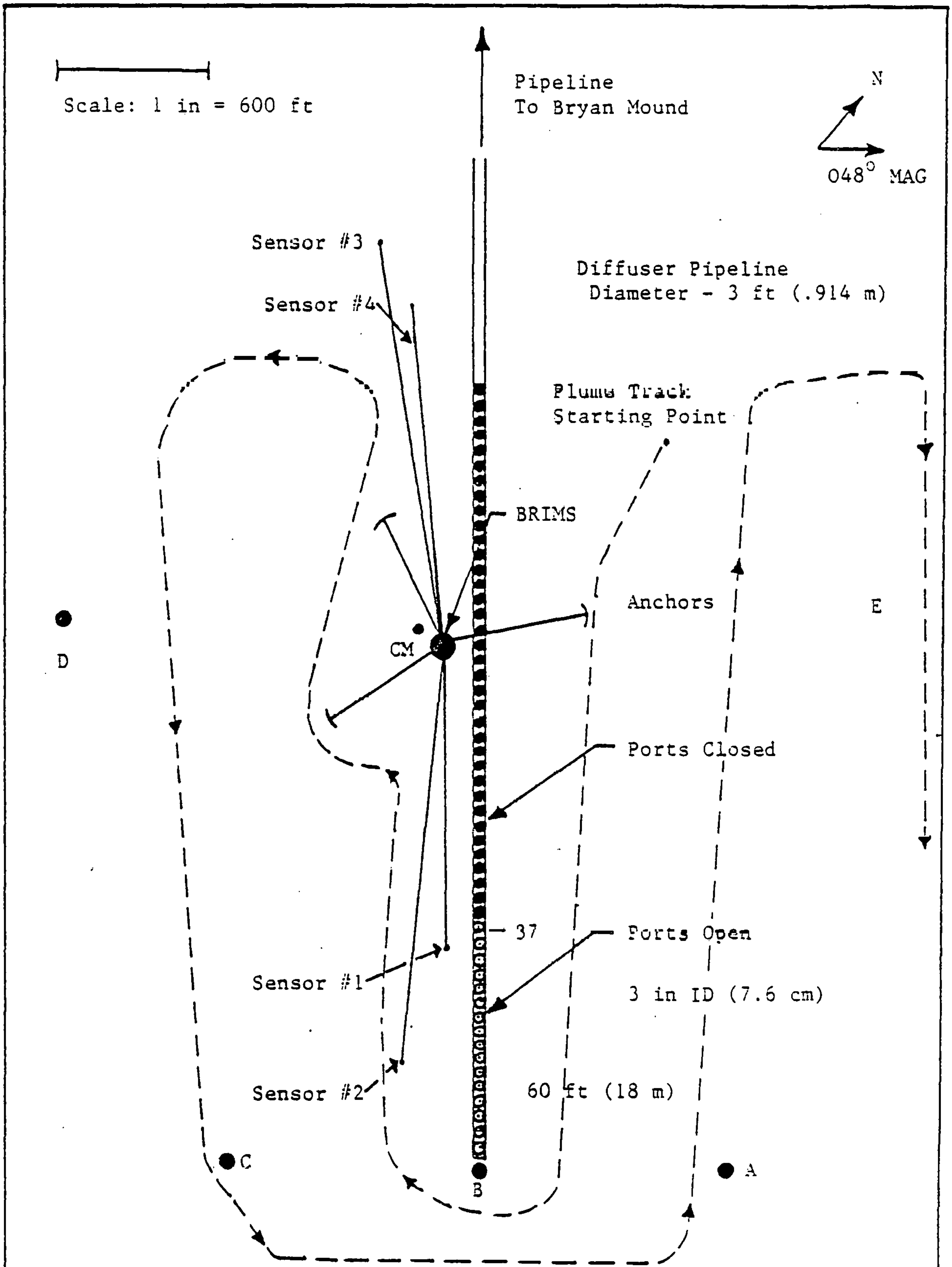


Figure 2-1. General schematic of the Bryan Mound diffuser area.

ing vertically from the pipeline to the top of the trench, or original sea floor. Connected to each rigid pipe at the sea floor is a flexible 3 inch (7.6 cm) inside diameter pipe which extends 6 feet (1.8 m) above the bottom. Each pipe is called a diffuser port, and presently there are 15 ports (port numbers 37 through 52) which are open. These ports have an inside diameter of 3 inches (7.6 cm) and are approximately 60 feet (18 m) apart. The brine is pumped from the brine pit through the large pipeline to the diffuser and out into the Gulf of Mexico via the diffuser ports. The average flow rate through the diffuser has been about 225,000 barrels per day which corresponds to an exit velocity of approximately 20 ft/s (6.1 m/s). The concentration, or salinity, of the brine solution has varied during the intensive study period, but it is on the order of 230 $^{o}/oo$ as compared to the bottom ambient sea water which varies from 32 to 36 $^{o}/oo$, Kelly and Randall (1980). As the brine exits from the diffuser ports it is diluted initially due to jet mixing, and then it falls to the bottom as a result of the greater density and simultaneously spreads laterally. The plume is then dispersed by advection due to currents and diffusion due to turbulence. This negatively buoyant plume is expected to be found in a layer next to the bottom which is predicted to be on the order of 2 - 4 ft (0.6 - 1.2 m).

The behavior of the brine plume for the Bryan Mound is characterized as a negatively buoyant plume which can be divided into three areas (NOAA, 1977) as shown in Figure 2-2. These three areas depend upon the physical process by which the plume is being dispersed. The first area is called the near field area where the effluent dilution is affected by turbulent jet mixing which is a function of the ambient current velocity, diffuser design, and the water depth. This area is defined as the distance downstream where the individual plumes from each diffuser port

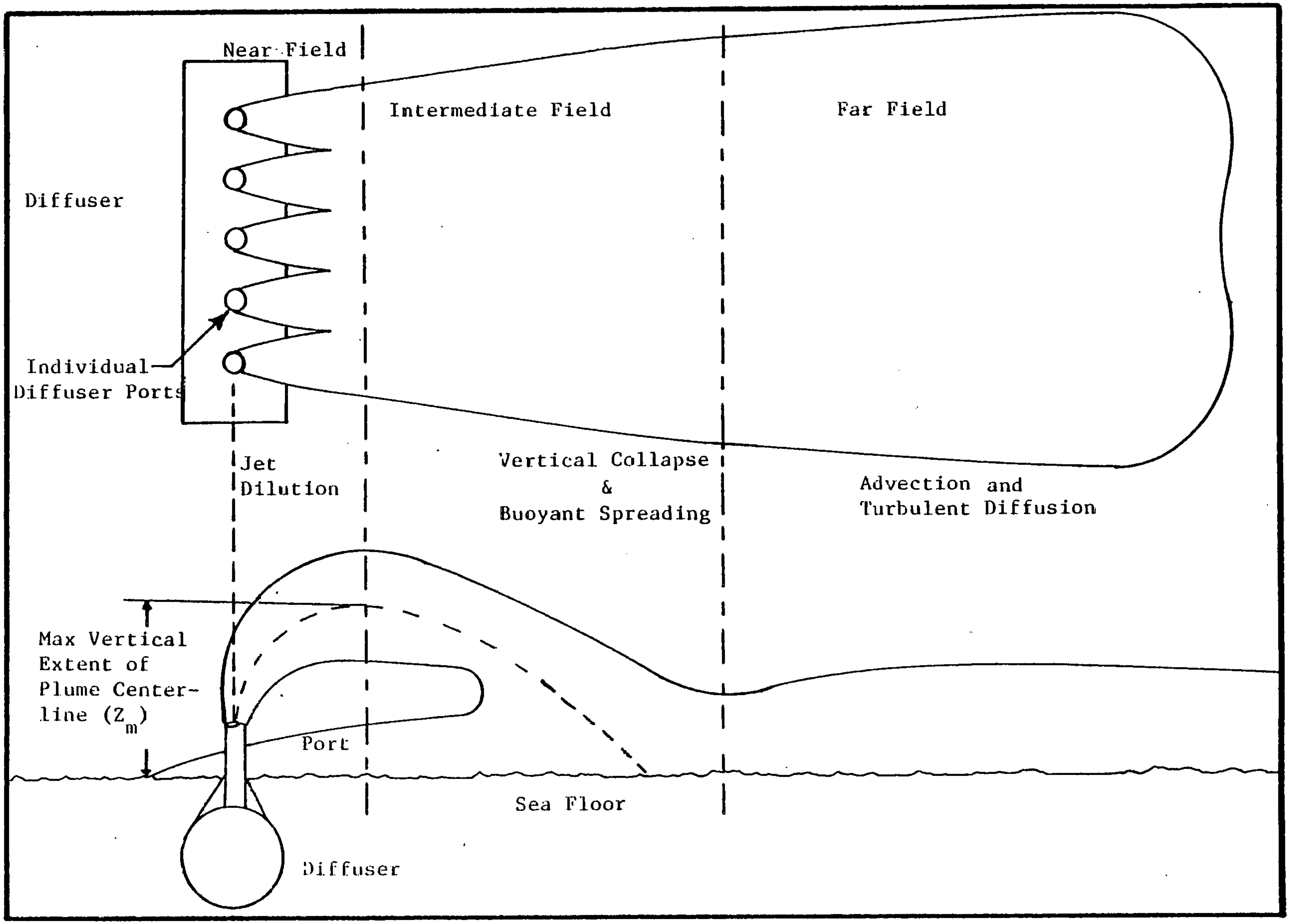


Figure 2-2. Schematic of Brine Plume Characteristics.

merge to form a continuous plume. This distance has been estimated to be on the order of 100 ft (30 m) for the Bryan Mound diffuser. In the intermediate field area the plume experiences buoyant lateral spreading and vertical collapse, and the end of this area is estimated to be on the order of 1000 ft (305 m). The final plume area is called the far field which is the largest area and is affected most by the physical processes of advection and diffusion. These processes are most important in determining the accumulation of brine. It is this far field area which is measured and described later in this report.

The near field area is most affected by the diffuser design and the rationale for the Bryan Mound diffuser is discussed in a report by NOAA (1977). The initial fixed parameters were selected as a flowrate of 650,000 barrels per day, excess concentration of 230 $^{o}/oo$ and a discharge relative density difference ($\Delta\rho/\rho$) of 0.25. The diffuser was selected to be perpendicular to the coast in order to maximize the interception of ambient water, and the ports were selected to be vertical. Initially the water depth was selected as 50 ft (15 m), but it was changed to 70 ft (21 m). The diffuser length of 2000 ft (10 m) was chosen such that the intermediate field area would be large enough such that a wedge of brine would not form under normal conditions. The parameters of exit velocity and port diameter are most important for the proper performance of the diffuser. Plume dilution will improve with increasing exit velocity and decreasing port diameter. Values of 25 ft/s (7.6 m/s) for the exit velocity and 3 in (7.6 cm) for the port diameters were chosen. The port spacing was selected as 60 ft (18 m).

Prior to the discharge of brine, it became apparent that the design flowrate of 650,000 barrels per day could not be accomplished for the initial discharge and that a lower flowrate of 200,000 to 250,000 barrels per day would actually be possible. Since the pipeline had already been constructed with 37 open ports, the lower flowrate would result in low exit velocities which would substantially reduce initial dilution. This was unsatisfactory so the only approach was to close off sufficient diffuser ports such that a suitable exit velocity was obtained. Subsequently, all open ports were capped except the last fifteen. This resulted in a normal exit velocity of 20 ft/s (6.1 m/s) which was deemed acceptable. In summary the active diffuser which was used during this reported study period consisted of 15 diffuser ports spaced 60 ft (18 m) apart with a diameter of 3 in (7.6 cm). The exit velocity was in the neighborhood of 20 ft/s (6.1 m/s) depending on the flowrate. The diffuser ports were mounted vertically upward from the main pipeline which was oriented perpendicular to the shore.

The performance of the diffuser in the near field can be predicted using the procedures described in a report by the U.S. Army Engineer Waterways Experiment Station (1971). These procedures can be used to determine maximum height of plume jet. During the intensive study period vertical profiles were measured in near field and they are compared to the above mentioned predictions of plume vertical extent.

The concentrations in the far field are of the utmost interest in this study and have been predicted by the MIT transient plume developed by Adams et al (1975). Predictive results from this model for the Bryan Mound diffuser in several design configurations are described in a report by NOAA (1977). The results of these studies showed that strong ambient currents produced long narrow plumes and during periods of near slack currents the plume expanded in all directions and stayed close to the diffuser. The concentrations near the diffuser were generally higher during slack currents and a build up of concentration was predicted during slack periods. It was also shown that areas associated with the larger concentrations were generally greater for periods when low currents existed. The areas with smaller concentrations were frequently the smallest for the low current regions.

Other studies have been conducted which are directly related to the discharge of a negatively buoyant brine plume. Gaboury and Stolzenbach (1979) discuss the development of a non-dimensional formulation of the MIT transient plume model. This formulation is used to evaluate alternate levels of acceptable impact based on the terms of organism mortality as a function of concentration and exposure time.

Tong and Stolzenbach (1979) report on an analytical and experimental study of the discharge of a negatively buoyant fluid. These experiments were directed toward the investigation of near field dilution of a single port diffuser with varying discharges and cross flow. Procedures were developed for determining the port diameter, discharge velocity, port spacing, and port height to obtain a desired near field mixing condition.

In summary, this report will briefly describe the probe monitoring system used in tracking the brine plume and the procedures employed to attain the salinity plume contours which describe the areal coverage of the brine plume 10 in (25.4 cm) off the bottom. The results of five plume tracks are described and the near field vertical salinity profiles are compared to the predictions of the vertical extent of the plume. The comparison of the measured plume tracks with predicted results from the MIT transient plume model is being conducted separately and are described by NOAA, 1980.

2.2 Description of the Probe Monitoring System

2.2.1 Rationale for the Probe Monitoring System

Two monitoring systems were considered for tracking a negatively buoyant brine plume which would be located very near the bottom (2-4 ft, 0.6-1.2 m). The first monitoring system, called a probe monitoring system, consists of an _in situ_ water quality system mounted in a sled which is designed to be towed along the ocean bottom. The second system consists of a long suction hose towed near the bottom through which a water sample was pumped to water quality monitoring equipment on board the towing vessel. A complete description of the design of these two systems is described by Randall (1980).

The concept of pumping a water sample to the research vessel required that a long 350 ft (107 m) suction hose be towed at a constant depth within 2-4 ft (0.6-1.2 m) from the bottom. The probability of successfully accomplishing this towing requirement was very low when a reasonable expectation of wave heights is three to five feet (0.9-1.5 m). Also, the possibility of snagging objects on the bottom was high, and a release mechanism for the hose would have to be designed. The idea of a probe monitoring system with an _in situ_ conductivity, temperature, and depth (CTD) probe was also studied. The data from this type of system had greater credibility than that of the pumped water sample because of the effects of changes in mixing, temperature, and pressure on the water sample. In addition, the probe would be mounted in a towing sled and could be easily rigged to break free from the towing vessel, R/V EXCELLENCE, if it should become snagged on the bottom. The system could also be designed so that the probe was a constant distance off the bottom, and the probe depth sensor would indicate whether the probe stayed on the bottom. For the above reasons the probe monitoring system was selected and designed for use in tracking a negatively buoyant brine plume, and a schematic of the system is illustrated in Figure 2-3.

2.2.2 Towing Sled Design

When the towing sled is lowered to the ocean bottom, it is necessary for the probe to be at a known distance off the bottom. In order to satisfy this requirement, the cross section of the sled was designed to be an equilateral triangle, and the probe was located at the centroid of the triangle. Since the probe must be in direct contact with the ambient sea water, the sled was designed to allow free flow of water past the probe. The length of the sled and the diameter of the legs, or runners, were picked so that the size and weight of the sled could be handled on the stern of the R/V EXCELLENCE by two people. The length was selected as 6 ft (1.8 m) and the legs were constructed with 3/4 in (1.9 cm) black iron pipe. Braces for the legs and the bracket for holding the probe were constructed with the same material. The probe which was inserted in the towing sled has an outside diameter of 3.1 in (7.9 cm) and an overall length of 16.5 in (41.8 cm). A detailed drawing of the towing sled is shown in Figure 2-4. With this design, the probe was always 10 in (25.4 cm) off the bottom no matter which set of legs were in contact with the sea floor. This was very important because the sled could be deployed without concern for its orientation, and it could tumble without effecting probe distance off the bottom.

Since the sled was going to be towed on the sea floor, the possiblility of snagging was always present. Therefore, weak links were designed for

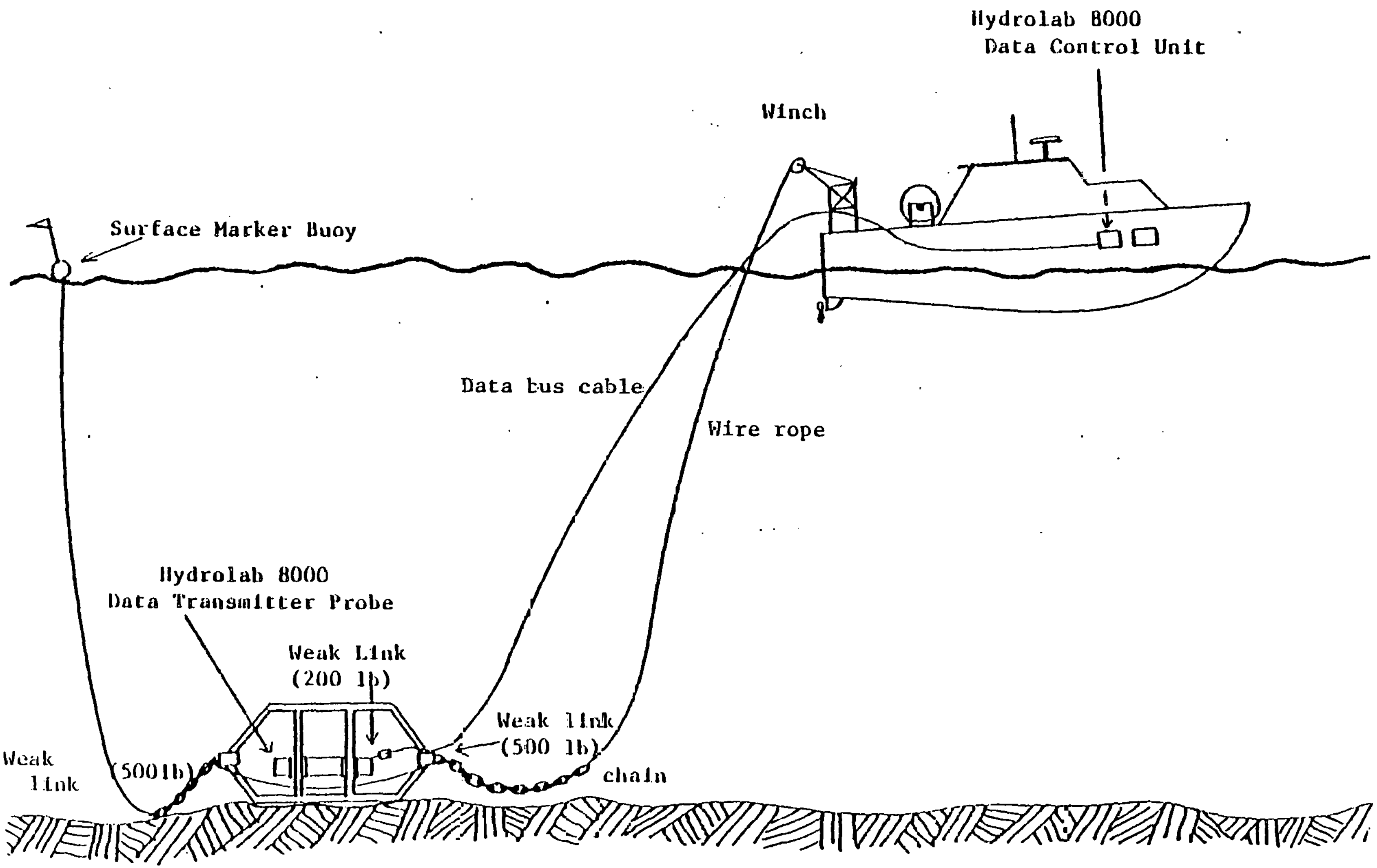


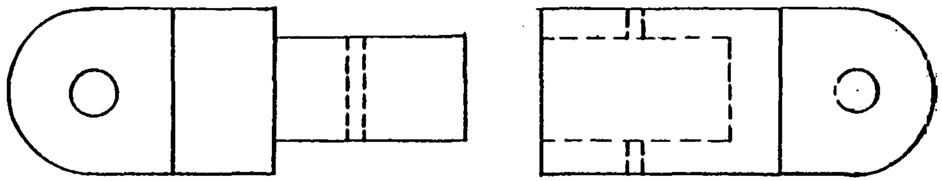
Figure 2-3. Schematic of probe monitoring system.

releasing the sled and probe from the tow cable and data bus cable respectively. A drawing of the weak links for the data bus and towing cables is shown in Figure 2-4. The weak link for the towing cable is connected between the towing wire (Figure 2-3) and the sled, and it will release with a tension of 500 lb (2224 N). A second cable is shackled to the towing cable and attached to the weak link at the rear of the sled. If the sled is snagged, the second cable will attempt to tumble the sled over the obstacle on which it is snagged. If it is freed, the sled will be winched to the boat, rerigged, and redeployed. If the sled remains snagged, the second weak link will release at the same tension. The data bus cable is also attached to a weak link and it will release with 200 lbs (896 N) of tension. When all the weak links have released, the sled is completely free from the towing vessel. The sled is marked with a buoy which is attached at all times during the tracking operation. Therefore, the boat can locate the sled and attempt to recover it or send divers down to investigate and retrieve the probe.

2.2.3 Description of Water Quality System

The Hydrolab 8000 water quality system, Hydrolab (1980), which is manufactured by the Hydrolab Corporation is used in the Probe Monitoring System. The water quality system has three components: the data transmitting unit (probe), the data bus cable, and the data control unit (readout). The probe is capable of measuring conductivity (0-200 mmho/cm), depth (0-200 m), temperature (-5 - +45^{o}C), dissolved oxygen (0-20 ppm), and pH/ORP. The latter two parameters are used in the water and sediment portion of the project. The probe is inserted in a cylindrical Lexan housing which contains a small stirring device to move water past probes. This de-

Towing Cable Weak Link - 500 lb release



Data Bus Cable Weak Link - 200 lb release

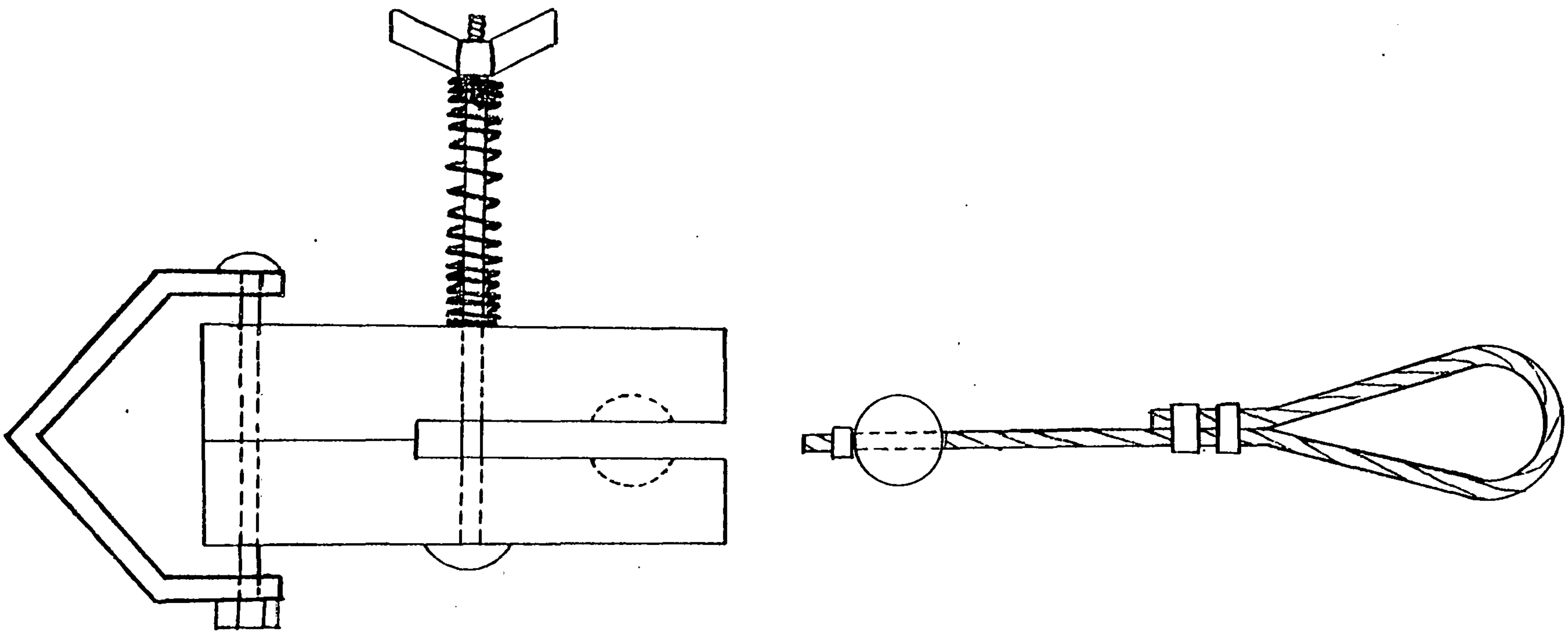


Figure 2-4. Schematic of sled weak links.

vice is necessary for measuring dissolved oxygen but will not be used during plume tracking. Two data bus cables are available, 328 ft (100 m) and 492 ft (150 m), which have 12 conductors and are 3/8 in (1 cm) in diameter. The data control unit displays selected output digitally and provides parallel analog output data signals for each parameter. The temperature, depth, and conductivity output data signals are recorded on a three pen Texas Instrument strip chart recorder.

The accuracy of the conductivity sensor is ± 0.5 per cent of full scale which is 200 mmho/cm at 25°C. This corresponds to ± 1 mmho/cm or ± .7 ‰. The accuracy of the conductivity sensor is improved to at least ± .5 ‰ by calibrating with standard solutions using a Grunde laboratory salinometer which has an accuracy of ± .003 ‰, Grunde (1978). The data control unit displays the conductivity to one tenth of a mmho/cm, and thus a change of that magnitude can be resolved by the sensor. The temperature and depth sensors have an accuracy of ± .2°C and ± 3 ft (1 m). The accuracy of these sensors is adequate for plume tracking.

2.3 Plume Tracking Procedures

2.3.1 General Procedures

The water quality system is initially tested the day before going to the field to insure that any equipment problems are discovered early. Next, the conductivity sensor is adjusted to agree with the laboratory salinometer, the temperature sensor is adjusted to an accurate thermometer, and the depth sensor is calibrated to zero pressure. Finally, all data log books, necessary instruction books, recorder paper, navigation charts, tools, and miscellaneous equipment are assembled and loaded for the field trip.

In the field the water quality system and other previously mentioned equipment are transferred to the R/V EXCELLENCE at a very early hour prior to leaving the dock for the tracking area. The sled and associated equipment is normally kept in the field, and they are also loaded on board the EXCELLENCE. A final check is made by assembling the entire probe monitoring system. One exception is that the probe is not inserted into the sled, but it is lowered separately into the water for a final check out. All sensors are checked and the recorder is zeroed and checked for proper operation. The weak links and marker buoy are assembled on the sled and checked for proper assembly. Provided all systems check out satisfactorily, which normally takes approximately one hour, the ship is ready to leave the dock.

Upon leaving the dock, the ship heads for the control station which is station 39 used in the bimonthly conductivity, temperature, and depth measurements illustrated in the previous section. This station is located 4 nautical miles (7.4 km) up the coast from diffuser and at the same depth contour. A vertical profile of conductivity, temperature, and depth are recorded. These data are used to determine the ambient conditions for the sea water in the vicinity of the diffuser. When the vertical profile is completed the water quality probe is inserted into the bracket on the towing sled and the probe monitoring system is rigged for deployment in transit to the diffuser site.

At the diffuser site the ship anchors near buoy B to determine the currents at top, middle and bottom depths. These measurements provide an indication of the expected direction of the plume and the expected general area for finding the brine plume. These measurements normally take approximately one half hour.

Next, the ship weighs anchor and heads for starting point for plume tracking. During the transit to the starting point, the ship travels as close as possible to buoy B and the BRIMS buoy. The LORAN C coordinates of these buoys are recorded in order to determine corrections to the navigational chart.

The starting point is normally located approximately 1/2 mile (0.9 km) inshore of and in between the BRIMS buoy and buoy E as shown on the previously described Figure 2-1. At this point, the towing sled is deployed while the ship maintains a slow (2 kts, 3.7 km/hr) headway, and the water quality system and recorder are activated. The towing cable and the data bus cable are let out simultaneously until 300 ft (91 m) are in the water. This is the optimum length of cable for towing at a normal speed of 3 kts (5.6 km/hr) while the sled remains on the bottom. The position of the sled on the bottom is confined by the depth trace on the recorder.

The ship steers a course parallel to the diffuser and at a distance of approximately 200 ft (61 m) away as illustrated in Figure 2-1. This course is maintained until the ship reaches buoy B, and then the ship turns around buoy B and returns on the reverse course approximately 400 ft (122 m) from the diffuser in order to avoid BRIMS sensors and anchors. This course is maintained until the monitoring system indicates the bottom water is within 1.0 $^{o}/oo$ above the ambient salinity or no change occurs after a significant length of time. Next, a reverse course is selected which is at a greater distance from the diffuser. The new distance is selected based upon an estimate of the plume size which is determined from the magnitude of the above ambient salinity near the diffuser, the rate of decrease of above ambient salinity, and experience from previous plume measurements. This new course is run until the probe indicates it is again out of the plume.

The zig zag course is continued until the 1.0 $^{o}/oo$ above ambient water limits have been found. Then, the vessel takes a course on the opposite side of the diffuser and a similar procedure is followed. The above described tracking procedures normally take 5 to 8 hours to complete.

During the tracking procedure the parameters of conductivity, temperature, and depth are recorded continuously on the strip chart recorder. At the same time the conductivity values are being recorded manually every one minute in a log book. Along with conductivity readings, the ships location in terms of LORAN C coordinates is being recorded every one minute in a separate log book. Watches with sweep hands are synchronized at the start to insure simultaneous recording of data. These data provide the capability of immediately converting the conductivity to salinity, plotting the ship's track, and correcting for the location of sled, and finally determining the salinity contours.

After the far field tracking is completed, the ship returns to the diffuser and the near field measurements are made. These measurements consist of measuring vertical conductivity profiles which permits the evaluation of the vertical extent of the plume in the near field. It also provides additional bottom salinity data very close to the diffuser (within 100 ft, 30 m).

2.3.2 Navigation Procedures

Two navigational systems are available for plume tracking and these are the Del Norte Trisponder and the LORAN C. The Del Norte Trisponder system is a microwave ranging system which uses the intersection of range circles to indicate the ships position. This system is very accurate for pin pointing locations, but it is difficult for use in navigating the ship.

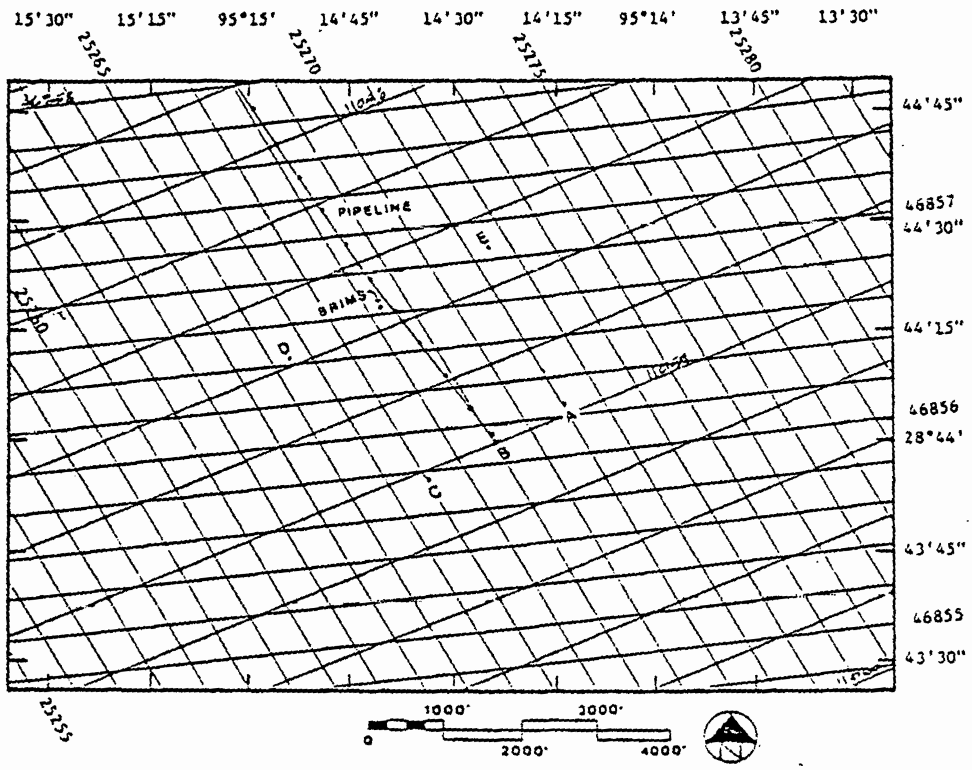


Figure 2-5. Sample LORAN C chart used for plume tracking

Also, the transmitting and receiving equipment must be maintained by project personnel. The LORAN C is a government owned and operated system, whose use is familar to almost all boat captains. This system is the easiest with which to navigate and its accuracy has been deemed satisfactory for the plume tracking.

A special LORAN C chart was constructed for the diffuser area for the specific purpose of tracking the plume. An example of this chart at a larger scale is shown in Figure 2-5. The two stations primarily used are the 46000 and the 25000 LORAN C stations. The 25 lines run approximately normal to the coast and parallel to the pipeline, and the 46 lines run parallel to the coast and normal to the pipeline. The chart is used to plot the ship's track during the plume track and to plot the ship's location and corresponding salinity readings from which the salinity contours are determined.

A Raytheon 6000 LORAN C receiver was purchased for the project, and it reads out the LORAN C coordinates to the nearest 0.1 of a microsecond. (μs). For the 25000 station a 0.1 μs represents a distance of 50 ft (15 m), and a 0.1 μs is 250 feet (76 m) for the 46000 station. The output from the receiver frequently jumps a 0.1 μs, and thus the accuracy is estimated to be ± 50 ft (15 m) and ± 250 ft (76 m) for the two stations used.

The location of the diffuser and buoys on the constructed LORAN C chart and their location given by the coordinates from the LORAN C receiver are usually not exactly the same. Therefore, the LORAN C coordinates of buoy B and the BRIMS buoy are recorded in order to determine correction factors which are normally constant during the time of plume tracking and are usually within a couple microseconds from day to day. These corrections are applied to all data in order to obtain the most accurate ship position.

2.4 Plume Tracking Results

2.4.1 General Comments

Continuous brine discharge from Bryan Mound began on March 13, 1980 at a nominal rate of 230,000 barrels per day, and the salinity of the brine was nominally 225 parts per thousand ($^{o}/oo$). Original plans called for the plume to be measured for five consecutive days beginning on the third day of discharge and once a week thereafter for the first month. However, the weather in the area resulted in high sea state conditions which precluded meeting the desired schedule. It was possible to measure the plumes on March 22, 26, 30, 31, April 9, and 10, 1980, and the results from the individual plume tracks are described in the following paragraphs.

2.4.2 March 22, 1980 Brine Plume Contours

March 16, 1980 was the first day scheduled for plume tracking, but high seas and fog caused postponement until March 22 when the seas were moderately rough (4-6 ft, 1.2-1.8 m) and the sky was clear. The CTD data at station 39 were collected and the bottom salinity was determined to be 33.2 $^{o}/oo$. In previously measured data the bottom salinity (6 ft, 1.8 m off the bottom) was observed to vary by as much as 1.0 $^{o}/oo$ but in most cases the March and April data of 1978 and 1979, Kelly and Randall (1980) or Hann et. al. (1979), showed the variation was normally not more than $\pm$ 0.5 $^{o}/oo$. Thus, the ambient bottom salinity is hard to define exactly, but it is felt that a reasonable value is obtained by using the bottom salinity (measured within 2 ft (0.6 m) of the bottom) at station 39 rounded to the nearest part per thousand. Thus, the ambient bottom salinity was determined to be 33 $^{o}/oo$ on March 22.

The average current for the time of plume tracking was determined by vector averaging half hour data points obtained from the data record of the bottom current (6 ft, 1.8 m above the bottom) meter located at instrument site C (Figure 2-1). The bottom current data are described in detail in Chapter 1. The average current speed was 0.27 kts (14 cm/s) and the direction was 200°T. This current is shown at buoy C on Figure 2-6 which illustrates the plume track for March 22, 1980. The direction of the brine plume, which is measured 10 in (25.4 cm) off the bottom, follows very closely to the average bottom current.

On March 22 the brine was being discharged at a rate of 195,000 barrels per day at a salinity of 225 $^{o}/oo$. The bottom isohalines are drawn on Figure 2-6 to show the area covered by saline water which is above the ambient value of 33 $^{o}/oo$. The 34 $^{o}/oo$ isohaline could not be closed, but the 35 and 36 $^{o}/oo$ isohalines are closed. The area within the 36 $^{o}/oo$ contour is 90 acres (0.36 km^2), and within the 35 $^{o}/oo$ contour the area is 177 acres (0.72 km^2). The highest salinity measured was 37 $^{o}/oo$ which is 4 $^{o}/oo$ above ambient. The data points with salinity values alongside are shown as small dots in Figure 2-6. These points were used to draw the salinity contours and a polar plenimeter was used to determine the areas.

The time required to track the plume was 5½ hours. Therefore, the isohaline contours shown in Figure 2-6 are a type of average over the time period. During the period of plume tracking the bottom current may change and this can distort the plume contours. Since the current is measured at site C continuously, the variation in the current over the plume tracking period is known. This should be kept in mind when comparing the plume tracking data with the results of predictive mathematical models which

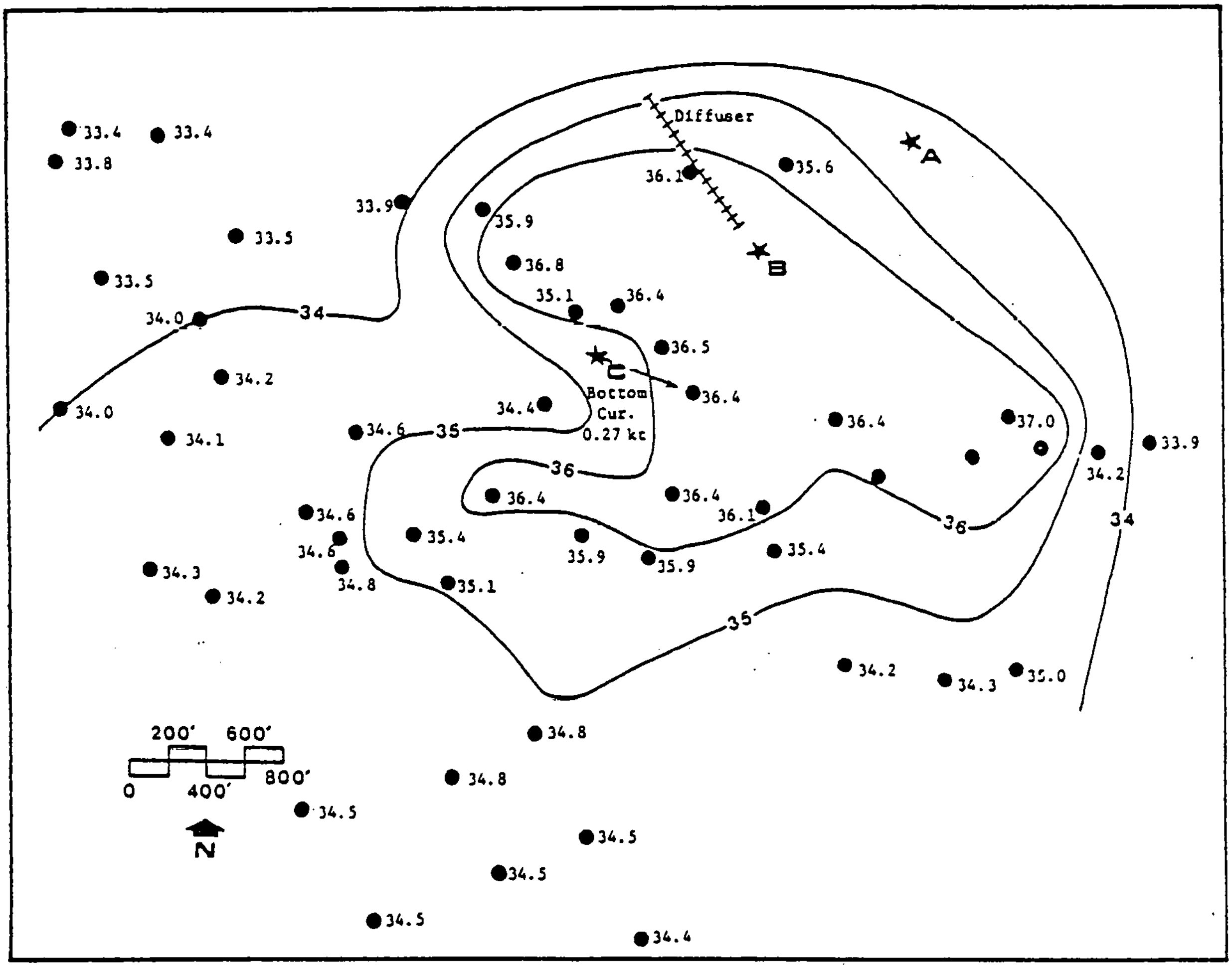


Figure 2-6. Brine plume contours for March 22, 1980.
Bottom ambient salinity is 33 o/oo.

provide a more instantaneous picture of the plume.

2.4.3 March 26, 1980 Brine Plume Contours

The second day of plume tracking was conducted under very adverse sea conditions, waves were 6-8ft (1.8-2.4 m), and therefore the results are not as complete. The ambient salinity was 32 ppt, the brine discharge rate was 225 thousand barrels per day, the brine salinity was 226^{o}/oo. The average bottom current was 0.33 kts (17 cm/s) in a direction of 216^{o}T which is illustrated in Figure 2-7. This figure shows that the highest measured salinity was 35.2 ^{o}/oo which is 3.2 ^{o}/oo above the ambient value. None of the contour lines were closed because the high seas caused the tracking time to be cut 2½ hours, and therefore no areas could be computed. However, the contour lines show again the alignment of the plume with the bottom current.

2.4.4 March 30, 1980 Brine Plume Contours

The weather conditions improved considerably for the March 30 plume track in that the wave heights were only 2-4 ft (0.6-1.2 m) and the sky was partly cloudy. The brine discharge rate was 208 thousand barrels per day with the salinity at 229 ^{o}/oo. The ambient salinity at station 39 was 33^{o}/oo, and the average current was 0.49 kts (25 cm/s) in a direction of 026^{o}T. The total tracking time was 5 hours.

The largest excess salinity contour is 35 ^{o}/oo as shown in Figure 2-8, and the area inside this contour is 63 acres (.25 km^2). The largest bottom salinity measured was 36.1 ^{o}/oo in the immediate vicinity of the diffuser which is only 3.1 ^{o}/oo above ambient. The area within the 34^{o}/oo contour is 174 acres (0.70 km^2). The high bottom currents tended to disperse the brine well which led to a lower excess concentration than that found on March 22.

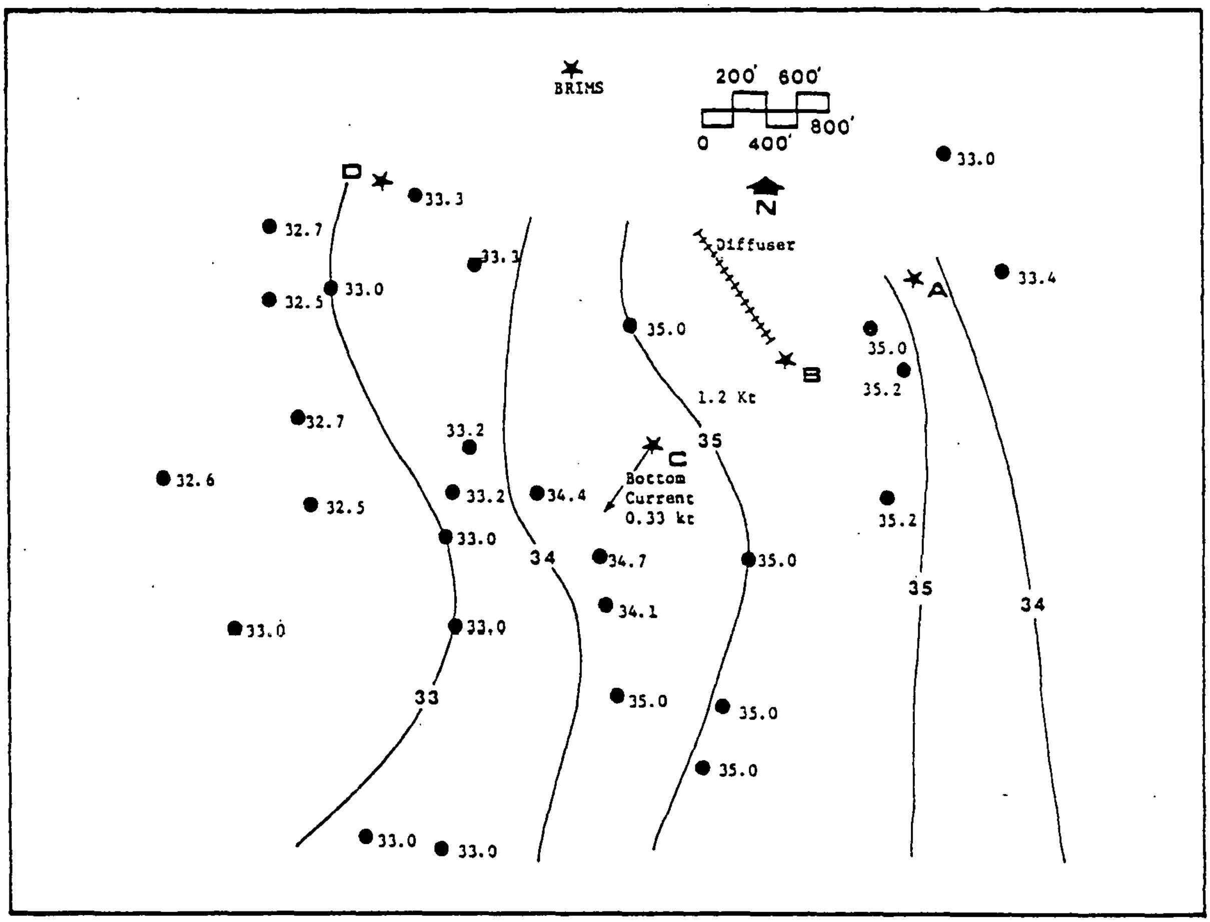


Figure 2-7. Brine plume contours for March 26, 1980. Bottom ambient salinity is 32 ^{o}/oo.

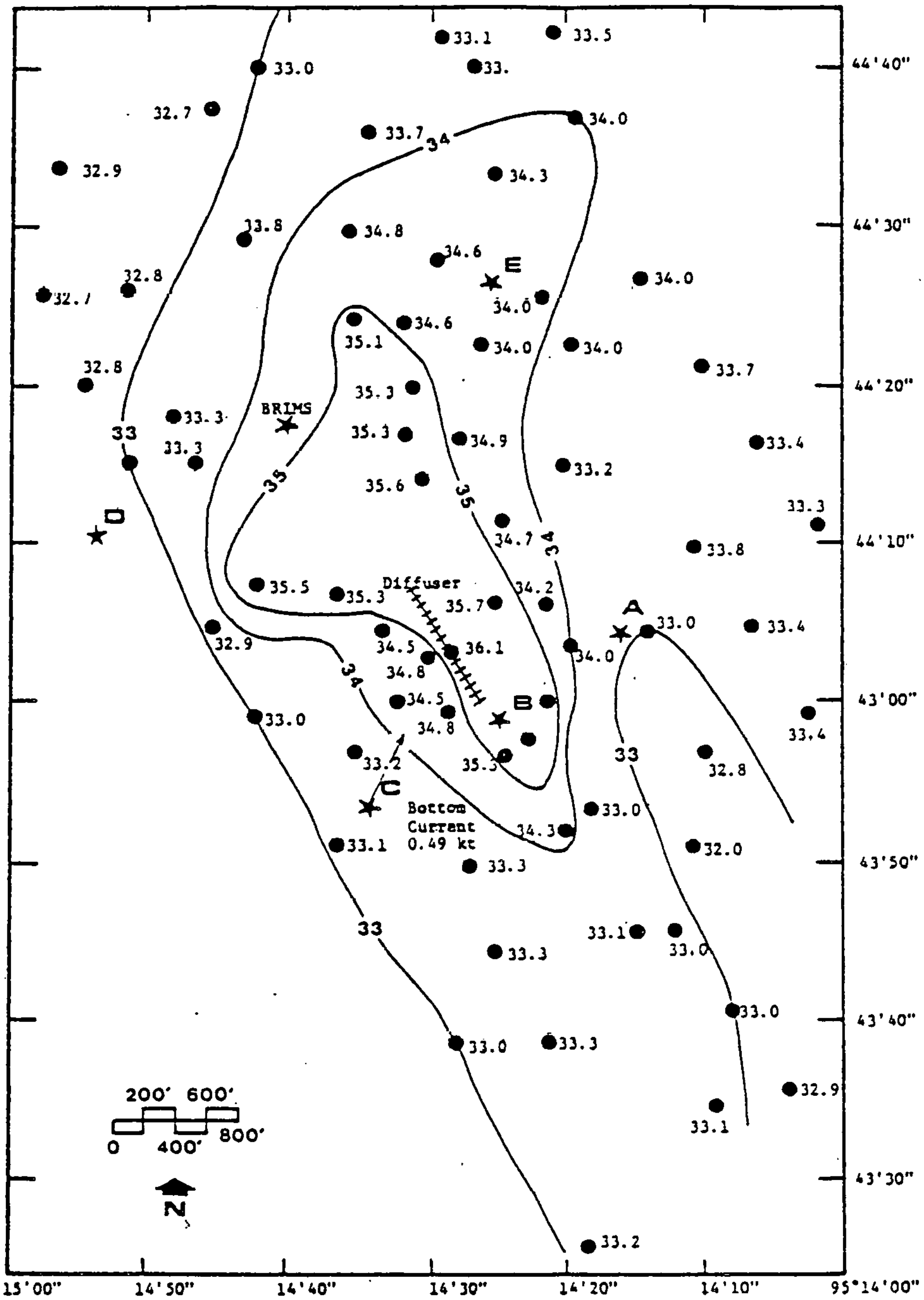


Figure 2-8. Brine plume contours for March 30, 1980.
Bottom ambient salinity is 33 $^{o}/oo$.

In this case the general direction of the plume agreed reasonably well with the bottom current but wasn't as convincing as on previous days.

2.4.5 March 31, 1980 Brine Plume Contours

The weather remained nice for the March 31 plume track which took 5 hours to complete. The brine discharge characteristics were a flowrate of 220 thousand barrels per day and a salinity of 234 $^{o}/oo$. The ambient water salinity was 33 $^{o}/oo$, and the average current was computed to be 0.31 kts (16 cm/s) in a direction of 028^{o}T. The plume contours shown in Figure 2-9 agree very well with the general current direction. It must be noted that brine discharge was stopped for four hours immediately prior to this plume track, and the data shown in Figure 2-9 was collected after discharge was restarted.

The excess salinity contours of 1 and 2 $^{o}/oo$ above ambient are shown in Figure 2-9 and they cover areas of 30 acres (0.12 km^2) and 118 acres (0.48 km^2) respectively. These areas were the smallest detected and this is undoubtedly due to the stoppage of discharge prior to tracking. A high salinity of 38.7 $^{o}/oo$ (5.7$^{o}/oo$ above ambient) was measured in the trench for the pipeline and this was the highest salinity measured up to that time. The highest excess salinity contour is only 2 $^{o}/oo$ above ambient, and it stretches 1900 ft (579 m) downstream from the diffuser and is 900 ft (274 m) wide at its widest point.

2.4.6 April 9, 1980 Brine Plume Contours

On April 9, 1980 the brine pit salinity was 247$^{o}/oo$ which was the highest salinity discharged for a plume track, and the flowrate was increased to 330 thousand barrels per day. The average current was found to be

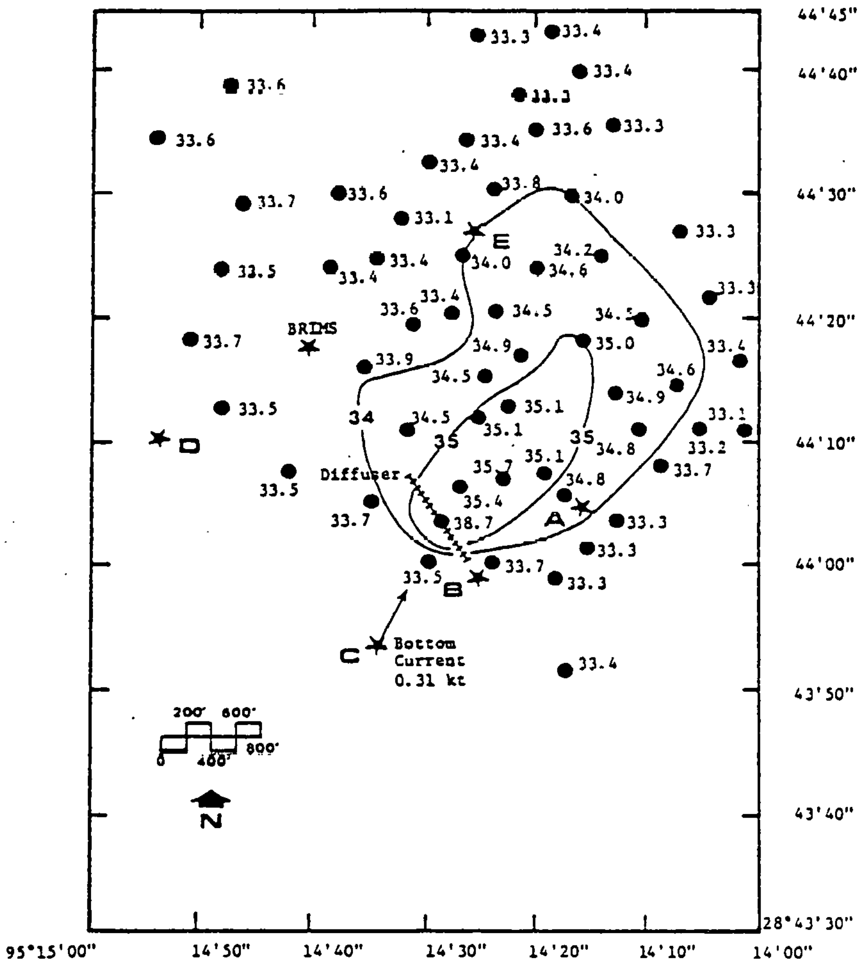


Figure 2-9. Brine plume contours for March 31, 1980. Bottom ambient salinity is 33 $^{o}/oo$.

0.06 kts (3 cm/s) in the direction of 102°T which is obviously a very low current condition. The ambient bottom salinity was measured as 34 °/oo.

The 37 and 38 °/oo isohaline contours are closed by the data as shown in Figure 2-10. The areal coverage of the 38°/oo isohaline is 31 acres (0.1 km^2) and the 37 °/oo isohaline covers 206 acres (0.8 km^2). The contour for 36 °/oo isohaline is not completely closed so an estimate was made which is illustrated by a dashed line on Figure 2-10. The area within the 36 °/oo contour is 1422 acres (5.8 km^2). The distance downstream from the diffuser to the 36 °/oo contour is approximately one nautical mile (1.8 km) and upstream from the diffuser the 36 °/oo contour is 2400 ft (732 m). The boundary of the 35 °/oo area could not be determined from the measured data because the transects were too close together and time didn't permit tracking to continue. As it was, the plume track was taken over a 6½ hour period. This plume covered the largest bottom area of the plumes measured during the intensive period, and this is expected because of the very low current regime. In this case the general direction of the plume does not correspond as well with the bottom current as has been observed on other plume tracking days.

2.4.7 April 10, 1980 Brine Plume Contour

The weather was very nice for this tracking day with wave heights less than 3 ft (.9 m) and the wind was less than 10 kts (18.5 km/hr). The 247 °/oo brine was being discharged at a rate of 325 thousand barrels per day. The average bottom current was 0.25 kts (13 cm/s) in the direction of 041°T, and the ambient bottom salinity was 33 °/oo.

The brine plume contours are shown in Figure 2-11. Like the plume track on the previous day, this plume area was much larger than those

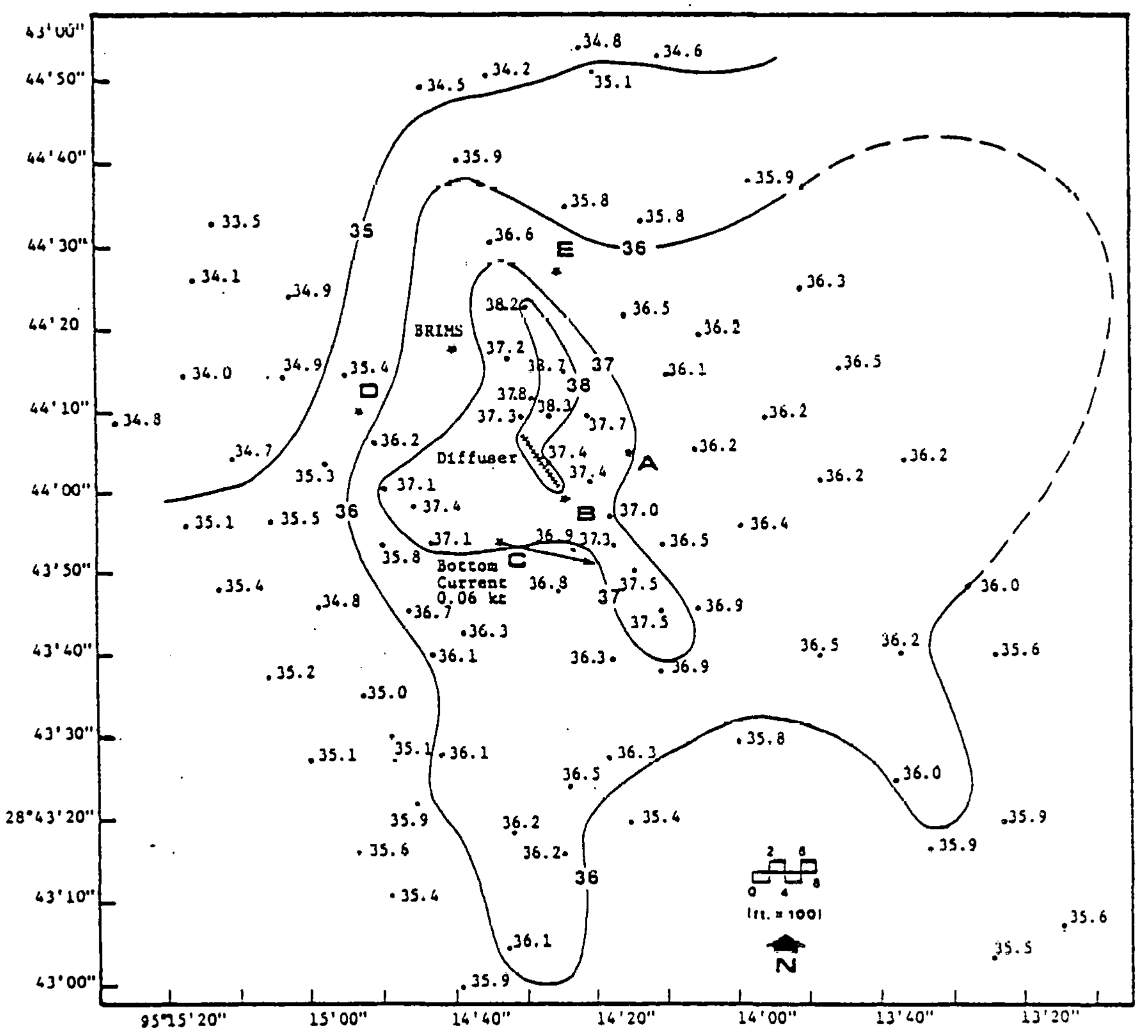


Figure 2-10. Brine plume contours for April 9, 1980.
Bottom ambient salinity is 34 ^{o}/oo.

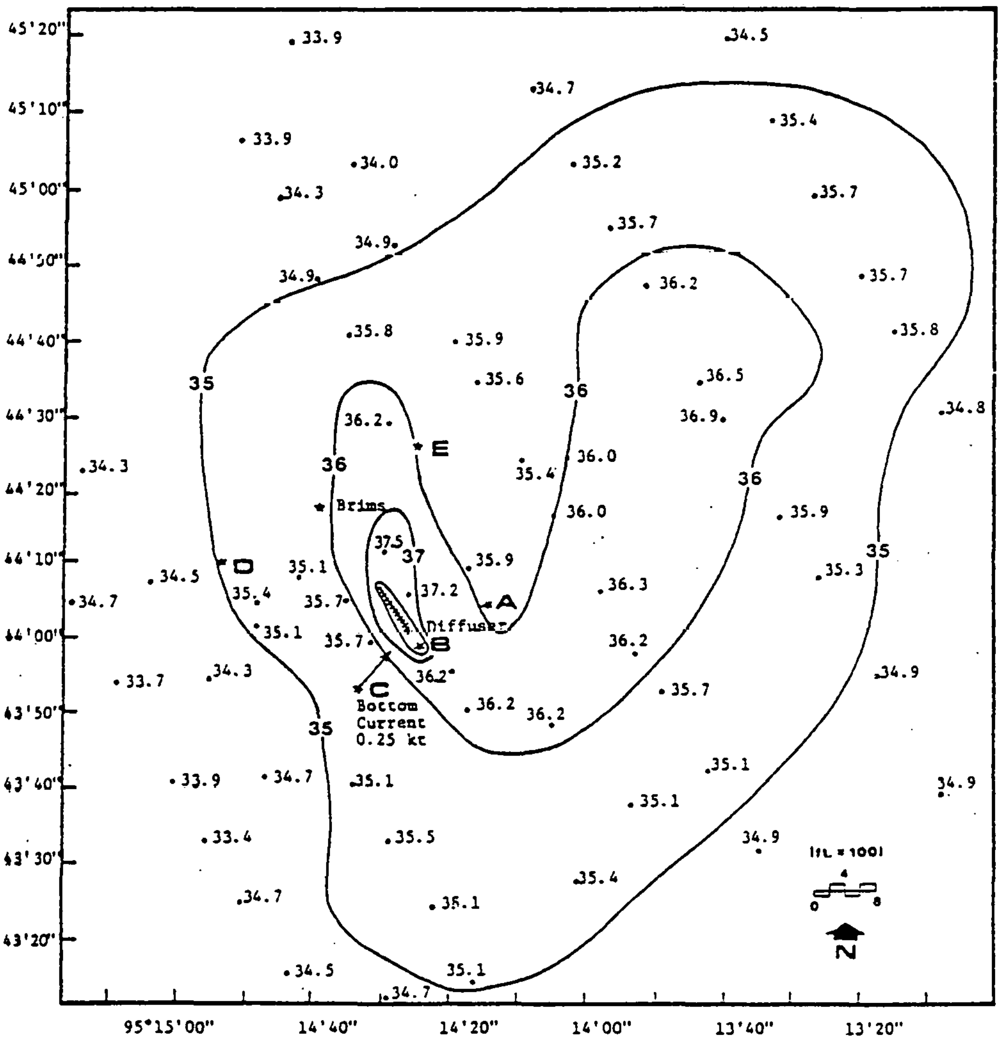


Figure 2-11. Brine plume contours for April 10, 1980. Bottom ambient salinity is 33 $^{o}/oo$.

measured in March. The highest salinity shown is 38.8 $^{o}/oo$ which is 5.8 $^{o}/oo$ above ambient and is close to the values for March 31 and April 9. The area within the 38, 37, 36, and 35 $^{o}/oo$ isohaline contour lines is 6, 25, 487, and 1828 acres (0.02, 0.1, 2.0, and 7.4 km^2) respectively. The 1.0 $^{o}/oo$ above ambient salinity contour could not be plotted. The 2 $^{o}/oo$ excess isohaline extends 1.5 nm (2.7 km) downstream from the diffuser and 1600 ft (488 m) upstream. The width of the plume inside the 35 $^{o}/oo$ contour is 1.4 nm (2.6 km). The general direction of the plume closely follows the direction of the bottom currents. The salinity data points for this plume track were collected over a six and one half hour period.

2.5 Results of Near Field Measurements of Brine Plume

2.5.1 General Comments

The near field region is the distance from the diffuser to the point where the plumes from each jet merge. This has been estimated to be 100 ft (30 m) from the diffuser, NOAA (1977). Initially, it was intended to tow the probe monitoring system parallel to the diffuser to see if the merging of the individual plumes could be detected. However, towing the sled within 100 ft (30 m) of the diffuser was hazardous and if it got into the trench it would surely entangle with one of the port cages. Also, the bottom current usually didn't run normal to the diffuser which meant the parallel course was not optimum.

The nearfield studies consisted of anchoring the vessel and attempting to get vertical profiles directly over the diffuser and on either side out to approximately 100 ft (30 m). These vertical profiles were used to determine the vertical extent of the brine plume, and these results are compared against values determined from empirical relationships developed by Tong and Stolzenbach (1979) and U.S. Army Engineer Waterways Experiment Station (1971). The remainder of this section will discuss the results of the experimental measurements of the vertical profiles in the near field. Vertical profiles were not obtained for the dates of March 22 and 26 because of an equipment malfunction on March 22 and electrical interference in winching system on March 26.

2.5.2 Near Field Measurements of the Brine Plume on March 30, 1980

The vertical profiles measured on March 30, 1980 are shown in Figure 2-12. The vertical profile for station 39 is considered the ambient profile, and the other profiles were measured in the immediate vicinity of the active diffuser. The vertical profile 150 ft (46 m) downstream shows that the thickness of the plume is 15 ft (4.6 m). A similar value for the plume thickness is shown by the data at 100 ft (30 m) downstream of the diffuser. The profiles upstream of the diffuser do not show evidence of a salinity increase near the bottom.

The comparison of the ambient profile and those near the diffuser for the mid water column is difficult. It appears that fresher water is present in the upper 16 ft (5 m) of the water column at the diffuser area but not at station 39. Station 39 also shows a gradual increase in salinity with depth and the profiles at the diffuser indicate a rapid increase in salinity in the top layer and a relatively constant value for the middle layer. The salinity increases again as a result of the brine discharge on the downstream side of the diffuser but remains essentially constant at 34 $^{o}/oo$ on the upstream side. The difficulty of knowing the exact ambient profile at the diffuser makes it very difficult to make any conclusions

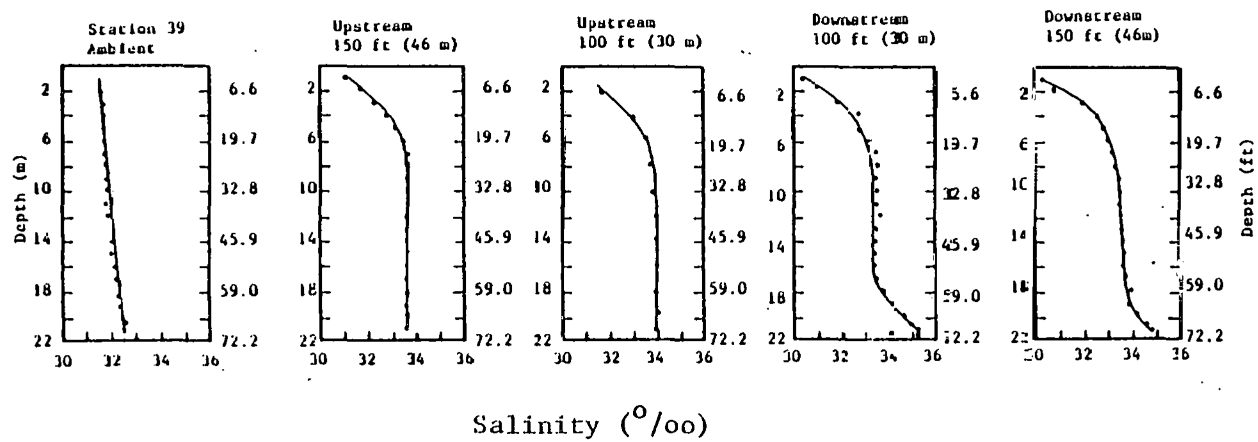


Figure 2-12. Vertical salinity profiles near diffuser for March 30, 1980.

about the possibility of low level mixing of brine into the mid water layer as might be suggested by Figure 2-12. However, the approximate 15 ft (4.6 m) thickness of the plume in the near field on the downstream side of the diffuser is conclusive.

2.5.3 Near Field Measurements of the Brine Plume on March 31, 1980

The vertical profile at station 39, Figure 2-13, shows fresher water at the surface and a strong halocline in the upper half of the water column. The lower half is nearly isohaline with a salinity of 33 ^{o}/oo. This ambient condition is now compared to other vertical profiles taken in the near field region of the brine diffuser.

A vertical profile was taken directly over the diffuser with the salinity probe being lowered to the bottom of the trench in which the diffuser is lying. Figure 2-13 shows that the fresher water is present in the upper half of the water column as was found at station 39. At mid depth the water becomes isohaline at 33^{o}/oo until a depth of 56 ft (17 m) is reached where the strong halocline begins. This strong halocline is the result of the brine being discharged from the diffuser. The salinity at the bottom of the trench (77 ft, 23.5 m) is shown to be 38.8^{o}/oo. Thus, the vertical extent of the plume directly over the diffuser is approximately 15 ft (4.6 m) above the natural ocean bottom which is a depth of 71 ft (21.6 m).

The vertical profiles on the upstream side of the diffuser shows a more gradual increase in the salinity near the bottom. At an approximate distance of 50 ft (15 m) from the diffuser the salinity increase begins at a depth of 62 ft (19 m) and increases to 34.5^{o}/oo at the bottom. At an upstream distance of 100 ft (30 m) the salinity begins increasing at a

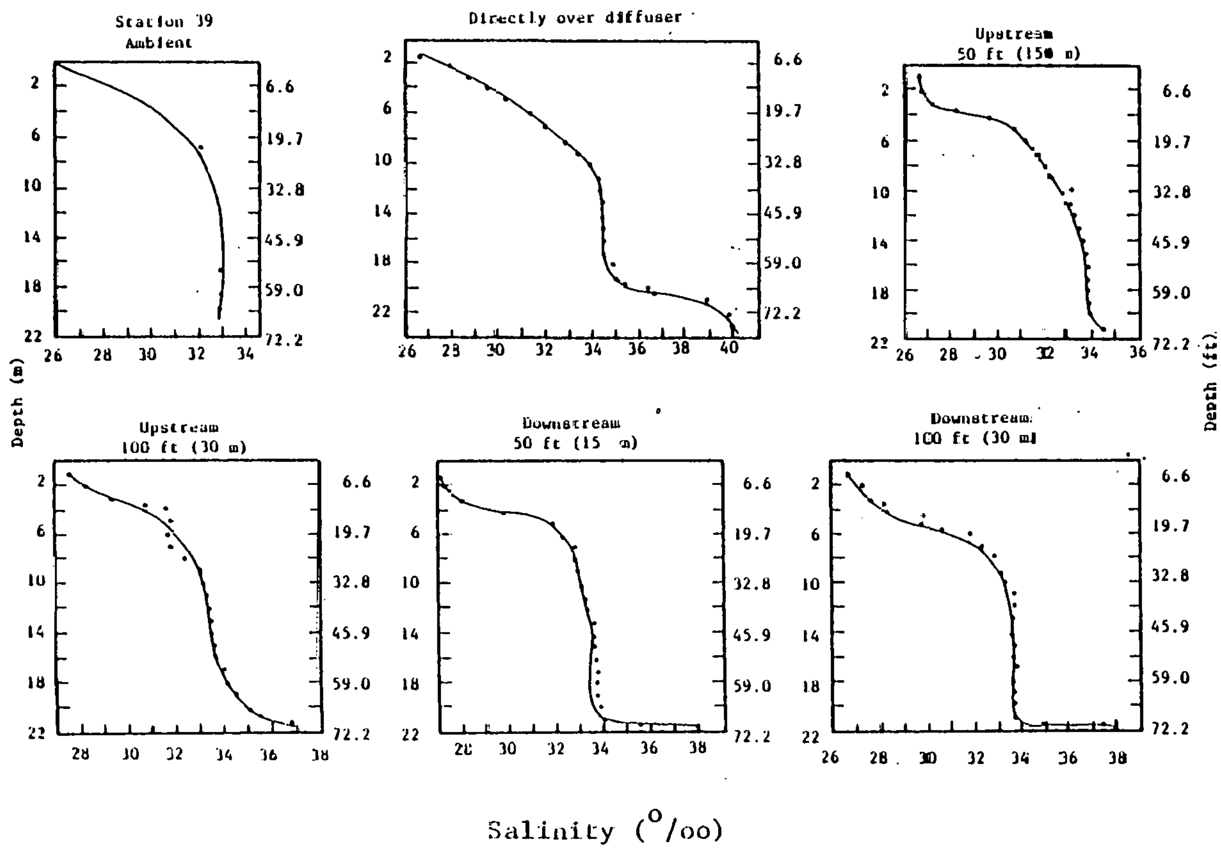


Figure 2-13. Vertical salinity profiles near diffuser for March 31, 1980.

depth of 46 ft (14 m) and increases to 36.8 $^{o}/oo$ at the bottom. Although the plume is expected to be on the upstream side under certain conditions, it is not expected to be thicker. Thus, it is not clear why the plume is so thick at this upstream location.

On the downstream side of the diffuser a rapid increase in salinity near the bottom is illustrated in Figure 2-13, and the thickness of the plume is much smaller than that found directly over the diffuser. The downstream profiles show the salinity begins to increase at a depth of 65.6 ft (20 m) and then increases rapidly at a depth of 68.9 ft (21 m) to a salinity of 38 $^{o}/oo$. Thus, the plume is shown to quickly fall to the bottom and be within 5 ft (1.6 m) of the bottom at a distance 100 ft (30 m) down-current from the diffuser.

2.5.4 Near Field Measurements of the Brine Plume on April 9, 1980

The vertical profile at station 39 shows that the salinity gradually increases from 33.4 $^{o}/oo$ at the surface to 34 $^{o}/oo$ at the bottom as shown in Figure 2-14. In comparing this profile with the one taken directly over the diffuser, it is seen that the brine plume extends to a depth of 62.3 ft (19 m) where the salinity begins increasing at a greater rate than that in the ambient profile. This indicates the plume is 9 ft (2.7 m) thick directly over the diffuser. A maximum salinity of 40 $^{o}/oo$ is indicated at depths of 72.2 ft (22 m) and 75.4 ft (23 m) which are located within the trench for the diffuser, and this was the highest salinity measured in the intensive plume tracking studies.

Wind and current conditions were such that the research vessel laid nearly parallel to the diffuser when at anchor. As a result, several vertical profiles were measured at several locations along the diffuser length

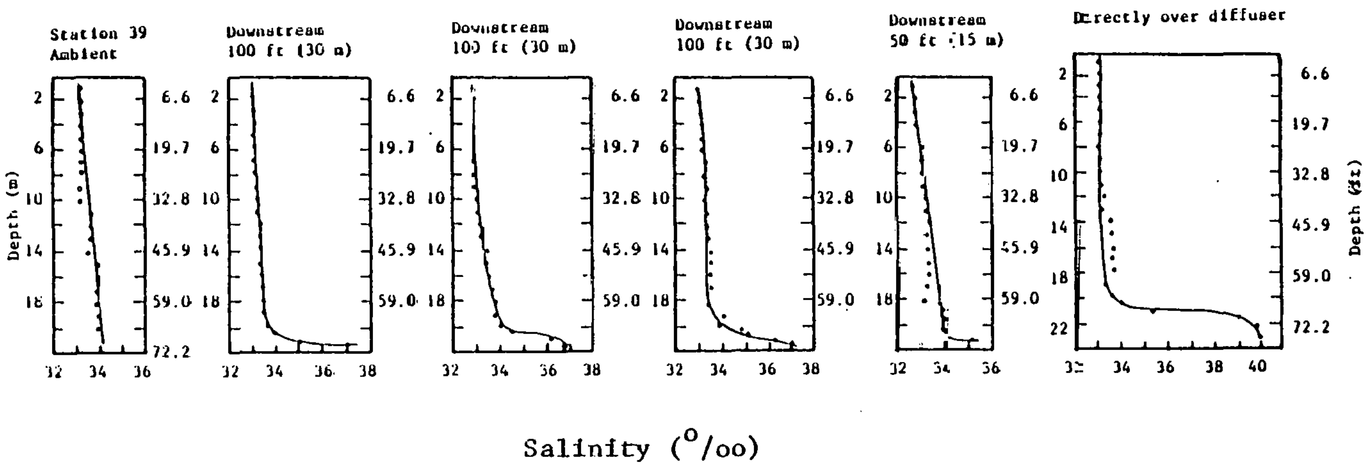


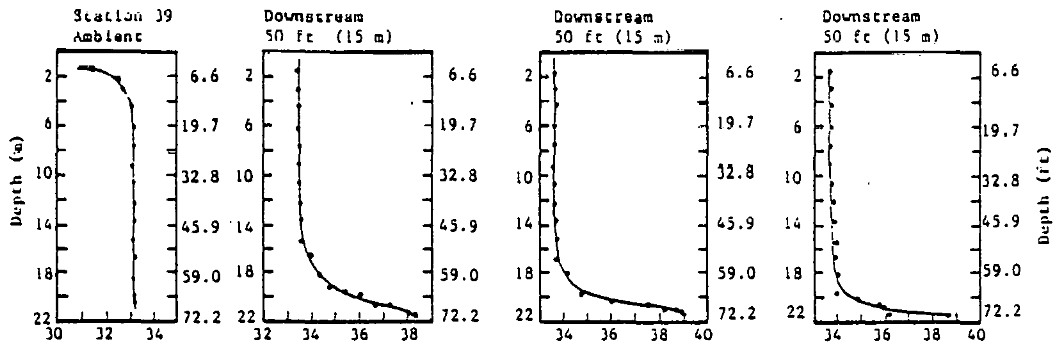
Figure 2-14. Vertical salinity profiles near diffuser for April 9, 1980.

on the downstream side. The first three profiles were 100 ft (30 m) and the fourth was at 50 ft (15 m) downstream of the diffuser. These profiles, Figure 2-14, show the brine plume is also encountered at a depth of 62.3 ft (19 m) and a strong halocline is present with the salinity increasing from $34^{o}/oo$ to $37^{o}/oo$. The depth of the natural sea floor in the area of the diffuser is 71 ft (21.5 m) and thus the plume is 9 ft (2.7 m) thick.

2.5.5 Near Field Measurements of the Brine Plume on April 10, 1980

The vertical profile for station 39 on Figure 2-15 shows that a thin layer of fresher water ($31.5^{o}/oo$) is located near the surface. The salinity increases rapidly to $33^{o}/_{oo}$ at a depth of 13 ft (4 m) and remains isohaline to the bottom. As on the previous day the wind and current conditions resulted in the ship lining up parallel to the diffuser when at anchor. Consequently, vertical profiles were taken only on the downstream side of the diffuser.

The three vertical profiles shown in Figure 2-15 were taken at a distance of approximately 50 ft (15 m) downstream of the diffuser. Two of these profiles show the salinity is $33.5^{o}/_{oo}$ at the surface, and the water column is isohaline down to 55.8 ft (17 m). The third profile is isohaline down to 46 ft (14 m). At these depths the salinity increases sharply to approximately $39^{o}/_{oo}$ which is 5.5 above the ambient salinity. This increase in salinity is attributed to the brine discharge and it indicates the vertical extent at that location. Thus the thickness of the plume is shown to be 15 ft (4.6 m) in two profiles and 25 ft (7.6 m) on another profile. These near field profiles indicate the brine plume is confined to the bottom third of the water column (24 ft, 7 m).



Salinity (^{o}/oo)

Figure 2-15. Vertical salinity profiles near diffuser for April 10, 1980.

2.5.6 Comparison of Calculated and Measured Values of the Plume Vertical Extent

Empirical relationships have been determined from laboratory experiments to compute the maximum vertical extent of a negatively buoyant plume. One relationship from U.S. Army Engineer Waterways Experiment Station (1971) is

$$\frac{Z_m - D}{D_0} = CF_D \qquad 2\text{-}1$$

where

$$F_D = \frac{V_0}{\left[\frac{\Delta\rho_m}{\rho_f} g D_0\right]^{1/2}}$$

$$C = 3.4\times10^{-0.148 (U/V_0) F_D}$$

Z_m is the maximum vertical extent of the plume centerline, D is the diameter of the diffuser pipe, D_0 is the exit port diameter, V_0 is the exit velocity, ρ_f is the ambient fluid density, $\Delta\rho_m$ is the difference in the density of the brine and ambient sea water, U is the ambient current speed, and g is the acceleration due to gravity, 32.2 ft/s. The second relationship is from the work of Tong and Stolzenbach (1979),

$$Z_m = 1.7\ U \left[\frac{D_0}{g^1}\right]^{1/2} \qquad 2\text{-}2$$

where

$$g' = g \frac{\Delta\rho_m}{\rho_f}$$

The vertical profiles discussed in the previous sections show the vertical extent of the plume at the specific locations where measurements were taken. Now it is desired to compare the vertical extent of the plume as measured during the plume tracks with those values computed from Equations 2-1 and 2-2. The maximum vertical extent was computed using physical oceanographic data collected during the plume tracking period and the known diffuser characteristics, and the results of the computed and measured values are tabulated in Table 2-1.

The computed values for the vertical extent (Z_m) of the plumes on March 22 and 26 indicate the centerline of the plume should reach 13.4 ft (4.0m) and 14.5 ft (4.4m) respectively using Equation 2-2. Equation 2-1 indicates the values should be 20.8 ft (6.3m) and 22.5 ft (6.9m). The exit velocity was determined to be 17 ft/s (518 cm/s) and 20 ft/s (610 cm/s), respectively. However, no vertical data was collected on those days. On March 30 the predicted Z_m was 13.8 ft (4.2m) which compares favorably with the measured value of 15 ft (4.6m) for a location approximately 100 ft (30m) downstream. The predicted value of 14.2 ft (4.3m) for March 31 agrees well with the measured value of 15 ft (4.6m) directly over the diffuser. The measured values decrease as expected at distances upstream and downstream from the diffuser.

