LOOP MARINE AND ESTUARINE MONITORING PROGRAM, 1978–95

Edited by

Charles E. Sasser
and
Jenneke M. Visser

Coastal Ecology Institute, Center for Coastal, Energy, and Environmental Resources
Louisiana State University

VOLUME 3: PHYSICAL HYDROGRAPHY

By

Carole Current [1]
William J. Wiseman, Jr. [1],
Erick M. Swenson [2],
and Michelle Kasprzak [3]

[1] Coastal Studies Institute, Center for Coastal, Energy, and Environmental Resources
Louisiana State University

[2] Coastal Ecology Institute, Center for Coastal, Energy, and Environmental Resources
Louisiana State University

[3] Coastal Ecology Section
Louisiana Department of Wildlife and Fisheries

Research Report No. 316
LTRC Project No. 97-3IMP
State Project No. 736-99-0449
LSU Project No. 169-25-4115

Conducted for
Louisiana Transportation Research Center

1998

This is Volume 3 of a six volume set that includes: Volume 1: Executive Summary; Volume 2: Water Chemistry; Volume 3: Physical Hydrography; Volume 4: Zooplankton and Ichthyoplankton; Volume 5: Demersal Nekton; and Volume 6: Sediment Quality.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

page

LIST OF FIGURES (continued)

page

LIST OF FIGURES (continued)

page

LIST OF FIGURES (continued)

page

LIST OF FIGURES (continued)

page

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

page

LIST OF TABLES (continued)

page

ACKNOWLEDGMENTS

This work was funded and accomplished as part of the Louisiana Offshore Terminal Authority (LOTA) Monitoring Program. This particular report is only a part of the larger project analyzing the environmental impacts on water chemistry, zooplankton and ichthyoplankton, demersal nekton, and sediment quality. Dr. J. Geaghan of the Louisiana State University Department of Experimental Statistics constructively assisted in the analysis.

MEASUREMENT ABBREVIATIONS

C.	Celsius
cpd	cycles per day
cpy	cycles per year
ha.	hectares
km.	kilometers
m.	meters
mi.	miles
ppt	parts per thousand

EXECUTIVE SUMMARY

Introduction

The complex region of interest is associated with the Mississippi River deltaic plain. The estuarine portion (Barataria Basin) has resulted from the subsidence of abandoned river distributaries and associated marsh; the offshore region is strongly influenced by the discharge plumes from the present delta. The hydrographic data sets collected by the Louisiana Offshore Oil Port (LOOP) Environmental Monitoring Program are among the longest continuous records from this region and clearly define the inter-annual and intra-annual hydrographic variability of the area. The most complete of these concern the temperature and salinity variations.

Methods

These data sets were used to estimate statistics, which objectively characterize the hydrography of the region, to estimate the presence of trends and/or changes in this character during the course of LOOP operations, and to determine the possible causes of any such changes identified.

The data were collected by the Louisiana Department of Wildlife and Fisheries (LDWF) using standard technologies. Some data sets were from continuous recorders while others were from fixed stations sampled at nearly regular intervals. The records were quality controlled and the final data sets analyzed using standard statistical techniques, both parametric and non-parametric. Particular emphasis was placed on estimating changes before and after important LOOP-related activities (major brine discharges following construction, cessation of brine discharge) and significant environmental events (Hurricane Andrew, the active 1985 hurricane season, the freeze of 1989, variations in Mississippi River flow).

The region was divided into four sub-regions having different hydrographic characteristics and different dominant physics: an offshore region dominated (at least in the surface layers) by the effluent plumes of the Mississippi River, a nearshore region where the influence of the coast directed flow parallel to shore and shallow waters permitted strong air-sea interactions, a lower estuarine region where broad areas of open water connected to the nearshore region through multiple tidal inlets allowing significant exchange of estuarine and coastal water, and an upper estuarine region of broad shallow lakes interconnected by narrow bayous and tidal channels which restrict exchange processes. Each region was considered separately.

Results

The seasonal variability within each region was consistent with patterns observed in earlier, less comprehensive studies. Temperatures varied in response to summer heating and winter cooling. Salinities responded to the discharge pattern of the Mississippi River and to local rainfall and evaporation. Interannual variability was less than intra-annual variability in both parameters.

Trends in parameters were observed at many, but not all, stations. These trends were most common in temperature and were generally positive. Five near-bottom stations in the offshore region recorded positive salinity trends. Other trends were not spatially coherent and often resulted from short records which could have been strongly influenced by climatological variability. The most spatially-coherent signals were increasing temperature trends at offshore stations. These may have been due to the effects of Loop Current rings. An adequate time series of Loop Current variability was not available to test this hypothesis. We could not develop a rational hypothesis for how LOOP activities could alter these hydrographic variables other than by an alteration of estuarine flow patterns. There was no indication of such an effect.

BACI analyses did not indicate any statistically significant interaction term except for the analysis of oil spill impacts on bottom salinity at the offshore terminal. The before-after contrast, though, was insignificant suggesting that the control and impact stations were different, but not due to the spills.

Conclusions

We were unable to identify a clear change or trend in hydrographic variables attributable to LOOP activities. The hydrographic data set, though, defines the interannual and intra-annual variability of these parameters for comparison with biological and water chemistry parameters.

This will allow identification of changes in covariates, if biological changes are observed.

Summary for Task 3

Continuation of this data set, using a reduced and modified sampling protocol, is probably advisable. Proposed alterations to the Mississippi River discharge pattern may be expected to result in habitat alterations in the future. Consequent impacts on the biota can only be properly assessed and related to causative factors if the changing physical characteristics of the water column are adequately tracked in space and time

DATA ANALYSIS OF THE LOOP MARINE AND ESTUARINE MONITORING PROGRAM, 1978–95

by

Carole L. Current[2],
William J. Wiseman, Jr.[2],
Erick M. Swenson[1],
and
Michelle Kasprzak[3]

[1]Coastal Ecology Institute
Center for Coastal, Energy, and Environmental Resources
Louisiana State University

[2]Coastal Studies Institute
Center for Coastal Energy, and Environmental Resources
Louisiana State University

[3]Coastal Ecology Section
Louisiana Department of Wildlife and Fisheries

INTRODUCTION

Louisiana Offshore Oil Port

The Louisiana Offshore Oil Port (LOOP) facilities in coastal Louisiana provide the United States with the country's only superport for off-loading deep draft tankers. The facilities are located in Lafourche Parish in southeast Louisiana, south of New Orleans and adjacent offshore waters west of the Mississippi River Delta. The development is operated by LOOP LLC, a private corporation owned by Shell Oil Company, Texaco Inc., Ashland Inc., Murphy Oil Corporation, and Marathon Pipeline Company.

LOOP INC, (later restructured as LOOP LLC) was organized in 1972 as a consortium of companies to design, construct and operate a deepwater port on the Louisiana coast. Pre-permit baseline studies related to the proposed development were conducted from 1972 to 1975. Major documents related to these studies are listed in Table 1. State and federal licenses to own and operate a deepwater port were issued in January 1977, and accepted on August 1, 1977. The state license was issued to LOOP pursuant to the Louisiana Offshore Terminal Act (LA R.S. 34:3101 et seq.). A federal *License to Own, Construct and Operate a Deepwater Port* was issued to LOOP by the U.S. Department of Transportation (USDOT) pursuant to the federal Deepwater Ports Act (33 U.S.C. 1501, et seq.). The first oil tanker was offloaded on May 5, 1981.

Facility Description

The superport complex consists of an offshore marine terminal located about 30 km from the mainland in the Gulf of Mexico, an onshore storage facility at the Clovelly salt dome near Galliano about 50 km inland from the coast, and a large diameter pipeline system including a pumping booster station near Fourchon onshore to deliver oil to the storage facility. The pipeline system also connects the Clovelly salt dome oil storage facility to transportation facilities on the Mississippi River. A large brine storage reservoir (101 ha) is positioned near the Clovelly salt dome storage facilities. A small-boat harbor and logistics facility is located at Port Fourchon, on Bayou Lafourche.

Table 1. List of reports produced for superport planning (after Sasser et al. 1982)

Year	Title	Comment
1972	LOOP feasibility study	LOOP's Engineering Feasibility Study
1972	A Superport for Louisiana	Superport Task Force Report
1972	LSU Superport Study #1	Requested by Superport Task Force
1972	LSU Superport Study #2	Requested by National Sea Grant Program
1973	LSU Superport Study #3	Requested by LOTA to formulate EPP
1973	LSU Superport Study #4	Requested by LOTA to formulate EPP
1974	Alternate Site Location Evaluation	Prepared by Dames and Moore for LOOP, Inc.
1976	Environmental Baseline Studies Vols. 1?4	Prepared by LSU for LOOP, Inc.
1976	Environmental Impact Study	US Department of Transportation

The marine terminal consists of three Single Point Mooring (SPM) structures connected by pipelines to a platform-mounted pumping station in the Gulf of Mexico, 30 km southeast of Belle Pass, Louisiana. Water depth at the platform is 36 m. From the offshore marine terminal facility, crude oil is pumped northward through a large diameter (48 inch) buried pipeline, through the onshore booster station at Fourchon, to the Clovelly salt dome storage complex near Galliano. The crude oil is stored in caverns constructed in subterranean salt domes. These storage chambers were formed by solution mining utilizing local surface water in the area. A second pipeline extends southward parallel to the oil pipeline and carries brine leached from the Clovelly storage facility to the diffuser disposal site located in open Gulf of Mexico waters approximately 4.8 km (3 mi.) offshore and adjacent to the LOOP oil pipeline. Additional distributary pipelines move oil from the Clovelly complex to outlying pipelines and refining centers.