In April the plume tracks were conducted when the brine discharge was at a higher flowrate and greater concentration than that in March. The predictions using Equation 2-2 show the vertical extent should be increased to 17.9 ft (5.5m), but the measured value on April 9 indicates the plume stayed considerably closer to the bottom (9 ft, 4.6m). On April 10 the measured values of 14.8 ft (4.5m) for the downstream location agreed better with the predicted value of 17.7 ft (5.4m), but no data was obtained directly over the diffuser. The maximum extent of the plume should occur very near to the diffuser (10 ft) with some variation depending on the am-

Table 2-1. Comparison of Measured and Computed Vertical Extent of Brine Plume

Date	Calculated Max Vertical Extent of Plume Centerline above Sea Floor (Z_m)				Measured Vertical Extent of Plume above Sea Floor						Average Ambient Current		Brine Flowrate	Exit Velocity	
	Eqn. 1-2		Eqn. 1-1		Upstream (~100 ft, 30m)		Directly Over Diffuser		Downstream (~100 ft, 30m)						
	ft	m	ft	m	ft	m	ft	m	ft	m	kts	cm/s	barrels/day	ft/s	cm/s
3/22/80	13.4	4.0	20.8	6.3	-	-	-	-	-	-	0.27	14	195,089	17	518
3/26/80	14.5	4.4	22.5	6.9	-	-	-	-	-	-	0.33	17	225,258	20	610
3/30/80	13.8	4.2	21.4	6.5	0	0	-	-	15	4.6	0.49	25	207,212	18	549
3/31/80	14.2	4.3	22.0	6.7	9	2.6	15	4.6	5	1.6	0.30	16	220,212	19	579
4/9/80	17.9	5.5	28.1	8.6	-	-	9	2.6	9	2.6	0.06	3	329,651	29	884
4/10/80	17.7	5.4	27.8	8.5	-	-	-	-	15	4.6	0.25	13	324,787	29	884

NOTE: - indicates no data collected

bient current. Therefore, the measurements directly over the diffuser are best for comparison. The comparison, although not exact, does confirm the predictions that the vertical extent of the brine plume will be within the lower third (24 ft) of the water column. More vertical profile measurements need to be taken in the plume to establish a better three dimensional picture of the plume. However, excursions by the sled off the bottom have indicated the plume has been confined to a distance on the order of 3 ft (1 m) off the bottom outside the nearfield.

2.6 Summary of Results

On March 13, 1980 continuous disposal of a nominal 230‰ brine solution began at a rate of 225,000 barrels per day from a multiport diffuser in 71 ft (21.6 m) of water at a distance of 12.5 statute miles (20 km) off the Freeport, Texas coast. The brine plume emanating from the diffuser was negatively buoyant, and therefore was located very close to the sea floor.

A monitoring system was designed and assembled to measure the excess salinity and the areal extent of the brine plume. The monitoring system consisted of a towing sled in which an <u>in situ</u> conductivity, temperature, and depth probe was mounted. The towing sled and probe were towed by the R/V EXCELLENCE on a predetermined search course through the expected plume area, and this operation is commonly called plume tracking. The probe continuously measured the salinity at a distance of 10 in (25.4 cm) off the sea floor. These data were then used to construct isohalines, or constant salinity contours, of the bottom area. The resulting contour plots indicated the areal coverage of the plume and the magnitude of the excess salinity concentration. In addition, vertical salinity profiles were measured to evaluate the vertical extent of the plume.

Plume tracking was conducted on March 22, 26, 30, 31, April 9 and 10, 1980 aboard the R/V EXCELLENCE. The salinity of the water 10 in (25.4 cm) off the bottom was recorded and used to determine contours of excess salinity above the ambient sea water salinity. In March the highest excess salinity contour was 2 ‰ above ambient, and it was present on all days except March 30. The largest area within the +3 ‰ contour was 90 acres (.4 km^2) which occurred on March 22. The plotted 1‰ above ambient contour line was the lowest contour line plotted, and the largest area within this contour was 174 acres (0.7 km^2) on March 30. The average length of time required for each plume tracking operation in March was approximately 5 hours.

In April, the plume tracking was conducted when the brine solution was nominally 247 ‰ and the discharge rate was approximately 330,000 barrels/day. The measured plumes in April covered a much larger area and the excess concentrations were higher. On April 9, the highest excess concentration was 4 ‰ above ambient and the areal coverage within the contour was 31 acres (0.1 km^2). The lowest excess salinity contour which could be closed was +2 ‰ and the area within this contour was 1422 acres (5.8 km^2). One of the important natural means for dispersing the brine plume is the bottom current, and during the April 9 plume tracking period the bottom current was a low 0.06 kts (3cm/s). Previous bottom currents in March were from 0.3 to 0.5 kts (15 to 26 cm/s).

On the following day, April 10, an excess salinity contour of +5 ‰ was detected, but it was small (6 acres, 0.02 km^2). The 4‰ above ambient contour covered 25 acres (0.1 km^2), and the 2‰ contour covered an area of 1828 acres (7.4 km^2). Thus the areal coverage of higher concentrations was greater than, and the coverage of the lower concentrations was less than that measured on April 9.

The actual plume contours are illustrated in section 2.5 and a tabular summary of the plume tracking results is contained on the next page in Table 2-2. In the nearfield, or within 100 ft (30 m) of the diffuser, vertical profiles were measured to evaluate the vertical extent of the plume. These measurements showed that the plume was located in the bottom third of the water column (24 ft, 7 m). The largest measured vertical excursion of the plume directly over the diffuser was 15 ft (4.6 m) which occurred on March 30, 31, and April 10. These results are in good agreement with predictions of laboratory determined empirical relationships.

In conclusion, the probe monitoring system performed satisfactorily, and the areal coverage, nearfield vertical extent, and the excess salinity concentrations of the brine plume were determined. The comparison of predicted and measured nearfield vertical extent was good. A comparison of the results of a predictive mathematical model for area coverage and excess salinity concentrations and of the measured plume results described in this report is being conducted by NOAA and the initial results are described by NOAA (1980).

Table 2-2. Summary of Brine Plume Tracking Data Collected During Intensive Study Period

Date	Average Bottom Current Speed		Direction	Brine Salinity	Discharge Rate	Ambient Bottom Salinity	Excess Salinity Contours	Area Inside Salinity Contour		Time of Tracking	Comments
	kts	cm/s	°True	‰	10^3 barrels/day	‰	‰	acres	km^2	hrs	
3/22/80	0.27	14	200	225	195	33	+2 +3	117 90	0.72 0.36	5.5	
3/26/80	0.33	17	216	226	225	32	+1 +2 +3	contours were not closed		2.5	Adverse weather caused curtailment of tracking
3/30/80	0.49	25	026	229	208	33	+1 +2	174 63	0.70 0.25	5.0	
3/31/80	0.31	16	102	237	220	34	+1 +2	118 30	0.48 0.12	5.0	Brine discharge stopped 4 hrs prior to tracking
4/9/80	0.06	3	102	247	330	34	+2 +3 +4	1422 206 31	5.8 0.8 0.1	6.5	
4/10/80	0.25	13	041	247	325	33	+2 +3 +4 +5	1828 487 25 6	7.4 2.0 0.1 0.02	6.5	

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

CHAPTER 3

WATER AND SEDIMENT QUALITY

J. Frank Slowey
Environmental Engineering Division
Civil Engineering Department

and

Lela M. Jeffrey
Department of Oceanography

3.1 Introduction

As part of the monitoring plan by DOE (1979) for brine discharge into the Gulf of Mexico at the Strategic Petroleum Reserve Program's Bryan Mound site, the Environmental Engineering Division, Texas A&M University, in January 1979, began conducting a water and sediment quality study designed to provide baseline data for evaluation of the environmental effects of the brine discharge. This study consisted of the routine monthly water quality analyses listed in Table 3-1. In addition, quarterly water and sediment analyses, also presented in Table 3-1, were commenced in August 1980. In accordance with the DOE plan, this baseline study was carried out until the time that actual brine discharge was to begin. The results of this study were presented in a predisposal report previously submitted to DOE (Slowey, 1980).

In addition to this routine study which is to be continued, the DOE monitoring plan required that a special, more intensive sampling and analyses program be carried out during the period that the brine discharge first began. This special program, Table 3-2, was to be conducted approximately one week before and four weeks after commencement of brine discharge from the brine discharge diffuser located 12.5 statute miles (20 km) off the Freeport, Texas coast. Furthermore, one week after discharge

Table 3-1. Monthly and quarterly water and sediment quality measurements.

MONTHLY

Water only:

Dissolved oxygen, salinity, temperature, pH, total and volatile suspended solids, oil and grease, chlorophyll-a and pheophytin-a, nutrients (nitrate, nitrite, ammonia, silica, ortho and total phosphate).

QUARTERLY

Water:

Dissolved oxygen, salinity, temperature, pH, total and volatile suspended solids, oil and grease, chlorophyll-a and pheophytin-a, nutrients (nitrate, nitrite, ammonia, silica, ortho and total phosphate), dissolved heavy metals (Cd, Cr, Cu, Hg, Zn, Pb, Al, Fe, Ni), dissolved bulk ions (Ca^{++}, Mg^{++}, Na^{+}, K^{+}, Br^{-}, I^{-}, Cl^{-}, SO_4^{--}).

Sediment:

Oil and grease, Eh/pH, heavy metals (Cd, Cr, Cu, Hg, Zn, Pb, Al, Fe, Ni), pore water (Ca^{++}, Mg^{++}, Na^{+}, Cl^{-}, SO_4^{--}, K^{+}, and total dissolved solids).

Table 3-2. Special water, sediment and biota sampling program measurements.

WATER:

Dissolved oxygen, salinity, temperature, pH, total and volatile suspended solids, oil and grease, chlorophyll-a and pheophytin-a, nutirents (nitrate, nitrite, ammonia, silica, ortho and total phosphate), dissolved heavy metals (Cd, Cr, Cu, Hg, Zn, Pb, Al, Fe, Ni), dissolved bulk ions (Ca^{++}, Mg^{++}, Na^{+}, K^{+}, Br^{-}, I^{-}, Cl^{-}, SO_4^{--}).

SEDIMENT:

Oil and grease, Eh/pH, heavy metals (Cd, Cr, Cu, Hg, Zn, Pb, Al, Fe, Ni), pore water (Ca^{++}, Mg^{++}, Na^{+}, K^{+}, Cl^{-}, SO_4^{--}, and total dissolved solids), pesticides (Molinate; Propanil; Trifluralin; Vernolate; 2,4-D; 2,4,5-T; Aldrin; Dieldrin; Total DDT; Chlordane and its isomers), polychlorinated biphenyls (aroclor 1254 and 1242) and high molecular weight hydrocarbons.

BIOTA:

Pesticides, PCB's and heavy metals (all same as above).

began, a routine quarterly sampling study as described in the predisposal report and presented in Table 3-1 was to be made.

The intensive special study samples collected one week before and four weeks after start of brine discharge were to consist of water (three depths) and sediment samples collected at each of the 13 stations used for the baseline studies (Slowey, 1980). In addition, selected biota (brown shrimp, white shrimp, zooplankton and croaker) for limited chemical analyses were to be collected in the area of the diffuser and at one of the control stations. These biota were to be analyzed for heavy metals, pesticides and polychlorinated biphenyls (PCB's).

Water samples were to be analyzed for salinity, dissolved oxygen, nutrients (nitrogen, phosphorus and silica), major bulk ions (Na^+, K^+, Ca^+, Mg^+, Cl^-, SO_4^{--}, Br^- and I^-), soluble heavy metals (Al, Cd, Cr, Cu, Hg, Fe, Ni, Pb and Zn), and estimates of organic matter (oil and grease), turbidity (total and volatile suspended solids) and productivity (chlorophyll _a_ and pheophytin _a_ pigments). The sediment samples were to be analyzed for Eh, pH, oil and grease, selected pesticides and PCB's, high molecular weight hydrocarbons and the same heavy metals as for the water samples as well as the major ions (Na^+, K^+, Ca^+, Mg^+, Cl^- and SO_4^{--}) and total dissolved solids present in the interstitial or pore waters of the sediments.

The routine quarterly water and sediment samples collected one week after brine discharge began were to be analyzed for the same parameters as for the above mentioned special samples with the exception that hydrocarbons, pesticide and PCB analyses were not required. Also, biota for chemical analyses were not to be collected.

In February, Texas A&M University was notified by DOE of their intent to commence brine discharge in early March. As a result, the first extensive sampling (immediate predisposal) was undertaken on February 29 and March 1, 1980. Water, sediment, and zooplankton samples were collected during this period. However, lack of all the desired biota in the study area postponed completion of biota sampling until March 5 when brown and white shrimp were found and collected in the diffuser area only. Although croaker were the planned demersal fish for the study, none were found in tows made in the study area and, as a last resort, sand trout (C. arenarius) usually present in this area were collected as representative of the demersal fish. Furthermore, postdisposal biota sampling was not completed until May 27, 1980 due to sparcity of suitable biota in the area at the time.

Additional modification of the sampling plans were required by DOE's decision to commence operation of the diffuser with only a portion (15) of the discharge ports open rather than the entire 52. The discharge rate was to be about 225,000 barrels per day rather than the 650,000 barrels per day originally planned. The 15 ports opened were at the end of the diffuser rather than over its 3,000 foot (915 m) length as anticipated when the original diffuser sampling stations were selected. This change required the addition of three sampling stations near the outer diffuser end so that monitoring of this portion of the discharge area could be accomplished. These stations (D19 through D21) were located 500 ft (152 m) further seaward than the previous outer diffuser stations (D10, D13 and D16) and brought to 12 the number of sample stations located around the diffuser during the intensive study. Location of all stations sampled during the intensive studies are shown in Figure 3-1. Geographic locations of the three new stations are as follows:

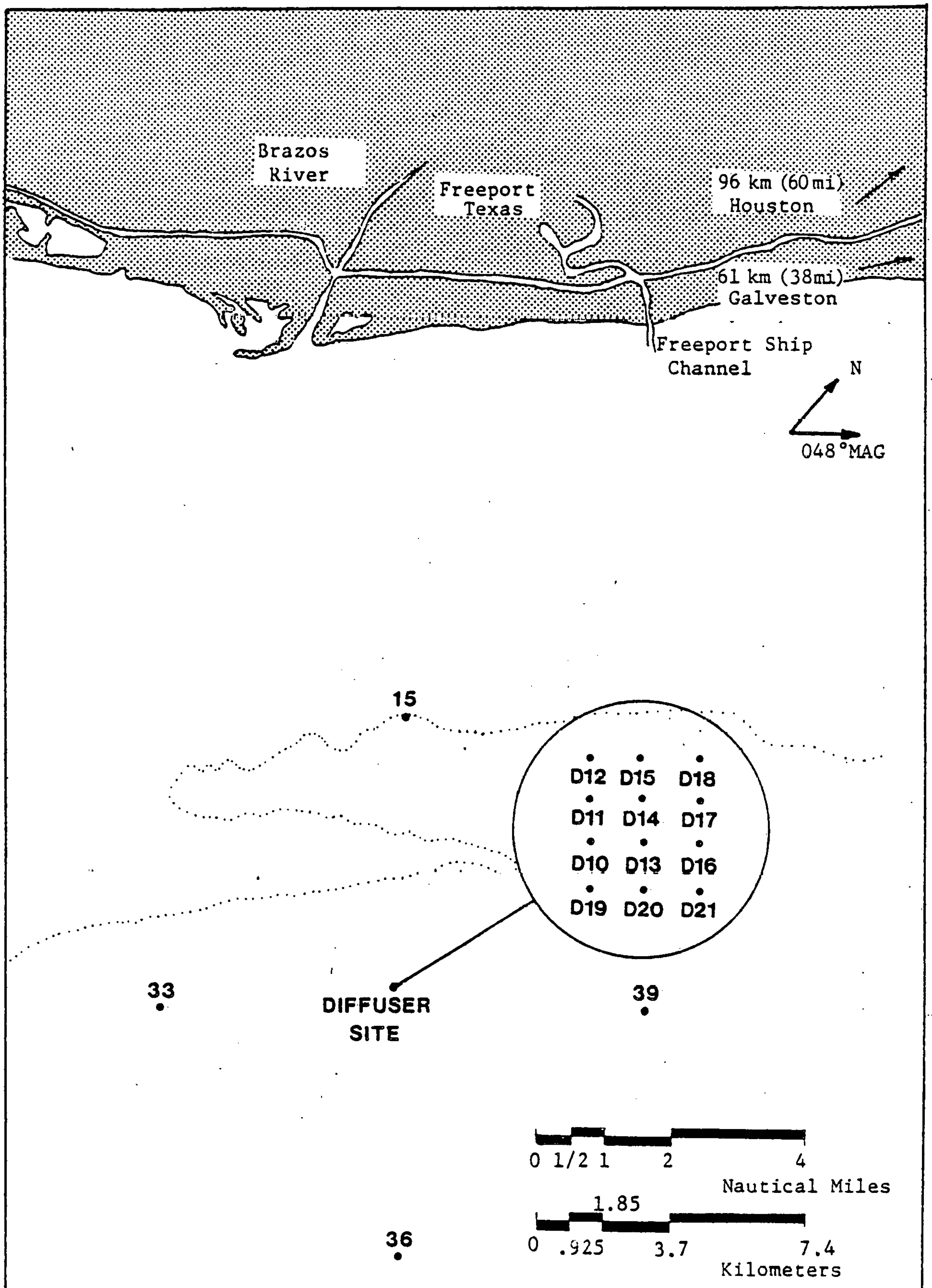


Figure 3-1. Water and sediment sampling stations during intensive study.

	LATITUDE	LONGITUDE
D19	28°43'58" N	95°14'32" W
D20	28°44'01" N	95°14'26" W
D21	28°44'04 N	95°14'22" W

Water and sediment samples collected at these three stations were analyzed for all parameters except hydrocarbons, pesticides and PCB's. These analyses are quite expensive and sufficient funds were not available under the present contract for them. However, these extra samples were preserved and the special analyses can be made at a later date if deemed necessary based upon results from the other nine diffuser area stations.

Although actual brine discharge did not begin until March 13, 1980, the February 29 sample date was considered close enough to meet the requirement for samples to be collected approximately one week before discharge. Some slippage in sampling times was anticipated at the start of the project to allow for adverse weather conditions and boat availability restrictions.

The routine quarterly sampling scheduled about one week after start of discharge was made on March 25, 1980, and the second special, intensive sampling on April 7, 1980. However, the absence of desired organisms in the study area in April precluded completion of biota sampling for this second special sampling period. Zooplankton samples were obtained on April 11, 1980 but brown and white shrimp and sand trout were not collected until May 27, 1980.

3.2 Results

3.2.1 General Water Quality

Results of the analyses for general water quality (salinity, temperature, dissolved oxygen, pH, total and volatile solids and oil and grease) during the period of the intensive study are presented in Tables 3-3 through 3-5. These results indicate that during this period the water column was fairly well mixed with a slight salinity (s%) gradient with depth. Salinities ranged from approximately 30 to 34 $^{o}/oo$ on February 29, 26 to 34 $^{o}/oo$ on March 25 (12 days after start of brine discharge) and 28 to 37 $^{o}/oo$ on April 7 (25 days after start of discharge). Highest levels were observed in the area of the diffuser on April 7 and were about 2½ $^{o}/oo$ over ambient. This increase in salinity was expected based upon results of the plume tracking studies reported in Chapter 2 of this report.

No changes were observed for dissolved oxygen (D.O.), temperature or pH in the water column that could be attributed to brine discharge. In the case of suspended solids, high total and volatile solids observed in bottom water at control station 15 on March 25 were attributed to terrestrial organic detritus at this near-shore station. Elevated levels of volatile suspended solids at several diffuser stations on March 25, especially D14, might be related to the increased oil and grease levels observed at this time. Otherwise, no increase in suspended solids attributable to brine discharge were observed.

In addition to salinity, the only other noticeable change over a broad area was in the levels of "oil and grease" observed on March 25. During the preceding year, oil and grease concentrations were seldom over 1 mg/l and then only on a scattered basis. On February 29, the levels were 0.5 mg/l or less. However, on March 25, 22 of the 45 samples analyzed were above 5 mg/l. This oil and grease was most prevalent in bottom waters. In the diffuser area, stations D10, D11, D14, D15, D17, D18 and D19 were all over 5 mg/l. These stations lie generally in a north-south direction through the diffuser area (see Figure 3-1). At mid depths,

Table 3-3. Selected water quality parameters at Bryan Mound Disposal site and control sites.

February 29, 1980

Sta. No.	Depth m	Salinity °/oo	Temp. °C.	D.O. mg/l	TSS mg/l	VSS mg/l	O&G mg/l	pH
D10	0.5	29.9	16.2	8.0	6.0	1.4	<0.5	8.2
	9.2	32.3	14.7	8.7	4.4	0.2	<0.5	8.4
	18.8	34.2	16.1	8.2	12.0	1.6	<0.5	8.2
D11	0.7	29.9	15.8	8.9	11.4	1.4	<0.5	8.3
	9.5	32.2	14.7	7.2	1.6	<0.1	<0.5	8.2
	18.8	33.9	16.0	7.9	12.4	2.0	<0.5	8.2
D12	0.5	29.6	15.7	8.6	3.0	0.4	<0.5	8.3
	8.7	32.3	14.7	8.2	13.2	3.2	<0.5	8.3
	18.6	32.9	16.1	8.0	2.4	<0.1	<0.5	8.2
D13	0.8	30.4	15.3	8.1	10.4	2.2	<0.5	8.2
	9.6	32.3	14.6	8.3	9.4	2.6	<0.5	8.3
	18.3	34.2	16.1	8.0	14.0	2.8	<0.5	8.2
D14	0.9	29.9	15.7	8.2	1.6	<0.1	<0.5	8.3
	9.3	32.6	14.7	6.8	6.0	0.8	<0.5	8.3
	18.3	34.0	16.0	7.9	7.4	1.2	<0.5	8.2
D15	0.5	30.4	15.7	8.2	2.0	0.2	<0.5	8.4
	9.2	32.4	14.6	8.2	4.0	1.0	<0.5	8.4
	18.5	34.0	16.0	7.9	19.6	4.6	<0.5	8.2
D16	0.8	30.2	15.7	8.9	6.6	1.2	<0.5	8.3
	9.2	32.2	14.7	8.4	2.2	0.2	<0.5	8.3
	18.3	34.4	15.3	8.5	17.8	2.8	<0.5	8.2
D17	0.9	30.1	15.9	6.6	12.8	3.0	<0.5	8.3
	9.3	32.4	14.7	6.8	10.6	6.8	<0.5	8.3
	18.5	33.9	16.0	7.9	2.8	0.8	<0.5	8.2
D18	0.9	30.5	15.2	8.6	2.2	<0.1	<0.5	8.4
	9.0	32.6	14.9	8.3	13.6	2.8	<0.5	8.3
	18.9	34.0	16.0	7.9	4.2	<0.1	<0.5	8.2
D19	1.0	31.2	14.3	8.6	5.4	<0.1	<0.5	8.4
	9.0	32.3	14.5	7.1	5.4	1.4	<0.5	8.3
	18.9	34.2	16.1	8.2	12.2	1.6	<0.5	8.2
D20	0.5	30.1	15.7	8.4	6.2	1.2	0.5	8.3
	10.0	32.6	14.7	8.3	6.8	0.6	0.5	8.3
	18.5	33.6	16.2	7.1	5.8	<0.1	0.5	8.2

Table 3-3. Selected water quality parameters at Bryan Mound Disposal site and control sites (continued).

February 29, 1980

Sta. No.	Depth m	Salinity °/oo	Temp. °C.	D.O. mg/1	TSS mg/1	VSS mg/1	O&G mg/1	pH
D21	0.7	30.9	14.7	7.2	4.8	2.4	<0.5	8.4
	9.5	32.5	14.8	7.6	10.4	1.8	<0.5	8.3
	19.3	33.9	16.1	7.3	4.2	0.1	<0.5	8.2
15	0.5	29.6	14.5	8.8	12.2	2.6	<0.5	8.3
	9.0	31.2	14.2	7.2	8.6	0.8	<0.5	8.2
	18.0	33.0	14.9	6.8	10.4	3.2	<0.5	8.2
33	0.9	28.8	16.1	8.6	9.0	3.2	<0.5	8.3
	9.5	31.0	14.3	8.4	4.0	<0.1	<0.5	8.3
	18.9	33.1	15.9	7.7	5.0	<0.1	<0.5	8.2
36	0.7	30.9	14.8	8.6	4.6	0.6	<0.5	8.3
	9.5	33.2	14.3	8.4	0.8	0.2	<0.5	8.3
	18.9	34.5	15.9	7.7	2.8	<0.1	<0.5	8.2
39	0.7	29.6	14.8	8.6	3.4	<0.1	<0.5	8.6
	9.5	32.8	15.2	8.6	3.0	0.8	<0.5	8.4
	18.4	34.1	14.5	7.6	3.0	<0.1	<0.5	8.2

Table 3-4. Selected water quality parameters at Bryan Mound Disposal site and control sites.

March 25, 1980

Sta. No.	Depth m	Salinity °/oo	Temp. °C	D.O. mg/1	TSS mg/1	VSS mg/1	O&G mg/1	pH
D10	0.5	26.1	15.5	7.0	7.6	4.0	<0.5	7.3
	9.0	31.5	16.0	6.9	17.0	8.2	<0.5	7.6
	18.0	32.9	16.0	7.2	22.2	7.2	5.9	7.5
D11	0.5	28.1	15.5	7.8	13.0	5.6	<0.5	7.6
	9.4	29.5	15.5	7.8	12.6	3.4	8.3	7.7
	18.8	32.9	16.0	7.6	24.3	4.2	10.4	8.0
D12	0.5	28.1	16.0	7.6	3.4	2.6	10.1	7.9
	9.0	29.5	16.0	7.8	15.8	4.6	9.8	7.5
	18.0	31.5	17.0	7.9	1.8	2.2	<0.5	8.0
D13	0.5	30.2	16.0	8.3	15.2	5.4	<0.5	8.2
	9.1	30.2	15.5	7.9	1.8	1.8	<0.5	8.2
	18.3	33.6	16.0	7.8	32.3	11.3	<0.5	8.2
D14	0.5	29.5	16.0	8.3	17.4	10.4	11.4	8.0
	9.2	30.2	15.5	7.7	18.6	10.0	13.2	8.0
	18.5	33.6	16.0	7.8	23.0	12.8	14.0	8.0
D15	0.5	29.5	15.5	8.2	10.2	3.4	0.5	8.1
	9.2	29.5	16.0	8.1	2.2	2.2	12.2	8.1
	18.5	33.6	16.0	7.6	7.6	5.0	12.3	8.1
D16	0.5	29.5	16.0	8.2	13.8	6.4	8.9	8.2
	9.1	30.2	16.0	8.2	12.2	5.6	0.5	8.4
	18.3	34.2	16.0	7.7	11.0	3.6	0.5	8.6
D17	0.5	30.2	15.5	8.1	14.8	6.4	<0.5	7.5
	9.4	30.8	16.0	8.2	7.4	4.0	8.1	8.2
	18.8	34.2	16.0	8.0	25.2	8.8	11.9	7.7
D18	0.5	30.2	15.5	8.4	4.8	0.6	0.5	8.4
	9.4	30.2	16.0	8.2	7.4	4.0	8.1	8.2
	18.9	34.2	16.0	7.5	9.2	2.4	14.0	8.4
D19	0.5	28.8	15.5	8.3	9.2	5.6	0.7	7.9
	9.0	28.8	15.5	8.1	2.0	1.6	<0.5	8.0
	18.3	32.9	16.0	7.8	24.2	7.8	6.5	8.0
D20	0.5	29.5	16.0	8.1	4.0	5.8	<0.5	---
	9.2	29.5	16.0	8.3	4.8	3.8	<0.5	---
	18.5	34.9	16.0	7.5	23.5	6.5	0.5	---

Table 3-4. Selected water quality parameters at Bryan Mound Disposal site and control sites (continued).

March 25, 1980

Sta. No.	Depth m	Salinity °/oo	Temp. °C.	D.O. mg/1	TSS mg/1	VSS mg/1	O&G mg/1	pH
D21	0.5	29.5	15.5	8.2	4.0	2.2	12.9	8.2
	9.6	29.5	15.5	8.0	12.6	5.8	<0.5	8.0
	19.3	33.6	16.0	7.6	36.0	8.2	0.5	8.2
15	0.5	27.5	16.0	8.2	35.7	9.7	0.7	8.4
	9.0	28.1	16.0	8.0	9.4	4.8	8.4	8.4
	18.0	27.3	16.0	7.8	177.0	44.0	<0.5	8.4
33	0.5	31.5	16.0	8.3	10.6	7.8	12.6	7.9
	9.2	31.5	16.0	8.5	7.8	5.0	8.6	8.0
	18.5	34.2	16.0	7.7	5.4	2.8	9.3	8.3
36	0.5	33.6	16.0	8.1	20.4	7.6	<0.5	7.6
	9.8	33.6	16.0	8.0	5.8	2.8	<0.5	7.8
	19.7	34.2	16.0	8.0	19.0	9.4	10.5	7.9
39	0.5	28.8	16.0	8.5	8.6	4.8	<0.5	7.9
	9.2	28.8	16.0	8.1	12.2	5.2	0.5	8.0
	18.4	32.9	16.0	7.1	43.0	10.5	<0.5	7.9

Table 3-5. Selected water quality parameters at Bryan Mound disposal site and control sites.

April 7, 1980

Sta. No.	Depth (M)	Salinity $^{o}/oo$	Temp. (^{o}C)	D.O. (mg/l)	TSS (mg/l)	VSS (mg/l)	O&G (mg/l)	pH
D10	0.5	31.5	18.8	8.4	8.0	3.2	<0.5	8.2
	10.3	33.5	17.7	8.1	8.2	2.2	<0.5	8.1
	20.0	33.7	17.9	7.5	6.0	3.0	0.5	8.2
D11	0.3	28.0	19.9	8.2	2.0	1.2	2.7	8.3
	9.4	33.5	17.8	6.4	5.0	4.4	0.5	8.2
	19.4	36.2	17.9	7.6	4.2	1.4	0.5	8.1
D12	0.3	29.4	20.1	8.0	4.0	2.0	<0.5	8.2
	9.5	33.4	18.0	7.6	11.6	4.0	<0.5	8.2
	19.6	36.2	17.9	7.6	15.8	4.4	<0.5	8.1
D13	0.1	32.8	19.3	7.8	3.2	1.2	0.5	8.2
	8.6	33.7	17.8	7.5	13.4	2.6	<0.5	8.2
	19.8	36.9	18.0	7.6	4.6	0.6	0.5	8.2
D14	0.6	33.1	18.8	7.6	1.4	0.4	0.8	8.2
	9.6	33.7	17.8	7.6	5.0	0.8	<0.5	8.2
	19.8	36.9	18.0	7.6	15.6	4.4	0.5	8.2
D15	1.0	33.4	18.4	7.6	6.8	2.6	0.6	8.2
	9.8	33.7	17.8	7.7	2.8	1.8	<0.5	8.2
	18.8	36.6	17.9	7.6	13.0	4.4	0.5	8.1
D16	0.3	32.8	18.8	8.1	8.0	4.4	<0.5	8.2
	9.5	33.6	17.8	7.6	1.0	0.4	<0.5	8.2
	18.8	35.8	18.0	7.6	4.8	3.6	0.8	8.2
D17	0.2	32.3	19.0	7.7	10.8	2.8	0.7	8.2
	9.8	33.6	17.8	7.7	5.0	0.8	0.6	8.2
	19.0	36.2	17.8	7.6	9.2	4.6	0.6	8.1
D18	0.3	31.7	19.7	7.8	3.2	1.6	0.7	8.2
	9.5	33.6	17.8	7.8	3.4	0.8	<0.5	8.2
	19.0	35.7	17.8	—	6.4	1.2	<0.5	8.1
D19	0.5	30.6	18.7	7.5	1.6	0.6	<0.5	8.2
	10.2	33.5	17.7	7.7	0.2	0.2	0.5	8.1
	20.0	33.6	17.8	7.4	8.6	2.6	0.5	8.1
D20	0.8	33.4	18.2	8.5	0.6	0.2	<0.5	8.2
	9.2	33.7	17.8	7.9	6.2	5.0	0.6	8.2
	19.3	36.5	17.9	6.2	3.8	0.2	<0.5	8.1

Table 3-5. Selected water quality parameters at Bryan Mound disposal site and control sites (continued).

April 7, 1980

Sta. No.	Depth (M)	Salinity °/oo	Temp. (°C)	D.O. (mg/1)	TSS (mg/1)	VSS (mg/1)	O&G (mg/1)	pH
D21	0.4	31.4	19.5	7.5	4.8	2.4	0.6	8.2
	10.0	33.6	17.8	7.8	11.0	3.6	3.7	8.2
	18.4	34.0	18.0	7.9	12.2	3.4	0.7	8.2
15	0.8	26.7	18.9	8.6	4.4	3.0	<0.5	8.3
	8.0	32.3	18.2	7.5	6.4	3.0	<0.5	8.2
	17.7	33.3	17.9	7.0	17.0	6.0	<0.5	8.1
33	0.4	33.1	18.4	7.9	4.6	1.2	0.6	8.2
	10.4	34.0	18.0	7.6	5.0	1.6	0.7	8.2
	19.6	34.2	18.1	8.0	14.6	3.2	<0.5	8.0
36	0.3	33.6	18.5	8.3	3.0	2.6	0.8	8.2
	10.0	34.3	18.1	7.6	1.8	1.6	0.6	8.2
	20.9	34.5	18.1	7.8	10.6	6.2	0.5	8.2
39	1.4	30.9	19.6	8.2	8.8	4.2	0.6	8.2
	8.8	33.9	18.0	7.8	4.2	2.4	<0.5	8.2
	17.3	34.0	18.0	7.5	10.8	5.6	0.5	8.2

values over 5 mg/l were found at stations D11, D12, D14, D15, D17 and D18. These stations cover the shoreward side of the diffuser area and lie in a northeast-southwest direction. At the surface, values over 5 mg/l were found only at stations D12, D14, D16 and D21. These stations lie in an east-west direction. It would appear that the observed oil and grease had its origin near the bottom and diminshed toward the surface, undergoing a clockwise orientation or spiral as it rose. This pattern would not be unexpected if the oil and grease had been released at the diffuser and rose toward the surface under the oceanographic conditions existing at that time.

However, it should be noted that high levels of oil and grease were also observed in bottom and/or mid waters at three of the control stations (15, 33 and 36) and at the surface at one of the control stations (33). Therefore, it cannot be determined whether this oil and grease had its origin at the diffuser (possibly from cleanout of the pipeline and associated equipment) or resulted from some other source either within or outside of this general area of the coast. Since the term "oil and grease" covers a broad range of organics soluble in the Freon solvent, it is not possible to determine the nature of this material without specific analyses of large volume samples. However, as Table 3-5 indicates, by April 7 the oil and grease levels had dropped below 5 mg/l and with only 2 exceptions below 1 mg/l. This suggests that whatever the source it was not of a continuous nature.

Results of nutrient analyses for this period are given in Tables 3-6 through 3-8. Although values for the various forms of nitrogen and phosphorus continue to be low, there were slight increases over preceding months. These slight changes are not a result of brine discharge but are

Table 3-6. Nutrients in water column at Bryan Mound Disposal site and control sites.

February 29, 1980

Sta. No.	Depth m	NO_3-N mg/l	NO_2-N mg/l	NH_3-N mg/l	O-PO_4-P mg/l	Total P mg/l	SiO_2 mg/l
D10	0.5	<0.01	<0.01	<0.01	<0.01	0.03	0.3
	9.2	<0.01	<0.01	<0.01	<0.01	0.04	<0.1
	18.8	<0.01	<0.01	<0.01	0.02	0.01	0.1
D11	0.7	0.01	<0.01	<0.01	<0.01	0.01	0.1
	9.5	<0.01	<0.01	0.04	<0.01	<0.01	<0.1
	18.8	<0.01	<0.01	0.01	<0.01	0.01	0.1
D12	0.5	<0.01	<0.01	0.04	<0.01	0.01	0.5
	8.7	<0.01	<0.01	<0.01	<0.01	0.01	0.1
	18.6	<0.01	<0.01	<0.01	<0.01	0.01	0.3
D13	0.8	<0.01	<0.01	<0.01	<0.01	0.03	0.3
	9.6	0.01	<0.01	<0.01	<0.01	0.01	0.1
	18.3	<0.01	<0.01	<0.01	0.01	0.02	0.1
D14	0.7	<0.01	<0.01	0.02	<0.01	0.02	0.1
	9.3	<0.01	<0.01	0.05	<0.01	0.03	0.1
	18.3	<0.01	<0.01	<0.01	0.01	0.02	0.1
D15	0.5	<0.01	<0.01	<0.01	<0.01	0.01	0.1
	9.2	<0.01	<0.01	<0.01	<0.01	0.01	0.4
	18.5	0.01	<0.01	<0.01	0.02	0.01	0.3
D16	0.8	<0.01	<0.01	0.01	0.02	0.02	0.5
	9.2	<0.01	<0.01	<0.01	<0.01	0.01	0.1
	18.3	<0.01	<0.01	<0.01	<0.01	0.06	0.3
D17	0.9	<0.01	<0.01	0.01	<0.01	0.03	0.5
	9.3	<0.01	<0.01	<0.01	<0.01	0.05	<0.1
	18.5	0.01	<0.01	0.01	<0.01	0.03	0.5
D18	0.9	<0.01	<0.01	<0.01	<0.01	0.02	0.1
	9.0	<0.01	<0.01	<0.01	<0.01	0.01	0.5
	18.9	<0.01	<0.01	<0.01	<0.01	0.01	<0.1
D19	1.0	<0.01	<0.01	0.01	<0.01	0.01	0.1
	9.0	<0.01	<0.01	<0.01	<0.01	0.01	0.1
	18.9	<0.01	<0.01	<0.01	<0.01	0.01	0.5

Table 3-6. Nutrients in water column at Bryan Mound Disposal site and control sites (continued)

February 29, 1980

Sta. No.	Depth m	NO_3-N mg/l	NO_2-N mg/l	NH_3-N mg/l	O-PO_4-P mg/l	Total P mg/l	SiO_2 mg/l
D20	0.5	<0.01	<0.01	0.03	<0.01	0.02	0.1
	10.0	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
	18.5	<0.01	<0.01	<0.01	<0.01	0.02	0.1
D21	0.7	0.01	<0.01	<0.01	<0.01	0.03	0.1
	9.5	<0.01	<0.01	<0.01	---	0.01	0.2
	19.3	<0.01	<0.01	<0.01	<0.01	0.01	<0.1
15	0.5	<0.01	<0.01	<0.01	<0.01	0.03	0.1
	9.0	<0.01	<0.01	<0.01	<0.01	0.04	0.3
	18.0	0.01	<0.01	<0.01	<0.01	0.03	0.2
33	0.9	<0.01	<0.01	<0.01	0.02	0.01	0.3
	9.5	<0.01	<0.01	<0.01	<0.01	0.01	<0.1
	18.9	<0.01	<0.01	<0.01	<0.01	0.03	0.5
36	0.7	<0.01	<0.01	<0.01	<0.01	0.01	0.1
	9.5	<0.01	<0.01	<0.01	<0.01	0.07	<0.1
	18.9	<0.01	<0.01	<0.01	<0.01	0.01	0.1
39	0.7	<0.01	<0.01	<0.01	<0.01	0.03	0.1
	9.5	<0.01	<0.01	<0.01	<0.01	0.01	0.3
	18.4	<0.01	<0.01	<0.01	<0.01	0.03	0.1

Table 3-7. Nutrients in water column at Bryan Mound Disposal site and control sites.

March 25, 1980

Sta No.	Depth m	NO_3-N mg/l	NO_2-N mg/l	NH_3-N mg/l	O-PO_4-P mg/l	Total P mg/l	SiO_2 mg/l
D10	0.5	0.01	<0.01	0.03	0.01	0.01	0.6
	9.0	0.01	<0.01	0.09	0.01	<0.01	0.3
	18.0	<0.01	<0.01	0.01	0.03	<0.01	0.6
D11	0.5	<0.01	<0.01	0.05	0.02	<0.01	0.6
	9.4	<0.01	<0.01	0.01	0.01	<0.01	0.2
	18.8	0.01	<0.01	<0.01	0.01	0.01	0.7
D12	0.5	0.01	<0.01	0.02	<0.01	<0.01	0.1
	9.0	0.01	<0.01	<0.01	<0.01	<0.01	0.6
	18.0	<0.01	<0.01	<0.01	0.03	<0.01	0.6
D13	0.5	0.02	<0.01	0.03	0.01	<0.01	0.6
	9.1	0.01	<0.01	0.04	<0.01	<0.01	0.5
	18.3	<0.01	0.01	0.06	0.02	0.01	1.0
D14	0.5	<0.01	<0.01	0.01	<0.01	<0.01	0.6
	9.2	0.01	<0.01	0.01	<0.01	<0.01	0.4
	18.3	<0.01	<0.01	0.03	0.01	<0.01	0.9
D15	0.5	0.01	<0.01	0.02	<0.01	<0.01	0.5
	9.2	0.01	<0.01	<0.01	0.01	<0.01	0.5
	18.5	<0.01	<0.01	0.05	0.01	<0.01	0.5
D16	0.5	<0.01	<0.01	0.11	0.01	<0.01	0.5
	9.1	0.05	<0.01	0.11	0.01	<0.01	0.4
	18.8	0.01	<0.01	0.01	0.01	0.01	0.4
D17	0.5	<0.01	<0.01	0.07	0.01	<0.01	0.6
	9.4	<0.01	<0.01	0.03	0.01	<0.01	0.4
	18.8	<0.01	<0.01	0.01	0.01	0.01	0.4
D18	0.5	<0.01	<0.01	0.01	0.01	<0.01	0.5
	9.4	<0.01	<0.01	0.09	0.01	<0.01	0.4
	18.9	0.01	<0.01	0.03	0.01	<0.01	0.4
D19	0.5	0.01	<0.01	0.01	<0.01	<0.01	0.8
	9.0	0.05	<0.01	0.05	0.06	<0.01	0.5
	18.3	0.01	<0.01	0.03	0.03	<0.01	0.4
D20	0.5	0.01	<0.01	0.02	0.01	<0.01	0.5
	9.2	0.01	<0.01	<0.01	<0.01	<0.01	0.3
	18.5	<0.01	<0.01	0.02	0.01	<0.01	0.5

Table 3-7. Nutrients in water column at Bryan Mound Disposal site and control sites (continued).

March 25, 1980

Sta. No.	Depth m	NO_3-N mg/1	NO_2-N mg/1	NH_3-N mg/1	O-PO_4-P mg/1	Total P mg/1	SiO_2 mg/1
D21	0.5	0.01	<0.01	0.02	0.01	<0.01	0.5
	9.6	0.01	<0.01	0.02	0.01	0.01	0.4
	19.3	0.01	<0.01	0.02	0.02	0.03	0.7
15	0.5	0.02	<0.01	0.02	0.03	0.03	1.2
	9.0	0.02	<0.01	0.03	0.04	0.04	1.7
	18.0	0.02	<0.01	0.10	0.01	0.20	4.5
33	0.5	<0.01	<0.01	0.02	0.04	<0.01	0.3
	9.2	<0.01	<0.01	0.02	<0.01	<0.01	0.2
	18.5	<0.01	<0.01	0.02	<0.01	<0.01	0.2
36	0.5	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
	9.8	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
	19.7	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
39	0.5	0.01	<0.01	0.01	0.01	<0.01	0.7
	9.2	0.01	<0.01	0.05	0.01	0.01	0.7
	18.4	0.01	<0.01	0.07	0.06	0.05	1.8

Table 3-8. Nutrients in water column at Bryan Mound disposal site and control sites.

April 7, 1980

Sta. No.	Depth (M)	NO_3-N (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	O-PO_4-P (mg/l)	Total P (mg/l)	SiO_2 (mg/l)
D10	0.5	0.04	<0.01	0.01	<0.01	0.01	0.6
	10.3	<0.01	<0.01	0.01	<0.01	0.03	0.1
	20.0	0.01	<0.01	<0.01	<0.01	0.01	0.1
D11	0.3	0.03	<0.01	<0.01	<0.01	0.01	0.1
	9.4	0.01	<0.01	<0.01	0.01	<0.01	0.1
	19.4	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
D12	0.3	0.04	<0.01	<0.01	<0.01	<0.01	0.1
	9.5	<0.01	<0.01	<0.01	<0.01	0.01	0.2
	19.6	<0.01	<0.01	0.01	<0.01	0.01	0.3
D13	0.1	<0.01	<0.01	<0.01	<0.01	0.01	0.1
	8.6	<0.01	<0.01	<0.01	<0.01	0.01	0.1
	19.8	<0.01	<0.01	<0.01	0.01	0.01	0.1
D14	0.6	<0.01	<0.01	<0.01	0.01	0.06	0.1
	9.6	0.01	<0.01	<0.01	<0.01	<0.01	0.1
	18.9	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
D15	1.0	<0.01	<0.01	<0.01	<0.01	0.01	0.4
	9.8	<0.01	<0.01	<0.01	<0.01	<0.01	0.4
	18.8	<0.01	<0.01	<0.01	<0.01	0.03	0.1
D16	0.3	<0.01	<0.01	<0.01	<0.01	0.01	0.2
	9.5	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
	18.8	<0.01	<0.01	<0.01	0.01	0.03	0.1
D17	0.2	<0.01	<0.01	<0.01	<0.01	0.01	0.1
	9.8	<0.01	<0.01	0.04	<0.01	<0.01	0.1
	19.0	<0.01	<0.01	0.01	<0.01	0.01	0.1
D18	0.3	0.01	<0.01	<0.01	<0.01	<0.01	0.1
	9.5	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
	19.0	<0.01	<0.01	0.01	<0.01	0.01	0.1
D19	0.5	0.02	<0.01	0.02	<0.01	<0.01	0.1
	10.2	0.01	<0.01	<0.01	<0.01	0.01	0.7
	20.0	<0.01	<0.01	<0.01	<0.01	0.01	0.1
D20	0.8	<0.01	<0.01	<0.01	<0.01	0.01	0.5
	9.2	<0.01	<0.01	<0.01	<0.01	0.01	0.1
	19.3	<0.01	<0.01	<0.01	<0.01	0.01	0.1

Table 3-8. Nutrients in water column at Bryan Mound disposal site and control sites (continued).

April 7, 1980

Sta. No.	Depth m	NO_3-N (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	O-PO_4-P (mg/l)	Total P (mg/l)	SiO_2 (mg/l)
D21	0.4	<0.01	<0.01	<0.01	<0.01	0.01	0.1
	10.0	<0.02	<0.01	<0.01	0.01	0.01	0.3
	18.4	0.01	<0.01	<0.01	<0.01	0.01	0.3
15	0.8	<0.01	<0.01	<0.01	0.01	0.01	1.2
	8.0	<0.01	<0.01	<0.01	<0.01	0.01	0.4
	17.7	0.05	<0.01	0.02	<0.01	<0.01	0.1
33	0.4	0.01	<0.01	<0.01	<0.01	0.01	0.1
	10.4	<0.01	<0.01	<0.01	<0.01	0.01	0.1
	19.6	<0.01	<0.01	0.03	0.01	0.06	0.1
36	0.3	0.04	<0.01	0.04	<0.01	0.01	0.1
	10.0	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
	20.9	<0.01	<0.01	0.03	<0.01	<0.01	0.1
36	1.4	0.03	<0.01	0.02	<0.01	0.01	0.1
	8.8	0.01	<0.01	<0.01	0.01	0.03	0.5
	17.3	0.01	<0.01	<0.01	<0.01	0.01	0.1

expected at this time of year and result from winter nutrient regeneration and spring runoff. This is also reflected in the higher silica values observed for March 25 and April 7.

3.2.2 Major Ions and Heavy Metals in Water Column

In addition to the general water quality parameters mentioned above (3.2.1), the major ions making up the bulk of the salts both in sea water and in the brine were measured in water samples collected on all three sample dates. These analyses are presented in Tables 3-9 through 3-11. From this data, it is apparent that the only change observed for the diffuser area (stations D10 through D21) relative to the offshore control stations (33, 36 and 39) were on April 7. If we divide the diffuser area into the near field diffuser stations (D13, D14, D15 and D20), the downcoast intermediate field diffuser stations (D10, D11, D12 and D19) and the upcoast intermediate field diffuser stations (D16, D17, D18 and D21) we can then compare the bottom waters of these areas of the diffuser with the control or ambient bottom waters (33, 36 and 39). This comparison for the mean values of these parameters for April 7, 1980 along with the standard deviations (s) observed for them in the diffuser grid during the three background sampling periods is as follows:

	diffuser	downcoast	upcoast	ambient	s
Na^{+} (g/l)	10.20	10.00	10.02	9.97	0.56
K^{+} (g/l)	0.410	0.414	0.404	0.407	0.014
Ca^{++} (g/l)	0.380	0.388	0.380	0.373	0.017
Mg^{++} (g/l)	1.09	1.04	1.08	1.04	0.055
Cl^{--} (g/l)	19.88	18.95	19.22	19.07	0.66
SO_4^{--} (g/l)	2.99	2.97	3.01	2.98	0.15

Table 3-9. Major ionic species in water column at Bryan Mound Disposal site and control sites

February 29, 1980

Sta. No.	Depth m	S^o/oo	Na g/1	K g/1	Ca g/1	Mg g/1	Cl g/1	SO_4 g/1	Br mg/1	I mg/1
D10	0.5	29.8	7.8	0.321	0.35	0.96	16.8	2.30	54.3	0.22
	9.2	32.3	9.0	0.347	0.37	1.10	17.9	2.40	60.2	0.21
	18.8	34.2	9.6	0.374	0.39	1.17	18.6	2.20	62.8	0.19
D11	0.7	29.9	7.6	0.326	0.34	1.01	16.0	2.25	-	-
	9.5	32.2	8.4	0.358	0.37	1.22	18.4	2.40	60.1	0.13
	18.8	33.9	10.5	0.379	0.38	1.19	18.6	2.45	64.5	0.19
D12	0.5	29.6	9.4	0.329	0.35	1.03	16.0	2.25	51.9	0.21
	8.7	32.3	9.0	0.353	0.33	1.14	17.4	2.35	60.4	0.21
	18.6	32.9	9.0	0.384	0.39	1.17	18.9	2.60	64.5	0.19
D13	0.8	30.4	7.4	0.337	0.36	1.03	15.4	2.25	55.0	0.21
	9.6	32.3	7.8	0.347	0.39	1.14	19.0	2.45	56.4	0.21
	18.3	34.2	7.6	0.374	0.40	1.22	18.9	2.40	65.1	0.17
D14	0.9	29.9	7.8	0.332	0.36	1.07	16.6	2.40	58.0	0.24
	9.3	32.6	10.1	0.353	0.38	1.12	17.5	2.45	60.6	0.27
	18.3	33.8	9.2	0.368	0.39	1.17	18.6	2.60	-	0.21
D15	0.5	30.4	9.4	0.332	0.36	1.04	16.2	2.35	55.8	0.21
	9.2	32.4	9.4	0.358	0.38	1.17	17.9	2.60	59.2	0.21
	18.5	34.0	8.7	0.363	0.39	1.22	19.0	2.90	61.0	0.19
D16	0.8	30.2	7.8	0.314	0.34	1.10	16.2	2.20	56.5	0.19
	9.2	32.2	7.8	0.329	0.36	1.14	17.9	2.45	60.7	0.16
	18.3	34.4	9.0	0.344	0.36	1.17	16.6	2.55	63.7	0.21
D17	0.9	30.1	8.3	0.304	0.34	1.03	17.0	2.55	53.7	0.21
	9.3	32.4	9.0	0.329	0.35	1.14	17.6	2.40	59.2	0.17
	18.5	33.9	8.7	0.349	0.38	1.22	18.9	2.45	62.8	0.19
D18	0.9	30.5	7.8	0.353	0.34	1.07	16.5	2.75	54.2	0.19
	9.0	32.6	9.0	0.412	0.37	1.17	18.9	2.50	64.0	0.19
	18.9	34.0	8.8	0.344	0.36	1.17	18.6	2.75	60.0	0.21
D19	1.0	31.2	7.8	0.305	0.33	1.03	16.5	2.35	58.8	0.19
	9.0	32.3	9.0	0.347	0.36	1.14	16.7	2.55	62.8	0.24
	18.9	34.2	8.7	0.358	0.37	1.17	18.7	2.55	64.5	0.21
D20	0.5	30.1	8.1	0.334	0.33	1.07	15.7	2.35	54.9	0.17
	10.0	32.6	8.4	0.347	0.35	1.10	17.8	2.50	59.3	0.21
	18.5	33.6	9.1	0.379	0.36	1.17	18.6	2.85	62.5	0.16

Table 3-9. Major ionic species in water column at Bryan Mound Disposal site and control sites (continued).

February 29, 1980

Sta. No.	Depth m	S^o/oo	Na g/l	K g/l	Ca g/l	Mg g/l	Cl g/l	SO_4 g/l	Br mg/l	I mg/l
D21	0.7	30.9	8.4	0.304	0.33	1.07	16.4	2.25	55.4	0.22
	9.5	32.5	8.7	0.341	0.36	1.14	17.8	2.45	59.9	0.17
	19.3	33.9	8.4	0.331	0.36	1.17	18.8	2.55	63.0	0.32
15	0.5	29.6	7.8	0.340	0.34	1.03	15.8	2.30	53.5	0.22
	9.0	31.2	8.7	0.369	0.35	1.14	--	2.40	61.0	0.21
	18.0	33.0	7.4	0.338	0.34	1.03	18.9	2.15	55.2	0.21
33	0.9	28.8	7.1	0.320	0.32	1.07	16.1	2.15	55.2	0.17
	9.5	31.0	7.9	0.338	0.35	1.07	17.2	2.15	60.0	0.19
	18.9	33.8	8.5	0.357	0.36	1.07	19.1	2.40	63.7	0.21
36	0.7	30.9	9.5	0.313	0.34	1.07	16.8	2.10	57.7	0.19
	9.5	33.2	8.2	0.340	0.36	1.17	18.9	2.45	62.3	0.21
	18.9	34.5	8.2	0.340	0.37	1.19	19.5	2.45	62.8	0.17
39	0.7	29.6	6.5	0.287	0.33	1.03	16.5	2.35	52.8	0.24
	9.5	32.8	6.8	0.313	0.34	1.07	16.8	2.95	56.3	0.22
	18.4	34.1	7.8	0.327	0.36	1.17	19.6	2.30	71.3	0.21

Table 3-10. Major ionic species in water column at Bryan Mound Disposal site and control sites.

March 25, 1980

Sta. No.	Depth m	S^{o}/oo	Na g/l	K g/l	Ca g/l	Mg g/l	Cl g/l	SO_4 g/l	Br mg/l	I mg/l
D10	0.5	26.1	9.2	0.340	0.372	0.99	16.2	2.50	58.2	0.19
	9.0	31.5	10.6	0.353	0.376	1.15	17.4	2.60	60.6	0.24
	18.0	32.9	11.0	0.370	0.406	1.22	18.9	3.00	62.2	0.19
D11	0.5	28.1	9.2	0.334	0.372	1.09	16.8	2.55	54.8	0.24
	9.4	29.5	10.6	0.353	0.388	1.15	17.7	2.75	60.8	0.24
	18.8	32.9	10.4	0.370	0.440	1.28	18.8	2.85	62.5	0.22
D12	0.5	28.1	9.4	0.367	0.388	1.15	16.8	2.75	57.7	0.22
	9.0	29.5	10.0	0.334	0.406	1.22	18.1	2.85	58.9	0.22
	18.0	31.5	10.6	0.360	0.428	1.22	19.2	3.00	61.3	0.22
D13	0.5	30.2	9.6	0.334	0.368	1.09	16.9	2.75	53.7	0.22
	9.1	30.2	9.8	0.340	0.362	1.09	17.4	2.75	56.2	0.22
	18.3	33.6	10.6	0.367	0.394	1.12	18.0	2.90	62.5	0.22
D14	0.5	29.5	9.2	0.334	0.362	1.02	17.5	2.35	55.4	0.24
	9.2	30.2	9.8	0.340	0.368	1.06	17.9	2.35	55.8	0.24
	18.5	32.9	9.8	0.360	0.400	1.15	18.5	2.75	59.6	0.21
D15	0.5	29.5	10.2	0.327	0.363	1.02	16.8	2.40	55.5	0.23
	9.2	29.5	10.3	0.334	0.362	1.06	17.3	2.45	55.8	0.24
	18.5	33.6	11.0	0.367	0.394	1.15	18.2	3.00	59.0	0.21
D16	0.5	29.5	10.3	0.337	0.362	1.09	16.2	2.55	56.6	0.29
	9.1	30.2	10.6	0.340	0.372	1.02	16.7	2.50	52.9	0.22
	18.3	34.2	11.4	0.360	0.406	1.15	18.4	2.90	64.5	0.22
D17	0.5	30.2	10.0	0.334	0.36	1.02	16.7	2.60	55.9	0.22
	9.4	30.8	10.6	0.334	0.36	1.09	17.1	2.40	56.8	0.25
	18.8	34.2	11.4	0.370	0.39	1.22	19.1	2.55	60.2	0.21
D18	0.5	30.2	10.0	0.334	0.36	1.02	16.7	2.50	52.5	0.21
	9.4	30.2	10.2	0.340	0.37	1.09	16.9	2.75	57.9	0.27
	18.9	34.2	10.6	0.367	0.39	1.22	18.7	3.00	58.6	0.22
D19	0.5	28.8	9.6	0.340	0.36	1.06	17.0	2.00	52.6	0.24
	9.0	28.8	10.0	0.347	0.37	1.09	17.5	2.90	58.0	0.24
	18.3	32.9	10.6	0.367	0.39	1.15	18.6	2.75	64.5	0.25
D20	0.5	29.5	9.6	0.334	0.36	1.06	16.5	2.35	62.9	0.27
	9.2	29.5	10.6	0.347	0.37	1.02	17.6	2.25	50.7	0.27
	18.5	34.9	10.4	0.367	0.39	1.15	18.7	3.00	64.2	0.24

Table 3-10. Major ionic species in water column at Bryan Mound Disposal site and control sites (continued).

March 25, 1980

Sta. No.	Depth m	S^{o}/oo	Na g/1	K g/1	Ca g/1	Mg g/1	Cl g/1	SO_4 g/1	Br mg/1	I mg/1
D21	0.5	29.5	9.6	0.340	0.36	1.06	16.8	2.75	53.6	0.24
	9.6	29.5	10.6	0.334	0.36	1.02	17.6	2.50	55.9	0.22
	19.3	33.6	10.4	0.367	0.39	1.18	18.7	2.20	57.5	0.19
15	0.5	27.5	9.5	0.320	0.34	0.96	15.5	1.95	57.4	0.25
	9.0	28.1	9.8	0.313	0.34	0.90	16.0	1.90	51.6	0.30
	18.0	27.3	9.6	0.313	0.35	0.96	15.7	2.25	50.8	0.24
33	0.5	31.5	9.9	0.347	0.38	1.02	17.4	2.60	54.8	0.22
	9.2	31.5	10.2	0.353	0.39	1.09	18.0	2.65	59.0	0.19
	18.5	34.2	11.8	0.367	0.41	1.28	18.7	2.85	64.8	0.22
36	0.5	33.6	10.6	0.367	0.40	1.25	18.6	3.00	60.2	0.19
	9.8	33.6	10.6	0.367	0.40	1.28	19.0	3.15	65.5	0.22
	19.7	34.2	10.6	0.367	0.40	1.31	19.5	3.00	65.2	0.24
39	0.5	28.8	10.1	0.313	0.34	1.22	15.8	2.25	54.8	0.29
	9.2	28.8	10.0	0.327	0.35	1.06	16.9	2.65	54.0	0.22
	18.4	32.9	10.6	0.347	0.38	1.15	17.8	3.00	60.9	0.25

Table 3-11. Major ionic species in water column at Bryan Mound Disposal site and control sites.

April 7, 1980

Sta. No.	Depth m	S^{o}/oo	Na g/l	K g/l	Ca g/l	Mg g/l	Cl g/l	SO_4 g/l	Br mg/l	I mg/l
D10	0.5	31.5	9.1	0.355	0.42	0.81	15.9	2.70	52.7	0.27
	10.3	33.5	9.7	0.406	0.41	0.95	19.2	3.00	60.9	0.24
	20.0	33.7	9.8	0.406	0.41	0.97	18.9	3.08	61.9	0.27
D11	0.3	28.0	8.8	0.355	0.40	0.88	16.8	2.50	55.1	0.30
	9.4	33.5	9.9	0.406	0.40	1.00	18.3	2.80	60.4	0.25
	19.4	36.2	10.0	0.426	0.40	1.01	18.7	2.90	62.1	0.27
D12	0.3	29.4	9.4	0.368	0.40	0.92	17.3	2.70	53.4	0.25
	9.5	33.4	9.7	0.394	0.39	1.02	18.9	2.80	58.1	0.21
	19.6	36.2	10.2	0.419	0.37	1.10	19.1	2.95	60.7	0.25
D13	0.1	32.8	10.3	0.400	0.36	1.04	18.4	2.92	61.2	0.27
	8.6	33.7	10.3	0.406	0.38	1.07	18.8	2.90	57.3	0.30
	19.8	36.9	10.0	0.406	0.38	1.09	19.1	2.95	63.3	0.33
D14	0.6	33.1	9.9	0.400	0.38	1.04	18.9	2.80	61.4	0.30
	9.6	33.7	10.0	0.406	0.38	1.07	19.1	2.98	61.8	0.32
	18.9	36.7	10.6	0.413	0.38	1.09	20.1	3.05	64.2	0.22
D15	1.0	33.4	9.7	0.400	0.38	1.02	18.9	2.80	56.4	0.32
	9.8	33.7	9.6	0.410	0.37	1.09	19.1	2.90	64.2	0.24
	18.8	36.6	10.1	0.413	0.38	1.10	19.7	3.00	55.5	0.30
D16	0.3	32.8	9.7	0.387	0.35	1.01	18.2	2.90	59.6	0.33
	9.5	33.6	10.0	0.410	0.36	1.09	18.4	2.90	62.9	0.24
	18.8	35.8	10.2	0.400	0.37	1.11	19.1	3.08	63.5	0.24
D17	0.2	32.3	9.6	0.387	0.36	0.94	18.0	2.60	62.4	0.27
	9.8	33.6	9.6	0.410	0.37	1.00	18.7	2.90	61.4	0.24
	19.0	36.2	10.0	0.406	0.38	1.02	20.0	2.95	60.3	0.27
D18	0.3	31.7	9.5	0.374	0.40	0.94	17.0	2.60	59.2	0.24
	9.5	33.6	10.1	0.406	0.38	1.06	19.5	2.95	64.1	0.32
	19.0	35.7	10.0	0.406	0.37	1.09	19.0	2.95	64.4	0.27
D19	0.5	30.6	9.1	0.371	0.36	1.02	17.4	2.80	57.6	0.24
	10.2	33.5	10.0	0.400	0.38	1.00	18.4	2.90	60.4	0.29
	20.0	33.6	10.0	0.406	0.37	1.09	19.1	2.95	61.4	0.25
D20	0.8	33.4	10.0	0.403	0.38	1.06	18.3	2.90	62.8	0.25
	9.2	33.7	10.1	0.406	0.37	1.07	18.8	2.90	64.4	0.30
	19.3	36.5	10.1	0.406	0.38	1.09	20.6	2.95	63.0	0.29

Table 3-11. Major ionic species in water column at Bryan Mound Disposal site and control sites (continued).

April 7, 1980

Sta. No.	Depth m	S^{o}/oo	Na g/l	K g/l	Ca g/l	Mg g/l	Cl g/l	SO_4 g/l	Br mg/l	I mg/l
D21	0.4	31.4	9.5	0.381	0.38	1.00	17.2	2.70	61.2	0.25
	10.0	33.6	10.0	0.400	0.38	1.06	19.0	2.90	61.8	0.19
	18.4	34.0	9.9	0.406	0.36	1.11	18.8	3.05	61.9	0.27
15	0.8	26.7	9.7	0.316	0.37	0.83	14.2	2.40	47.8	0.33
	8.0	32.3	9.9	0.400	0.35	1.09	18.4	2.70	60.3	0.19
	17.7	33.3	10.1	0.387	0.38	1.01	19.0	2.90	56.1	0.33
33	0.4	33.1	9.9	0.394	0.37	1.03	19.4	2.65	60.6	0.26
	10.4	34.0	9.7	0.406	0.38	1.04	20.0	2.90	57.8	0.32
	19.6	34.2	10.0	0.400	0.38	1.04	20.0	3.00	61.4	0.24
36	0.3	33.6	10.0	0.406	0.38	1.07	19.6	2.70	63.8	0.22
	10.0	34.3	10.0	0.410	0.37	1.07	19.8	2.80	65.5	0.24
	20.9	34.5	10.0	0.410	0.37	1.04	18.9	2.95	62.2	0.24
39	1.4	30.9	8.7	0.368	0.333	0.90	16.9	2.50	56.9	0.24
	8.8	33.9	9.7	0.397	0.362	1.01	18.3	2.90	60.9	0.24
	17.3	34.0	9.9	0.410	0.371	1.03	18.3	3.00	63.4	0.27

Br^- (mg/l)	61.5	61.5	62.5	62.3	1.9
I^- (mg/l)	0.28	0.26	0.26	0.25	0.03
S $^o/oo$	36.7	34.9	35.4	34.2	0.3

The standard deviation (s) represents a pooled estimate of errors based upon all background values for the diffuser area bottom waters prior to discharge. This assumes that natural variability of these parameters on a scale smaller than a 1000 ft (305 m) grid are unimportant for this particular area. Based upon these results, it appears that we can detect changes only in salinity (S%) as being different at the diffuser from ambient at $\pm 2s$. The upcoast intermediate field salinity is also significantly different at $\pm 2s$. Since the salinity at the diffuser is about 2½ $^o/oo$ over ambient and since the brine is composed mostly of Na^+ and Cl^-, we might expect these two ions to be close to 1 $^o/oo$ over ambient each. Although Cl^- approaches this, the Na^+ does not. Furthermore, the standard deviation observed for these two ions over the diffuser brid during the background studies would preclude our assuming even a 1 $^o/oo$ increase in each as being significant at $\pm 2s$. We must therefore conclude that at the level of discharge during this period of study, no measurable changes in major ion concentrations across the diffuser grid occurred.

Since it is known that the ratios of several of the major ions to each other are different between seawater and the salt dome brine, their ratios for the water column were also determined. Major cation ratios (Na/K and Ca/Mg) are presented in Table 3-12 and the anion ratios (SO_4/Cl and Br/I) in Table 3-13. Although differences are observed from one sample period to another, they occur at the control stations also and

Table 3-12. Major cation ratios in water column near Bryan Mound diffuser.

Sta. No.	Depth*	Sodium/Potassium February	March	April	Calcium/Magnesium February	March	April
D10	S	24.3	27.1	25.6	0.365	0.375	0.518
	M	25.9	30.0	23.9	0.337	0.327	0.432
	D	25.7	29.7	24.1	0.333	0.334	0.423
D11	S	23.3	27.5	24.8	0.336	0.342	0.452
	M	23.5	30.0	24.4	0.304	0.337	0.399
	D	27.7	28.1	23.5	0.318	0.344	0.395
D12	S	28.6	25.6	25.5	0.339	0.337	0.436
	M	25.5	29.9	24.6	0.289	0.334	0.381
	D	23.4	29.4	24.3	0.333	0.352	0.337
D13	S	22.0	28.7	25.7	0.348	0.354	0.345
	M	22.5	28.8	25.4	0.342	0.349	0.357
	D	20.3	28.9	24.6	0.329	0.347	0.350
D14	S	23.5	27.5	24.8	0.338	0.354	0.364
	M	28.6	28.8	24.6	0.333	0.349	0.357
	D	25.0	27.2	25.7	0.333	0.347	0.350
D15	S	28.3	31.2	24.3	0.345	0.355	0.371
	M	26.3	30.8	23.4	0.324	0.343	0.340
	D	24.0	30.0	24.5	0.321	0.342	0.346
D16	S	24.8	30.6	25.1	0.310	0.333	0.346
	M	23.7	31.2	24.4	0.316	0.364	0.331
	D	26.2	31.7	25.5	0.307	0.353	0.334
D17	S	27.3	29.9	24.8	0.329	0.352	0.384
	M	27.4	31.7	23.4	0.307	0.331	0.369
	D	24.9	30.8	24.6	0.313	0.321	0.371
D18	S	22.1	29.9	25.4	0.319	0.450	0.426
	M	21.8	30.0	24.9	0.316	0.340	0.360
	D	25.6	28.9	24.6	0.307	0.321	0.340
D19	S	25.6	28.2	24.5	0.319	0.341	0.352
	M	25.9	28.8	25.0	0.316	0.340	0.379
	D	24.3	28.9	24.6	0.316	0.339	0.340
D20	S	24.3	28.7	24.8	0.310	0.341	0.360
	M	24.2	30.5	24.9	0.319	0.362	0.347
	D	24.8	28.3	24.9	0.307	0.339	0.350
D21	S	27.6	28.2	24.9	0.310	0.341	0.379
	M	25.5	31.7	25.0	0.316	0.352	0.360
	D	25.4	28.3	24.4	0.307	0.330	0.325

*S = surface; M = mid; D = bottom

Table 3-12. Major cation ratios in water column near Bryan Mound diffuser (continued).

Sta. No.	Depth*	Sodium/Potassium February	Sodium/Potassium March	Sodium/Potassium April	Calcium/Magnesium February	Calcium/Magnesium March	Calcium/Magnesium April
15	S	22.9	29.7	30.7	0.329	0.354	0.445
	M	23.6	31.3	24.8	0.307	0.380	0.322
	D	21.9	30.7	26.1	0.329	0.365	0.375
33	S	22.2	28.5	25.1	0.300	0.371	0.358
	M	23.4	28.9	23.9	0.328	0.359	0.364
	D	23.8	32.2	25.0	0.338	0.321	0.364
36	S	30.4	28.9	24.6	0.319	0.321	0.357
	M	24.1	28.9	24.4	0.307	0.313	0.347
	D	24.1	28.9	24.4	0.310	0.305	0.354
39	S	22.6	32.3	23.6	0.319	0.280	0.372
	M	21.7	30.6	24.4	0.319	0.332	0.357
	D	23.9	30.5	24.1	0.307	0.330	0.359
Bryan Mound brine collected 3/20/80			146.0			1.210	
Typical Seawater (Riley and Skirrow, 1965)			27.6			0.300	

*S = surface; M = mid; D = bottom

Table 3-13. Major anion ratios in water column near Bryan Mound diffuser.

Sta. No.	Depth*	Sulfate/Chloride February	Sulfate/Chloride March	Sulfate/Chloride April	Bromide/Iodide February	Bromide/Iodide March	Bromide/Iodide April
D10	S	0.137	0.154	0.170	247	306	195
	M	0.134	0.149	0.156	287	253	254
	D	0.118	0.159	0.163	331	327	229
D11	S	0.141	0.152	0.149	---	228	184
	M	0.130	0.155	0.153	462	253	242
	D	0.132	0.152	0.155	339	284	230
D12	S	0.141	0.164	0.156	247	262	214
	M	0.135	0.157	0.148	288	268	277
	D	0.138	0.156	0.154	339	279	243
D13	S	0.146	0.163	0.159	262	244	227
	M	0.129	0.158	0.154	269	255	191
	D	0.127	0.161	0.154	383	284	192
D14	S	0.145	0.134	0.148	242	231	205
	M	0.140	0.131	0.156	224	232	193
	D	0.140	0.149	0.152	---	284	292
D15	S	0.145	0.143	0.148	266	241	176
	M	0.145	0.142	0.146	282	232	268
	D	0.153	0.165	0.152	321	281	185
D16	S	0.136	0.157	0.159	297	195	181
	M	0.137	0.150	0.158	379	240	262
	D	0.154	0.158	0.161	303	293	265
D17	S	0.150	0.156	0.144	256	254	231
	M	0.136	0.140	0.155	348	227	256
	D	0.130	0.134	0.147	331	287	223
D18	S	0.167	0.150	0.153	285	250	247
	M	0.132	0.163	0.151	337	214	200
	D	0.148	0.160	0.155	286	266	239
D19	S	0.142	0.118	0.161	309	219	240
	M	0.153	0.166	0.158	262	242	208
	D	0.136	0.148	0.154	307	258	246
D20	S	0.150	0.142	0.158	323	233	251
	M	0.140	0.128	0.154	282	188	215
	D	0.153	0.160	0.143	391	368	217
D21	S	0.138	0.164	0.157	252	223	245
	M	0.138	0.142	0.153	352	254	325
	D	0.136	0.118	0.162	197	303	229

*S = surface, M = mid, D = bottom

Table 3-13. Major anion ratios in water column near Bryan Mound diffuser (continued).

Sta. No.	Depth*	Sulfate/Chloride February	March	April	Bromide/Iodide February	March	April
15	S	0.146	0.126	0.169	243	230	145
	M	---	0.119	0.147	290	172	317
	D	0.114	0.143	0.153	263	212	170
33	S	0.134	0.149	0.137	325	249	233
	M	0.125	0.147	0.145	316	311	181
	D	0.126	0.152	0.150	303	295	256
36	S	0.125	0.161	0.138	304	317	290
	M	0.130	0.166	0.141	297	298	273
	D	0.126	0.154	0.156	369	272	259
39	S	0.142	0.142	0.148	220	189	237
	M	0.176	0.157	0.158	256	245	254
	D	0.117	0.169	0.164	340	244	235
Bryan Mound brine collected 3/20/80			0.024			27	
Typical Seawater (Riley and Skirrow, 1965)			0.143			1083	

*S = surface, M = mid, D = bottom

do not appear significant.

Soluble heavy metal concentrations in waters collected on the three sample dates are given in Tables 3-14, 3-15 and 3-16. Changes as a result of brine discharge are not indicated by these results.

3.2.3 Major Ions and Heavy Metals in Sediments

Sediment samples were collected at the 15 stations shown in Figure 3-1 on February 29, March 25 and April 7. Results of selected general sediment quality parameters (Eh, pH and oil and grease) are presented in Table 3-17. The greatest change observed was the higher redox potential (Eh) of the sediments during all three sample periods as compared with the values observed during August and November 1979. This increase had primarily occurred by February 29 and suggested that the reducing environment previously observed had essentially disappeared in the surface sediments. There also appeared to be some increase in oil and grease in sediments from three stations near the diffuser on March 25. Since this corresponds to the period at which high water column oil and grease was observed, this presence in the sediment is probably related to the same source. However, the three stations were widely scattered around the diffuser and only one occurred on the diffuser proper. Since values obtained for April were again low for the three stations, the presence in March is not considered of major importance at this time.

Major ions were measured in the pore waters taken from the sediments and are presented in Tables 3-18, 3-19 and 3-20 for February, March and April, respectively. If we take this data and treat it as we did for the bottom waters, i.e. compare the means for the near field (diffuser), down-coast and upcoast intermediate diffuser fields with those for ambient (control stations 33, 36 and 39) we obtain the following results:

Table 3-14. Soluble heavy metal distribution in waters around Bryan Mound diffuser and control sites

February 29, 1980

Sta. No.	Depth m	Al µg/l	Cd µg/l	Cr µg/l	Cu µg/l	Fe µg/l	Hg µg/l	Ni µg/l	Pb µg/l	Zn µg/l
D10	0.5	1.9	<0.5	<3	3.2	4	<0.2	<5	<2	6
	9.2	1.7	<0.5	<3	1.7	3	<0.2	<5	<2	1
	18.8	2.5	<0.5	<3	1.9	3	<0.2	<5	<2	4
D11	0.7	0.8	<0.5	<3	1.7	4	<0.2	<5	<2	2
	9.5	0.3	<0.5	<3	1.4	6	<0.2	<5	<2	4
	18.8	1.7	<0.5	<3	1.4	6	<0.2	<5	<2	4
D12	0.5	1.7	<0.5	<3	2.4	3	<0.2	<5	<2	3
	8.7	1.1	<0.5	<3	1.4	2	<0.2	<5	<2	2
	18.6	0.8	<0.5	<3	1.9	3	<0.2	<5	<2	5
D13	0.8	0.4	<0.5	<3	1.1	4	<0.2	<5	<2	1
	9.6	0.8	<0.5	<3	1.9	3	<0.2	<5	<2	3
	18.3	<0.3	<0.5	<3	0.8	3	<0.2	<5	<2	1
D14	0.9	0.3	<0.5	<3	3.2	3	<0.2	<5	<2	4
	9.3	3.0	<0.5	<3	1.7	3	<0.2	<5	<2	2
	18.3	1.4	<0.5	<3	3.2	3	<0.2	<5	<2	4
D15	0.5	<0.3	1.1	<3	1.7	4	<0.2	<5	<2	2
	9.2	1.7	<0.5	<3	1.3	2	<0.2	<5	<2	2
	18.5	3.6	<0.5	<3	1.5	8	<0.2	<5	<2	2
D16	0.8	1.7	2.4	<3	2.8	2	<0.2	<5	<2	3
	9.2	1.7	<0.5	<3	2.8	4	<0.2	<5	<2	5
	18.3	0.3	<0.5	<3	1.9	4	<0.2	<5	<2	6
D17	0.9	1.4	<0.5	<3	1.8	4	<0.2	<5	<2	2
	9.3	<0.3	<0.5	<3	2.3	7	<0.2	<5	<2	4
	18.5	1.9	<0.5	<3	2.3	4	<0.2	<5	<2	4
D18	0.9	0.8	<0.5	<3	2.3	3	<0.2	<5	<2	8
	9.0	2.8	<0.5	<3	11.6	3	<0.2	<5	<2	6
	18.9	1.9	<0.5	<3	1.9	3	<0.2	<5	<2	6
D19	1.9	0.8	<0.5	<3	1.6	2	<0.2	<5	<2	2
	9.0	1.9	<0.5	<3	1.0	3	<0.2	<5	<2	1
	18.9	1.7	<0.5	<3	6.9	3	<0.2	<5	<2	1
D20	0.5	1.1	<0.5	<3	1.8	5	<0.2	<5	<2	3
	10.0	1.1	<0.5	<3	1.4	2	<0.2	<5	<2	1
	18.5	1.1	<0.5	<3	1.1	9	<0.2	<5	<2	2

Table 3-14. Soluble heavy metal distribution in waters around Bryan Mound diffuser and control sites (continued).

February 29, 1980

Sta. No.	Depth m	Al µg/l	Cd µg/l	Cr µg/l	Cu µg/l	Fe µg/l	Hg µg/l	Ni µg/l	Pb µg/l	Zn µg/l
D21	0.7	0.3	<0.5	<3	1.4	3	<0.2	<5	<2	3
	9.5	<0.3	<0.5	<3	1.4	3	<0.2	<5	<2	1
	19.3	0.6	<0.5	<3	0.7	2	<0.2	<5	<2	2
15	0.5	<0.3	<0.5	<3	2.8	3	<0.2	<5	<2	6
	9.0	1.1	<0.5	<3	1.2	2	<0.2	<5	<2	4
	18.0	1.1	<0.5	<3	6.5	6	<0.2	<5	<2	2
33	0.9	1.1	<0.5	<3	2.4	3	<0.2	<5	<2	5
	9.5	1.7	<0.5	<3	3.2	5	<0.2	<5	<2	6
	18.9	1.1	<0.5	<3	1.3	1	<0.2	<5	<2	2
36	0.7	1.1	1.1	<3	2.4	3	<0.2	<5	<2	4
	9.5	2.8	<0.5	<3	2.3	4	<0.2	<5	<2	4
	18.9	1.4	<0.5	<3	0.8	1	<0.2	<5	<2	2
39	0.7	1.7	<0.5	<3	2.2	2	<0.2	<5	<2	5
	9.5	1.1	<0.5	<3	2.3	5	<0.2	<5	<2	6
	18.4	0.6	<0.5	<3	0.7	3	<0.2	<5	<2	3

Table 3-15. Soluble heavy metal distribution in waters around Bryan Mound diffuser and control sites.

March 25, 1980

Sta. No.	Depth m	Al µg/l	Cd µg/l	Cr µg/l	Cu µg/l	Fe µg/l	Hg µg/l	Ni µg/l	Pb µg/l	Zn µg/l
D10	0.5	1.2	<0.5	<3	0.3	4	<0.2	<5	<1	6
	9.0	1.0	<0.5	<3	6.8	5	<0.2	<5	<1	26
	18.0	1.1	<0.5	<3	1.5	5	<0.2	<5	<1	5
D11	0.5	0.8	<0.5	<3	2.1	4	0.5	<5	<1	2
	9.4	1.7	<0.5	<3	1.5	4	0.4	<5	<1	18
	18.8	1.1	<0.5	<3	1.8	5	<0.2	<5	<1	4
D12	0.5	1.4	<0.5	<3	1.2	2	<0.2	<5	<1	44
	9.0	0.8	<0.5	<3	0.6	4	<0.2	<5	<1	4
	18.0	1.2	<1.1	<3	0.9	5	<0.2	<5	<1	8
D13	0.5	0.4	<0.5	<3	1.2	5	<0.2	<5	<1	2
	9.1	0.6	<0.5	<3	1.5	7	<0.2	<5	<1	5
	18.3	1.2	<0.5	<3	1.2	5	<0.2	<5	<1	4
D14	0.5	0.7	<0.5	<3	2.1	7	<0.2	<5	<1	7
	9.2	0.7	1.2	<3	1.2	7	<0.2	<5	<1	6
	18.5	0.8	<0.5	<3	1.2	7	<0.2	<5	<1	6
D15	0.5	0.6	<0.5	<3	0.6	5	<0.2	<5	<1	4
	9.2	1.0	<0.5	<3	1.8	4	<0.2	<5	<1	11
	18.5	0.7	<0.5	<5.2	1.5	5	<0.2	<5	<1	4
D16	0.5	0.4	<0.5	<3	1.5	7	<0.2	<5	<1	2
	9.1	1.0	<0.5	<3	1.5	9	<0.2	<5	<1	8
	18.3	0.7	<0.5	<3	1.5	7	<0.2	<5	<1	6
D17	0.5	1.2	<0.5	<3	1.8	5	<0.2	<5	<1	4
	9.4	1.2	<0.5	<3	0.9	5	<0.2	<5	<1	15
	18.9	0.7	<0.5	<3	0.3	5	<0.2	<5	<1	2
D18	0.5	0.7	<0.5	<3	0.9	4	0.2	<5	<1	6
	9.4	5.1	<0.5	<3	0.6	5	<0.2	<5	<1	14
	18.9	1.1	<0.5	<3	2.4	5	<0.2	<5	<1	5
D19	0.5	1.1	3.4	<3	2.4	4	<0.2	<5	<1	7
	9.0	2.4	1.2	<3	1.6	8	<0.2	<5	<1	18
	18.3	0.7	<0.5	<3	1.5	6	<0.2	<5	<1	9
D20	0.5	1.5	<0.5	<3	2.0	18	<0.2	<5	<1	6
	9.2	0.8	<0.5	<3	1.5	12	<0.2	<5	<1	6
	18.5	0.7	<0.5	<3	1.0	6	<0.2	<5	<1	5

Table 3-15. Soluble heavy metal distribution in waters around Bryan Mound diffuser and control sites (continued).

March 25, 1980

Sta. No.	Depth m	Al µg/l	Cd µg/l	Cr µg/l	Cu µg/l	Fe µg/l	Hg µg/l	Ni µg/l	Pb µg/l	Zn µg/l
D21	0.5	2.1	<0.5	<3	1.5	4	<0.2	<5	<1	6
	9.6	0.3	<0.5	<3	1.5	6	<0.2	<5	<1	6
	19.3	1.1	<0.5	<3	1.0	5	<0.2	<5	<1	9
15	0.5	2.1	<0.5	<3	8.5	5	<0.2	<5	<1	10
	9.0	0.7	<0.5	<3	1.5	5	<0.2	<5	<1	5
	18.0	<0.3	<0.5	<3	1.0	5	<0.2	<5	<1	4
33	0.5	0.7	<0.5	<3	1.5	8	<0.2	<5	<1	5
	9.2	0.7	<0.5	<3	1.5	5	<0.2	<5	<1	5
	18.5	0.8	<0.5	<3	1.5	10	<0.2	<5	<1	6
36	0.5	0.4	<0.5	<3	1.2	8	<0.2	<5	<1	5
	9.8	<0.3	<0.5	<3	2.0	8	<0.2	<5	<1	5
	19.7	<0.3	<0.5	<3	1.5	6	<0.2	<5	<1	5
39	0.5	1.2	<0.5	<3	1.5	6	<0.2	<5	<1	7
	9.2	0.7	<0.5	<3	1.5	5	<0.2	<5	<1	4
	18.4	1.1	<0.5	<3	1.2	6	<0.2	<5	<1	5

Table 3-16. Soluble heavy metal distribution in waters around Bryan Mound diffuser and control sites.

April 7, 1980

Sta. No.	Depth	Al µg/l	Cd µg/l	Cr µg/l	Cu µg/l	Fe µg/l	Hg µg/l	Ni µg/l	Pb µg/l	Zn µg/l
D10	0.5	1.5	<0.5	<1	1.6	2	<0.2	<5	<1	3
	10.3	0.9	<0.5	<1	0.8	4	<0.2	<5	<1	2
	20.0	0.9	<0.5	<1	0.8	2	<0.2	<5	<1	87
D11	0.3	1.8	<0.5	<1	1.3	5	<0.2	<5	<1	3
	9.4	2.3	<0.5	<1	3.4	4	<0.2	<5	<1	3
	19.4	1.1	<0.5	<1	1.0	25	<0.2	<5	<1	4
D12	0.3	2.3	<0.5	<1	1.8	4	<0.2	<5	<1	4
	9.5	1.8	<0.5	<1	1.0	4	<0.2	<5	<1	3
	19.6	1.6	1.7	<1	0.8	4	0.2	<5	<1	3
D13	0.1	2.0	<0.5	<1	1.3	5	<0.2	<5	<1	4
	8.6	0.9	<0.5	<1	1.0	6	<0.2	<5	<1	2
	19.8	1.6	<0.5	<1	1.0	8	<0.2	<5	<1	5
D14	0.6	1.6	<0.5	<1	1.3	2	0.2	<5	<1	3
	9.6	2.7	<0.5	<1	1.3	9	<0.2	<5	<1	3
	18.9	1.6	<0.5	<1	1.0	6	<0.2	<5	<1	4
D15	1.0	1.1	<0.5	<1	1.0	4	<0.2	<5	<1	2
	9.8	0.9	<0.5	<1	1.0	2	<0.2	<5	1	3
	18.8	0.9	<0.5	<1	1.0	6	<0.2	<5	<1	2
D16	0.3	1.6	<0.5	<1	1.3	2	<0.2	<5	<1	3
	9.5	1.4	<0.5	<1	1.3	4	<0.2	<5	1	3
	18.8	0.9	<0.5	<1	1.0	4	<0.2	<5	<1	2
D17	0.2	1.8	<0.5	<1	1.3	2	<0.2	<5	<1	3
	9.8	0.5	<0.5	1	1.0	4	<0.2	<5	<1	2
	19.0	0.9	<0.5	1	1.0	5	<0.2	<5	5	2
D18	0.3	0.7	<0.5	<1	1.3	4	<0.2	<5	<1	3
	9.5	<0.3	<0.5	<1	1.3	2	<0.2	<5	<1	2
	19.0	0.4	<0.5	<1	1.6	4	<0.2	<5	<1	3
D19	0.5	2.0	<0.5	<1	1.6	5	<0.2	<5	<1	3
	10.2	2.0	<0.5	<1	1.3	4	<0.2	<5	1	4
	20.0	0.5	<0.5	<1	0.9	7	<0.2	<5	<1	33
D20	0.8	0.4	<0.5	<1	2.0	7	<0.2	<5	<1	5
	9.2	0.4	<0.5	<1	1.7	10	0.2	<5	<1	6
	19.3	0.8	<0.5	<1	1.5	7	<0.2	<5	<1	10

Table 3-16. Soluble heavy metal distribution in waters around Bryan Mound diffuser and control sites (continued).

April 7, 1980

Sta. No.	Depth	Al µg/l	Cd µg/l	Cr µg/l	Cu µg/l	Fe µg/l	Hg µg/l	Ni µg/l	Pb µg/l	Zn µg/l
D21	0.4	<0.3	<0.5	<1	1.7	10	<0.2	<5	<1	3
	10.0	<0.3	<0.5	<1	1.5	10	<0.2	<5	<1	4
	18.4	0.8	<0.5	<1	1.1	9	<0.2	<5	<1	6
15	0.8	1.1	<0.5	<1	2.0	7	<0.2	<5	<1	5
	8.0	<0.3	<0.5	<1	1.7	7	<0.2	<5	<1	5
	17.7	1.4	<0.5	<1	1.3	7	<0.2	<5	<1	6
33	0.4	0.4	<0.5	<1	1.3	6	<0.2	<5	<1	8
	10.4	1.0	<0.5	<1	1.3	10	<0.2	<5	<1	5
	19.6	1.0	<0.5	1	0.9	5	<0.2	<5	<1	6
36	0.3	0.5	0.8	<1	1.1	10	<0.2	<5	<1	5
	10.0	<0.3	<0.5	<1	1.1	7	0.2	<5	<1	5
	20.9	0.7	<0.5	<1	0.9	8	<0.2	<5	<1	11
39	1.4	2.5	<0.5	<1	1.7	8	<0.2	<5	<1	7
	8.8	<0.3	<0.5	<1	1.5	7	<0.2	<5	<1	6
	17.3	2.2	<0.5	<1	0.9	4	0.3	<5	<1	6

Table 3-17. Eh, pH and oil and grease for Bryan Mound and control site sediments in February, March and April, 1980.

Station Number	Eh mv			pH			oil and grease mg/kg		
	Feb	Mar	Apr	Feb	Mar	Apr	Feb	Mar	Apr
D10	92	62	108	7.1	7.0	7.5	94	26	78
D11	94	22	92	7.0	6.5	7.2	67	69	54
D12	81	88	67	7.0	6.8	7.1	34	264	77
D13	102	74	17	7.2	6.8	7.0	80	54	68
D14	-66	66	16	7.1	7.0	7.0	53	25	58
D15	79	110	177	7.1	6.8	6.8	46	73	44
D16	111	67	114	7.3	7.1	7.4	23	27	72
D17	72	47	92	7.2	7.0	7.1	39	131	58
D18	104	-5	55	7.2	7.0	7.2	13	80	80
D19	72	51	81	7.3	7.0	7.3	63	30	38
D20	97	34	60	7.6	7.1	7.2	36	291	82
D21	67	126	39	7.8	6.9	7.5	54	--	60
15	87	42	78	7.4	7.0	7.2	50	<10	45
33	82	-3	67	7.0	6.8	7.2	48	64	67
36	122	52	50	7.0	7.0	7.2	<10	<10	102
39	123	68	56	7.0	7.0	7.0	14	48	111

Table 3-18. Total dissolved solids and major ionic species in sediment pore waters at Bryan Mound disposal site and control sites.

February 29, 1980

Sta. No.	TDS g/l	Na g/l	K g/l	Ca g/l	Mg g/l	Cl g/l	SO_4 g/l
D10	36.6	12.1	0.44	0.41	1.18	19.9	2.90
D11	35.9	11.3	0.44	0.42	1.22	19.0	2.70
D12	36.5	11.4	0.45	0.42	1.22	19.3	2.90
D13	35.7	11.6	0.43	0.42	1.27	19.9	2.95
D14	39.6	12.8	0.48	0.43	1.33	21.1	2.95
D15	37.2	11.4	0.48	0.42	1.30	20.1	2.70
D16	37.5	11.9	0.46	0.42	1.28	19.5	3.05
D17	38.2	11.9	0.47	0.42	1.20	19.7	2.70
D18	37.0	11.9	0.48	0.42	1.22	20.7	2.90
D19	38.5	12.8	0.44	0.43	1.24	19.7	2.90
D20	38.1	11.4	0.45	0.43	1.17	20.1	2.80
D21	38.0	11.4	0.45	0.42	1.30	20.5	2.95
15	35.1	11.3	0.40	0.41	1.22	19.7	2.42
33	37.2	11.4	0.43	0.43	1.35	19.7	2.70
36	40.2	12.6	0.45	0.43	1.32	20.6	2.80
39	38.4	12.1	0.42	0.42	1.34	17.5	2.65
Typical Seawater	-	10.5	0.38	0.40	1.35	19.0	2.71
Overlying bottom water (2/29/80)	-	8.7	0.36	0.37	1.17	18.9	2.51

Table 3-19. Total dissolved solids and major ionic species in sediment pore waters at Bryan Mound disposal site and control sites.

March 25, 1980

Sta. No.	TDS g/l	Na g/l	K g/l	Ca g/l	Mg g/l	Cl g/l	SO_4 m/g
D10	40.2	12.6	0.46	0.41	1.19	18.8	2.55
D11	40.6	11.9	0.46	0.42	1.20	20.0	2.65
D12	41.0	12.3	0.43	0.43	1.20	20.1	2.48
D13	41.6	11.9	0.43	0.43	1.25	20.1	2.70
D14	37.0	11.6	0.43	0.41	1.20	19.6	2.48
D15	38.4	11.2	0.43	0.41	1.25	19.4	2.45
D16	37.1	11.2	0.44	0.42	1.26	19.0	2.40
D17	36.8	11.2	0.46	0.41	1.19	19.6	2.35
D18	39.0	11.6	0.44	0.41	1.20	18.3	2.42
D19	37.3	11.4	0.41	0.41	1.20	18.9	2.55
D20	37.1	11.4	0.44	0.41	1.20	18.9	2.50
D21	36.2	11.2	0.44	0.41	1.23	19.8	2.35
15	33.3	10.4	0.42	0.39	1.13	16.9	2.50
33	36.3	11.8	0.46	0.42	1.24	18.0	2.65
36	37.0	11.6	0.47	0.42	1.25	19.0	2.80
39	34.5	11.6	0.42	0.41	1.20	18.3	2.65

Table 3-20. Total dissolved solids and major ionic species in sediment pore waters at Bryan Mound disposal site and control sites.

April 7, 1980

Sta. No.	TDS g/l	Na g/l	K g/l	Ca g/l	Mg g/l	Cl g/l	SO_4 g/l
D10	37.2	11.4	0.41	0.40	1.14	18.0	2.75
D11	38.2	11.6	0.45	0.41	1.19	18.9	2.80
D12	39.1	11.4	0.44	0.42	1.33	19.7	2.70
D13	37.0	11.6	0.43	0.41	1.17	20.0	2.85
D14	39.0	12.8	0.45	0.42	1.25	19.3	2.95
D15	--*	12.8	0.53	0.47	1.41	23.6	2.90
D16	38.3	12.1	0.43	0.42	1.23	19.6	2.80
D17	34.6	11.3	0.42	0.36	1.07	17.2	2.50
D18	38.5	11.4	0.44	0.41	1.19	19.4	2.70
D19	38.6	11.3	0.42	0.41	1.17	19.0	2.65
D20	39.1	11.3	0.44	0.41	1.22	20.0	2.65
D21	33.6	10.2	0.38	0.37	1.17	16.8	2.35
15	37.2	11.1	0.43	0.41	1.18	19.1	2.50
33	32.1	11.1	0.42	0.36	1.07	17.4	2.40
36	33.0	11.4	0.43	0.37	1.10	17.3	2.42
39	29.3	11.2	0.45	0.41	1.24	20.3	2.70

*Insufficient sample

	diffuser	downcoast	upcoast	ambient	s
Na	12.1	11.4	11.2	11.2	0.42
K	0.46	0.43	0.42	0.43	0.021
Ca	0.43	0.41	0.39	0.38	0.14
Mg	1.26	1.21	1.16	1.14	0.051
Cl	20.7	18.9	18.2	18.3	0.64
SO_4	2.84	2.72	2.59	2.51	0.10
TDS	38.4	38.3	36.2	31.5	1.9

Again, the standard deviation ($\bar{s}$) is a pooled estimate of errors for the diffuser area based upon background values. For the pore waters, total dissolved solids (TDS) as determined gravimetrically were determined in place of salinity. At $\pm 2s$, there appears to be no significant differences in any of the major ions or TDS. At $\pm 1s$, the TDS in near and both intermediate diffuser areas were different in April from ambient. Also at $\pm 1s$, Ca^{++} and SO_4^{--} were different at the diffuser (near field) and downcoast intermediate diffuser field and Na^+ and Cl^- different at the diffuser from ambient. However, if these values are considered relative to February ambient, they do not appear significant. Obviously, changes with time will have to be considered before true significance in any differences can be determined. This can come only as additional analyses with time are obtained.

Major ion ratios for the pore waters are calculated and given in Table 3-21. No significance can be attached to any differences, if any, at this time.

Heavy metal analyses of 1N HNO_3 leachate from three sets of sediments are presented in Tables 3-22, 3-23 and 3-24. Although some differences occur from station to station with time, they are not important in terms of diffuser stations versus control stations and indicate no effects of brine discharge on sediment metals at this time.

Table 3-21. Major ion ratios in sediment pore waters near the Bryan Mound diffuser.

Sta. No.	Sodium/Potassium			Calcium/Magnesium			Sulfate/Chloride		
	February	March	April	February	March	April	February	March	April
D10	27.5	27.4	27.8	0.347	0.343	0.351	0.146	0.136	0.153
D11	25.7	25.9	25.8	0.346	0.349	0.343	0.142	0.132	0.148
D12	25.3	28.6	25.9	0.346	0.357	0.315	0.150	0.123	0.137
D13	27.0	27.7	27.0	0.331	0.345	0.350	0.148	0.130	0.142
D14	26.7	27.0	28.4	0.323	0.340	0.337	0.140	0.127	0.153
D15	23.8	26.0	24.2	0.323	0.329	0.334	0.134	0.126	0.123
D16	25.9	25.5	28.1	0.328	0.334	0.343	0.156	0.126	0.143
D17	25.3	24.3	26.9	0.349	0.343	0.338	0.137	0.120	0.145
D18	24.8	26.4	25.9	0.346	0.340	0.343	0.140	0.132	0.139
D19	29.1	27.1	26.9	0.348	0.340	0.350	0.147	0.135	0.139
D20	25.3	25.9	25.7	0.345	0.340	0.337	0.147	0.132	0.132
D21	25.3	25.5	26.8	0.323	0.334	0.316	0.144	0.119	0.140
15	28.2	24.8	25.8	0.337	0.345	0.347	0.123	0.148	0.131
33	26.5	25.7	26.4	0.318	0.340	0.338	0.137	0.147	0.138
36	28.0	24.7	26.5	0.325	0.337	0.337	0.136	0.147	0.140
39	28.8	27.6	24.9	0.313	0.340	0.332	0.151	0.144	0.133

Table 3-22. Heavy metal concentrations in leached (1N HNO_3) sediments from Bryan Mound diffuser and control sites (dry weight basis)

February 29, 1980

Sta. No.	Al mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
D10	795	0.01	1.7	2.0	2370	1.8	3.8	12.4
D11	815	0.02	1.8	1.8	2420	1.9	3.0	14.0
D12	530	0.01	1.0	1.8	1570	2.0	1.1	8.2
D13	630	0.01	1.2	0.9	1675	1.4	1.6	8.4
D14	520	0.01	0.7	0.8	1325	0.9	0.7	7.8
D15	1020	0.01	2.1	2.4	2650	3.0	2.8	13.6
D16	1040	0.03	2.0	2.8	2935	2.9	3.3	16.7
D17	745	0.01	1.5	2.7	2320	3.2	2.7	13.3
D18	795	0.01	2.5	2.4	2355	2.6	1.6	13.0
D19	1505	0.02	2.5	3.4	4020	6.4	5.5	19.3
D20	960	0.02	2.0	2.9	2875	3.2	3.9	15.8
D21	1235	0.02	2.9	3.6	3320	4.0	5.9	18.0
15	2690	0.04	4.9	5.3	5640	8.4	12.2	25.9
33	1225	0.02	3.1	3.3	3525	6.7	4.2	18.4
36	980	0.01	2.4	3.4	3170	4.8	4.0	17.7
39	1025	0.02	2.0	2.8	3350	6.1	3.6	18.5

Table 3-23. Heavy metal concentrations in leached (1N HNO_3) sediments from Bryan Mound diffuser and control sites (dry weight basis)

March 25, 1980

Sta. No.	Al mg/kg	Cd mg/kg	Cu mg/kg	Fe mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
D10	470	0.01	0.6	1610	2.2	2.8	10.1
D11	595	0.01	1.3	1940	2.8	2.8	11.8
D12	460	0.01	0.7	1375	2.2	2.1	7.8
D13	910	0.01	1.4	2665	3.3	3.4	14.3
D14	715	0.02	1.3	2520	4.2	2.0	13.8
D15	1365	0.02	2.3	3580	6.6	6.7	16.5
D16	695	0.01	2.1	2340	3.4	3.1	15.2
D17	750	0.01	1.5	2550	2.9	3.4	13.8
D18	750	0.01	1.7	2300	3.0	1.9	12.9
D19	950	0.01	1.9	2710	4.1	4.4	14.0
D20	1700	0.03	2.1	2910	4.0	4.7	13.7
D21	880	0.01	1.8	2520	4.0	2.6	12.8
15	2375	0.04	3.6	4920	6.9	11.7	22.7
33	1030	0.01	1.8	3310	4.4	4.6	16.2
36	1205	0.01	2.2	3290	4.8	5.9	15.4
39	1770	0.02	2.9	4615	6.6	6.4	19.2

Table 3-24. Heavy metal concentrations in leached (1N HNO_3) sediments from Bryan Mound diffuser and control sites (dry weight basis)

April 7, 1980

Sta. No.	Al mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
D10	625	0.01	1.5	2.8	2140	2.9	4.0	12.5
D11	680	0.01	1.6	2.8	1850	3.3	4.2	12.4
D12	610	0.01	1.7	2.7	2110	3.2	2.5	12.2
D13	415	0.01	1.0	2.2	1545	2.7	2.4	8.1
D14	350	0.01	1.0	1.8	1315	2.3	1.6	7.8
D15	295	0.01	0.8	2.0	1270	2.5	3.2	8.9
D16	610	0.01	1.4	2.3	2090	3.0	3.5	12.3
D17	585	0.01	1.5	2.3	1980	4.2	3.1	12.1
D18	680	0.02	2.0	3.8	2430	6.1	3.8	14.8
D19	595	0.01	1.8	3.1	2140	5.9	5.2	12.4
D20	955	0.02	2.2	5.3	2900	6.9	6.2	16.9
D21	970	0.01	2.6	3.7	2715	6.1	5.4	16.3
15	1440	0.02	3.5	5.9	2950	7.1	7.7	15.6
33	1010	0.01	2.5	4.3	3070	6.6	5.5	18.3
36	870	0.01	2.7	4.1	2915	7.2	6.1	17.4
39	1140	0.02	3.0	5.0	3465	8.0	7.5	20.5

3.2.4 Heavy Hydrocarbons in Sediments

Although the concentration of hydrocarbons in sediments is not considered to be an adequate indicator of petroleum pollution in sediments, it is probably worthwhile to consider changes in concentrations at a given station, as well as any compositional changes. In nearshore areas, sediments are often inhomogenous without petroleum contamination and there can be differences in concentrations at a given station. Seasonal concentration changes are also highly possible in a nearshore shallow water area.

The sediments in the Bryan Mound area generally showed an increase in total gas chromatography derived concentrations (mg/g dry sediment) from the first collection made on August 30, 1979 to the second one collected February 29, 1980 (see Table 3-25). This increase occurred at both the diffuser site and at stations 33, 36, and 39. There was a concentration decrease at station 15 between August 1979 and February 1980. However, between the second and third collection of sediments (between February 29 and April 7), there was only a slight increase at stations 36, 39, 15, D10, D12, D18, but a decrease in totals at D11, D13, D14, D15, D16 and station 33. In most cases though, the increase was not appreciable. See Tables 3-25, 3-26, 3-27, and Figures 3-2 and 3-3.

For the hexane fractions there was also a mixed picture of change (see Tables 3-26 and 3-27 and Figures 3-4 and 3-5). Generally, there was an increase in hexane fraction concentrations from August to February, except for stations D11, and station 15. From February to April, however there was a slight increase at stations D10, D12, and station 15, but a decrease at all others. In some cases, the decrease

Table 3-25. Comparison of total extract hydrocarbon concentrations for the three sample periods.

Station Number	August 1979	February 1980	April 1980
D10	5.853	5.473	5.765
D11	3.386	5.352	2.953
D12	3.417	4.312	5.004
D13	1.368	5.417	4.991
D14	2.133	4.710	1.881
D15	0.870	5.544	1.947
D16	5.517	5.484	4.970
D17	3.356	4.863	-----
D18	4.010	4.926	5.994
33	6.530	9.210	4.935
36	5.369	4.325	5.588
39	2.823	6.448	6.893
15	42.892	10.340	16.028

Table 3-26. Sediment hydrocarbon data for the Bryan Mound site.

February 29, 1980

Sta. No.	Mg/g in hexane fraction		Mg/g in 40% benzene in hexane fraction	Mg/g in benzene fraction	Total concen- tration (Mg/g)	Odd to even ratio
	resolved	UCM*				
D10	0.387	1.718	1.294	0.355	3.754	5.01
D11	1.024	1.111	2.873	0.344	5.352	3.91
D12	0.353	1.659	2.142	0.158	4.312	2.56
D13	0.552	1.590	1.186	0.334	3.662	2.79
D14	0.425	2.600	1.186	0.499	4.710	4.01
D15	1.568	1.960	1.735	0.281	5.544	3.36
D16	0.449	2.600	2.038	0.397	5.484	2.59
D17	0.792	2.196	1.507	0.368	4.863	3.11
D18	0.704	2.125	1.820	0.277	4.926	3.52
33	1.129	3.457	4.444	0.180	9.210	3.46
36	0.452	2.326	1.359	0.188	4.325	3.21
39	0.709	2.440	2.169	1.130	6.448	4.21
15	1.713	4.381	3.724	0.522	10.340	4.99

*UCM = unresolved complex mixture

Table 3-27. Sediment hydrocarbon data for the Bryan Mound site.

April 7, 1980

Sta. No.	Mg/g in hexane fraction resolved	UCM*	Mg/g in 40% benzene in hexane fraction	Mg/g in benzene fraction	Total concentration (Mg/g)	Odd to even ratio
D10	0.750	2.105	2.820	0.09	5.765	7.13
D11	0.407	1.252	1.264	0.03	2.953	2.59
D12	0.521	1.593	2.770	0.12	5.004	3.32
D13	0.768	1.183	1.300	1.740	4.991	12.24
D14	0.204	0.769	0.813	0.095	1.881	3.55
D15	0.313	0.804	0.801	0.029	1.947	5.33
D16	0.726	1.296	2.348	0.600	4.970	5.43
D17	-	-	-	-	-	-
D18	0.602	1.967	3.324	0.101	5.994	4.76
33	0.590	1.380	2.211	0.754	4.935	3.28
36	0.689	1.339	3.407	0.153	5.588	4.80
39	0.922	1.416	3.457	1.098	6.893	2.28
15	2.058	9.841	3.422	0.707	16.028	2.96

*UCM = unresolved complex mixture

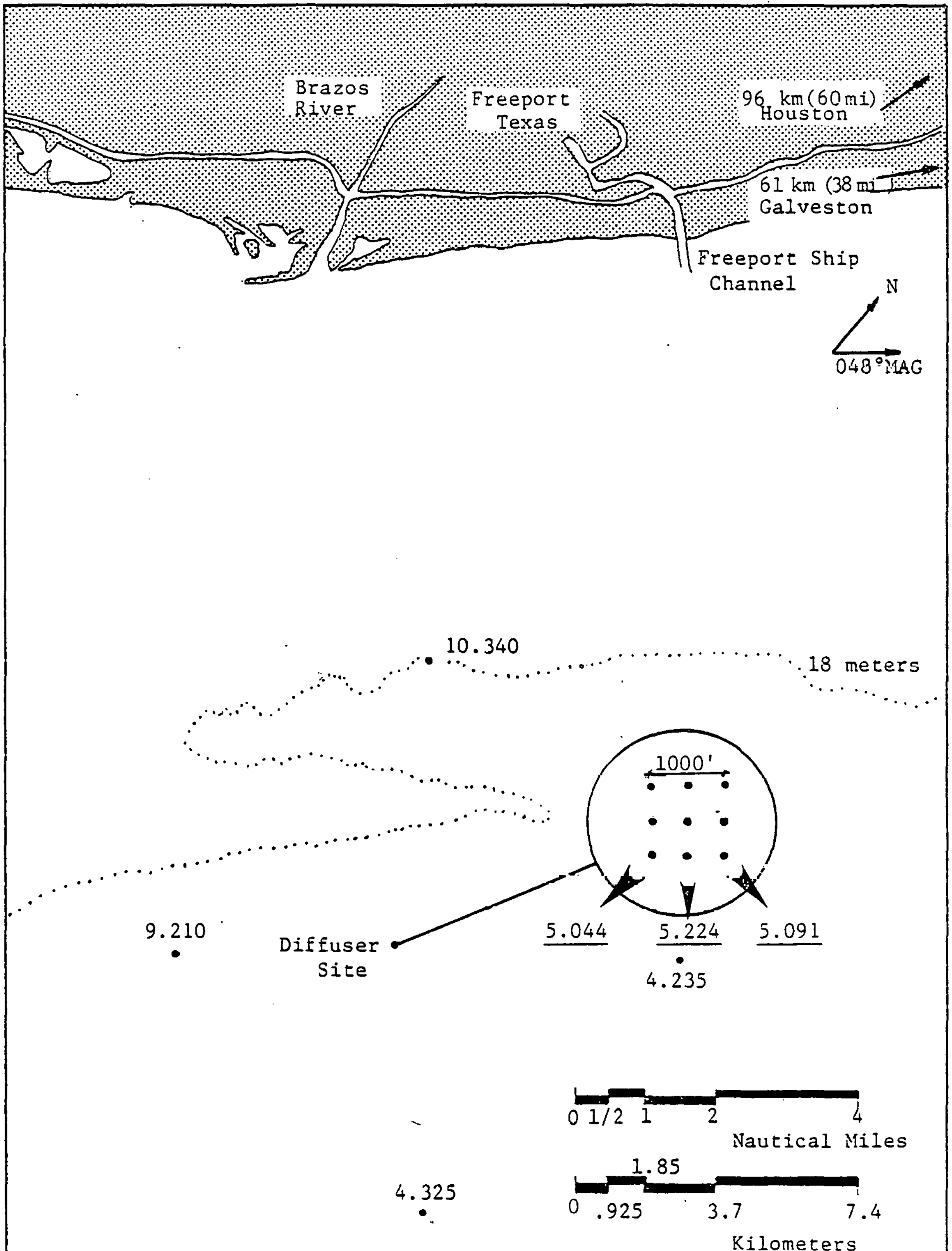


Figure 3-2. Total extract concentrations in µg/g (as determined by gas chromatography) for sediments collected February 9, 1980.

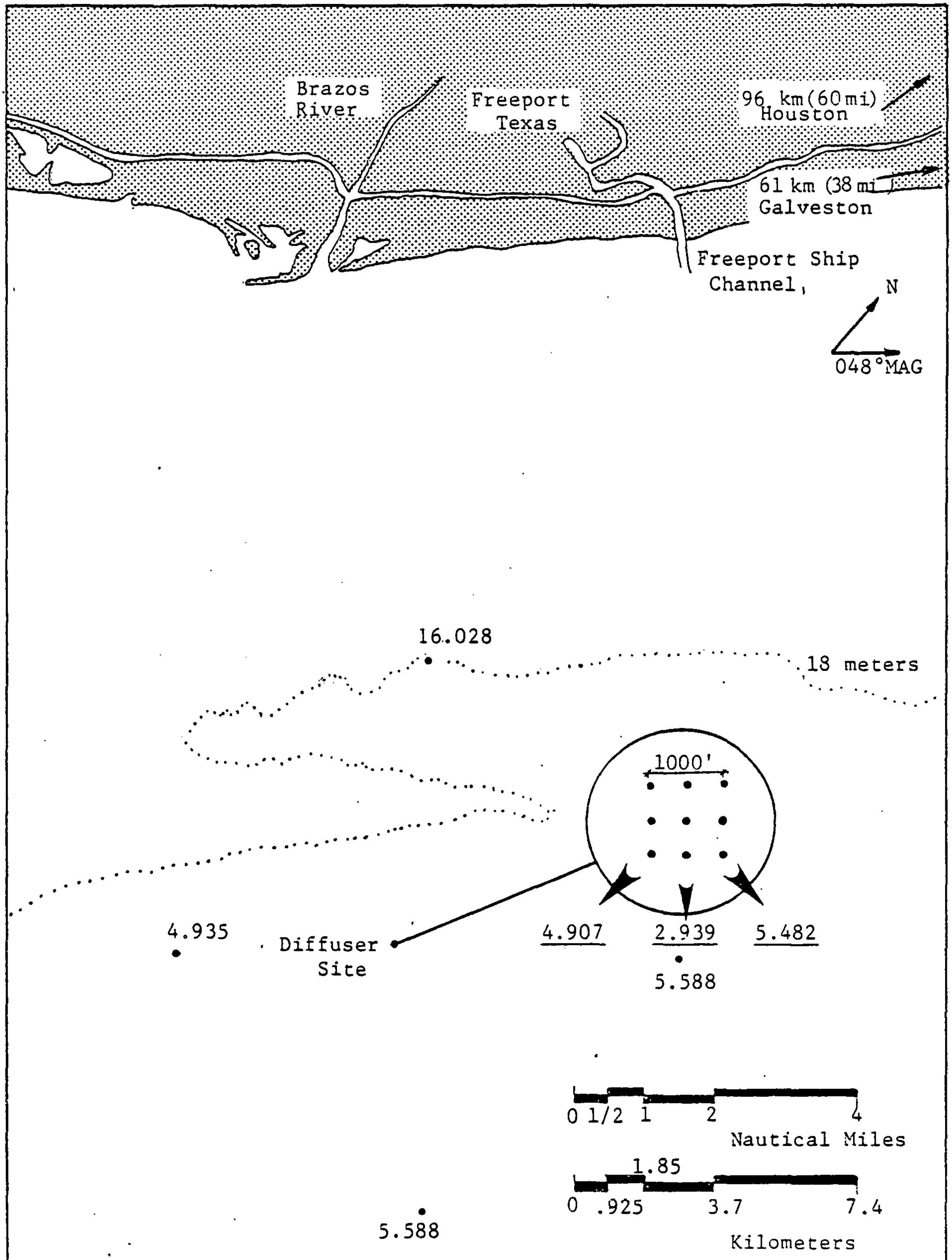


Figure 3-3. Total extract concentrations in µg/g (as determined by gas chromatatography) for sediments collected April 7, 1980.

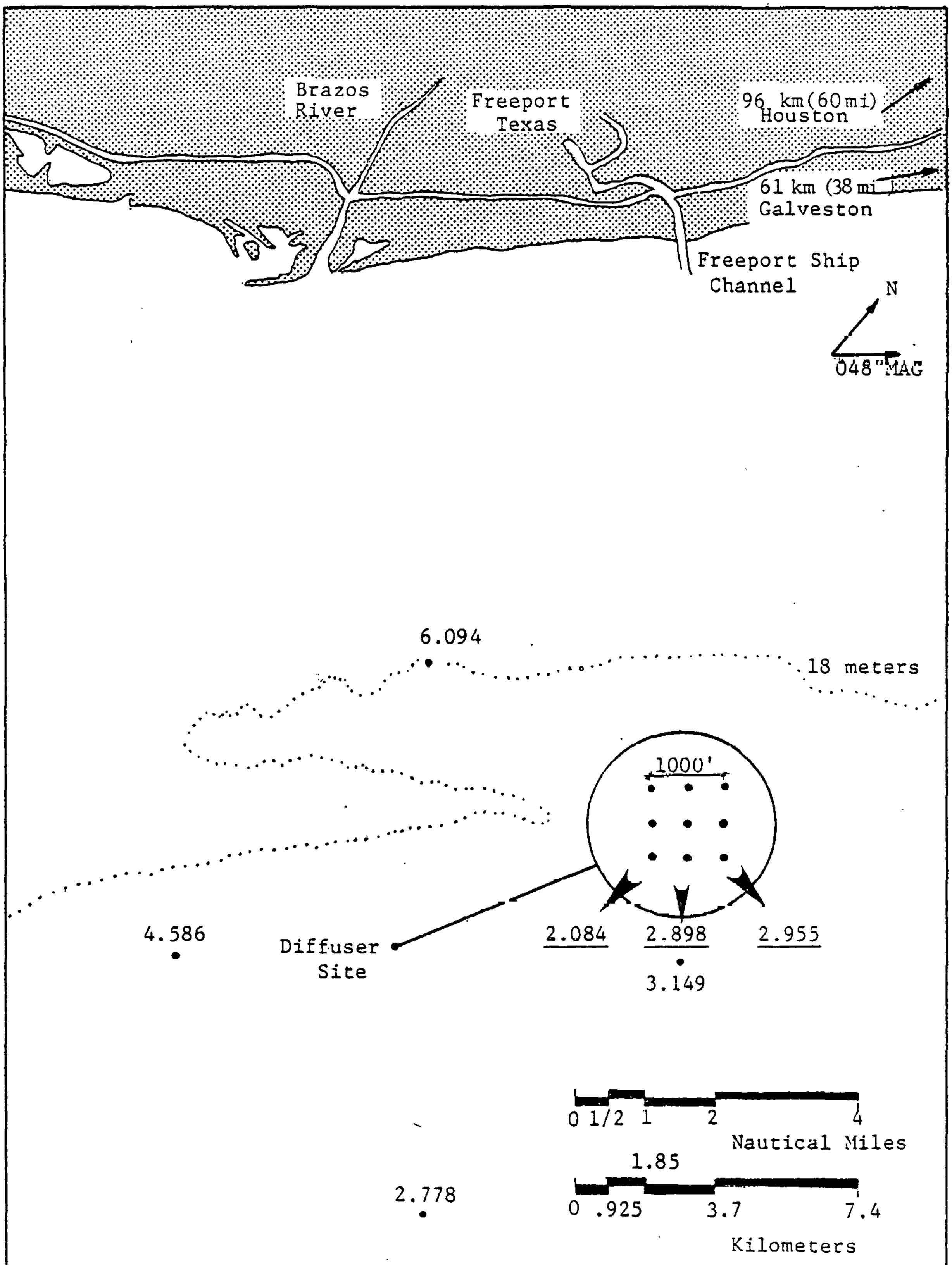


Figure 3-4 . Hexane fraction concentrations in µg/g (by GC) for sediments collected February 29, 1980.

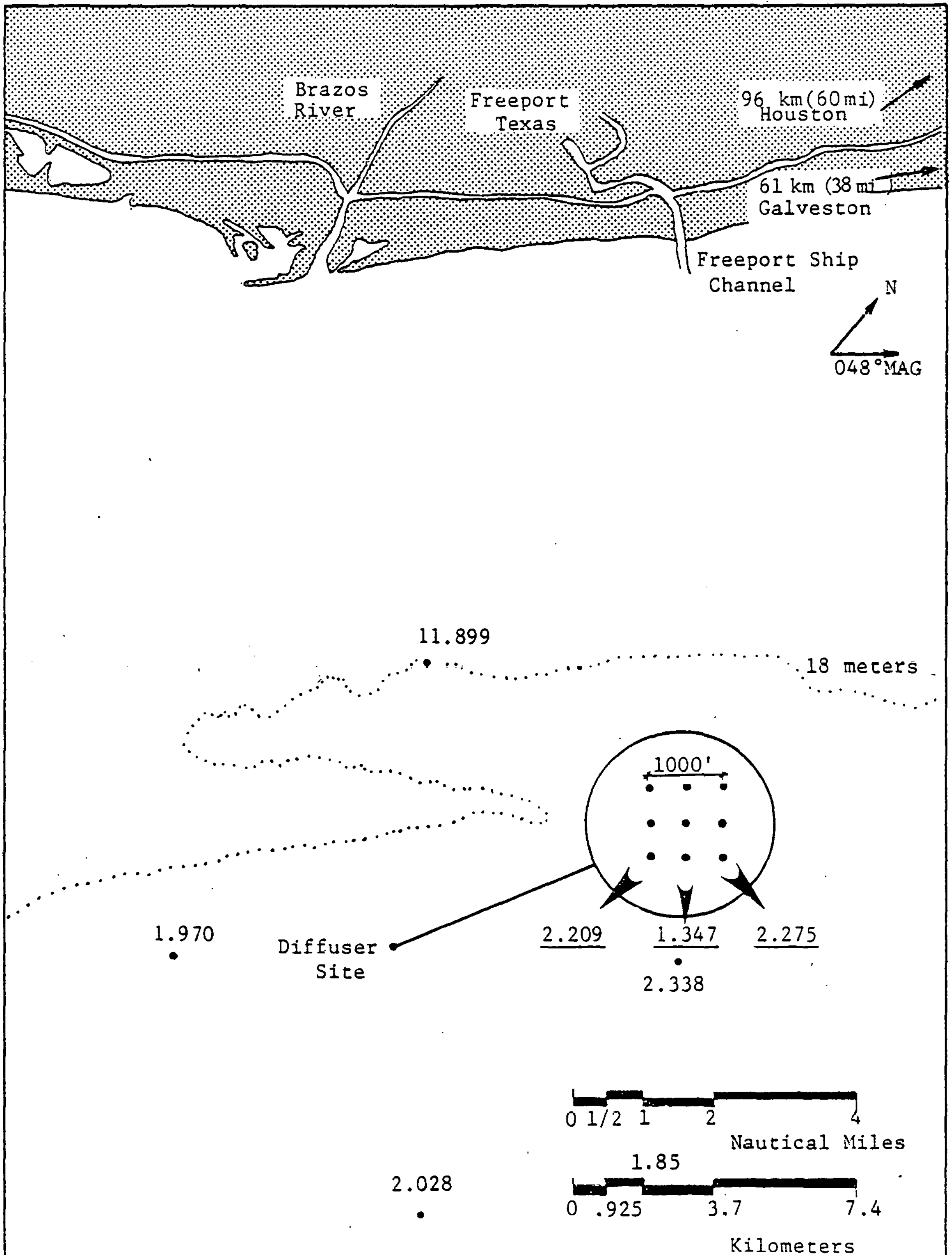


Figure 3-5 . Hexane fraction concentrations in μg/g (by GC) for sediments collected April 7, 1980.

or increase was not significant. The same picture holds for the 40% benzene in hexane fraction, see Tables 3-26 and 3-27 and Figure 3-6 and 3-7.

Examination of the gas chromatograms of the sediment samples collected before and after diffuser operation gave no indication of detectable oil pollution. The odd to even ratios of the n-alkanes (of the hexane fraction) are all above 2 and mostly 3 to 5, indicative of biologically derived alkanes. The odd to even ratio of alkanes of crude oil is near 1.0. The bimodel distribution of the n-alkanes also supports the fact that crude oil is not present because crude oils usually are unimodal with fairly even distribution of n-alkanes with an odd to even preference (OEP) of 1 especially above C-21 alkane. In many of the February 29 sediment samples (D11, D13, D14, D15, D18, 33 and 15) there was a dominance of C-31 n-alkane with C-29 alkane not far behind. As was mentioned in the predisposal report (Slowey, 1980), C-27, C-29, C-31 and C-33 are indicators of terrestrial or riverine sources. An increase in these high molecular weight compounds at the above stations in February was responsible for the increase in hexane fraction concentrations over those in August 1979, and in most cases the total concentrations of G-C resolvable compounds. Polyoelfins of marine origin eluting between C-20 and C-21 are the second most dominant compounds at the above listed February stations and were the dominant compounds at the other stations, with C-31 alkane being the second most dominant.

In the alkane fraction of the samples collected on April 7, 1980, after the diffuser started operating, the C-31 alkane was dominant only at stations D10, D13, D18 and D39. The polyolefins at KI 2077-2087

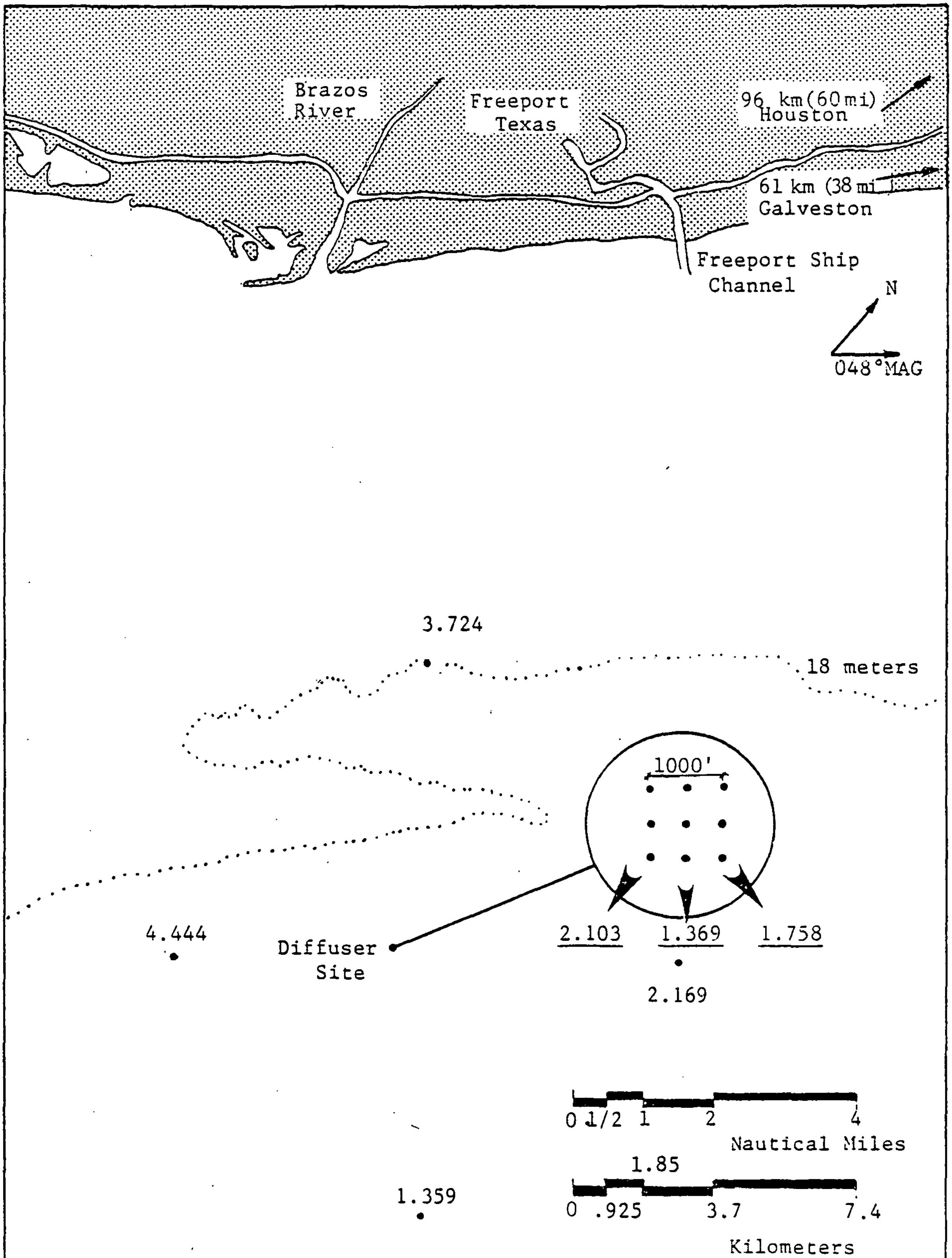


Figure 3-6 . 40% benzene in hexane fraction concentrations in µg/g for sediments collected February 29, 1980.

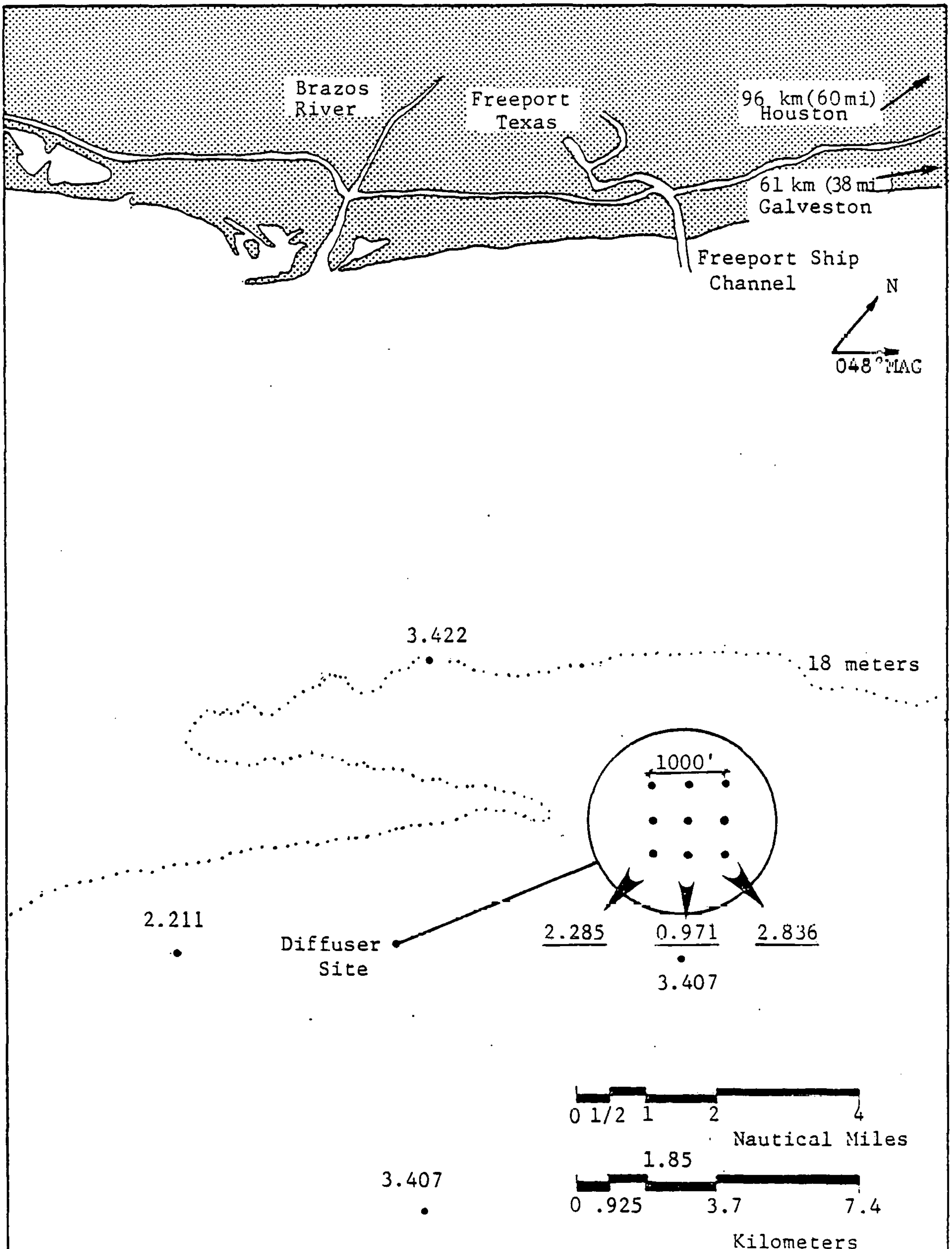


Figure 3-7 . 40% benzene in hexane fraction concentrations in µg/g for sediments collected April 7, 1980.

were dominant at the other stations, but in all there was a fairly strong C-31 alkane component. There was no indication from chromatograms of the hexane fractions of any detectable oil contamination in the April 7, 1980 sediment samples.

The aromatic (or 40% benzene) fraction also did not show any indications of oil contamination. The gas chromatograms of the 40% benzene fractopms were similar in both the February and April sediment samples, as well as the August 30, 1979 samples. The main differences were in concentrations.

3.2.5 Analyses of Biota

As mentioned earlier, considerable difficulty was encountered in obtaining suitable biota for analyses at times desired. The results of metal analyses of the biota obtained are presented in Table 3-28. Results indicate no differences between samples collected at the diffuser and at a control station (15 or 36) that could be attributed to brine discharge. Pesticide analyses will be included in a separate report.

3.3 Conclusions

Intensive study sampling was carried out on February 29, March 25 and April 7, 1980 to evaluate the effect of brine discharge that commenced on March 13, 1980 at the offshore diffuser located off Freeport, Texas. Both water and sediment samples were collected at 15 stations (13 in the area of the diffuser). Results of laboratory analyses of these samples indicate that no changes resulting from brine discharge could be measured with the exception of salinity increases in bottom waters at the diffuser site in April. Sediment pore water analyses suggest slight increases over ambient for TDS and several major ions in April; however, additional analyses with time are needed before valid conclusions can be made

Table 3-28. Heavy metal content of selected biota.

(dry weight basis)

Location (Date)	Description (species)	Al mg/kg	Fe mg/kg	Cu mg/kg	Cr mg/kg	Cd mg/kg	Hg mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
				Predisposal						
Diffuser (2/26/80)	White Shrimp-flesh (P. setiferus)	4.9	5.8	4.9	<0.05	<0.03	<0.02	<0.1	<0.1	45
Diffuser (2/26/80)	Brown Shrimp-flesh (P. aztecus)	0.4	6.2	33.	<0.05	<0.03	<0.02	0.3	<0.1	46
Diffuser (2/26/80)	Sand Trout-flesh (C. arenarius)	0.7	8.7	2.0	<0.05	<0.03	<0.02	<0.2	<0.1	32
Station 36* (2/26/80)	Sand Trout-flesh (C. arenarius)	0.5	4.3	1.4	<0.05	<0.03	<0.02	0.3	<0.1	23
Station 36* (2/29/80)	Zooplankton-whole (mixed, mostly copepods)	8.2	61.	6.3	0.51	0.56	<0.02	0.4	0.25	86
Diffuser (2/29/80)	Zooplankton-whole (mixed, mostly copepods)	11.4	49.	17.0	0.32	0.24	<0.02	0.5	0.43	58

*Station 36 is a control station (see Figure 3-1).

Table 3-28. Heavy metal content of selected biota. (continued)

(dry weight basis)

Location (Date)	Description (species)	Al mg/kg	Fe mg/kg	Cu mg/kg	Cr mg/kg	Cd mg/kg	Hg mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
					Postdisposal					
Station 15* (5/27/80)	White Shrimp-flesh (P. setiferus)	3.3	29.	37	<0.05	<0.03	<0.02	<0.2	<0.1	38
Diffuser (5/27/80)	White Shrimp-flesh (P. setiferus)	4.9	32.	30	<0.05	<0.03	<0.02	<0.2	<0.1	60
Station 36* (5/27/80)	Brown Shrimp-flesh (P. aztecus)	1.8	16.	30	0.12	<0.03	<0.02	0.8	<0.1	52
Diffuser (5/27/80)	Brown Shrimp-flesh (P. aztecus)	1.4	6.2	31	0.26	<0.03	<0.02	0.4	<0.1	53
Station 36* (4/10/80)	Sand Trout-flesh (C. arenarius)	0.3	5.7	1	<0.05	<0.03	<0.02	<0.2	<0.1	11
Diffuser (4/10/80)	Sand Trout-flesh (C. arenarius)	1.0	2.8	<1	<0.05	<0.03	<0.02	<0.2	<0.1	7
Station 36* (4/11/80)	Zooplankton-whole (mixed, mostly copepods)	11.7	59.	9	0.08	0.27	<0.02	0.6	0.41	70
Diffuser (4/11/80)	Zooplankton-whole (mixed, mostly copepods)	7.8	78.	11	0.11	0.41	<0.02	0.4	<0.2	78

* Stations 15 and 36 are control stations (see Figure 3-1).

concerning these changes.

Increased oil and grease levels in the water column on March 25 suggest they might have occurred as a result of brine discharge, but high levels at control stations also indicate the oil and grease may have had another source. Shipboard analyses of oil and grease would have helped solve this problem since large samples for specific organic analyses could have been collected at the time. Use of portable analyzers capable of analyzing oil and grease immediately should be considered in the future.

On the basis of the gas chromatograms of the sediment extracts on February 29 and April 7, there is no indication that the diffuser operation caused any detectable accumulation of crude oil in the sediments, despite some variation in total or fractional concentrations.

CHAPTER 4

NEKTON

Mark E. Chittenden, Jr.
Department of Wildlife and Fisheries

4.1 Introduction

This chapter describes the effects of brine disposal on the nekton community near the diffuser off Freeport, Texas. It describes cruise tracks and sampling procedures in the March-April 1980 intensive postdisposal period (Section 4.2) and field impressions of the effects of brine disposal on the nekton (Section 4.3). Station by station abundance is compared to determine effects of brine disposal on major nekton species within the March-April 1980 intensive postdisposal period (Section 4.4) and within the March-April 1979 predisposal period (Section 4.4). Nekton compositions in the March-April 1980 intensive postdisposal period are described and compared with compositions during the March-April 1979 predisposal period (Section 4.5), and descriptions of compositions are supplemented with comparisons of station by station species diversity (Section 4.5). Finally the various sections are integrated in an overall summary (Section 4.6).

4.2 Materials and Methods

Nekton collections in the intensive postdisposal period were made aboard a chartered commercial shrimp trawler off Freeport in March and April 1980 focusing around the March 13 start-up of brine disposal. Details of the cruises, cruise tracks and procedures in that time period follow.

4.2.1 Cruises Completed and Cruise-Tracks

During the March-April 1980 intensive postdisposal period three night cruises and three day cruises were completed after diffuser start up. These cruises were made at spaced intervals which covered approximately one month after diffuser start up. Tables 4-1 and 4-2 summarize dates when cruises were made, cruise intervals in relation to diffuser start up, and the stations occupied in each cruise. Stations 9, 26, and 14-25 inclusive were occupied in the intensive postdisposal period. These stations were all located near the diffuser and correspond to those occupied in the predisposal phase (Table 4-3, Figure 4-1).

4.2.2 Collection, Processing and Analytical Procedures

Collection and processing procedures used were those employed in the predisposal studies, with some minor modifications. Collections were made aboard a chartered shrimp trawler using two 34-foot Hollis-Special commercial trawls equipped with tickler chains and 1-3/4 inch stretch-mesh netting in the cod-end. Loran C was used to locate starting points for each tow, and tows were made in straight-line fashion. Duplicate tows were made at each station at a speed of about 2.75 knots for ten minutes bottom time duration. Nekton catches were processed to identify and enumerate species on each tow. Special observations on the presence or absence of dead or dying nekton were made at each station and recorded on a Special Observations Form (Appendix I, Figure I-1).

The objectives of the field operations were to:

1) determine if Dramatic Lethal Effects had occurred and,
2) collect data for subsequent statistical analysis in the laboratory to determine if lesser effects had occurred.

Table 4-1 Summary of accomplished Night (N) and Day (D) cruise tracks. A + in the body of the table indicates the tow was successfully made; a - indicates no tow was made.

Station	5-6 Mar.	19-20 Mar.	24-25 Mar.	27-28 Mar.	4-5 Apr.	10-11 Apr.	14-15 Apr.
	N	D	N	D	N	D	N
14a	+	+	+	+	+	+	+
14b	+	+	+	+	+	+	+
15a	+	+	+	+	+	+	+
15b	+	+	+	+	+	+	-
16a	+	+	+	+	+	+	-
16b	+	+	+	+	+	+	-
17a	+	+	+	+	+	+	+
17b	+	+	+	+	+	+	+
18a	+	+	+	+	+	+	+
18b	+	+	+	+	+	+	+
19a	+	+	+	+	+	+	+
19b	+	+	+	+	+	+	+
20a	+	+	+	+	+	+	+
20b	+	+	+	+	+	+	+
21a	+	+	+	+	+	+	+
21b	+	+	+	+	+	+	+
22a	+	+	+	+	+	+	+
22b	+	+	+	+	+	+	+
23a	+	+	+	+	+	+	+
23b	+	+	+	+	+	+	+
24a	+	+	+	+	+	+	+
24b	+	+	+	+	+	+	+
25a	+	+	+	+	+	+	+
25b	+	+	+	+	+	+	+
9a	+	+	+	+	+	+	+
9b	+	+	+	+	+	+	+
26a	+	+	+	+	+	+	+
26b	+	+	+	+	+	+	+

Table 4-2 Summary of cruise dates and diel time periods stations were occupied.

Dates of Cruise	Diel Period	Time in Relation to Diffuser Startup
5-6 March 1980	Night	t - 7, 8 days
19-20 March 1980	Day	t + 6, 7 days
24-25 March 1980	Night	t + 11, 12 days
27-28 March 1980	Day	t + 14, 15 days
4-5 April 1980	Night	t + 21, 22 days
10-11 April 1980	Day	t + 27, 28 days
14-15 April 1980	Night	t + 31, 32 days

Table 4-3 Locations of stations occupied in the intensive postdisposal period.

Station	Latitude	Longitude
9	28°46.06'	95°15.20'
26	28°41.14'	95°13.41'
14	28°43.20'	95°16.12'
15	28°44.08'	95°14.59'
16	28°44.19'	95°14.41'
17	28°45.04'	95°12.89'
18	28°43.84'	95°14.96'
19	28°44.38'	95°14.05'
20	28°44.09'	95°15.65'
21	28°44.32'	95°14.49'
22	28 44.99'	95 14.04'
23	28 43.25'	95 15.00'
24	28 43.67'	95 14.18'
25	28 44.11'	95 13.35'

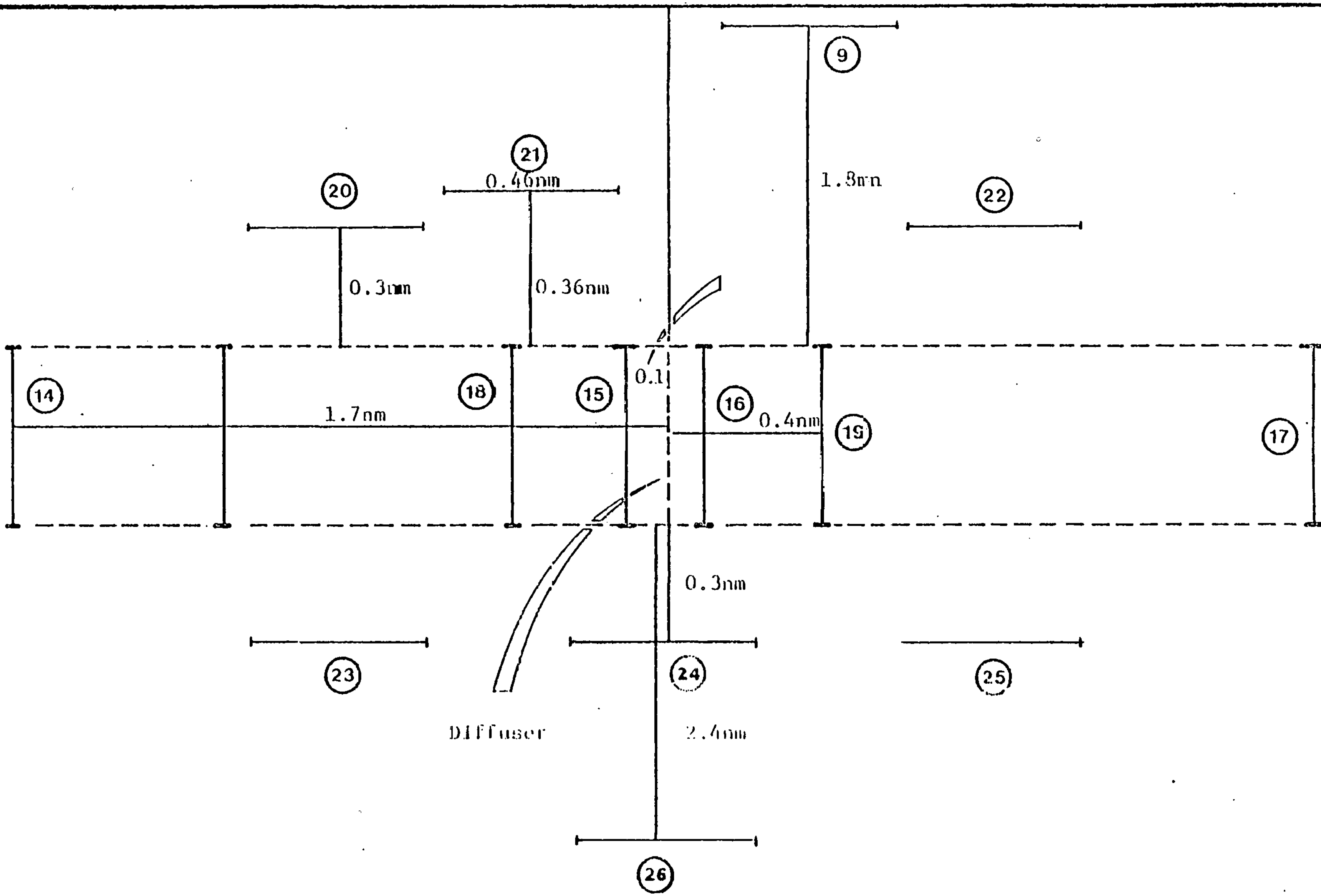


Figure 4-1. Diagrammatic sketch details of station positions near the diffuser

Dramatic Lethal Effects were indicated in the catches by one or more of the following characteristics:

1) the presence of many dead or dying fish and/or shrimp in the catch or floating about the area, and/or
2) a sharply reduced trawl catch volume at stations nearest the diffuser, and/or
3) sharply reduced numbers of several selected species in catches at stations nearest the diffuser. These selected species included: a) Penaeid shrimp (*Penaeus aztecus*, *P. setiferus*, and *P. duorarum*), b) a fish of strictly bottom habit (*Syacium gunteri*), c) a fish of pelagic habit (*Peprilus burti* or *Chloroscombrus chrysurus*), and d) a fish of the dominant family Sciaenidae (*Cynoscion nothus* or *Cynoscion arenarius*).

Subsequent to intensive postdisposal period field operations, counts of abundance of selected nekton were compared statistically to determine if there were significant differences between stations that might be attributed to brine disposal. Comparisons of abundance between stations were made using Duncan's Multiple Range test (Steel and Torrie 1960) as calculated using the SAS program Proc ANOVA (Helvig and Council 1979). Comparisons between stations were made within each cruise for given species using a one way completely randomized experimental design. Calculations used a $\log_e (x + 1)$ transformation to improve the basic assumptions of analysis of variance. Assessments of significance were made using the 1% special protection level. Counts of mean abundance presented for each station (Appendix I, Tables I-1 - I-83) were calculated from the number of replicate tows indicated in the tables.

To support analyses of nekton abundance in the intensive postdisposal period (see above paragraph), similar analyses of the abundance of the selected nekton were made to determine if there were significant differences between stations during the March-April 1979 predisposal period. Statistical procedures followed those described above in terms of experimental design, multiple range tests, transformations, special protection levels, etc.

Finally, to support analysis of nekton compositions, ichthyofauna diversity was compared statistically to determine if there were significant differences between stations. Statistical procedures for diversity followed those described above for abundance in terms of experimental design, multiple range tests, special protection levels, etc. However, diversity values were not transformed prior to analysis. Diversity was expressed as Shannon-Wiener's H (Krebs, 1972). Mean diversity presented for each station (Appendix I, Tables I-1 - I-10) was calculated from the number of replicates indicated in the tables.

4.3 Field Observations of the Effects of Brine Disposal on Nekton

Field observations indicated no Dramatic Lethal Effects at any station in any cruise. Data recorded on the Special Observations Forms at no time and at no station suggested any unusual behavior of the nekton in the catch or dead or dying nekton in the water. Furthermore, plots and observations of biomass volumes and raw species counts did not suggest obvious sharp reductions in catch.

4.4 Effects of Brine Disposal on Abundance of Selected Nekton, March-April 1980 Intensive Postdisposal Period.

4.4.1 General Comments

Taxa subjected to detailed statistical analyses using Duncan's Multiple range tests, their percentage compositions in the catches during the March-April 1980 intensive postdisposal period, and report sections presenting their analyses are listed in Table 4-4. Reasons why a given taxon was selected for analysis are presented at the beginning of each individual analysis. However, in general, these particular taxa were selected to include species that supported valuable commercial fisheries, were characteristic of and abundant near the diffuser, or had biological habits that might especially expose them to the effects of brine disposal. Taxa selected included each Penaeid shrimp found off Freeport, pelagic fishes, fishes of flattened form that reside on the substrate, fishes of the dominant inshore family Sciaenidae, and characteristic fishes of the offshore brown shrimp community. Analyses presented herein include all the dominant and very abundant species at the diffuser area in the cruises of 5-6 March, 19-20 March, 24-25 March, 27-28 March, and 4-5 April, and most of the abundant species in the cruises of 10-11 April and 14-15 April. In total, these fishes made up 90-95% of the fish catch in each of the first five cruises, 86% in the 10-11 April cruise, and 28% for the 14-15 April cruise when the warm season fauna became more important.

The following sections present the rationale of the data interpretation and a detailed analysis of abundance for the selected species to determine if there were significant differences between stations that might be attributed to brine disposal. In the detailed analysis for each species, the following is presented in the indicated sequence: 1) reasons for selection, 2) an analysis of patterns of abundance during the March-April 1979 predisposal period (Sections 4.4.-.1) to include a summary statement of conclusions about conditions in that period followed by a more detailed description for each individual cruise, and 3) an analysis of patterns of abundance during the March-April 1980 intensive postdisposal period (Sections 4.4.-.2) to include a summary statement of conclusions about the effects of brine disposal followed by a more detailed description for each individual cruise. Conclusions about the effects of brine disposal presented in sections 4.5.-.2 were made after integrating patterns of abundance in March-April 1979 (before brine disposal) with patterns in March-April 1980 (after brine disposal). Summary statements (eg. topic paragraphs) are presented before the detailed analysis to indicate the conclusions drawn and help guide the reader through the subsequent detail. However, it is necessary for the reader to examine the supporting multiple range tables (Appendix I) to follow the analysis for individual cruises. The particular multiple range tables that support a section are indicated after the species names that constitutes a section title. Tables that support predisposal analyses are indicated before tables that support postdisposal analyses.

4.4.2 Rationale of the Data Interpretation

This section describes the rationale of how abundance data were analyzed for the selected nekton species. It describes the meaning of "significant differences" and "non-significant differences", points out how significance tests of the present data could lead to two types of very misleading interpretations, and describes how data were interpreted in the present studies to minimize or avoid such errors. Finally, it describes the meaning of a term "minor significant differences" used to describe the results of some significance tests.

The words "significant difference" were repeatedly employed herein in the technical sense that there is sufficient statistical evidence that an observed difference between stations is real, not due to random

Table 4-4 Percentage compositions of selected nekton in the Penaeid shrimp catch and in the fish catch at the diffuser area (Stations 14-25 inclusive) by cruise, March-April 1980. "A" indicates absent. Numbers beneath species names indicate report sections wherein abundance patterns are analyzed.

Species	5-6 Mar.	19-20 Mar.	24-25 Mar.	27-28 Mar.	4-5 Apr.	10-11 Apr.	14-15 Apr.
Penaeus aztecus (4.5.3)	72	78	82	67	81	100	79
Penaeus duorarum (4.5.4)	4	14	13	8	14	0	10
Penaeus setiferus (4.5.5)	24	7	5	25	5	0	12
Cynoscion arenarius (4.5.6)	1	4	1	<1	1	<1	4
Cynoscion nothus (4.5.7)	74	72	84	84	88	1	4
Syacium gunteri (4.5.8)	10	10	6	3	3	6	13
Halieutichthys aculeatus (4.5.9)	5	1	2	<1	1	A	4
Chloroscombrus chrysurus (4.5.10)	A	A	A	A	A	51	3
Peprilus burti (4.5.11)	<1	8	1	6	1	28	0

variation. Causes of a significant difference must be explained to properly interpret them. Significant differences in the present studies could be due to an effect of brine disposal or to some natural background phenomena. Unfortunately, counts of abundance data characteristically fluctuate greatly and show significant differences because of difficult-to-identify natural background phenomena such as schooling behavior, movements, mortality, time of day, substrate composition, substrate relief, etc. The words, "no significant difference", in contrast, imply: 1) the observed difference is due to random variation, or 2) the observed difference may be real, not random, but there is not sufficient evidence to establish that.

Therefore, from the preceding paragraph, significance tests could lead to two types of error in the present studies of the effects of brine disposal in the March-April 1980 intensive postdisposal period: 1) evidence might not be sufficient to declare significant a real effect of brine disposal on abundance, and 2) a significant difference due to natural background phenomena could be wrongly blamed on brine disposal. To minimize these two possible types of error, findings of significant differences (and non-significant differences) were supplemented by a "common sense" analysis of the pattern that counts of abundance showed in March-April 1980 in order to judge: 1) why differences were significant, and 2) was there a non-significant pattern that suggested an effect due to brine disposal. An effect due to brine should be evidence by low abundance near the diffuser (Stations 15 and 16) with increased abundance radiating out from there. When abundance was comparatively low at Stations 15 and 16--which could be due to random variation--counts were examined at stations further from the diffuser.

At times, on one or both sides of the diffuser, counts were comparatively low at stations closest to the diffuser (such as 15 or 16) and furthest removed from the diffuser (such as 14 or 17) but counts were comparatively high at stations intermediate in distance (such as 18 or 19) from the diffuser. At other times, counts were both high and low at stations far from the diffuser with no pattern of abundance being apparent. In such cases, it was not considered reasonable to conclude that comparatively low abundance near the diffuser was due to brine disposal--whether differences were significant or not. Finally, natural background patterns of abundance in the March-April 1979 predisposal period were compared with patterns in the March-April 1980 intensive post-disposal period to further clarify the effects of brine disposal.

The term "minor significant difference" has been used herein to describe the meaning of many significant tests. Multiple range tests compared all mean counts within sets of mean counts that formed a gradient from low abundance to high abundance. These tests have a built-in property that significant differences often are declared between one or a few highest counts and one or a few lowest counts. Such significant differences were termed "minor significant differences" if the supporting common sense analysis of the patterns of abundance indicated that it was not reasonable to attribute the differences to an effect of brine disposal or to some general pattern of abundance in the diffuser area such as an inshore-offshore gradient or an easterly-westerly gradient.

4.4.3 Penaeus aztecus (See Appendix I, Tables I-1 to I-10)

Penaeus aztecus was selected because it is a commercially valuable shrimp and a dominant Penaeid in the diffuser area.

4.4.3.1 March-April 1979 Predisposal Period

During March-April 1979 there were minor significant differences in abundance in two of the three cruises. No general pattern was apparent, although abundance tended to be high at Station 26. However, abundance at a given station fluctuated from cruise to cruise. For example: 1) abundance was intermediate at Stations 15 and 16 on two occasions (12 March, 5 April) but low on another (20 April), 2) abundance was high at Station 20 on two cruises (12 March, 20 April) but low on another (5 April), 3) abundance was high at Station 25 on one occasion (12 March) but intermediate on two other cruises (5 April, 20 April), 4) abundance was low at Station 24 on two occasions (12 March, 5 April) but high on another (20 April), and 5) abundance was low at Station 14 on two cruises (12 March, 20 April) but high on the third (5 April). These fluctuations were not consistent, however, even at stations near one another. For example, abundance was high at Station 20 on 12 March and 20 April, but low at the nearby Station 14; on 5 April abundance was low at Station 20 but high at Station 14.

About 198 _P. aztecus_ were captured at the diffuser stations during the 12 March 1979 night cruise. There were minor significant differences in that abundance was higher at Station 26 than at most other stations, but no general pattern was apparent. Abundance at Station 15 and 16 was intermediate among stations.

About 194 _P. aztecus_ were captured at the diffuser stations during the 5 April 1979 night cruise. There were minor significant differences between the station of highest abundance (26) and the stations of lowest

lowest abundance (2, 20, 22, 24). However, no general pattern of abundance was apparent. Abundance at Stations 15 and 16 was intermediate.

Only 29 P. aztecus were captured at the diffuser stations during the 20 April 1979 day cruise. There were no significant differences between stations. Abundance at Stations 15 and 16 was low.

4.4.3.2 March-April 1980 Intensive Postdisposal Period

Brine disposal apparently had little or no effect on abundance of P. aztecus. During the March-April 1979 predisposal period there was no general pattern of abundance between stations nor significant differences, except the minor significant difference that abundance tended to be higher at Station 26 which is located a few miles offshore from the diffuser. However, abundance at a given station fluctuated greatly from cruise to cruise in the predisposal period. During the March-April 1980 intensive postdisposal period there usually were no significant differences between stations, which is similar to the findings during the 1979 predisposal period. Moreover, during March-April 1980 there were no significant differences that could be attributed to brine disposal on any cruise, nor were there patterns between stations that reasonably could be interpreted to indicate that brine disposal affected abundance. Abundance at Stations 15 and 16, which are closest to the diffuser, fluctuated greatly from cruise to cruise in both March-April 1979 and March-April 1980.

About 512 P. aztecus were captured at the diffuser stations during the 5-6 March 1980 night cruise. There was no significant difference in abundance except minor significant differences between a few stations of highest (26, 24) and lowest (17, 18) abundance. Abundance at Station 15 and 16 was intermediate among the stations.

About 250 P. aztecus were captured at the diffuser stations during the 19-20 March day cruise. There were minor significant differences in abundance in that Station 26 and the inshore stations (20, 21, and 22) showed lower abundance than other stations. However, there was no pattern suggesting that abundance was affected by brine disposal. Abundance was relatively high at Stations 15 and 16.

About 379 P. aztecus were captured at the diffuser stations during the 24-25 March night cruise. There was no significant difference in abundance except a minor significant difference between the stations of highest (17) and lowest abundance (16). However, there was no pattern suggesting that abundance was affected by brine disposal. Abundance at Stations 15 and 16 was low, but this was also true of Stations 9, 26, 14, and 23 which are far from the diffuser.

About 115 P. aztecus were captured at the diffuser stations during the 27-28 March day cruise. There was no significant difference in abundance between stations, and the observed pattern of abundance did not suggest any effect due to brine disposal. Although abundance was low at Station 15, it was intermediate or high at Stations 16, 18 and 19 which are close to the diffuser. In contrast, abundance was low or intermediate at Stations 9, 26, 20, 23, and 25 which are well removed from the diffuser.

About 223 P. aztecus were captured at the diffuser stations during the 4-5 April 1980 night cruise. There was no significant difference in abundance between stations and no pattern suggesting that brine disposal affected abundance. Abundance at Stations 15 and 16 was intermediate among the stations.

Only six P. aztecus were captured at the diffuser stations during the 10-11 April 1980 day cruise. None were captured at Stations 15, or 16 or at Stations 9 and 26, but there were no significant differences in abundance between stations.

About 139 P. aztecus were captured at the diffuser stations during the 14-15 April 1980 night cruise when Stations 15b and 16 could not be occupied. There were no significant differences in abundance between stations and no pattern suggesting that brine disposal affected abundance. Abundance was lowest at Stations 15a, 19, and 22, but it was also low at Station 14.

4.4.4 Penaeus duorarum (See Appendix I, Tables I-11 - I-20)

Penaeus duorarum was selected because it is a Penaeid shrimp. However, it is not a principal Penaeid off Freeport, except about May, and few were captured during the March-April 1980 period.

4.4.4.1 March-April 1979 Predisposal Period

During March-April 1979 there were no significant differences in abundance in any of the three cruises, although few P. duorarum were caught in the 20 April 1979 cruise in contrast to 53 on 12 March 1979 and 71 on 5 April 1979. No general pattern of abundance was apparent in any cruise. Abundance was intermediate at Stations 15 and 16 during each cruise.

4.4.4.2 March-April 1980 Intensive Postdisposal Period

Brine disposal apparently had little or no effect on abundance of P. duorarum. During the March-April 1979 predisposal period there were no significant differences between stations nor was any general pattern of abundance apparent. During the March-April 1980 intensive postdisposal period there usually were no significant differences between stations, which is similar to the findings during the 1979 predisposal eriod. Moreover, during March-April 1980 there were no significant differences and no patterns between stations that reasonably could be interpreted to indicate that brine disposal affected abundance. Abundance at Stations 15 and 16, which are closest to the diffuser, was intermediate during the 1979 predisposal period and generally was high or intermediate during the 1980 intensive postdisposal period.

Only 17 P. duorarum were captured at the diffuser stations during the 5-6 March 1980 night cruise. There was no significant difference between stations and no apparent pattern of abundance. Abundance at Stations 15 and 16 was high or intermediate.

Only 17 P. duorarum were captured at the diffuser stations during the 19-20 March day cruise. There were minor significant differences between two stations of high abundance (15, 23) and several stations where none were caught (18, 20, 21, 22, 25, 26). However, there was no pattern suggesting that brine disposal affected abundance. Abundance was greatest at Station 15 but intermediate at stations far from the diffuser (14, 17).

About 46 P. duorarum were captured at the diffuser stations during the 24-25 March night cruise. There was no significant difference in abundance between stations, and no pattern suggesting any effect due to brine disposal. Abundance at Stations 15 and 16 was high or intermediate among the stations.

Only nine P. duorarum were captured at the diffuser stations during the 27-28 March day cruise. There were minor significant differences between a few stations where P. duorarum was caught (21, 22, 14, 24) and the other stations where none were caught. However, there was no pattern suggesting that brine disposal affected abundance. No P. duorarum were captured at Stations 15 and 16, but that was also the case at Stations

9 and 26 and at most of the diffuser stations.

Only 24 P. duorarum were captured at the diffuser stations during the 4-5 April night cruise. There were no significant differences except for a minor significant difference between the stations of highest (14) and lowest abundance (24, 25, 26). However, there was no pattern to suggest any effect due to brine disposal. Abundance was high at Stations 15 and 16.

No P. duorarum were captured at the diffuser stations during 10-11 April day cruise.

Only ten P. duorarum were captured at the diffuser stations during the 14-15 April night cruise when stations 15b and 16 could not be occupied. There were no significant differences and no pattern suggesting that brine disposal affected abundance. Abundance was high at Stations 15a and 18 which are close to the diffuser.

4.4.5 Penaeus setiferus (See Appendix I, Tables I-21 - I-30)

Penaeus setiferus was selected because it is a commercially valuable shrimp and an important Penaeid in the diffuser area at times. However, the diffuser area is near its bathymetric limit off Freeport.

4.4.5.1 March-April 1979 Predisposal Period

During March-April 1979 there were no significant differences in abundance in two cruises (5 April, 20 April). There were minor differences in the 12 March cruise between stations of high abundance (21, 17, 16) and low abundance (15, 18, 26). No patterns of abundance were apparent between stations. Abundance fluctuated from cruise to cruise at Stations 15 and 16, but the pattern was not consistent. Abundance was high at Station 16 on 12 March, but not at Station 15. Few or no

P. setiferus were captured at Stations 15 and 16 on two cruises (5 April, 20 April), and the same was true at many other stations on those cruises.

About 337 *P. setiferus* were captured at the diffuser stations during the 12 March 1979 night cruise. There were no significant differences except minor significant differences between a few stations of high abundance (21, 17, 16) and a few stations of low abundance (15, 18, 26). It should be noted that abundance at Station 16 was significantly higher than that at Station 15.

Only 34 *P. setiferus* were captured at the diffuser stations during the 5 April 1979 night cruise. There were no significant differences in abundance between stations and no pattern of abundance. No *P. setiferus* were captured at Stations 15 and 16, but few were captured at half the stations.

Only 21 *P. setiferus* were captured at the diffuser stations during the 20 April 1979 day cruise. There were no significant differences in abundance between stations. Few or no *P. setiferus* were captured at Stations 15 and 16 and at most other stations.

4.4.5.2 March-April 1980 Intensive Postdisposal Period

Brine disposal apparently had little or no effect on abundance of *P. setiferus*. During the March-April 1979 predisposal period there was no general pattern of abundance between stations nor significant differences except that on one cruise (12 March) there was a minor significant difference between a few stations of high abundance (21, 17, 16) and low abundance (15, 18, 26). During the March-April 1980 intensive postdisposal period there usually were no significant differences which is similar to the findings during the 1979 predisposal period. On 5-6 March 1980 there were minor significant differences between a few stations of high (16, 23) and low abundance (17, 26). Although minor significant differences were found in early March of both the predisposal and postdisposal periods, the station pattern was not consistent. For examples: 1) abundance was high at Station 16 in both years, 2) abundance at Station 17 was high in 1979 but low in 1980, and 3) at Stations 15 and 23 abundance was high in 1980 but low in 1979. There were no significant differences and no pattern between stations in March-April 1980 that reasonably could be interpreted to indicate that brine disposal affected abundance.

About 105 P. setiferus were captured at the diffuser stations during the 5-6 March 1980 night cruise. There were minor significant differences in abundance between a few stations of high (16, 23) and low abundance (17, 26), but there was no general pattern of abundance. Abundance was low at Station 9, which is inshore of the diffuser stations, and at Station 26 where P. setiferus approaches its bathymetric limits off Freeport. Abundance was highest or intermediate at Stations 15 and 16.

About 32 P. setiferus were captured at the diffuser stations during the 19-20 March day cruise. There were no significant differences in abundance between stations and no pattern to suggest any effect due to brine disposal. Abundance at Stations 15 and 16 was intermediate in magnitude.

Only 17 P. setiferus were captured at the diffuser stations during the 24-25 March night cruise. There were no significant differences in abundance between stations and no pattern to suggest any effect due to brine disposal. Abundance was intermediate at Station 15 and equal to that at Station 9 far inshore. No P. setiferus were caught at Station 16.

About 27 P. setiferus were captured at the diffuser stations during the 27-28 March day cruise. There were no significant differences in abundance between stations and no pattern to suggest any effect due to brine disposal. Abundance at Stations 15 and 16 was intermediate and about equal to that at Station 9 far inshore.

Only nine P. setiferus were captured at the diffuser stations during the 4-5 April 1980 night cruise. There were no significant differences in abundance between stations and no pattern to suggest any effect due to brine disposal. Abundance was high at Station 15 but none were captured at Station 16.

No Penaeus setiferus were captured at the diffuser stations during the 10-11 April 1980 day cruise.

Only 13 P. setiferus were captured at the diffuser stations during the 14-15 April 1980 night cruise when Stations 15b and 16 were not occupied. There were no significant differences in abundance between stations and no pattern to suggest that brine disposal had any effect.

4.4.6 Cynoscion arenarius (See Appendix I, Tables I-31 - I-40)

Cynoscion arenarius was selected because it is one of the principal members of the dominant family Sciaenidae of the white shrimp community and because it is abundant at times in the diffuser area.

4.4.6.1 March-April 1979 Predisposal Period

During March-April 1979 there were no significant differences on the two cruises (5 April, 20 April) when many fish were caught except a minor significant difference between a station of high abundance (17) and others where no C. arenarius were caught (9, 23, 24, 25). No general pattern was apparent between stations. Abundance fluctuated at given stations from cruise to cruise. For example: 1) abundance was low at Station 24 on 5 April but high on 20 April, 2) abundance was high at Station 14 on 5 April but low on 20 April, and 3) abundance was high on 20 April at Station 16 but low at the nearby Station 15 while abundance was intermediate at those two stations on 5 April.

Only four _C. arenarius_ were captured at the diffuser stations during the 12 March 1979 night cruise.

About 53 _C. arenarius_ were captured at the diffuser stations during the 5 April 1979 night cruise. There were no significant differences except the minor significant difference between a station of high abundance (17) and others where no _C. arenarius_ were caught (9, 23, 24, 25). Abundance was intermediate at Stations 15 and 16, but there was no general pattern between stations.

About 96 _C. arenarius_ were captured at the diffuser stations during the 20 April 1979 day cruise. There were no significant differences between stations and no apparent general pattern. Abundance was high at Station 16 but low at Station 15.

4.4.6.2 March-April 1980 Intensive Postdisposal Period

Brine disposal apparently had little or no effect on abundance of _C. arenarius_. During the March-April 1979 predisposal period there were no significant differences, except minor significant differences between stations of highest and lowest abundances and no pattern of abundance between stations. Abundance fluctuated at given stations from cruise to cruise. Similarly, during the March-April 1980 intensive postdisposal period there were no significant differences between stations except a few minor significant differences between stations of highest and lowest abundances. These stations of highest and lowest abundance varied from cruise to cruise in March-April 1980 as catches fluctuated in the March-April 1979 predisposal period. Moreover, there was no pattern of abundance between stations in March-April 1980 that reasonably could be interpreted to indicate that brine disposal affected abundance. Abundance at Stations 15 and 16 fluctuated from cruise to cruise in 1980 as it did in the predisposal period.