Project Area

The Barataria estuary and the offshore area in which LOOP is located is an extremely diverse and complex natural system. It is located in the Mississippi River Deltaic Plain region. This region was formed and is continually influenced by processes associated with the deposition of massive amounts of sediments carried by the Mississippi River. The LOOP pipeline traverses the major wetland habitats in the Louisiana coastal area. The 159 km pipeline crosses the near-offshore Gulf of Mexico, beach/barrier headland, and estuary. Within the estuary, four salinity zones -- saline, brackish, intermediate and fresh -- are traversed, each providing a unique habitat supporting a variety of species.

The coastal marshes of Louisiana are one of the most productive ecosystems in the world, supporting a wide variety of estuarine-dependent organisms. Louisiana leads fishery production within the northern Gulf of Mexico and is second only to Alaska among all states (NMFS 1997). Louisiana is the leader in the United States for the production of shrimp, blue crab, oyster, crawfish, tuna, red snapper, wild catfish, black drum, sea trout, and mullet (McKenzie et al. 1995). Ninety-five percent of the Louisiana fish and shellfish landings are estuarine-dependent species (McKenzie et al. 1995). The fish community of Barataria estuary is the most diverse of any estuary in Louisiana with 191 species from 68 families (Condrey et al. 1995).

Monitoring Program

In recognition of the potential for significant environmental impacts much attention was given to environmental safeguards by state and federal agencies and by the superport developers (Sasser et al. 1982). Because of the potential risks associated with the construction and operation of the superport (e.g. bringing the world's largest oil tankers to one of the most productive fisheries resources in the world), both state and federal licenses required environmental monitoring of LOOP construction and operational activities. The environmental monitoring program (EMP) was developed under mandate of the Superport Environmental Protection Plan (revised, 1977), a regulation of the State of Louisiana implementing the Offshore Terminal Act. Components of the estuarine/marine monitoring program include: water chemistry, physical hydrography, brine discharge, zooplankton/ichthyoplankton, demersal nekton, benthos, and sediment quality. The Louisiana Department of Wildlife and Fisheries collected the data related to these components from 1978 to 1995. Vegetation and wildlife components were monitored by LSU (Visser et al. 1996). This report is the second component in a series of five reports that analyze of the impacts of LOOP construction, operation, and maintenance on the estuarine/marine environment. These five reports analyzed the following components: 1) Water Chemistry, 2) Physical Hydrography, 3) Zooplankton / Ichthyoplankton, 4) Demersal Nekton, and 5) Sediment Quality.

Literature Review

The region of interest is complex, and the hydrographic character of each associated sub-region responds to the dominance of different dynamics and external forcing factors. Within the study area, we can identify both a mid-shelf and inner shelf sub-region of the coastal bight immediately west of the Mississippi delta. This region has been referred to as the Louisiana Bight (Wiseman et al. 1982, Rouse and Coleman 1976). The estuarine (in the sense of Pritchard 1967) portion of the study area can also be subdivided into an open water, lower estuary and complex, inter-connected upper estuarine region.

The dominant feature of the bight west of the Mississippi delta is the effluent plume from Southwest Pass (Rouse and Coleman 1976, Wiseman et al. 1974, Wiseman et al. 1975, Walker 1996, Rouse 1997), which often makes an anticyclonic (clockwise) turn within the bight before merging with a coastal current near shore. The dynamics of the region are poorly understood. Wind forcing appears to be important (Rouse and Coleman 1976, Rouse 1976). Mixing is complicated (Wiseman et al. 1975), and the effect of biological uptake on the distribution of nutrients remains an open question (Hitchcock et al. 1997). Tides are diurnal and small (Marmer 1954). Inertial oscillations are important (Daddio et al. 1978). Most hydrographic studies of the area have been of short duration, a few years at most. Seasonal water mass variability has been defined (Wiseman et al. 1982) from the data collected during the LOOP environmental assessment (Wiseman et al. 1974). The other long-term data set (Temple et al. 1977) was used extensively in the broader scale studies of Cochrane and Kelly (1986) and Dinnel and Wiseman (1986). Data collected by NOAA's Nutrient Enhanced Coastal Ocean Program (NECOP) cruises have been presented separately in a number of locations (e.g. Rabalais et al. 1991). These data were largely collected during mid-summer monitoring cruises, but indicate significant inter-annual variability. Other data sets are of less than a year in duration, e.g. Turner and Allen (1982).

As the effluent plumes from the Mississippi River approach within one Rossby radius of the coast, the presence of a coastal boundary directly influences the flow dynamics (Gill 1982, Csanady 1981). (The Rossby radius is the horizontal scale above which rotational effects become as important as buoyancy effects on circulation in a given domain; Gill, 1982.). The flow turns westward along the coast (Cochrane and Kelly 1986, Wiseman and Kelly 1994) although reversals due to wind forcing can occur on a regular basis (Dinnel et al. 1997, see also discussion of flow variability below). The hydrographic characteristics of this region were included in the analysis of Wiseman et al.(1982) and are similar to those observed at a nearshore station further westward offshore of Cocodrie (Wiseman et al. 1997).

Within the estuarine portion of the study area, a number of studies including water mass properties have been carried out. Those involving the longest records are Wiseman et al. (1990a, 1990b). The most important conclusion from these studies was that the low-frequency salinity variability could be adequately represented using an auto-regressive, moving average model forced by Mississippi River discharge. This implied that higher frequency processes effectively flushed estuarine waters from the system and exchanged them with coastal ocean waters. The processes involved, by analogy with Terrebonne Bay (Wiseman and Inoue 1993, McKee et al. 1994) and inspection of the power spectra of the salinity records from the Barataria Basin, are tidal exchange and wind-driven exchange (Kjerfve 1973, Kjerfve 1975, Byrne et al. 1976, Schroeder and Wiseman 1986). Flushing times for different portions of the estuary have been estimated by Von Arx (1949) and Wiseman and Swenson (1989), among others. Numerical models of the system have been developed by Hacker (1973), D.-H. Park (personal communication) and Suhayda and Aravamuthan (personal communication). The first description of the seasonal variability of salinity conditions within the system of which we are aware is Barrett et al. (1971). This description has not altered significantly, although description of the interannual modulation has been refined.

The general goal of our data analysis program was to analyze and report on the LOOP Marine/Estuarine environmental monitoring data collected from 1978-1995, with respect to the EMP objectives.

- We define the seasonal variability of the hydrographic properties of the study region. In particular, means and variances are estimated along with long term trends in these properties. Other important statistics of the data sets are identified.

- We test for any anomalous changes in these properties during operation and/or construction of the LOOP facilities.

- Where such changes are identified, we attempt to identify possible causes of these changes.

- We attempt to interpret the available data so that future changes in the hydrography of the environment or concurrent changes in the biota may be identified as anomalous or due to expected environmental stochastic variability.

METHODS

Field Methods

The Louisiana Department of Wildlife and Fisheries (LDWF) deployed 13 stations to constantly record high resolution time series of temperature and salinity, located in both estuarine and offshore regions as depicted in Figure 1. Current direction and speed were also recorded at stations 306, 318, 319, and 335. The type of instrumentation used at these fixed stations, and period of use for each type of instrument, is detailed specifically for each station in Figure 2. The high resolution measurement frequencies varied from once per minute to once per hour, depending on the station and deployment. These measurements of variable frequency were converted to hourly values by Coastal Studies Institute personnel as described below.

The time series data collected at these fixed station locations were supplemented by monthly measurements of temperature and salinity that were taken at top, middle, and bottom depths at 152 stations throughout the study region over a period of 18 years. Salinity was measured at inshore stations using a Beckman RS5-3 portable salinometer from 1978-1989. From 1990-1995 a Hydrolab Surveyor 2 was used, although sometimes the Beckman instrument was used for inshore salinities as a backup. From 1978-1984, the Martek Mark VI was used at offshore stations with numbers in the 700's (Figure 3), as well as at stations with numbers in the 400's. During these years, the Beckman RS5 was used at stations 21, 22, 35, 36, 37, 52, 53, 54, and 55, though the Martek instrument was used as an occasional backup. From 1985-1995, a Guildline CTD was used at offshore stations: a CTD is a standard oceanographic instrument for measuring conductivity, temperature, and depth. From 1990-1995, the Seabird SBE19 CTD was used offshore as a backup instrument. Monthly measurements at these stations provided a broad spatial sampling of temperature and salinity fields in the study area over the full eighteen years of the study, although of a lower sampling frequency than at the fixed stations.

Salinity was also recorded on a monthly basis at top, middle, and bottom levels at 42 water chemistry stations. This was done from 1978-1984 by titration; after that time an Autosal analyzer was employed. These water chemistry salinity data were collected concurrently with