About 93 C. arenarius were captured at the diffuser stations during the 5-6 March 1980 night cruise. There were no significant differences except the minor significant difference that abundance at Station 21 was much higher than at any other station. Few or no C. arenarius were taken at most stations including the stations (9, 20, and 22) closest to Station 21. Abundance was high at Stations 15 and 16.

About 291 C. arenarius were captured at the diffuser stations during the 19-20 March 1980 day cruise. There were no significant differences and no pattern suggesting that brine disposal affected abundance. As in the preceding cruise, abundance was greatest at Station 21. No C. arenarius were captured at Stations 15 and 16; but few or none were captured at Stations 9 and 26. Stations far from the diffuser showed low abundance (14, 17, 22, 25), while stations close to the diffuser showed high abundance (18 and 19).

About 78 C. arenarius were captured at the diffuser stations in the 24-25 March 1980 night cruise. There were no significant differences and no pattern suggesting that brine disposal affected abundance. Abundance at Stations 15 and 16 was intermediate or low. Highest abundance was at stations far from the diffuser (25, 22, 17) as was low abundance (14, 9).

About 38 C. arenarius were captured at the diffuser stations in the 27-28 March 1980 day cruise. There were no significant differences and

and no pattern suggesting that brine disposal affected abundance. Abundance at Station 15 was intermediate, but no C. arenarius were captured at Stations 16 or 9. Highest abundance was at stations far from the diffuser (22, 25, 23) as was low abundance (9, 20, 14, 26).

About 77 C. arenarius were captured in the 4-5 April 1980 night cruise. There were no significant differences except minor significant differences between a few stations of highest (26, 19) and lowest abundance (21, 22). However, there was no pattern suggesting that brine disposal affected abundance. Abundance at Stations 15 and 16 was intermediate among stations. Highest abundance was at stations close to the diffuser (18, 19) as was low abundance (Stations 9, 14, 17, 22).

Only four C. arenarius were captured in the 10-11 April 1980 day cruise. There was no significant differences between stations.

About 36 C. arenarius were captured in the 14-15 April 1980 night cruise when Stations 15b and 16 could not be occupied. There were no significant differences except minor significant differences between a few stations of high abundance (21, 22) and several stations where none were caught (9, 14, 15, 18). However, there was no pattern suggesting that brine disposal affected abundance; because few C. arenarius were captured except at Stations 21 and 22. Stations 15a, 18, and 19, which were the closest to the diffuser, showed both high abundance (19) and no fish (15b and 18). Few C. arenarius were captured westerly of the diffuser (Stations 14, 15a, 18, 20, 23); but few were also captured at Station 17, the most easterly station.

4.4.7 Cynoscion nothus (See Appendix I, Tables I-41 - I-50)

Cynoscion nothus was selected because it is a dominant member of the white shrimp community and because it is very abundant at times in the diffuser area, especially during the winter-spring period when catches of many other fishes are low.

4.4.7.1 March-April 1979 Predisposal Period

During March-April 1979 there were significant differences in abundance between stations in two cruises (12 March, 5 April) but not in the third cruise (20 April). There was a tendency in all cruises, however, for abundance to be lowest offshore and greatest at stations located inshore and/or in an easterly direction (21, 22, 9, 17, 19). Abundance was usually intermediate at Stations 15 and 16. Despite that pattern, abundance fluctuated at some stations, such as Station 24.

About 1,663 C. nothus were captured at the diffuser stations during the 12 March 1979 night cruise. There were minor significant differences in that abundance was higher at Station 21 than at Stations 20, 25, 24, 14, and 26. There seemed to be a tendency, although nonsignificant, for abundance to be lower at stations located furthest offshore and highest at stations located in an inshore and easterly direction (9, 21, 22, 17, 19). Abundance was intermediate at Stations 15 and 16.

About 419 C. nothus were captured at the diffuser stations during the 5 April 1979 night cruise. There were significant differences in that abundance tended to be highest at stations located in an inshore and easterly direction (21, 22, 9, 17, 20, 19), which is similar to the nonsignificant pattern in the previous cruise. Abundance was lowest at stations located furthest offshore as in the previous cruise, and abundance was again intermediate at Stations 15 and 16.

About 1,589 C. nothus were captured at the diffuser stations during the 20 April 1979 day cruise. There were no significant differences in abundance. The previous pattern of greatest abundance at stations located in an easterly and inshore direction (22, 20, 19, 9, 17, 21) seemed to continue, but abundance varied at the most offshore stations (23, 24, 25, 26). Abundance was intermediate at Station 15 but low at Station 16.

4.4.7.2 March-April 1980 Intensive Postdisposal Period

Brine disposal apparently had little or no effect on abundance of *C. nothus*. During the March-April 1979 predisposal period there were significant differences in abundance between stations in two cruises (12 March, 5 April), but not in the 20 April cruise. There seemed to be a tendency, however, in all predisposal cruises for abundance to be lowest offshore and greatest at stations located inshore and in an easterly direction (21, 22, 9, 17, 19). That pattern was not apparent during the March-April 1980 intensive postdisposal period. Abundance was comparatively low at Stations 17 and 19 in the 5 March 1980 cruise--which occurred before brine disposal actually commenced. These stations are located easterly of the diffuser, so that the apparent pattern in 1979 did not exist in 1980--even prior to brine disposal. Moreover, abundance fluctuated greatly at other inshore and easterly stations during 1980 as it did at Station 24 during 1979. For example, abundance was low in 1980 at Stations 21 and 22 during the cruises of 19-20 and 24-25 March but high during the cruises of 27-28 March, 4-5 April, and 10-11 April. Furthermore, although often there were minor significant differences between stations of high and low abundance during the intensive postdisposal period, there seemed to be no significant differences and no pattern of abundance between stations that reasonably could be interpreted to indicate that brine disposal affected abundance. Both high and low abundances regularly occurred at stations far from the diffuser. Finally, abundance was usually intermediate at Stations 15 and 16 during both 1979 and 1980, and these are the stations closest to the diffuser.

About 6,083 C. nothus were captured at the diffuser stations during the 5-6 March 1980 night cruise. There were minor significant differences between a few stations of high (26, 22, 9) and low (16, 17, 19, 25) abundance. The low abundance observed at Stations 17 and 19 contrasts with the pattern in the March-April 1979 predisposal period when abundance was high at the inshore and easterly stations. Abundance at Stations 15 and 16 was low or intermediate.

About 5,651 C. nothus were captured at the diffuser stations during the 19-20 March 1980 day cruise. There were minor significant differences between a few stations of high (17, 25,9) and low abundance (22, 21, 26), but there was no pattern suggesting that brine disposal affected abundance. High abundances were at stations far from the diffuser (17, 25) but so were low abundances (Stations 14, 22). Abundance at Stations 15 and 16 was intermediate.

About 6,069 C. nothus were captured in the 24-25 March 1980 night cruise. There were minor significant differences between the station of highest abundance (17) and a few stations of low abundance (22, 21, 25, 26). However, there was no pattern suggesting that brine disposal affected abundance. Abundance was high at stations far from the diffuser (17, 14) but also low (Stations 22,25). Abundance at Stations 15 and 16 was intermediate in magnitude.

About 10,302 C. nothus were captured in the 27-28 March 1980 day cruise. There were no significant differences and no pattern suggesting that brine disposal affected abundance. Abundance at Stations 15 and 16 was intermediate. High abundance was at stations far from the diffuser (14, 17, 22) as was low abundance (Station 20).

About 6,023 C. nothus were captured in the 4-5 April 1980 night cruise. There were no significant differences except the minor significant difference that abundance was lower at Station 25 than at several other stations (21, 22, 20, 14, 26, 18). However, there was no pattern suggesting that brine disposal affected abundance. Abundance at Stations 15 and 16 was low or intermediate, and abundance at the inshore stations (20, 21, 22) was higher than at the offshore stations (23, 24, 25).

Only 12 C. nothus were captured in the 10-11 April 1980 day cruise. There were no significant differences except the minor significant differences that Stations 20, 21, and 22 exhibited greater abundance than the many stations where none were captured. However, there was no pattern suggesting that brine disposal affected abundance. Like the preceding cruise, abundance at the inshore stations (20, 21, 22) was higher than at the offshore stations (23, 24, 25). Abundance at Stations 15 and 16 was intermediate.

Only 40 C. nothus were captured at the diffuser stations during the 14-15 April 1980 night cruise when Stations 15b and 16 were not occupied. There were no significant differences and no pattern suggesting that brine disposal affected abundance. Stations 18 and 19, which are close to the diffuser, showed intermediate abundance. No C. nothus were captured at Station 15b, but none were captured at Station 25 which is far from the diffuser.

4.4.8 Syacium gunteri (See Appendix I, Tables I-51 - I-60)

Syacium gunteri was selected because it is one of the most characteristic fishes of the diffuser area and is a principal member of the brown shrimp community. Moreover, this flatfish is closely associated with the bottom and would be more exposed to the effects of brine.

4.4.8.1 March-April 1979 Predisposal Period

During March-April 1979 there were no significant differences between stations on any cruise except a minor significant difference on 20 April between the stations of highest (26) and lowest abundance (18). No general pattern was apparent, although abundance tended to be high at Station 26. Abundance varied at Stations 15 and 16 from cruise to cruise, but the pattern was not consistent.

About 655 _S. gunteri_ were captured at the diffuser stations during the 12 March 1979 night cruise. There were no significant differences and no apparent pattern of abundance between stations. Abundance was high at Station 16 but low at Station 15.

About 103 _S. gunteri_ were captured at the diffuser stations during the 5 April 1979 night cruise. There were no significant differences and no apparent pattern of abundance between stations. Abundance was high at Station 15 and intermediate at Station 16.

About 163 _S. gunteri_ were captured at the diffuser stations during the 20 April 1979 day cruise. There were no significant differences except a minor significant difference between the station of highest abundance (26) and the station of lowest abundance (18). However, there was no general pattern of abundance. Abundance was intermediate at Stations 15 and 16.

4.4.8.2 March-April 1980 Intensive Postdisposal Period

Brine disposal apparently had little or no effect on abundance of _S. gunteri_. During the March-April 1979 predisposal period there were essentially no significant differences and no general pattern of abundance was apparent. Similarly, there were no significant differences in abundance during the March-April 1980 postdisposal period, even at the 5% level in those instances when that special protection level was used. In contrast to the predisposal period, patterns of abundance were apparent during a few cruises in March-April 1980, albeit nonsignificant ones. During the first three cruises in March-April 1980 (5-6 March, 19-20 March, and 24-25 March), the inshore stations (9, 20, 21, 22) generally exhibited lower abundance than the offshore stations (23, 24, 25). Thereafter, that pattern broke down and there was little difference between these stations. The change in pattern after 24-25 March might be associated with the movement offshore that S. gunteri apparently undertakes about March-April (noted in the May 1980 predisposal report) as it abandons the inshore area (< 10 fathoms) for the spring and summer. However, in addition to the complete absence of significant differences, there were no patterns in most cruises (5-6 March, 19-20 March, 4-5 April, 10-11 April, 14-15 April) that reasonably could be interpreted to indicate that brine disposal affected abundance. Moreover, abundance at Stations 15 and 16 was intermediate or high in those cruises. On two cruises (24-25 and 27-28 March), the distribution of S. gunteri at Stations 14, 15, 16, 17, 18 and 19 resembled the proposed pattern (see Section 4.5.2, "Rationale of the Data Interpretation") suggesting reduced abundance near the diffuser. However, the differences between stations were not significant--even at the 5% special protection level--so that there is not sufficient evidence to say that the difference reflected anything more than random variation.

About 835 S. gunteri were captured at the diffuser stations during the 5-6 March 1980 night cruise. There were no significant differences in abundance. Abundance at Stations 15 and 16 was high or intermediate. The inshore stations (9, 20, 21, and 22) showed lower abundance than the offshore stations (23, 24, 25) which might reflect the fact that this species is typical of the offshore brown shrimp community, not the inshore white shrimp community.

About 812 S. gunteri were captured at the diffuser stations during the 19-20 March 1980 day cruise. There were no significant differences and no pattern suggesting that brine disposal affected abundance. Abundance at Stations 15 and 16 was high or intermediate. As in the preceding cruise, the inshore stations (20, 21, 22) exhibited lower abundance than the offshore stations (23,24, 25).

About 410 S. gunteri were captured at the diffuser stations in the 24-25 March 1980 night cruise. There were no significant differences between stations, even at the 5% level. As in the preceding two cruises, the inshore stations (9, 20, 21, 22) exhibited lower abundance than the offshore stations (23, 24, 25, 26). Stations 15 and 16 exhibited low abundance in comparison to stations far (14, 17) and intermediate (18, 19) from the diffuser. The distribution of S. gunteri at Stations 14, 15, 16, 17, 18, and 19 in this cruise resembled the proposed pattern that might be interpreted to suggest reduced abundance near the diffuser. However, there is not sufficient evidence to say that the observed distribution reflects anything more than random variation; because the differences between stations were not significant even at the 5% level.

About 294 S. gunteri were captured at the diffuser stations in the 27-28 March 1980 day cruise. There were no significant differences in abundance between stations, even at the 5% level. Abundance was equal at the most offshore diffuser stations (23, 24, 25) and at the most inshore diffuser stations (20, 21, 22), reversing the pattern in the cruises of 5-6 March, 19-20 March and 24-25 March. Abundance at Stations 15 and 16 was low in comparison to catches at stations far from the diffuser (14, 17) and intermediate from the diffuser (18, 19), continuing a pattern that also appeared a few days previously on the 24-25 March night cruise. The observed distribution on S. gunteri at Stations 14, 15, 16, 17, 18, and 19 in this cruise again might be interpreted to suggest reduced abundance near the diffuser. However, there is not sufficient evidence to say that the observed differences reflect anything more than random variation, because the differences between stations were not significant even at the 5% level.

About 177 S. gunteri were captured at the diffuser stations in the 4-5 April 1980 night cruise. There were no significant differences and no pattern suggesting that brine disposal had any effect. Abundance at Stations 15 and 16 was intermediate. High abundances were at stations far from the diffuser (14, 17) as were low abundances (20, 22, 23, 25).

About 121 S. gunteri were captured at the diffuser stations in the 10-11 April 1980 day cruise. There were no significant differences except a minor significant difference between stations of high abundance (20, 21) and stations where none were caught (9, 17, 19, 25). However, there was no pattern suggesting that brine disposal affected abundance. Abundance at Stations 15 and 16 was intermediate. High abundances were at stations far from the diffuser (20, 14) as were low abundances (17, 22, 23, 25).

About 129 S. gunteri were captured at the diffuser stations in the 14-15 April 1980 night cruise when Stations 15b and 16 could not be occupied. There were no significant differences in abundance. There also was no pattern suggesting that brine disposal affected abundance, although abundance was low at the Stations (15b, 18, 19) closest to the diffuser.

High abundances were at stations far from the diffuser (9, 26, 20, 17, 23) as were the lowest abundances (14, 25).

4.4.9 Halieutichthys aculeatus (See Appendix I, Tables I-61 - I-69)

Halieutichthys aculeatus was selected because it is characteristic of and abundant in the diffuser area at times and is a member of the brown shrimp community. Moreover, its flattened form indicates it is closely associated with the bottom and would be more exposed to the effects of brine.

4.4.9.1 March-April 1979 Predisposal Period

During March-April 1979 there were no significant differences in between stations nor was there any consistent pattern of abundance. Abundance varied between high and low at Stations 15 and 16.

About 32 Halieutichthys were captured at the diffuser stations during the 12 March 1979 night cruise. There were no significant differences between stations and no apparent pattern in abundance. Abundance was high at Station 16 but low at Station 15.

About 25 Halieutichthys were captured at the diffuser stations during the 5 April 1979 night cruise. There were no significant differences between stations and no apparent pattern in abundance. Abundance was intermediate at Stations 15 and 16.

Only 5 Halieutichthys were captured at the diffuser stations during the 20 April 1979 day cruise.

4.4.9.2 March-April 1980 Intensive Postdisposal Period

Brine disposal apparently had little or no effect on abundance of H. aculeatus. During the March-April 1979 predisposal period there were no significant differences in abundance and no general pattern of abundance was apparent. Similarly, there was no apparent pattern between stations during the March-April 1980 postdisposal period, especially one that reasonably could be interpreted to indicate that brine disposal affected abundance. There were significant differences between stations at times but no pattern indicating an effect from brine disposal. Usually, abundance was both high and low at stations far from the diffuser. Abundance at Stations 15 and 16 varied from cruise to cruise as it did in the March-April 1979 predisposal period.

About 416 H. aculeatus were captured at the diffuser stations during the 5-6 March 1980 night cruise. There was no significant difference in abundance between stations. Abundance at Stations 15 and 16 was high or intermediate among stations.

About 48 H. aculeatus were captured at the diffuser stations during the 19-20 March 1980 day cruise. There were significant differences between stations of high abundance (23, 18, 14, 19) and stations where none were caught but no pattern suggesting that brine disposal affected abundance. Abundance was intermediate at Station 15 and low at Station 16. Abundance was high at stations far from the diffuser (14, 23) as well as low (Stations 9, 26, 17, 22). Similarly, abundance was both high (18, 19) and low (21, 24) at stations intermediate in distance from the diffuser.

About 121 H. aculeatus were captured at the diffuser stations in the 24-25 March 1980 day cruise. There were no significant differences except a minor significant difference between the stations of lowest abundance (16) and highest abundance (23). However, there was no pattern suggesting that brine disposal affected abundance. Abundance was low at Stations 15 and 16, but abundance at stations far from the diffuser was both high

(14, 17, 23) and low (20, 25, 26).

Only 22 H. aculeatus were captured at the diffuser stations in the 27-28 March 1980 day cruise. There were no significant differences except the minor significant difference that abundance at Station 14 was greater than at most stations. However, the pattern of abundances did not suggest any effect due to brine disposal. No H. aculeatus were captured at Stations 15 and 16, but stations far from the diffuser showed high abundance (14, 17) and no Halieutichthys (20, 22, 23, 24).

About 74 H. aculeatus were captured at the diffuser stations in the 4-5 April 1980 night cruise. There were no significant differences except a minor significant difference between a few stations of highest abundance (14, 26) and the station of lowest abundance (25). However, there was no pattern suggesting that brine disposal affected abundance. Abundance at Stations 15 and 16 was intermediate among stations. High abundances were at stations (14, 26) far from the diffuser as were low abundances (17, 20, 25).

No H. aculeatus were captured at the diffuser stations during the 10-11 April 1980 day cruise.

About 39 H. aculeatus were captured at the diffuser stations during the 14-15 April 1980 night cruise when Stations 15b and 16 could not be occupied. There were no significant differences and no pattern suggesting that brine disposal affected abundance. Abundance was low at stations located near the diffuser (15b, 18, 19), but abundance was equally low at stations far from the diffuser (14, 17).

4.4.10 Chloroscombrus chrysurus (See Appendix I, Tables I-70 - I-73)

Chloroscombrus chrysurus was selected because it is a pelagic species that is a dominant off Freeport in spring, summer and fall.

4.4.10.1 March-April 1979 Predisposal Period

During March-April 1979, few or no Chloroscombrus were captured during two cruises (12 March and 5 April). There were no significant differences nor patterns of abundance between stations during the 20 April 1979 day cruise, although 4,482 Chloroscombrus were captured. Abundance was intermediate at Stations 15 and 16 in that cruise.

4.4.10.2 March-April 1980 Intensive Postdisposal Period

Brine disposal apparently had little or no effect on abundance of Chloroscombrus. During the March-April 1979 predisposal period there were no significant differences and no apparent pattern of abundance in the one cruise when many Chloroscombrus were captured. Similarly, there was no apparent pattern between stations during the March-April 1980 postdisposal period, especially one that reasonably could be interpreted to indicate that brine disposal affected abundance. There were minor significant differences between stations but no pattern indicating an effect from brine disposal. Moreover, abundance was intermediate at Stations 15 and 16 in March-April of both years.

About 1,095 C. chrysurus were captured at the diffuser stations in the 10-11 April 1980 day cruise. There were no significant differences except a minor significant difference between a station of high abundance (9) and a few stations of low abundance (21, 22, 25). However, there was no pattern suggesting that brine disposal affected abundance. High abundances were at stations far from the diffuser (9, 26, 14, 23) as were low abundances (Stations 20, 22, 25). Abundance at Stations 15 and 16 was intermediate.

Only 29 C. chrysurus were captured at the diffuser stations during the 14-15 April 1980 night cruise. The difference in abundance of Chloroscombrus between the 10-11 April and the 14-15 April cruises probably reflects the great diel variation in catches typical of this species. Stations 15b and 16 could not be occupied during this cruise. There were no significant differences except the minor significant difference between two stations of high abundance (9, 17) and the other stations. However, there was no pattern suggesting that brine disposal affected abundance. No fish were captured at most stations, but a few were captured at Stations 18 and 19 which were among the closest to the diffuser.

4.4.11 *Peprilus burti* (See Appendix I, Tables I-74 - I-83)

Peprilus burti was selected because it is a pelagic species of widespread distribution, and because it is very abundant near the diffuser at times.

4.4.11.1 March-April 1979 Predisposal Period

During March-April 1979 there were distinct significant--and non-significant--patterns in abundance. In one cruise (12 March) abundance was much greater at stations oriented perpendicular to the shoreline than at stations oriented parallel to the shoreline, a phenomenon that might reflect differences in currents depending on orientation and/or boat handling in response to such factors. In a second cruise (5 April) there were no significant differences of any importance, no pattern of abundance, and comparatively few fish caught. In a third cruise (20 April) abundance was much greater, in general, at stations located easterly of the diffuser than westerly. The seeming great shifts in the distribution of *P. burti* in the latter two cruises probably reflect movements of schools of this pelagic species and contagion, not any consistent pattern of differences between stations.

About 521 P. burti were captured at the diffuser stations during the 12 March 1979 night cruise. There were significant differences between stations that formed a distinct pattern. Abundance was much greater at all stations oriented perpendicular to the shoreline than at the stations oriented parallel to the shoreline. The reason for the phenomenon is not clear, but may reflect different current patterns related to station orientation and/or boat operation in response to such factors. Abundance at Station 15 and 16 was similar to that at the other stations oriented perpendicular to shore.

Only 22 P. burti were captured at the diffuser stations during the 5 April 1979 night cruise. There was a minor significant difference between the station of highest abundance (9) and several stations of lower abundance. However, no pattern of abundance was apparent. Abundance was intermediate at Stations 15 and 16.

About 1,177 P. burti were captured at the diffuser stations during the 20 April 1979 day cruise. There were significant differences between stations associated with an apparent pattern of abundance. In general, abundance was significantly greater at stations located easterly of the diffuser (25, 17, 24, 19, 15, 16, 22) than at Station 9 and 26 or stations located westerly of the diffuser (23, 20, 14, 21, 18).

4.4.11.2 March-April 1980 Intensive Postdisposal Period

Brine disposal apparently had little or no effect on abundance of P. burti. During the March-April 1979 predisposal period there were definite--often significant--patterns in abundance. However, those patterns probably reflected movements of schools of this pelagic species, and possibly, different current patterns related to station orientation, not consistent differences in abundance between stations. During five cruises in the March-April 1980 intensive postdisposal period there were no significant differences or patterns of abundance that reasonably could be interpreted to indicate that brine disposal affected abundance. During one of these five cruises (27-28 March 1980) significantly greater catches were made at stations oriented perpendicular to the shoreline. A similar pattern was observed in one predisposal period cruise (12 March 1979) and that phenomenon might reflect different current patterns related to station orientation, not consistent differences in abundance between stations. On another cruise (10-11 April), however, there were significant differences that might be interpreted to mean that brine disposal affected abundance in a restricted near-diffuser area (Stations 15, 16, and possibly 19). However, abundance was also low at one station (14) far from the diffuser, so that the observed significant differences on that cruise might reflect only the strong schooling behavior and contagious distribution of this species.

About 51 *P. burti* were captured at the diffuser stations during the 5-6 March 1980 night cruise. There was no significant difference except the minor significant difference between the stations of highest abundance (15) and lowest abundance (20). Abundance was greatest at Station 15, but it was among the lowest at Station 16. High abundances were at stations (14, 23) far from the diffuser as were low abundances (17, 20, 26).

About 622 *P. burti* were captured at the diffuser stations during the 19-20 March 1980 day cruise. There were no significant differences except the minor significant difference between stations of highest (26, 22, 25) and lowest abundance (9, 18). However, there was no pattern suggesting that brine disposal affected abundance. Abundance at Stations

15 and 16 was intermediate. High abundances were at stations (22, 25, 26) far from the diffuser as were low abundances (9, 20, 23).

About 55 P. burti were captured at the diffuser stations during the 24-25 March 1980 night cruise. There were no significant differences except the minor significant difference that Station 26 exhibited greater abundance than any other station. However, there was no pattern suggesting that brine disposal affected abundance. Abundance was low at Stations 15 and 16. High abundances were at stations (14, 23, 25) far from the diffuser as were low abundances (17, 20, 22).

About 676 P. burti were captured at the diffuser stations in the 27-28 March 1980 day cruise. There were significant differences between stations but no pattern suggesting that brine disposal affected abundance. Catches were lowest at Station 9 and the six stations oriented perpendicular to the shore. A similar pattern was observed during the predisposal period in the cruise of 12 March 1979. This pattern might reflect differences in current patterns related to station orientation and/or vessel handling in response to such factors.

About 54 P. burti were captured at the diffuser stations in the 4-5 April 1980 night cruise. There were no significant differences except minor significant differences between a few stations of high (26, 25) and low abundance (17, 23). However, there was no pattern suggesting that brine disposal affected abundance. Abundance at Stations 15 and 16 was intermediate. High abundance was observed at stations (9, 26, 14, 20, 25) far from the diffuser as was low abundance (17, 22, 23).

About 599 P. burti were captured at the diffuser stations in the 10-11 April 1980 day cruise. There were significant differences in that abundance at Stations 15 and/or 16 was lower than abundance at several other stations (9, 20, 25, 22). However, the cause of these significant differences is not clear, and the differences might only reflect the strong schooling behavior and contagion of this species. Abundance was lowest at Stations 14, 15, and 16, but Station 14 is far from the diffuser. Therefore, if brine disposal affected abundance on this cruise, it largely affected the near-diffuser area of Stations 15 and 16 and possibly extended easterly toward Station 19.

Only two P. burti were captured at the diffuser stations in the 14-15 April 1980 night cruise. The difference in abundance of P. burti between the 10-11 April and 14-15 April cruises probably reflects the great diel variation in catches typical of this species, because a similar change also occurred with Chloroscombrus chrysurus. Peprilus burti made up 7.4% of the catch during day cruises in the predisposal period of December 1979-February 1980 but only 0.6% of the catch during night cruises.

4.4.12 Section Summary

The between stations abundance of nine species of Penaeid shrimp and fish were compared in detail for each of seven cruises during the March-April 1980 intensive postdisposal period using Duncan's multiple range tests in a one-way completely randomized experimental design. Data from the March-April 1979 predisposal period also were analyzed in the same manner to describe predisposal conditions. Findings for the 1979 predisposal period were compared to findings during the 1980 intensive postdisposal period to help assess effects of brine disposal. The species examined included: Penaeus aztecus, P. duorarum, P. setiferus, Cynoscion arenarius, C. nothus, Halieutichthys aculeatus, Chloroscombrus chrysurus, Syacium gunteri and Peprilus burti.

For seven species, brine disposal had no apparent effect on abundance during the March-April 1980 intensive postdisposal period. For each of these seven species, there were no significant differences between stations in the March-April 1979 predisposal period or only minor significant differences between a few stations of high and low abundance. In all instances except one, however, there was no apparent general pattern of abundance between stations such as an inshore-offshore or easterly-westerly gradient. The distribution of Cynoscion nothus was the exception to the previous sentence. In that species, there was a pattern during March-April 1979 that abundance tended to be greatest at stations located inshore and/or easterly of the diffuser. However, that pattern did not exist in March-April 1980--even before brine disposal commenced. As occurred during the March-April 1979 predisposal period, for each of these seven species, there were no significant differences between stations in the March-April 1980 intensive postdisposal period or only minor significant differences between a few stations of high and low abundance. In all instances, however, there were no significant differences that reasonably could be interpreted to indicate that brine disposal affected abundance, nor was there any pattern that might be interpreted to indicate that brine disposal affected abundance. Moreover, abundance tended to fluctuate greatly at given stations in no apparent pattern during 1979 and 1980 and was both high and low at stations far removed from the diffuser. Abundance at Stations 15 and 16, which are closest to the diffuser, tended to fluctuate in 1979 and 1980 or seemed to maintain its relative ranking between stations. The above conclusions apply to Penaeus aztecus, P. duorarum, P. setiferus, Cynoscion arenarius, C. nothus, Halieutichthys aculeatus and Chloroscombrus chrysurus.

The above conclusions apply also to Syacium gunteri and Peprilus burti for the March-April 1979 predisposal period and for most cruises during the March-April 1980 intensive predisposal period. Brine disposal had no apparent effect on abundance of Syacium gunteri during five postdisposal period cruises (5-6 March, 19-20 March, 4-5 April, 10-11 April, and 14-15 April) and had no apparent effect on abundance of Peprilus burti during six postdisposal period cruises (all except the cruise of 10-11 April). Exceptions to the above conclusions specifically should be noted for Syacium gunteri on two cruises (24-25 March and 27-28 March) and for Peprilus burti on the cruise of 10-11 April.

Brine disposal might have affected abundance of Peprilus burti during the cruise of 10-11 April 1980. During that cruise there was a distinct and significant reduction in abundance of P. burti in a restricted near-diffuser area (Stations 15, 16 and possibly 19). However, low abundance was also observed at Station 14 which is located far from the diffuser. Peprilus burti is a pelagic, schooling species and typically would show great fluctuations in counts of abundance. Such fluctuations, particularly marked station to station shifts in abundance, occurred in the March-April 1979 predisposal period. Therefore, the observed significant differences in the 10-11 April 1980 cruise might reflect only the strong schooling behavior and consequent contagious distribution of P. burti, particularly when abundance was also low at one station (14) located far from the diffuser. Assuming that brine disposal did affect abundance of P. burti in this instance, the effect was apparently restricted to a near-diffuser area encompassing Stations 15, 16 and possibly 19. The reason for that is that abundance was relatively high at Stations 18, 21, and 24 which are close to and more or less surround the diffuser.

Brine disposal might have affected abundance of Syacium gunteri during the cruises of 24-25 March and 27-28 March. During these cruises there was a distinct pattern in that abundance increased, radiating out from the diffuser at Stations 14, 15, 16, 17, 18 and 19. This pattern conceivably might be interpreted to suggest that brine disposal affected abundance. However, the observed differences between stations were not significant--even at the 5% special protection level--so that there is not sufficient evidence to say that the observed differences reflected anything more than random variation. Moreover, on 27-28 March there was a reversal of a previous pattern that S. gunteri tended to be more abundant at the offshore Stations 23, 24, and 25 as opposed to the inshore Stations 20, 21, and 22. That change suggests that the observed nonsignificant pattern at Stations 14-19 inclusive may have had nothing to do with brine disposal.

All in all, these analyses of comparative abundance have indicated that brine disposal had little or no effect on abundance of nekton during the March-April 1980 intensive postdisposal period. That conclusion reinforces the field observations that brine disposal had no obvious effects and certainly no Dramatic Lethal Effects. Any possible effect due to brine disposal apparently was small even in the three instances noted during which abundance was comparatively low near the diffuser.

4.5 Comparative Nekton Compositions and Diversity in the March-April 1979 Predisposal Period and March-April 1980 Intensive Postdisposal Period.

4.5.1 General Comments

The following report sections describe nekton compositions (4.5.2) and ichthyofauna diversities (4.5.3) at the diffuser area (Stations 14-25, inclusive) during the March-April 1979 predisposal period and during the March-April 1980 intensive postdisposal period. The rationale of the diversity data interpretation and sequence of materials presented in the text follows that employed in analysis of abundance data and is described more fully in Sections 4.4.1 and 4.4.2.

4.5.2 Nekton Compositions

This section describes Penaeid shrimp compositions in the diffuser area each cruise (Table 4-5) and the principal ichthyofauna (Table 4-6). Each species listed in Table 4-6 made up 2% or more of the catch. A very few species designated as dominant made up 15% or more of the catch and a few other species designated as very abundant made up 5-14% of the catch. In general, species listed in Table 4-6 made up at least 88% of the catch on each cruise at the diffuser area in 1979 and at least 89% in 1980. Exact percentages for each cruise appear in Table 4-6. More detailed descriptions and tables of the nekton compositions each cruise, which include percentage compositions for all species, were prepared but are not included in this report to reduce its volume. They are available upon request.

The ichthyofauna in the diffuser area during the March-April 1980 intensive postdisposal period was quite similar to that in the March-April 1979 predisposal period. The dominant species during 1979 were Cynoscion nothus and Syacium gunteri in March and Cynoscion nothus and Chloroscombrus chrysurus in April. The dominant species during 1980 were Cynoscion nothus in March and Cynoscion nothus and Chloroscombrus chrysurus in April. Although not defined as dominant, Syacium gunteri was the second most important fish in March 1980. This species made up 10% of the catch in each of two March 1980 cruises, one of which occurred before brine disposal actually commenced. The very abundant species at the diffuser area in March-April 1979 included Cynoscion nothus, (a dominant), Syacium gunteri, (a dominant), Chloroscombrus chrysurus, (a dominant), Peprilus burti, Saurida brasiliensis, Etropus crossotus, Urophycis floridanus,

Table 4-5 Composition of Penaeid shrimp catches in the diffuser area during each cruise in the March-April 1980 intensive postdisposal period and in the March-April 1979 predisposal period. Species codes represent the first letter in the trivial name of each species, and Σ represents the total catch.

		1980			1979	
Species	Cruise	Σ	%	Cruise	Σ	%
A.	5-6 March, N	308	72	12 March, N	198	34
D.		17	4		53	9
S.		105	24		337	57
Σ.		430			588	
A.	19-20 March, D	170	78			
D.		17	14			
S.		32	7			
Σ.		219				
A.	24-25 March, N	286	82			
D.		46	13			
S.		17	5			
Σ.		349				
A.	27-28 March, D	73	67			
D.		9	8			
S.		27	25			
Σ.		109				
A.	4-5 April, N	140	81	5 April, N	194	65
D.		24	14		71	24
S.		9	5		34	11
Σ.		173			299	
A.	10-11 April, D	5	100	20 April, D	29	53
D.		0	0		5	9
S.		0	0		21	38
Σ.		5			55	

Table 4-5. (Continued)

Species	Cruise	1980 Σ	1980 %	Cruise	1979 Σ	1979 %
A.	14-15 April, N	84	79			
D.		10	9			
S.		13	12			
Σ.		107				

Table 4-6. Summary of the principal ichthyofauna found at the diffuser area (Stations 14-25 inclusive) during each cruise in the March-April 1980 intensive postdisposal period and during the March-April 1979 predisposal period. Principal species each made up 2% or more of the catch. Dominant (D) species made up 15% or more of the catch and very abundant species (*) made up 5-14% of the catch. The total percentage that these principal species made up of the catch is presented in parentheses at the end of the listing for each area each cruise.

	1980	1979
I.	5-6 March, Night:	12 March, Night:
	Cynoscion nothus* D Syacium gunteri* Halieutichthys aculeatus* (90%)	Cynoscion nothus D Syacium gunteri D Peprilus burti* Saurida brasiliensis* Etropus crossotus* Centropristis philadelphica* Lepophidium graellsi Symphurus civitatus (92%)
II.	19-20 March, Day:	
	Cynoscion nothus* D Syacium gunteri* Peprilus burti* Cynoscion arenarius (94%)	
III.	24-25 March, Night:	
	Cynoscion nothus* D Syacium gunteri (90%)	
IV.	27-28 March, Day:	
	Cynoscion nothus* D Peprilus burti* Syacium gunteri (97%)	
V.	4-5 April, Night:	5 April, Night:
	Cynoscion nothus* D Syacium gunteri* (91%)	Cynoscion nothus D Syacium gunteri* Etropus crossotus* Cynoscion arenarius* Urophycis floridanus* Trichiurus lepturus

Table 4-6. (Continued)

	1980	1979
V.		5 April, Night (Continued): Symphurus civitatus Anchoa hepsetus Urophycis cirratus Halieutichthys aculeatus Centropristis philadelphica Peprilus burti (88%)
VI.	10-11 April, Day: Chloroscombrus chrysurus* D Peprilus burti* Syacium gunteri* Saurida brasiliensis Harengula jaguana Engraulis eurystole Diplectrum bivittatum (93%)	20 April, Day: Chloroscombrus chrysurus D Cynoscion nothus D Peprilus burti* Anchoa hepsetus* Trichiurus lepturus* Harengula jaguana Diplectrum bivittatum (95%)
VII.	14-15 April, Night: Syacium gunteri* D Diplectrum bivittatum* D Cynoscion nothus Lepophidium graellsi* Etropus crossotus* Halieutichthys aculeatus Urophycis floridanus Chloroscombrus chrysurus Symphurus civitatus Synodus foetens Saurida brasiliensis Lutjanus campechanus Cynoscion arenarius Centropristis philadelphica Bregmaceros atlanticus (87%)	

Cynoscion arenarius, Anchoa hepsetus, Trichiurus lepturus, and Centropristis philadelphica. Halieutichthys aculeatus and Lepophidum graellsi were not defined as very abundant in 1979, but these species exhibited percentage compositions as high as 2.5-4% on a given cruise in March-April. The very abundant species in March-April 1980 included Cynoscion nothus, (a dominant), Chloroscombrus chrysurus, (a dominant), Syacium gunteri, Peprilus burti, Halieutichthys aculeatus, Diplectrum bivittatum, Lepophidium graellsi, and Etropus crossotus. Urophycis floridanus, Saurida brasiliensis, and Cynoscion arenarius were not defined as very abundant, but these species exhibited percentage compositions as high as 2-4% on a given cruise in March-April 1980.

The Penaeid shrimp fauna in the diffuser area during the March-April 1980 intensive postdisposal period was quite similar to that in the March-April 1979 predisposal period, although Penaeus aztecus may have been more important in 1980 than in 1979. The Penaeid shrimp fauna at the diffuser area during March 1979 was dominated by Penaeus setiferus and P. aztecus. During March 1980 Penaeus aztecus dominated the shrimp catch at the diffuser area. The Penaeid shrimp fauna during April 1979 was dominated by Penaeus aztecus, but P. setiferus and P. duorarum were also very important. Penaeus aztecus dominated the shrimp catch at the diffuser area during April 1980. Although Penaeus aztecus appeared more important in the catch at the diffuser in 1979 than in 1980, if real, this was apparently due to natural fluctuation; because brine disposal had no effect on between stations abundance of the Penaeid shrimps (see sections 4.4.3, 4.4.4, 4.4.5). Moreover, Penaeid shrimp percentage compositions are based only on three species and, therefore, would tend to fluctuate widely.

4.5.3 Species Diversity of the Ichthyfauna (See Appendix I, Tables I-84-93)

4.5.3.1 March-April 1979 Predisposal Period

During March-April 1979 there were no significant differences in ichthyofauna diversity in any cruise, and there were no general patterns of diversity. Diversity showed a varied pattern at given stations and at stations located close together. Diversity generally was intermediate at Stations 15 and 16, although it was high at Station 16 on one occasion. Diversity fluctuated greatly from cruise to cruise at some stations. For example: 1) diversity at Station 26 was high on 12 March, low on 5 April and high on 20 April, 2) diversity at Station 17 was low on 12 March, intermediate on 5 April, and low on 20 April, and 3) diversity at Station 22 was low on 12 March, high on 5 April, and intermediate on 20 April. At other stations diversity maintained the same ranking. For example, diversity was always low at Stations 9 and 21 but always high at Station 20. Stations 20 and 21 are close together, and this great variation in diversity within a small area appeared also at other stations located close together. For example: 1) Stations 17 and 25 showed high (25) and low (17) diversity on 12 March, reversed high (17) and low (25) diversity on 5 April, and low (17) and intermediate (25) diversity on 20 April.

About 4,251 fishes of 40 species were captured at the diffuser stations during the 12 March 1979 night cruise. There were no significant differences in diversity between stations, and no general pattern was apparent. Diversity was high or intermediate at Stations 15 and 16.

About 1,046 fishes of 39 species were captured at the diffuser stations during the 5 April 1979 night cruise. There were no significant differences in diversity between stations, and no general pattern was apparent. Diversity was intermediate at Stations 15 and 16.

About 1,046 fishes of 39 species were captured at the diffuser stations during the 20 April 1979 day cruise. There were no significant differences in diversity between stations, and no general pattern was apparent. Diversity was intermediate at Stations 15 and 16.

4.5.3.2 March-April 1980 Intensive Postdisposal Period

Brine disposal had little or no effect on diversity of the ichthyofauna. During the March-April 1979 predisposal period there was no general pattern between stations nor any significant differences in diversity. Moreover, diversity often varied from cruise to cruise at given stations in the predisposal period and varied between stations located close together. Diversity usually was intermediate at Stations 15 and 16 in the predisposal period. During the March-April 1980 intensive postdisposal period there often were minor significant differences between stations of highest and lowest diversity. This pattern first appeared on the 5-6 March cruise--which was before brine disposal started. However, there were no significant differences that could be attributed to brine disposal on any cruise, nor were there patterns between stations that reasonably could be interpreted to indicate that brine disposal affected diversity.

About 8,143 fishes of 41 species were captured at the diffuser stations during the 5-6 March 1980 night cruise. There were significant differences between several stations of high diversity (16, 18, 19, 15, 24, 25) and low diversity (9, 22, 20). Many of the stations with high diversity were ones close to the diffuser.

About 7,868 fishes of 37 species were captured at the diffuser stations during the 19-20 March 1980 day cruise. There were no significant differences between stations, and no pattern suggesting that brine disposal affected diversity. Diversity was intermediate at Stations 15 and 16 as it usually was during the March-April 1979. Diversity at stations far from the diffuser was both high (14, 23) and low (17, 20, 25).

About 7,183 fishes of 32 species were captured at the diffuser stations during the 24-25 March 1980 night cruise. There were minor significant differences between several stations of high diversity (26, 25, 24, 21) and several stations of low diversity (9, 17, 16). There was no pattern suggesting that brine disposal affected diversity, although many patterns might be read into diversities found in this cruise. Diversity was intermediate or low at Stations 15 and 16. Stations of highest diversity were seaward of the diffuser (26, 25, 24), but stations of highest diversity were also inshore (21, 22). Stations next to or easterly of the diffuser (15, 19, 16, 17) exhibited lowest diversity, but diversity was much the lowest at the station (17) furthest from the diffuser. Finally, diversity was often greater at stations oriented parallel to the shoreline (25, 24, 21, 22, 23) than at stations oriented perpendicular to the shoreline (14, 18, 15, 19, 16, 17). Similar or reversed patterns were observed for the abundance of a few species such as Peprilus burti on occasion, but it is not clear why diversity would exhibit such a pattern.

About 11,610 fishes of 31 species were captured at the diffuser stations during the 27-28 March 1980 day cruise. There were minor significant differences between a few stations of high diversity (26, 24, 25) and the remaining stations. However, there was no pattern suggesting that brine disposal affected diversity. As in the preceding cruise, diversity was highest at stations seaward of the diffuser (26, 24, 25) and diversity remained intermediate or low at Stations 15 and 16.

About 6,830 fishes of 38 species were captured at the diffuser stations during the 4-5 April 1980 night cruise. There were minor significant differences between a few stations of high diversity (25, 26, 24) and the remaining stations. However, there was no pattern suggesting that brine disposal affected diversity. As in the preceding two cruises, diversity was highest at stations seaward of the diffuser (25, 26, 24). For the first time, diversity was lowest at stations shoreward of the diffuser (20, 22, 21). Diversity remained intermediate at Stations 15 and 16.

About 2,150 fishes of 22 species were captured at the diffuser stations during the 10-11 April 1980 day cruise. There were no significant differences between stations, and there was no clear pattern suggesting that brine disposal affected diversity. Although diversity was low at Stations 15 and 16, it was also low at Stations 14, 25 and 23 which are far from the diffuser. High diversity was often at stations intermediate from the diffuser (21, 18, 24, 19).

About 972 fishes of 37 species were captured at the diffuser stations during the 14-15 April 1980 night cruise when Stations 15b and 16 could not be occupied. There were no significant differences between stations and no clear pattern that brine disposal affected diversity. Diversity was low at Stations 15, 17 and 19, which are located easterly of the diffuser.

4.6 Overall Summary

Nekton collections in the March-April 1980 intensive postdisposal period were made aboard a chartered commercial shrimp trawler off Freeport focusing around the March 13 startup of brine disposal. Three night and three day cruises were made at spaced intervals after diffuser startup occupying Stations 9, 26, and 14-25 inclusive. Collection and processing procedures generally were the same as those employed in the predisposal studies. However, special observations on the presence of dead or dying nekton were made at each station and recorded on a Special Observations Form.

Field observations in the March-April 1980 intensive postdisposal period indicated no Dramatic Lethal Effects at any station in any cruise. There was no unusual behavior of the nekton in the catch or dead and dying nekton in the water. Observations and plots of biomass volumes did not suggest obvious sharp reductions in catch.

The nekton in the diffuser area (Stations 14-25, inclusive) during March-April 1980 was very similar to that in March-April 1979. Nekton compositions were summarized for each cruise in the March-April 1980 intensive postdisposal period and in the March-April 1979 predisposal period. Dominant or very abundant fishes during March-April 1979 included Cynoscion nothus (a dominant), Syacium gunteri, (a dominant), Peprilus burti, Saurida brasiliensis, Etropus crossotus, Urophycis floridanus, Cynoscion arenarius, Anchoa hepsetus, Trichiurus lepturus, and Centropristis philadelphica. Dominant or very abundant fishes during March-April 1980 included Cynoscion nothus (a dominant), Chloroscombrus chrysurus (a dominant), Syacium gunteri, Peprilus burti, Halieutichthys aculeatus, Diplectrum bivittatum, Lepophidium graellsi, and Etropus crossotus. Although defined as very abundant in one year, five species were not very abundant in the other year; however, they exhibited percentage compositions as high as 2-4% of the catch in the year of their lowest importance. These species included Halientichthys aculeatus and Lepophidium graellsi which were least important in 1979 and Urophycis floridanus, Saurida brasiliensis, and Cynoscion arenarius which were least important in 1980. Penaeus aztecus and P. setiferus dominated the shrimp catch in 1979, but P. aztecus alone predominated in 1980. That change, if real, was apparently due to natural fluctuation; because brine disposal had no apparent effect on between stations abundance of any Penaeid shrimp.

Brine disposal had little or no effect on ichthyofauna diversity. Between stations ichthyofauna diversity was compared in detail for each of seven cruises during the March-April 1980 intensive postdisposal period and for each of three cruises during the March-April 1979 predisposal period. During the March-April 1979 predisposal period there was no general pattern between stations nor any significant difference in diversity. Diversity often varied from cruise to cruise at given stations in the predisposal period and varied between stations located close together. Diversity usually was intermediate at Stations 15 and 16 in the predisposal period. During the March-April 1980 intensive postdisposal period there often were significant differences between stations of highest and lowest diversity. This pattern first appeared on the 5-6 March cruise--which was before brine disposal started. However, there were no significant differences that could be attributed to brine disposal on any cruise, nor were there patterns between stations that reasonably could be interpreted to indicate that brine disposal affected diversity.

The between stations abundance of nine species of Penaeid shrimp and fish were compared in detail for each of seven cruises during the March-April 1980 intensive postdisposal period using Duncan's multiple range tests in a one-way completely randomized experimental design. Data from the March-April 1979 predisposal period also were analyzed in the same manner to describe predisposal conditions. Findings for the 1979 predisposal period were compared to findings during the 1980 intensive postdisposal period to help assess effects of brine disposal. The species examined included: *Penaeus aztecus*, *P. duorarum*, *P. setiferus*, *Cynoscion arenarius*, *C. nothus*, *Halieutichthys aculeatus*, *Chloroscombrus chrysurus*, *Syacium gunteri* and *Peprilus burti.*

For seven species, brine disposal had no apparent effect on abundance during the March-April 1980 intensive postdisposal period. For each of these seven species, there were no significant differences between stations in the March-April 1979 predisposal period or only minor significant differences between a few stations of high and low abundance. In all instances except one there was no apparent general pattern of abundance between stations such as an inshore-offshore or easterly-westerly gradient. The distribution of *Cynoscion nothus* was the exception to the previous sentence. In that species, there was a pattern during March-April 1979 in that abundance tended to be greatest at stations located inshore and/or easterly of the diffuser. However, that pattern did not exist in March-April 1980--even before brine disposal commenced. As occurred during the March-April 1979 predisposal period, for each of these seven species, there were no significant differences between stations in the March-April 1980 intensive postdisposal period or only minor significant differences between a few stations of high and low abundance. In all instances, however, there were no significant differences that reasonably could be interpreted to indicate that brine disposal affected abundance, nor was there any pattern that might be interpreted to indicate that brine disposal affected abundance. Moreover, abundance tended to fluctuate greatly at given stations in no apparent pattern during 1979 and 1980 and often was both high and low at stations far removed from the diffuser. Abundance at Stations 15 and 16, which are closest to the diffuser, tended to fluctuate in 1979 and 1980 or seemed to maintain its relative ranking between stations. The above conclusions apply to _Penaeus aztecus_, _P. duorarum_, _P. setiferus_, _Cynoscion arenarius_, _C. nothus_, _Halieutichthys aculeatus_ and _Chloroscombrus chrysurus_.

The above conclusions also apply to _Syacium gunteri_ and _Peprilus burti_ for the March-April 1979 predisposal period and for most cruises during the March-April 1980 intensive postdisposal period. Brine disposal had no apparent effect on abundance of _Syacium gunteri_ during five postdisposal period cruises (5-6 March, 19-20 March, 4-5 April, 10-11 April, and 14-15 April) and had no apparent effect on abundance of _Peprilus burti_ during six postdisposal period cruises (all except the cruise of 10-11 April). Exceptions to the above conclusions specifically should be noted for _Syacium gunteri_ on two cruises (24-25 March and 27-28 March) and for _Peprilus burti_ on the cruise of 10-11 April.

Brine disposal _might_ have affected abundance of _Peprilus burti_ during the cruise of 10-11 April 1980. During that cruise there was a distinct and significant reduction in abundance of _P. burti_ in a _restricted near-diffuser_ area (Stations 15, 16 and possibly 19). However, low abundance was also observed at Station 14 which is located far from the diffuser. _Peprilus burti_ is a pelagic, schooling species and typically would show great fluctuations in counts of abundance. Such fluctuations, particularly marked station to station shifts in abundance, occurred in the March-April 1979 predisposal period. Therefore, the observed significant differences in the 10-11 April 1980 cruise might reflect only the strong schooling behavior and consequent contagious distribution of _P. burti_, particularly when abundance was also low at one station (14) located far from the diffuser. Assuming that brine disposal did affect abundance of _P. burti_ in this instance, the effect was apparently restricted to a near-diffuser area encompassing Stations 15, 16 and possibly 19. The reason for that is that abundance was relatively high at Stations 18, 21, and 24 which are close to and more or less surround the diffuser.

Brine disposal might have affected abundance of Syacium gunteri during the cruises of 24-25 March and 27-28 March. During these cruises there was a distinct pattern in that abundance increased, radiating out from the diffuser at Stations 14, 15, 16, 17, 18 and 19. This pattern conceivably might be interpreted to suggest that brine disposal affected abundance. However, the observed differences between stations were not significant--even at the 5% special protection level--so that there is not sufficient evidence to say that the observed differences reflected anything more than random variation. Moreover, on 27-28 March there was a reversal of a previous pattern that S. gunteri tended to be more abundant at the offshore Stations 23, 24, and 25 as opposed to the inshore Stations 20, 21, and 22. That change suggests that the observed non-significant pattern at Stations 14-19 inclusive may have had nothing to do with brine disposal.

Conclusions reached from field observations of the effects of brine disposal, from analysis of abundance patterns for nine species of Penaeid shrimp and fish during March-April predisposal and postdisposal periods, and from faunal compositions and diversity during March-April redisposal and postdisposal periods support and reinforce one another. All lead to the basic conclusion that brine disposal had little or no effect on nekton during March-April 1980, even in the three instances noted during which comparatively low abundance near the diffuser might be due to brine disposal.

CHAPTER 5

BENTHOS

Donald E. Harper, Jr.
Larry D. McKinney
Department of Marine Biology
Texas A&M University at Galveston

5.1 Introduction

The benthic portion of the intensive experimental study occurred during the period 10 March through 21 April 1980. The immediate predisposal collection was completed on 10 March, several hours prior to initial turn-on of the pumping system. Subsequent collections were made on 20 March, 3 April and 21 April, intervals of 10 days, 24 days and 42 days after initial turn-on, respectively. The purpose of these collections was to document the occurrence of any acute impact on the benthic invertebrates caused by the discharge of brine.

5.2 Materials and Methods

The methods employed in both field and laboratory were identical to those described in the predisposal report with one exception. On 3 April, we began the practice of allowing the sediment samples to settle overnight, then measuring the salinity of the pore (or interstitial) water with a refractometer to more accurately define the environment in which the benthic organisms were living at the time of collection.

5.3 Results

5.3.1 Temperature

During the winter of 1979-80, the sediment temperature (and the overlying water temperature) remained much warmer than during the preceding years, never decreasing below 14°C. It is probable that the warmer temperatures had some effect on the seasonal population changes, but these changes probably will not be manifest until later in the year. There was no difference in the sediment temperature at nearfield and farfield stations during any collection (Table 5-1).

5.3.2 Salinity

The salinity of the bottom water was fairly stable for most of the study period, remaining between 20 and 31 ^{o}/oo except during the last collection (21 April) when an average of 36.6 ^{o}/oo was recorded (Table 5-2).

The bottom water salinity was, however, apparently not indicative of the salinity to which the infaunal organisms were subjected. Measurements made on 3 and 21 April indicated the salinity of the pore water was somewhat different than of the overlying water. On 3 April the seas were rough. The average surface water salinity was 26.6 ^{o}/oo and it was evident that mixing was occurring because the bottom salinity ranged from 29 to 30 ^{o}/oo (average 29.4 ^{o}/oo) as opposed to about 31 ^{o}/oo during prior collections. The sediment salinity, however, was 32 to 36 ^{o}/oo (Figure 5-1). There was a very evident lateral pore water salinity gradient extending away from the diffuser, principally to the southwest, but no detectable bottom water salinity gradient. On 21 April, a calm day following several calm days, there was again a difference between the pore water and the overlying water salinities, with

Table 5-1. Sediment temperature data collected during cruises 22-30 (October 1979 - 21 April 1980).

CRUISE	MEAN	10A1	10A2	10A3	10A4	10A5	10A6	10A7	10D1	10D2
18 OCT 79	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
15 NOV 79	20.8	21.5	21.0	31.0	21.0	20.0	20.0	20.0	21.0	21.0
16 DEC 79	16.3	16.0	16.0	16.0	16.0	16.0	16.0	16.5	16.0	16.0
18 JAN 80	16.5	16.0	17.0	17.0	17.0	16.0	16.0	16.5	17.0	16.0
13 FEB 80	14.5	14.5	14.0	14.0	14.0	14.0	14.0	14.0	18.0	14.0
10 MAR 80	15.9	16.0	16.0	16.0	16.0	15.5	16.0	16.0	15.0	16.0
20 MAR 80	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
3 APR 80	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
21 APR 80	19.1	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0
MEAN	18.0	17.0	18.0	18.0	18.0	17.7	17.8	17.9	18.4	17.9

CRUISE	10D3	10E1	10E2	10E3	10F1	10G1	10A8	10A9	10B1	10C1
18 Oct 79	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
15 NOV 79	21.0	21.5	21.0	20.5	20.0	21.0	21.0	21.0	21.0	21.0
16 DEC 79	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	21.0	16.0
18 JAN 80	17.0	16.0	16.5	16.0	17.0	17.0	17.0	16.0	17.0	16.0
13 FEB 80	14.0	14.0	14.5	14.0	14.0	14.0	14.0	18.0	14.0	14.0
10 MAR 80	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
20 MAR 80	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
3 APR 80	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
21 APR 80	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.5	20.0	19.0
MEAN	18.0	17.9	18.0	17.8	17.9	18.0	18.0	18.4	18.4	17.9

Table 5-2. Bottom water salinity data collected during cruises 22-30 (October 1979 - April 1980).

CRUISE	MEAN	10A1	10A2	10A3	10A4	10A5	10A6	10A7	10D1	10D2
18 OCT 79	31.6	32.0	32.0	31.0	31.5	32.5	32.0	32.5	31.0	30.0
15 NOV 79	30.7	28.7	30.0	30.0	31.0	32.0	31.5	30.0	30.0	29.5
16 DEC 79	30.1	30.2	30.0	30.0	30.0	30.5	30.5	30.5	29.5	29.8
18 JAN 80	30.7	31.0	31.0	30.0	31.0	30.0	31.2	31.2	29.8	29.0
13 FEB 80	31.3	31.0	31.5	32.0	31.5	31.5	31.0	31.0	28.5	31.5
10 MAR 80	31.4	31.8	31.5	31.3	31.8	31.0	31.5	31.0	31.3	31.3
20 MAR 80	31.9	32.0	32.0	32.0	32.0	31.5	32.0	32.0	32.0	31.5
3 APR 80	29.4	29.5	29.0	29.5	29.5	29.0	30.0	30.0	28.5	28.5
21 APR 80	36.6	35.0	36.0	35.0	36.0	38.0	37.5	37.0	37.0	36.0
MEAN	31.5	31.2	31.4	31.2	31.6	31.8	31.9	31.7	31.1	30.8

CRUISE	10D3	10E1	10E2	10E3	10F1	10G1	10A8	10A9	10B1	10C1
18 OCT 79	31.5	31.2	31.5	31.5	31.5	32.0	31.5	32.0	31.5	31.0
15 NOV 79	31.0	30.5	30.5	31.5	30.5	31.0	32.0	31.5	32.0	31.0
16 DEC 79	30.0	30.2	30.2	31.0	29.5	30.5	30.0	30.5	29.9	30.0
18 JAN 80	30.0	31.0	31.0	31.5	30.0	31.0	31.0	31.0	31.0	31.0
13 FEB 80	31.0	32.5	32.0	32.5	31.0	32.0	31.5	29.5	31.5	32.0
10 MAR 80	31.0	32.0	31.5	30.0	31.0	32.0	32.0	31.5	31.0	31.5
20 MAR 80	32.0	32.0	32.0	32.0	32.0	32.0	32.5	32.0	31.5	32.0
3 APR 80	29.0	30.0	30.0	30.0	29.0	29.0	29.5	29.5	39.0	29.5
21 APR 80	36.0	34.5	36.0	37.5	35.0	36.0	38.0	37.5	38.0	40.0
MEAN	31.3	31.5	31.6	31.9	31.1	31.7	32.0	31.9	31.7	32.0

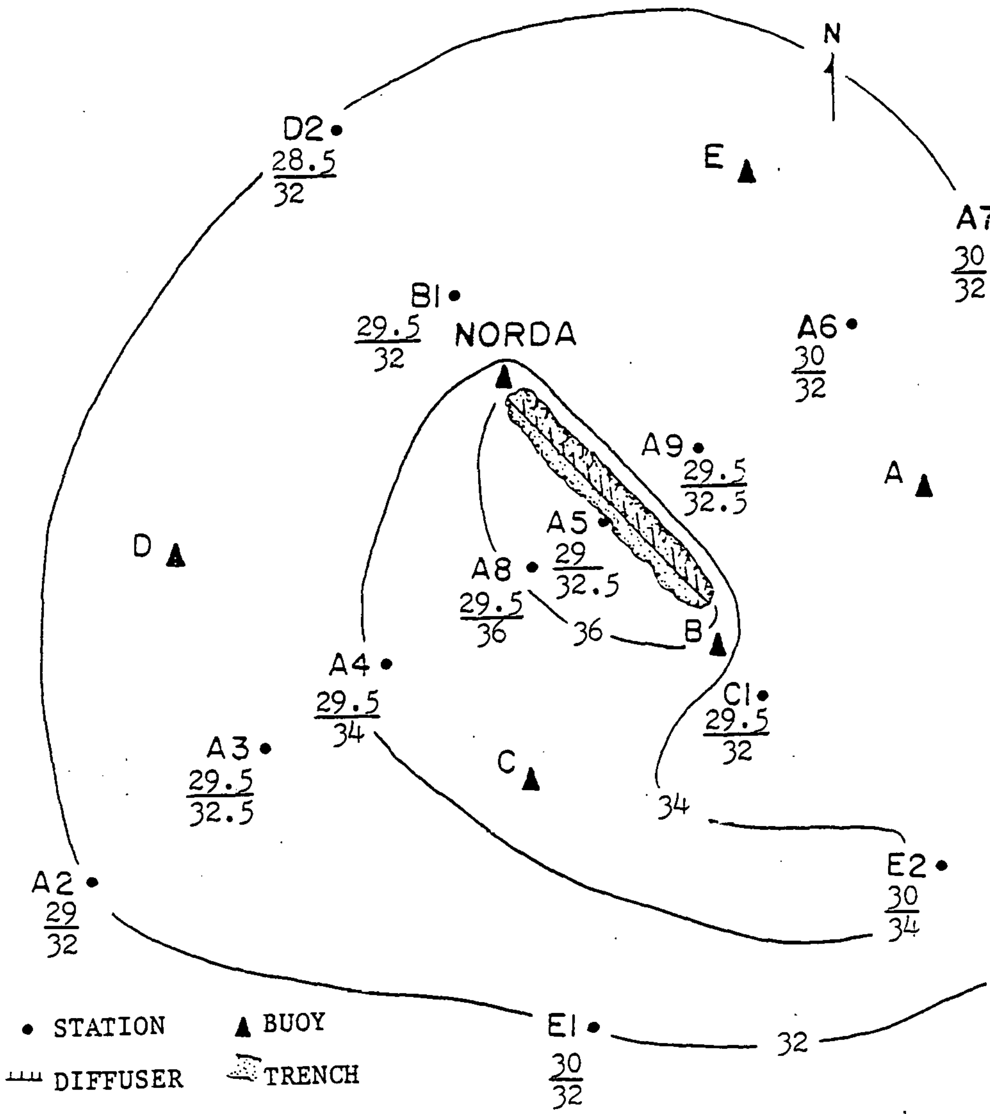


Figure 5-1. Chart of the diffuser area showing the bottom water (top number) and pore water (bottom number) salinities at the near and intermediate field stations on 3 April 1980. Sea conditions were choppy. Suggested isohalines have been superimposed. Bottom salinities were 29-30 $^o/oo$. ——— represents sediment isohalines.

the pore water salinity being lower, i.e. 35 to 37°/oo vs. 36 to 40°/oo in the overlying water. Again a definite lateral salinity gradient occurred; the pore water salinity isopleths formed an ellipse around the diffuser while the currents appeared to be carrying the brine plume to the east (Figure 5-2). The brine plume was visible at station A8 on 21 April as a hazy layer about 12 cm thick. The bottom had a veneer of fine silt that was interlaced with animal trails. Young shrimp (*Trachypeneus similis* and *Sicyonia* sp.) were abundant (estimated $10/m^2$), and all were actively probing the sediment with their thoracic legs, apparently searching for food. None showed signs of being stressed by the brine.

5.3.3 Dissolved Oxygen

The dissolved oxygen (D.O.) concentration of the water was highest in the winter and began to decrease as the water warmed. There was no indication that the D.O. was lower in the vicinity of the diffuser than in the more distant stations (Table 5-3).

5.3.4 Sediments

Shepard diagrams (Figure 5-3) indicate that the sediments were clayey or silty sand, or sand-silt-clay. Grain size shifts occurred at many stations, but because this same pattern occurred during the pre-disposal period, no significance is attached to the shifts. The mean grain sizes were mostly in the 4.0 to 6.0 ϕ range (Table 5-4). The principal exceptions occurred around the diffuser (stations A5, A8, A9, B1) where the mean grain sizes ranged from 3.4 to 4.0 ϕ. We believe this was caused when the pipe line trench was dug; the heavier sand was deposited near the trench while the lighter fractions drifted away. There also appears to have been a decrease in the mean grain size at stations A1 through A7 compared with

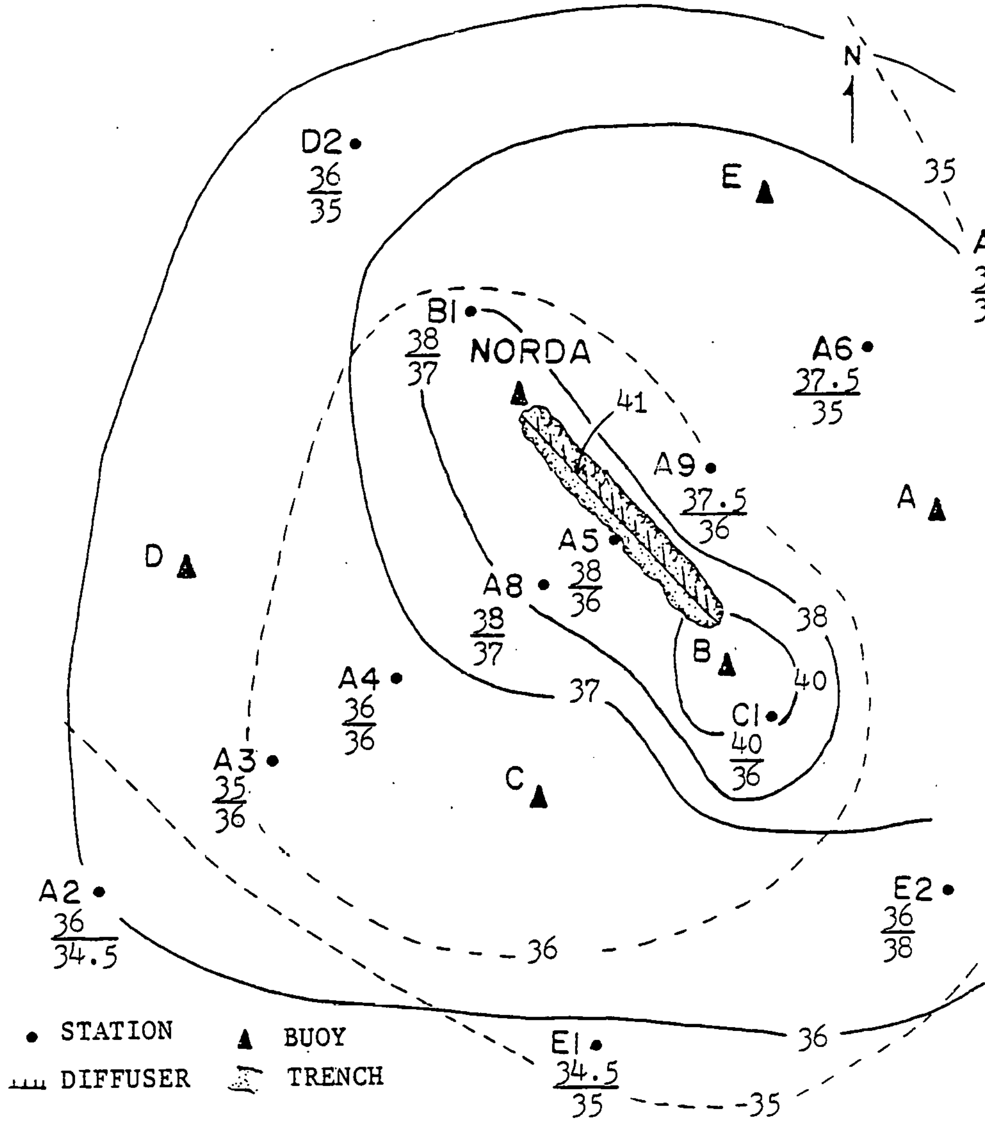


Figure 5-2. Chart of the diffuser area showing the bottom water (top number) and pore water (bottom number) salinities at the near and intermediate field stations on 21 April 1980. Sea conditions were calm. Suggested isohalines have been superimposed. ——— represents bottom isohalines and - - - sediment isohalines. The 41 $^{o}/oo$ reading was recorded in the trench near the diffuser.

Table 5-3. Bottom water dissolved oxygen (D.O.) data collected during cruises 22-30 (October 1979 - April 1980).

CRUISE	MEAN	10A1	10A2	10A3	10A4	10A5	10A6	10A7	10D1	10D2
18 OCT 79	5.4	5.4	5.1	6.0	5.6	5.2	5.9	6.0	5.2	5.1
15 NOV 79	5.9	5.9	6.3	6.2	5.8	4.8	5.6	5.6	6.2	6.2
16 DEC 79	6.9	6.9	6.8	7.0	6.7	6.8	6.7	6.8	6.9	7.0
18 JAN 80	6.7	6.3	7.2	6.9	6.6	6.7	6.6	6.4	7.1	7.0
13 FEB 80	7.3	7.4	7.4	7.4	7.3	7.3	7.7	7.4	6.5	7.6
10 MAR 80	7.1	7.0	6.9	6.8	7.1	6.8	7.4	7.4	6.9	7.2
20 MAR 80	7.0	6.6	6.9	7.0	7.0	6.8	6.9	7.4	7.0	7.1
3 APR 80	6.2	6.2	5.9	6.0	5.9	6.6	6.3	6.0	6.5	6.5
21 APR 80	5.9	6.1	5.8	6.2	5.8	6.0	5.8	5.6	6.1	6.0
MEAN	6.5	6.4	6.5	6.6	6.4	6.3	6.5	6.5	6.5	6.6

CRUISE	10D3	10E1	10E2	10E3	10F1	10G1	10A8	10A9	10B1	10C1
18 OCT 79	5.8	5.4	6.0	5.6	4.8	5.0	5.2	4.4	5.4	5.1
15 NOV 79	6.0	5.9	5.9	6.4	7.0	6.0	5.8	5.2	5.5	5.9
16 DEC 79	6.8	6.8	6.9	7.0	6.9	6.6	6.9	7.0	7.0	6.9
18 JAN 80	6.9	6.7	6.5	6.1	7.2	6.8	6.8	7.0	6.7	6.4
13 FEB 80	7.6	7.2	7.4	7.6	7.6	7.7	7.3	6.6	7.3	7.3
10 MAR 80	6.3	7.4	7.6	6.8	7.9	7.4	6.9	7.1	7.2	6.9
20 MAR 80	7.1	6.9	7.0	6.9	6.6	6.9	7.0	7.8	7.0	6.9
3 APR 80	5.9	6.2	6.3	6.0	6.2	5.9	6.3	6.6	6.8	6.3
21 APR 80	5.8	5.8	5.8	5.8	6.1	6.6	5.8	5.8	5.6	5.4
MEAN	6.5	6.5	6.6	6.5	6.7	6.5	6.4	6.4	6.5	6.3

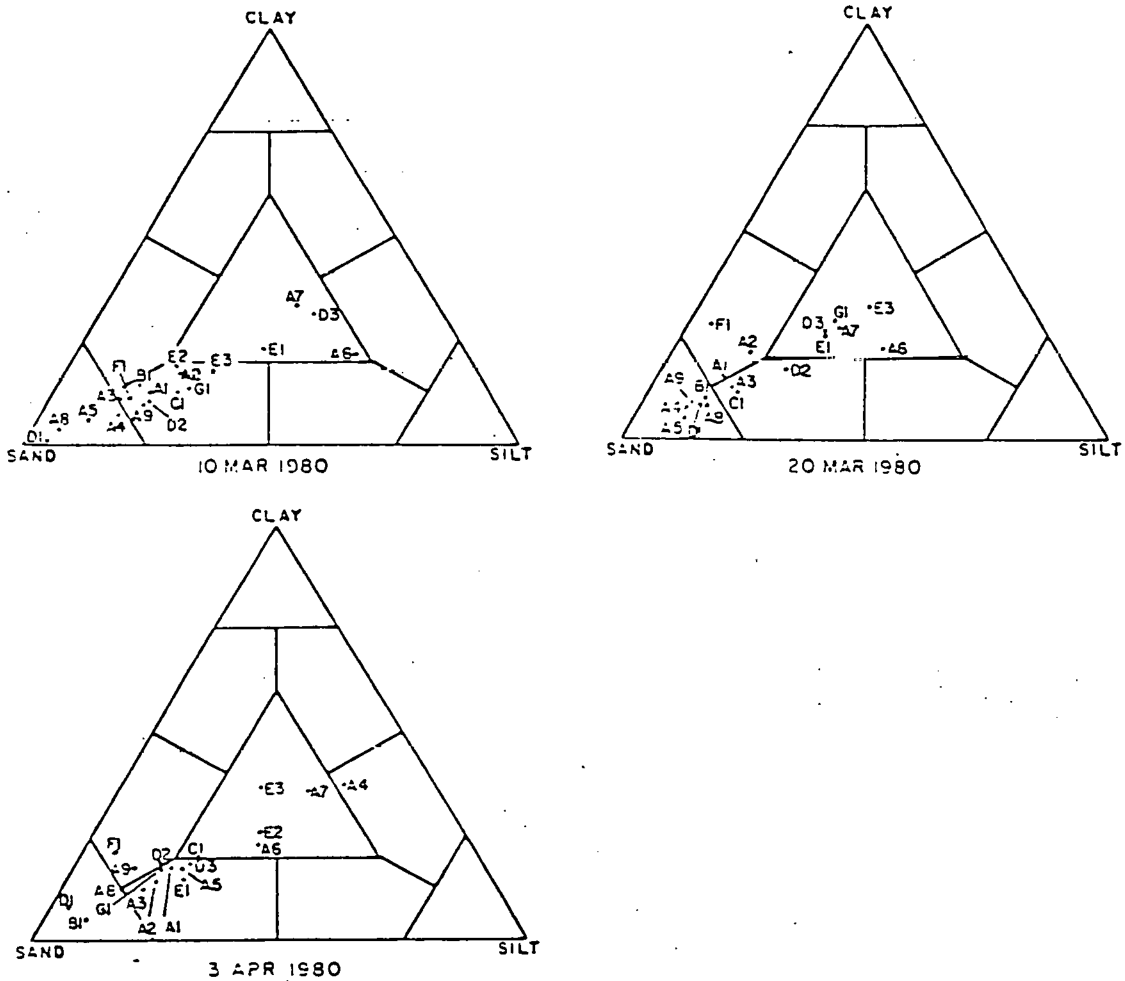


Figure 5-3. Shepard diagrams of the sediment characteristics of the 19 stations.

Table 5-4. Mean grain size of the 19 stations. Also included for comparison are the mean grain sizes for stations A1-A7 during the predisposal period.

Station	Experimental	Predisposal
A1	4.58	5.81
A2	4.58	5.46
A3	4.02	5.31
A4	4.50	5.66
A5	3.62	5.44
A6	5.08	6.50
A7	6.06	6.83
A8	3.42	
A9	3.98	
B1	3.77	
C1	4.54	
D1	2.86	
D2	4.49	
D3	5.63	
E1	5.27	
E2	5.57	
E3	5.80	
F1	4.15	
G1	5.19	

predisposal data; this is probably not significant because the means are based on only three samples taken during the early spring when sea conditions are more turbulent and lighter sediment fractions are less likely to settle.

5.3.5 Areal Distributions of Species and Populations

5.3.5.1 Species

The distribution of species demonstrates no adverse effect attributable to the discharge of brine, either during the period October 1979 - 21 April 1980 (cruises 22-30) (Figure 5-4) or during the three experimental cruises (28-30) (Figure 5-5). The highest diversities occurred at sandy bottomed stations D1 and A5. The numbers of species at nearfield and farfield stations varied little.

5.3.5.2 Populations

The areal distributions of total populations, cruises 22-30, do not suggest stress due to brine. Most stations had populations ranging from 1100 to 1800 individuals/m^2 with the largest number occurring at station A9, 500 m northeast of the diffuser (Figure 5-6). Analysis of the predisposal data only (cruises 22-27) indicates a relatively uniformly distributed population, with station A9 having the largest population (Figure 5-7). However, when only the experimental data are analyzed (cruises 29-30), there appears to have been a crescent of depressed populations southwest of station A5; these populations were still larger than at several of the farfield stations (Figure 5-8). The largest populations occurred at station A5 which does not conform with a brine induced depression in the nearfield region.

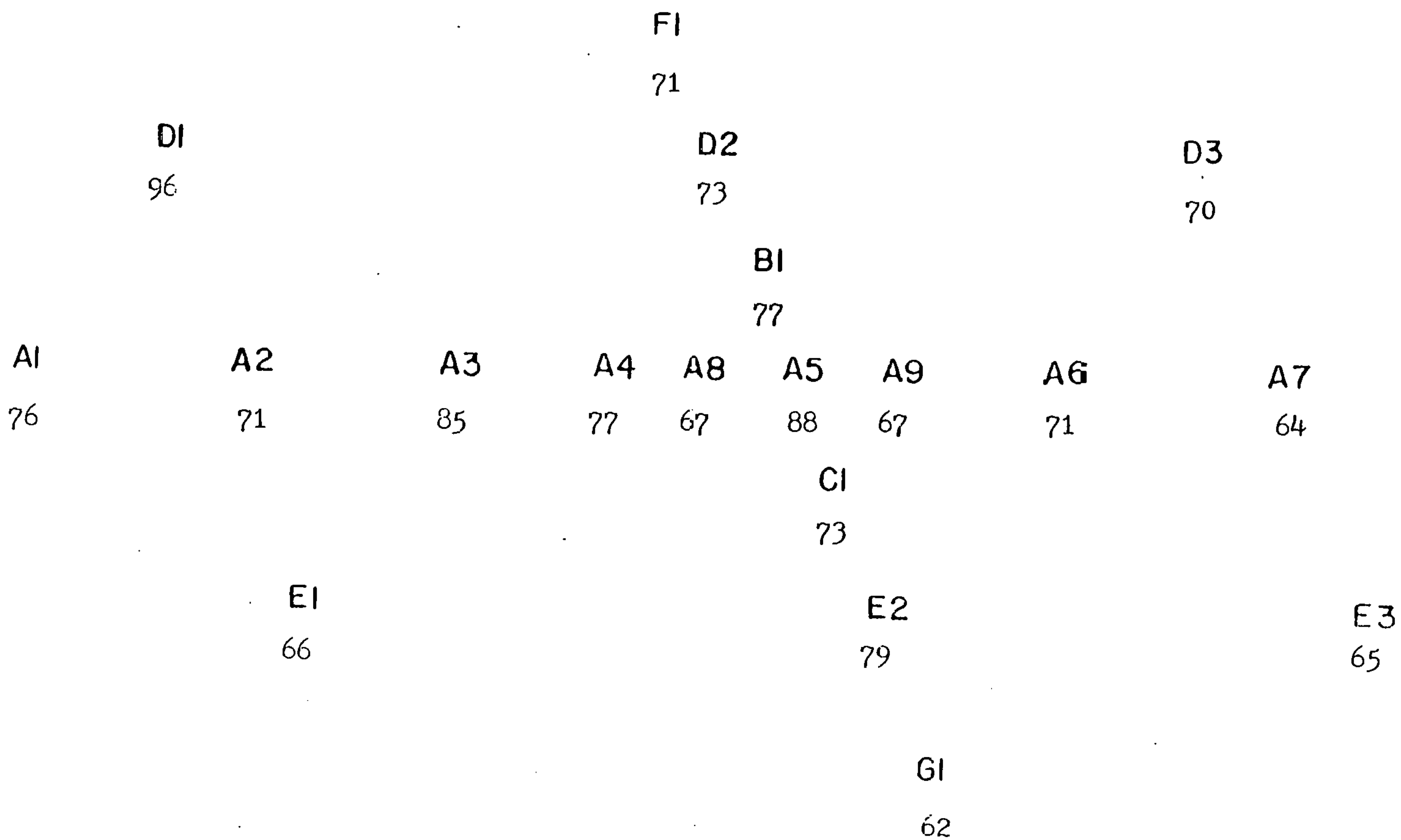


Figure 5-4. Areal distribution of total number of species at each of the offshore stations, cruises 22-30 (Oct. 1979 - 21 Apr. 1980).

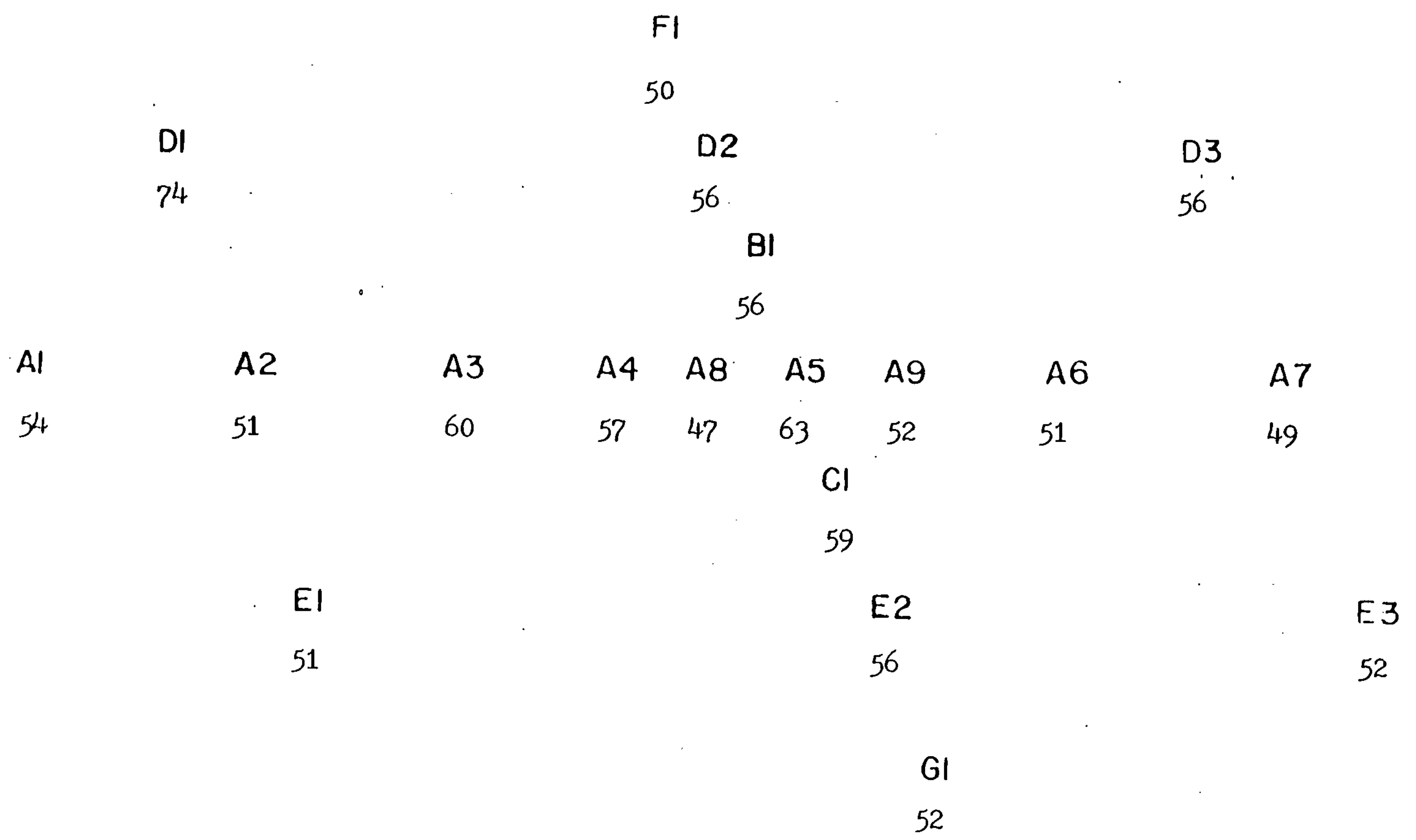


Figure 5-5. Areal distribution of total number of species at each offshore station, experimental cruises (28-30).

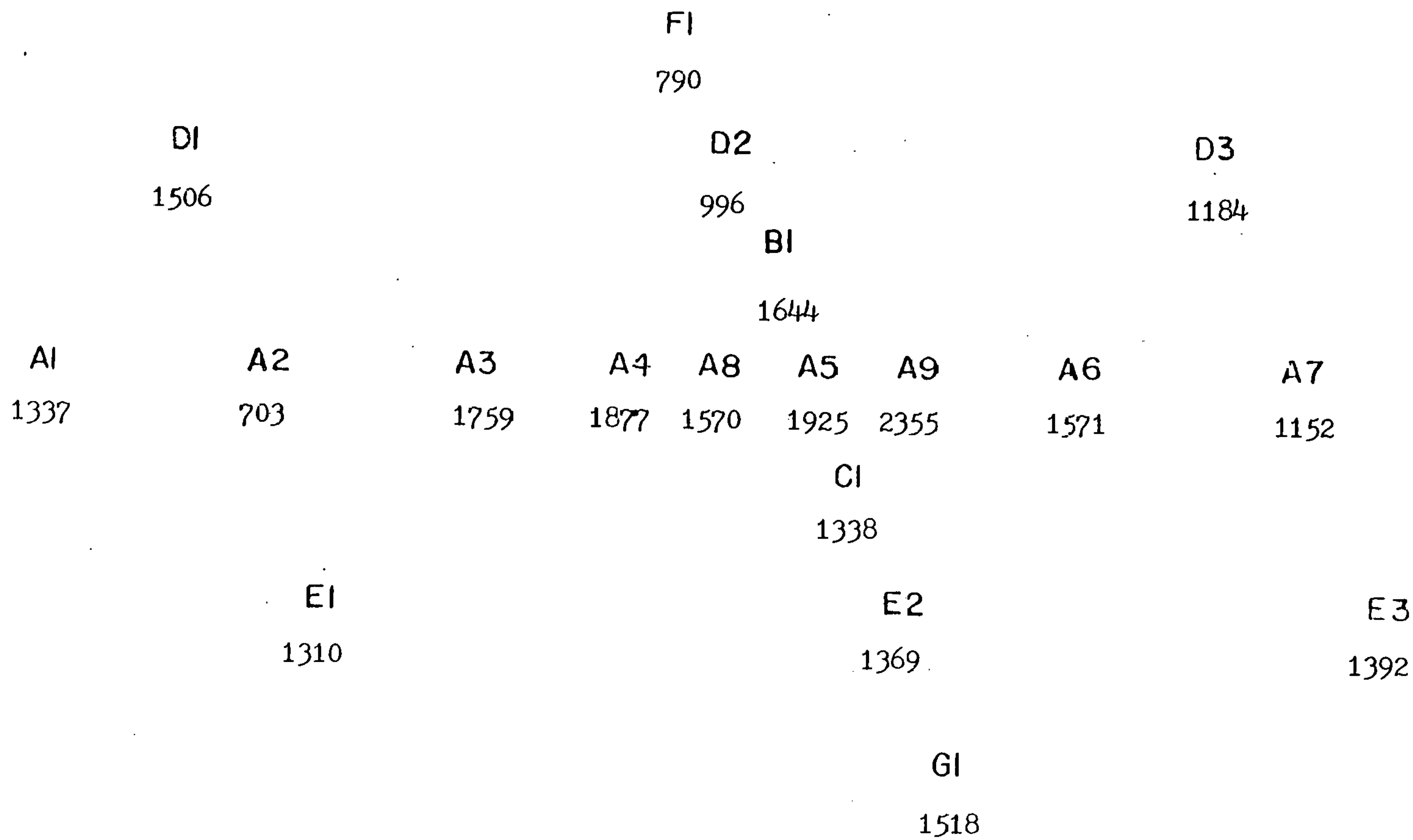


Figure 5-6. Areal distribution of total populations at each of the offshore stations, cruises 22-30 (Oct. 1979 - 21 Apr. 1980).

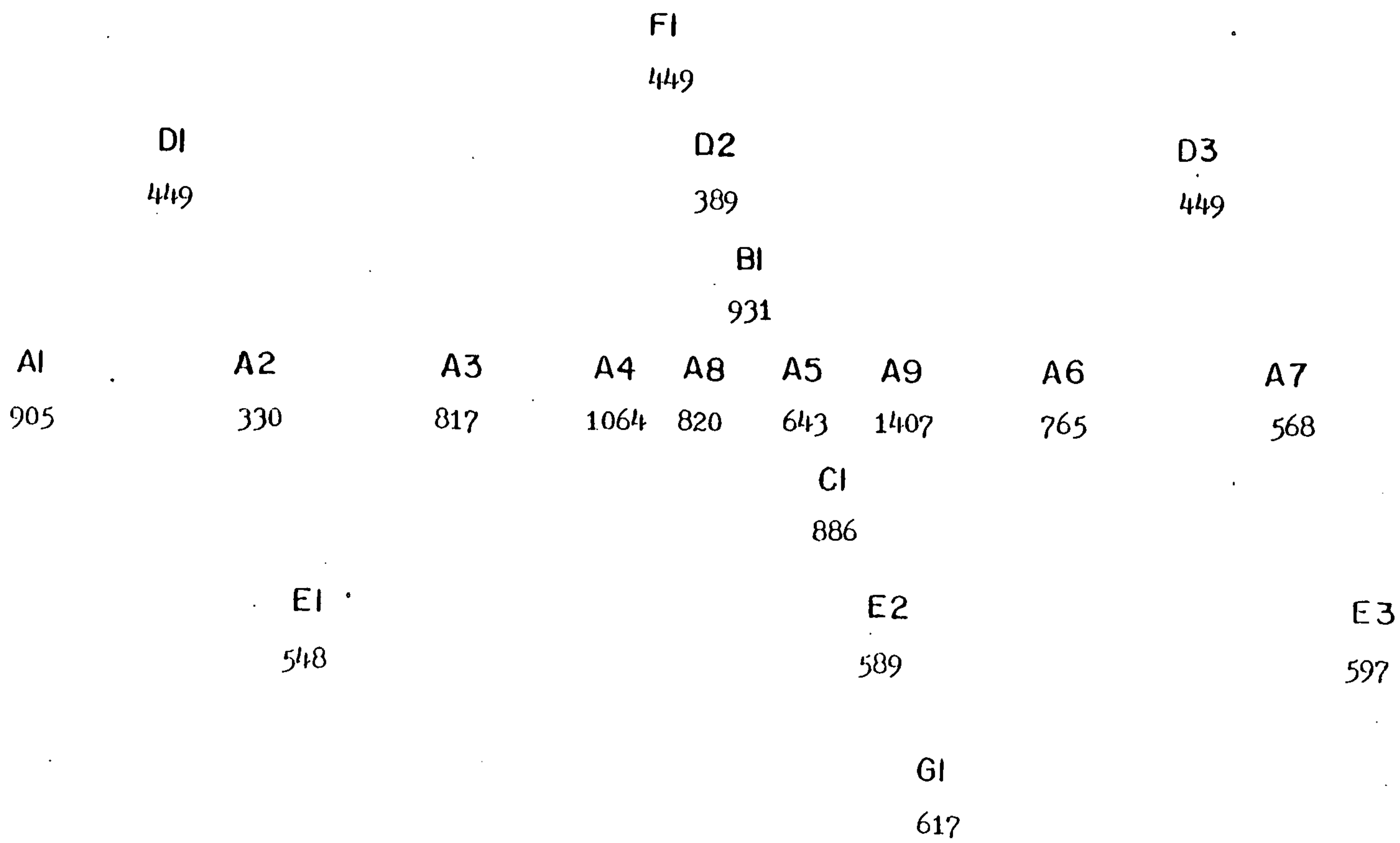


Figure 5-7. Areal distribution of total populations at each of the offshore stations, predisposal cruises (22-27).

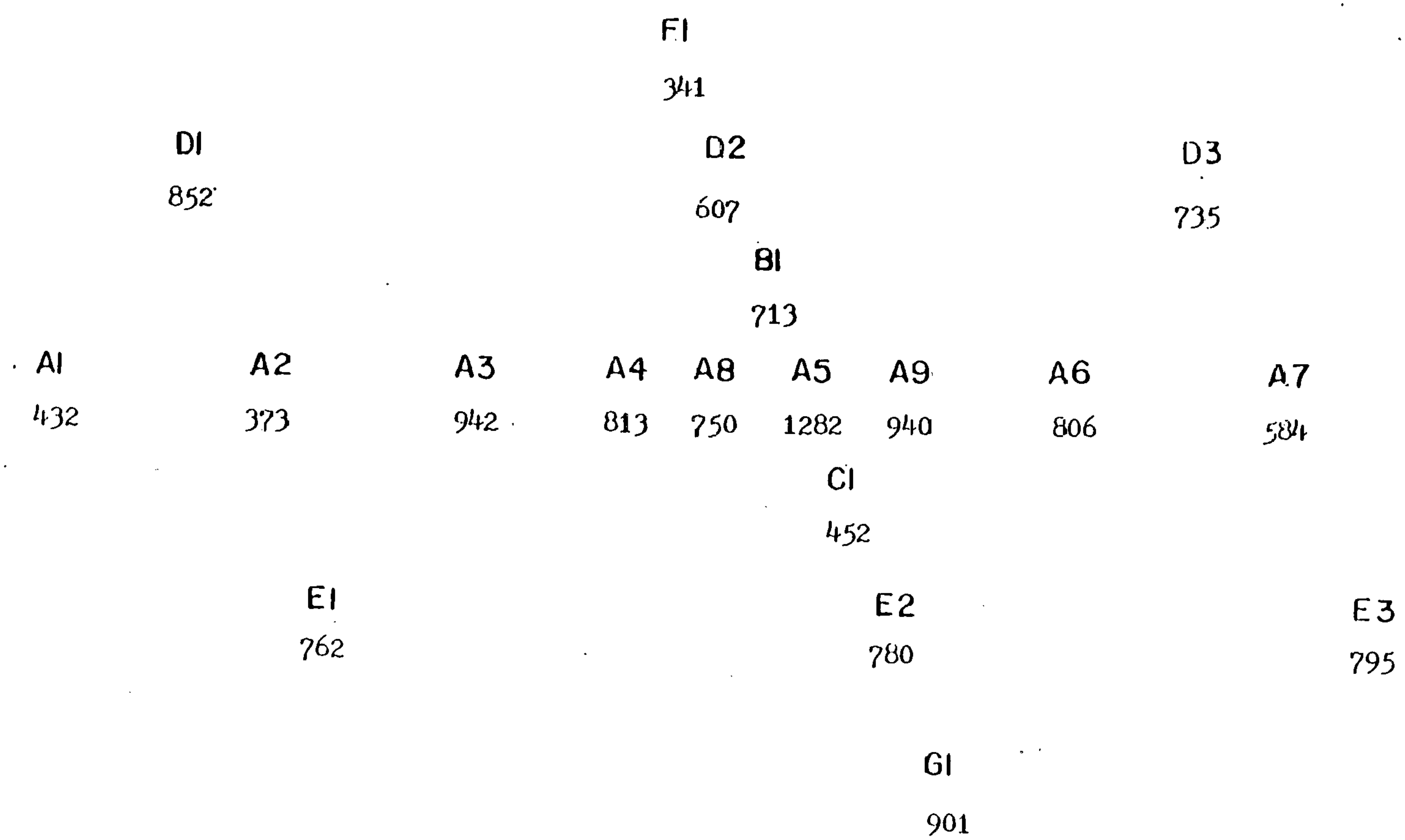


Figure 5-8. Areal distribution of total populations at each of the offshore stations, experimental cruises (28-30).

5.3.5.3 Diversity Indices

The diversity indices for all stations appeared to be relatively uniform during the experimental period and there is no indication that brine altered the H' at any of the stations (Table 5-5).

5.3.5.4 Cluster Analysis

Cluster analysis of the data collected on cruises 22-30 produced one station group with three subclusters (Figure 5-9). All the stations had a high degree of ecological similarity and there was no indication of any effect caused by brine; nearfield and farfield stations were mixed within subclusters. Analysis of the data from the three experimental cruises (28-30) produced similar results (Figure 5-10). The stations all had high ecological similarity and there was no indication of a brine induced effect.

5.3.5.5 Statistics

Analysis of variance indicated there were no significant differences in the Shannon diversity means between stations during the experimental period (Table 5-6).

5.3.5.6 Principal Components Analysis

No station clusters were produced by principal components analysis that could be attributable to effects of brine discharge, either when cruises 22-30 or the three experimental cruises data were analyzed (Figures 5-11, 5-12).

Table 5-5. Diversity indices calculated for each station during cruises 28-30.

CRUISE	MEAN	10A1	10A2	10A3	10A4	10A5	10A6	10A7	10D1	10D2
20 MAR 80	2.45	2.58	2.60	2.69	2.43	2.53	2.58	1.99	2.67	2.43
3 APR 80	2.31	2.10	2.46	2.57	1.63	2.28	2.41	2.43	2.91	2.11
21 APR 80	2.36	1.90	2.12	2.55	2.42	2.22	1.93	2.06	2.61	2.72
MEAN	2.37	2.19	2.40	2.60	2.16	2.34	2.31	2.16	2.73	2.42

CRUISE	10D3	10E1	10E2	10E3	10F1	10G1	10A8	10A9	10B1	10C1
20 MAR 80	2.60	2.53	2.67	2.67	2.23	2.55	2.19	2.32	2.38	2.00
3 APR 80	2.09	2.29	2.52	1.98	2.12	2.38	2.30	2.38	2.36	2.55
21 APR 80	2.32	2.42	2.23	2.39	2.45	2.55	2.35	2.27	2.46	2.85
MEAN	2.34	2.41	2.47	2.35	2.27	2.49	2.28	2.32	2.40	2.47

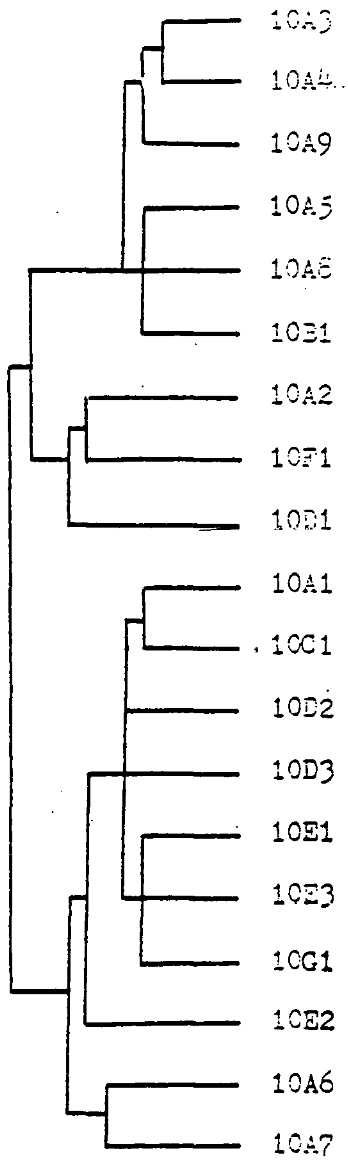


Figure 5-9. Results of cluster analysis comparing data collected at 19 stations, cruises 22-30 (Oct. 1979 - 21 Apr. 1980).

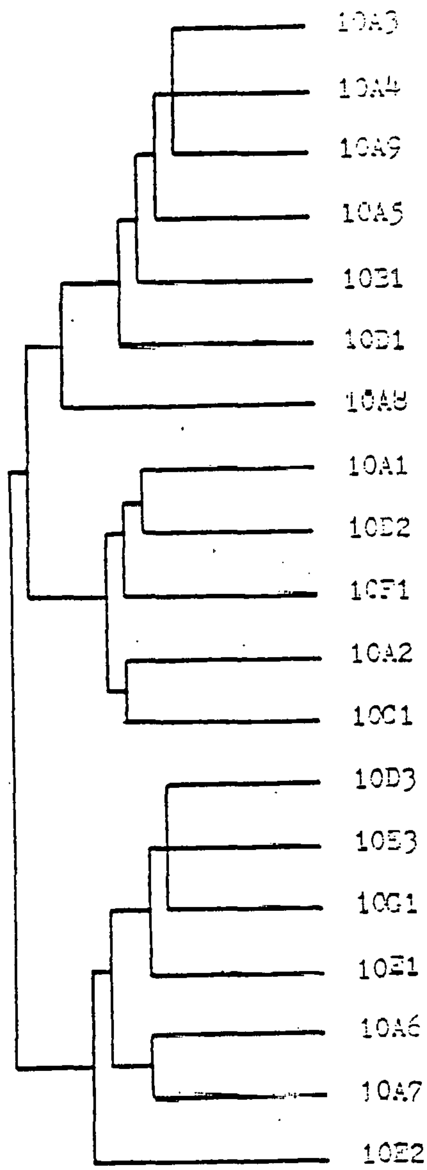


Figure 5-10. Results of cluster analysis comparing data collected at 19 stations, experimental cruises (28-30).

Table 5-6. ANOVA results testing the calculated means of Shannon diversity index for 15 stations, 3 cruises, and 3 replicates per station.

Source	DF	SS	F value	Pr > F
Temperature	1	0.32	2.41	0.1223
Salinity	1	0.31	2.23	0.1372
D.O.	1	0.09	0.67	0.4147
Station	18	3.39	1.38	0.1502
Cruise	2	0.07	0.28	0.7590

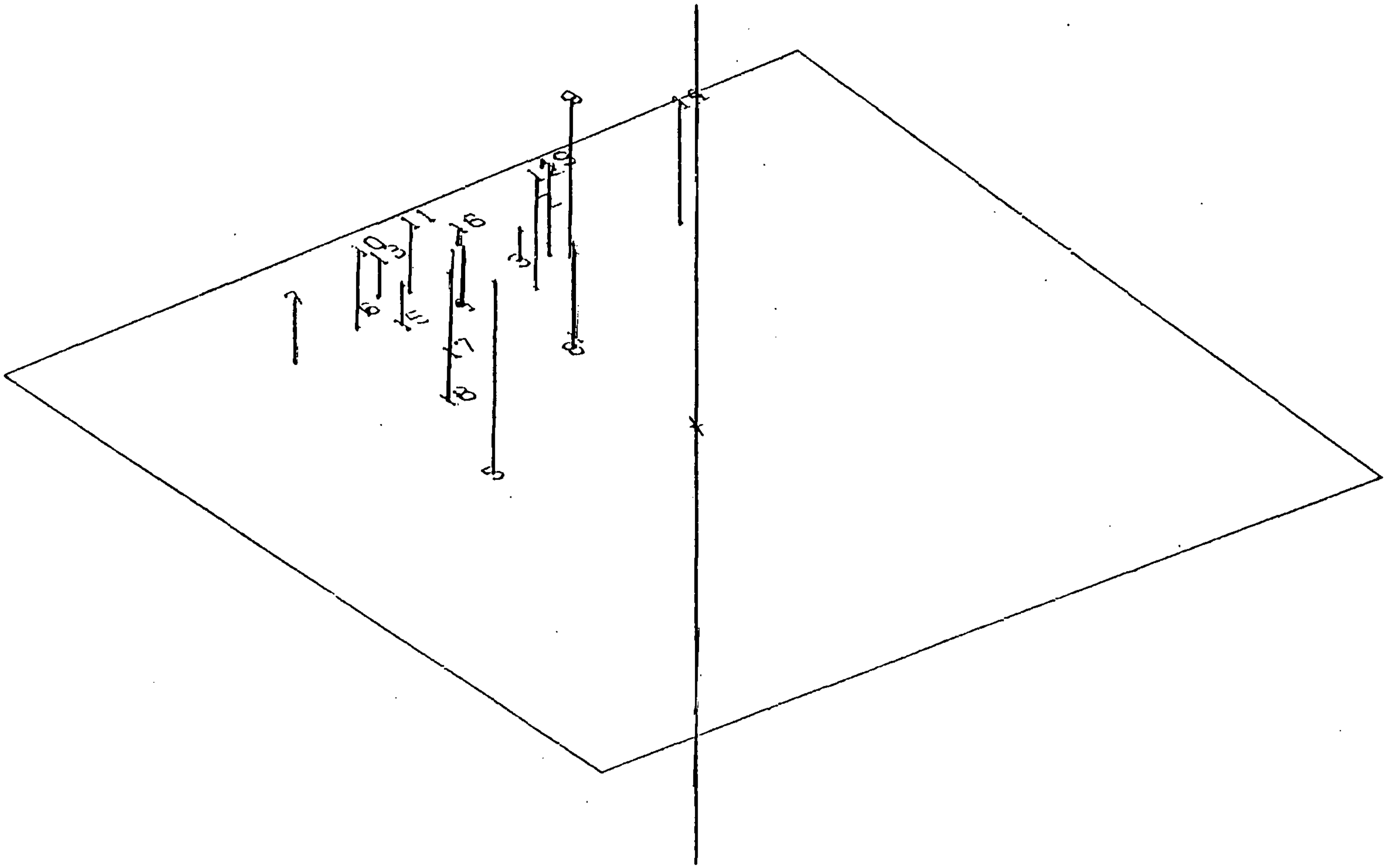


Figure 5-11 Principal components analysis of stations during experimental period (20 March - 21 April 1980).

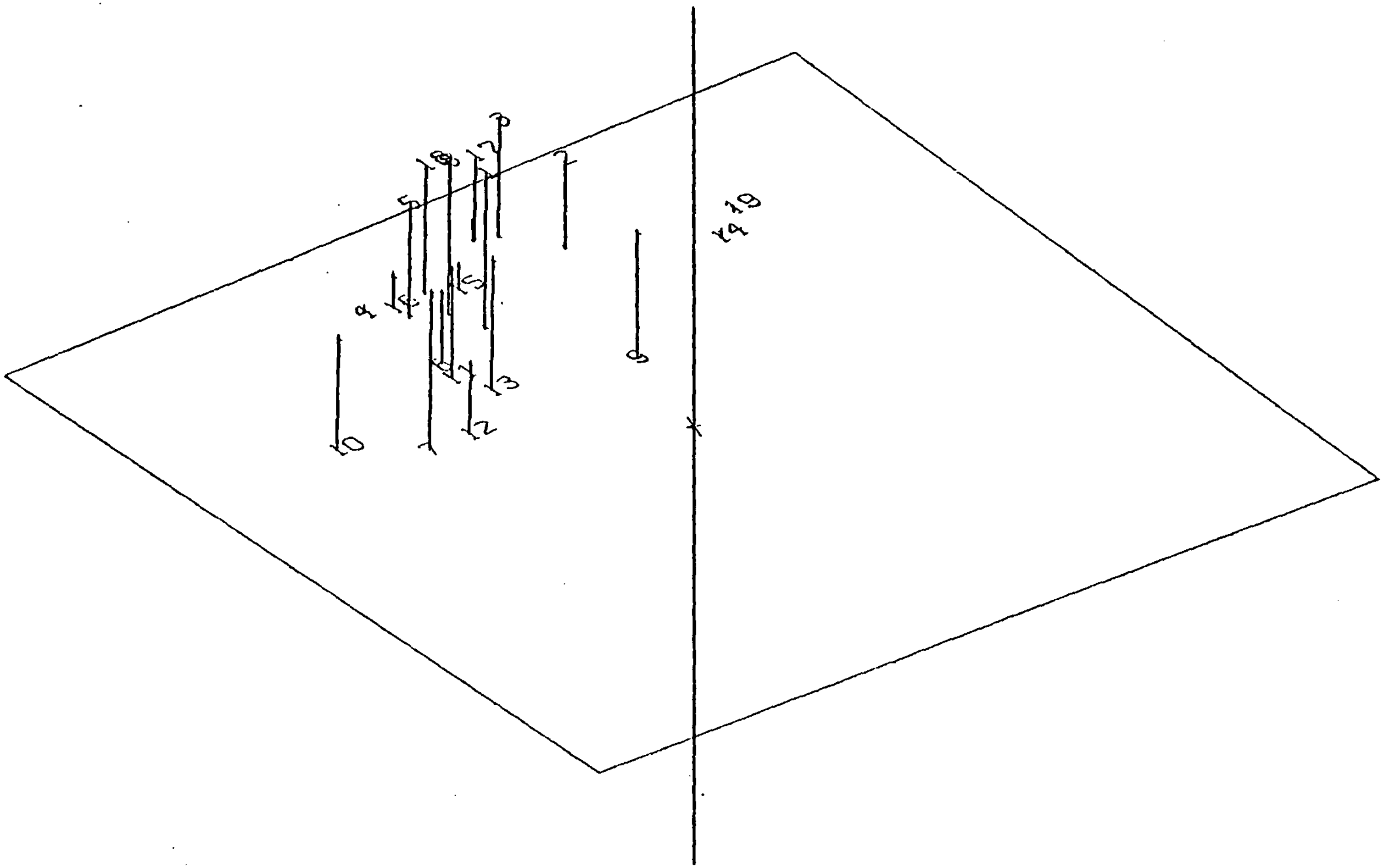


Figure 5-12 Principal components analysis of stations over the period 18 October 1979 through 21 April 1980.

5.3.6 Temporal Distributions of Species and Populations

5.3.6.1 Species

As illustrated in Figure 5-13, the number of species increased through the spring months even more rapidly in 1980 than in 1979, and more species were collected in 1980. A downturn occurred after the diffuser system was started up which persisted through early April, after which the number of species increased again. The decrease may have been related to brine discharge or may have been a natural population fluctuation similar to the slight decrease that occurred in February 1979. Comparison of the number of species collected at the original 15 stations and at the 19 stations indicates a rather consistent difference and there does not appear to be a marked difference in numbers of species that one might expect if the 4 "new" stations closest to the diffuser were being affected by brine (Figure 5-13).

5.3.6.2 Populations

In contrast with the comparable late 1978 period, populations in 1979 were quite low, not having recovered from the hypoxic period that occurred during the preceding summer (Figure 5-14). A rapid population increase occurred beginning between November and December 1979 and continued even after the diffuser began operating, excepting a very slight decrease that occurred on 3 April. We expect the major seasonal population downturn to occur betweeen April and May, based on initial analysis of May data.

5.3.6.3 Cluster Analysis

Cluster analysis of the data by cruises (time) resulted in the formation of 2 distinct time groups, as might have been expected, for both 15 and 19 station data (Figure 5-15; only clusters based on 19 stations shown).

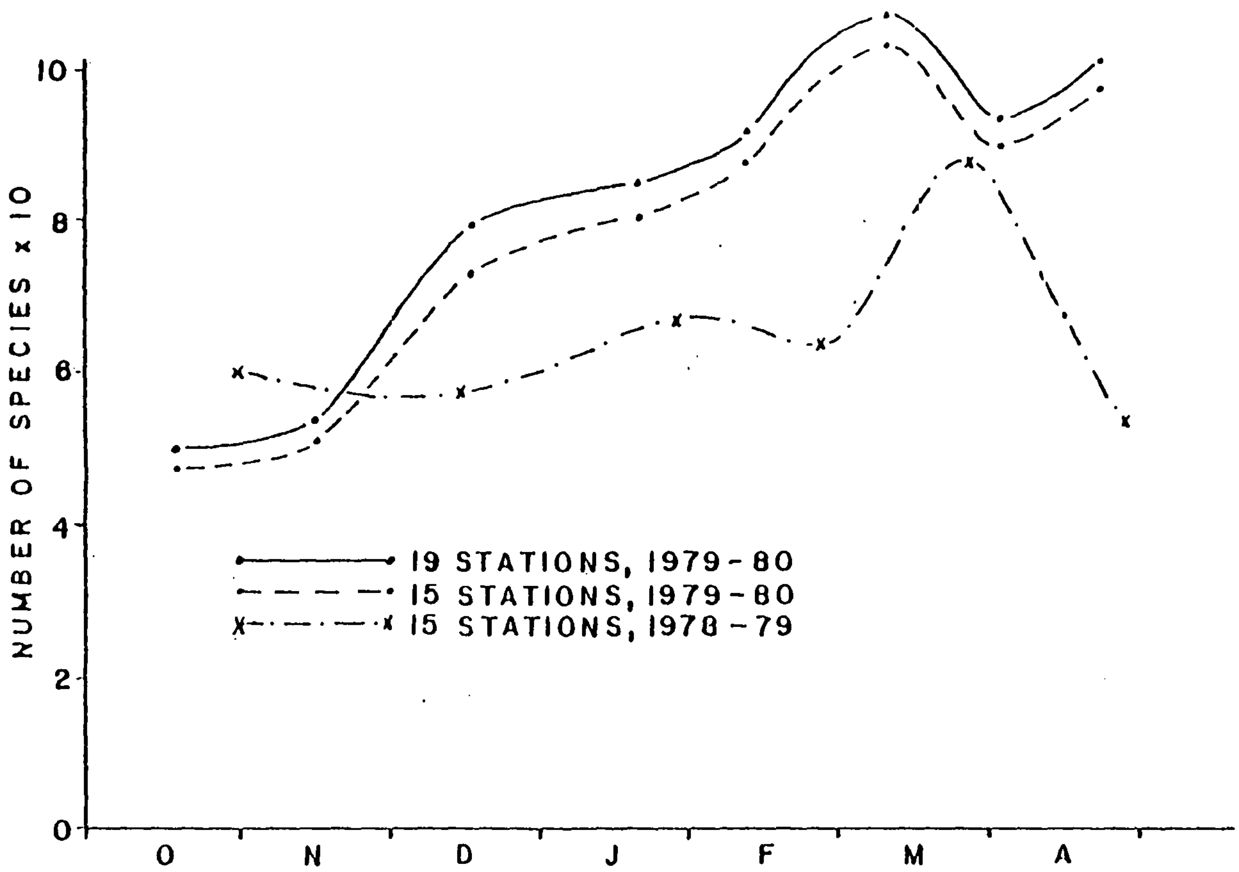


Figure 5-13. Temporal trends in the total number of species comparing data collected at 19 stations vs the original 15 stations, cruises 22-30, with the corresponding period in 1978-79.

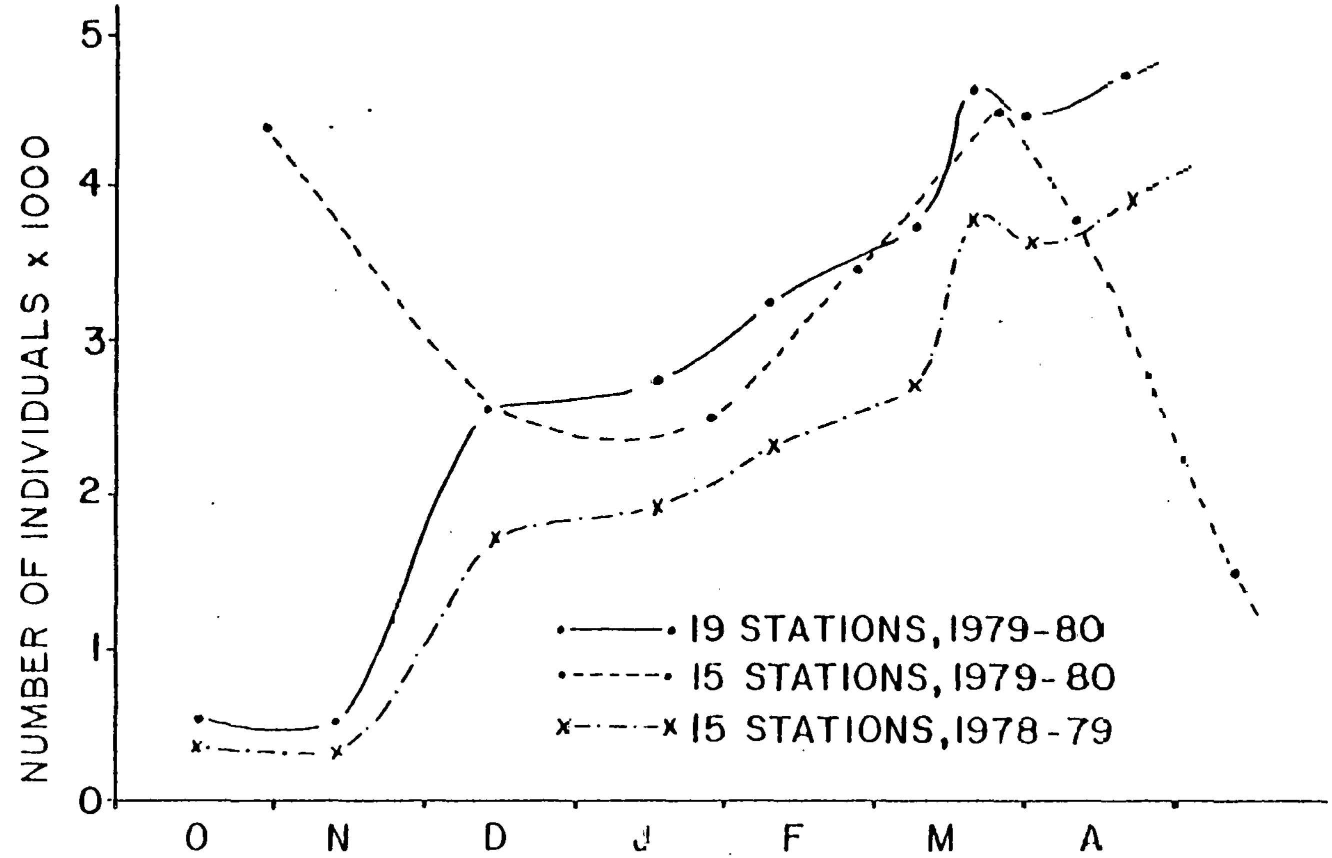


Figure 5-14. Temporal trends in the total populations comparing data collected at 19 stations vs the original 15 stations, cruises 22-30, with the corresponding period 1978-79.

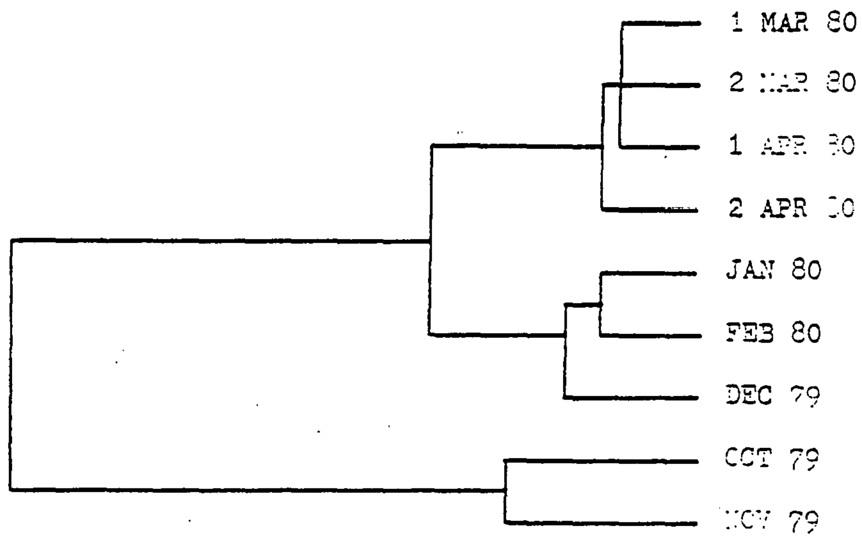


Figure 5-15. Results of cluster analysis comparing data collected at 19 stations, cruises 22-30 (Oct. 1979 - 21 Apr. 1980).

The post-hypoxic populations (October and November 1979) were quite distinct from the subsequent populations. The larger cluster was separated into two subclusters representing the winter months and the experimental period (including the immediate predisposal collection made on 10 March). The species were separated into two main clusters with the smaller cluster principally responsible for the arrangement of cruise clusters; the members of the smaller species group were virtually absent in October-November, present in small numbers in December-February and moderately abundant in March-April. Thus the clusters represent a seasonal progression rather than a brine related effect.

For comparison, the corresponding time period in 1978-79 was analyzed (15 stations). Essentially the same results occurred, with a separation into two time clusters caused by a few species that were common in the September-January months and abundant in February-April (Figure 5-16).

5.4 Discussion

From the preceding data there is little evidence that discharge of brine had a drastic or even measurable effect on the benthic community near the diffuser. Only the areal population data collected during the intensive experimental period suggest a nearfield depression, and even these stations had larger populations than some of the farfield stations. It is not surprising that effects were minimal at most. This study was conducted during the spring when sea conditons are usually rough and currents strong. The turbulence and currents tend to mix the water column and rapidly carry the diluted brine away from the discharge site. The currents also tend to be variable in direction over relatively short time spans, thus the benthos in any particular patch of bottom may not have been subjected to brine for more

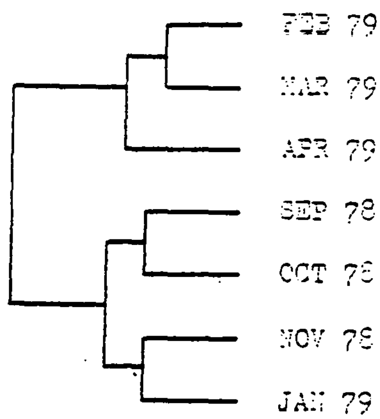


Figure 5-16. Results of cluster analysis comparing data collected at 15 stations, Sept. 1978 - Apr. 1980.

than a few hours at a time. Another factor tending to mitigate potential impact was that the brine was not being discharged at full strength. It is expected that the most severe effects will occur in late summer when seas are generally calmer and a greater possibility of stagnation occurs.

CHAPTER 6

ZOOPLANKTON

E. Taisoo Park and Thomas J. Minello
Department of Marine Biology
Texas A&M University at Galveston

6.1 Introduction

Three zooplankton cruises were made during the intensive study period. Samples from our three stations located near the diffuser were collected 14 days (February 28) before the initiation of continuous discharge (March 13) and also on two occasions after the initiation of discharge. The postdisposal cruises were made 9 and 34 days following the beginning of discharge. Total zooplankton biomass, population densities, and species diversity were measured during these cruises and compared with the data analyzed in the predisposal study (Park and Minello, 1980). These predisposal data along with other work done by Park (1979), Park and Turk (1980), and Minello (1980) in this general area off the Texas coast have given us baseline information on typical population densities and fluctuations in density within the zooplankton near the diffuser site.

In this intensive study therefore, we have compared data from zooplankton samples collected near the diffuser site on two cruises after the initiation of discharge with data from samples collected before discharge. The spatial variability of the zooplankton populations, determined by the differences among our three stations, were also examined before and after discharge.

6.2 Methods and Materials

Sampling methods and laboratory analyses were identical to those used in the predisposal study (Park and Minello, 1980). The locations of the stations sampled are shown in Figure 6-1. Station B is located near the diffuser and Stations A and C are two nautical miles away from the diffuser site. The sampling dates for the three cruises are listed in Table 6-1.

Table 6-1. Cruise data for the intensive study zooplankton cruises.

Cruise	Date	Days From Discharge Initiation (D)
8	2-28-80	D - 14
continuous discharge initiated	3-13-80	D
9	3-22-80	D + 9
10	4-16-80	D + 34

Temperature and salinity profiles were taken at each of the three stations during all three cruises using a Hydrolab Conductivity Meter. Bottom current data (from approximately 2 m off the bottom) were obtained from Mr. Frank Kelly of the physical oceanography section. These data were measured at current meter Site C, located approximately 1000 ft (305 m) southeast from the end of the diffuser.

All of the zooplankton displacement volumes and densities analyzed in detail in this study were derived from tows covering the entire

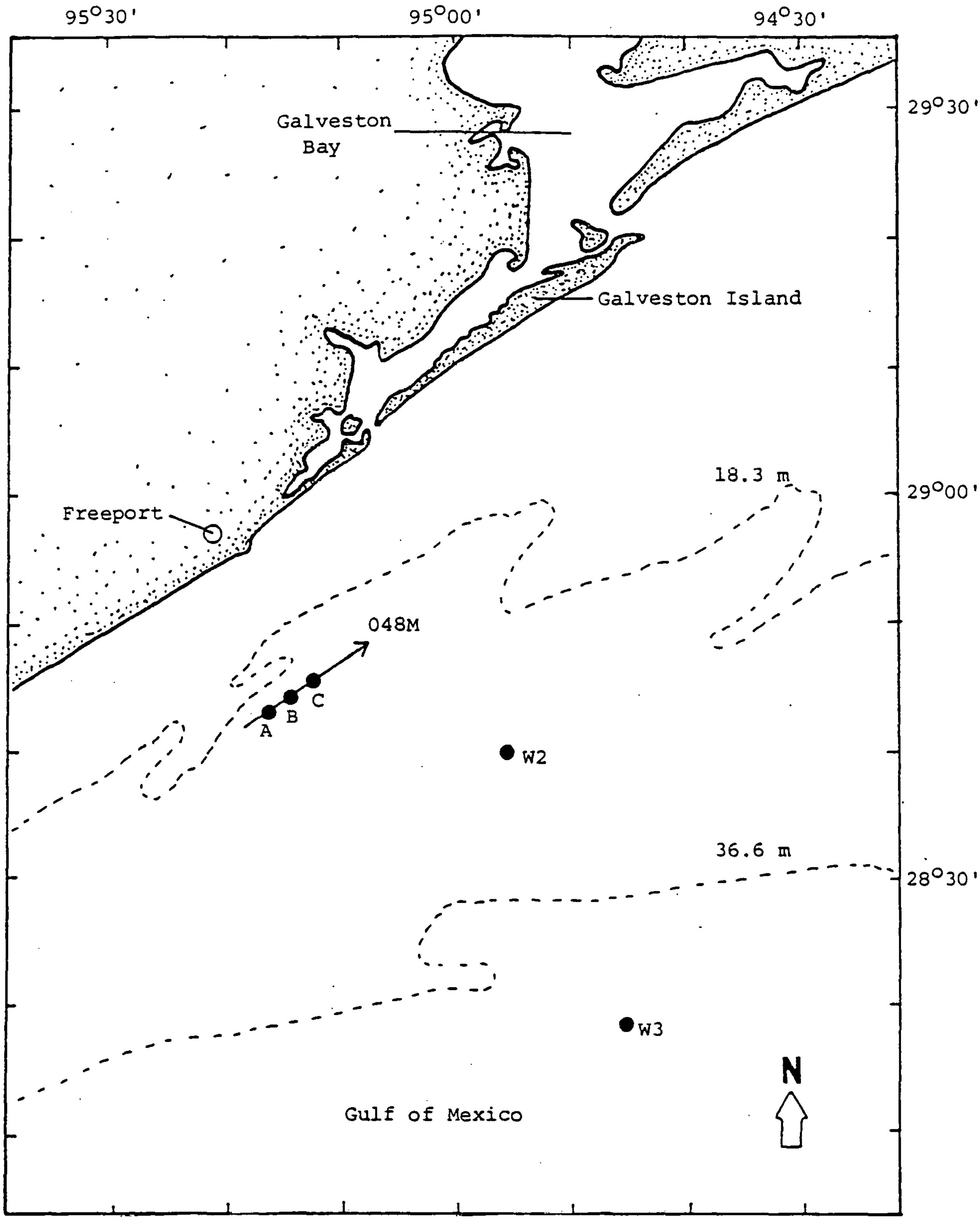


Figure 6-1. Location of sampling stations off Freeport, Texas. Brine diffuser is located near Station B. Historical data was collected at Stations W2 and W3.

water column (usually only down to approximately 17 m). Data from the half depth tows (tow 4), which are also presented in the Appendix II Tables, were used only in Section 6.3.7 to roughly examine vertical distributions.

6.3 Results and Discussion

6.3.1 Temperature, Salinity, and Bottom Currents

The temperature and salinity profiles measured during each cruise (Figure 6-2) did not appear to indicate any significant differences in the water column after the initiation of brine discharge. Temperatures were fairly uniform throughout the water column during all three cruises. Although the lowest salinities were found near the surface, no dramatic increases near the bottom were evident. Our deepest measurements, however, were usually made approximately one meter off the bottom. Since the preliminary work done on tracking the brine plume indicated that the elevation in salinity from the brine was confined to the water very close to the bottom, an increase in salinity near the bottom in our profiles should probably not be expected.

In order to identify the stations most likely to be affected by the brine, information on bottom currents near the diffuser was obtained from the physical oceanography section. Generally these bottom currents were highly variable, changing in both direction and speed frequently. This made the identification of 'down current' stations difficult. During the period preceeding Cruise 9, the direction of the bottom current near the diffuser was highly variable. On March 21 bottom currents changed from a northeast direction to a

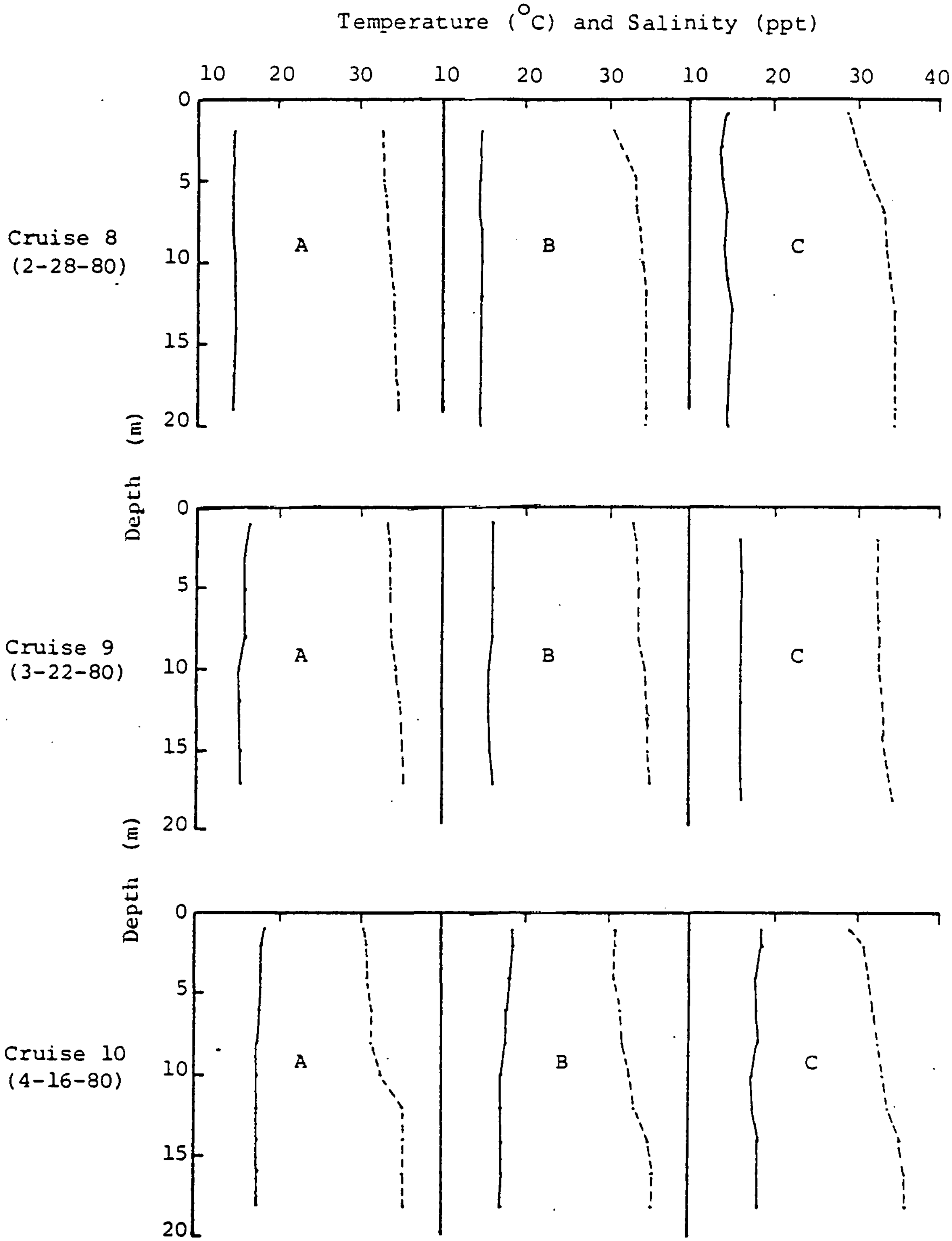


Figure 6-2. Temperature (solid line) and salinity (dashed line) profiles measured at each station (A,B,C) on the intensive study cruises.

northwest direction. On March 22, during the zooplankton sampling, the bottom current was in a south southwest direction with an average speed of approximately 23 cm/sec (0.45 knots). Bottom current stability appeared greater around the Cruise 10 sampling period. For several days preceeding sampling and on the sampling date (March 16) bottom currents were in a north to northeast direction. Current speeds during the time of zooplankton sampling averaged 22 cm/sec. Station C during this cruise could probably be considered a down current station. The stations most likely to be affected by the brine, therefore, would include Station B on both Cruise 9 and 10 and perhaps Station C on Cruise 10.

6.3.2 Biomass

Displacement volumes appeared generally similar for all three intensive study cruises and the volumes measured after the initiation of discharge (Cruises 9 and 10) did not appear to be significantly different from those recorded on Cruise 8 (Figure 6-3). Mean values were all below 1.0 ml/m^3 and these values were similar to the displacement volumes measured in the predisposal study from July through January. The variability among the three stations in the intensive study cruises did not appear to have increased after the initiation of discharge.

6.3.3 Densities of Total Zooplankton and Major Zooplankton Groups

Total zooplankton densities from the three intensive study cruises did not appear abnormal for this area. Mean zooplankton densities at the three stations during Cruise 8 ranged from 3970 to

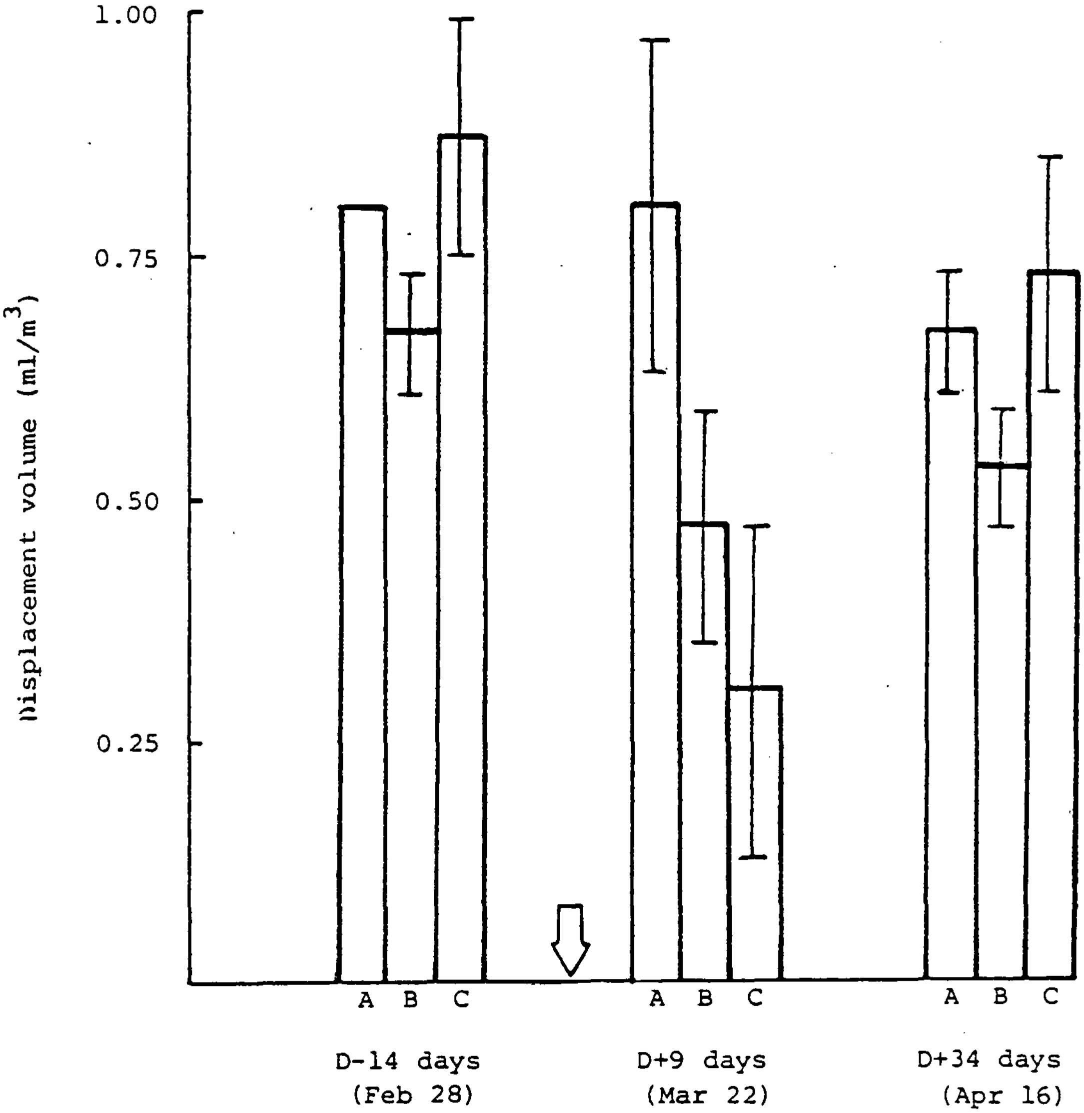


Figure 6-3. Zooplankton biomass data from the three intensive study cruises. Mean displacement volumes from tows taken over the entire water column are shown for each station on every cruise. The error bars indicate ± one standard deviation based on three replicate tows. The arrow indicates the interval of brine discharge initiation. Continuous discharge was intitiated on March 13 (D).

6045 organisms/m^3 (Figure 6-4). Mean densities were lower during Cruise 9 (2335 to 2517 organisms/m^3) but values were elevated again during Cruise 10 (4063 to 5845 organisms/m^3). The decrease in density from Cruise 8 to Cruise 9 would not appear to be atypical considering the monthly variability exhibited in the data from the predisposal study. Variability among the three stations was insignificant at the 1% level on Cruises 8 and 9, based on Duncan's multiple range test. This variability appeared especially low during Cruise 9 which was made 9 days following the initiation of discharge. Although some differences existed among the three stations during Cruise 10 (April 16) none of the stations was different from both of the other stations at the 1% significance level.

Mean densities for all major groups of zooplankton identified for each tow taken in the intensive study are listed in Appendix II, Table II-1. Copepods dominated the zooplankton during all three of the cruises averaging 82.1%, 61.6%, and 50.3% of the zooplankton for Cruises 8, 9, and 10, respectively (Table 6-2). The percentage of copepods appeared relatively stable among stations within a cruise. When station variability was tested based on copepod densities, the three stations were similar during Cruises 8 and 9. On Cruise 10 however, Station B was significantly different (1% level) from Stations A and C (Figure 6-5).

The percentage of adult females within the copepods at the three stations ranged from 42 to 60% on Cruise 8, 29 to 43% on Cruise 9, and 43 to 57% on Cruise 10 (Figure 6-5). Immature forms (copepodids) were generally second in abundance and adult males usually made up a

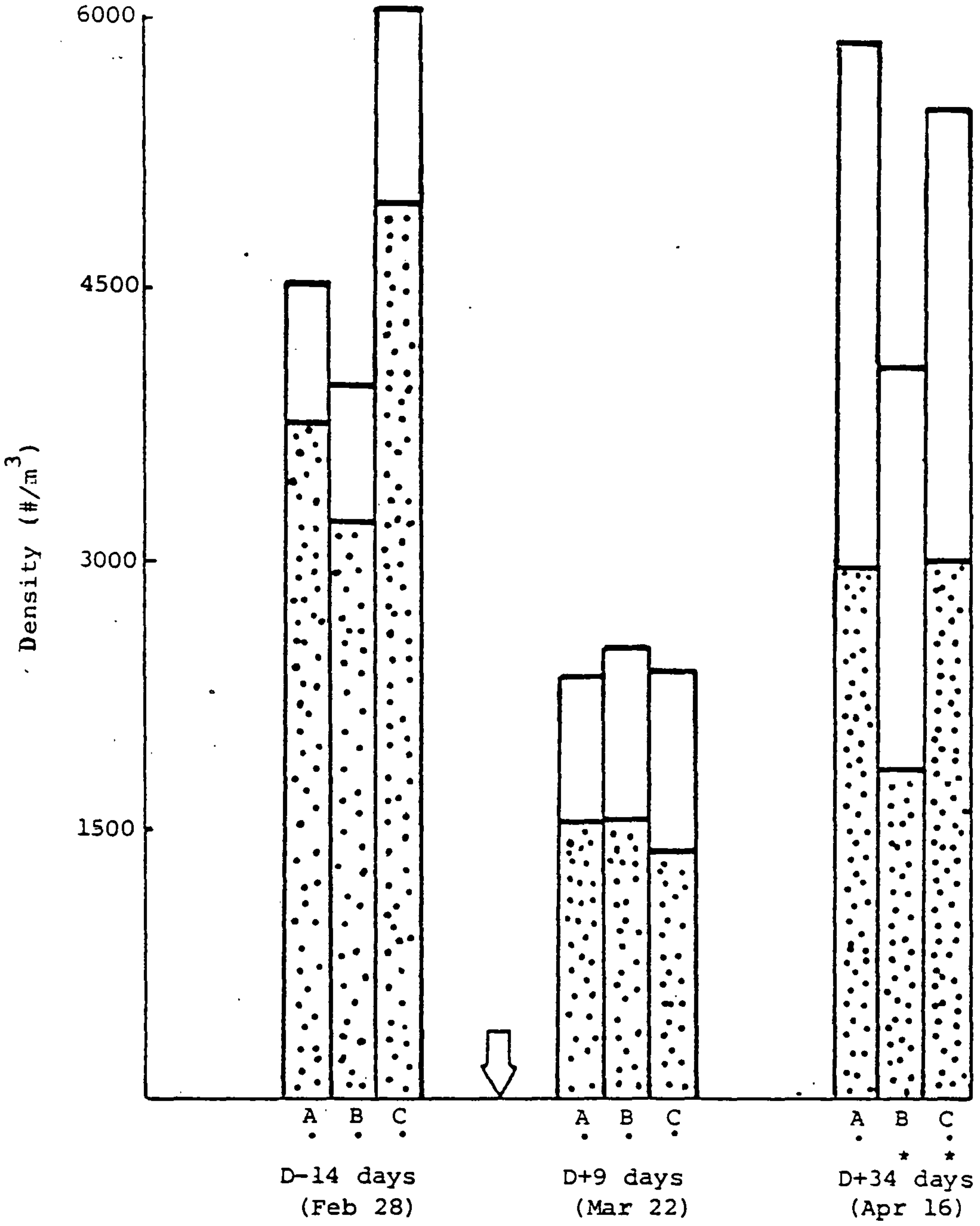


Figure 6-4. Total zooplankton densities and densities of copepods (stippled) within the zooplankton. Values represent means from three replicate tows taken over the entire water column. Stations with the same symbols (• or ☆) were similar at the 1% level based on Duncan's multiple range test done on log transformed densities of total zooplankton. The arrow indicates the interval of continuous brine discharge initiation which occurred on March 13 (D).

Table 6-2. Dominant zooplankton groups in the intensive study cruises. Percentages are based on total mean densities from tows covering the entire water column.

Cruises 8-10 combined

Group	% of zooplankton	cum. %
Copepods	64.9	64.9
Larvacea	12.4	77.3
Chaetognaths	5.9	83.2
Polychaete larvae	2.9	86.1
Euconchoecia	2.6	88.7
Doliolida	2.5	91.2
Bivalve larvae	1.8	93.0
Barnacle cypris larvae	1.3	94.3
Medusae	1.2	95.5
Gastropod larvae	0.9	96.4

Cruise	Group	% of zooplankton	cum. %
8	Copepods	82.1	82.1
Feb. 28	Larvacea	5.9	88.0
	Doliolida	3.3	91.3
	Bivalve larvae	3.3	94.6
	Chaetognaths	1.3	95.9
	Gastropod larvae	1.3	97.2
9	Copepods	61.6	61.6
Mar. 22	Larvacea	18.6	80.2
	Euconchoecia	6.9	87.1
	Chaetognaths	4.4	91.5
	Doliolida	2.4	93.9
	Medusae	1.5	95.4
10	Copepods	50.3	50.3
Apr. 16	Larvacea	15.7	66.0
	Chaetognaths	10.9	76.9
	Polychaete larvae	6.2	83.1
	Euconchoecia	2.9	86.0
	Barnacle cypris larvae	2.6	88.0

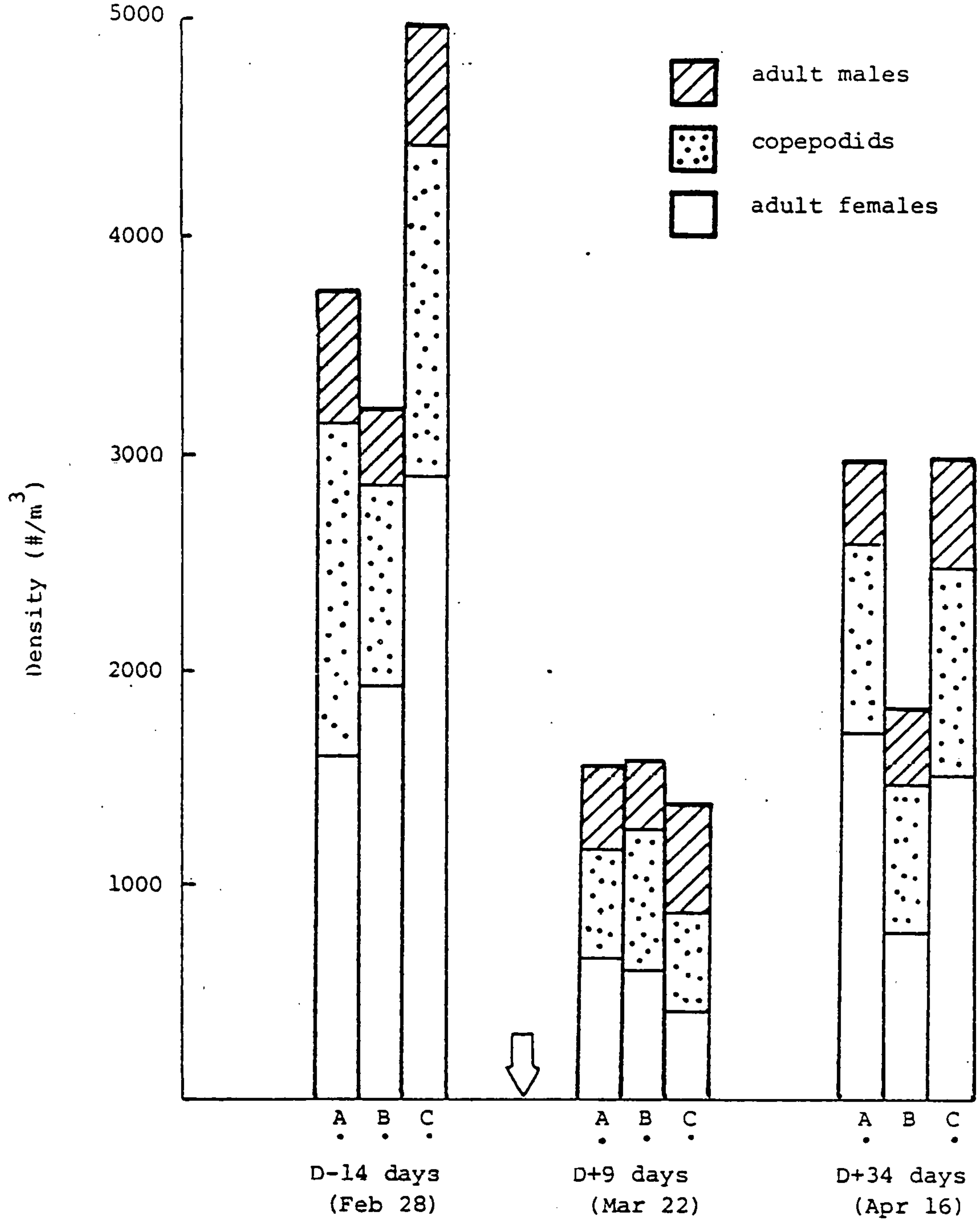


Figure 6-5. Densities of adult males, copepodids, and adult females within the copepods (total height of bar). Values graphed are means from the three tows taken over the entire water column. Stations with the same symbols (• or *) were similar at the 1% significance level based on Duncan's multiple range test done on log transformed densities of copepods. The arrow indicates the interval of continuous discharge initiation which occurred on March 13 (D).

relatively small percentage of the copepods. At Station C on Cruise 9 however, adult males were the most abundant of the three groups making up 37% of the copepods.

Calanoids dominated the copepods in the intensive study cruises with percentages generally ranging from 60 to 85% (Figure 6-6). Cyclopoids were more abundant than calanoids only at Station C on Cruise 9. Harpacticoids made up a very small percentage of the copepods.

Other dominant zooplankton groups identified in the intensive study samples were the larvacea, chaetognaths, polychaete larvae, and the ostracod *Euconchoecia*. Mean densities of larvacea increased over the intensive study period and the greatest numbers were found on Cruise 10 (Figure 6-7). Overall, densities were similar to those reported in the predisposal study. The density of chaetognaths also appeared greatest in the Cruise 10 samples (Figure 6-7). Densities of this group were relatively low on Cruises 8 and 9.

Polychaete larvae were found in low densities on Cruises 8 and 9 (mean densities were less than $50/m^3$) and in relatively high numbers on Cruise 10 with a maximum mean density of $467/m^3$ at Station A (Figure 6-8). On Cruise 9, the density at Station B was significantly lower than the densities at Stations A and C. The mean density of polychaete larvae at Station B was also relatively low during Cruise 10.

Mean densities of *Euconchoecia* were very low in the Cruise 8 samples (Figure 6-8). Densities were relatively high on Cruises 9 and 10. Station variability was low on all three cruises in relation to the variability among replicate tows.

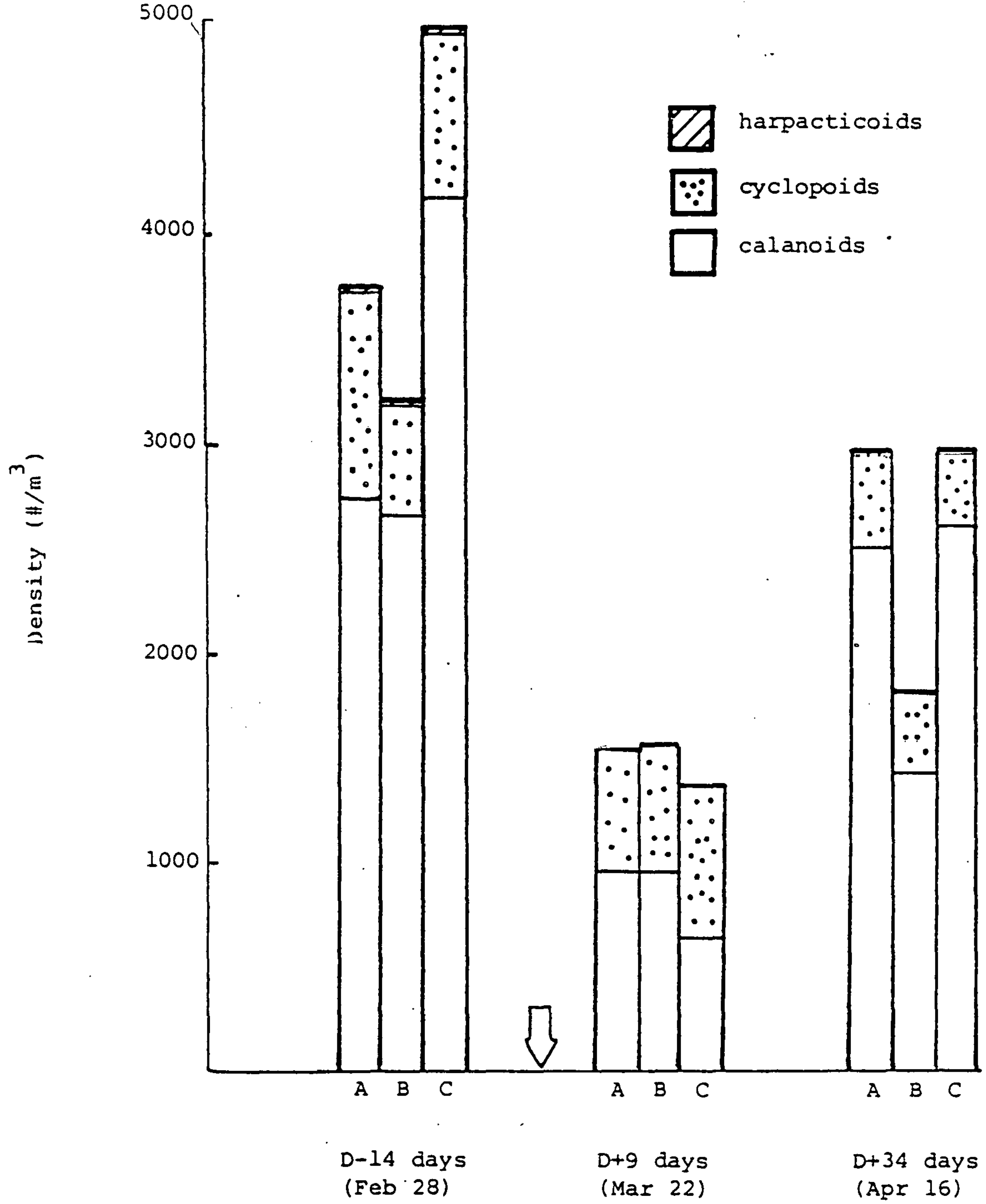


Figure 6-6. Densities of calanoids, cyclopoids, and harpacticoids within the copepods (total height of bar). Values graphed are means from the three tows taken over the entire water column. The arrow indicates the interval of continuous discharge initiation which occurred on March 13 (D).

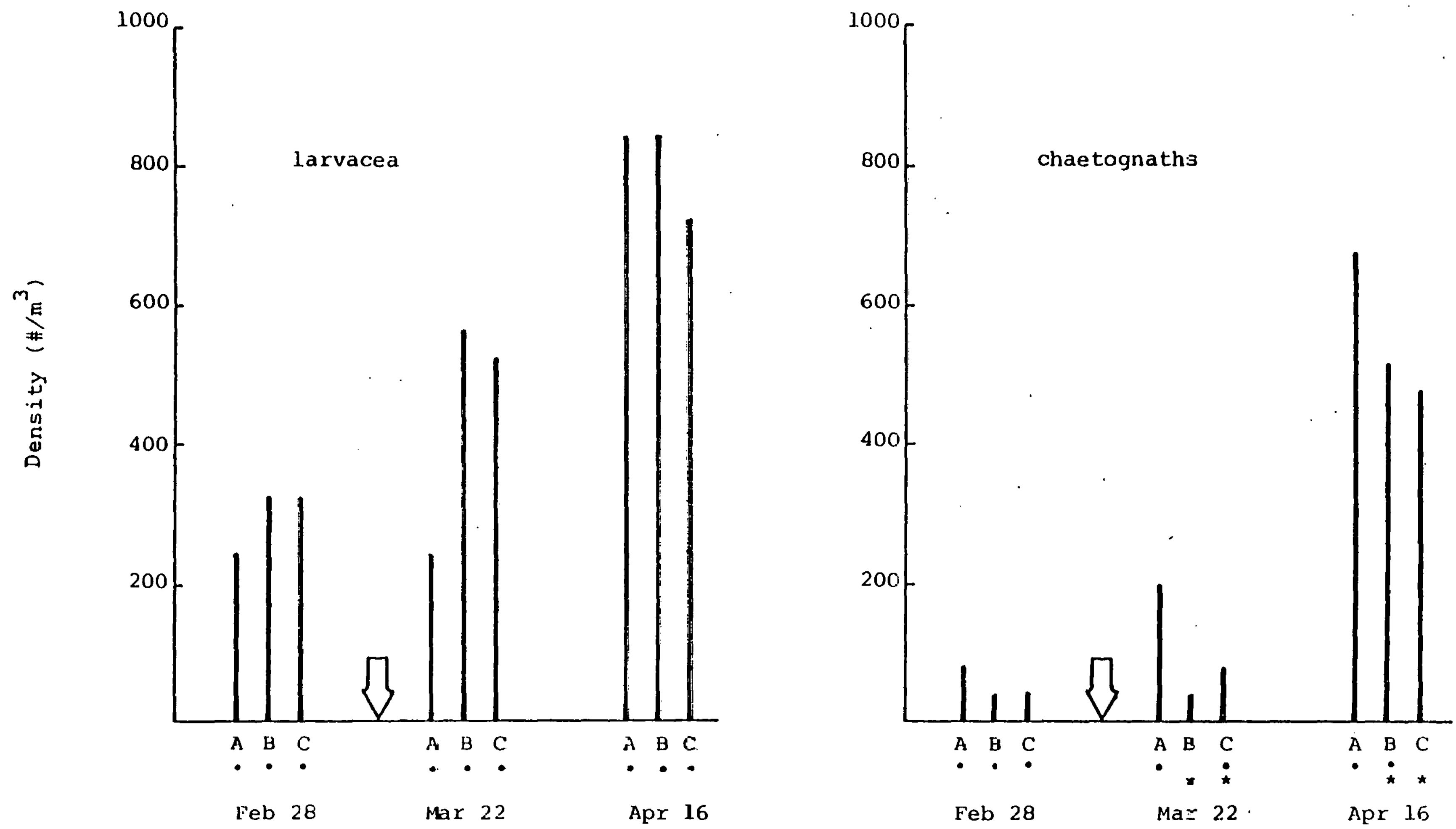


Figure 6-7. Mean densities of larvacea and chaetognaths at each station during the three intensive study cruises. Bars represent means from three replicate tows taken over the entire water column. Stations with the same symbols (• or ⋆) were similar at the 1% significance level based on Duncan's multiple range test performed on log transformed densities. The arrow indicates the interval of continuous brine discharge initiation which occurred on March 13.

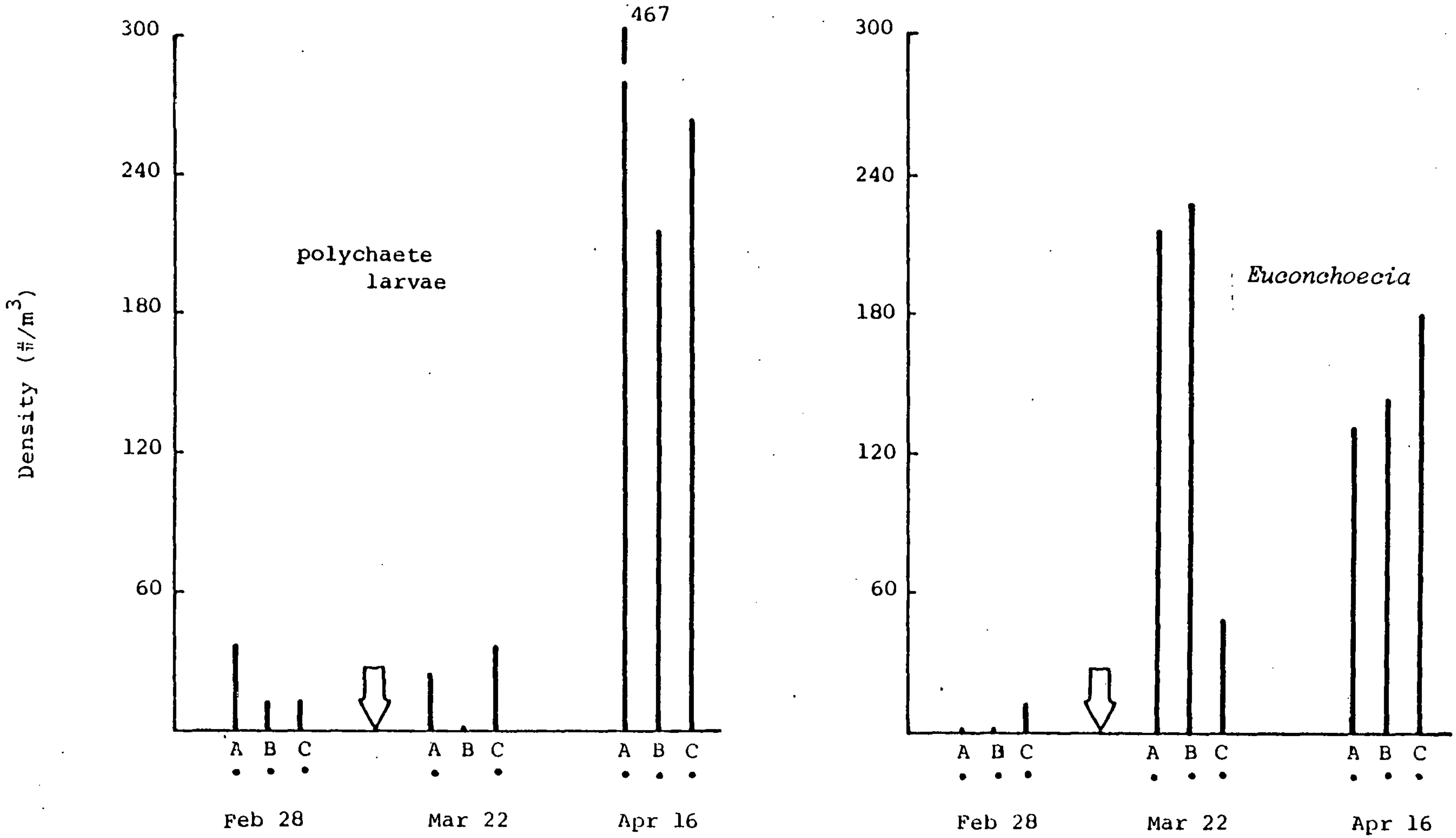


Figure 6-8. Mean densities of polychaete larvae and *Euconchoecia* at each station during the three intensive study cruises. Bars represent means from three replicate tows taken over the entire water column. Graphed as in Figure 6-7 (Page 6-14).

Mean densities were also graphed for bivalve larvae and barnacle cypris larvae (Figure 6-9) since these organisms were abundant in the samples of the predisposal study. Mean densities of bivalve larvae were highest on Cruise 8 and these organisms were found in relatively low numbers on Cruises 9 and 10. None of the mean values found in the intensive study approached the maximum number of bivalve larvae (over $2000/m^3$) observed on the December cruise of the predisposal study. Barnacle cypris larvae were found in low densities on Cruises 8 and 9 and densities at all three stations were high on Cruise 10. Station variability on all cruises appeared to be low in relation to tow variability.

The densities of the major groups of zooplankton did not appear to be greatly affected by the initiation of brine discharge. Some of the dominant groups such as *Euconchoecia* and the bivalve larvae exhibited relatively large changes in density from Cruise 8 to Cruises 9 and 10. Densities of *Euconchoecia* increased and densities of bivalve larvae decreased after the initiation of discharge. These differences, however, did not appear to be large in relation to the monthly variability for these groups seen in the data from the predisposal study. The variability among stations for the major zooplankton groups also did not appear excessive in relation to the station variability exhibited in the predisposal study.

6.3.4 Copepod Species

Mean densities of all species of copepods identified from each tow taken on the intensive study cruises are listed in Appendix II,

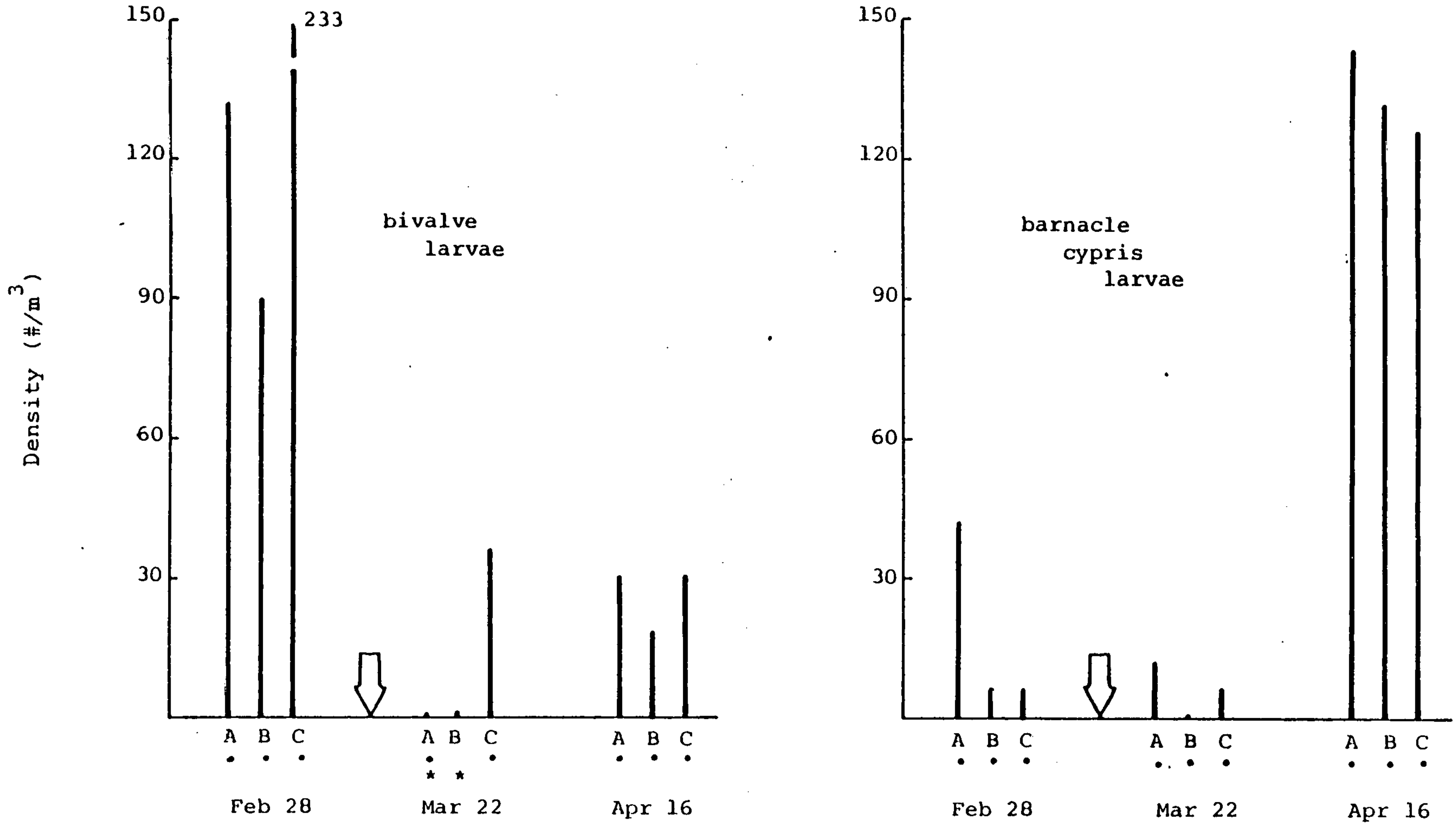


Figure 6-9. Mean densities of bivalve larvae and barnacle cypris larvae at each station during the three intensive study cruises. Bars represent means from three replicate tows taken over the entire water column. Graphed as in Figure 6-7 (Page 6-14).

Table II-2. The two dominant species of adult female copepods found in the intensive study were *Paracalanus quasimodo* and *Acartia tonsa* (Table 6-3). These two species made up 82.5% of all adult females examined. Other abundant species included *Corycaeus americanus*, *Temora turbinata*, *Corycaeus amazonicus*, *Paracalanus indicus*, and *Oncaea venusta*. These seven species made up 93.8 % of the adult females examined. *Paracalanus quasimodo* was the dominant species on all three cruises. Mean densities reached 2571/m^3 at Station C on Cruise 8 (Figure 6-10). This value was higher than any density recorded for this species in the predisposal study. Overall, densities were high on Cruise 8 in relation to Cruises 9 and 10. On Cruise 10, Station B had a significantly (1% level) low mean density in relation to the other stations. *Acartia tonsa* was found in low densities on Cruises 8 and 9 and in relatively high numbers on Cruise 10 (Figure 6-10). The mean density recorded for Station A on Cruise 9 was significantly higher than the mean densities at the two other stations.

The densities of ten other abundant species of copepods are shown for the three intensive study cruises in Figures 6-11 to 6-15. No distinct changes attributable to the initiation of brine discharge were apparent in these data.