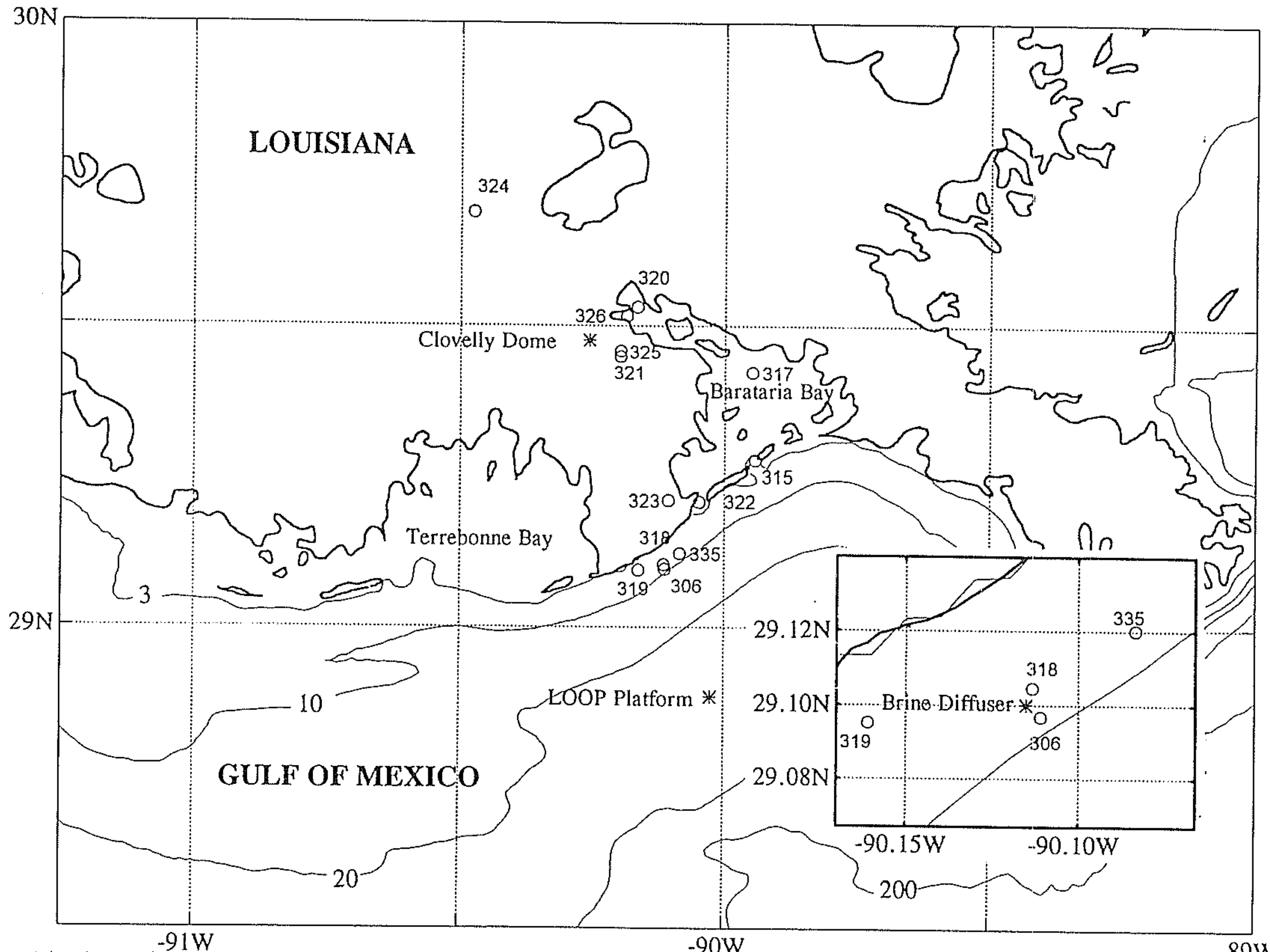

Figure 1. Fixed mooring locations at which temperature and salinity were measured; in addition to these variables, current speed and direction were measured at stations 306, 318, 319, and 335. Inset (5:1) shows location of brine diffuser.

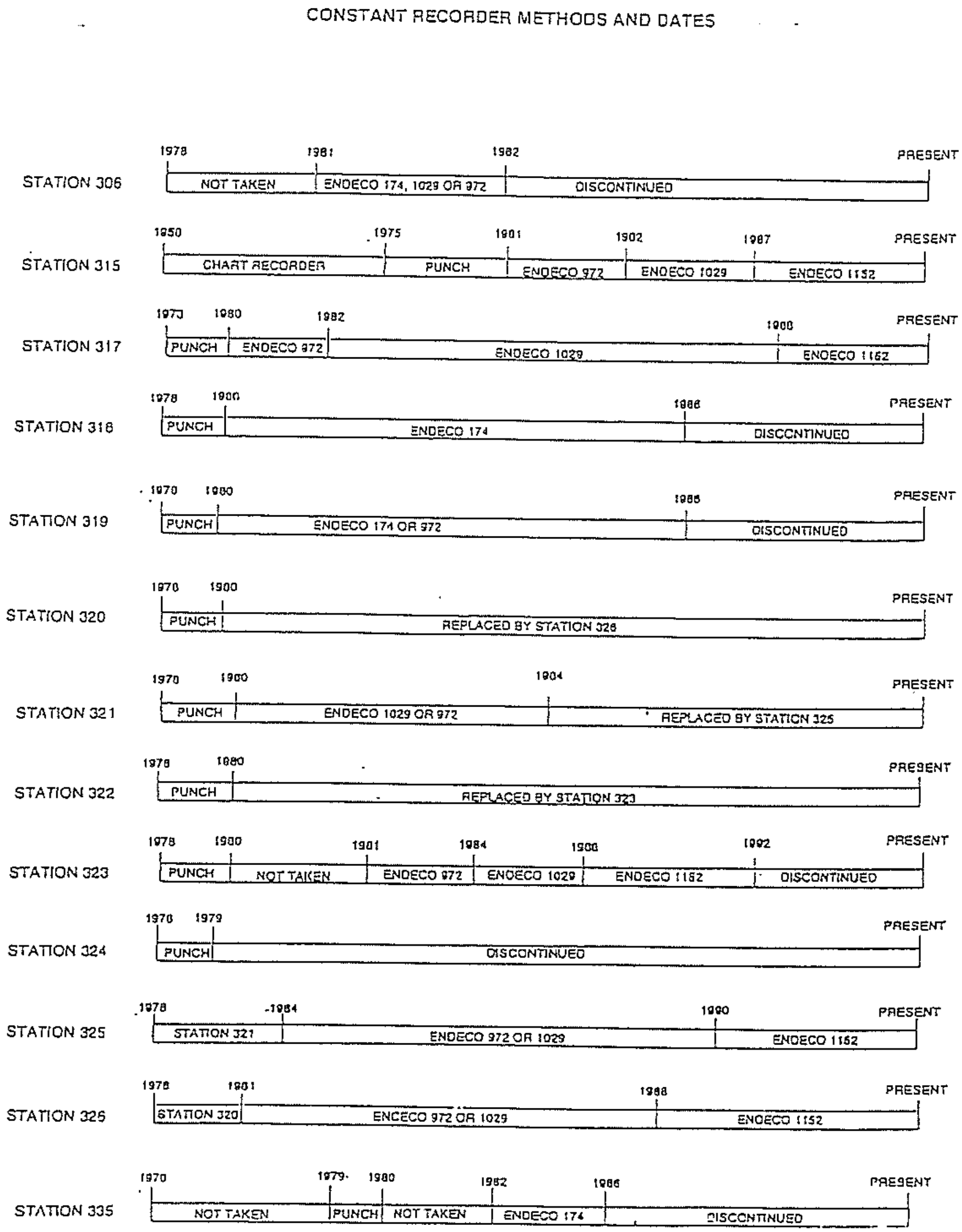

Figure 2. Constant recorder methods and dates. Figure courtesy of LDWF.

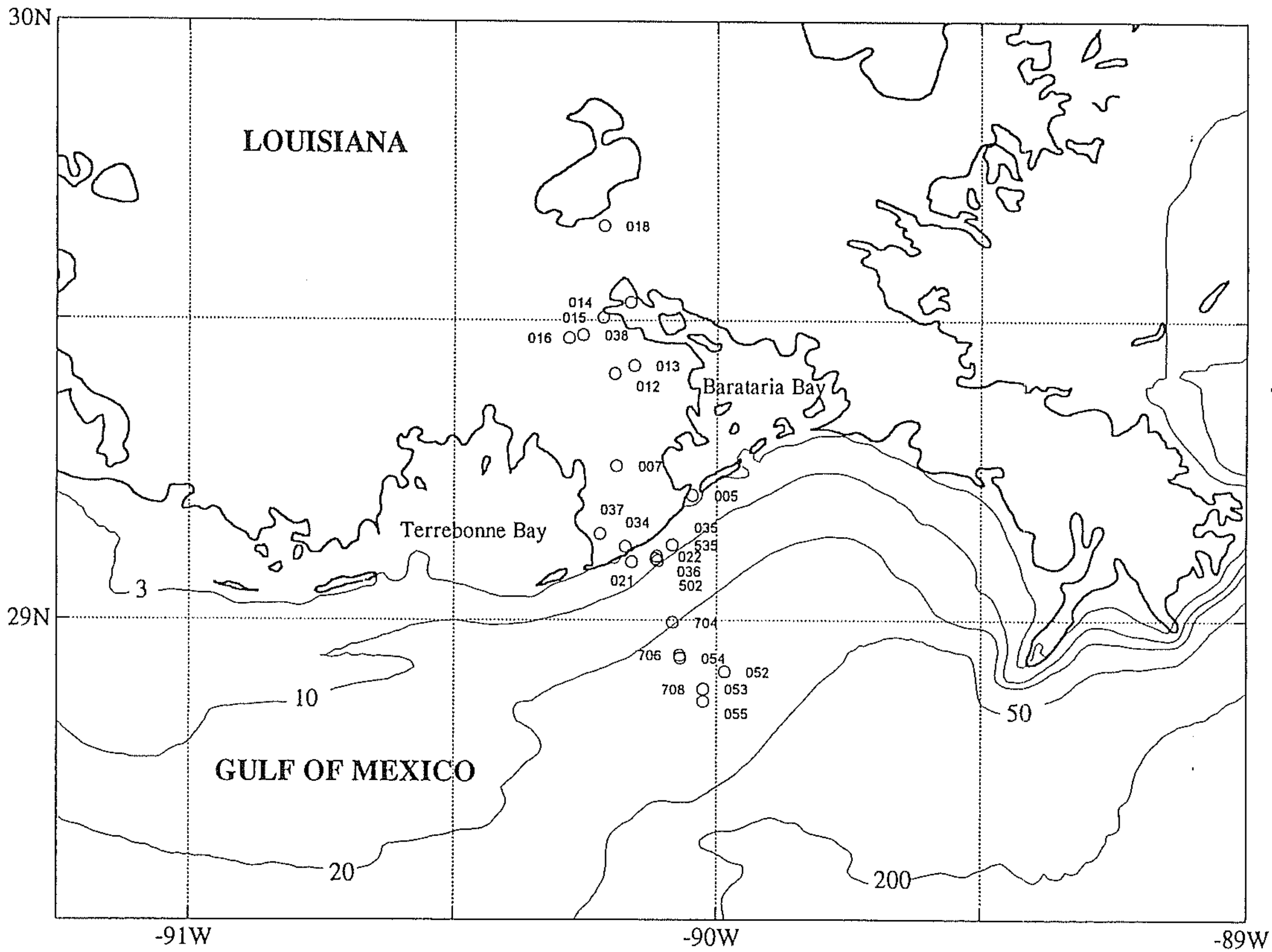

Figure 3. Locations of 24 stations used for long term temperature and salinity trend study.

some of the physical hydrography data, and they were used in this study to verify the monthly physical hydrography salinity data. Although the water chemistry data were measured using preferred methods and instruments, there are more stations and more measurements available in the data set designated for the study of physical hydrography.

LDWF also recorded 1143 profiles of temperature, salinity, oxygen, and pH collected by CTD from 1988-1995 at 25 stations throughout the study region. The temperature and salinity profiles were used to supplement time series data in this study.

Water level measurements and cumulative precipitation measurements were made from 1978-1980 at stations 315, 320, and 322 (water level only). The importance of freshwater derived from land drainage to an understanding of the hydrography and flow patterns within the estuarine waters of the Barataria system was mentioned in the introduction. A good record of long-term precipitation from this basin is not available. The few short period records collected during the monitoring program are not of a length which lend themselves to an analysis of seasonal variability or interannual trend analysis. The absence of such long term records will continue to inhibit a comprehensive description of the physical hydrography of the basin.

Laboratory Methods/Computer Processing of Data

A modified data set was created for use in the analysis of the physical hydrography data. This was done using common procedures that prepare instrument output for use by the scientific community. This section of the report contains both a description of the procedures used by Coastal Studies Institute personnel to create the modified data set, as well as the method of verification of the physical hydrography salinity data using salinity data from the water chemistry data set.

Discrete monthly measurements of salinity, temperature, depth of measurement, seafloor depth, and additional physical hydrographic variables were taken by LDWF at top, middle, and bottom depths at 152 stations all of which are at known locations. Outliers more than five standard deviations from the local mean were removed from monthly temperature and salinity samples. This method of outlier removal is a standard quality control procedure used in physical oceanographic projects such as LATEX, the Louisiana-Texas Shelf Physical Oceanography Program (Jochens and Nowlin 1994). Because stratification in the region is known to be stable and dominated by salinity structure, bottom salinity values recorded simultaneously with mid-depth salinity values that exceeded them were discarded. Further monthly or quarterly measurements of salinity from the water quality (chemistry) data at 42 stations were processed also. Headers were added to the physical hydrography and water quality data files which include general information, data format, Fortran format of the data, specification of flags used to indicate any missing values, and identification of the information and units of measurement in each column. A very important part of creating a data set suitable for scientific use is the creation of regular columns of information. These include columns for station number, decimal day following 1/1/78 0000 at which the sample was collected, seafloor depth, sampling depth, and salinity for the water quality data file, as well as temperature, east current velocity, and north current velocity columns for the physical hydrography data file.

Hydrographic profiles of temperature, salinity, and oxygen were visually inspected; obvious outliers were identified and removed manually, and gaps were flagged and recorded.

The high resolution time series data from stations 306, 315, 317, 318, 319, 320, 321, 323, 324, 325, 326, and 335 were reduced to hourly values from varied and inconsistent higher resolution sampling frequencies by means of linear interpolation of the nearest values within 30 minutes before and after the hour. Another procedure that could have been used is the estimation of variable values on the hour by an hourly mean; this is a useful technique that inherently smooths the data but requires a weighting algorithm in data that are collected at variable sampling frequencies. Gaps in the hourly rendition of the data that spanned from 2-20 hours were filled by means of linear interpolation. Larger gaps were left intact. Temperature, salinity, east velocity, and north velocity values that exceeded three standard deviations from the local mean were removed. Standard headers were added to each high resolution data file and these include general information, station number, geographic coordinates, start and stop dates for recorded measurements, data format, Fortran format of the data, specification of flags used to indicate any missing values, and identification of the information and units of measurement in each column. Month, day, year, hour, decimal day following 1/1/78 0000 at which the sample was collected, temperature, and salinity follow, and east current velocity and north current velocity also follow for stations at which they are available (stations 306, 318, 319, and 335).

Salinity records from the physical hydrography and water chemistry data sets were statistically analyzed and visually compared. Monthly salinity measurements in the physical data set (appendix B) are consistent with those of the water chemistry data set (appendix C). Means and standard deviations of salinity measurements at individual stations are similar between these two data sets. Differences in statistical moments between data sets can be attributed to the greater number of monthly measurements in the physical data set than in the chemical data set, and to the use of different instrumentation in measurements recorded in these data sets (as detailed above).

Linear regression (with the physical hydrography as the dependent variable and the water chemistry salinity as the independent variable) was used to compare the salinity data collected by the physical hydrography sampling (in-situ with a conductivity-temperature instrument) to the salinity data collected by the water chemistry sampling (water sample that was analyzed upon return to the laboratory) to address the comparability of the data bases. Only the surface measurements were used, since we can be certain that the water bottle sample and the conductivity probe sampled the exact same depth. The comparison using all data (n=5652) yielded a slope of 0.982, with an intercept of 0.275 ppt, and an r-square of 0.976. The surface individual station comparisons yielded the following results:

- 43 stations had correlation coefficients greater than 0.95
- 22 stations had correlation coefficients between 0.90 and 0.95
- 5 stations had correlation coefficients between 0.80 and 0.90
- 4 stations had correlation coefficients less than 0.85 (0.83, 0.77, 0.66, 0.60)

Offshore bottom salinity records in the physical data set included some anomalously low salinity values that were not duplicated in the chemical data set. Investigations into the numerous possible reasons for such anomalies have led us to believe that these low salinities may be due to occasional isolated problems due to the accidental introduction of air bubbles in the CTD or possibly occasional unintentional dragging of the CTD along the bottom. Some of these anomalous values were removed as outliers by the procedures discussed above.

Since, aside from these occasional anomalies, monthly salinity measurements from the physical hydrography data set appear to be valid, and since the physical hydrography data set includes many more monthly measurements of salinity than does the water chemistry data set, the water chemistry data set was not used further in characterizing the physical hydrography of the region or in impact analysis.

From the modified data sets described in this section, monthly and weekly means and variances were computed and used for plotting and further analysis. Long term trends were determined and impact analyses performed by various statistical methods as discussed in the following section.

Statistical Methods

Three statistical methods of computing long term trends were used in this study. The solution to a simple linear regression model

$$y_i = \beta_o + \beta_1 x_i + e_i$$

was obtained by least squares fit, minimizing square of the statistical error e_i. Here y_i is i^{th} value of either temperature or salinity, depending on the time series being analyzed for trend, and x_i is the time of measurement. Linear regression of this kind is a parametric method of trend analysis and normality is assumed (Weisberg 1985). Linear regression by least squares is a standard technique; however a nonparametric test is to be preferred if the data represent samples of quantities that may be skewed or otherwise deviate from normality. This could in fact be the case despite the quality control procedures described above.

A nonparametric test, Kendall's test for correlation, commonly known as Kendall's tau, was therefore implemented as described by M.G. Kendall (1938), both for the salinity and the temperature time series. The probability that a trend exists ($p_{nonseasonal}$) was determined separately from the data at each station. Kendall's tau is a non-parametric test for randomness against trend in which the null hypothesis (H_o) states that the data are a sample of n independent and identically distributed random variables, and the alternate hypothesis (H_1) is that this is not the case. The test statistic is

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}\left(y_j - y_k\right)$$

where

$$\text{sgn}(\theta) = \begin{cases} 1 & \text{if } \theta > 0 \\ 0 & \text{if } \theta = 0 \\ -1 & \text{if } \theta < 0 \end{cases}$$

and the symbol $\sum$ indicates summation. This test statistic S is used to determine the probability $p_{\text{nonseasonal}}$ that a trend exists. This is the second method used in the present analysis to detect trend.

The Kendall tau test does not customarily take into account the possible effects of seasonality on the test for trend. A seasonal Kendall tau test has been developed for water quality applications by Hirsch et al. (1982) and is the third method applied to the LOOP time series data in this analysis of long term trend. It is similar to the standard (non-seasonal) Kendall tau test, but is insensitive to the existence of seasonality. Here, the null hypothesis H_o is similar to that stated above for the standard Kendall tau test, but the identical distribution of the random variables is only assumed to exist separately for each of 12 months of the year. The test statistics

$$S_i = \sum_{k=1}^{n_i - 1} \sum_{j=k+1}^{n_i} \text{sgn}\left(y_{ij} - y_{ik}\right)$$

are used to determine the probability p_{seasonal} that a trend exists, and a slope estimator B is the median of the $d_{ijk} = \left(y_{ij} - y_{ik}\right) / \left(j - k\right)$ for all pairs i=1, 2, ..., 12 . Further information on this method is available in Hirsch et al. (1982).

Trend analyses were individually conducted using all three methods on surface salinity and temperature time series at the 24 stations having the most complete monthly records (5, 7, 12, 13, 14, 15, 16, 18, 21, 22, 34, 35, 36, 37, 38, 52, 502, 704, 706, and 708). Trend analyses on bottom salinity and temperature time series using the same methods were performed for 17 stations having the most complete monthly measurements taken near the bottom (5, 18, 21, 22, 35, 36, 37, 38, 52, 53, 54, 55, 502, 535, 704, 706, and 708). Trend analyses were conducted independently for each station at which 120 or more monthly measurements were available.