6.3.5 The Analysis of Variance

An analysis of variance on log transformed densities was used to determine whether the three stations sampled were similar during each of the three intensive study cruises. A separate analysis was used for total zooplankton, some of the major zooplankton groups,

Table 6-3. Dominant species of copepods during the intensive study cruises. Percentages are based on total mean densities of adult females from tows covering the entire water column.

Cruises 8-10 combined

Species	% of adult females	cum. %
Paracalanus quasimodo	66.5	66.5
Acartia tonsa	16.0	82.5
Corycaeus americanus	5.8	88.3
Temora turbinata	1.7	90.0
Corycaeus amazonicus	1.7	91.7
Paracalanus indicus	1.1	92.8
Oncaea venusta	1.0	93.8
Centropages hamatus	0.9	94.7
Eucalanus pileatus	0.9	95.6
Clausocalanus jobei	0.7	96.3
Oncaea mediterranea	0.7	97.0
Centropages velificatus	0.7	97.7

Cruise	Species	% of adult females	cum. %
8	*Paracalanus quasimodo*	86.4	86.4
Feb. 28	*Corycaeus americanus*	5.3	91.7
	Temora turbinata	1.6	93.3
	Oncaea venusta	1.4	94.7
	Clausocalanus jobei	1.0	95.7
	Acartia tonsa	0.7	96.4
9	*Paracalanus quasimodo*	46.0	46.0
Mar. 22	*Acartia tonsa*	17.7	63.7
	Corycaeus americanus	11.2	74.9
	Eucalanus pileatus	4.3	79.2
	Temora turbinata	3.7	82.9
	Oncaea mediterranea	3.6	86.5
10	*Paracalanus quasimodo*	42.9	42.9
Apr. 16	*Acartia tonsa*	39.8	82.7
	Corycaeus americanus	4.3	87.0
	Corycaeus amazonicus	3.2	90.2
	Paracalanus indicus	2.0	92.2
	Centropages velificatus	1.4	93.6

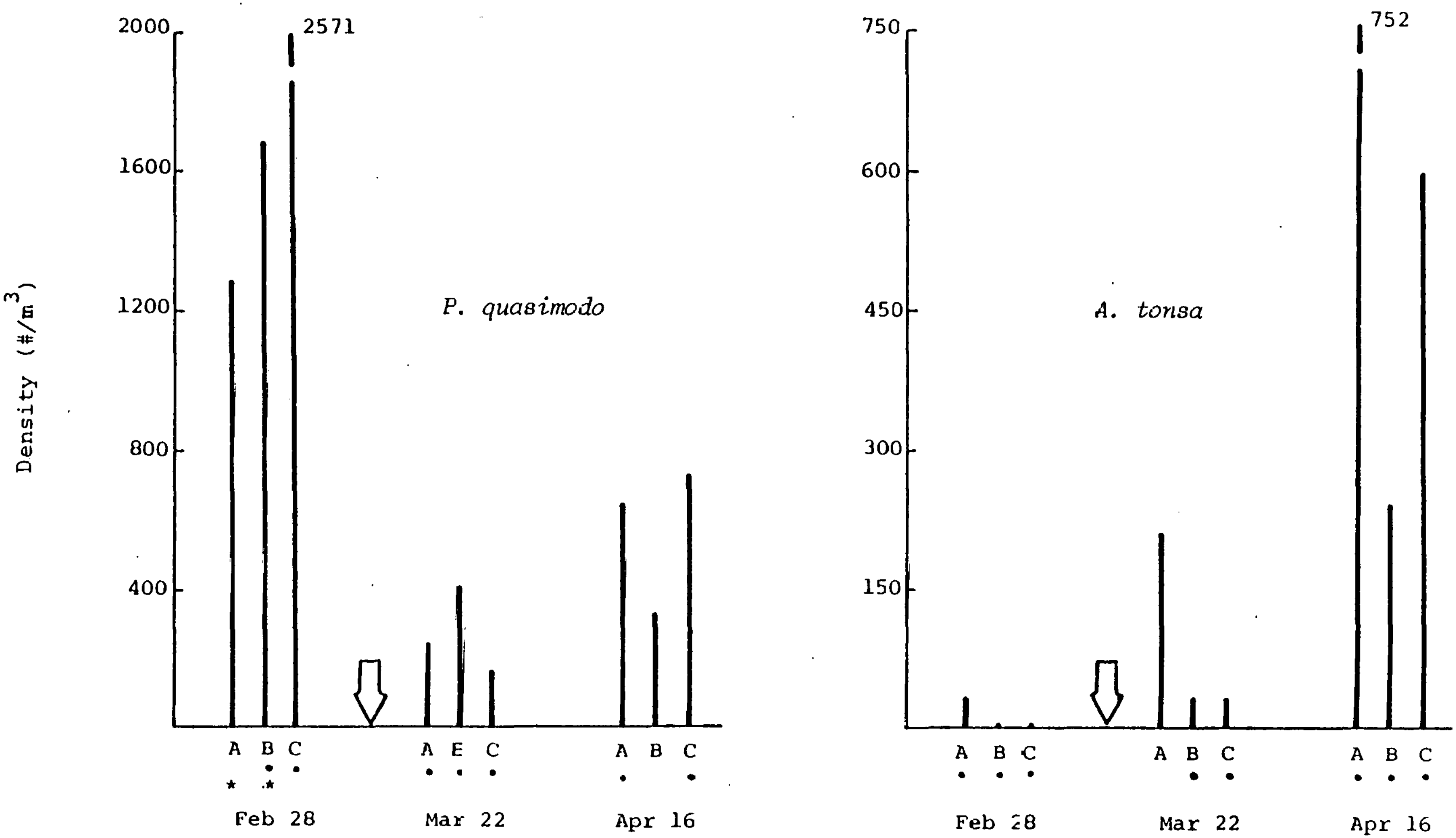


Figure 6-10. Mean densities of *Paracalanus quasimodo* and *Acartia tonsa* at each station during the three intensive study cruises. Bars represent mean densities of adult females from three replicate tows taken over the entire water column. Graphed as in Figure 6-7 (Page 6-14).

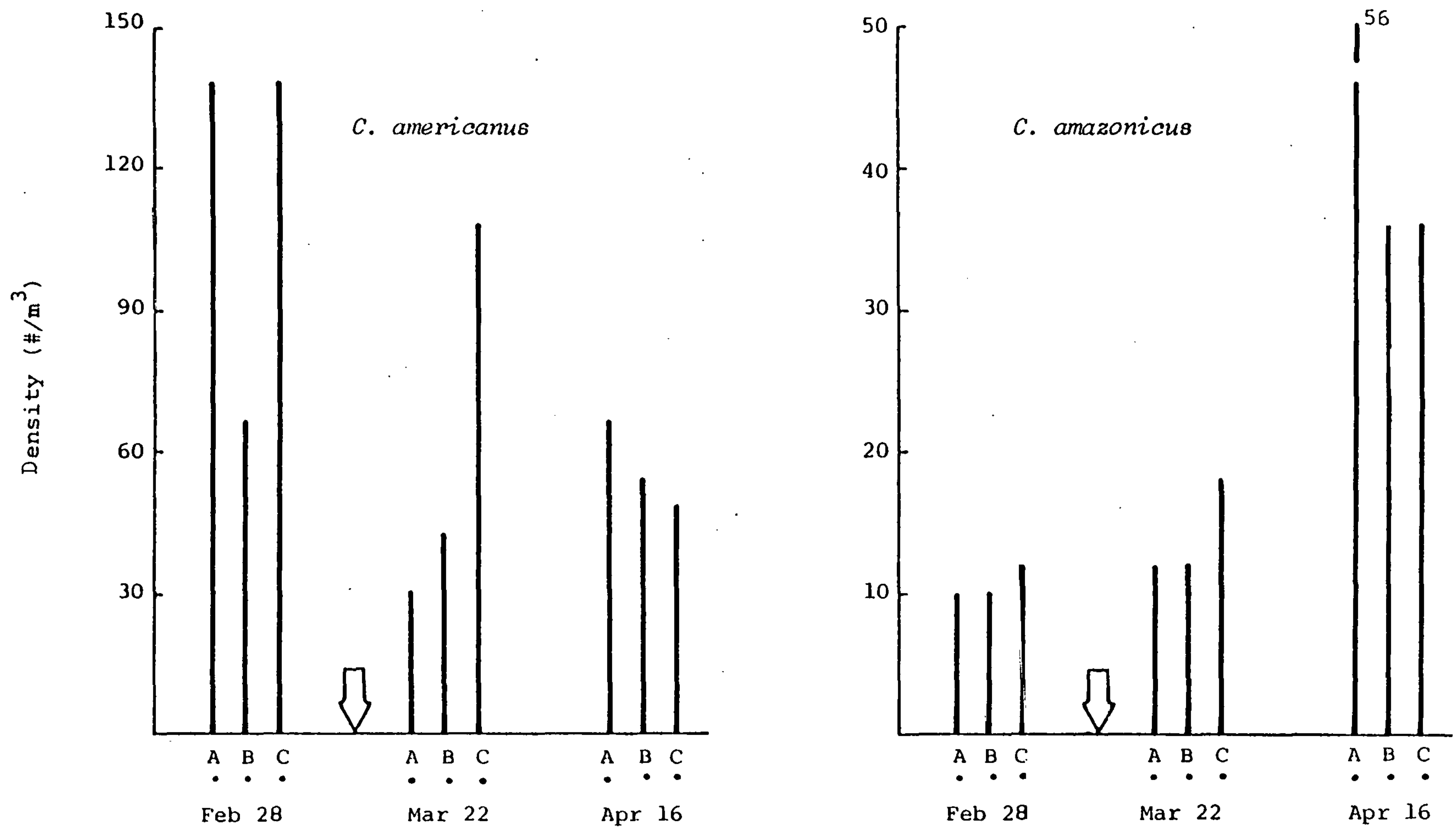


Figure 6-11. Mean densities of *Corycaeus americanus* and *Corycaeus amazonicus* at each station during the three intensive study cruises. Bars represent mean densities of adult females from three replicate tows taken over the entire water column. Graphed as in Figure 6-7 (Page 6-14).

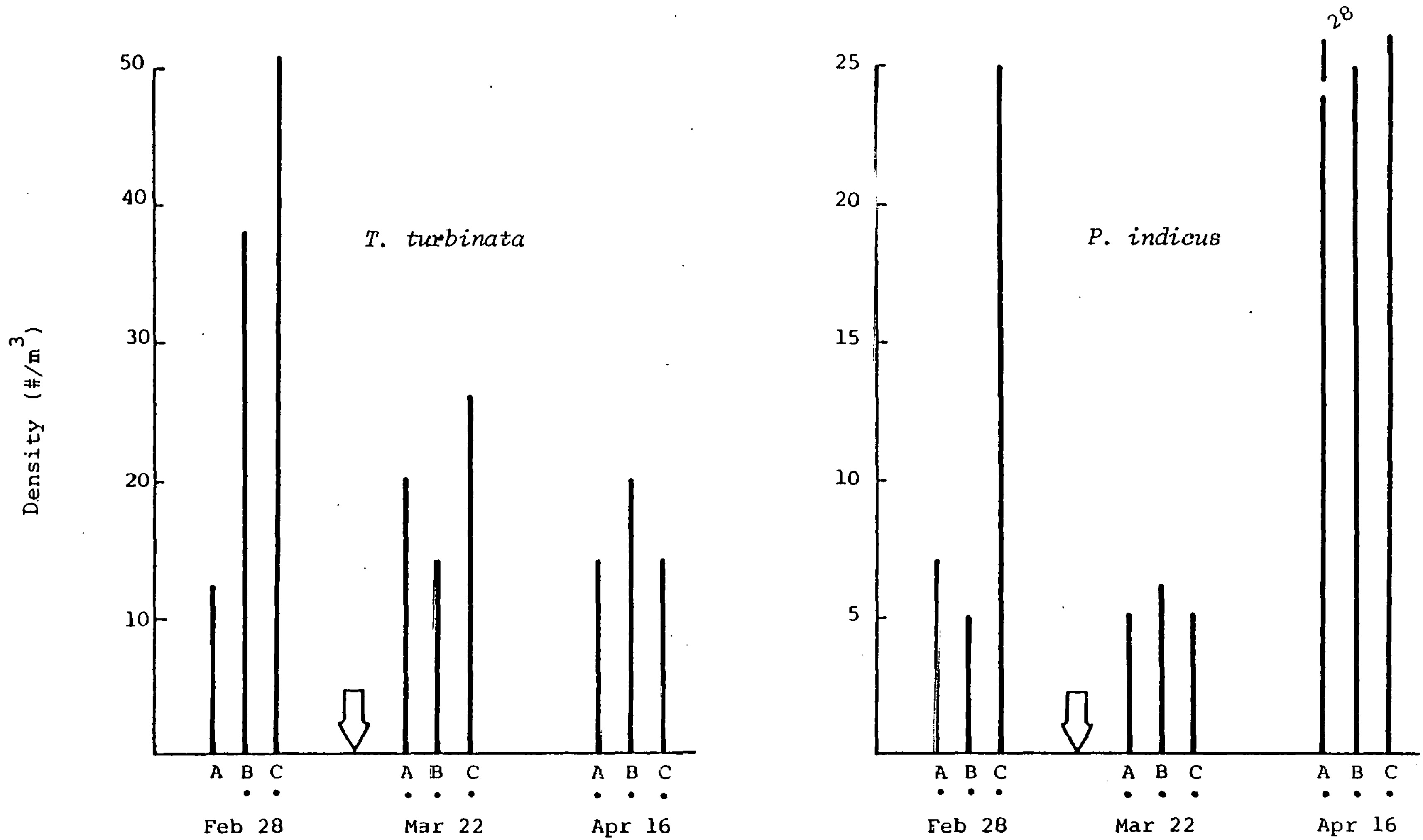


Figure 6-12. Mean densities of *Temora turbinata* and *Paracalanus indicus* at each station during the three intensive study cruises. Bars represent mean densities of adult females from three replicate tows taken over the entire water column. Graphed as in Figure 6-7 (Page 6-14).

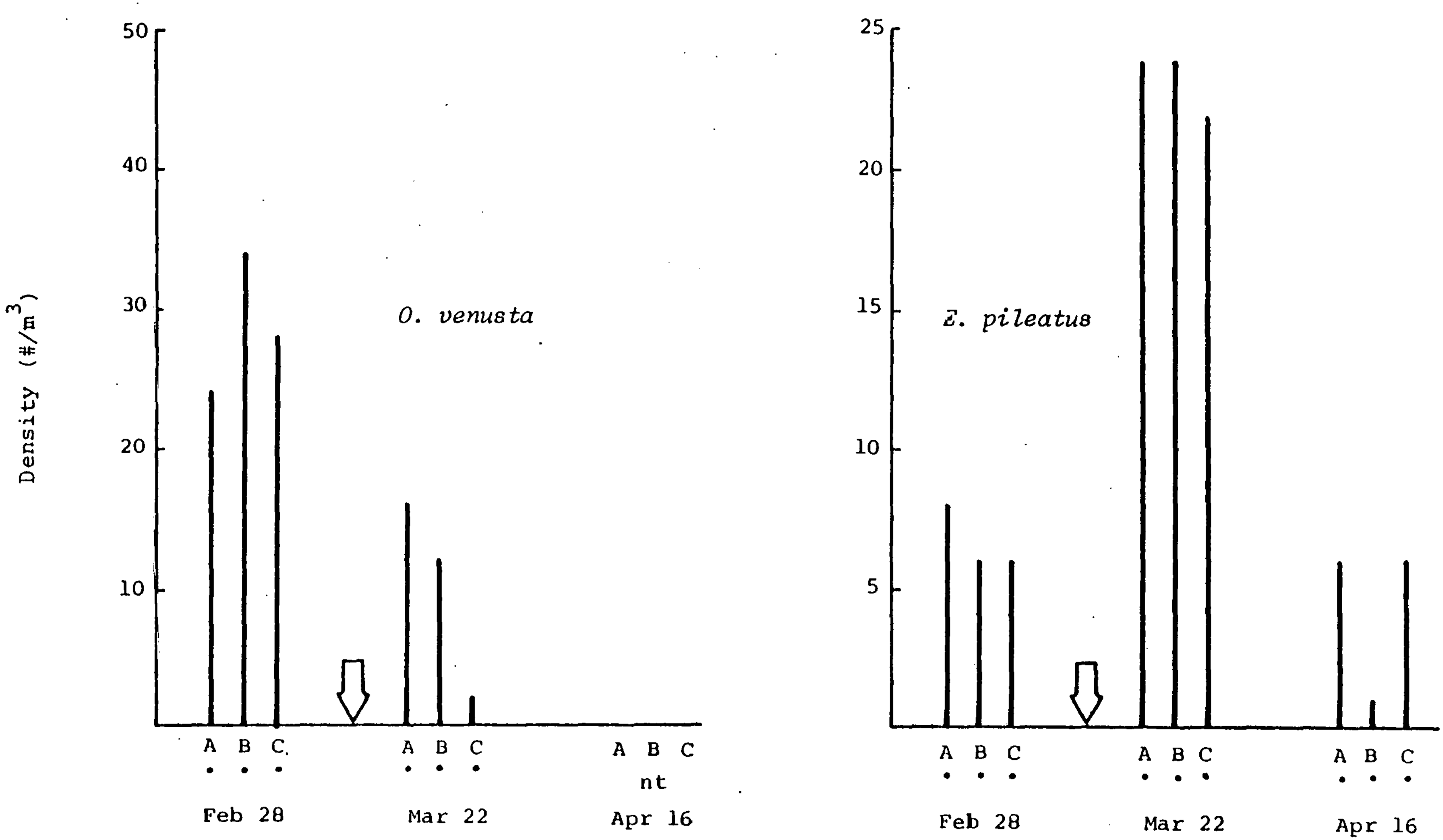


Figure 6-13. Mean densities of *Oncaea venusta* and *Eucalanus pileatus* at each station during the three intensive study cruises. Bars represent mean densities of adult females from three replicate tows taken over the entire water column. Graphed as in Figure 6-7 (Page 6-14).

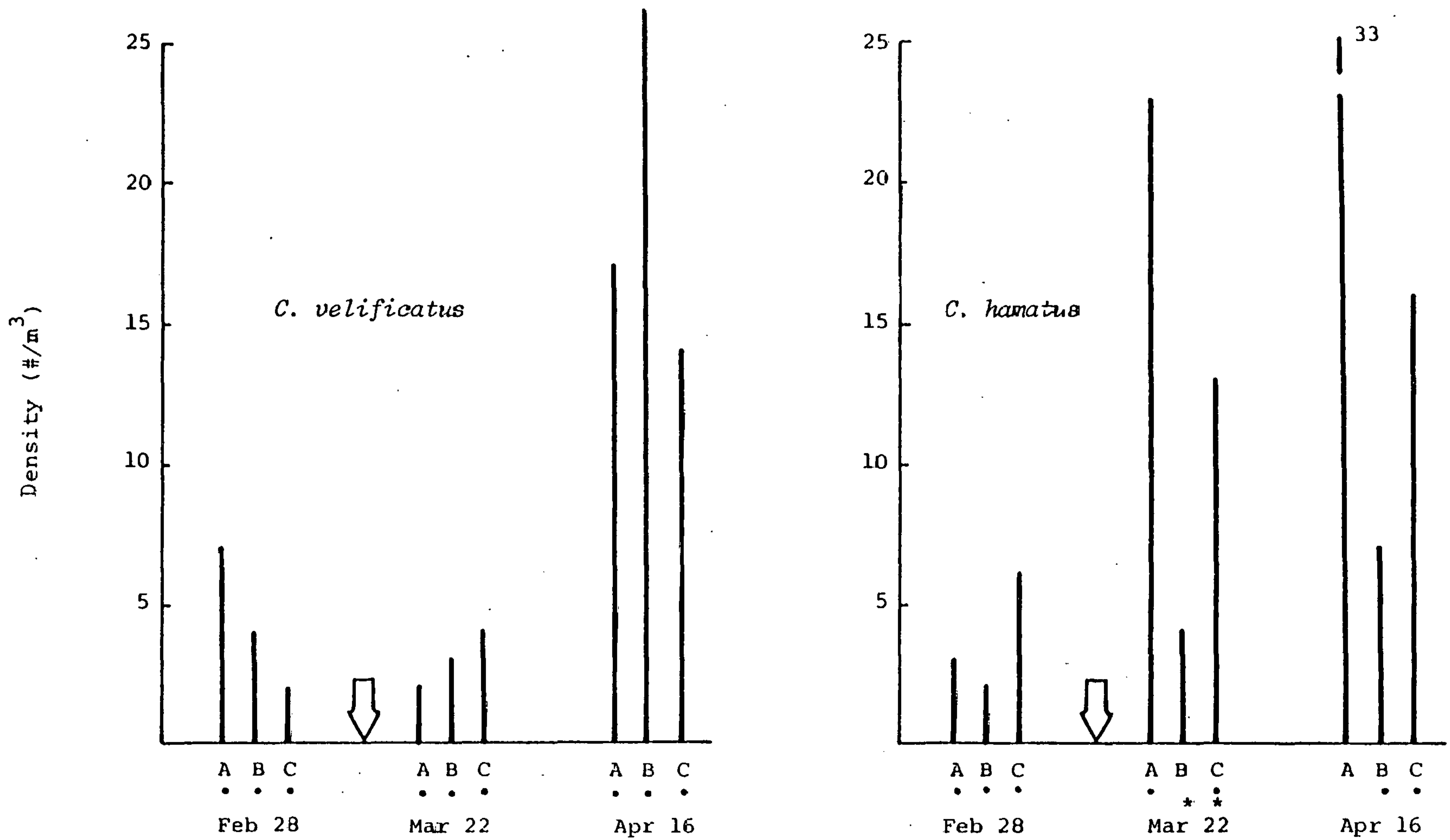


Figure 6-14. Mean densities of *Centropages velificatus* and *Centropages hamatus* at each station during the three intensive study cruises. Bars represent mean densities of adult females from three replicate tows taken over the entire water column. Graphed as in Figure 6-7 (Page 6-14).

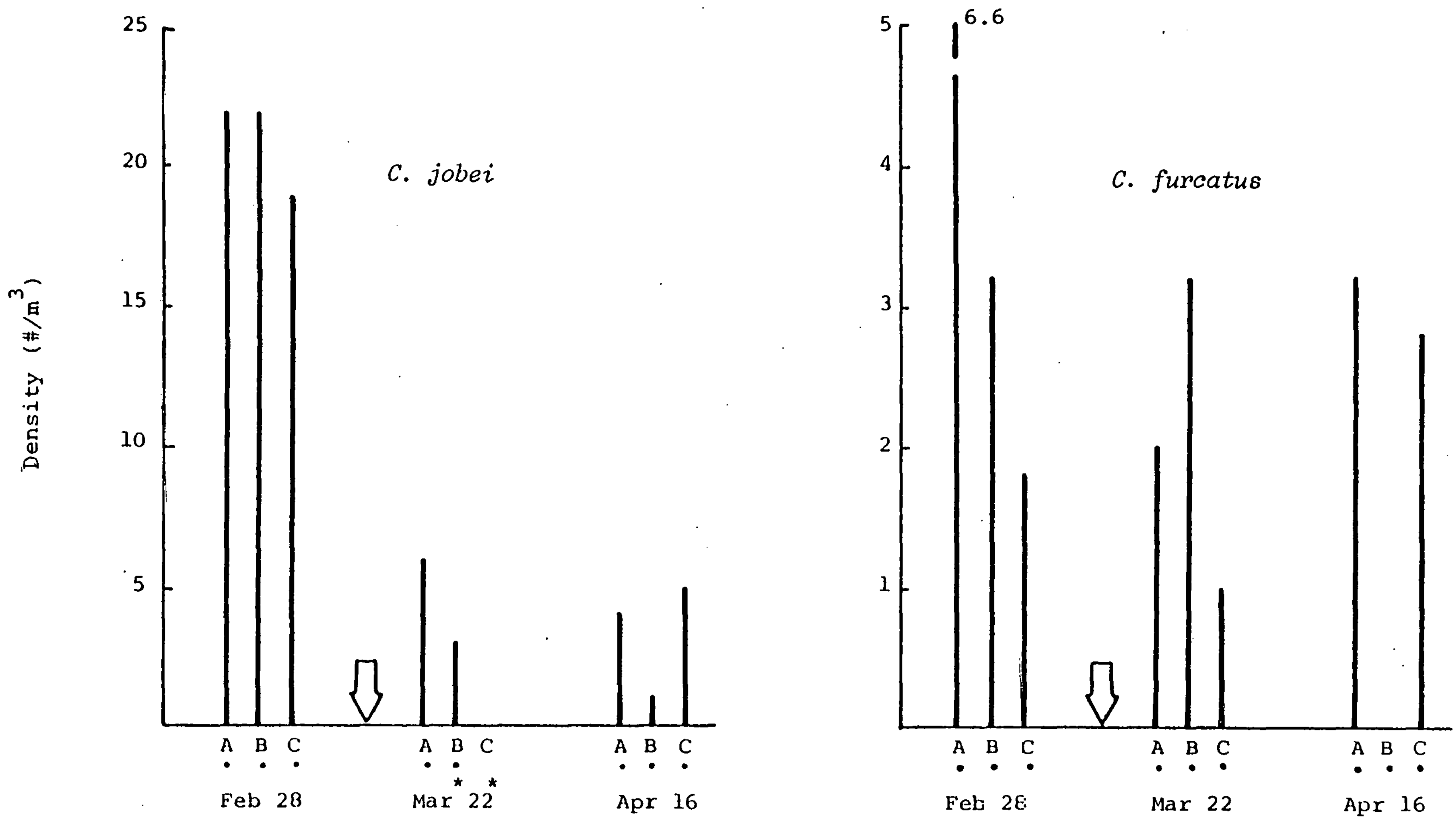


Figure 6-15. Mean densities of *Clausocalanus jobei* and *Clausocalanus furcatus* at each station during the three intensive study cruises. Bars represent mean densities of adult females from three replicate tows taken over the entire water column. Graphed as in Figure 6-7 (Page 6-14).

and the dominant species of copepods. The F-test compares station variability with replicate tow variability.

The AOV results for total zooplankton indicated that the three stations were not different at the 1% significance level during any of the three cruises (Table 6-4). At the 5% level however, the stations were dissimilar during Cruise 10. Although scattered, low probability values can be seen in Table 6-4 for the other groups and species of copepods, none of these groups or species showed significant differences at the 1% level for both postdisposal cruises (9 and 10). At the 5% level the three stations were significantly different on these two cruises when the analysis was based on chaetognath densities.

Although this analysis only provides a limited amount of information on spatial variability, major differences among stations should be detectable. The frequency of significant differences among stations did not appear to increase after the initiation of brine discharge. In general, these results indicate that the brine discharge did not drastically affect the spatial variability of the zooplankton among the three stations.

6.3.6 Species Diversity

Species diversity was measured as the number of species of adult female copepods identified at a station. This number of species in the intensive study cruises was fairly stable and values ranged from 18 to 24 (Figure 6-16). The diversity during Cruise 9 appeared to be slightly higher than the diversity during the other cruises. The numbers

Table 6-4. Analysis of variance results for total zooplankton, dominant zooplankton groups, and dominant species of copepods. Probability values are listed for each cruise. Values below 0.050 indicate that there was a significant difference among the three stations during that cruise at the 5% level. All analyses were based on log transformed densities.

Group/Species	Cruise 8	Cruise 9	Cruise 10
Total Zooplankton	0.169	0.997	0.018
Copepods	0.176	0.865	0.007
Larvacea	0.563	0.024	0.654
Chaetognaths	0.265	0.022	0.010
Polychaete larvae	0.168	0.009	0.215
Euconchoecia	0.459	0.017	0.871
Adult female copepods			
Paracalanus quasimodo	0.012	0.064	0.000
Acartia tonsa	0.025	0.003	0.250
Corycaeus americanus	0.157	0.036	0.484
Temora turbinata	0.002	0.102	0.337
Corycaeus amazonicus	0.719	0.392	0.222
Paracalanus indicus	0.442	0.948	0.885
Oncaea venusta	0.798	0.063	..
Eucalanus pileatus	0.854	0.764	0.389
Centropages velificatus	0.335	0.752	0.106
Paracalanus crassirostris	..	0.257	0.079
Clausocalanus furcatus	0.211	0.211	0.216

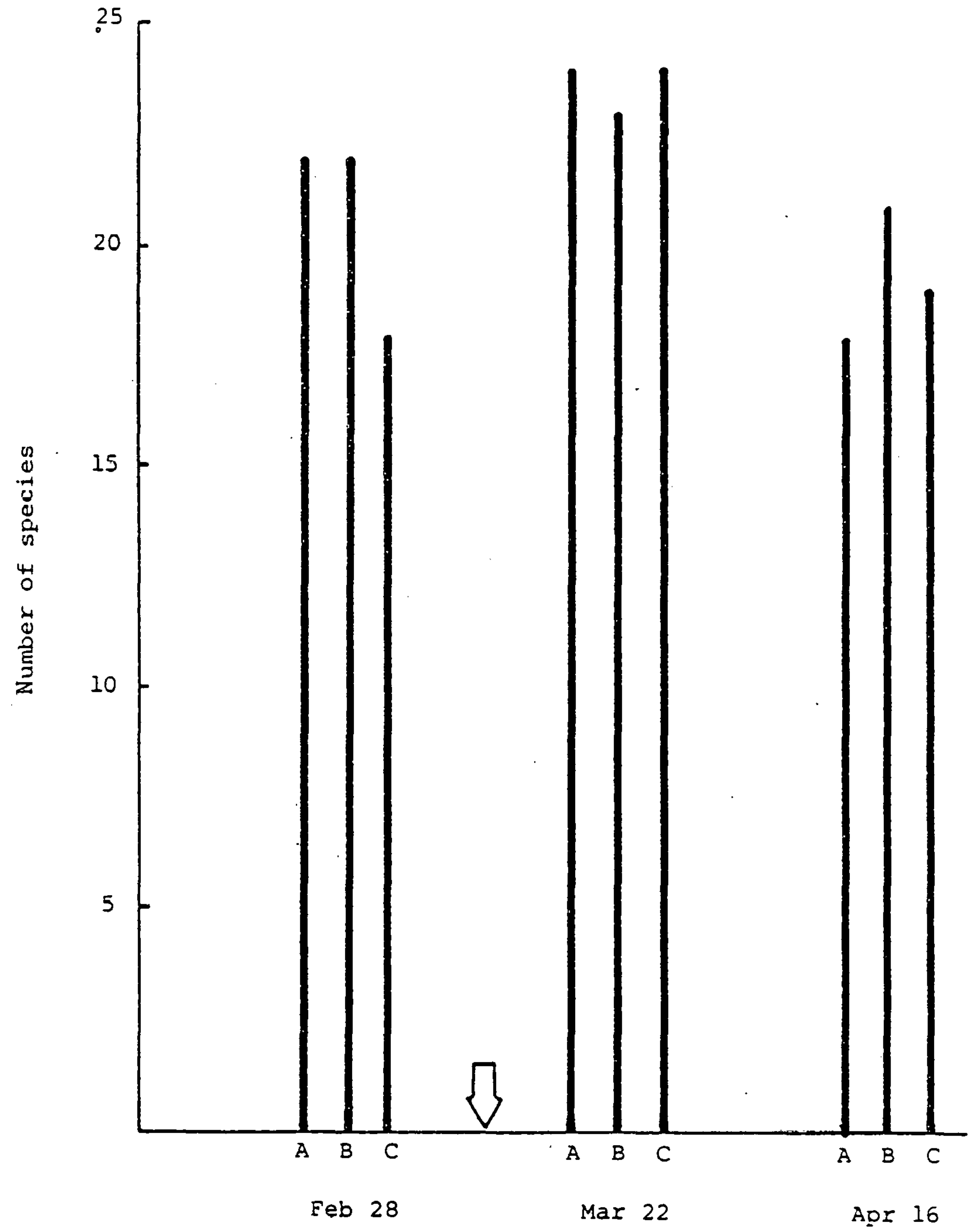


Figure 6-16. The number of species of adult female copepods at each station for the three intensive study cruises. Values represent the total number of species identified from all tows at each station. The arrow indicates the interval of continuous brine discharge initiation which occurred on March 13.

of species found during the intensive study cruises were generally similar to the numbers found in the predisposal study.

6.3.7 Half Depth Tows

The vertical distribution of the zooplankton was examined by comparing densities from the half depth tows (tow 4) with the densities from the tows covering the entire water column (tows 1-3). Most major groups of zooplankton and species of copepods showed no consistent pattern of vertical distribution. The densities of *Acartia tonsa*, however, were always highest in the half depth tows. This concentration in the upper 1/2 of the water column was also apparent in the predisposal study.

The effect of brine discharge on the vertical distribution of the zooplankton is difficult to determine due to the inconsistency of these data. The results from the predisposal study indicated that barnacle cypris larvae and tornaria larvae appeared to be present in greatest numbers in the lower 1/2 of the water column. At two out of the three stations during Cruise 8, however, cypris larvae were found in greatest densities in the upper 1/2 of the water column. Tornaria larvae were found only in very low densities in all of the intensive study cruises.

6.4 Conclusions and Summary

The data from the three intensive study cruises indicate that the initiation of brine discharge in the sampling area appears to have had no immediately obvious effect on the zooplankton in the water column.

Biomass and total zooplankton densities were apparently unaffected by the discharge in the area. Some groups of zooplankton and species of copepods exhibited elevated or depressed densities following the initiation of discharge but these changes can probably be attributed to seasonal fluctuations. The continued monitoring of the zooplankton population levels will enable us to substantiate this conclusion.

An analysis of variance and Duncan's multiple range test were used to examine station variability in relation to replicate tow variability. These results indicated no consistent differences among stations after the initiation of discharge. More postdisposal data, however, will enable us to determine with greater confidence whether the discharge of brine in the area is increasing station variability.

CHAPTER 7

PHYTOPLANKTON

Laurel A. Loeblich
Department of Marine Biology
Texas A&M University at Galveston

7.1 Introduction

The present report covers the three month period - March, April and May 1980 - after initiation of the brine discharge from the Bryan Mound Strategic Petroleum Reserve discharge area off Freeport, Texas. Analyses of the phytoplankton assemblage (including dominant taxa) in the study area were made to determine whether there were significant differences attributable to the brine discharge. Specifically, the data were analyzed to determine: 1) appearance of any new taxa in the control area, 2) disappearance of any dominant species, 3) differences between the top and bottom water phytoplankton composition and abundance, and 4) changes in diversity or abundance of the phytoplankton between the experimental area (discharge area) and the control area (outlying sites).

7.2 Materials and Methods

Each month, samples were collected at 13 stations, 4 in the control area and 9 in the experimental area. At each station a water sample was collected from one meter below the surface and one meter above the bottom using Van Dorn water samplers. Temperature and salinity data were taken from the water in the samplers while they were brought onboard. A 1-quart cubitainer of water was saved from each water sample for laboratory analyses, and the cubitainers were stored in an insulated ice chest to minimize temperature changes in the samples while they were brought to the laboratory.

In the laboratory "in vivo" chlorophyll a determinations were made for each sample. Three aliquots of 10 ml each, from each cubitainer were placed in disposable test tubes, and examined in a Turner Model III fluorometer for chlorophyll determination (Lorenzen 1966).

Phytoplankton composition and abundance was determined for each sample using a light microscope and Palmer-Maloney counting chambers. One seventh of a Palmer-Maloney counting chamber (0.1ml) was observed for its phytoplankton content, and three such subsamples were analyzed for each sample. The standardization factor was thus 70 for each subsample count to give counts in numbers of cells per millimeter (cells/ml). During these observations phytoplankters were identified to the most specific taxon possible - usually to genus.

7.3 Results

7.3.1 Phytoplankton diversity

From the 74 samples collected during the experimental period, or after brine discharge was initiated, 19 taxa of diatoms, 7 taxa of dinoflagellates, 1 chlorophyte, and 1 flagellate accounted for the 28 taxa of phytoplankton identified. The various taxa are listed alphabetically in Table 7-1 under each category: diatoms, dinoflagellates, and "others". A greater total diversity was found in the experimental area than in the control area (Figure 7-1), however, this is a likely result of the fact that there were more than twice as many samples examined in the experi-

Table 7-1. A list of the phytoplankton collected during the brine disposal period (March-May 1980) for the Bryan Mound Strategic Petroleum Reserve from the study area offshore from Freeport, Texas.

Diatoms	Dinoflagellates
Asterionella	Ceratium
Bacteriastrum	Gonyaulax
Biddulphia	Gymnodinium
Chaetoceros	Gyrodinium
Coscinodiscus	Peridinium
Cyclotella	Prorocentrum
Diploneis	Dinoflagellate-unidentified
Ditzlum	
Eucaupia	
Grammatophora	**Others - unidentified**
Navicula	Chlorophyta
Nitzschia	Flagellate
Plenrosigma	
Rhizosolenia	
Skeletonema	
Thalassionema	
Thalassiosira	
Thalassiothrix	
Diatom-unidentified	

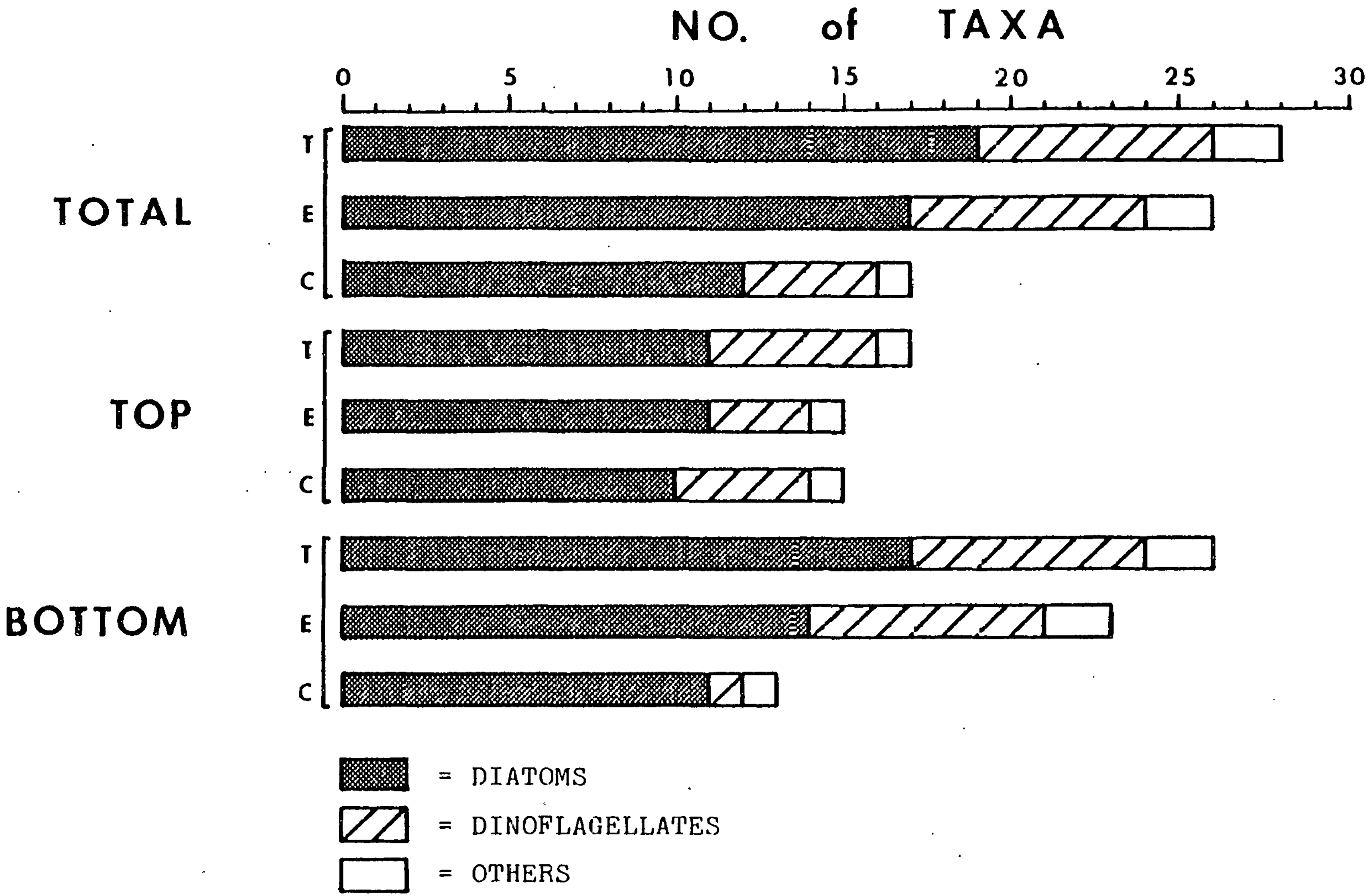


Figure 7-1. Diversity or distribution of phytoplankton taxa identified during the brine disposal period (March-May 1983) for the Bryan Mound Strategic Petroleum Reserve from the study area off Freeport, Texas. T = Total, E = Experimental area, C = Control area.

mental area than in the control area (18 vs. 8). No new species appeared during this time (March-May 1980). A greater total diversity was found in samples from the bottom water than the surface water.

The taxa collected during this study period were much the same as those collected earlier (June 1979-February 1980). Among the most abundant taxa, i.e. dominants, were *Chaetoceros*, unidentified dinoflagellates, *Navicula*, *Nitzschia*, *Rhizosolenia*, and *Skeletonema*. No single taxon was found in all the 74 samples, and only six taxa were found during all three months of this study. These six were: *Coscinodiscus*, *Navicula*, *Nitzschia*, *Skeletonema*, unidentified dinoflagellates, and unidentified flagellates. There were generally about twice as many taxa of diatoms found as taxa of dinoflagellates.

7.3.2 Phytoplankton abundances

The abundances of phytoplankton showed considerable fluctuation from March through May 1980 (Figure 7-2). Total abundance during March averaged 830 cells/ml and it increased to 1629 cells/ml in April. In May, however, the abundance had fallen to only 87 cells/ml. Variability found among samples from control and experimental areas were minor compared with these monthly shifts. Differences between control and experimental average abundance for each month were not great.

Phytoplankton were more abundant in the surface waters than in the bottom waters during March and April when phytoplankton was plentiful (Table 7-2). This was particularly true of both control and experimental areas in April, and can be attributed to greater abundances of diatoms in the surface waters.

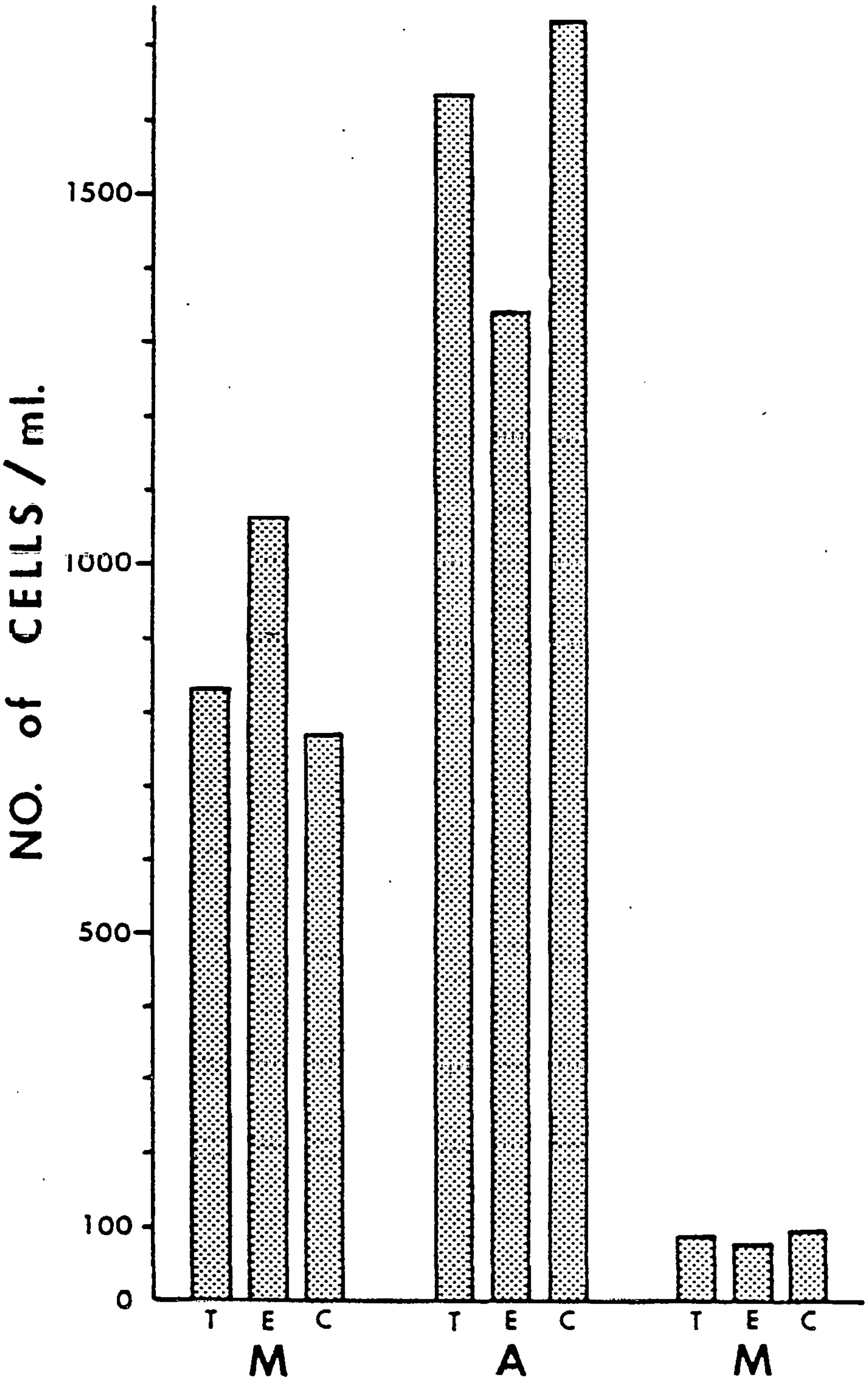


Figure 7-2. Abundances of phytoplankton during the brine disposal period (March-May 1980) for the Bryan Mound Strategic Petroleum Reserve from the study area off Freeport, Texas. T = Total, E = Experimental area, C = Control area.

Table 7-2. Abundances of phytoplankton taxa during the brine disposal period (March-May 1980) for the Bryan Mound Strategic Petroleum Reserve from the study area offshore from Freeport, Texas.

Experimental Area: Phytoplankters' Abundances

Taxon	March Top (9)	March Bot (9)	April Top (9)	April Bot (9)	May Top (9)	May Bot (9)
Diatoms:						
Asterionella				88.1		
Bacteriastrum	7.8		13.0			
Chaetoceros	264.4	176.3	165.9	23.3		
Coscinodiscus	5.2	10.4	2.6		2.6	
Cyclotella		2.6				
Diploneis				2.6		
Ditylum				5.2		
Eucampia		2.6				10.4
Grammatophora						5.2
Navicula	2.6	46.7	1179.6	223.0		2.6
Nitzschia	246.3	176.3	7.8	2.6		15.6
Pleurosigma			2.6			
Rhizosolenia	75.2	7.8	171.1			
Skeletonema	487.4	560.0	243.7	267.0		31.1
Thalassionema			10.4	7.8		
Thalassiothrix			51.9	5.2	5.2	
Diatom-unid.			5.2			
Dinoflagellates:						
Ceratium		2.6				
Gonyaulax						5.2
Gymnodinium	10.4	10.4	2.6			
Gyrodinium					2.6	5.2
Peridinium						2.6
Prorocentrum		2.6	2.6			
Dinoflagellate - unid.	15.6	10.4	20.7	54.4	13.0	43.8
Others:						
Chlorphyta				49.3		
Flagellate	2.6		44.1	25.9	2.6	5.2

Table 7-2 (continued)

Control Area: Phytoplankters' Abundances

Taxa	March Top (4)	March *Bot (4)	April Top (4)	April Bot (4)	May Top (2)	May Bot (2)
Diatoms:						
Bacteriastrum			23.3			
Biddulphia				5.8		
Chaetoceros	175.0	5.8	204.2	99.2		
Coscinodiscus	5.8	5.8		11.7		
Navicula		5.8	1464.2	315.0	11.7	11.7
Nitzschia	332.5	58.3	70.0	87.5		
Pleurosigma			17.5	11.7	11.7	11.7
Rhizosolenia	46.7	35.0	128.3	17.5		
Skeletonema	478.3	280.0	247.9	437.5		
Thalassionema				11.7		
Thalassiosira		17.5	11.7			
Thalassiothrix			52.5	17.5	11.7	
Dinoflagellates:						
Gymnodinium	11.6					
Peridinium	5.8					
Prorocentrum	5.8					
Dinflagellate - unid.	23.3	40.8	52.5	40.8		58.3
Others:						
Flagellate	5.8	5.8	46.7	29.2	23.3	46.7

* = # of samples

SUMMARY TABLE 7-2

Abundances (cells/ml)

	March		April		May	
	Top	Bottom	Top	Bottom	Top	Bottom
Control	1091	455	2319	1085	58	128
Exper.	1118	1008	1924	754	26	127
$\overline{X}$	1096	566	2240	1019	48	128
Grand $\overline{X}$ *	831		1629		88	

Diversity (# of taxa)

	March		April		May	
	Top	Bottom	Top	Bottom	Top	Bottom
Control	10	9	11	12	4	4
Exper.	10	12	15	12	5	10
Total	16		21		13	

$$* \quad \text{Grand } \overline{X} = \frac{(\text{Number of control sites sampled} \cdot \overline{X}c) + \overline{X}e}{\text{Number of control sites sampled} + 1}$$

$\overline{X}c$ = mean of control sites' abundances

$\overline{X}e$ = mean of experimental sites' abundances

During May when few phytoplankton were present, there were more cells in the bottom samples than near the surface.

7.3.3 Chlorophyll determinations

Chlorophyll a content of both surface and bottom waters in the control and experimental areas were rather low during March according to their "in vivo" fluorescence. (Fig. 7-3A) No significant differences were found between control and experimental areas, nor between top and bottom waters, for the March samples. Chlorophyll a content in April was twice the March values, but still no real differences were found between control and experimental areas. Bottom water chlorophyll a content appeared to be slightly lower than at the surface water. The May chlorophyll a concentrations were back to the level of those in March, and no significant differences were found between control and experimental areas nor between top and bottom waters. The two fold increase in April's chlorophyll a concentrations matched the two-fold increase in total phytoplankton abundance. The great decrease in phytoplankton abundance found in May was not as severely marked by the "in vivo" chlorophyll a concentrations. Extracted chlorophyll a concentrations showed a slightly different picture of the monthly changes at and near the diffuser station (D14)(Figure 7-3B). Concentrations were between 200 and 300 relative fluorometer units (RFU) and were among the four depths and among the three stations for March, with the only low value being 100 RFU at the 10 m depth at the diffuser site. Only a slight decrease in chlorophyll a concentration was found at mid-depths at the diffuser station, and in the surface and bottom waters of the down-current station in April. During May the surface and 10 m concentrations were only slightly higher, but the bottom concentrations

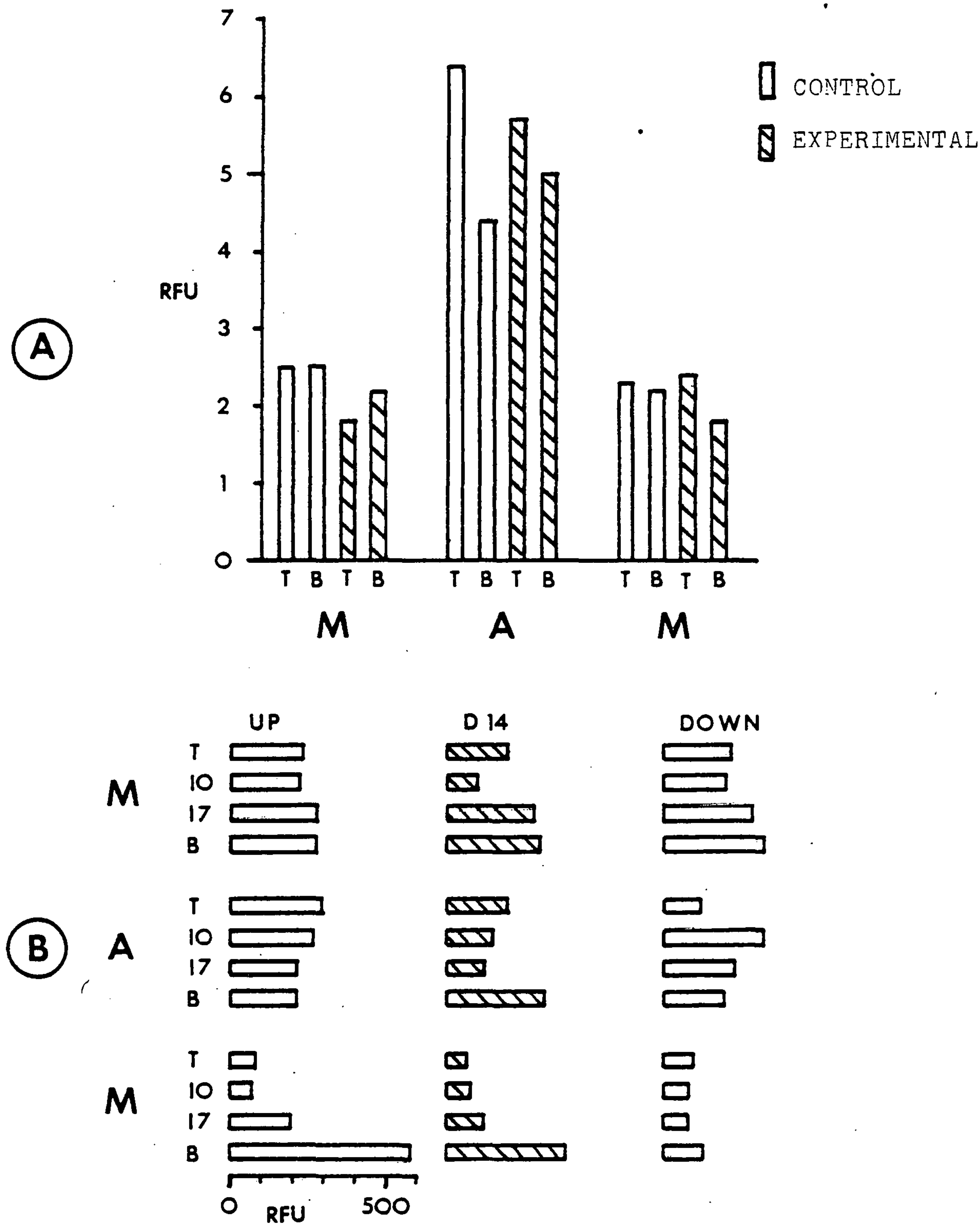


Figure 7-3. In vivo and extracted chlorophyll a concentration from water samples taken during the intensive study period, March-May 1980, at the Bryan Mound Strategic Petroleum Reserve brine disposal site off Freeport, Texas. Figure 7-3A summarizes the in vivo measurements; Figure 7-3B summarizes the extracted chlorophyll a measurements. All values are in relative fluorescence units (RFU).

varied greatly. The up-current bottom concentration was 590 RFU, at the diffuser it was 376, and down-current it was only 132 RFU.

7.4 Conclusions

No new taxa were found in either the experimental or the control areas during this three month period. The dominant species and their relative abundances appeared to be essentially unchanged from last year. Total phytoplankton abundance and chlorophyll _a_ concentrations did not appear to be affected by the brine discharge.

CHAPTER 8

DATA MANAGEMENT

Robert J. Case
James A. Cummings
Environmental Engineering Division
Civil Engineering Department

8.1 Introduction

During the intensive monitoring program the data management staff performed their normal functions in addition to acquiring data from the BRIMS Data Buoy System and transmitting a daily summary of sampling activities to the Strategic Petroleum Reserve Project Management Office in New Orleans. The normal functions which include the coding, processing and transmission of data to the Environmental Data and Information Service by other principal investigators have been discussed in previous project reports and will not be repeated here.

8.2 Data Collection

Each day during the monitoring phase the data was collected from either personnel located at Bryan Mound site itself, from the SPR Management Office in New Orleans, or through a computerized conference line established by EDIS in Washington, D. C. The latter method was performed by dialing up the system via remote computer terminal, entering the necessary commands, and printing out the data on the terminal.

8.3 Results

The BRIMS data consists of the date, time, conductivity and temperature measured from three sensors in the diffuser area, barometric pressure, wind velocity, and the flow rate of brine through the diffuser. This information is shown in Appendix III, Tables III-1 through III-44. A daily summary of four brine pit parameters is shown in Table III-45. These parameters include the average daily brine flow rate, the total daily brine volume pumped per day, and the salinity and pH of the brine pit.

BIBLIOGRAPHY

Adams, E. E.; Stolzenbach, K. D.; Harleman, D. R. F. (Dept. of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA). Near and far field analysis of buoyant surface discharges into large bodies of water. Report no. 205; 1977.

Chittenden, M. E. (Texas A&M Univ., College Station, TX). Nekton. Hann, R. W., Jr., ed. Evaluation of brine disposal from the Bryan Mound site of the Strategic Petroleum Reserve Program; final report of predisposal studies to U. S. Dept. of Energy; 1980.

Chittenden, M. E.; McEachran, J. D.; McEachran, L. (Texas A&M Univ., College Station, TX). Composition, ecology, and dynamics of demersal fish communities on the northwestern Gulf of Mexico continental shelf, with a similar synopsis for the entire Gulf. Sea Grant publ. no. TAMU-SG-76-208; 104p.; 1976.

Gaboury, D. R.; Stolzenbach, K. D. (Dept. of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA). Dispersion zone characteristics of ocean discharges. Report no. 244; 1979.

Grunde Environmental Systems. Grunde environmental systems model 6230N laboratory salinometer instruction manual; 1978.

Hann, R. W., Jr.; Randall, R. E., et al. (Texas A&M Univ., College Station, TX). Evaluation of brine disposal from the Bryan Mound site of the Strategic Petroleum Reserve Program; progress report to U. S. Dept. of Energy; 1979.

Hann, R. W., Jr.; Randall, R. E., et al. (Texas A&M Univ., College Station, TX). Evaluation of brine disposal from the Bryan Mound site of the Strategic Petroleum Reserve Program; final report of predisposal studies to U. S. Dept. of Energy; 1980.

Harper, D. E. (Texas A&M Univ., Galveston, TX). Benthos. Hann, R. W., Jr., ed. Evaluation of brine disposal from the Bryan Mound site of the Strategic Petroleum Reserve Program; final report of predisposal studies to U. S. Dept. of Energy; 1980.

Helvig, J. P.; Council, K. A., editors. SAS users guide. Riley, NC: SAS Institute, Inc.; 194p.; 1979.

Hydrolab Corporation. Hydrolab 8000 water quality system operation instructions. Austin, TX; 1980.

Kelly, F. J.; Randall, R. E. (Texas A&M Univ., College Station, TX). Physical Oceanography. Hann, R. W., Jr., ed. Evaluation of brine disposal from the Bryan Mound site of the Strategic Petroleum Reserve Program; final report of predisposal studies to U. S. Dept. of Energy; 1980.

Krebs, C. J. Ecology. New York: Harper and Row; 694p.; 1972.

Loeblich, L. A. (Texas A&M Univ., Galveston, TX). Phytoplankton. Hann, R. W., Jr., ed. Evaluation of brine disposal from the Bryan Mound site of the Strategic Petroleum Reserve Program; final report of predisposal studies to U. S. Dept. of Energy; 1980.

Lorenzen, C. J. A method for the continuous measurement of in vivo chlorophyll concentration. Deep-Sea Research. 13:223-227; 1966.

Minello, T. J. The neritic zooplankton of the northwestern Gulf of Mexico. College Station, TX: Texas A&M Univ.; 1980. Dissertation.

National Oceanic and Atmospheric Administration. Analysis of brine disposal in the Gulf of Mexico, Bryan Mound. Report to Federal Energy Administration; 1977.

National Oceanic and Atmospheric Administration. Comparison of observed and modeled brine discharges for the Bryan Mound site. Washington, D. C.: NOAA, Marine Environmental Assessment Division; 1980.

Park, E.T. (Texas A&M Univ., Galveston, TX). Zooplankton. Flint, R. W.; Griffin, C. W., eds. Environmental studies, South Texas Outer Continental Shelf, biology and chemistry, 1977. Final report to Bureau of Land Management; Contract AA550-CT7-11; 1979: 14-1 to 14-58.

Park, E. T.; Minello, T. J. (Texas A&M Univ., Galveston, TX). Zooplankton. Hann, R. W., Jr., ed. Evaluation of brine disposal from the Bryan Mound site of the Strategic Petroleum Reserve Program; final report of predisposal studies to U. S. Dept. of Energy; 1980: 6-1 to 6-171.

Park, E. T.; Turk, P. (Texas A&M Univ., Galveston, TX). Zooplankton. Flint, R. W.; Rabalais, N., eds. Environmental studies, South Texas Outer Continental Shelf, 1975-1977. Report to Bureau of Land Management; Contract AA551-CT8-51; 3:1980.

Randall, R. E. (Texas A&M Univ., College Station, TX). Analysis of discharge plume. Hann, R. W., Jr., ed. Evaluation of brine disposal from the Bryan Mound site of the Strategic Petroleum Reserve Program; final report of predisposal studies to U. S. Dept. of Energy; 1980.

Riley, J. P.; Skirrow, G. Chemical oceanography. New York: Academic Press; 712p.; 1965.

Slowey, J. F. (Texas A&M Univ., College Station, TX). Water and sediment quality. Hann, R. W., Jr., ed. Evaluation of brine disposal from the Bryan Mound site of the Strategic Petroleum Reserve Program; 1980.

Steel, R. G. D.; Torrie, J. H. Principles and procedures of statistics. New York: McGraw-Hill Book Co.; 1960.

Tong, S. S.; Stolzenbach, K. D. (Dept. of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA). Submerged discharges of a dense effluent. Report no. 243; 1979.

U. S. Army Engineer Waterways Experiment Station. Model studies of outfall systems for desalinization plants. Research report H-71-2; 1971.

Wilk, M. B.; Kempthorne, O. Fixed, mixed, and random models. J. Amer. Statist. Assoc., 50:1144-1167; 1955.

APPENDIX I

SUPPORTING DATA FOR NEKTON STUDIES

SPECIAL OBSERVATIONS
Intensive Postdisposal Period

STATION#____________ DATE____________ D-N____________ RECORDER____________

Observations on Dead or Dying shrimp or fish in water:

None________. Specify if other than none:

Observations on Behavior of shrimp and fish in catch:

Normal__________. Specify if other than normal:

Any Unusual Phenomena or Other Observations:

Are other vessels trawling in the area? If so, how many and general comments on their operations:

Figure I-1 Form used to record data for each station field observations related to the effects of brine disposal on the nekton.

Table I-1. Duncan's multiple range test for differences in abundance of Penaeus aztecus, 5-6 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.106032

GROUPING			MEAN	N	STA
	A		3.236945	2	26
	A				
B	A		3.036522	2	24
B	A				
B	A	C	3.005634	2	23
B	A	C			
B	A	C	2.884160	2	25
B	A	C			
B	A	C	2.861793	2	22
B	A	C			
B	A	C	2.705823	2	16
B	A	C			
B	A	C	2.659060	2	15
B	A	C			
B	A	C	2.628748	2	21
B	A	C			
B	A	C	2.596478	2	9
B	A	C			
B	A	C	2.341066	2	19
B	A	C			
B	A	C	2.171903	2	20
B	A	C			
B	A	C	2.138333	2	14
B		C			
B		C	2.047172	2	18
		C			
		C	1.903331	2	17

Table I-2. Duncan's multiple range test for differences in abundance of Penaeus aztecus, 19-20 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=0.203011

GROUPING				MEAN	N	STA
		A		2.736135	2	17
		A				
		A		2.699081	2	16
		A				
		A		2.570832	2	23
		A				
		A		2.441401	2	15
		A				
B		A		2.297560	2	19
B		A				
B		A		2.215408	2	9
B		A				
B		A		2.158744	2	18
B		A				
B		A		2.012676	2	14
B		A				
B		A	C	1.497866	2	24
B		A	C			
B	D	A	C	1.242453	2	25
B	D		C			
B	D		C	0.895880	2	26
	D		C			
	D		C	0.346574	2	21
	D					
	D			0.000000	2	20
	D					
	D			0.000000	2	22

Table I-3. Duncan's multiple range test for differences in abundance of <u>Penaeus aztecus</u>, 24-25 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.218558

GROUPING		MEAN	N	STA
	A	2.967447	2	17
	A			
B	A	2.841790	2	20
B	A			
B	A	2.764715	2	25
B	A			
B	A	2.636500	2	24
B	A			
B	A	2.596478	2	22
B	A			
B	A	2.585242	2	19
B	A			
B	A	2.582393	2	21
B	A			
B	A	2.445175	2	14
B	A			
B	A	2.389562	2	18
B	A			
B	A	2.292484	2	23
B	A			
B	A	2.282174	2	26
B	A			
B	A	1.666102	2	15
B	A			
B	A	1.589027	2	9
B				
B		1.242453	2	16

Table I-4. Duncan's multiple range test for differences in abundance of Penaeus aztecus, 27-28 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=0.477527

GROUPING	MEAN	N	STA
A	2.197225	2	17
A			
A	1.589027	2	19
A			
A	1.386294	2	14
A			
A	1.319529	2	22
A			
A	1.319529	2	24
A			
A	1.242453	2	18
A			
A	1.098612	2	16
A			
A	0.895880	2	20
A			
A	0.895880	2	23
A			
A	0.895880	2	21
A			
A	0.895880	2	25
A			
A	0.895880	2	26
A			
A	0.804719	2	15
A			
A	0.346574	2	9

Table I-5. Duncan's multiple range test for differences in abundance of *Penaeus aztecus*, 4-5 Apr 80, night

ALPHA LEVEL=.01 DF=14 MS=0.760857

GROUPING	MEAN	N	STA
A	2.930393	2	26
A			
A	2.564949	2	17
A			
A	2.537587	2	19
A			
A	2.418141	2	10
A			
A	2.215408	2	14
A			
A	1.700599	2	21
A			
A	1.386294	2	16
A			
A	1.319529	2	15
A			
A	1.151293	2	9
A			
A	1.151293	2	22
A			
A	1.151293	2	23
A			
A	1.039721	2	20
A			
A	0.693147	2	25
A			
A	0.549306	2	24

Table I-6. Duncan's multiple range test for differences in abundance of *Penaeus aztecus*, 10-11 Apr 80, day

ALPHA LEVEL=.01 DF=14 MS=.0514771

GROUPING	MEAN	N	STA
A	0.693147	2	19
A			
A	0.346574	2	21
A			
A	0.346574	2	22
A			
A	0.346574	2	24
A			
A	0.000000	2	9
A			
A	0.000000	2	14
A			
A	0.000000	2	15
A			
A	0.000000	2	16
A			
A	0.000000	2	17
A			
A	0.000000	2	18
A			
A	0.000000	2	20
A			
A	0.000000	2	23
A			
A	0.000000	2	25
A			
A	0.000000	2	26

Table I-7. Duncan's multiple range test for differences in abundance of Penaeus aztecus, 14-15 Apr 80, night

ALPHA LEVEL=.01 DF=12 MS=0.385436

GROUPING	MEAN	N	STA
A	2.418141	2	26
A			
A	2.178354	2	20
A			
A	1.791759	2	23
A			
A	1.700599	2	25
A			
A	1.589027	2	21
A			
A	1.497866	2	9
A			
A	1.497866	2	18
A			
A	1.497866	2	24
A			
A	1.242453	2	14
A			
A	1.242453	2	17
A			
A	1.151293	2	22
A			
A	1.098612	1	15
A			
A	0.895880	2	19

Table I-8. Duncan's multiple range test for differences in abundance of Penaeus aztecus, 12 Mar 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.194006

GROUPING		MEAN	N	STA
	A	3.853306	2	26
	A			
B	A	2.802901	2	25
B				
B		2.433767	2	20
B				
B		2.418141	2	22
B				
B		2.297560	2	19
B				
B		2.197225	2	16
B				
B		2.071567	2	15
B				
B		2.047172	2	17
B				
B		1.956012	2	18
B				
B		1.935601	2	21
B				
B		1.903331	2	23
B				
B		1.844440	2	14
B				
B		1.791759	2	24
B				
B		1.445186	2	9

Table I-9. Duncan's multiple range test for differences in abundance of <u>Penaeus aztecus</u>, 5 Apr 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.357633

GROUPING		MEAN	N	STA
	A	3.471078	2	26
	A			
B	A	2.861793	2	19
B	A			
B	A	2.659060	2	17
B	A			
B	A	2.540702	2	14
B	A			
B	A	2.322195	2	15
B	A			
B	A	2.215408	2	23
B	A			
B	A	2.071567	2	18
B	A			
B	A	2.047172	2	16
B	A			
B	A	2.003667	2	25
B	A			
B	A	1.609438	2	21
B				
B		1.354025	2	22
B				
B		1.098612	2	9
B				
B		1.039721	2	20
B				
B		1.039721	2	24

Table I-10. Duncan's multiple range test for differences in abundance of *Penaeus aztecus*, 20 Apr 79, day.

ALPHA LEVEL=.01 DF=14 MS=0.330892

GROUPING	MEAN	N	STA
A	1.844440	2	20
A			
A	1.242453	2	23
A			
A	1.098612	2	24
A			
A	1.039721	2	26
A			
A	0.895880	2	9
A			
A	0.895880	2	25
A			
A	0.346574	2	15
A			
A	0.346574	2	21
A			
A	0.346574	2	22
A			
A	0.000000	2	14
A			
A	0.000000	2	16
A			
A	0.000000	2	17
A			
A	0.000000	2	18
A			
A	0.000000	2	19

Table I-11. Duncan's multiple range test for differences in abundance of <u>Penaeus duorarum</u>, 5-6 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.263257

GROUPING	MEAN	N	STA
A	0.895880	2	15
A			
A	0.693147	2	9
A			
A	0.693147	2	17
A			
A	0.693147	2	22
A			
A	0.693147	2	24
A			
A	0.346574	2	14
A			
A	0.346574	2	16
A			
A	0.346574	2	18
A			
A	0.346574	2	19
A			
A	0.346574	2	20
A			
A	0.346574	2	25
A			
A	0.346574	2	26
A			
A	0.000000	2	21
A			
A	0.000000	2	23

Table I-12. Duncan's multiple range test for differences in abundance of *Penaeus duorarum*, 19-20 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=0.10591

GROUPING		MEAN	N	STA
	A	1.242453	2	15
	A			
	A	1.098612	2	23
	A			
B	A	1.039721	2	19
B	A			
B	A	0.346574	2	9
B	A			
B	A	0.346574	2	14
B	A			
B	A	0.346574	2	16
B	A			
B	A	0.346574	2	17
B	A			
B	A	0.346574	2	24
B				
B		0.000000	2	18
B				
B		0.000000	2	20
B				
B		0.000000	2	21
B				
B		0.000000	2	22
B				
B		0.000000	2	25
B				
B		0.000000	2	26

Table I-13. Duncan's multiple range test for differences in abundance of Penaeus duorarum, 24-25 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.281404

GROUPING	MEAN	N	STA
A	1.609438	2	14
A			
A	1.589027	2	15
A			
A	1.445186	2	21
A			
A	1.354025	2	19
A			
A	1.098612	2	22
A			
A	0.895880	2	20
A			
A	0.693147	2	16
A			
A	0.693147	2	18
A			
A	0.549306	2	23
A			
A	0.346574	2	24
A			
A	0.346574	2	26
A			
A	0.000000	2	9
A			
A	0.000000	2	17
A			
A	0.000000	2	25

Table I-14. Duncan's multiple range test for differences in abundance of Penaeus duorarum, 27-28 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=.0573486

GROUPING		MEAN	N	STA
	A	1.039721	2	21
	A			
	A	0.895880	2	22
	A			
B	A	0.346574	2	14
B	A			
B	A	0.346574	2	24
B				
B		0.000000	2	9
B				
B		0.000000	2	15
B				
B		0.000000	2	16
B				
B		0.000000	2	17
B				
B		0.000000	2	18
B				
B		0.000000	2	19
B				
B		0.000000	2	20
B				
B		0.000000	2	23
B				
B		0.000000	2	25
B				
B		0.000000	2	26

Table I-15. Duncan's multiple range test for differences in abundance of *Penaeus duorarum*, 4-5 Apr 80, night

ALPHA LEVEL=.01 DF=14 MS=0.131134

GROUPING		MEAN	N	STA
	A	1.497866	2	14
	A			
B	A	0.895880	2	15
B	A			
B	A	0.895880	2	16
B	A			
B	A	0.895880	2	19
B	A			
B	A	0.693147	2	9
B	A			
B	A	0.693147	2	17
B	A			
B	A	0.549306	2	18
B	A			
B	A	0.346574	2	20
B	A			
B	A	0.346574	2	21
B	A			
B	A	0.346574	2	22
B	A			
B	A	0.346574	2	23
B				
B		0.000000	2	24
B				
B		0.000000	2	25
B				
B		0.000000	2	26

Table I-16. Duncan's multiple range test for differences in abundance of *Penaeus duorarum*, 10-11 Apr 80, day

ALPHA LEVEL=.01 DF=14 MS=0

GROUPING	MEAN	N	STA
A	0.000000	2	9
B	0.000000	2	14
C	0.000000	2	15
D	0.000000	2	16
E	0.000000	2	17
F	0.000000	2	18
G	0.000000	2	19
H	0.000000	2	20
I	0.000000	2	21
J	0.000000	2	22
K	0.000000	2	23
L	0.000000	2	24
M	0.000000	2	25
N	0.000000	2	26

Table I-17. Duncan's multiple range test for differences in abundance of Penaeus duorarum, 14-15 Apr 80, night

ALPHA LEVEL=.01 DF=12 MS=0.150384

GROUPING	MEAN	N	STA
A	0.693147	1	15
A			
A	0.693147	2	21
A			
A	0.549306	2	18
A			
A	0.346574	2	20
A			
A	0.346574	2	22
A			
A	0.346574	2	23
A			
A	0.346574	2	24
A			
A	0.346574	2	25
A			
A	0.000000	2	9
A			
A	0.000000	2	14
A			
A	0.000000	2	17
A			
A	0.000000	2	19
A			
A	0.000000	2	26

Table I-18. Duncan's multiple range test for differences in abundance of Penaeus duorarum, 12 Mar 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.336573

GROUPING	MEAN	N	STA
A	1.497866	2	20
A			
A	1.386294	2	21
A			
A	1.354025	2	14
A			
A	1.242453	2	23
A			
A	1.151293	2	16
A			
A	1.098612	2	15
A			
A	1.039721	2	25
A			
A	0.895880	2	18
A			
A	0.895880	2	22
A			
A	0.693147	2	17
A			
A	0.693147	2	19
A			
A	0.693147	2	24
A			
A	0.549306	2	9
A			
A	0.549306	2	26

Table I-19. Duncan's multiple range test for differences in abundance of Penaeus duorarum, 5 Apr 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.407985

GROUPING	MEAN	N	STA
A	2.158744	2	21
A			
A	1.609438	2	14
A			
A	1.545521	2	9
A			
A	1.386294	2	22
A			
A	1.242453	2	15
A			
A	1.242453	2	20
A			
A	1.242453	2	26
A			
A	1.098612	2	23
A			
A	1.098612	2	25
A			
A	1.039721	2	18
A			
A	0.895880	2	16
A			
A	0.693147	2	19
A			
A	0.549306	2	24
A			
A	0.000000	2	17

Table I-20. Duncan's multiple range test for differences in abundance of <u>Penaeus duorarum</u>, 20 Apr 79, day.

ALPHA LEVEL=.01 DF=14 MS=0.10337

GROUPING	MEAN	N	STA
A	0.549306	2	20
A			
A	0.549306	2	25
A			
A	0.346574	2	22
A			
A	0.000000	2	9
A			
A	0.000000	2	14
A			
A	0.000000	2	15
A			
A	0.000000	2	16
A			
A	0.000000	2	17
A			
A	0.000000	2	18
A			
A	0.000000	2	19
A			
A	0.000000	2	21
A			
A	0.000000	2	23
A			
A	0.000000	2	24
A			
A	0.000000	2	26

Table I-21. Duncan's multiple range test for differences in abundance of Penaeus setiferus, 5-6 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.108846

GROUPING					MEAN	N	STA
			A		2.470821	2	16
			A				
	B		A		2.047172	2	23
	B		A				
	B		A	C	1.935601	2	20
	B		A	C			
	B	D	A	C	1.777674	2	18
	B	D	A	C			
	B	D	A	C	1.732868	2	15
	B	D	A	C			
E	B	D	A	C	1.589027	2	21
E	B	D	A	C			
E	B	D	A	C	1.589027	2	24
E	B	D	A	C			
E	B	D	A	C	1.497866	2	25
E	B	D		C			
E	B	D		C	1.242453	2	19
E	B	D		C			
E	B	D		C	1.098612	2	14
E		D		C			
E		D		C	0.895880	2	9
E		D		C			
E		D		C	0.895880	2	22
E		D					
E		D			0.693147	2	26
E							
E					0.549306	2	17

Table I-22. Duncan's multiple range test for differences in abundance of Penaeus setiferus, 19-20 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=0.334173

GROUPING	MEAN	N	STA
A	1.666102	2	9
A			
A	1.151293	2	21
A			
A	1.039721	2	17
A			
A	1.039721	2	18
A			
A	0.895880	2	16
A			
A	0.895880	2	23
A			
A	0.804719	2	19
A			
A	0.693147	2	14
A			
A	0.693147	2	24
A			
A	0.346574	2	15
A			
A	0.346574	2	20
A			
A	0.346574	2	22
A			
A	0.346574	2	25
A			
A	0.346574	2	26

Table I-23. Duncan's multiple range test for differences in abundance of Penaeus setiferus, 24-25 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.102954

GROUPING	MEAN	N	STA
A	1.039721	2	18
A			
A	1.039721	2	20
A			
A	0.693147	2	17
A			
A	0.693147	2	21
A			
A	0.693147	2	22
A			
A	0.346574	2	9
A			
A	0.346574	2	14
A			
A	0.346574	2	15
A			
A	0.346574	2	24
A			
A	0.000000	2	16
A			
A	0.000000	2	19
A			
A	0.000000	2	23
A			
A	0.000000	2	25
A			
A	0.000000	2	26

Table I-24. Duncan's multiple range test for differences in abundance of _Penaeus setiferus_, 27-28 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=0.250968

GROUPING	MEAN	N	STA
A	1.445186	2	17
A			
A	1.151293	2	21
A			
A	0.895880	2	24
A			
A	0.693147	2	9
A			
A	0.693147	2	15
A			
A	0.549306	2	14
A			
A	0.549306	2	20
A			
A	0.549306	2	23
A			
A	0.346574	2	16
A			
A	0.346574	2	18
A			
A	0.346574	2	19
A			
A	0.346574	2	25
A			
A	0.000000	2	22
A			
A	0.000000	2	26

Table I-25. Duncan's multiple range test for differences in abundance of *Penaeus setiferus*, 4-5 Apr 80, night

ALPHA LEVEL=.01 DF=14 MS=0.23857

GROUPING	MEAN	N	STA
A	0.804719	2	9
A			
A	0.693147	2	15
A			
A	0.549306	2	17
A			
A	0.346574	2	14
A			
A	0.346574	2	18
A			
A	0.346574	2	20
A			
A	0.346574	2	21
A			
A	0.346574	2	24
A			
A	0.346574	2	26
A			
A	0.000000	2	16
A			
A	0.000000	2	19
A			
A	0.000000	2	22
A			
A	0.000000	2	23
A			
A	0.000000	2	25

Table I-26. Duncan's multiple range test for differences in abundance of Penaeus setiferus, 10-11 Apr 80, day

ALPHA LEVEL=.01 DF=14 MS=0.017159

GROUPING	MEAN	N	STA
A	0.346574	2	9
A			
A	0.000000	2	14
A			
A	0.000000	2	15
A			
A	0.000000	2	16
A			
A	0.000000	2	17
A			
A	0.000000	2	18
A			
A	0.000000	2	19
A			
A	0.000000	2	20
A			
A	0.000000	2	21
A			
A	0.000000	2	22
A			
A	0.000000	2	23
A			
A	0.000000	2	24
A			
A	0.000000	2	25
A			
A	0.000000	2	26

Table I-27. Duncan's multiple range test for differences in abundance of Penaeus setiferus, 14-15 Apr 80, night

ALPHA LEVEL=.01 DF=12 MS=0.288139

GROUPING	MEAN	N	STA
A	1.039721	2	21
A			
A	0.972955	2	20
A			
A	0.549306	2	9
A			
A	0.346574	2	17
A			
A	0.346574	2	23
A			
A	0.346574	2	24
A			
A	0.000000	2	14
A			
A	0.000000	1	15
A			
A	0.000000	2	18
A			
A	0.000000	2	19
A			
A	0.000000	2	22
A			
A	0.000000	2	25
A			
A	0.000000	2	26

Table I-28. Duncan's multiple range test for differences in abundance of <u>Penaeus setiferus</u>, 12 Mar 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.102184

GROUPING				MEAN	N	STA
		A		3.401197	2	21
		A				
B		A		3.205909	2	17
B		A				
B		A	C	2.990707	2	16
B		A	C			
B	D	A	C	2.659060	2	19
B	D	A	C			
B	D	A	C	2.636500	2	22
B	D	A	C			
B	D	A	C	2.636500	2	24
B	D	A	C			
B	D	A	C	2.470821	2	25
B	D	A	C			
B	D	A	C	2.393746	2	20
B	D	A	C			
B	D	A	C	2.322195	2	9
B	D		C			
B	D		C	2.302585	2	23
B	D		C			
B	D		C	2.282174	2	14
	D		C			
	D		C	2.047172	2	15
	D		C			
	D		C	1.994492	2	18
	D					
	D			1.700599	2	26

Table I-29. Duncan's multiple range test for differences in abundance of <u>Penaeus setiferus</u>, 5 Apr 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.308972

GROUPING	MEAN	N	STA
A	1.589027	2	19
A			
A	1.497866	2	17
A			
A	1.386294	2	21
A			
A	1.039721	2	22
A			
A	0.895880	2	9
A			
A	0.895880	2	20
A			
A	0.549306	2	14
A			
A	0.549306	2	24
A			
A	0.549306	2	26
A			
A	0.346574	2	18
A			
A	0.346574	2	25
A			
A	0.000000	2	15
A			
A	0.000000	2	16
A			
A	0.000000	2	23

Table I-30. Duncan's multiple range test for differences in abundance of *Penaeus setiferus*, 20 Apr 79, day.