Long term trends for surface salinity, surface temperature, bottom salinity, and bottom temperature were determined for the entire eighteen year study period, and before and after the following events:

1. Year long cessation of brine discharge, 1990;
2. Hurricane Andrew, August 1992;
3. Hurricane Season of 1985 (Hurricanes Danny, Elena, and Juan);
4. Major brine discharge of 4/1/80 - 12/31/82 following construction of LOOP facilities;
5. Onset of heavy Mississippi River flow in 1983; and
6. The "Big Freeze" of December 1989.

The potential effects of these events on long term trends in hydrology in the study region were thus addressed. Of particular concern is whether brine discharge associated with LOOP activities was associated with changes in long term salinity trends in the region. Cessation of brine discharge in 1990 might also affect long term salinity trends. The onset of years of heavy river flow might be expected to decrease local salinity. The extreme cold front of 1989 might be expected to affect temperature trends. Hurricanes, particularly Hurricane Andrew might also be expected to disturb long term trends in hydrology in the estuarine regions. The hurricanes of 1985 and the cold front of 1989 are events that occur on a short time scale and are expected to have lesser effects on long term trends than Hurricane Andrew (due to its severity and path), consecutive years of heavy river outflow, and the major brine discharge following LOOP construction which also occurred over several years time.

Trend analyses were also conducted for monthly averaged data taken at fixed stations for the full length of record at each location.

LOOP activities were analyzed for potential impacts on the physical hydrography data using Before-After, Control-Impact (BACI) modeling with the General Linear Models (GLM) procedure in the "Statistical Analysis System (SAS)", (SAS 1990 a, b, c). The "before" and "after "classes are based upon the timing of the events being studied and the "control" and "impact" classes are assigned based upon the distance between a given measurement station and the location where the event being studied occurred. The BACI model looks at the interaction of the before-after and the control-impact statistical tests. If there is an effect, this term will be significant. A discussion of BACI analysis can be found in Underwood (1994). In using the model, the data is divided into "before" and "after" and "control" and "impact" classes. The basic model is as follows:

Response Variable = BA YEAR(BA) CI STATION(CI)
BA*CI YEAR*BA*STATION(CI)

Where: BA denotes before/after class
YEAR denotes measurement over time
CI denotes control/impact class
* denotes an interaction term and parentheses denote nesting

It is possible to have a difference between the control and impact stations (the CI term in the model would be significant) without an actual impact due to the event if the differences between stations is always present. Similarly, it is possible to have a difference between the before and after samples (the BA term in the model would be significant) without an actual impact due to the event if all stations had the same response (i.e., all of the stations increased after the event). In order to show an impact, the BA*CI interaction term must be significant. This means that the impact stations are responding differently than the control stations to the impact.

The standard BACI model was run to investigate the possible impact of (1) LOOP construction, and (2) brine pumping. A modification of the standard BACI model was run to investigate the possible impact of oil spills. In this model the amount of oil spilled is added as a covariate in the model. The modified model is:

Response Variable = BA YEAR(BA) CI STATION(CI) OIL
BA*CI YEAR*BA*STATION(CI)

Where: OIL denotes amount of oil spilled (all other terms are the same)

The time periods for the construction were those suggested by LDWF: pre-construction before January 1979, construction from January 1979 through December 1980, and after construction following December 1980. The time periods for the brine pumping and the oil spills was based upon the data documenting these events. Figure 4 presents a plot of the oil spills at Clovelly Dome, the Fourchon small boat harbor, and the offshore terminal as well as the brine discharge. The actual amount of oil spilled was used in the model as a covariate with the before time period corresponding to the time before any oil was spilled and the after time period corresponding to the time after all oil was spilled. In the case of the brine pumping, the before time period corresponds to times before any pumping started (dates before 01-05-80), the during time period corresponds to the time period during which major pumping occurred (01-05-80 to 01-12-82), and the after time period corresponds to the time period after major pumping stopped (dates after 01-12-82).

Stations on or close to the LOOP pipeline route during construction were classified as impact stations, and those removed from the pipeline route, but still in the inshore area were classified as control stations. Regarding brine pumping, the stations very close to the brine diffuser were classified as impact stations and the stations removed from the brine diffuser were classified as control stations. Oil spills were analyzed for the Clovelly Dome and the offshore terminal only. The Fourchon small boat harbor did not have a suitable control station (there is not another Bayou LaFourche station), and the amount of oil spilled was quite small (see Figure 4).

A second model, using a "high" and "low" impact classification was also employed. In this model stations at the impact site (offshore terminal) were classified as high impact stations, stations close by were classified as low impact stations, and stations further away were classified as control. The purpose of this model was to determine the extent of an impact, if one existed. The time periods used and the stations used for all analyses are summarized in Table 2.

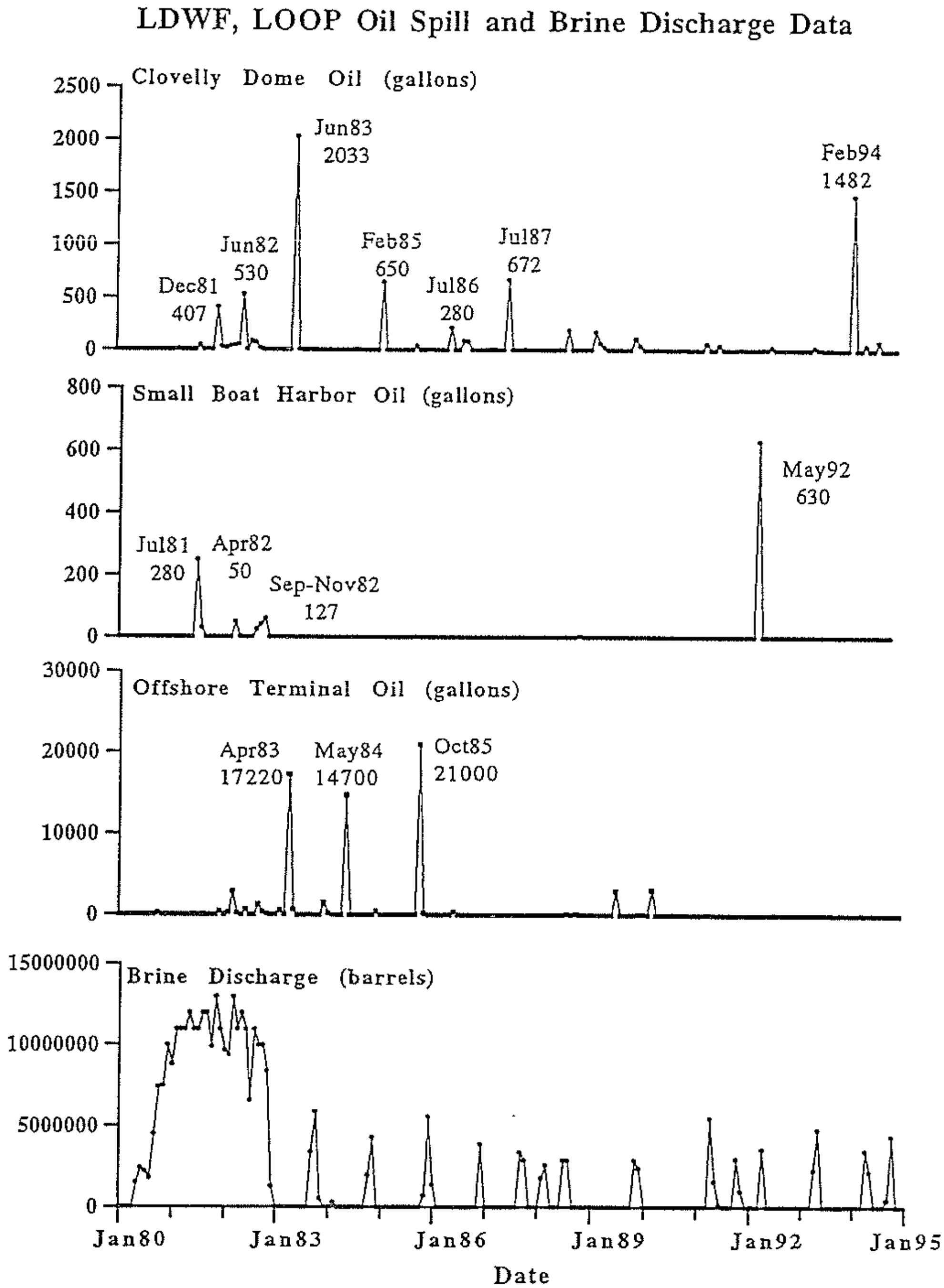

Figure 4. Time series plots of oil spills and brine discharge. Plots represent (top to bottom) gallons of oil spilled at the Clovelly Storage Dome, the Fourchon small boat harbor, the offshore terminal, and the barrels of brine discharged at the offshore diffuser. The dates and amount of oil spilled, for the more noticable peaks on the plot, are listed.

Table 2. Summary of statistical techniques used to investigate possible impacts of LOOP. Listed, for each potential impact type, is the time period over which the impact did (and did not) occur, the LDWF stations used in the analysis, and the type of analysis. The stations are classified as a control, a low impact or a high impact station.

Impact	Time Period: Before	Time Period: During	Time Period: After	Stations Used: Control	Stations Used: Low Impact	Stations Used: High Impact	Statistical Tests
Construction	<Jan79	>Jan79	>Dec80	5		34	BACI Model
		<=Dec80		12		7	
				15		38	
				14			
Brine Pumping	<May80	>May80	>Dec82	21		22	BACI Model
		<=Dec82		35		36	
				502			
Oil Spills							
• Clovelly Dome	<Dec81	>=Dec81	>Feb94	15		38	BACI Model
		<=Feb94		14			with oil spilled
							as covariate
• Offshore Terminal 1	<Apr83	>Apr83	>Apr90[1]	704		53	BACI Model
		<=Apr90[1]		706		55	with Oil spilled
				707		708	as covariate
						52	
						54	
• Offshore Terminal 2	<Apr83	>Apr83	>Apr90[1]	704	52	53	BACI Model
		<=Apr90[1]		706	54	55	with Oil spilled
				707		708	as covariate

[1] April 1990 was used as the end date for the offshore oil spill period because following this month offshore oil spills exceeding 50 gallons did not occur.

RESULTS AND DISCUSSION

General Discussion of Physical Results

General descriptive statistics including mean, minimum, maximum, and standard deviation for salinity, temperature, east current velocity, and north current velocity time series were calculated from available time series records. These statistics were computed for temperature and salinity time series spanning all or part of 1978-1995, for those stations at which 20 or more monthly measurements were recorded over the nearly 18 year study period. Statistics were obtained separately for top, middle, and bottom monthly samples at the 93 stations at which physical parameters were measured, and at the 44 stations at which chemical parameters were concurrently measured (appendix A). The average seafloor and sampling depth measurements, and number of measurements used to compile statistics are also tabulated. Appendix A also contains general descriptive statistics for measurements collected at an hourly or higher sampling rate at 12 stations. These measurements include salinity, temperature, east current velocity, and north current velocity data (as available) . Current velocities were available at stations 306, 318, 319, and 335. Figure 3 illustrates the locations of those stations at which the most monthly sampled data were obtained, and Figure 1 depicts the locations of all stations where the high resolution time series were collected.

The statistics presented in appendix A illustrate very clearly the influence of freshwater outflow on the upper areas of the marsh as decreasing mean salinity at stations 14, 15, 16, 18, and 38, for example. Stations at locations such as St. Mary's Point (station 317) exhibit relatively high standard deviations for salinity that may be due to occasional influxes of Gulf of Mexico water into Barataria Bay, temporarily elevating salinity, freshwater incursions following major rainfall events, temporarily lowering salinity, and the advection of strong salinity gradients past the sampling site by tidal and subtidal currents. Surface temperatures are more evenly distributed, probably due to the effectiveness and uniformity of heat exchange at the surface boundary. Bottom temperature means are consistently lower than surface temperature means which may be a result of the influx of heat energy at the sea surface.

Time series plots of quality controlled monthly measurements of salinity and temperature at near surface, middle, and near bottom depths are available for the physical data set in appendix B. Appendix C contains plots of salinity records for the chemical data set. Time series plots of monthly means and monthly variances of salinity, temperature, east velocity, and north velocity from 1978-1995 at stations having the most complete high resolution records are available in appendix D. The seasonal cycle of temperature data is easily visible in these temperature time series, some of which are nearly two decades in length.

Water level data are generally collected relative to an arbitrary reference, due to the technical difficulties in determining an absolute reference level and lack of consensus concerning absolute reference levels. Coastal Studies Institute personnel referenced the present water level data to the mean water level at each station, by subtracting that mean value from each data point (de-meaning the data). Positive values of de-meaned water level are thus above that station's mean sea level, and negative values are below that station's mean sea level. De-meaned water level (figs. 5-7) and monthly averaged de-meaned water level averaged for the three years from 1978-1980 was computed and plotted (fig. 8) for each of the three tide gauges, and squared coherence between measurements at these three tide gauges is presented in Figure 9. The coherence squared here represents a correlation coefficient between water level at two stations and is presented as a function of frequency. Water level at station 315 and water level at station 322 are coherent at all periods greater than 24 hours, with 95 percent or better confidence. Water level at stations 315 and 320 is coherent at periods greater than 30 hours, with 95 percent or better confidence. These plots demonstrate that water level is spatially coherent and that the water level data from these instruments, which was previously unverified, appears to be reasonably consistent. The annual cycles for stations 315 and 322 (fig. 8) resemble typical coastal Gulf of Mexico bimodal annual water level patterns as reported by Whitaker (1971). This characteristic water level signal on the Texas-Louisiana shelf is thought to be due to the combination of thermally-induced, wind-induced, and riverine-induced annual signals. The summer minimum in water level is regarded as the combination of the effects of summer wind patterns and currents, and the winter minimum is generally attributed to the relative lack of thermal expansion in the water column during that season.

Results of long term trend analyses for salinity and temperature for surface and bottom

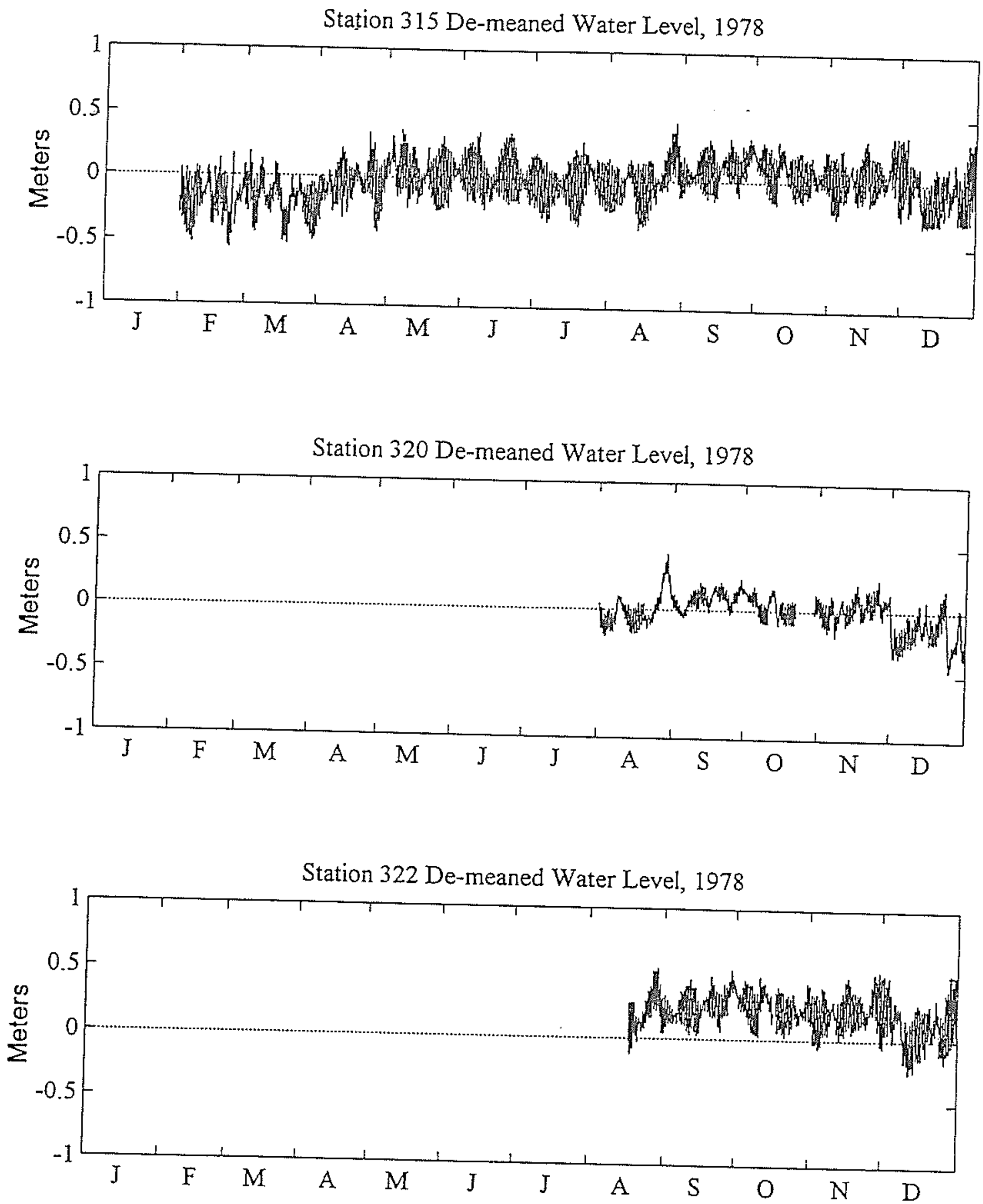

Figure 5. De-meaned water level time series at stations 315, 320, and 322 during 1978.