ALPHA LEVEL=.01 DF=14 MS=0.249135

GROUPING	MEAN	N	STA
A	1.151293	2	19
A			
A	1.151293	2	25
A			
A	0.693147	2	20
A			
A	0.693147	2	24
A			
A	0.549306	2	21
A			
A	0.549306	2	22
A			
A	0.346574	2	16
A			
A	0.346574	2	17
A			
A	0.000000	2	9
A			
A	0.000000	2	14
A			
A	0.000000	2	15
A			
A	0.000000	2	18
A			
A	0.000000	2	23
A			
A	0.000000	2	26

Table I-31. Duncan's multiple range test for differences in abundance of Cynoscion arenarius, 5-6 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.558963

GROUPING		MEAN	N	STA
	A	2.555994	2	21
	A			
B	A	0.895880	2	16
B	A			
B	A	0.895880	2	17
B	A			
B	A	0.693147	2	15
B	A			
B	A	0.346574	2	22
B	A			
B	A	0.346574	2	25
B	A			
B	A	0.346574	2	26
B				
B		0.000000	2	9
B				
B		0.000000	2	14
B				
B		0.000000	2	18
B				
B		0.000000	2	19
B				
B		0.000000	2	20
B				
B		0.000000	2	23
B				
B		0.000000	2	24

Table I-32. Duncan's multiple range test for differences in abundance of <u>Cynoscion arenarius</u>, 19-20 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=1.33856

GROUPING	MEAN	N	STA
A	2.802901	2	21
A			
A	1.151293	2	19
A			
A	0.895880	2	24
A			
A	0.693147	2	18
A			
A	0.693147	2	20
A			
A	0.693147	2	23
A			
A	0.549306	2	14
A			
A	0.346574	2	17
A			
A	0.346574	2	22
A			
A	0.346574	2	25
A			
A	0.346574	2	26
A			
A	0.000000	2	9
A			
A	0.000000	2	15
A			
A	0.000000	2	16

Table I-33. Duncan's multiple range test for differences in abundance of Cynoscion arenarius, 24-25 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.312259

GROUPING	MEAN	N	STA
A	2.292484	2	25
A			
A	1.777674	2	22
A			
A	1.589027	2	24
A			
A	1.497866	2	18
A			
A	1.445186	2	17
A			
A	1.319529	2	23
A			
A	1.242453	2	26
A			
A	1.039721	2	20
A			
A	0.972955	2	16
A			
A	0.895880	2	15
A			
A	0.895880	2	19
A			
A	0.693147	2	9
A			
A	0.693147	2	21
A			
A	0.549306	2	14

Table I-34. Duncan's multiple range test for differences in abundance of Cynoscion arenarius, 27-28 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=0.286316

GROUPING	MEAN	N	STA
A	1.791759	2	24
A			
A	1.319529	2	25
A			
A	1.242453	2	22
A			
A	1.098612	2	23
A			
A	0.895880	2	17
A			
A	0.549306	2	15
A			
A	0.549306	2	21
A			
A	0.549306	2	26
A			
A	0.346574	2	14
A			
A	0.346574	2	18
A			
A	0.346574	2	19
A			
A	0.346574	2	20
A			
A	0.000000	2	9
A			
A	0.000000	2	16

Table I-35. Duncan's multiple range test for differences in abundance of Cynoscion arenarius, 4-5 Apr 80, night

ALPHA LEVEL=.01 DF=14 MS=0.181046

GROUPING				MEAN	N	STA
		A		2.470821	2	26
		A				
B		A		2.012676	2	19
B		A				
B		A	C	1.791759	2	18
B		A	C			
B		A	C	1.791759	2	23
B		A	C			
B		A	C	1.609438	2	15
B		A	C			
B		A	C	1.589027	2	25
B		A	C			
B	D	A	C	1.319529	2	16
B	D	A	C			
B	D	A	C	1.242453	2	20
B	D	A	C			
B	D	A	C	1.151293	2	17
B	D	A	C			
B	D	A	C	1.151293	2	24
B	D	A	C			
B	D	A	C	1.098612	2	14
B	D		C			
B	D		C	0.895880	2	9
	D		C			
	D		C	0.346574	2	21
	D					
	D			0.000000	2	22

Table I-36. Duncan's multiple range test for differences in abundance of *Cynoscion arenarius*, 10-11 Apr 80, day

ALPHA LEVEL=.01 DF=14 MS=.0945824

GROUPING	MEAN	N	STA
A	0.549306	2	21
A			
A	0.346574	2	14
A			
A	0.346574	2	22
A			
A	0.346574	2	26
A			
A	0.000000	2	9
A			
A	0.000000	2	15
A			
A	0.000000	2	16
A			
A	0.000000	2	17
A			
A	0.000000	2	18
A			
A	0.000000	2	19
A			
A	0.000000	2	20
A			
A	0.000000	2	23
A			
A	0.000000	2	24
A			
A	0.000000	2	25

Table I-37. Duncan's multiple range test for differences in abundance of Cynoscion arenarius, 14-15 Apr 80, night

ALPHA LEVEL=.01 DF=12 MS=0.140675

GROUPING		MEAN	N	STA
	A	2.393746	2	21
	A			
B	A	1.497866	2	22
B				
B	C	0.895880	2	19
B	C			
B	C	0.693147	2	25
B	C			
B	C	0.549306	2	26
B	C			
B	C	0.346574	2	17
B	C			
B	C	0.346574	2	20
B	C			
B	C	0.346574	2	23
B	C			
B	C	0.346574	2	24
	C			
	C	0.000000	2	9
	C			
	C	0.000000	2	14
	C			
	C	0.000000	1	15
	C			
	C	0.000000	2	18

Table I-38. Duncan's multiple range test for differences in abundauce of <u>Cynoscion arenarius</u>, 12 Mar 79, night.

ALPHA LEVEL=.01 DF=14 MS=.0916667

GROUPING	MEAN	N	STA
A	0.895880	2	26
A	0.346574	2	9
A	0.346574	2	17
A	0.346574	2	20
A	0.346574	2	21
A	0.346574	2	23
A	0.000000	2	14
A	0.000000	2	15
A	0.000000	2	16
A	0.000000	2	18
A	0.000000	2	19
A	0.000000	2	22
A	0.000000	2	24
A	0.000000	2	25

Table I-39. Duncan's multiple range test for differences in abundance of <u>Cynoscion arenarius</u>, 5 Apr 79, night.

ALPHA LEVEL=.01   DF=14   MS=0.320951

GROUPING		MEAN	N	STA
	A	2.071567	2	17
	A			
B	A	1.589027	2	21
B	A			
B	A	1.386294	2	20
R	A			
B	A	1.242453	2	14
D	A			
B	A	1.242453	2	26
B	A			
B	A	1.151293	2	18
B	A			
B	A	1.151293	2	19
B	A			
B	A	0.804719	2	15
B	A			
B	A	0.693147	2	16
B	A			
B	A	0.346574	2	22
B				
B		0.000000	2	9
B				
B		0.000000	2	23
B				
B		0.000000	2	24
B				
D		0.000000	2	25

Table I-40. Duncan's multiple range test for differences in abundance of *Cynoscion arenarius*, 20 Apr 79, day.

ALPHA LEVEL=.01 DF=14 MS=0.927968

GROUPING	MEAN	N	STA
A	2.138333	2	24
A			
A	2.094827	2	20
A			
A	1.844440	2	16
A			
A	1.416607	2	21
A			
A	1.354025	2	9
A			
A	1.319529	2	17
A			
A	1.319529	2	26
A			
A	1.242453	2	19
A			
A	1.039721	2	18
A			
A	1.039721	2	22
A			
A	0.972955	2	15
A			
A	0.804719	2	25
A			
A	0.693147	2	14
A			
A	0.346574	2	23

Table I-41. Duncan's multiple range test for differences in abundance of Cynoscion nothus, 5-6 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.121913

GROUPING				MEAN	N	STA
		A		6.219247	2	26
		A				
B		A		6.152189	2	22
B		A				
B		A	C	6.111573	2	9
B		A	C			
B	D	A	C	6.004792	2	20
B	D	A	C			
B	D	A	C	5.736645	2	14
B	D	A	C			
B	D	A	C	5.675056	2	24
B	D	A	C			
B	D	A	C	5.631154	2	23
B	D	A	C			
B	D	A	C	5.587578	2	21
B	D	A	C			
B	D	A	C	5.156140	2	15
B	D		C			
B	D		C	4.993685	2	18
B	D		C			
B	D		C	4.991334	2	16
	D		C			
	D		C	4.934034	2	17
	D		C			
	D		C	4.933204	2	19
	D					
	D			4.907820	2	25

Table I-42. Duncan's multiple range test for differences in abundance of Cynoscion nothus, 19-20 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=0.555755

GROUPING				MEAN	N	STA
		A		6.540308	2	17
		A				
		A		6.397970	2	25
		A				
B		A		5.946803	2	9
B		A				
B		A	C	5.457671	2	18
B		A	C			
B		A	C	5.347787	2	24
B		A	C			
B		A	C	5.106221	2	16
B		A	C			
B		A	C	5.076149	2	20
B		A	C			
B		A	C	5.030417	2	15
B		A	C			
B		A	C	4.896836	2	19
B		A	C			
B		A	C	4.882343	2	23
B		A	C			
B	D	A	C	4.686655	2	14
B	D		C			
B	D		C	3.624963	2	22
	D		C			
	D		C	3.117205	2	21
	D					
	D			2.393746	2	26

Table I-43. Duncan's multiple range test for differences in abundance of <u>Cynoscion nothus</u>, 24-25 Mar 80, night

ALPHA LEVEL=.01   DF=14   MS=0.313303

GROUPING		MEAN	N	STA
	A	6.694721	2	17
	A			
B	A	5.976866	2	19
B	A			
B	A	5.783707	2	9
B	A			
B	A	5.556955	2	14
B	A			
B	A	5.439024	2	23
B	A			
B	A	5.313121	2	18
B	A			
B	A	5.239066	2	15
B	A			
B	A	5.221042	2	20
B	A			
B	A	5.066048	2	24
B	A			
B	A	4.951294	2	16
B				
B		4.737543	2	22
B				
B		4.715300	2	21
B				
B		4.465313	2	25
	C	0.895880	2	26

Table I-44. Duncan's multiple range test for differences in abundance of Cynoscion nothus, 27-28 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=2.42702

GROUPING	MEAN	N	STA
A	6.726886	2	17
A			
A	6.608726	2	22
A			
A	6.390308	2	19
A			
A	6.384442	2	14
A			
A	6.041749	2	9
A			
A	5.640799	2	23
A			
A	5.612828	2	16
A			
A	5.083426	2	25
A			
A	5.010635	2	15
A			
A	4.938777	2	18
A			
A	4.600599	2	21
A			
A	4.583977	2	20
A			
A	4.268498	2	26
A			
A	4.071759	2	24

Table I-45. Duncan's multiple range test for differences in abundance of <u>Cynoscion nothus</u>, 4-5 Apr 80, night

ALPHA LEVEL=.01 DF=14 MS=0.370169

GROUPING		MEAN	N	STA
	A	6.077279	2	21
	A			
	A	6.026356	2	22
	A			
	A	5.853720	2	20
	A			
	A	5.804767	2	14
	A			
	A	5.772115	2	26
	A			
	A	5.655252	2	18
	A			
B	A	5.516088	2	19
B	A			
B	A	5.268363	2	15
B	A			
B	A	5.174855	2	17
B	A			
B	A	5.169450	2	9
B	A			
B	A	5.058290	2	16
B	A			
B	A	4.373438	2	23
B	A			
B	A	4.048561	2	24
B				
B		3.483012	2	25

Table I-46. Duncan's multiple range test for differences in abundance of Cynoscion nothus, 10-11 Apr 80, day

ALPHA LEVEL=.01 DF=14 MS=.0695837

GROUPING			MEAN	N	STA
	A		1.354025	2	21
	A				
B	A		1.098612	2	22
B	A				
B	A	C	0.549306	2	20
B		C			
B		C	0.346574	2	9
		C			
		C	0.000000	2	14
		C			
		C	0.000000	2	15
		C			
		C	0.000000	2	16
		C			
		C	0.000000	2	17
		C			
		C	0.000000	2	18
		C			
		C	0.000000	2	19
		C			
		C	0.000000	2	23
		C			
		C	0.000000	2	24
		C			
		C	0.000000	2	25
		C			
		C	0.000000	2	26

Table I-47. Duncan's multiple range test for differences in abundance of Cynoscion nothus, 14-15 Apr 80, night

ALPHA LEVEL=.01 DF=12 MS=0.370273

GROUPING		MEAN	N	STA
	A	2.561982	2	9
	A			
B	A	1.386294	2	17
B	A			
B	A	1.386294	2	20
B	A			
B	A	1.354025	2	21
B	A			
B	A	1.319529	2	18
B	A			
B	A	1.151293	2	19
B	A			
B	A	1.039721	2	14
B	A			
B	A	0.693147	2	24
B				
B		0.346574	2	22
B				
B		0.346574	2	23
B				
B		0.346574	2	26
B				
B		0.000000	1	15
B				
B		0.000000	2	25

Table I-48. Duncan's multiple range test for differences in abundance of _Cynoscion nothus_, 12 Mar 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.091877

GROUPING		MEAN	N	STA
	A	4.956620	2	21
	A			
B	A	4.593280	2	17
B	A			
B	A	4.262283	2	22
B	A			
B	A	4.260194	2	19
B	A			
B	A	4.226594	2	15
B	A			
B	A	4.206472	2	23
B	A			
B	A	4.197513	2	9
B	A			
B	A	4.193428	2	16
B	A			
B	A	4.165191	2	18
B				
B		3.865965	2	20
B				
B		3.826510	2	25
B				
B		3.762820	2	24
B				
B		3.720367	2	14
	C	2.696814	2	26

Table I-49. Duncan's multiple range test for differences in abundance of Cynoscion nothus, 5 Apr 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.233882

GROUPING			MEAN	N	STA
	A		4.938597	2	21
	A				
B	A		3.603559	2	22
B					
B			3.208366	2	9
B					
B	C		2.326980	2	17
	C				
D	C		1.700599	2	20
D	C				
D	C	E	1.497866	2	19
D	C	E			
D	C	E	1.386294	2	16
D	C	E			
D	C	E	0.895880	2	15
D		E			
D		E	0.693147	2	18
		E			
		E	0.000000	2	14
		E			
		E	0.000000	2	23
		E			
		E	0.000000	2	24
		E			
		E	0.000000	2	25
		E			
		E	0.000000	2	26

Table I-50. Duncan's multiple range test for differences in abundance of Cynoscion nothus, 20 Apr 79, day.

ALPHA LEVEL=.01 DF=14 MS=2.18066

GROUPING	MEAN	N	STA
A	5.071252	2	22
A			
A	4.837823	2	24
A			
A	4.345573	2	20
A			
A	4.297632	2	19
A			
A	4.059848	2	9
A			
A	3.695091	2	16
A			
A	3.545038	2	17
A			
A	3.471561	2	21
A			
A	3.296522	2	25
A			
A	3.113268	2	14
A			
A	2.596478	2	23
A			
A	1.868835	2	26
A			
A	1.748254	2	18
A			
A	1.716994	2	15

Table I-51. Duncan's multiple range test for differences in abundance of _Syacium gunteri_, 5-6 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.216235

GROUPING	MEAN	N	STA
A	4.076819	2	24
A			
A	3.725621	2	19
A			
A	3.723878	2	16
A			
A	3.722417	2	23
A			
A	3.708790	2	15
A			
A	3.692615	2	26
A			
A	3.572992	2	25
A			
A	3.503348	2	18
A			
A	3.425592	2	17
A			
A	3.412187	2	14
A			
A	3.263979	2	9
A			
A	3.222066	2	22
A			
A	3.020127	2	21
A			
A	2.511940	2	20

Table I-52. Duncan's multiple range test for differences in abundance of Syacium gunteri, 19-20 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=0.19565

GROUPING	MEAN	N	STA
A	3.905987	2	14
A			
A	3.881511	2	23
A			
A	3.810353	2	15
A			
A	3.712381	2	25
A			
A	3.681005	2	17
A			
A	3.597218	2	18
A			
A	3.592694	2	9
A			
A	3.525928	2	19
A			
A	3.416516	2	24
A			
A	3.314021	2	16
A			
A	3.310037	2	20
A			
A	2.967447	2	26
A			
A	2.911523	2	22
A			
A	2.505318	2	21

Table I-53. Duncan's multiple range test for differences in abundance of Syacium gunteri, 24-25 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=1.10346

GROUPING	MEAN	N	STA
A	3.492821	2	17
A			
A	3.218075	2	19
A			
A	3.100255	2	14
A			
A	2.831480	2	25
A			
A	2.787975	2	24
A			
A	2.746531	2	26
A			
A	2.659060	2	23
A			
A	2.537587	2	22
A			
A	2.368099	2	18
A			
A	2.178354	2	21
A			
A	2.087194	2	20
A			
A	1.868835	2	16
A			
A	1.791759	2	15
A			
A	1.589027	2	9

Table I-54. Duncan's multiple range test for differences in abundance of Syacium gunteri, 27-28 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=2.15129

GROUPING	MEAN	N	STA
A	3.251395	2	17
A			
A	2.943052	2	14
A			
A	2.585242	2	26
A			
A	2.255430	2	18
A			
A	2.249905	2	19
A			
A	2.178354	2	22
A			
A	2.124248	2	25
A			
A	1.945910	2	21
A			
A	1.763180	2	20
A			
A	1.445186	2	15
A			
A	1.354025	2	9
A			
A	1.319529	2	24
A			
A	1.039721	2	23
A			
A	0.693147	2	16

Table I-55. Duncan's multiple range test for differences in abundance of *Syacium gunteri*, 4-5 Apr 80, night

ALPHA LEVEL=.01 DF=14 MS=1.32464

GROUPING	MEAN	N	STA
A	3.308701	2	26
A			
A	2.908556	2	14
A			
A	2.359249	2	19
A			
A	2.292484	2	18
A			
A	2.124248	2	17
A			
A	1.609438	2	16
A			
A	1.589027	2	15
A			
A	1.589027	2	23
A			
A	1.522261	2	22
A			
A	1.319529	2	20
A			
A	1.198948	2	21
A			
A	0.804719	2	24
A			
A	0.346574	2	9
A			
A	0.000000	2	25

Table I-56. Duncan's multiple range test for differences in abundance of Syacium gunteri, 10-11 Apr 80, day

ALPHA LEVEL=.01 DF=14 MS=0.591336

GROUPING			MEAN	N	STA
	A		3.151309	2	20
	A				
B	A		2.881026	2	21
B	A				
B	A	C	1.386294	2	26
B	A	C			
B	A	C	0.895880	2	16
B	A	C			
B	A	C	0.804719	2	14
B	A	C			
B	A	C	0.804719	2	15
B		C			
B		C	0.549306	2	18
B		C			
B		C	0.549306	2	23
B		C			
B		C	0.346574	2	22
B		C			
B		C	0.346574	2	24
		C			
		C	0.000000	2	9
		C			
		C	0.000000	2	17
		C			
		C	0.000000	2	19
		C			
		C	0.000000	2	25

Table I-57. Duncan's multiple range test for differences in abundance of Syacium gunteri, 14-15 Apr 80, night

ALPHA LEVEL=.01 DF=12 MS=0.985012

GROUPING	MEAN	N	STA
A	3.516753	2	26
A			
A	2.661505	2	9
A			
A	2.238668	2	24
A			
A	2.191013	2	20
A			
A	2.124248	2	17
A			
A	2.071567	2	23
A			
A	1.965913	2	21
A			
A	1.700599	2	22
A			
A	1.589027	2	18
A			
A	1.151293	2	19
A			
A	1.098612	1	15
A			
A	1.039721	2	14
A			
A	0.972955	2	25

Table I-58. Duncan's multiple range test for differences in abundance of Syacium gunteri, 12 Mar 79, night.

ALPHA LEVEL=.01 DF=14 MS=.0920294

GROUPING	MEAN	N	STA
A	3.605040	2	23
A			
A	3.512769	2	26
A			
A	3.496508	2	20
A			
A	3.466712	2	16
A			
A	3.414356	2	25
A			
A	3.396172	2	24
A			
A	3.386540	2	14
A			
A	3.377302	2	22
A			
A	3.321895	2	18
A			
A	3.270515	2	19
A			
A	3.039967	2	9
A			
A	3.034213	2	15
A			
A	2.959447	2	17
A			
A	2.876286	2	21

Table I-59. Duncan's multiple range test for differences in abundance of *Syacium gunteri*, 5 Apr 79, night.

ALPHA LEVEL=.01 DF=14 MS=1.40147

GROUPING	MEAN	N	STA
A	2.124248	2	21
A			
A	2.021526	2	26
A			
A	1.818793	2	22
A			
A	1.748254	2	15
A			
A	1.567747	2	25
A			
A	1.319529	2	24
A			
A	1.039721	2	14
A			
A	1.039721	2	16
A			
A	0.895880	2	20
A			
A	0.804719	2	23
A			
A	0.549306	2	18
A			
A	0.346574	2	9
A			
A	0.346574	2	19
A			
A	0.000000	2	17

Table I-60. Duncan's multiple range test for differences in abundance of *Syacium gunteri*, 20 Apr 79, day.

ALPHA LEVEL=.01 DF=14 MS=0.738318

GROUPING		MEAN	N	STA
	A	3.301972	2	26
	A			
B	A	2.620874	2	19
B	A			
B	A	2.372466	2	20
B	A			
B	A	2.341066	2	14
B	A			
B	A	2.171903	2	24
B	A			
B	A	2.109754	2	16
B	A			
B	A	1.903331	2	22
B	A			
B	A	1.700599	2	25
B	A			
B	A	1.445186	2	23
B	A			
B	A	1.386294	2	15
B	A			
B	A	0.972955	2	21
B	A			
B	A	0.895880	2	9
B	A			
B	A	0.895880	2	17
B				
B		0.000000	2	18

Table I-61. Duncan's multiple range test for differences in abundance of *Halieutichthys aculeatus*, 5-6 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.307282

GROUPING	MEAN	N	STA
A	3.407820	2	14
A			
A	3.293775	2	18
A			
A	3.198465	2	24
A			
A	2.938868	2	15
A			
A	2.827996	2	16
A			
A	2.826245	2	19
A			
A	2.791748	2	22
A			
A	2.770632	2	20
A			
A	2.756714	2	23
A			
A	2.668769	2	26
A			
A	2.302585	2	25
A			
A	2.021526	2	21
A			
A	2.003667	2	9
A			
A	1.892095	2	17

Table I-62. Duncan's multiple range test for differences in abundance of <u>Halieutichthys aculeatus</u>, 19-20 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=.0983016

GROUPING				MEAN	N	STA
		A		1.892095	2	23
		A				
		A		1.868835	2	18
		A				
B		A		1.497866	2	14
B		A				
B		A		1.497866	2	19
B		A				
B		A	C	1.098612	2	15
B		A	C			
B	D	A	C	0.895880	2	20
B	D		C			
B	D		C	0.693147	2	25
	D		C			
	D		C	0.346574	2	9
	D		C			
	D		C	0.346574	2	16
	D		C			
	D		C	0.346574	2	26
	D					
	D			0.000000	2	17
	D					
	D			0.000000	2	21
	D					
	D			0.000000	2	22
	D					
	D			0.000000	2	24

Table I-63. Duncan's multiple range test for differences in abundance of *Halieutichthys aculeatus*, 24-25 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.373026

GROUPING		MEAN	N	STA
	A	2.671167	2	23
	A			
B	A	2.249905	2	14
B	A			
B	A	2.249905	2	24
B	A			
B	A	1.777674	2	17
B	A			
B	A	1.732868	2	19
B	A			
B	A	1.497866	2	21
B	A			
B	A	1.445186	2	9
B	A			
B	A	1.445186	2	22
B	A			
B	A	1.445186	2	25
B	A			
B	A	1.242453	2	18
B	A			
B	A	1.242453	2	20
B	A			
B	A	1.039721	2	15
B	A			
B	A	0.804719	2	26
B				
B		0.346574	2	16

Table I-64. Duncan's multiple range test for differences in abundance of *Halieutichthys aculeatus*, 27-28 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=0.158686

GROUPING		MEAN	N	STA
	A	1.497866	2	14
	A			
B	A	1.242453	2	17
B	A			
B	A	1.242453	2	18
B	A			
B	A	1.039721	2	9
B	A			
B	A	0.549306	2	19
B				
B		0.000000	2	15
B				
B		0.000000	2	16
B				
B		0.000000	2	20
B				
B		0.000000	2	21
B				
B		0.000000	2	22
B				
B		0.000000	2	23
B				
B		0.000000	2	24
B				
B		0.000000	2	25
B				
B		0.000000	2	26

Table I-65. Duncan's multiple range test for differences in abundance of Halieutichthys aculeatus, 4-5 Apr 80, night

ALPHA LEVEL=.01 DF=14 MS=0.377701

GROUPING		MEAN	N	STA
	A	2.515219	2	14
	A			
	A	2.215408	2	26
	A			
B	A	2.012676	2	18
B	A			
B	A	1.445186	2	21
B	A			
B	A	1.445186	2	22
B	A			
B	A	1.039721	2	23
B	A			
B	A	0.895880	2	9
B	A			
B	A	0.895880	2	15
B	A			
B	A	0.895880	2	19
B	A			
B	A	0.804719	2	16
B	A			
B	A	0.693147	2	17
B	A			
B	A	0.693147	2	20
B	A			
B	A	0.549306	2	24
B				
B		0.000000	2	25

Table I-66. Duncan's multiple range test for differences in abundance of Halieutichthys aculeatus, 14-15 Apr 80,night

ALPHA LEVEL=.01 DF=12 MS=0.539936

GROUPING	MEAN	N	STA
A	1.868835	2	26
A			
A	1.445186	2	20
A			
A	1.386294	2	21
A			
A	1.386294	2	23
A			
A	1.198948	2	9
A			
A	1.098612	2	24
A			
A	0.895880	2	17
A			
A	0.804719	2	18
A			
A	0.693147	1	15
A			
A	0.693147	2	25
A			
A	0.549306	2	14
A			
A	0.346574	2	19
A			
A	0.346574	2	22

Table I-67. Duncan's multiple range test for differences in abundance of Halieutichthys aculeatus, 12 Mar 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.180404

GROUPING	MEAN	N	STA
A	1.354025	2	16
A			
A	1.242453	2	23
A			
A	1.151293	2	26
A			
A	1.090612	2	21
A			
A	0.895880	2	22
A			
A	0.895880	2	24
A			
A	0.895880	2	25
A			
A	0.693147	2	18
A			
A	0.693147	2	19
A			
A	0.549306	2	9
A			
A	0.549306	2	20
A			
A	0.346574	2	14
A			
A	0.346574	2	15
A			
A	0.000000	2	17

Table I-68. Duncan's multiple range test for differences in abundance of _Halieutichthys aculeatus_, 5 Apr 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.198408

GROUPING	MEAN	N	STA
A	1.445186	2	22
A			
A	1.039721	2	18
A			
A	1.039721	2	24
A			
A	0.895880	2	21
A			
A	0.693147	2	23
A			
A	0.549306	2	16
A			
A	0.346574	2	15
A			
A	0.346574	2	26
A			
A	0.000000	2	9
A			
A	0.000000	2	14
A			
A	0.000000	2	17
A			
A	0.000000	2	19
A			
A	0.000000	2	20
A			
A	0.000000	2	25

Table I-69. Duncan's multiple range test for differences in abundance of <u>Halieutichthys aculeatus</u>, 20 Apr, day.

ALPHA LEVEL=.01 DF=14 MS=0.111741

GROUPING	MEAN	N	STA
A	0.549306	2	25
A			
A	0.346574	2	15
A			
A	0.346574	2	19
A			
A	0.346574	2	24
A			
A	0.346574	2	26
A			
A	0.000000	2	9
A			
A	0.000000	2	14
A			
A	0.000000	2	16
A			
A	0.000000	2	17
A			
A	0.000000	2	18
A			
A	0.000000	2	20
A			
A	0.000000	2	21
A			
A	0.000000	2	22
A			
A	0.000000	2	23

Table I-70. Duncan's multiple range test for differences in abundance of <u>Chloroscombrus chrysurus</u>, 24-25 Mar 80, night.

ALPHA LEVEL=.01 DF=14 MS=0.747124

GROUPING	MEAN	N	STA
A	6.234528	2	17
A			
A	5.571959	2	21
A			
A	5.545055	2	19
A			
A	5.402718	2	9
A			
A	5.363173	2	16
A			
A	5.248297	2	22
A			
A	4.853584	2	15
A			
A	4.608956	2	23
A			
A	4.497210	2	20
A			
A	4.483497	2	18
A			
A	4.451908	2	24
A			
A	4.429682	2	14
A			
A	4.168555	2	26
A			
A	4.122167	2	25

Table I-71. Duncan's multiple range test for differences in abundance of Chloroscombrus chrysurus, 10-11 Apr 80,day

ALPHA LEVEL=.01 DF=14 MS=1.34535

GROUPING		MEAN	N	STA
	A	5.328394	2	9
	A			
B	A	4.835147	2	14
B	A			
B	A	4.208686	2	26
B	A			
B	A	4.082966	2	23
B	A			
B	A	3.681640	2	19
B	A			
B	A	3.429283	2	15
B	A			
B	A	3.412187	2	17
B	A			
B	A	2.943052	2	18
B	A			
B	A	2.705823	2	16
B	A			
B	A	1.589027	2	20
B	A			
B	A	1.445186	2	24
B				
B		1.098612	2	21
B				
B		1.039721	2	22
B				
B		0.895880	2	25

Table I-72. Duncan's multiple range test for differences in abundance of <u>Chloroscombrus chrysurus</u>, 14-15 Apr 80,night

ALPHA LEVEL=.01 DF=12 MS=0.144966

GROUPING	MEAN	N	STA
A	2.518476	2	17
A			
A	1.647918	2	9
B	0.346574	2	18
B			
B	0.346574	2	19
B			
B	0.000000	2	14
B			
B	0.000000	1	15
B			
B	0.000000	2	20
B			
B	0.000000	2	21
B			
B	0.000000	2	22
B			
B	0.000000	2	23
B			
B	0.000000	2	24
B			
B	0.000000	2	25
B			
B	0.000000	2	26

Table I-73. Duncan's multiple range test for differences in abundance of Chloroscombrus chrysurus, 5 Apr 79, night.

ALPHA LEVEL=.01 DF=14 MS=.0857952

GROUPING		MEAN	N	STA
	A	1.039721	2	19
	A			
B	A	0.346574	2	17
B	A			
B	A	0.346574	2	21
B	A			
B	A	0.346574	2	22
B	A			
B	A	0.346574	2	23
B				
B		0.000000	2	9
B				
B		0.000000	2	14
B				
B		0.000000	2	15
B				
B		0.000000	2	16
B				
B		0.000000	2	18
B				
B		0.000000	2	20
B				
B		0.000000	2	24
B				
B		0.000000	2	25
B				
B		0.000000	2	26

Table I-74. Duncan's multiple range test for differences in abundance of *Peprilus burti*, 5-6 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.253964

GROUPING		MEAN	N	STA
	A	1.956012	2	15
	A			
B	A	1.589027	2	14
B	A			
B	A	1.242453	2	23
B	A			
B	A	1.242453	2	24
B	A			
B	A	1.151293	2	19
B	A			
B	A	1.039721	2	9
B	A			
B	A	0.895880	2	21
B	A			
B	A	0.895880	2	18
B	A			
B	A	0.895880	2	25
B	A			
B	A	0.693147	2	22
B	A			
B	A	0.346574	2	16
B	A			
B	A	0.346574	2	17
B	A			
B	A	0.346574	2	26
B				
B		0.000000	2	20

Table I-75. Duncan's multiple range test for differences in abundance of <u>Peprilus burti</u>, 19-20 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=0.455517

GROUPING			MEAN	N	STA
	A		4.524910	2	26
	A				
	A		4.323057	2	22
	A				
	A		4.262581	2	25
	A				
B	A		3.864868	2	24
B	A				
B	A	C	3.074234	2	21
B	A	C			
B	A	C	2.851891	2	15
B	A	C			
B	A	C	2.770632	2	14
B	A	C			
B	A	C	2.740319	2	16
B	A	C			
B	A	C	2.524928	2	17
B	A	C			
B	A	C	2.433767	2	23
B	A	C			
B	A	C	2.255430	2	19
B		C			
B		C	1.666102	2	20
		C			
		C	1.386294	2	18
		C			
		C	0.804719	2	9

Table I-76. Duncan's multiple range test for differences in abundance of Peprilus burti, 24-25 Mar 80, night

ALPHA LEVEL=.01 DF=14 MS=0.309984

GROUPING	MEAN	N	STA
A	3.273393	2	26
B	1.522261	2	25
B			
B	1.497866	2	18
B			
B	1.497866	2	24
B			
B	1.319529	2	23
B			
B	1.098612	2	14
B			
B	1.098612	2	19
B			
B	1.039721	2	9
B			
B	1.039721	2	21
B			
B	0.895880	2	15
B			
B	0.895880	2	17
B			
B	0.693147	2	20
B			
B	0.549306	2	16
B			
B	0.346574	2	22

Table I-77. Duncan's multiple range test for differences in abundance of Peprilus burti, 27-28 Mar 80, day

ALPHA LEVEL=.01 DF=14 MS=0.170371

GROUPING		MEAN	N	STA
	A	4.698825	2	26
	A			
B	A	4.502764	2	21
B	A			
B	A	4.077394	2	25
B	A			
B	A	4.038568	2	24
B	A			
B	A	3.950689	2	20
B	A			
B	A	3.352207	2	22
B				
B		3.198465	2	23
	C	1.732868	2	16
	C			
	C	1.497866	2	14
	C			
	C	1.497866	2	19
	C			
	C	1.242453	2	9
	C			
	C	1.242453	2	15
	C			
	C	1.242453	2	17
	C			
	C	0.693147	2	18

Table I-78. Duncan's multiple range test for differences in abundance of Peprilus burti, 4-5 Apr 80, night

ALPHA LEVEL=.01 DF=14 MS=0.136161

GROUPING			MEAN	N	STA
	A		2.452637	2	26
	A				
B	A		1.956012	2	25
B	A				
B	A	C	1.497866	2	9
B		C			
B	D	C	1.242453	2	14
B	D	C			
B	D	C	1.242453	2	20
B	D	C			
B	D	C	1.242453	2	24
B	D	C			
B	D	C	1.151293	2	21
B	D	C			
B	D	C	1.098612	2	15
B	D	C			
B	D	C	1.098612	2	16
B	D	C			
B	D	C	1.039721	2	22
B	D	C			
B	D	C	0.895880	2	18
B	D	C			
B	D	C	0.895880	2	19
	D	C			
	D	C	0.693147	2	23
	D				
	D		0.000000	2	17

Table I-79. Duncan's multiple range test for differences in abundance of *Peprilus burti*, 10-11 Apr 80, day

ALPHA LEVEL=.01 DF=14 MS=0.939599

GROUPING				MEAN	N	STA
		A		5.048869	2	9
		A				
B		A		3.864208	2	20
B		A				
B		A	C	3.596467	2	25
B		A	C			
B		A	C	3.395611	2	22
B		A	C			
B	D	A	C	3.285441	2	21
B	D	A	C			
B	D	A	C	3.193440	2	17
B	D	A	C			
B	D	A	C	3.162179	2	26
B	D	A	C			
B	D	A	C	3.149475	2	24
B	D	A	C			
B	D	A	C	2.138333	2	18
B	D	A	C			
B	D	A	C	2.079442	2	23
B	D		C			
B	D		C	0.895880	2	19
	D		C			
	D		C	0.346574	2	14
	D		C			
	D		C	0.346574	2	15
	D					
	D			0.000000	2	16

Table I-80. Duncan's multiple range test for differences in abundance of Peprilus burti, 14-15 Apr 80, night

ALPHA LEVEL=.01 DF=12 MS=.0400378

GROUPING	MEAN	N	STA
A	0.346574	2	14
A			
A	0.346574	2	17
A			
A	0.000000	2	9
A			
A	0.000000	1	15
A			
A	0.000000	2	18
A			
A	0.000000	2	19
A			
A	0.000000	2	20
A			
A	0.000000	2	21
A			
A	0.000000	2	22
A			
A	0.000000	2	23
A			
A	0.000000	2	24
A			
A	0.000000	2	25
A			
A	0.000000	2	26

Table I-81. Duncan's multiple range test for differences in abundance of *Peprilus burti*, 12 Mar 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.34748

GROUPING	MEAN	N	STA
A	3.982946	2	17
A			
A	3.739085	2	15
A			
A	3.739085	2	18
A			
A	3.565449	2	14
A			
A	3.469627	2	16
A			
A	3.454377	2	19
B	1.589027	2	26
B			
B	1.497866	2	23
B			
B	0.549306	2	9
B			
B	0.346574	2	24
B			
B	0.000000	2	20
B			
B	0.000000	2	21
B			
B	0.000000	2	22
B			
B	0.000000	2	25

Table I-82. Duncan's multiple range test for differences in abundance of Peprilus burti, 5 Apr 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.19547

GROUPING		MEAN	N	STA
	A	1.868835	2	9
	A			
B	A	1.386294	2	20
B	A			
B	A	1.039721	2	21
B	A			
B	A	0.895880	2	17
B	A			
B	A	0.693147	2	22
B				
B		0.346574	2	15
B				
B		0.346574	2	18
B				
B		0.346574	2	19
B				
B		0.346574	2	23
B				
B		0.346574	2	24
B				
B		0.346574	2	25
B				
B		0.000000	2	14
B				
B		0.000000	2	16
B				
B		0.000000	2	26

Table I-83. Duncan's multiple range test for differences in abundance of <u>Peprilus burti</u>, 20 Apr 79, day.

ALPHA LEVEL=.01 DF=14 MS=0.212835

GROUPING			MEAN	N	STA
	A		4.900229	2	25
	A				
B	A		4.319174	2	17
B	A				
B	A		4.268498	2	24
B	A				
B	A		4.135135	2	19
B	A				
B	A		4.068698	2	15
B	A				
B	A	C	3.849921	2	16
B	A	C			
B	A	C	3.597594	2	22
B	A	C			
B	A	C	3.580423	2	23
B		C			
B	D	C	3.107304	2	20
B	D	C			
B	D	C	2.766695	2	14
	D	C			
	D	C	2.393746	2	21
	D				
	D		2.071567	2	26
	D				
	D		2.047172	2	9
	D				

Table I-84. Duncan's multiple range test for differences in ichthyofauna diversity, 12 Mar 79, night.

ALPHA LEVEL=.01 DF=14 MS=.0604357

GROUPING	MEAN	N	STA
A	3.490000	2	26
A			
A	3.395000	2	16
A			
A	3.325000	2	20
A			
A	3.290000	2	25
A			
A	3.285000	2	14
A			
A	3.225000	2	24
A			
A	3.220000	2	19
A			
A	3.165000	2	15
A			
A	3.110000	2	23
A			
A	3.105000	2	18
A			
A	3.090000	2	22
A			
A	3.040000	2	9
A			
A	2.920000	2	17
A			
A	2.650000	2	21

Table I-85. Duncan's multiple range test for differences in ichthyofauna diversity, 5 Apr 79, night.

ALPHA LEVEL=.01 DF=14 MS=0.157957

GROUPING	MEAN	N	STA
A	3.665000	2	20
A			
A	3.250000	2	18
A			
A	3.100000	2	22
A			
A	3.075000	2	17
A			
A	3.025000	2	14
A			
A	3.010000	2	19
A			
A	2.980000	2	16
A			
A	2.915000	2	15
A			
A	2.895000	2	24
A			
A	2.840000	2	23
A			
A	2.705000	2	9
A			
A	2.595000	2	25
A			
A	2.580000	2	26
A			
A	2.365000	2	21

Table I-86. Duncan's multiple range test for differences in ichthyofauna diversity, 20 Apr 79, day.

ALPHA LEVEL=.01 DF=14 MS=0.175907

GROUPING	MEAN	N	STA
A	2.930000	2	24
A			
A	2.870000	2	20
A			
A	2.840000	2	14
A			
A	2.690000	2	26
A			
A	2.475000	2	19
A			
A	2.475000	2	23
A			
A	2.470000	2	25
A			
A	2.405000	2	15
A			
A	2.365000	2	16
A			
A	2.305000	2	22
A			
A	2.170000	2	18
A			
A	1.945000	2	9
A			
A	1.640000	2	21
A			
A	1.620000	2	17

Table I-87. Duncan's multiple range test for differences in ichthyofauna diversity, 5-6 Mar 80, night.

ALPHA LEVEL=.01 DF=14 MS=.0481107

GROUPING				MEAN	N	STA
		A		2.420000	2	16
		A				
B		A		2.365000	2	18
B		A				
B		A		2.335000	2	19
B		A				
B		A		2.265000	2	15
B		A				
B		A		2.200000	2	24
B		A				
B		A		2.100000	2	25
B		A				
B		A	C	2.015000	2	17
B		A	C			
B	D	A	C	1.700000	2	14
B	D	A	C			
B	D	A	C	1.695000	2	23
B	D		C			
B	D	E	C	1.625000	2	21
	D	E	C			
	D	E	C	1.355000	2	26
	D	E				
	D	E		1.090000	2	9
	D	E				
	D	E		1.060000	2	22
		E				
		E		0.960000	2	20

Table I-88. Duncan's multiple range test for differences in ichthyofauna diversity, 19-20 Mar 80, day.

ALPHA LEVEL=.01 DF=14 MS=0.247582

GROUPING	MEAN	N	STA
A	2.355000	2	21
A			
A	2.255000	2	14
A			
A	2.250000	2	19
A			
A	2.115000	2	23
A			
A	2.055000	2	15
A			
A	1.960000	2	26
A			
A	1.895000	2	16
A			
A	1.800000	2	18
A			
A	1.495000	2	24
A			
A	1.445000	2	22
A			
A	1.370000	2	9
A			
A	1.180000	2	20
A			
A	0.980000	2	25
A			
A	0.970000	2	17

Table I-89. Duncan's multiple range test for differences in ichthyofauna diversity, 24-25 Mar 80, night.

ALPHA LEVEL=.01 DF=14 MS=.0373821

GROUPING				MEAN	N	STA
		A		2.845000	2	26
		A				
B		A		2.310000	2	29
B						
B		C		1.940000	2	24
B		C				
B		C		1.940000	2	21
B		C				
B		C	D	1.735000	2	22
		C	D			
E		C	D	1.455000	2	23
E		C	D			
E	F	C	D	1.400000	2	14
E	F		D			
E	F	G	D	1.280000	2	18
E	F	G	D			
E	F	G	D	1.250000	2	20
E	F	G	D			
E	F	G	D	1.245000	2	15
E	F	G	D			
E	F	G	D	1.120000	2	19
E	F	G				
E	F	G		1.025000	2	16
	F	G				
	F	G		0.775000	2	17
		G				
		G		0.675000	2	9

Table I-90. Duncan's multiple range test for differences in ichthyofauna diversity, 27-28 Mar 80, day.

ALPHA LEVEL=.01 DF=14 MS=.0882786

GROUPING			MEAN	N	STA
	A		2.020000	2	26
	A				
B	A		1.925000	2	24
B	A				
B	A	C	1.420000	2	25
B		C			
B	D	C	1.015000	2	21
	D	C			
	D	C	0.945000	2	18
	D	C			
	D	C	0.940000	2	23
	D	C			
	D	C	0.810000	2	20
	D	C			
	D	C	0.745000	2	15
	D	C			
	D	C	0.575000	2	9
	D	C			
	D	C	0.570000	2	14
	D	C			
	D	C	0.560000	2	17
	D	C			
	D	C	0.480000	2	16
	D	C			
	D	C	0.470000	2	22
	D				
	D		0.345000	2	19

Table I-91. Duncan's multiple range test for differences in ichthyofauna diversity, 5 Apr 80, night.

ALPHA LEVEL=.01 DF=14 MS=.0855536

GROUPING			MEAN	N	STA
	A		2.010000	2	25
	A				
	A		1.895000	2	26
	A				
B	A		1.585000	2	24
B	A				
B	A	C	1.465000	2	14
B	A	C			
B	A	C	1.435000	2	17
B	A	C			
B	A	C	1.430000	2	19
B	A	C			
B	A	C	1.400000	2	23
B	A	C			
B	A	C	1.380000	2	18
B	A	C			
B	A	C	1.270000	2	15
B	A	C			
B	A	C	1.165000	2	16
B	A	C			
B	A	C	1.100000	2	9
B		C			
B		C	0.655000	2	20
		C			
		C	0.510000	2	22
		C			
		C	0.505000	2	21

Table I-92. Duncan's multiple range test for differences in ichthyofauna diversity, 9-10 Apr 80, day.

ALPHA LEVEL=.01 DF=14 MS=0.498361

GROUPING	MEAN	N	STA
A	2.510000	2	21
A			
A	2.270000	2	20
A			
A	1.785000	2	18
A			
A	1.730000	2	17
A			
A	1.680000	2	24
A			
A	1.600000	2	19
A			
A	1.590000	2	26
A			
A	1.565000	2	9
A			
A	1.485000	2	22
A			
A	1.250000	2	23
A			
A	1.070000	2	25
A			
A	0.855000	2	15
A			
A	0.820000	2	16
A			
A	0.555000	2	14

Table I-93. Duncan's multiple range test for differences in ichthyofauna diversity, 14-15 Apr 80, night.

ALPHA LEVEL=.01 DF=12 MS=0.123442

GROUPING	MEAN	N	STA
A	3.760000	2	25
A			
A	3.680000	2	14
A			
A	3.665000	2	24
A			
A	3.595000	2	23
A			
A	3.535000	2	22
A			
A	3.470000	2	9
A			
A	3.470000	2	18
A			
A	3.425000	2	26
A			
A	3.340000	2	20
A			
A	3.330000	1	15
A			
A	3.225000	2	17
A			
A	3.175000	2	19
A			
A	3.140000	2	21

APPENDIX II

SUPPORTING DATA FOR ZOOPLANKTON STUDIES

Table II-1. Mean densities (#/m^3) of the zooplankton groups identified from the three cruises made during the intensive study period. Mean values from three subsamples are listed for each tow taken at the three stations (A,B,C) near the diffuser. Tow 4 sampled only the upper 1/2 of the water column.

CRUISE/STATION/TOW	8/A/1	8/A/2	8/A/3	8/A/4
MEDUSAE	62.8	27.8	11.6	11.9
POLYCHAETE LARVAE	57.1	60.2	3.9	4.0
BIVALVE LARVAE	102.7	180.6	142.7	29.8
GASTROPOD LARVAE	205.5	37.0	15.4	31.8
HETEROPODA	0.0	0.0	0.0	0.0
PTEROPODA	0.0	0.0	0.0	0.0
CLADOCERA				
PENILIA	0.0	0.0	0.0	0.0
PODON	0.0	0.0	0.0	2.0
EUCONCHOECIA (OSTRACODA)	0.0	4.6	3.9	6.0
COPEPODA				
CALANOIDA	4223.7	2240.7	1751.5	665.8
CYCLOPOIDA	947.5	1356.5	686.7	498.9
HARPACTICOIDA	28.5	18.5	11.6	2.0
BARNACLE NAUPLII	0.0	0.0	0.0	2.0
BARNACLE CYPRIS	11.4	69.4	38.6	13.9
AMPHIPODA	11.4	18.5	0.0	0.0
CUMACEA	0.0	0.0	0.0	0.0
LUCIFER	0.0	0.0	0.0	0.0
MYSIDACEA	0.0	0.0	0.0	0.0
OTHER CRUSTACEANS	0.0	0.0	0.0	0.0
OTHER CRUSTACEAN LARVAE	11.4	4.6	15.4	0.0
ECHINODERM LARVAE	0.0	0.0	0.0	0.0
TORNARIA LARVAE	11.4	0.0	0.0	0.0
DOLIOLIDA	142.7	46.3	19.3	41.7
LARVACEA	268.3	300.9	131.2	131.2
FISH LARVAE	5.7	0.0	0.0	0.0
FISH EGGS	0.0	0.0	0.0	2.0
CHAETOGNATHA	57.1	106.5	84.9	41.7
OTHERS	0.0	4.6	0.0	0.0

Table II-1. (continued)

CRUISE/STATION/TOW	8/B/1	8/B/2	8/B/3	8/B/4
MEDUSAE	10.8	43.7	38.7	25.9
POLYCHAETE LARVAE	5.4	8.7	5.9	6.5
BIVALVE LARVAE	146.1	83.0	74.3	67.9
GASTROPOD LARVAE	70.3	65.5	56.5	55.0
HETEROPODA	0.0	0.0	0.0	0.0
PTEROPODA	0.0	4.4	0.0	0.0
CLADOCERA				
PENILIA	0.0	0.0	0.0	0.0
PODON	0.0	0.0	0.0	0.0
EUCONCHOECIA (OSTRACODA)	5.4	8.7	3.0	6.5
COPEPODA				
CALANOIDA	2581.2	2909.6	2539.4	1943.9
CYCLOPOIDA	487.0	511.1	508.5	410.8
HARPACTICOIDA	27.1	17.5	14.9	9.7
BARNACLE NAUPLII	0.0	4.4	5.9	0.0
BARNACLE CYPRIS	5.4	17.5	0.0	9.7
AMPHIPODA	10.8	0.0	5.9	0.0
CUMACEA	0.0	0.0	0.0	0.0
LUCIFER	0.0	0.0	0.0	0.0
MYSIDACEA	0.0	0.0	0.0	0.0
OTHER CRUSTACEANS	0.0	0.0	0.0	0.0
OTHER CRUSTACEAN LARVAE	10.8	4.4	3.0	3.2
ECHINODERM LARVAE	0.0	0.0	0.0	0.0
TORNARIA LARVAE	0.0	0.0	0.0	0.0
DOLIOLIDA	173.2	244.6	133.8	388.1
LARVACEA	416.7	284.0	205.2	291.1
FISH LARVAE	0.0	0.0	5.9	3.2
FISH EGGS	0.0	0.0	3.0	0.0
CHAETOGNATHA	48.7	39.3	59.5	64.7
OTHERS	0.0	0.0	0.0	0.0

Table II-1. (continued)

CRUISE/STATION/TOW	8/C/1	8/C/2	8/C/3	8/C/4
MEDUSAE	87.9	107.3	53.2	190.3
POLYCHAETE LARVAE	16.5	11.9	21.3	16.8
BIVALVE LARVAE	335.0	154.9	207.7	246.3
GASTROPOD LARVAE	43.9	41.7	21.3	33.6
HETEROPODA	0.0	6.0	0.0	5.6
PTEROPODA	0.0	0.0	0.0	0.0
CLADOCERA				
PENILIA	0.0	0.0	0.0	0.0
PODON	0.0	0.0	0.0	0.0
EUCONCHOECIA (OSTRACODA)	11.0	0.0	21.3	11.2
COPEPODA				
CALANOIDA	3712.2	5363.5	3439.8	4186.6
CYCLOPOIDA	867.7	774.7	670.9	917.9
HARPACTICOIDA	32.9	17.9	26.6	39.2
BARNACLE NAUPLII	60.4	71.5	74.5	72.8
BARNACLE CYPRIS	11.0	0.0	0.0	0.0
AMPHIPODA	11.0	11.9	0.0	0.0
CUMACEA	0.0	0.0	0.0	0.0
LUCIFER	0.0	0.0	0.0	0.0
MYSIDACEA	0.0	0.0	0.0	0.0
OTHER CRUSTACEANS	0.0	0.0	0.0	0.0
OTHER CRUSTACEAN LARVAE	11.0	6.0	0.0	11.2
ECHINODERM LARVAE	0.0	0.0	0.0	0.0
TORNARIA LARVAE	0.0	0.0	0.0	5.6
DOLIOLIDA	258.1	238.4	181.0	431.0
LARVACEA	461.3	268.2	234.3	285.4
FISH LARVAE	5.5	6.0	0.0	0.0
FISH EGGS	5.5	0.0	0.0	0.0
CHAETOGNATHA	76.9	47.7	47.9	50.4
OTHERS	0.0	0.0	0.0	0.0

Table II-1. (continued)

CRUISE/STATION/TOW	9/A/1	9/A/2	9/A/3	9/A/4
MEDUSAE	24.1	11.7	12.3	39.7
POLYCHAETE LARVAE	24.1	21.0	12.3	37.7
BIVALVE LARVAE	18.5	16.3	8.8	7.9
GASTROPOD LARVAE	18.5	7.0	12.3	6.0
HETEROPODA	0.0	0.0	0.0	0.0
PTEROPODA	11.1	7.0	1.8	0.0
CLADOCERA				
PENILIA	0.0	0.0	0.0	0.0
PODON	1.9	0.0	0.0	0.0
EUCONCHOECIA (OSTRACODA)	222.2	242.5	171.0	57.5
COPEPODA				
CALANOIDA	781.5	1114.7	997.8	1051.6
CYCLOPOIDA	566.7	583.0	542.9	678.6
HARPACTICOIDA	1.9	4.7	5.3	17.9
BARNACLE NAUPLII	5.6	9.3	14.1	2.0
BARNACLE CYPRIS	1.9	25.7	3.5	4.0
AMPHIPODA	5.6	28.0	12.3	17.9
CUMACEA	0.0	0.0	0.0	0.0
LUCIFER	0.0	0.0	0.0	0.0
MYSIDACEA	9.3	0.0	0.0	4.0
OTHER CRUSTACEANS	0.0	0.0	0.0	0.0
OTHER CRUSTACEAN LARVAE	25.9	9.3	5.3	15.9
ECHINODERM LARVAE	0.0	0.0	0.0	0.0
TORNARIA LARVAE	0.0	0.0	0.0	0.0
DOLIOLIDA	24.1	18.7	40.5	25.8
LARVACEA	253.7	233.2	283.8	515.9
FISH LARVAE	0.0	2.3	1.8	0.0
FISH EGGS	1.9	0.0	1.8	0.0
CHAETOGNATHA	155.6	195.9	192.1	353.2
OTHERS	0.0	0.0	0.0	0.0

Table II-1. (continued)

CRUISE/STATION/TOW	9/B/1	9/B/2	9/B/3	9/B/4
MEDUSAE	19.6	25.7	16.9	8.1
POLYCHAETE LARVAE	1.6	4.0	7.7	2.7
BIVALVE LARVAE	16.4	17.8	4.6	2.7
GASTROPOD LARVAE	11.5	11.9	4.6	4.1
HETEROPODA	0.0	0.0	0.0	0.0
PTEROPODA	1.6	0.0	0.0	0.0
CLADOCERA				
PENILIA	0.0	0.0	0.0	0.0
PODON	0.0	0.0	0.0	0.0
EUCONCHOECIA (OSTRACODA)	219.3	330.7	149.1	109.6
COPEPODA				
CALANOIDA	1157.1	1306.9	435.1	458.8
CYCLOPOIDA	669.4	681.2	375.2	664.5
HARPACTICOIDA	4.9	7.9	3.1	14.9
BARNACLE NAUPLII	11.5	2.0	4.6	1.4
BARNACLE CYPRIS	0.0	2.0	0.0	0.0
AMPHIPODA	8.2	7.9	9.2	16.2
CUMACEA	0.0	0.0	0.0	0.0
LUCIFER	0.0	0.0	0.0	0.0
MYSIDACEA	1.6	2.0	0.0	0.0
OTHER CRUSTACEANS	1.6	0.0	0.0	0.0
OTHER CRUSTACEAN LARVAE	16.4	21.8	7.7	16.2
ECHINODERM LARVAE	0.0	0.0	0.0	0.0
TORNARIA LARVAE	0.0	0.0	0.0	0.0
DOLIOLIDA	27.8	31.7	29.2	24.4
LARVACEA	581.0	742.6	367.5	420.9
FISH LARVAE	4.9	4.0	3.1	4.1
FISH EGGS	1.6	0.0	3.1	0.0
CHAETOGNATHA	63.8	69.3	30.8	39.2
OTHERS	4.9	0.0	4.6	0.0

Table II-1. (continued)

CRUISE/STATION/TOW	9/C/1	9/C/2	9/C/3	9/C/4
MEDUSAE	97.0	57.0	53.1	46.7
POLYCHAETE LARVAE	63.3	16.5	16.7	29.9
BIVALVE LARVAE	71.4	37.5	28.8	48.5
GASTROPOD LARVAE	18.9	6.0	4.6	9.3
HETEROPODA	0.0	0.0	0.0	0.0
PTEROPODA	0.0	0.0	0.0	1.9
CLADOCERA				
PENILIA	0.0	0.0	0.0	0.0
PODON	1.3	0.0	0.0	0.0
EUCONCHOECIA (OSTRACODA)	82.2	16.5	56.2	132.6
COPEPODA				
CALANOIDA	783.9	451.1	651.1	634.8
CYCLOPOIDA	1069.5	575.5	546.4	672.1
HARPACTICOIDA	20.2	18.0	9.1	14.9
BARNACLE NAUPLII	31.0	6.0	7.6	14.9
BARNACLE CYPRIS	6.7	3.0	4.6	3.7
AMPHIPODA	24.2	16.5	22.8	18.7
CUMACEA	0.0	0.0	0.0	0.0
LUCIFER	0.0	0.0	0.0	0.0
MYSIDACEA	4.0	0.0	3.0	7.5
OTHER CRUSTACEANS	0.0	0.0	0.0	0.0
OTHER CRUSTACEAN LARVAE	24.2	28.5	19.7	14.9
ECHINODERM LARVAE	0.0	0.0	0.0	0.0
TORNARIA LARVAE	0.0	0.0	0.0	0.0
DOLIOLIDA	156.3	130.4	63.7	76.5
LARVACEA	611.5	560.6	394.6	597.4
FISH LARVAE	4.0	3.0	3.0	1.9
FISH EGGS	0.0	0.0	0.0	0.0
CHAETOGNATHA	121.2	79.4	47.0	97.1
OTHERS	4.0	0.0	0.0	0.0

Table II-1. (continued)

CRUISE/STATION/TOW	10/A/1	10/A/2	10/A/3	10/A/4
MEDUSAE	58.9	24.6	126.5	11.7
POLYCHAETE LARVAE	521.3	430.7	447.7	62.5
BIVALVE LARVAE	45.3	28.7	48.7	39.1
GASTROPOD LARVAE	13.6	36.9	38.9	31.3
HETEROPODA	0.0	0.0	0.0	0.0
PTEROPODA	4.5	0.0	0.0	0.0
CLADOCERA				
PENILIA	0.0	0.0	0.0	0.0
PODON	86.1	110.8	77.9	70.3
EUCONCHOECIA (OSTRACODA)	117.9	139.5	126.5	105.5
COPEPODA				
CALANOIDA	2524.8	2567.8	2408.8	2625.0
CYCLOPOIDA	376.2	525.0	384.4	179.7
HARPACTICOIDA	27.2	16.4	19.5	0.0
BARNACLE NAUPLII	190.4	155.9	184.9	171.9
BARNACLE CYPRIS	136.0	110.8	189.8	31.3
AMPHIPODA	22.7	24.6	24.3	11.7
CUMACEA	0.0	0.0	0.0	0.0
LUCIFER	0.0	0.0	0.0	0.0
MYSIDACEA	0.0	0.0	0.0	0.0
OTHER CRUSTACEANS	0.0	0.0	0.0	0.0
OTHER CRUSTACEAN LARVAE	77.1	57.4	68.1	35.2
ECHINODERM LARVAE	9.1	0.0	0.0	0.0
TORNARIA LARVAE	0.0	0.0	0.0	0.0
DOLIOLIDA	113.3	41.0	233.6	7.8
LARVACEA	997.2	652.2	880.8	335.9
FISH LARVAE	0.0	0.0	0.0	0.0
FISH EGGS	13.6	0.0	0.0	0.0
CHAETOGNATHA	648.2	660.4	700.7	328.1
OTHERS	4.5	4.1	0.0	3.9

Table II-1. (continued)

CRUISE/STATION/TOW	10/B/1	10/B/2	10/B/3	10/B/4
MEDUSAE	51.1	24.6	25.7	32.8
POLYCHAETE LARVAE	201.6	154.7	286.8	135.2
BIVALVE LARVAE	34.1	21.1	40.4	32.8
GASTROPOD LARVAE	45.4	21.1	51.5	16.4
HETEROPODA	0.0	0.0	0.0	0.0
PTEROPODA	0.0	0.0	3.7	0.0
CLADOCERA				
PENILIA	0.0	0.0	0.0	0.0
PODON	59.6	66.8	110.3	266.4
EUCONCHOECIA (OSTRACODA)	156.2	147.7	110.3	217.2
COPEPODA				
CALANOIDA	1527.7	1417.0	1444.9	1307.4
CYCLOPOIDA	366.3	291.8	367.6	262.3
HARPACTICOIDA	5.7	3.5	11.0	8.2
BARNACLE NAUPLII	36.9	38.7	95.6	90.2
BARNACLE CYPRIS	110.7	193.4	95.6	16.4
AMPHIPODA	2.8	21.1	11.0	0.0
CUMACEA	0.0	0.0	0.0	0.0
LUCIFER	0.0	0.0	0.0	0.0
MYSIDACEA	0.0	0.0	0.0	4.1
OTHER CRUSTACEANS	0.0	0.0	0.0	0.0
OTHER CRUSTACEAN LARVAE	99.4	70.3	99.3	53.3
ECHINODERM LARVAE	0.0	0.0	0.0	0.0
TORNARIA LARVAE	0.0	0.0	3.7	0.0
DOLIOLIDA	56.8	17.6	95.6	24.6
LARVACEA	860.4	727.8	900.7	1143.4
FISH LARVAE	0.0	7.0	3.7	8.2
FISH EGGS	0.0	0.0	0.0	0.0
CHAETOGNATHA	570.8	488.7	496.3	811.5
OTHERS	0.0	17.6	18.4	4.1

Table II-1. (continued)

CRUISE/STATION/TOW	10/C/1	10/C/2	10/C/3	10/C/4
MEDUSAE	32.7	63.6	144.9	63.9
POLYCHAETE LARVAE	364.1	250.5	181.2	213.1
BIVALVE LARVAE	32.7	33.6	64.4	21.3
GASTROPOD LARVAE	46.7	48.6	36.2	42.6
HETEROPODA	0.0	0.0	0.0	0.0
PTEROPODA	0.0	3.7	0.0	0.0
CLADOCERA				
PENILIA	0.0	0.0	0.0	5.3
PODON	32.7	7.5	8.1	16.0
EUCONCHOECIA (OSTRACODA)	228.7	115.9	205.3	85.2
COPEPODA				
CALANOIDA	3440.1	2231.8	2149.8	2946.0
CYCLOPOIDA	345.4	358.9	390.5	213.1
HARPACTICOIDA	4.7	15.0	8.1	10.7
BARNACLE NAUPLII	144.7	37.4	48.3	26.6
BARNACLE CYPRIS	112.0	145.8	120.8	58.6
AMPHIPODA	23.3	18.7	20.1	16.0
CUMACEA	0.0	0.0	4.0	0.0
LUCIFER	4.7	0.0	0.0	0.0
MYSIDACEA	0.0	0.0	0.0	0.0
OTHER CRUSTACEANS	0.0	71.0	0.0	0.0
OTHER CRUSTACEAN LARVAE	79.4	86.0	52.3	63.9
ECHINODERM LARVAE	0.0	0.0	0.0	0.0
TORNARIA LARVAE	284.7	302.8	132.9	154.5
DOLIOLIDA	51.3	82.2	84.5	63.9
LARVACEA	886.9	512.1	805.2	1267.9
FISH LARVAE	0.0	0.0	4.0	0.0
FISH EGGS	9.3	3.7	0.0	0.0
CHAETOGNATHA	546.1	441.1	467.0	484.8
OTHERS	0.0	0.0	0.0	0.0

Table II-2. Mean densities (#/m^3) of the copepod species (adult females) identified from the three cruises made during the intensive study period. Mean values from three subsamples are listed for each tow taken at the three stations (A,B,C) near the diffuser.

CRUISE/STATION/TOW	8/A/1	8/A/2	8/A/3	8/A/4
CALANOIDA				
ACARTIA TONSA	5.7	41.7	30.9	17.9
ACROCALANUS LONGICORNIS	0.0	0.0	0.0	0.0
ANOMALOCERA ORNATA	0.0	0.0	7.7	0.0
CALANOID A	0.0	0.0	0.0	0.0
CENTROPAGES HAMATUS	0.0	9.3	0.0	8.0
CENTROPAGES VELIFICATUS	11.4	9.3	0.0	6.0
CLAUSOCALANUS FURCATUS	11.4	4.6	3.9	4.0
CLAUSOCALANUS JOBEI	34.2	23.1	7.7	4.0
EUCALANUS PILEATUS	5.7	13.9	3.9	0.0
EUCHAETA PARACONCINNA	5.7	0.0	0.0	0.0
LABIDOCERA AESTIVA	0.0	27.8	19.3	2.0
LUCICUTIA PARACLAUSI	0.0	0.0	0.0	0.0
NANNOCALANUS MINOR	11.4	0.0	0.0	2.0
PARACALANUS ACULEATUS	0.0	0.0	0.0	0.0
PARACALANUS CRASSIROSTRIS	0.0	0.0	0.0	4.0
PARACALANUS INDICUS	0.0	4.6	15.4	8.0
PARACALANUS QUASIMODO	1113.0	1467.6	1215.3	471.0
PARUNDINELLA SPINODENTICULA	0.0	0.0	0.0	0.0
STEPHOS DEICHMANNAE	0.0	0.0	0.0	0.0
TEMORA STYLIFERA	0.0	0.0	0.0	2.0
TEMORA TURBINATA	11.4	13.9	7.7	11.9
CYCLOPOIDA				
CORYCAEUS AMAZONICUS	11.4	13.9	3.9	6.0
CORYCAEUS AMERICANUS	142.7	208.3	57.9	49.7
CORYCAEUS GIESBRECHTI	0.0	0.0	0.0	0.0
LICHOLMOLGOIDEA	0.0	0.0	0.0	0.0
OITHONA COLCARVA	0.0	0.0	0.0	0.0
OITHONA NANA	17.1	13.9	3.9	0.0
OITHONA PLUMIFERA	17.1	9.3	0.0	0.0
OITHONA SPP	0.0	0.0	0.0	0.0
ONCAEA CONIFERA	0.0	0.0	0.0	0.0
ONCAEA MEDIA	5.7	4.6	0.0	4.0
ONCAEA MEDITERRANEA	0.0	4.6	0.0	0.0
ONCAEA VENUSTA	22.8	23.1	27.0	91.4
SAPPHIRINA NIGROMACULATA	0.0	0.0	0.0	0.0
SAPPHIRINA SPP	0.0	0.0	0.0	0.0

Table II-2. (continued)

CRUISE/STATION/TOW	8/B/1	8/B/2	8/B/3	8/B/4
CALANOIDA				
ACARTIA TONSA	5.4	8.7	26.8	12.9
ACROCALANUS LONGICORNIS	0.0	0.0	0.0	0.0
ANOMALOCERA ORNATA	0.0	0.0	0.0	0.0
CALANOID A	0.0	4.4	0.0	0.0
CENTROPAGES HAMATUS	0.0	0.0	5.9	6.5
CENTROPAGES VELIFICATUS	5.4	4.4	3.0	0.0
CLAUSOCALANUS FURCATUS	5.4	4.4	0.0	3.2
CLAUSOCALANUS JOBEI	32.5	13.1	20.8	16.2
EUCALANUS PILEATUS	0.0	4.4	14.9	0.0
EUCHAETA PARACONCINNA	0.0	0.0	0.0	3.2
LABIDOCERA AESTIVA	0.0	4.4	0.0	0.0
LUCICUTIA PARACLAUSI	0.0	0.0	0.0	0.0
NANNOCALANUS MINOR	5.4	13.1	0.0	0.0
PARACALANUS ACULEATUS	0.0	0.0	0.0	0.0
PARACALANUS CRASSIROSTRIS	0.0	0.0	0.0	0.0
PARACALANUS INDICUS	5.4	8.7	0.0	0.0
PARACALANUS QUASIMODO	1612.6	1935.3	1457.0	1235.5
PARUNDINELLA SPINODENTICULA	0.0	0.0	0.0	0.0
STEPHOS DEICHMANNAE	0.0	0.0	0.0	0.0
TEMORA STYLIFERA	0.0	0.0	3.0	0.0
TEMORA TURBINATA	37.9	39.3	35.7	19.4
CYCLOPOIDA				
CORYCAEUS AMAZONICUS	5.4	17.5	8.9	12.9
CORYCAEUS AMERICANUS	54.1	74.3	65.4	74.4
CORYCAEUS GIESBRECHTI	0.0	0.0	3.0	0.0
LICHOLMOLGOIDEA	0.0	0.0	0.0	0.0
OITHONA COLCARVA	0.0	4.4	0.0	0.0
OITHONA NANA	0.0	4.4	11.9	3.2
OITHONA PLUMIFERA	0.0	0.0	0.0	0.0
OITHONA SPP	0.0	0.0	0.0	0.0
ONCAEA CONIFERA	0.0	0.0	0.0	0.0
ONCAEA MEDIA	5.4	4.4	8.9	0.0
ONCAEA MEDITERRANEA	0.0	4.4	29.7	0.0
ONCAEA VENUSTA	43.3	34.9	23.8	32.3
SAPPHIRINA NIGROMACULATA	0.0	0.0	0.0	0.0
SAPPHIRINA SPP	0.0	0.0	0.0	0.0

Table II-2. (continued)

CRUISE/STATION/TOW	8/C/1	8/C/2	8/C/3	8/C/4
CALANOIDA				
ACARTIA TONSA	11.0	6.0	0.0	11.2
ACROCALANUS LONGICORNIS	0.0	0.0	0.0	0.0
ANOMALOCERA ORNATA	0.0	0.0	0.0	0.0
CALANOID A	0.0	0.0	0.0	0.0
CENTROPAGES HAMATUS	0.0	6.0	10.6	0.0
CENTROPAGES VELIFICATUS	5.5	0.0	0.0	0.0
CLAUSOCALANUS FURCATUS	0.0	0.0	5.3	5.6
CLAUSOCALANUS JOBEI	16.5	41.7	0.0	28.0
EUCALANUS PILEATUS	5.5	11.9	0.0	0.0
EUCHAETA PARACONCINNA	0.0	0.0	0.0	5.6
LABIDOCERA AESTIVA	0.0	0.0	0.0	0.0
LUCICUTIA PARACLAUSI	0.0	0.0	0.0	0.0
NANNOCALANUS MINOR	0.0	0.0	0.0	11.2
PARACALANUS ACULEATUS	0.0	0.0	0.0	0.0
PARACALANUS CRASSIROSTRIS	0.0	0.0	0.0	0.0
PARACALANUS INDICUS	0.0	47.7	26.6	0.0
PARACALANUS QUASIMODO	2240.5	3385.0	2087.3	2311.6
PARUNDINELLA SPINODENTICULA	0.0	0.0	0.0	0.0
STEPHOS DEICHMANNAE	0.0	0.0	0.0	0.0
TEMORA STYLIFERA	5.5	0.0	0.0	0.0
TEMORA TURBINATA	49.4	83.4	21.3	39.2
CYCLOPOIDA				
CORYCAEUS AMAZONICUS	16.5	6.0	10.6	11.2
CORYCAEUS AMERICANUS	181.2	89.4	138.4	218.3
CORYCAEUS GIESBRECHTI	0.0	0.0	0.0	0.0
LICHOLMOLGOIDEA	0.0	0.0	0.0	0.0
OITHONA COLCARVA	0.0	0.0	0.0	0.0
OITHONA NANA	16.5	23.8	10.6	22.4
OITHONA PLUMIFERA	0.0	0.0	0.0	5.6
OITHONA SPP	0.0	0.0	0.0	0.0
ONCAEA CONIFERA	0.0	0.0	0.0	0.0
ONCAEA MEDIA	0.0	0.0	0.0	0.0
ONCAEA MEDITERRANEA	5.5	6.0	5.3	0.0
ONCAEA VENUSTA	32.9	41.7	10.6	11.2
SAPPHIRINA NIGROMACULATA	0.0	0.0	0.0	0.0
SAPPHIRINA SPP	0.0	0.0	0.0	0.0

Table II-2.(continued)

CRUISE/STATION/TOW	9/A/1	9/A/2	9/A/3	9/A/4
CALANOIDA				
ACARTIA TONSA	220.4	207.6	230.9	339.3
ACROCALANUS LONGICORNIS	0.0	0.0	0.0	0.0
ANOMALOCERA ORNATA	0.0	0.0	0.0	0.0
CALANOID A	0.0	0.0	0.0	0.0
CENTROPAGES HAMATUS	16.7	32.6	19.4	19.8
CENTROPAGES VELIFICATUS	0.0	4.7	1.8	0.0
CLAUSOCALANUS FURCATUS	0.0	2.3	3.5	2.0
CLAUSOCALANUS JOBEI	7.4	4.7	5.3	7.9
EUCALANUS PILEATUS	37.0	21.0	14.1	17.9
EUCHAETA PARACONCINNA	1.9	0.0	0.0	0.0
LABIDOCERA AESTIVA	3.7	4.7	3.5	11.9
LUCICUTIA PARACLAUSI	7.4	4.7	1.8	0.0
NANNOCALANUS MINOR	5.6	0.0	0.0	0.0
PARACALANUS ACULEATUS	0.0	0.0	0.0	0.0
PARACALANUS CRASSIROSTRIS	1.9	0.0	1.8	0.0
PARACALANUS INDICUS	3.7	4.7	7.1	0.0
PARACALANUS QUASIMODO	161.1	312.5	232.7	162.7
PARUNDINELLA SPINODENTICULA	0.0	0.0	0.0	0.0
STEPHOS DEICHMANNAE	0.0	0.0	1.8	0.0
TEMORA STYLIFERA	3.7	2.3	5.3	0.0
TEMORA TURBINATA	7.4	25.7	28.2	23.8
CYCLOPOIDA				
CORYCAEUS AMAZONICUS	7.4	11.7	17.6	11.9
CORYCAEUS AMERICANUS	27.8	37.3	22.9	17.9
CORYCAEUS GIESBRECHTI	1.9	2.3	0.0	2.0
LICHOLMOLGOIDEA	0.0	0.0	0.0	0.0
OITHONA COLCARVA	0.0	0.0	0.0	0.0
OITHONA NANA	3.7	2.3	1.8	2.0
OITHONA PLUMIFERA	0.0	0.0	0.0	0.0
OITHONA SPP	0.0	0.0	0.0	0.0
ONCAEA CONIFERA	0.0	2.3	0.0	0.0
ONCAEA MEDIA	9.3	2.3	0.0	0.0
ONCAEA MEDITERRANEA	57.4	16.3	17.6	15.9
ONCAEA VENUSTA	25.9	16.3	7.1	9.9
SAPPHIRINA NIGROMACULATA	0.0	0.0	0.0	0.0
SAPPHIRINA SPP	0.0	0.0	0.0	0.0

Table II-2. (continued)

CRUISE/STATION/TOW	9/B/1	9/B/2	9/B/3	9/B/4
CALANOIDA				
ACARTIA TONSA	39.3	51.5	26.1	75.8
ACROCALANUS LONGICORNIS	0.0	0.0	0.0	0.0
ANOMALOCERA ORNATA	0.0	0.0	1.5	1.4
CALANOID A	0.0	0.0	0.0	0.0
CENTROPAGES HAMATUS	6.5	2.0	4.6	1.4
CENTROPAGES VELIFICATUS	1.6	4.0	3.1	4.1
CLAUSOCALANUS FURCATUS	3.3	2.0	4.6	0.0
CLAUSOCALANUS JOBEI	3.3	4.0	1.5	2.7
EUCALANUS PILEATUS	16.4	43.6	10.8	28.4
EUCHAETA PARACONCINNA	0.0	0.0	0.0	1.4
LABIDOCERA AESTIVA	0.0	0.0	0.0	0.0
LUCICUTIA PARACLAUSI	0.0	2.0	0.0	0.0
NANNOCALANUS MINOR	0.0	4.0	1.5	0.0
PARACALANUS ACULEATUS	0.0	0.0	0.0	0.0
PARACALANUS CRASSIROSTRIS	0.0	0.0	0.0	0.0
PARACALANUS INDICUS	9.8	4.0	3.1	0.0
PARACALANUS QUASIMODO	473.0	534.7	176.8	73.1
PARUNDINELLA SPINODENTICULA	0.0	0.0	0.0	0.0
STEPHOS DEICHMANNAE	0.0	0.0	0.0	0.0
TEMORA STYLIFERA	3.3	0.0	3.1	1.4
TEMORA TURBINATA	16.4	13.9	10.8	25.7
CYCLOPOIDA				
CORYCAEUS AMAZONICUS	16.4	9.9	9.2	8.1
CORYCAEUS AMERICANUS	65.5	41.6	26.1	47.4
CORYCAEUS GIESBRECHTI	0.0	0.0	0.0	1.4
LICHOLMOLGOIDEA	0.0	0.0	0.0	0.0
OITHONA COLCARVA	0.0	0.0	0.0	0.0
OITHONA NANA	0.0	2.0	4.6	2.7
OITHONA PLUMIFERA	0.0	0.0	0.0	0.0
OITHONA SPP	0.0	0.0	0.0	0.0
ONCAEA CONIFERA	0.0	4.0	0.0	0.0
ONCAEA MEDIA	0.0	0.0	3.1	2.7
ONCAEA MEDITERRANEA	18.0	27.7	26.1	4.1
ONCAEA VENUSTA	13.1	11.9	9.2	4.1
SAPPHIRINA NIGROMACULATA	1.6	2.0	0.0	0.0
SAPPHIRINA SPP	0.0	0.0	0.0	0.0

Table II-2. (continued)

CRUISE/STATION/TOW	9/C/1	9/C/2	9/C/3	9/C/4
CALANOIDA				
ACARTIA TONSA	56.6	15.0	22.8	39.2
ACROCALANUS LONGICORNIS	0.0	0.0	0.0	0.0
ANOMALOCERA ORNATA	0.0	0.0	1.5	0.0
CALANOID A	0.0	0.0	0.0	0.0
CENTROPAGES HAMATUS	6.7	9.0	24.3	3.7
CENTROPAGES VELIFICATUS	6.7	1.5	3.0	0.0
CLAUSOCALANUS FURCATUS	0.0	0.0	3.0	0.0
CLAUSOCALANUS JOBEI	0.0	0.0	0.0	0.0
EUCALANUS PILEATUS	33.7	12.0	21.2	41.1
EUCHAETA PARACONCINNA	1.3	3.0	0.0	0.0
LABIDOCERA AESTIVA	0.0	0.0	0.0	0.0
LUCICUTIA PARACLAUSI	1.3	1.5	0.0	1.9
NANNOCALANUS MINOR	1.3	0.0	1.5	0.0
PARACALANUS ACULEATUS	2.7	0.0	0.0	0.0
PARACALANUS CRASSIROSTRIS	1.3	0.0	0.0	0.0
PARACALANUS INDICUS	0.0	4.5	10.6	3.7
PARACALANUS QUASIMODO	148.2	94.4	132.0	97.1
PARUNDINELLA SPINODENTICULA	0.0	0.0	0.0	0.0
STEPHOS DEICHMANNAE	0.0	0.0	0.0	0.0
TEMORA STYLIFERA	2.7	0.0	0.0	0.0
TEMORA TURBINATA	28.3	24.0	27.3	29.9
CYCLOPOIDA				
CORYCAEUS AMAZONICUS	31.0	9.0	16.7	13.1
CORYCAEUS AMERICANUS	177.8	83.9	69.8	112.0
CORYCAEUS GIESBRECHTI	0.0	0.0	0.0	0.0
LICHOLMOLGOIDEA	0.0	0.0	0.0	0.0
OITHONA COLCARVA	0.0	0.0	0.0	0.0
OITHONA NANA	1.3	6.0	1.5	5.6
OITHONA PLUMIFERA	5.4	3.0	0.0	3.7
OITHONA SPP	2.7	0.0	0.0	1.9
ONCAEA CONIFERA	0.0	0.0	0.0	0.0
ONCAEA MEDIA	2.7	0.0	1.5	1.9
ONCAEA MEDITERRANEA	8.1	1.5	4.6	0.0
ONCAEA VENUSTA	5.4	3.0	0.0	5.6
SAPPHIRINA NIGROMACULATA	0.0	0.0	0.0	0.0
SAPPHIRINA SPP	0.0	0.0	56.2	0.0

Table II-2.(continued)

CRUISE/STATION/TOW	10/A/1	10/A/2	10/A/3	10/A/4
CALANOIDA				
ACARTIA TONSA	716.2	771.2	768.9	890.6
ACROCALANUS LONGICORNIS	0.0	0.0	0.0	0.0
ANOMALOCERA ORNATA	0.0	0.0	0.0	0.0
CALANOID A	0.0	0.0	0.0	0.0
CENTROPACES HAMATUS	36.3	36.9	24.3	43.0
CENTROPAGES VELIFICATUS	9.1	12.3	29.2	3.9
CLAUSOCALANUS FURCATUS	4.5	0.0	4.9	3.9
CLAUSOCALANUS JOBEI	0.0	8.2	4.9	7.8
EUCALANUS PILEATUS	9.1	4.1	4.9	0.0
EUCHAETA PARACONCINNA	0.0	0.0	0.0	0.0
LABIDOCERA AESTIVA	0.0	0.0	0.0	0.0
LUCICUTIA PARACLAUSI	0.0	0.0	0.0	0.0
NANNOCALANUS MINOR	0.0	0.0	0.0	0.0
PARACALANUS ACULEATUS	0.0	8.2	0.0	0.0
PARACALANUS CRASSIROSTRIS	0.0	0.0	0.0	3.9
PARACALANUS INDICUS	36.3	36.9	9.7	0.0
PARACALANUS QUASIMODO	661.8	713.7	608.3	855.5
PARUNDINELLA SPINODENTICULA	0.0	0.0	0.0	0.0
STEPHOS DEICHMANNAE	0.0	0.0	0.0	0.0
TEMORA STYLIFERA	4.5	4.1	0.0	0.0
TEMORA TURBINATA	18.1	16.4	4.9	7.8
CYCLOPOIDA				
CORYCAEUS AMAZONICUS	40.8	77.9	48.7	35.2
CORYCAEUS AMERICANUS	68.0	77.9	53.5	7.8
CORYCAEUS GIESBRECHTI	0.0	0.0	0.0	0.0
LICHOLMOLGOIDEA	0.0	0.0	0.0	0.0
OITHONA COLCARVA	0.0	0.0	0.0	0.0
OITHONA NANA	0.0	8.2	0.0	0.0
OITHONA PLUMIFERA	13.6	4.1	9.7	0.0
OITHONA SPP	0.0	8.2	0.0	0.0
ONCAEA CONIFERA	0.0	0.0	0.0	0.0
ONCAEA MEDIA	13.6	16.4	19.5	0.0
ONCAEA MEDITERRANEA	0.0	0.0	0.0	0.0
ONCAEA VENUSTA	0.0	0.0	0.0	0.0
SAPPHIRINA NIGROMACULATA	0.0	0.0	0.0	0.0
SAPPHIRINA SPP	0.0	0.0	0.0	0.0

Table II-2. (continued)

CRUISE/STATION/TOW	10/B/1	10/B/2	10/B/3	10/B/4
CALANOIDA				
ACARTIA TONSA	275.4	228.6	176.5	254.1
ACROCALANUS LONGICORNIS	2.8	0.0	0.0	0.0
ANOMALOCERA ORNATA	0.0	0.0	0.0	0.0
CALANOID A	0.0	0.0	0.0	0.0
CENTROPAGES HAMATUS	11.4	7.0	3.7	8.2
CENTROPAGES VELIFICATUS	17.0	35.2	25.7	8.2
CLAUSOCALANUS FURCATUS	0.0	0.0	0.0	0.0
CLAUSOCALANUS JOBEI	2.8	0.0	0.0	4.1
EUCALANUS PILEATUS	2.8	0.0	0.0	4.1
EUCHAETA PARACONCINNA	0.0	0.0	0.0	0.0
LABIDOCERA AESTIVA	0.0	0.0	0.0	0.0
LUCICUTIA PARACLAUSI	0.0	0.0	0.0	0.0
NANNOCALANUS MINOR	0.0	0.0	0.0	0.0
PARACALANUS ACULEATUS	0.0	0.0	7.4	0.0
PARACALANUS CRASSIROSTRIS	0.0	0.0	0.0	8.2
PARACALANUS INDICUS	19.9	7.0	47.8	4.1
PARACALANUS QUASIMODO	369.2	355.1	316.2	323.8
PARUNDINELLA SPINODENTICULA	0.0	0.0	3.7	0.0
STEPHOS DEICHMANNAE	2.8	3.5	0.0	0.0
TEMORA STYLIFERA	5.7	0.0	0.0	0.0
TEMORA TURBINATA	28.4	10.5	22.1	20.5
CYCLOPOIDA				
CORYCAEUS AMAZONICUS	34.1	28.1	44.1	16.4
CORYCAEUS AMERICANUS	59.6	28.1	66.2	16.4
CORYCAEUS GIESBRECHTI	0.0	0.0	0.0	0.0
LICHOLMOLGOIDEA	0.0	0.0	0.0	0.0
OITHONA COLCARVA	0.0	0.0	3.7	4.1
OITHONA NANA	5.7	0.0	3.7	4.1
OITHONA PLUMIFERA	0.0	14.1	0.0	12.3
OITHONA SPP	0.0	0.0	0.0	0.0
ONCAEA CONIFERA	0.0	0.0	0.0	0.0
ONCAEA MEDIA	19.9	7.0	40.4	4.1
ONCAEA MEDITERRANEA	0.0	3.5	0.0	0.0
ONCAEA VENUSTA	0.0	0.0	0.0	0.0
SAPPHIRINA NIGROMACULATA	0.0	0.0	0.0	0.0
SAPPHIRINA SPP	0.0	0.0	0.0	0.0

Table II-2.(continued)

CRUISE/STATION/TOW	10/C/1	10/C/2	10/C/3	10/C/4
CALANOIDA				
ACARTIA TONSA	980.2	459.8	350.2	756.5
ACROCALANUS LONGICORNIS	0.0	0.0	0.0	0.0
ANOMALOCERA ORNATA	0.0	0.0	0.0	0.0
CALANOID A	0.0	0.0	0.0	0.0
CENTROPAGES HAMATUS	14.0	11.2	24.2	26.6
CENTROPAGES VELIFICATUS	14.0	11.2	16.1	5.3
CLAUSOCALANUS FURCATUS	4.7	3.7	0.0	5.3
CLAUSOCALANUS JOBEI	0.0	7.5	8.1	0.0
EUCALANUS PILEATUS	0.0	15.0	4.0	10.7
EUCHAETA PARACONCINNA	0.0	0.0	0.0	0.0
LABIDOCERA AESTIVA	0.0	0.0	0.0	0.0
LUCICUTIA PARACLAUSI	0.0	0.0	0.0	0.0
NANNOCALANUS MINOR	0.0	0.0	0.0	0.0
PARACALANUS ACULEATUS	0.0	0.0	4.0	0.0
PARACALANUS CRASSIROSTRIS	4.7	0.0	4.0	0.0
PARACALANUS INDICUS	28.0	22.4	28.2	0.0
PARACALANUS QUASIMODO	742.2	628.0	704.5	1225.3
PARUNDINELLA SPINODENTICULA	0.0	0.0	0.0	0.0
STEPHOS DEICHMANNAE	0.0	0.0	0.0	0.0
TEMORA STYLIFERA	0.0	3.7	20.1	5.3
TEMORA TURBINATA	14.0	11.2	16.1	16.0
CYCLOPOIDA				
CORYCAEUS AMAZONICUS	28.0	33.6	48.3	26.6
CORYCAEUS AMERICANUS	32.7	59.8	60.4	32.0
CORYCAEUS GIESBRECHTI	0.0	0.0	0.0	0.0
LICHOLMOLGOIDEA	0.0	0.0	4.0	0.0
OITHONA COLCARVA	0.0	0.0	0.0	0.0
OITHONA NANA	4.7	0.0	0.0	0.0
OITHONA PLUMIFERA	18.7	3.7	16.1	10.7
OITHONA SPP	9.3	3.7	0.0	0.0
ONCAEA CONIFERA	0.0	0.0	0.0	0.0
ONCAEA MEDIA	14.0	3.7	12.1	10.7
ONCAEA MEDITERRANEA	0.0	0.0	0.0	0.0
ONCAEA VENUSTA	0.0	0.0	0.0	0.0
SAPPHIRINA NIGROMACULATA	0.0	0.0	0.0	0.0
SAPPHIRINA SPP	0.0	0.0	0.0	0.0

APPENDIX III

BRIMS DATA

Table III-1. BRIMS data for 3/10/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
1630	0.00	14.32	43.88	14.32	41.43	16.11	1014	8.9	186.0	0.000
1700	0.00	16.11	44.70	14.32	41.43	12.54	1014	6.3	183.0	2.960
1730	0.00	16.11	43.88	14.32	42.25	16.11	1014	8.1	194.0	1.680
1800	0.00	16.11	43.06	16.11	44.70	14.32	1021	10.8	186.0	3.140
2030	0.00	14.32	43.88	14.32	43.06	17.89	1014	10.8	177.0	1.680
2130	0.00	16.11	43.06	14.32	41.43	16.11	1014	9.9	186.0	1.680

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-2. BRIMS data for 3/11/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	45.51	16.11	43.88	14.32	42.25	14.32	1014	0.0	211.0	1.680
0400	46.33	14.32	43.99	14.32	43.06	19.68	1014	0.0	307.0	0.000
0501	45.51	14.32	43.88	14.32	40.61	12.54	1014	0.0	301.0	0.000
0600	45.51	16.11	43.06	14.32	40.61	10.75	1014	0.0	138.0	0.000
0930	45.51	16.11	43.88	16.11	40.61	10.75	1014	1.8	90.4	2.052
1000	44.70	16.11	43.06	14.32	42.25	12.57	1014	0.0	73.5	1.870
1034	45.51	14.32	43.88	14.32	44.70	17.89	1014	5.4	39.7	2.052
1104	46.33	16.11	43.88	14.32	43.06	17.89	1014	6.3	51.0	2.052
1130	45.51	16.11	43.88	14.32	43.06	14.32	1014	7.2	82.0	1.870
1200	46.33	16.11	43.88	14.32	39.79	12.54	1014	11.6	104.5	2.590
1230	45.51	16.11	43.88	14.32	40.61	10.75	1014	3.5	107.0	2.590
1300	45.51	16.11	43.88	14.32	43.88	17.89	1014	8.1	121.4	2.230
1400	45.51	14.32	43.88	14.32	41.43	16.11	1014	5.3	81.9	1.320
1500	45.51	14.32	44.70	14.32	40.61	12.54	1014	7.2	76.3	1.140
1600	46.33	16.11	43.88	14.32	41.43	10.75	1014	6.3	56.6	1.870
1700	45.51	16.11	43.88	16.11	43.88	17.89	1014	8.9	81.9	1.680
1800	45.51	16.11	43.06	14.32	40.61	10.75	1021	8.9	90.4	1.870
1900	46.33	16.11	43.88	14.32	42.25	16.11	1021	9.8	107.0	1.680
2000	46.33	16.11	43.88	16.11	42.25	12.54	1021	12.5	101.0	1.500
2030	45.51	14.32	43.88	14.32	44.70	17.89	1021	9.8	101.0	0.230

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-3. BRIMS data for 3/12/80.