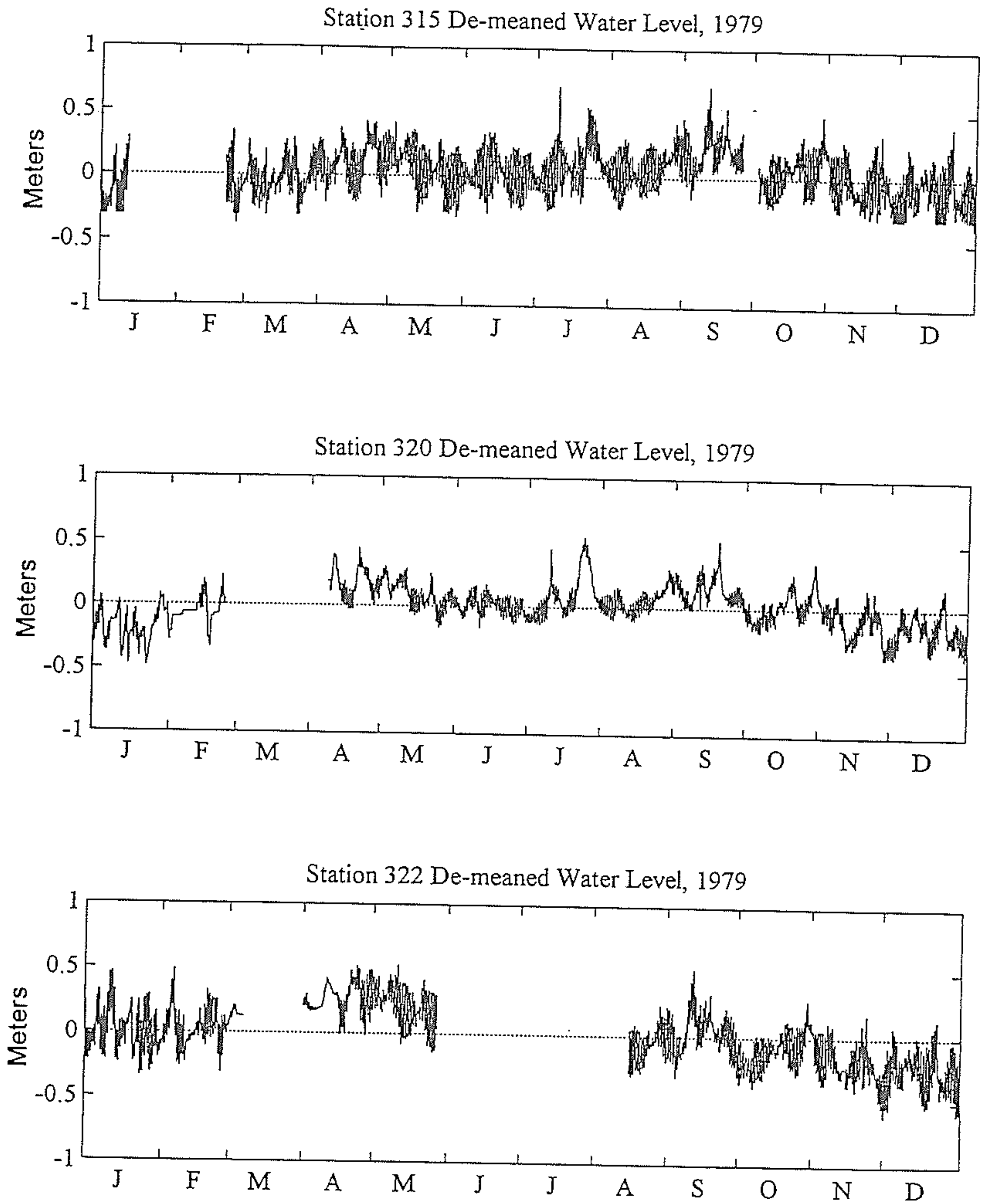

Figure 6. De-meaned water level time series at stations 315, 320, and 322 during 1979.

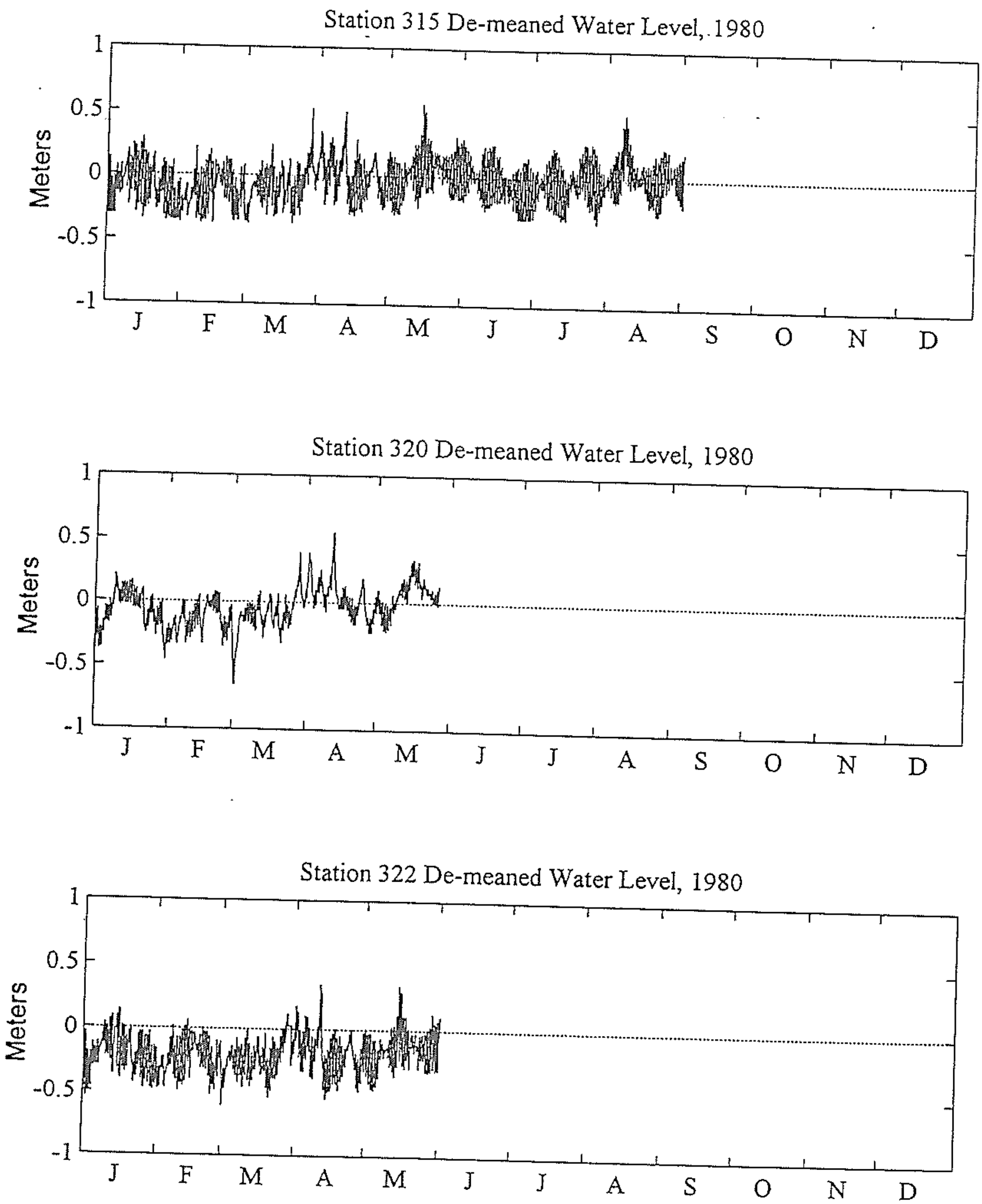

Figure 7. De-meaned water level time series at stations 315, 320, and 322 during 1980.

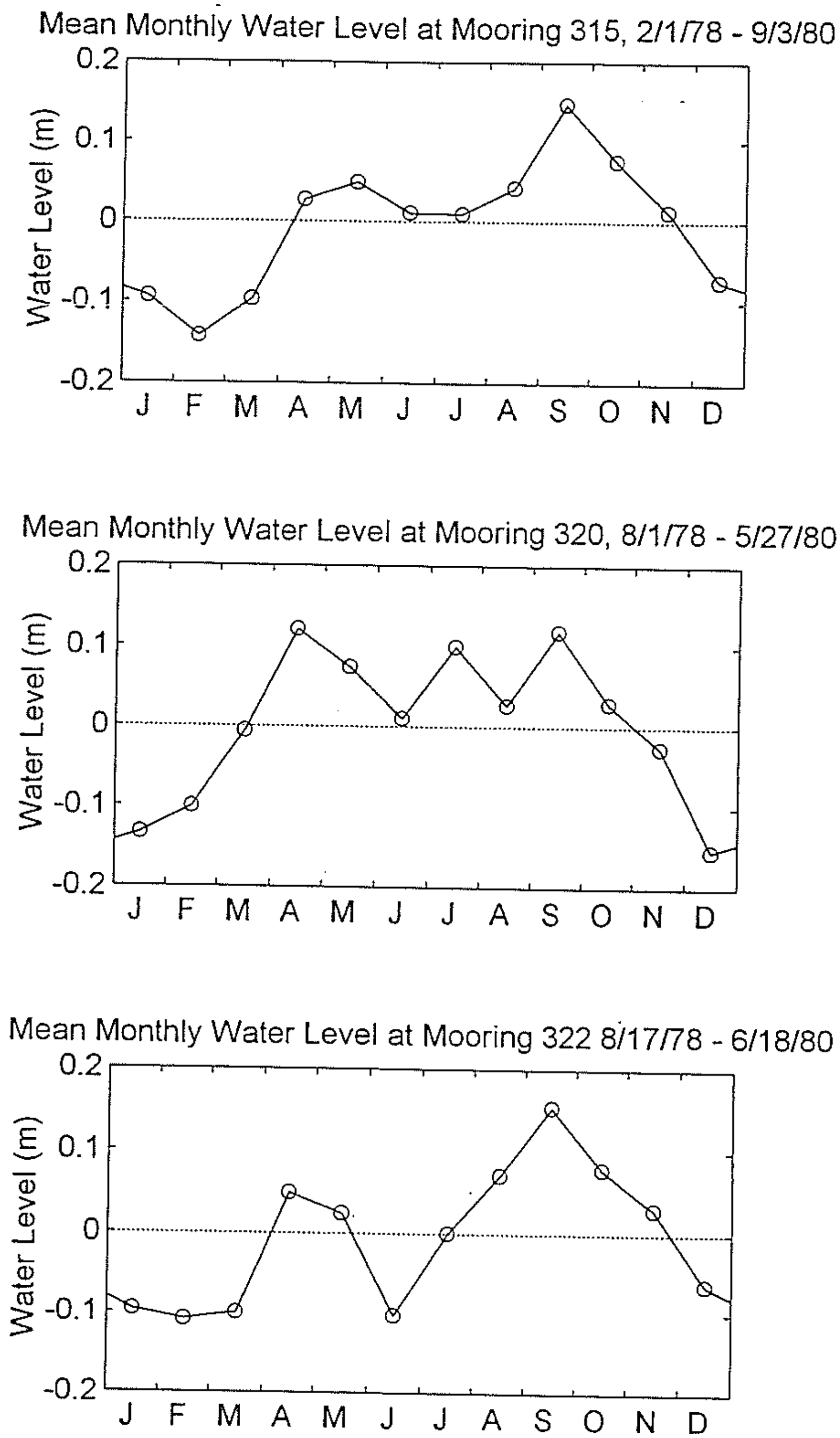

Figure 8. Mean annual water level cycle; means for each of the 12 months of the year computed from the individual 1978-1980 records taken at stations 315, 320, and 322.