	SENSOR #1		SENSOR #2		SENSOR #3		BAR	WIND	WIND	FLOW
TIME	COND.	TEMP.	COND.	TEMP.	COND.	TEMP.	PRES	VEL.	DIR.	X
0230	0.00	14.32	44.70	14.32	43.06	16.11	1014	0.0	124.0	2.416
1000	45.51	16.11	43.88	14.32	40.61	10.75	1014	0.0	219.0	1.870
1100	44.70	14.32	43.06	16.11	41.43	16.11	1014	4.5	183.0	1.325
1200	45.51	14.32	43.88	14.32	62.25	17.89	1014	3.6	203.0	0.415
1430	46.33	16.11	43.88	14.32	41.43	12.54	1014	6.3	200.0	-.310
1530	45.51	14.32	43.88	14.32	42.25	14.32	1014	6.3	203.0	1.680
1700	44.70	14.32	43.06	14.32	42.25	12.54	1014	9.9	211.0	1.500
1800	46.33	14.32	43.88	14.32	43.88	16.11	1021	9.9	217.0	2.050
1900	45.51	14.32	43.88	14.32	42.25	14.32	1021	7.2	197.0	2.230
2000	45.51	14.32	43.06	14.32	43.88	17.89	1021	6.3	222.0	2.050
2100	45.51	16.11	43.88	14.32	43.88	17.89	1014	2.7	231.0	2.050
2200	45.51	14.32	43.88	14.32	43.06	16.11	1014	4.5	236.0	1.870
2300	45.51	16.11	44.70	14.32	42.25	17.89	1014	4.5	231.0	1.680
2400	45.51	14.32	43.88	14.32	43.06	17.89	1014	5.4	208.0	1.320

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-4. BRIMS data for 3/13/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0300	45.51	14.32	43.06	14.32	40.61	12.54	1014	4.5	214.0	1.325
0100	45.51	16.11	43.06	14.32	42.25	12.54	1014	6.3	225.0	1.506
0200	45.51	14.32	43.06	14.32	40.61	10.75	1014	3.6	245.0	1.506
0300	45.51	14.32	43.88	14.32	40.61	14.32	1021	12.6	284.0	1.325
0400	46.33	16.11	43.88	14.32	40.61	10.75	1021	14.4	326.0	1.506
0500	45.51	14.32	43.88	14.32	43.88	17.89	1021	18.0	329.0	1.506
0730	46.33	14.32	43.88	14.32	39.79	12.54	1021	19.7	348.0	1.506
0800	46.33	16.11	43.88	14.32	41.43	12.54	1021	25.1	340.0	1.506
0900	46.33	14.32	43.88	16.11	40.61	14.32	1021	10.8	0.3	1.506
1000	46.33	16.11	43.88	14.32	43.88	16.11	1021	11.7	0.3	1.506
1100	46.33	14.32	43.88	14.32	43.88	17.89	1021	10.8	0.8	1.325
1200	46.33	14.32	43.88	14.32	43.88	17.89	1021	10.8	5.9	1.325
	46.33	16.11	43.06	14.32	42.25	14.32	1021	0.0	36.9	1.870
	0.00	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0	0.000
	45.51	14.32	43.88	14.32	43.06	14.32	1014	6.2	22.8	1.506
	46.33	16.11	43.88	14.32	43.06	17.89	1014	1.7	3.1	1.506
	46.33	14.32	43.88	14.32	44.70	17.89	1014	0.0	312.8	1.506
	45.51	16.11	43.88	14.32	40.61	14.32	1014	1.7	295.0	1.325
	46.33	14.32	43.88	14.32	41.43	16.11	1014	5.3	338.0	1.506
	46.33	16.11	43.06	14.32	43.06	14.32	1014	6.2	11.5	1.506
	46.33	16.11	44.70	14.32	40.61	12.54	1021	16.5	39.7	1.506

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-5. BRIMS data for 3/14/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	46.33	14.32	43.88	14.32	41.43	12.54	1021	15.3	28.4	1.325
0200	46.33	16.11	44.70	14.32	40.61	12.54	1021	16.2	39.7	1.506
0300	45.51	16.11	44.70	14.32	41.43	12.54	1021	16.2	50.9	1.325
0400	46.33	16.11	43.88	14.32	40.61	12.54	1021	11.7	50.9	1.325
0500	46.33	14.32	43.88	14.32	40.61	14.32	1021	13.5	53.8	1.325
0600	46.33	14.32	44.70	14.32	42.25	17.89	1021	12.5	59.4	1.140
0700	46.33	14.32	43.88	14.32	41.43	16.11	1021	14.4	59.4	1.140
0800	46.33	14.32	43.88	14.32	40.61	10.75	1021	17.1	67.8	1.330
1400	46.33	16.11	44.70	14.32	43.06	16.11	1021	18.0	79.1	1.140
1430	46.33	14.32	44.70	14.32	40.61	12.54	1021	16.2	82.0	0.000
2200	45.51	16.11	43.06	14.32	38.97	12.54	1021	17.1	107.3	0.597
2400	45.51	14.32	43.06	14.32	39.79	12.54	1021	16.2	104.5	0.778

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-6. BRIMS data for 3/15/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0300	45.51	14.32	43.06	14.32	39.79	14.32	1021	16.2	110.1	0.778
0400	44.70	14.32	43.06	14.32	42.25	17.89	1021	12.6	107.3	0.778
0500	44.70	14.32	42.25	16.11	39.79	12.54	1021	13.5	104.5	0.961
0600	44.70	14.32	42.25	12.54	42.25	12.54	1021	9.9	96.1	0.778
0700	44.70	14.32	42.25	14.32	38.97	12.54	1021	8.1	90.4	0.597
0800	44.70	14.32	42.25	14.32	38.97	12.54	1014	9.9	101.7	0.778
0900	0.00	0.00	42.25	0.00	40.61	16.11	1028	5.4	20.0	0.778
1000	43.88	14.32	42.25	14.32	41.43	16.11	1021	9.9	67.8	0.778
1130	0.00	0.00	41.43	0.00	38.97	16.11	1028	6.3	28.4	0.597
1200	43.06	14.32	41.43	14.32	38.97	14.32	1021	10.8	73.5	0.778
1300	43.06	14.32	41.43	14.32	41.43	16.11	1021	11.7	67.8	0.778
1400	43.06	14.32	41.43	14.32	39.79	12.54	1021	13.5	76.3	0.961
1500	43.06	16.11	41.43	14.32	37.34	12.54	1021	12.6	79.1	0.778
1600	43.06	14.32	41.43	14.32	38.97	16.11	1021	11.7	819.6	0.778
1700	43.06	14.32	41.43	14.32	40.61	17.89	1021	9.9	89.7	0.778
1800	43.06	14.32	41.43	14.32	40.61	16.11	1021	11.7	93.2	0.597
2000	43.06	16.11	41.43	14.32	37.34	12.54	1021	11.7	101.7	0.961
2200	42.25	16.11	40.61	14.32	39.79	14.32	1021	12.6	104.5	0.778
2300	42.25	16.11	40.61	14.32	36.53	12.54	1021	14.4	104.5	0.597
2400	42.25	16.11	40.61	14.32	38.16	12.54	1021	10.8	115.7	0.961

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-7. BRIMS data for 3/16/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	42.25	16.11	39.79	14.32	37.34	10.75	1021	14.4	129.0	0.961
0200	42.25	16.11	39.79	14.32	38.16	14.32	1021	8.1	121.4	0.778
0300	42.25	14.32	39.79	14.32	38.97	16.11	1021	6.3	129.8	0.778
0400	41.43	16.11	39.79	14.32	38.16	14.32	1021	8.1	149.0	0.778
0500	40.61	14.32	38.97	14.32	38.16	14.32	1021	10.8	155.0	0.778
0600	41.43	14.32	40.61	14.32	38.16	16.11	1021	12.6	155.1	1.142
0700	43.06	16.11	40.61	14.32	38.61	16.11	1021	16.2	152.0	0.961
0800	42.25	16.11	39.79	16.11	36.53	16.11	1021	16.2	146.0	1.142
0900	42.25	16.11	39.79	14.32	38.16	16.11	1021	9.9	146.0	0.597
1000	41.43	16.11	39.79	14.32	37.34	12.54	1014	8.1	146.0	0.961
1100	42.25	14.32	0.00	14.32	38.16	14.32	1014	3.6	27.0	0.778
1200	41.43	14.32	39.79	14.32	37.34	12.54	1014	0.0	0.0	1.140
1400	43.06	14.32	40.61	14.32	37.34	12.54	1014	8.1	112.9	0.778
1500	42.25	16.11	39.79	14.32	38.16	12.54	1021	9.0	118.6	0.223
1600	42.25	14.32	40.61	14.32	38.97	14.32	1014	8.1	149.5	0.415
1700	42.25	14.32	40.61	14.32	38.97	16.11	1021	11.7	158.0	0.415
1800	42.25	14.32	40.61	14.32	39.79	16.11	1021	9.9	158.0	0.597
1900	43.88	14.32	40.61	14.32	37.34	12.54	1021	10.8	158.0	0.778
2000	43.06	16.11	40.61	14.32	36.53	14.32	1021	11.7	155.1	0.778
2100	42.25	14.32	41.43	14.32	38.16	16.11	1021	6.3	158.0	0.597
2200	43.06	14.32	40.61	14.32	38.16	12.54	1014	6.3	152.3	0.597
2300	42.25	14.32	40.61	14.32	38.16	14.32	1014	447.0	149.0	0.231
2400	43.06	16.11	40.61	14.32	37.34	12.54	1021	11.7	155.1	0.778

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-8. BRIMS data for 3/17/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0300	43.06	14.32	40.61	14.32	38.97	14.32	1021	9.0	149.0	0.000
0900	43.06	16.11	41.43	14.32	38.97	17.89	1014	0.0	0.0	1.142
	43.06	14.32	40.61	14.32	38.16	16.11	1014	2.7	310.0	0.778
	43.06	14.32	41.43	14.32	38.97	14.32	1014	15.3	0.0	1.142
	43.06	16.11	41.43	14.32	38.97	16.11	1021	22.4	338.0	0.597
	43.06	14.32	41.43	12.54	40.61	16.11	1028	16.2	332.0	0.961
	43.06	17.89	41.43	14.32	38.97	14.32	1021	20.6	329.0	0.961
	43.88	14.32	41.43	14.32	41.43	16.11	1028	23.3	346.0	0.778
2000	43.88	16.11	41.43	14.32	41.43	16.11	1021	18.8	338.0	0.414
	43.88	0.00	41.43	14.32	39.79	14.32	1021	22.4	346.0	0.778
	43.88	0.00	41.43	14.32	40.61	14.32	1021	20.6	11.5	0.597
	43.88	0.00	42.25	14.32	39.79	16.11	1028	24.2	14.4	0.597
2400	43.06	0.00	42.25	14.32	41.43	17.89	1021	22.4	11.6	0.597

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-9. BRIMS data for 3/18/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0300	43.88	0.00	41.43	14.32	40.61	14.32	1028	16.2	17.2	0.597
0100	43.88	0.00	42.25	14.32	41.43	16.11	1028	26.9	22.8	0.597
0200	43.88	0.00	42.25	14.32	39.79	14.32	1028	21.5	20.0	0.597
0300	43.06	0.00	41.43	14.32	41.43	16.11	1028	31.4	22.8	0.000
0400	43.88	0.00	42.25	14.32	38.97	14.32	1028	24.2	31.3	0.051
0500	43.06	0.00	41.43	14.32	37.31	12.54	1028	20.6	36.9	0.233
0600	4.38	0.00	42.25	14.32	38.16	12.54	1028	19.7	48.2	0.000
0700	43.88	0.00	41.43	14.32	35.71	12.54	1028	22.4	34.1	0.051
0800	43.06	0.00	41.43	14.32	36.53	12.54	1021	20.6	28.4	0.051
0900	42.25	0.00	40.61	14.32	35.71	14.32	1021	22.4	31.3	0.233
1030	41.43	0.00	39.79	14.32	38.97	16.11	1021	21.5	45.4	0.233
1130	41.43	0.00	39.79	14.32	36.53	12.54	1028	18.9	48.2	0.233
1230	41.43	0.00	39.79	14.32	39.79	17.89	1021	15.3	59.4	0.051
1300	42.25	0.00	40.61	14.32	37.34	14.32	1021	12.6	67.8	0.233
1400	42.25	0.00	39.79	14.32	38.16	16.11	1021	9.9	50.9	0.415
1500	43.06	0.00	40.61	14.32	38.97	12.54	1028	18.8	48.2	0.233
1600	43.06	0.00	41.43	14.32	3.89	16.11	1028	16.2	65.1	0.233
1700	43.06	0.00	41.43	14.32	38.16	14.32	1028	14.4	79.1	0.051
1800	43.06	0.00	41.43	14.32	40.61	14.32	1028	18.0	70.7	0.051
1900	43.06	0.00	41.43	14.32	38.97	16.11	1028	17.9	81.9	0.051
2000	43.88	0.00	42.25	14.32	40.61	12.54	1021	14.4	79.1	0.051
2100	43.88	0.00	42.25	14.32	40.61	16.11	1028	13.5	93.2	0.233
2200	43.80	0.00	42.25	16.11	38.97	16.11	1021	14.3	104.0	0.051
2300	43.80	0.00	42.25	14.32	41.43	16.11	1021	13.5	101.7	0.415
2400	43.88	0.00	43.06	16.11	39.79	16.11	1021	13.5	104.0	0.051

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-10. BRIMS data for 3/19/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0300	43.88	0.00	42.25	14.32	41.43	16.11	1021	11.7	96.0	0.233
0100	43.88	0.00	42.25	14.32	39.79	16.11	1021	12.6	98.8	0.233
0200	44.70	0.00	42.25	16.11	40.61	12.54	1021	10.7	110.0	0.233
0300	44.70	0.00	42.25	14.32	41.43	16.11	1021	8.9	107.0	0.233
0400	44.70	0.00	42.25	14.32	39.79	16.11	1021	4.4	87.0	0.233
0500	43.88	0.00	42.25	16.11	41.43	16.11	1021	7.1	67.0	0.233
0600	43.88	0.00	42.25	16.11	37.79	16.11	1021	8.0	98.0	0.415
0700	43.88	0.00	42.25	14.32	39.79	12.54	1021	8.0	90.0	0.233
0800	44.70	0.00	42.25	14.32	39.79	14.32	1021	13.0	96.0	0.415
1030	43.88	14.32	42.25	14.32	40.61	16.11	1021	8.9	93.0	0.961
1430	43.06	14.32	42.25	14.32	39.79	16.11	1021	6.3	104.0	0.961
1500	43.06	16.11	41.43	14.32	38.97	14.32	1021	6.3	101.0	0.961
	43.06	16.11	42.25	14.32	38.16	14.32	1021	6.2	121.0	0.961
	44.70	16.11	42.25	14.32	39.79	14.32	1021	8.9	127.0	0.597
	44.70	16.11	43.06	14.32	41.43	17.89	1021	2.6	127.0	1.140
	43.88	16.11	43.06	14.32	39.79	14.32	1021	80.6	149.0	0.415
	44.70	16.11	42.25	14.32	41.43	16.11	1021	12.0	143.0	0.051
	44.70	16.11	43.06	16.11	39.79	12.54	1028	13.5	135.0	0.233
	44.70	14.32	42.25	16.11	39.79	12.54	1028	12.5	155.0	0.415
	44.70	14.32	43.04	16.11	40.61	12.54	1028	10.7	163.0	0.597
	44.70	16.11	43.06	14.32	42.25	16.11	1028	10.7	172.0	0.051

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-11. BRIMS data for 3/20/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0300	45.51	16.11	43.06	16.11	40.61	14.32	1028	11.6	169.0	0.961
0100	44.70	16.11	43.06	14.32	42.25	17.89	1028	9.8	172.0	0.415
0200	45.51	16.11	43.88	14.32	42.25	16.11	1021	8.0	160.0	0.597
0300	44.70	16.11	43.06	14.32	41.43	17.89	1028	9.8	149.0	0.597
0400	44.70	16.11	43.06	14.32	39.79	14.32	1028	7.2	149.0	0.597
0500	45.51	16.11	43.06	16.11	40.61	14.32	1028	10.7	135.0	0.778
0600	44.70	16.11	43.06	16.11	42.25	16.11	1028	8.9	132.0	0.415
0800	44.70	16.11	42.25	16.11	42.25	17.89	1028	9.8	149.0	0.415
	44.70	16.11	43.06	16.11	43.06	14.32	1028	12.5	141.0	0.597
	44.70	16.11	43.06	14.32	43.06	17.89	1028	8.9	158.0	0.597
	45.51	16.11	43.06	14.32	40.61	12.54	1021	6.2	163.0	0.597
	45.51	16.11	43.06	16.11	39.79	16.11	1021	7.2	172.0	0.597
	44.70	16.11	43.06	16.11	43.60	16.11	1021	6.2	200.0	0.778
1600	44.70	16.11	43.06	16.11	40.61	16.11	1028	9.8	200.0	0.961
1700	45.51	16.11	43.06	16.11	42.25	16.11	1028	10.7	219.9	0.597
1800	44.70	16.11	43.06	16.11	42.25	16.11	1021	3.5	284.0	0.415
1900	44.70	16.11	43.06	16.11	39.79	12.54	1028	17.9	332.0	0.961
2000	44.70	16.11	43.06	16.11	40.61	14.32	1028	19.7	338.0	0.597
2100	44.70	16.11	43.06	14.32	40.61	16.11	1028	14.3	320.0	0.415
2200	43.88	14.32	43.06	14.32	40.61	16.11	1028	20.6	0.3	0.597
2300	44.70	16.11	43.06	14.32	39.79	1.25	1035	18.8	3.1	0.597
2300	45.51	16.11	43.88	16.11	40.61	14.32	1035	18.8	3.1	0.597

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-12. BRIMS data for 3/21/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0300	45.51	16.11	43.88	16.11	41.43	17.89	1035	32.0	3.1	0.233
0100	45.51	16.11	43.06	16.11	42.25	16.11	1028	20.6	3.1	0.597
0200	44.70	16.11	42.25	16.11	42.25	16.11	1028	17.9	5.9	0.597
0300	44.70	16.11	43.06	16.11	40.61	12.54	1035	23.3	14.4	0.415
0400	44.70	16.11	42.25	14.32	39.79	12.54	1035	23.3	22.8	0.415
0500	44.70	16.11	43.06	16.11	42.25	17.89	1035	20.6	28.0	0.233
0600	44.70	16.11	42.25	16.11	42.25	16.11	1035	17.9	36.0	0.597
0700	44.70	16.11	43.06	14.32	40.61	16.11	1035	24.3	34.0	0.233
0800	45.51	16.11	43.06	16.11	41.43	17.89	1035	30.5	39.7	0.415
0900	44.70	16.11	43.06	14.32	42.25	17.89	1028	10.7	39.7	0.597
	44.70	16.11	43.06	14.32	39.79	16.11	1028	17.1	34.1	0.597
	45.51	16.11	43.06	16.11	39.79	14.32	1028	16.2	45.4	0.415
	45.51	16.11	43.06	41.32	40.61	12.54	1028	10.7	53.7	0.416
	45.51	16.11	43.88	16.11	42.25	17.89	1028	10.7	42.5	0.778
1500	42.25	16.11	43.06	16.11	42.25	17.89	1028	7.2	84.7	0.778
1800	44.70	16.41	43.06	16.11	41.43	14.32	1028	10.8	101.7	0.597
1900	44.70	14.32	43.06	14.32	43.06	17.68	1028	8.0	107.3	0.233
2000	45.51	16.11	43.06	16.11	40.61	14.32	1028	7.2	104.0	0.415
2100	45.51	16.11	43.88	16.11	40.61	12.54	1028	5.3	115.7	0.233
2200	46.33	16.11	44.70	16.11	42.25	17.89	1028	6.2	118.0	0.415
2300	45.51	16.11	43.88	16.11	42.25	17.89	1028	6.2	124.0	0.597
2400	45.51	16.11	43.06	16.11	43.06	19.68	1028	7.2	112.0	0.597

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-13. BRIMS data for 3/22/80.

	SENSOR #1		SENSOR #2		SENSOR #3		BAR	WIND	WIND	FLOW
TIME	COND.	TEMP.	COND.	TEMP.	COND.	TEMP.	PRES	VEL.	DIR.	X
0100	46.33	16.11	43.88	16.11	41.43	14.32	1028	7.2	118.0	0.597
0200	45.51	16.11	43.88	14.32	41.43	16.11	1028	8.9	132.6	0.233
0300	45.51	16.11	44.70	16.11	42.25	16.11	1028	7.2	118.0	0.000
0400	45.51	16.40	43.88	16.11	39.79	12.54	1028	6.3	118.0	0.233
0500	46.33	16.11	43.88	14.32	42.25	16.11	1028	13.5	107.0	0.233
0600	46.33	16.11	43.88	14.32	42.25	16.11	1028	13.5	90.0	0.233
0700	46.33	16.11	43.88	16.11	42.25	17.89	1028	12.5	98.0	0.233
0800	46.33	16.11	43.06	16.11	43.06	17.89	1028	18.5	104.0	0.233
0900	45.51	16.11	43.06	14.32	43.06	16.11	1028	13.5	96.0	0.415
1000	45.51	16.11	44.70	14.32	41.43	14.32	1028	14.3	96.0	0.415
1100	45.51	16.11	44.70	16.11	42.25	17.89	1028	11.6	90.0	0.233
1200	45.51	16.11	43.88	16.11	41.43	16.11	1028	13.5	101.0	0.415
1300	45.51	16.11	43.88	16.11	40.61	14.32	1028	12.5	101.7	0.233
1400	45.51	16.11	43.88	14.32	41.43	16.11	1028	14.3	98.0	0.415
1500	45.51	16.11	43.88	16.11	41.43	14.32	1028	13.5	87.0	0.415
1600	45.51	16.11	43.06	16.11	40.61	16.11	1028	11.5	87.0	0.000
1700	45.51	16.11	43.88	14.32	40.61	16.11	1028	9.8	93.0	0.233
1800	44.70	16.11	43.06	16.11	43.06	17.89	1028	11.6	93.0	0.000
1900	45.51	16.11	43.88	16.11	40.61	16.11	1028	8.9	110.0	0.415
2000	45.51	16.11	43.88	16.11	41.43	17.89	1028	8.1	107.0	0.415
2100	45.51	16.11	45.11	16.11	41.43	14.32	1028	7.0	104.0	0.415
2200	46.33	16.11	43.88	16.11	40.61	14.32	1028	11.6	129.0	0.415
2300	46.33	16.11	44.70	16.11	41.43	12.54	1028	10.7	138.0	0.415
2400	46.33	16.11	43.88	16.11	41.43	14.32	1028	10.7	138.0	0.415

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-14. BRIMS data for 3/23/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	46.33	16.11	44.70	16.11	41.43	17.89	1028	8.1	149.0	0.597
0200	46.33	16.11	44.70	16.11	42.25	17.89	1028	6.2	138.0	0.597
0300	46.33	16.11	44.70	16.11	42.25	17.89	1028	7.2	155.0	0.415
0400	46.33	16.11	44.70	16.11	40.61	14.32	1028	10.7	115.0	0.597
0500	46.33	16.11	43.88	16.11	40.61	12.54	1028	116.0	121.0	5.970
0600	46.33	16.11	43.88	16.11	41.43	17.89	1028	11.6	121.0	0.415
0700	46.33	16.11	43.88	16.11	41.43	16.11	1035	12.5	135.0	0.415
1200	46.33	16.11	43.88	16.11	43.06	17.89	1028	9.8	141.0	0.415
1300	46.33	16.11	44.70	14.32	41.43	14.32	1028	15.3	135.0	0.233
1400	46.33	16.11	43.88	16.11	39.79	14.32	1028	12.5	132.0	0.597
1500	45.51	16.11	43.88	16.11	41.43	17.89	1028	8.0	127.0	0.597
1530	45.51	16.11	43.88	16.11	38.97	12.54	1028	5.3	112.9	0.597
1600	45.51	16.11	43.88	16.11	40.61	17.89	1028	5.3	132.0	0.233
1630	45.51	16.11	43.88	14.32	40.61	17.89	1028	5.3	129.0	0.597
1700	44.70	16.11	43.88	16.11	38.16	14.32	1028	8.0	118.0	0.415
1730	45.51	16.11	43.06	16.11	40.61	16.11	1028	4.5	158.0	0.778
1800	45.51	16.11	43.88	16.11	38.16	12.54	1028	3.5	177.0	0.597
1830	43.88	16.11	43.06	16.11	39.79	17.89	1028	1.8	203.0	0.597
2200	44.70	16.11	42.25	14.32	38.97	14.32	1021	0.0	0.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-15. BRIMS data for 3/24/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0800	46.33	16.11	44.70	14.32	40.61	14.32	1035	17.9	0.3	0.597
0900	45.51	16.11	44.70	16.11	41.43	17.89	1035	14.3	0.3	0.597
1000	46.33	16.11	43.88	16.11	40.61	16.11	1035	23.0	0.3	0.415
1100	46.33	16.11	44.70	16.11	43.06	17.89	1035	17.9	349.0	0.597
1200	47.15	16.11	44.70	14.32	38.79	14.32	1035	13.5	349.0	0.597
1300	46.33	17.89	44.70	14.32	41.43	16.11	1035	71.6	3.1	0.597
1400	41.33	16.11	44.70	16.11	41.43	14.32	1028	0.0	14.4	0.597
1500	47.15	17.89	43.88	16.11	40.61	14.32	1028	2.6	36.9	0.778
1600	46.33	16.11	43.88	16.11	40.61	14.32	1028	0.0	62.2	0.778
1700	46.33	16.11	44.70	16.11	41.43	17.89	1028	0.0	112.0	0.597
1800	46.33	16.11	43.88	16.11	40.61	14.32	1028	8.0	101.0	0.415
1900	46.33	16.11	43.88	16.11	41.43	16.11	1028	0.0	81.9	0.587
2000	46.33	16.11	43.88	16.11	41.43	17.89	1028	0.0	32.9	0.778

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-16. BRIMS data for 3/25/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	46.33	16.11	44.70	16.11	41.43	17.89	1028	5.3	5.9	0.000
0300	42.55	16.11	44.70	16.11	43.88	19.68	1028	14.3	20.0	0.000
0900	47.55	16.11	44.70	14.32	43.06	17.89	1035	18.0	622.0	0.415
1400	46.33	16.11	43.88	16.11	41.43	14.32	1028	8.0	45.0	0.597
1500	46.33	16.11	45.51	16.11	40.61	14.32	1035	13.5	56.0	0.597
1600	47.15	16.11	45.51	16.11	43.06	17.89	1035	15.3	62.0	0.597
	48.78	17.89	46.33	16.11	40.61	14.33	1035	16.5	62.0	0.597
	47.97	16.11	45.51	16.11	40.61	14.32	1035	11.5	62.0	0.597
	40.33	16.11	44.70	16.11	42.25	16.11	1035	20.6	31.0	0.597

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-17. BRIMS data for 3/26/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0600	46.33	16.11	42.25	16.11	42.25	14.32	1035	18.8	62.0	0.597
0700	46.33	16.11	44.70	16.11	41.43	16.11	1035	19.7	93.0	0.597
0800	45.51	16.11	44.70	14.37	40.61	14.32	1035	17.0	90.0	0.597
1100	46.33	16.11	43.88	16.11	40.61	12.54	1028	15.0	87.0	0.597
1200	45.51	16.11	43.06	16.11	39.79	14.32	1035	17.9	98.0	0.960
1300	44.70	16.11	43.06	16.11	38.97	14.32	1035	10.7	90.0	0.960
1400	44.70	16.11	43.06	16.11	41.43	16.11	1035	18.8	87.0	0.597
1600	45.51	16.11	43.88	16.11	40.61	17.89	1035	18.8	101.0	1.510
1700	44.70	16.11	44.70	16.11	38.97	16.11	1035	18.8	96.0	1.510
1800	44.70	16.11	43.88	16.11	41.43	14.32	1035	17.0	104.0	1.140
1900	44.70	16.11	43.06	16.11	39.79	16.11	1035	15.2	87.0	1.140
2000	44.70	16.11	43.06	16.11	39.79	14.32	1035	17.0	90.0	1.510
2100	44.70	16.11	43.88	16.11	40.61	14.32	1028	8.9	45.0	1.320
2200	45.51	16.11	43.88	16.11	42.25	17.89	1035	10.7	42.0	1.325
2300	45.51	16.11	44.70	16.11	39.79	14.32	1028	9.8	45.0	1.325
2400	45.51	16.11	44.70	16.11	40.61	17.89	1035	12.5	56.0	1.680

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-18. BRIMS data for 3/27/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0600	44.70	16.11	43.88	16.11	42.25	17.89	1035	16.0	59.0	1.140
0700	44.70	16.11	43.88	16.11	40.61	14.32	1035	11.6	59.0	1.300
0900	45.51	16.11	43.88	16.11	41.43	14.32	1035	8.9	42.0	0.597
1000	44.70	16.11	43.06	14.32	42.25	17.89	1035	15.2	31.0	0.960
1100	45.51	16.11	43.88	16.11	41.43	17.89	1035	16.2	48.0	0.597
1200	45.51	16.11	44.70	14.32	40.61	14.32	1035	6.2	45.0	0.778
1300	44.70	16.11	43.06	16.11	40.61	14.32	1043	26.0	59.0	0.597
1400	45.51	16.11	43.89	16.11	41.43	16.11	1035	15.3	87.0	0.597
1500	45.51	16.11	43.88	14.32	41.43	14.32	1035	15.0	90.0	0.778
1600	46.33	16.11	43.88	16.11	42.25	16.11	1035	8.9	104.0	0.597
1700	45.51	16.11	43.88	16.11	42.25	14.32	1028	8.0	118.0	0.415
1800	46.33	16.11	43.88	16.11	40.61	17.89	1043	26.0	329.0	0.778
1900	45.51	17.89	44.70	16.11	41.43	17.89	1035	18.0	45.0	0.000
2000	45.51	16.11	43.06	16.11	40.61	17.89	1035	14.0	56.0	0.000
2100	44.70	16.11	43.88	16.11	39.79	14.32	1035	17.9	84.0	0.000
2200	45.51	16.11	43.88	16.11	41.43	16.11	1035	21.5	98.0	0.000
2300	45.51	16.11	43.88	16.11	39.79	14.32	1035	14.0	11.0	0.000
2400	45.51	16.11	43.06	16.11	40.61	14.32	1028	11.0	14.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-19. BRIMS data for 3/28/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	45.51	16.11	43.06	16.11	45.52	17.89	1035	9.8	28.0	0.000
2000	44.70	16.11	44.70	14.32	39.79	14.32	1035	9.8	27.1	0.960
0300	44.70	16.11	43.88	16.11	40.61	14.32	1028	6.2	8.7	1.500
0400	47.97	16.11	45.51	14.32	38.97	14.32	1035	5.3	36.9	1.325
0500	45.51	16.11	43.88	14.32	41.43	16.11	1035	9.8	31.3	1.406
0600	47.15	16.11	44.70	14.32	39.79	14.32	1035	8.9	166.0	2.400
1500	46.30	16.11	43.88	16.11	41.43	17.89	1035	8.9	112.0	1.330
1600	46.33	16.11	44.70	16.11	41.43	14.32	1035	12.5	155.0	1.680
1700	46.33	16.11	44.70	16.11	42.25	17.89	1035	9.8	34.0	1.320
1800	46.33	17.89	45.51	14.32	41.43	14.32	1035	8.9	59.0	1.140
1900	47.15	17.89	45.51	16.11	43.88	17.89	1035	11.6	186.0	1.506
2000	47.15	17.89	45.51	16.11	43.06	17.89	1035	8.9	132.0	0.960
2100	47.15	16.11	45.51	16.11	42.25	17.89	1035	7.2	0.0	1.680
2200	47.15	17.89	46.33	17.89	43.06	16.11	1028	6.2	0.0	1.325
2300	47.97	16.11	46.33	16.11	41.43	16.11	1028	2.6	165.5	0.233
2400	46.33	16.11	45.51	16.11	43.06	16.11	1028	4.4	349.0	1.140

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-20. BRIMS data for 3/29/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	47.15	16.11	44.70	16.11	42.25	17.89	1035	10.7	152.0	0.233
0200	46.33	16.11	44.70	16.11	42.25	17.89	1035	15.3	160.0	0.233
0300	47.15	17.89	44.70	16.11	42.25	17.89	1028	5.3	264.0	0.233
0400	47.15	16.11	45.51	16.11	42.25	16.11	1028	8.9	293.0	0.233
0500	47.15	16.11	44.70	14.32	41.43	14.32	1035	12.5	321.0	0.405
0600	47.05	16.11	44.70	16.11	42.25	17.89	1035	17.9	326.0	0.597
0700	47.15	16.11	44.70	16.11	42.25	16.11	1035	23.3	329.0	0.597
0800	46.33	16.11	43.88	16.11	42.25	16.11	1043	21.5	343.0	0.051
0900	46.33	17.89	47.15	16.11	40.61	14.32	1035	12.5	335.0	0.233
1000	46.33	16.11	46.33	16.11	41.43	17.89	1035	11.6	332.0	0.778
1100	47.15	17.89	46.33	16.11	40.61	17.89	1035	14.3	335.0	0.414
1200	47.15	17.89	45.51	16.11	42.25	16.11	1035	12.5	335.0	0.414
1300	47.15	16.11	44.70	14.32	41.43	14.32	1035	12.5	321.0	0.051
1400	47.15	16.11	45.51	16.11	42.25	17.89	1035	8.0	335.0	0.233
1500	47.15	16.11	44.70	16.11	42.25	17.89	1035	10.7	0.3	0.051
1600	47.15	16.11	44.70	16.11	42.25	17.80	1035	10.7	8.7	0.232
1700	46.33	16.11	44.70	16.11	42.25	16.11	1028	0.0	301.0	0.000
1800	46.33	16.11	45.51	16.11	41.43	17.89	1035	9.8	248.0	0.232
2000	47.15	16.11	44.70	16.11	43.06	17.87	1035	6.2	183.0	0.597
2100	47.15	16.11	44.70	14.32	40.61	14.32	1035	5.3	180.0	0.000
2200	47.15	16.11	45.51	16.11	43.06	17.80	1035	6.2	183.0	0.232
2300	47.15	16.11	44.70	16.11	41.43	16.11	1028	3.5	172.0	0.232
2400	47.15	16.11	45.51	16.11	43.06	16.11	1035	4.4	177.0	0.415

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-21. BRIMS data for 3/30/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	47.15	17.89	45.51	16.11	43.06	17.89	1028	3.5	172.0	0.597
0200	47.97	16.11	45.51	16.11	41.43	16.11	1035	6.2	141.0	0.415
0300	47.97	16.11	44.70	16.11	41.43	16.11	1035	5.3	135.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-22. BRIMS data for 3/31/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0930	47.15	16.11	44.71	16.11	41.43	16.11	1035	3.5	121.4	0.000
1200	47.15	16.11	45.51	16.11	40.61	14.32	1035	2.6	107.0	0.597
1300	47.97	17.89	45.51	16.11	43.06	17.89	1035	2.6	87.0	0.960
1400	47.97	16.11	45.51	16.11	43.06	17.89	1035	3.5	900.0	0.960
1500	47.97	16.11	46.33	16.11	43.06	17.89	1035	3.5	101.0	0.597
1600	47.97	16.11	46.33	16.11	41.43	14.32	1035	9.8	0.0	0.960
1700	47.97	16.11	46.33	16.11	41.43	14.32	1035	9.8	0.0	0.960
1800	47.97	16.11	45.51	16.11	42.25	14.32	1035	11.6	129.0	0.232
1900	47.15	16.11	45.51	16.11	43.06	17.89	1035	12.5	166.0	0.000
2000	47.15	16.11	45.51	16.11	42.25	16.11	1035	11.6	163.0	0.778
2100	47.15	16.11	45.51	16.11	42.25	16.11	1035	12.5	0.0	0.000
2200	47.15	17.89	46.33	16.11	41.43	16.11	1035	11.6	118.0	0.597
2300	47.97	17.89	45.51	16.11	42.25	17.89	1035	10.7	0.0	0.000
2400	47.97	17.89	45.51	16.11	43.88	17.89	1035	6.2	11.8	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-23. BRIMS data for 4/1/80 .

	SENSOR #1		SENSOR #2		SENSOR #3		BAR	WIND	WIND	FLOW
TIME	COND.	TEMP.	COND.	TEMP.	COND.	TEMP.	PRES	VEL.	DIR.	X
0100	47.97	16.11	45.51	16.11	43.06	16.11	1035	5.3	0.0	0.415
0200	47.15	16.11	44.70	16.11	43.06	17.89	1035	4.4	0.0	0.000
0300	46.33	16.11	45.51	16.11	41.43	14.32	1035	5.3	0.0	0.000
0400	47.15	17.89	44.70	16.11	42.25	17.89	1035	8.0	129.0	0.000
0500	47.97	16.11	45.51	16.11	42.25	14.32	1035	9.8	0.0	0.000
0600	47.15	16.11	45.51	16.11	42.25	17.89	1035	6.2	104.0	0.597
1030	47.97	17.89	45.51	16.11	42.25	17.89	1035	11.6	0.0	0.000
	47.15	17.89	45.51	16.11	42.25	17.89	1035	14.3	0.0	0.033
	47.97	16.11	45.51	16.11	41.43	16.11	1035	10.7	129.0	0.778
	47.15	16.11	45.51	16.11	43.88	17.89	1035	12.5	73.0	0.415
	47.15	17.89	45.51	16.11	43.06	17.89	1035	14.3	143.0	0.233
	47.97	16.11	45.51	16.11	43.06	17.89	1035	14.3	0.0	0.239
2000	47.15	17.89	46.33	16.11	41.43	14.32	1035	13.0	0.0	0.239
2100	47.97	17.89	44.70	16.11	43.06	17.89	1035	12.5	115.0	0.000
2200	47.97	16.11	44.70	16.11	42.25	16.11	1035	13.0	0.0	0.415
2300	47.15	16.11	45.51	16.11	43.06	16.11	1035	9.8	124.0	0.233

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-24. BRIMS data for 4/2/80 .

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	47.15	17.89	45.51	16.11	41.43	14.32	1035	11.7	121.0	0.415
0200	47.97	16.11	45.51	16.11	43.06	17.89	1035	6.2	0.0	0.597
0300	47.15	16.11	45.51	16.11	41.43	14.32	1035	8.9	135.0	0.000
	47.15	16.11	45.51	16.11	41.43	16.11	1035	6.2	0.0	0.415
	47.15	16.11	45.51	16.11	41.43	16.11	1035	6.2	53.0	0.000
	47.15	17.89	44.70	16.11	43.06	17.89	1035	5.3	0.0	0.000
0700	47.15	17.89	44.70	14.32	43.06	17.89	1035	3.5	118.0	0.233
0800	47.15	16.11	45.51	16.11	41.43	17.89	1035	4.4	0.0	0.000
	47.15	16.11	45.51	16.11	41.43	17.89	1035	15.2	12.9	0.000
	47.15	16.11	44.70	16.11	42.25	16.11	1035	2.6	0.0	0.415
	47.97	17.89	44.70	16.11	40.61	14.32	1035	3.5	0.0	0.000
	47.15	17.89	44.70	16.11	42.25	17.89	1035	6.2	0.0	0.000
	46.33	16.11	44.70	16.11	43.06	17.89	1028	3.5	101.0	0.000
	47.15	16.11	44.70	16.11	40.61	14.32	1035	6.2	160.0	0.233
	47.15	16.11	44.70	16.11	43.06	17.89	1028	5.3	0.0	0.000
	46.33	16.11	44.70	16.11	42.25	16.11	1035	3.5	107.0	0.000
	46.33	16.11	44.70	16.11	40.61	14.32	1028	1.7	104.0	0.000
	47.15	17.89	44.70	0.00	41.43	17.89	1035	3.5	115.0	0.000
	47.15	16.11	45.51	16.11	41.43	14.32	1028	5.3	0.0	0.000
	46.33	16.11	44.70	16.11	41.43	17.89	1035	5.3	0.0	0.000
	47.15	17.89	44.70	16.11	40.61	14.32	1035	7.0	101.0	0.000
	47.15	16.11	44.70	16.11	40.61	12.54	1028	0.9	0.0	0.000
	47.15	16.11	44.70	16.11	41.43	16.11	1028	26.0	62.0	0.000
	46.33	16.11	44.70	16.11	41.43	17.89	1028	0.0	0.0	0.000
	47.15	17.89	44.70	16.11	40.61	14.32	1028	0.0	31.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-25. BRIMS data for 4/3/80 .

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	47.15	16.11	44.70	16.11	39.79	14.32	1035	5.3	115.0	0.000
0200	47.15	17.89	44.70	16.11	41.43	16.11	1035	8.0	124.0	0.000
0300	46.33	16.11	43.88	16.11	41.43	16.11	1035	8.9	118.0	0.000
0400	45.51	17.89	43.88	16.11	41.43	16.11	1035	8.9	115.0	0.000
0500	45.51	16.11	43.88	16.11	40.61	17.89	1028	4.4	127.0	0.000
0600	45.51	17.89	43.88	16.11	39.79	17.89	1022	0.0	73.0	0.000
0700	45.51	16.11	43.88	16.11	40.61	17.89	1028	1.8	0.0	0.000
0800	46.33	17.89	44.70	16.11	39.79	14.32	1035	7.6	0.0	0.000
0900	44.33	16.11	44.70	16.11	42.25	17.89	1035	7.1	98.0	0.000
1000	46.33	16.11	44.70	16.11	40.11	14.32	1035	5.3	900.0	0.000
1100	47.15	16.11	44.70	16.11	42.25	17.89	1035	6.2	101.0	0.000
1200	47.15	17.89	44.70	16.11	41.43	14.32	1035	4.4	0.0	0.000
1300	47.15	17.89	44.70	16.11	40.61	14.32	1035	6.2	96.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-26. BRIMS data for 4/4/80 .

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0730	46.33	17.89	43.88	14.32	40.61	17.89	1043	24.2	14.4	0.000
0800	45.51	17.89	43.88	16.11	39.79	14.32	1043	25.1	20.0	0.000
0900	46.33	16.11	43.88	16.11	39.79	14.32	1043	19.7	22.0	0.000
1000	46.33	17.89	44.70	16.11	39.79	14.32	1043	17.9	14.0	0.000
1100	46.33	17.89	44.70	16.11	39.79	16.11	1043	15.2	20.0	0.000
1200	47.15	17.89	43.88	16.11	41.43	16.11	1043	17.0	34.0	0.000
1300	46.33	16.11	44.70	16.11	41.43	0.00	1043	13.0	34.0	0.000
1400	46.33	17.89	43.88	16.11	42.25	14.32	1043	5.3	48.0	0.000
1500	47.15	17.89	45.51	16.11	40.61	14.32	1035	5.3	48.0	0.000
1600	47.15	17.89	45.51	17.89	39.79	16.11	1035	5.3	42.0	0.000
1700	46.33	17.89	44.70	16.11	41.43	16.11	1035	5.3	45.0	0.000
1800	46.33	16.11	44.70	16.11	39.79	16.11	1035	5.3	42.0	0.000
1900	47.15	16.11	44.70	16.11	41.43	14.32	1035	4.4	65.0	0.000
2000	47.15	17.89	44.70	17.89	40.61	16.11	1035	0.0	62.0	0.000
2100	46.33	17.89	44.70	16.11	40.61	14.32	1035	0.0	87.0	0.000
2200	47.15	16.11	45.51	16.11	40.61	14.32	1035	0.0	50.0	0.000
2300	47.15	17.89	44.70	16.11	42.25	17.89	1035	2.6	56.0	0.000
2400	47.15	17.89	45.51	16.11	42.25	17.89	1035	4.4	45.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-27. BRIMS data for 4/5/80 .

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0030	47.15	17.89	45.51	16.11	40.61	14.32	1035	5.3	45.0	0.000
	47.15	17.89	45.51	16.11	40.61	17.89	1035	8.9	110.0	0.000
	47.15	17.89	45.51	16.11	40.61	14.32	1035	12.0	50.0	0.000
	47.15	17.89	44.70	16.11	42.25	17.89	1035	12.5	53.0	0.000
	47.15	17.89	44.70	16.11	42.25	17.89	1035	10.7	59.0	0.000
	47.15	17.89	44.70	17.89	41.43	16.11	1043	7.0	62.0	0.000
	47.15	17.89	45.51	16.11	42.25	16.11	1043	16.0	56.0	0.000
	46.33	16.11	44.70	16.11	41.43	16.11	1043	14.0	50.0	0.000
	47.15	17.89	45.51	16.11	41.43	14.32	1043	14.0	62.0	0.000
	46.33	17.89	44.70	17.89	39.79	14.32	1035	15.0	107.0	0.000
	47.15	17.89	44.70	16.11	40.61	17.89	1035	17.0	110.0	0.000
	46.33	17.89	44.70	16.11	39.79	12.54	1043	14.0	115.0	0.000
	46.33	16.11	43.88	16.11	41.43	17.89	1043	13.0	101.0	0.000
	46.33	16.11	43.88	16.11	41.43	17.89	1035	125.0	110.0	0.000
	46.33	16.11	44.70	16.11	40.61	17.89	1043	19.0	115.0	0.000
	47.15	17.89	43.88	16.11	40.61	14.32	1043	11.0	110.0	0.000
	46.33	16.11	44.70	16.11	41.43	17.89	1043	12.0	104.0	0.000
	46.33	17.89	44.70	16.11	39.79	12.54	1043	17.0	107.0	0.000
	46.33	16.11	43.88	16.11	39.79	16.11	1043	14.0	107.0	0.000
	46.33	17.89	43.88	16.11	39.79	14.32	1043	16.0	107.0	0.000
2400	46.33	17.89	43.88	16.11	41.43	17.89	1035	11.0	104.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-28. BRIMS data for 4/6/80 .

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0300	46.33	17.89	43.88	16.11	40.61	17.89	1035	6.2	112.0	0.000
0100	46.33	16.11	43.88	16.11	39.79	14.32	1035	44.0	115.0	0.000
0200	46.33	17.89	43.88	16.11	37.79	17.89	1035	62.0	110.0	0.000
0300	46.33	16.11	44.70	16.11	39.79	14.32	1043	13.0	104.0	0.000
0400	46.33	17.89	44.70	16.11	41.43	19.68	1043	12.0	101.0	0.233
0500	47.15	16.11	46.33	16.11	40.61	14.32	1038	12.0	118.0	0.233
0600	47.15	17.89	45.51	16.11	42.25	17.89	1043	13.0	118.0	0.415
0700	47.15	19.68	44.70	16.11	42.25	17.68	1035	11.6	110.0	0.415
0800	46.33	17.89	45.51	16.11	41.43	16.11	1035	10.0	107.0	0.415
0900	47.15	16.11	46.33	16.11	41.43	17.89	1043	13.4	104.0	0.597
1000	47.15	17.89	46.33	16.11	40.61	17.89	1035	10.0	112.0	0.597
1100	47.05	17.89	46.33	17.89	41.43	17.89	1035	13.0	121.0	0.778
1200	47.15	16.11	45.51	16.11	42.25	17.68	1035	10.0	112.0	0.000
1300	47.15	17.89	45.51	16.11	43.06	19.68	1035	11.0	124.0	0.000
1400	47.15	17.89	44.70	17.68	40.61	16.11	1043	13.0	132.0	0.000
1500	47.15	17.89	45.51	16.11	42.25	17.89	1035	12.0	124.0	0.000
1600	47.15	16.11	44.70	16.11	39.79	14.32	1035	11.0	129.0	0.000
1700	47.15	16.11	45.51	17.89	41.43	14.32	1035	5.3	121.0	0.000
1800	47.15	16.11	45.51	16.11	40.61	17.89	1035	7.1	127.0	0.000
1900	47.15	17.89	44.70	17.89	41.43	17.89	1035	5.3	127.0	0.000
2000	47.15	17.89	44.70	16.11	42.25	17.89	1035	3.5	129.0	0.000
2100	47.15	17.89	45.51	16.11	41.43	19.68	1035	0.0	127.0	0.232
2200	47.15	17.89	45.51	16.11	39.79	16.11	1035	6.2	127.0	0.415
2300	47.97	16.11	46.33	16.11	40.61	14.32	1035	1.7	152.0	0.778
2400	47.15	17.89	46.33	16.11	40.61	17.89	1035	6.2	42.0	0.597

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-29. BRIMS data for 4/7/80 .

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	47.15	17.89	45.51	16.11	40.61	16.11	1035	3.5	146.0	0.000
0200	47.15	17.89	46.33	16.11	40.61	17.89	1035	4.4	166.0	0.000
0300	46.33	16.11	46.33	16.11	40.61	16.11	1035	4.4	163.0	0.000
0400	47.15	17.89	46.33	16.11	39.79	14.32	1035	3.5	172.0	0.000
0500	47.15	16.11	45.51	16.11	39.79	16.11	1035	4.4	163.0	0.000
0600	47.97	16.11	45.51	16.11	40.61	16.11	1035	6.2	191.0	0.000
0700	47.15	16.11	44.70	17.89	38.97	14.32	1035	6.2	183.0	0.000
0800	47.15	17.89	45.51	16.11	40.61	16.11	1035	6.2	70.0	0.000
0900	46.33	16.11	45.51	17.89	41.43	16.11	1035	6.2	110.8	0.000
1000	47.15	17.89	44.70	16.11	40.61	16.11	1035	3.5	3.1	0.000
1100	47.15	17.89	45.51	16.11	42.25	17.89	1035	4.4	177.0	0.000
1200	47.15	16.11	44.33	16.11	41.43	17.89	1035	4.4	11.8	0.114
1300	47.15	17.89	47.97	17.89	40.61	17.89	1035	1.7	17.2	0.961
1400	47.97	17.89	47.15	16.11	41.43	17.89	1035	2.6	12.4	0.597
1500	47.97	17.89	47.15	16.11	41.43	16.11	1043	4.4	129.0	1.890
1600	47.87	0.00	47.15	16.11	40.61	16.11	1043	5.3	14.3	0.015
1700	47.97	17.89	47.97	16.11	41.43	17.89	1043	6.2	0.0	0.593
1800	48.78	17.89	47.97	16.11	41.43	14.32	1043	8.9	14.1	0.778
1900	48.78	17.89	47.97	17.89	40.61	16.11	1043	7.1	0.0	2.050
2000	48.78	17.89	47.97	16.11	41.43	17.89	1043	5.3	11.8	0.778
2100	49.60	19.68	47.15	16.11	43.06	17.89	1043	6.4	15.5	0.000
2200	47.97	17.89	46.33	16.11	41.43	19.68	1043	7.1	12.1	0.000
2300	47.97	17.89	45.51	17.89	42.25	17.89	1043	5.3	10.1	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-30. BRIMS data for 4/8/80 .

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	47.97	17.89	45.51	17.89	41.43	17.89	1043	4.4	0.0	0.000
0200	47.15	17.89	45.51	17.89	41.43	17.89	1035	2.6	0.0	0.000
0300	47.16	16.11	45.51	16.11	40.61	14.63	1035	2.6	0.0	0.000
0400	47.97	17.89	46.33	16.11	43.06	16.11	1043	4.4	0.0	0.000
0500	47.97	17.89	47.15	16.11	42.25	17.89	1043	0.0	17.2	0.590
0600	47.15	16.11	47.15	17.89	40.61	17.89	1050	24.0	0.0	0.230
0700	47.97	17.89	47.15	16.11	40.61	17.89	1050	22.0	0.3	0.960
0800	47.97	17.89	46.33	17.89	41.43	17.89	1050	17.1	5.9	0.590
0900	47.97	17.89	48.78	16.11	42.25	17.89	1050	11.6	349.0	0.960
1000	47.97	17.89	48.78	16.11	40.61	16.11	1050	3.5	3.1	0.590
1100	49.60	17.89	47.89	17.89	40.61	16.11	1050	16.1	0.3	0.230
1200	49.60	17.89	47.97	17.89	40.61	16.11	1050	17.8	59.0	0.960
1300	48.78	17.89	47.97	16.11	41.43	16.11	1043	14.3	11.0	0.780
1330	48.78	17.89	47.15	16.11	43.06	16.11	1050	12.5	8.7	0.000
1400	48.78	17.89	46.33	16.11	41.43	16.11	1043	12.5	3.1	0.000
1500	47.97	17.89	42.25	17.89	42.25	17.89	1050	10.7	346.0	0.000
1600	47.97	17.89	45.51	16.11	43.06	17.89	1050	10.7	346.0	0.000
1700	47.97	17.89	46.33	17.89	40.61	14.32	1050	17.1	338.0	0.000
1800	47.97	17.89	45.51	16.11	41.43	16.11	1043	10.7	335.0	0.770
1900	47.97	17.89	45.51	16.11	43.06	19.68	1043	6.2	338.0	1.300
2000	47.97	17.89	47.15	17.89	42.25	17.89	1043	10.7	340.0	1.330
2100	48.78	17.89	47.15	17.89	42.25	17.89	1043	8.9	338.0	0.590
2200	47.97	17.89	47.15	16.11	40.61	17.89	1043	11.0	343.0	1.300
2300	47.97	17.89	47.15	17.89	40.61	16.11	1043	10.6	0.3	0.590
2400	48.78	17.89	47.97	16.11	42.25	16.11	1043	11.6	31.0	0.960

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-31. BRIMS data for 4/9/80 .

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	48.78	17.89	47.15	16.11	40.61	16.11	1050	15.3	11.5	0.960
0200	48.78	17.89	47.97	17.89	40.61	16.11	1050	11.6	5.9	0.590
0300	47.97	17.89	47.97	16.11	40.61	16.11	1050	10.7	3.1	0.420
0400	48.78	17.89	46.33	16.11	41.25	17.89	1050	17.1	14.0	0.780
0500	49.60	17.89	47.15	17.89	40.61	16.11	1050	13.5	11.0	0.420
0600	47.97	17.89	47.15	17.89	41.43	17.89	1043	10.7	23.0	0.780
0700	47.97	17.89	46.33	17.89	42.25	17.89	1043	12.5	28.0	0.590
0800	47.97	17.89	46.33	16.11	40.61	14.32	1043	16.7	40.0	0.420
0900	47.97	17.89	46.33	17.89	42.25	17.89	1043	10.7	45.0	0.597
1100	47.97	17.89	46.33	17.89	40.61	14.32	1043	8.9	48.0	0.230
1200	47.97	17.89	46.33	17.89	41.43	16.11	1043	8.9	50.0	0.590
1300	47.97	17.89	46.33	16.11	41.43	19.68	1043	11.0	56.0	0.420
1400	47.97	17.89	47.15	16.11	40.61	16.11	1043	6.2	81.0	0.420
1500	47.97	17.89	47.97	16.11	42.25	16.11	1043	3.5	115.0	0.590
1600	47.97	17.89	47.15	17.89	41.41	17.89	1043	6.2	124.0	0.597
1700	47.97	17.89	47.15	17.89	40.61	16.11	1043	6.2	132.0	0.590
1800	47.97	17.89	46.33	17.89	41.43	16.11	1043	7.1	143.0	0.000
1900	47.97	17.89	45.51	17.89	41.43	14.32	1043	4.4	143.0	0.000
2000	47.97	17.89	45.51	16.11	42.25	17.89	1043	5.3	143.0	0.000
2100	47.15	17.89	45.51	16.11	41.43	16.11	1043	8.0	158.0	0.000
2200	48.78	19.68	47.15	16.11	40.61	16.11	1043	7.0	194.0	0.000
2300	47.97	17.89	47.15	16.11	41.43	16.11	1043	6.2	191.0	0.780
2400	48.78	17.89	46.33	17.89	42.25	17.89	1043	1.7	180.0	0.780

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-32. BRIMS data for 4/10/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	47.97	17.89	46.33	17.89	40.61	16.11	1035	0.0	31.0	0.420
0200	47.97	17.89	47.15	16.11	41.43	16.11	1035	0.0	31.0	0.420
0300	47.97	17.89	47.89	17.89	42.25	17.89	1035	0.0	20.0	0.420
0400	47.97	17.89	48.60	17.89	40.61	16.11	1043	4.4	0.0	0.000
0500	48.78	17.89	48.78	16.11	41.43	16.11	1043	4.4	0.0	0.000
0600	48.78	17.89	48.78	17.89	42.25	17.89	1043	7.1	121.0	0.420
0700	48.78	17.89	47.15	17.89	41.43	16.11	1043	5.3	118.0	0.410
0800	47.97	17.89	47.15	16.11	40.61	16.11	1043	10.0	101.0	0.230
0900	47.97	17.89	46.33	16.11	40.61	16.11	1043	8.9	115.0	0.420
1000	48.78	17.89	46.33	16.11	41.43	16.11	1043	3.5	115.0	0.780
1100	47.97	17.89	46.33	16.11	43.06	17.99	1043	10.7	112.0	0.230
1200	48.78	17.89	46.33	16.11	41.43	16.11	1043	9.8	104.0	0.230
1300	47.97	17.89	46.33	11.61	41.43	16.11	1043	9.8	110.0	0.780
1400	47.97	17.89	47.15	17.89	40.61	16.11	1043	13.0	0.0	0.230
1500	47.97	17.89	48.78	17.89	41.43	16.11	1043	10.0	0.0	0.420
1600	48.78	17.89	47.97	17.89	41.43	16.11	1043	10.0	110.0	0.960
1700	47.97	17.89	47.15	16.11	41.43	16.11	1043	11.0	121.0	0.597
1800	47.97	17.89	47.15	16.11	41.43	17.89	1043	10.0	42.0	0.590
1900	48.78	17.89	47.15	19.68	43.06	17.89	1043	14.0	0.0	0.960
2000	48.78	17.89	46.33	16.11	42.25	19.68	1043	10.0	163.0	0.780
2100	48.78	17.89	47.15	17.89	42.25	16.11	1043	11.6	0.0	0.590
2200	48.78	17.89	46.33	17.89	40.61	16.11	1043	9.8	132.0	0.590
2300	48.78	17.89	47.15	17.89	43.06	19.68	1050	10.0	138.0	0.780
2400	48.78	17.89	47.15	17.89	42.25	19.68	1043	12.0	135.0	0.780

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-33. BRIMS data for 4/11/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	48.78	17.89	47.97	17.89	41.43	14.32	1043	11.6	127.0	1.320
0200	48.78	17.89	49.60	16.11	41.43	14.32	1050	17.0	149.0	0.415
0300	48.78	17.89	49.60	16.11	42.25	16.11	1050	14.4	152.0	0.961
0400	49.60	17.89	49.60	17.89	42.25	17.89	1050	13.5	149.0	0.000
0500	49.60	17.89	47.15	17.89	43.06	19.68	1050	12.5	146.0	0.000
0600	49.60	17.89	47.97	17.89	43.88	19.68	1050	23.3	138.0	0.000
0700	50.42	17.89	47.97	17.89	43.88	19.68	1050	17.9	141.0	0.000
0800	48.78	17.89	47.15	17.89	43.88	19.68	1050	19.7	141.0	0.000
0900	49.60	17.89	47.15	17.89	42.25	16.11	1050	14.3	135.0	0.000
1000	49.60	19.68	47.15	16.11	43.06	16.11	1043	5.3	138.0	0.000
1100	49.60	17.89	47.15	17.89	42.25	16.11	1043	3.5	112.0	0.000
1200	49.60	17.89	47.15	17.89	42.25	19.68	1043	5.3	152.0	0.000
1230	49.60	17.89	47.97	17.89	43.06	17.89	1043	4.4	115.0	0.415
1300	49.60	17.89	47.15	17.89	43.88	19.68	1043	6.2	112.0	0.778
1400	48.78	17.89	47.97	17.89	42.25	16.11	1050	10.6	118.0	1.510
1500	49.60	17.89	47.97	17.89	43.88	19.68	1050	8.9	93.0	1.330
1600	49.68	17.89	49.60	17.89	42.25	19.68	1043	4.4	121.0	0.597
1700	48.78	17.89	48.78	16.11	43.06	17.89	1043	5.3	124.0	1.140
1800	48.78	17.89	47.15	17.89	42.25	17.89	1043	5.3	141.0	0.000
1900	50.42	17.89	47.97	16.11	43.06	17.89	1043	4.4	160.0	0.000
2000	48.78	17.89	47.15	17.89	41.43	16.11	1043	10.7	143.0	0.000
2100	49.60	17.89	47.15	17.89	43.88	17.89	1043	7.1	0.0	0.000
2200	50.42	17.89	47.15	43.06	19.68	10.68	1043	8.1	155.0	0.000
2300	48.78	17.89	46.33	17.89	40.61	14.32	1050	11.6	127.0	0.000
2400	48.78	17.89	47.15	16.11	41.43	14.32	1043	8.0	0.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-34. BRIMS data for 4/12/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR. PRES	WIND VEL.	WIND DIR.	FLOW X
0100	47.97	17.89	45.51	16.11	43.88	19.68	1043	6.2	10.4	0.000
0200	47.97	17.89	46.33	17.89	41.43	16.11	1043	3.5	17.4	0.597
0300	47.97	17.89	45.51	16.11	41.43	16.11	1043	5.3	17.4	1.330
0400	47.97	17.89	46.33	17.89	41.43	16.11	1043	5.3	15.5	0.961
0500	47.97	17.89	45.51	16.11	40.61	16.11	1043	4.4	13.8	0.415
0600	47.97	17.89	47.15	17.89	40.61	16.11	1043	2.6	23.1	0.778
0700	47.15	17.89	47.98	17.89	42.25	17.89	1043	0.0	17.4	0.961
0800	48.78	19.68	46.33	16.11	43.06	19.68	1043	0.0	1.7	0.000
0900	48.78	17.89	45.51	16.11	43.06	19.68	1050	13.0	0.0	0.000
1000	47.97	17.89	46.33	17.89	42.25	17.89	1050	16.0	28.0	0.000
1100	47.97	17.89	45.51	17.89	43.06	19.68	1050	20.0	14.0	0.000
1200	48.78	17.89	46.33	17.89	42.25	19.68	1050	16.0	3.1	0.000
1300	48.78	17.89	45.51	16.11	43.88	19.68	1050	14.0	20.0	0.000
1400	48.78	17.89	45.51	17.89	39.89	16.11	1050	17.0	22.0	0.000
1500	47.97	17.89	45.51	16.11	43.06	19.68	1050	20.0	17.0	0.000
1600	47.97	17.89	45.51	17.89	42.25	16.11	1057	21.0	28.0	0.000
1700	48.78	17.89	46.33	17.89	42.25	17.89	1050	8.9	0.3	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-35. BRIMS data for 4/13/80.

	SENSOR #1		SENSOR #2		SENSOR #3		BAR	WIND	WIND	FLOW
TIME	COND.	TEMP.	COND.	TEMP.	COND.	TEMP.	PRES	VEL.	DIR.	X

NO DATA AVAILABLE

Table III-36. BRIMS data for 4/14/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0800	49.60	17.89	46.33	17.89	43.06	16.11	1050	19.7	225.0	0.000
1430	49.60	17.89	46.33	17.89	43.06	19.74	1050	19.7	225.0	0.000
2000	47.97	17.89	45.51	17.89	42.25	17.89	1050	13.6	225.0	0.000
2230	48.78	17.89	46.33	17.89	40.61	16.11	1050	17.9	203.0	0.000
2300	48.78	17.89	46.33	17.89	40.61	16.11	1050	16.1	211.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-37. BRIMS data for 4/15/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	48.78	17.89	45.51	16.11	42.25	17.89	1050	14.3	211.0	0.000
0300	47.97	17.89	46.33	17.89	42.25	17.89	1050	16.2	211.0	0.000
0500	47.97	17.89	46.33	17.89	42.25	17.95	1050	17.9	222.0	0.000
0600	48.78	17.89	45.51	17.89	41.43	17.89	1050	18.8	231.0	0.000
0700	48.78	17.89	46.33	17.89	41.43	17.89	1050	17.9	228.0	0.000
1100	48.78	17.89	47.15	17.89	41.43	16.11	1050	14.4	25.9	0.000
2100	49.60	17.89	47.15	16.11	41.43	16.11	1050	11.6	18.6	0.000
2330	48.78	17.89	47.97	17.89	41.43	16.11	1050	9.8	15.5	0.000
2400	50.42	17.89	47.15	17.89	43.06	17.89	1050	10.7	17.4	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-38. BRIMS data for 4/16/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0900	50.42	17.89	47.97	17.89	43.06	19.68	1043	4.4	0.0	0.000
1200	50.42	17.89	47.97	16.11	43.06	19.68	1050	7.1	0.0	0.000
1400	50.42	17.89	48.78	16.11	43.06	19.68	1050	5.3	0.0	0.000
1600	51.23	17.89	48.78	17.89	43.06	16.11	1050	3.5	0.0	0.000
1700	51.23	17.89	48.78	17.89	43.88	17.89	1050	4.4	0.0	0.000
1800	50.42	17.89	47.97	16.11	43.06	17.89	1050	4.4	0.0	0.000
1900	50.42	17.89	48.78	16.11	42.25	19.68	1050	5.3	0.0	0.000
2000	50.42	17.89	47.97	16.11	42.25	16.11	1050	8.0	0.0	0.000
2100	51.23	19.68	48.78	16.11	42.25	16.11	1050	7.1	0.0	0.000
2200	50.42	17.89	48.78	16.11	42.25	16.11	1050	8.9	0.0	0.000
2300	50.42	17.89	47.97	17.89	42.25	17.89	1050	8.0	0.0	0.000
2400	50.42	17.89	48.78	17.89	43.06	19.68	1050	5.3	0.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-39. BRIMS data for 4/17/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	50.42	17.89	48.78	17.89	48.06	19.68	1050	5.3	0.0	0.000
0200	51.23	17.89	47.97	17.89	48.88	17.89	1050	4.4	0.0	0.000
0300	50.42	17.89	47.97	17.89	42.25	19.68	1050	7.1	0.0	0.000
0400	51.23	17.89	48.78	17.89	42.25	17.89	1050	0.1	0.0	0.000
0500	50.42	17.89	47.97	17.89	42.25	17.89	1050	2.6	0.0	0.000
0700	50.42	17.89	47.97	16.11	42.25	16.11	1043	2.6	0.0	0.000
0800	50.42	17.87	48.78	17.89	42.25	16.11	1043	0.0	0.0	0.000
0900	50.42	17.89	47.79	17.89	43.88	17.68	1050	0.0	0.0	0.000
1000	50.42	17.89	48.78	17.89	42.25	16.11	1050	2.6	0.0	0.000
1100	50.42	19.68	47.97	17.89	41.93	16.11	1050	4.4	0.0	0.000
1200	50.42	17.89	48.79	17.89	52.25	17.89	1050	5.3	0.0	0.000
1300	51.23	19.68	47.97	17.89	43.06	19.68	1050	7.1	0.0	0.000
1600	51.23	17.89	47.97	17.89	41.43	16.11	1057	10.7	0.0	0.000
1700	50.42	17.89	48.78	17.89	46.06	9.68	1057	8.9	0.0	0.000
2000	49.60	19.68	48.78	17.89	43.88	19.68	1050	4.4	0.0	0.000
2100	50.42	17.89	48.78	17.89	48.06	17.89	1050	4.4	0.0	0.000
2200	50.42	17.89	47.97	17.89	42.25	16.11	1050	4.4	0.0	0.000
2300	51.23	17.89	47.97	17.89	43.88	17.89	1050	7.1	0.0	0.000
2400	50.42	17.89	48.78	17.89	42.25	16.11	1050	8.9	0.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-40. BRIMS data for 4/18/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	50.42	17.89	48.78	17.89	43.06	17.89	1050	8.9	0.0	0.000
0200	50.42	17.89	48.78	17.89	43.06	17.89	1050	10.7	0.0	0.000
0300	50.42	19.68	48.78	17.89	42.25	17.89	1057	13.5	104.6	0.000
0400	50.42	17.89	47.97	17.89	43.88	16.11	1057	14.4	152.0	0.000
0500	50.42	17.89	47.97	17.89	42.25	17.89	1057	13.1	0.0	0.000
0600	51.23	19.68	47.97	17.89	42.25	14.32	1057	11.6	0.0	0.000
0700	50.42	17.89	47.97	16.11	42.88	19.68	1057	13.5	169.0	0.000
0800	50.42	17.89	49.60	17.89	43.06	17.89	1057	16.2	0.0	0.000
0900	50.42	17.89	49.60	17.89	43.88	19.68	1057	10.7	180.0	0.000
1130	52.05	17.89	51.23	17.89	41.43	17.89	1050	8.1	0.0	0.000
1200	52.86	17.89	52.10	17.89	43.88	19.68	1057	9.8	174.0	0.000
1300	50.42	17.89	49.60	17.89	43.06	17.89	1057	6.2	152.0	0.000
1400	51.23	19.68	48.78	17.89	43.88	17.89	1057	9.8	174.0	0.000
1500	51.23	17.89	48.78	17.89	43.88	19.68	1057	8.0	191.0	0.000
1600	51.23	19.68	48.78	17.89	43.88	19.68	1057	5.3	0.0	0.000
1700	51.23	17.89	48.78	17.89	42.25	16.11	1057	8.1	180.0	0.000
1800	50.42	17.89	48.78	17.89	43.88	7.89	1057	6.3	0.0	0.000
1900	51.23	17.89	50.42	17.89	42.25	19.68	1057	2.6	155.0	0.000
2000	51.23	17.89	49.60	17.89	43.88	17.89	1057	0.0	148.0	0.000
2100	51.23	19.68	49.60	17.89	43.06	17.89	1050	2.6	143.0	0.000
2200	51.23	17.89	48.78	17.89	42.25	16.11	1050	0.0	148.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-41. BRIMS data for 4/19/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	51.23	17.89	48.78	17.89	41.43	17.89	1050	2.6	124.0	0.000
0200	51.23	17.89	48.78	17.89	43.06	19.68	1050	1.7	129.0	0.000
0300	50.42	17.89	48.78	17.89	41.43	17.89	1050	2.6	0.0	0.000
0400	51.23	17.89	48.78	17.89	42.25	17.89	1050	4.4	0.0	0.000
0500	51.23	19.68	48.78	17.89	43.06	19.68	1050	2.6	0.0	0.000
0600	51.23	-7.89	48.78	17.89	42.25	19.68	1057	8.0	143.0	0.000
0700	50.42	17.89	48.78	17.89	42.25	17.89	1050	8.0	0.0	0.000
0800	50.42	17.89	49.60	17.89	42.25	16.11	1050	8.9	0.0	0.000
0900	51.23	17.89	49.60	17.89	43.88	19.68	1050	7.1	138.0	0.000
1000	50.42	19.68	49.60	17.89	42.25	16.11	1050	8.0	138.0	0.000
1100	50.42	17.89	49.60	17.89	43.06	19.68	1050	2.6	0.0	0.000
1200	50.42	17.89	48.89	17.89	41.43	16.11	1057	4.4	0.0	0.000
1300	51.23	17.89	48.78	17.89	43.06	19.68	1057	7.1	0.0	0.000
1500	51.23	17.89	48.78	17.89	43.88	17.89	1057	5.3	0.0	0.000
1700	50.42	17.89	48.78	17.89	43.88	19.68	1057	2.6	0.0	0.000
1800	51.23	19.68	48.78	17.89	43.88	19.68	1057	3.5	0.0	0.000
1900	52.05	19.68	48.78	17.89	43.06	17.89	1057	4.4	0.0	0.000
2000	51.23	19.68	48.78	17.89	43.06	19.68	1057	4.4	158.0	0.000
2100	51.23	17.89	48.78	17.89	43.88	19.68	1057	4.4	0.0	0.000
2200	51.23	17.89	48.78	17.89	42.25	16.11	1057	7.2	183.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-42. BRIMS data for 4/20/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0200	51.23	19.68	49.68	17.89	43.88	19.68	1057	5.3	177.0	0.000
0300	51.23	17.89	47.97	17.89	43.88	17.89	1057	4.4	0.0	0.000
0500	51.23	17.89	48.78	17.89	43.06	17.89	1057	6.2	138.0	0.000
0600	50.42	17.89	48.78	17.89	42.25	17.89	1057	3.5	118.0	0.000
0700	52.05	19.68	48.78	19.68	43.06	17.89	1050	0.8	98.0	0.000
0800	51.23	17.89	48.78	17.89	43.06	17.89	1050	0.0	0.0	0.000
1000	51.23	17.89	49.60	17.89	42.25	16.11	1057	0.0	0.0	0.000
1100	51.23	17.89	50.42	17.89	42.25	16.11	1057	0.0	0.0	0.000
1200	51.23	17.89	51.23	17.89	44.70	19.68	1057	0.0	0.0	0.000
1300	51.23	19.68	48.78	17.89	42.25	19.68	1057	0.0	0.0	0.000
1400	51.23	17.89	48.78	17.89	42.25	16.11	1064	0.0	0.0	0.000
1600	51.23	17.89	49.60	16.11	42.25	19.68	1057	0.0	0.0	0.000
1700	51.23	19.68	48.78	17.89	43.06	17.89	1057	0.0	0.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-43. BRIMS data for 4/21/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X
0100	51.23	17.89	49.60	17.89	43.88	17.68	1057	6.2	0.0	0.000
0200	51.23	17.89	49.60	17.89	42.25	16.11	1057	5.3	0.0	0.000
0300	51.23	17.89	51.23	17.89	43.88	17.89	1075	0.0	0.0	0.000
0500	52.05	17.89	49.60	17.89	42.25	16.11	1057	4.5	0.0	0.000
0600	51.23	17.89	48.78	19.68	43.88	19.68	1057	3.5	0.0	0.000
0700	51.23	17.89	48.78	17.89	41.43	16.11	1057	4.4	0.0	0.000
0800	51.23	17.89	50.42	17.89	42.25	17.89	1057	0.0	53.0	0.000
0900	52.05	19.68	50.42	17.89	43.88	19.68	1057	0.0	48.0	0.000
1000	52.05	17.89	50.42	19.68	43.06	17.89	1057	0.0	50.0	0.000
.100	52.05	17.89	50.42	17.89	43.88	19.68	1057	5.3	0.0	0.000
1200	51.23	19.68	50.42	17.89	42.25	16.11	1057	0.0	53.0	0.000
1300	51.23	19.68	48.78	17.89	42.25	17.89	1057	0.0	310.0	0.000
1400	51.23	17.89	48.78	17.89	42.25	17.89	1064	5.9	0.0	0.000
1500	52.05	17.89	49.60	17.89	42.25	17.89	1057	4.4	180.0	0.000
1600	51.23	19.68	48.78	17.89	43.88	17.89	1064	6.2	127.0	0.000
1700	52.05	19.68	48.78	17.89	43.06	16.11	1057	8.1	0.0	0.000
1800	51.23	19.68	48.48	17.89	43.88	19.68	1064	8.9	186.0	0.000
1900	51.23	19.68	49.60	19.68	43.88	19.68	1064	9.8	0.0	0.000
2000	52.05	17.89	48.78	17.89	46.88	17.89	1064	8.1	191.0	0.000
2100	51.23	17.68	49.60	17.89	46.06	16.11	1064	9.8	0.0	0.000
2200	51.23	19.68	52.05	17.89	41.43	17.89	1064	7.0	177.0	0.000
2300	51.23	9.68	49.60	17.89	44.70	19.68	1064	8.1	0.0	0.000
2400	51.23	19.68	48.78	17.89	43.06	17.89	1064	8.9	135.0	0.000

Conductivity	millimhos /cm sq.
Temperature	°Celsius
Barometric Pressure	millibars
Wind Velocity	knots

Table III-44. BRIMS data for 4/22/80.

TIME	SENSOR #1 COND.	SENSOR #1 TEMP.	SENSOR #2 COND.	SENSOR #2 TEMP.	SENSOR #3 COND.	SENSOR #3 TEMP.	BAR PRES	WIND VEL.	WIND DIR.	FLOW X

NO DATA AVAILABLE

Table III-45. Brine pit parameters.

	Date	Daily Brine Flow Rate Average-Barrels/Day	Daily Brine Volume Barrels/Day	Salinity (ppt)	pH
March	10	270,083	87,200	-	-
	11	283,726	176,383	83	8.17
	12	270,809	212,473	158	8.1
	13	228,841	228,841	195	7.14
	14	211,119	154,231	218	6.95
	15	176,055	176,055	295	7.17
	16	176,820	176,820	226	-
	17	224,599	175,749	226	-
	18	181,611	181,611	229	7.05
	19	213,947	213,947	229	7.16
	20	211,867	211,867	229	7.15
	21	217,577	217,577	234	7.0
	22	195,089	195,089	225	7.07
	23	207,500	207,500	226	7.07
	24	214,983	214,983	226	7.05
	25	245,744	168,949	226	7.07
	26	225,258	202,919	226	7.07
	27	181,652	145,851	226	7.08
	28	243,133	166,343	226	7.07
	29	208,767	208,767	228	7.05
	30	207,715	207,715	229	7.03
	31	220,212	151,856	234	7.04
April	1	191,941	191,947	234	7.2
	2	191,846	191,864	231	7.28
	3	183,954	111,139	228	7.17
	4	-	-	-	-
	5	-	-	-	-
	6	246,650	115,411	-	-
	7	334,202	137,301	244	7.10
	8	345,499	284,028	247	7.07
	9	329,651	288,527	247	6.93
	10	324,787	324,787	247	7.11
	11	335,300	208,863	246	7.15
	12	340,792	179,320	250	7.04
	13	314,432	114,112	-	-
	14	316,629	112,931	247	7.11
	15	338,909	113,817	252	7.19
	16	160,040	149,103	252	7.15
	17	190,479	182,145	250	7.08
	18	329,495	158,569	242	7.02
	19	337,340	164,734	242	7.20
	20	298,114	125,828	242	7.18
	21	302,978	131,542	239	7.18
	22	318,982	118,281	240	6.99