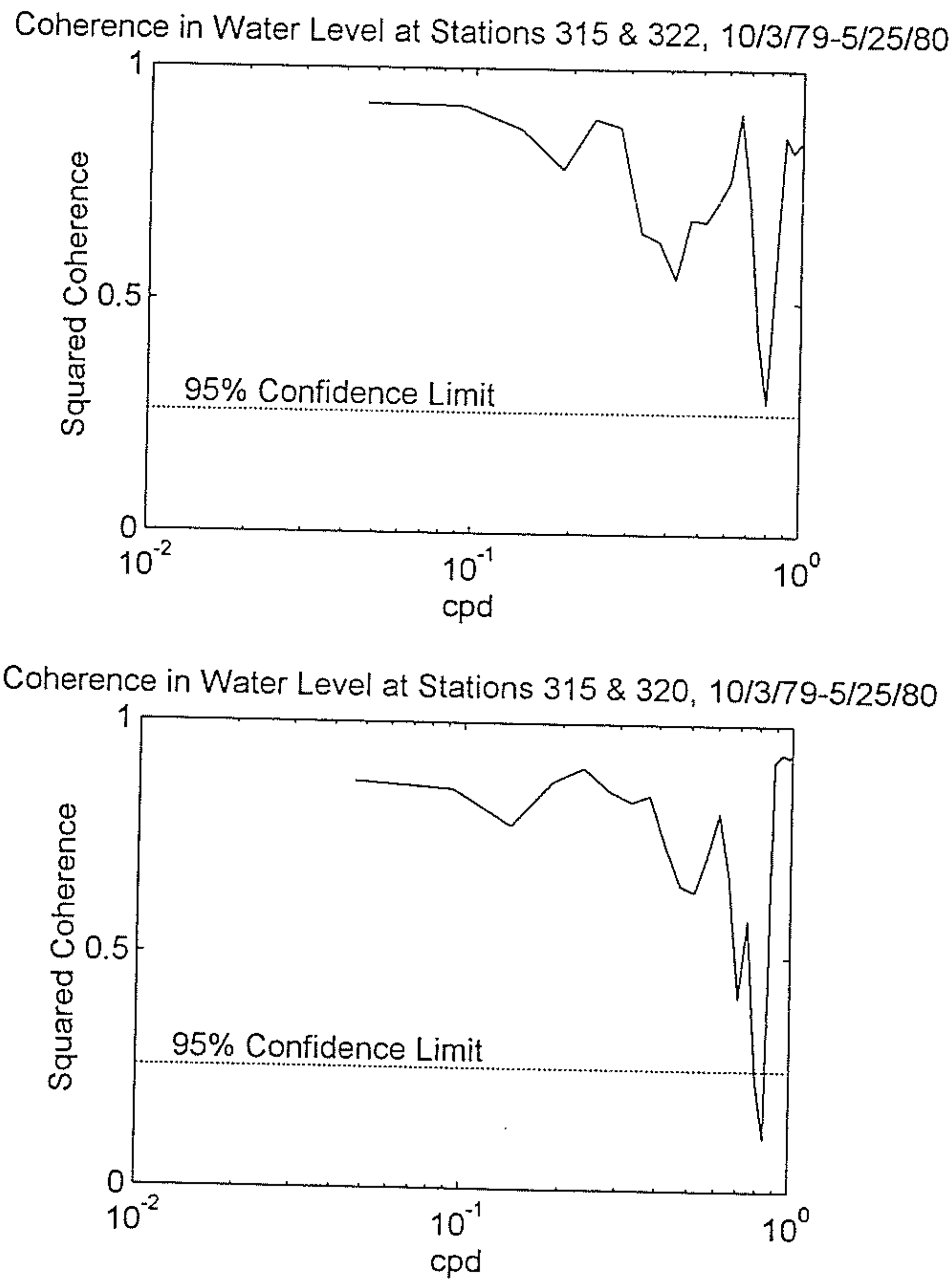

Figure 9. Coherence between water level records taken at stations 315, 320, and 322. Frequency is in units of cycles per day.

monthly measurement time series are summarized in Tables 3-6. The trend Tables in appendix E specify probability of a trend existing at each selected station for the entire period of nearly eighteen years. Also included are trends for periods before and after seven events to be studied for effects on long term trend. Tables E61 and E62 list the probability of trend existing at fixed stations over the span of their records. This was accomplished using the standard Kendall tau and the seasonal Kendall tau tests for trend. The masking effects of seasonality on determination of trend explains the standard Kendall tau values $p_{nonseasonal}$, which in this study are less frequently significant than are the probabilities of trend determined using the seasonal Kendall tau method ($p_{seasonal}$) for the times series examined in this study. Slope of the trend using linear regression (B_1) differed from that estimated using the seasonal Kendall tau method (B), as might be expected in comparing the results of a parametric method with those of a nonparametric method; still, sign of the slope generally appears to be the same.

The three hurricanes of 1985, including Hurricane Juan, did not appear to affect long term salinity trends; no significant long term trends in salinity were detected during the study period either prior to or following the year 1985, with the exception of an increasing salinity field at station 706 preceding 1985. The change in bottom temperature trends at five of the seven offshore stations is not apparent in upper layer temperature trends at any of the offshore stations. The scale of these storms is large relative to the spacing of offshore stations, and energy from hurricane activity is transferred downwards across the surface boundary layer from the atmosphere to the water column. Yet increases in temperature were not as consistently observed in the upper water column as at greater depths. One may reasonably conclude that it is unlikely that any change in long term temperature or salinity trends, in the upper or bottom layers, was caused by these three hurricanes.

Hurricane Andrew also did not appear to affect the prevalence of significant long term trends in upper layer temperature, though the stations at which these increasing long term trends were detected after Hurricane Andrew tended to be further offshore. Curiously, an increase in the number of stations at which significant offshore long term bottom temperature trends occurred following Hurricane Andrew in 1992 is similar to the increase in offshore long term bottom temperature trends following the 1985 hurricane season. Since significant surface warming trends did not become more frequent after this hurricane, one may only conclude

Table 3. Summary of bottom salinity trends. Numbers of stations at which positive and negative trends were detected with probability greater than 0.95, and total number of stations analyzed for trend, for each time period.

Description of Time Period	table	+	-	total
Entire Study Period (1/1/78-12/31/95)	E1	5	0	17
Before 1985 Hurricane Season (1/1/78-12/31/84)	E5	1	0	17
After 1985 Hurricane Season (1/1/86-12/31/95)	E9	0	0	16
Before Year of No Brine Discharge (1/1/78-12/31/89)	E13	10	0	17
After Year of No Brine Discharge (1/1/90-12/31/95	E17	1	0	16
Before Hurricane Andrew (1/1/78-8/10/92)	E21	5	0	17
After Hurricane Andrew (8/30/92-12/31/95)	E25	2	0	16
Before Start of Heavy Brine Disposal (1/1/78-3/31/80)	E29	0	0	5
After Heavy Brine Disposal Ceased (1/1/83-12/31/95)	E33	5	0	17
Period of Light River Outflow (1/1/78-12/31/82)	E37	3	0	17
After Start of Heavy River Outflow (7/1/83-12/31/95)	E41	3	0	17
Before the Big Freeze of 1989 (1/1/78-12/1/89)	E45	10	0	17
After the Big Freeze of 1989 (1/1/90-12/31/95)	E49	0	0	16

Table 4. Summary of bottom temperature trends. Numbers of stations at which positive and negative trends were detected with probability greater than 0.95, and total number of stations analyzed for trend, for each time period.

Description of Time Period	table	+	-	total
Entire Study Period (1/1/78-12/31/95)	E2	6	0	17
Before 1985 Hurricane Season (1/1/78-12/31/84)	E6	0	0	17
After 1985 Hurricane Season (1/1/86-12/31/95)	E10	5	0	16
Before Year of No Brine Discharge (1/1/78-12/31/89)	E14	0	0	17
After Year of No Brine Discharge (1/1/90-12/31/95	E18	2	0	16
Before Hurricane Andrew (1/1/78-8/10/92)	E22	0	0	17
After Hurricane Andrew (8/30/92-12/31/95)	E26	9	0	16
Before Start of Heavy Brine Disposal (1/1/78-3/31/80)	E30	0	0	5
After Heavy Brine Disposal Ceased (1/1/83-12/31/95)	E34	7	0	17
Period of Light River Outflow (1/1/78-12/31/82)	E38	0	0	17
After Start of Heavy River Outflow (7/1/83-12/31/95)	E42	7	0	17
Before the Big Freeze of 1989 (1/1/78-12/1/89)	E46	0	0	17
After the Big Freeze of 1989 (1/1/90-12/31/95)	E50	4	0	16

Table 5. Summary of top salinity trends. Numbers of stations at which positive and negative trends were detected with probability greater than 0.95, and total number of stations analyzed for trend, for each time period.

Description of Time Period	table	+	-	total
Entire Study Period (1/1/78-12/31/95)	E3	0	0	24
Before 1985 Hurricane Season (1/1/78-12/31/84)	E7	0	0	24
After 1985 Hurricane Season (1/1/86-12/31/95)	E11	0	0	24
Before Year of No Brine Discharge (1/1/78-12/31/89)	E15	10	0	24
After Year of No Brine Discharge (1/1/90-12/31/95	E19	1	0	24
Before Hurricane Andrew (1/1/78-8/10/92)	E23	2	0	24
After Hurricane Andrew (8/30/92-12/31/95)	E27	10	0	24
Before Start of Heavy Brine Disposal (1/1/78-3/31/80)	E31	1	0	12
After Heavy Brine Disposal Ceased (1/1/83-12/31/95)	E35	0	0	24
Period of Light River Outflow (1/1/78-12/31/82)	E39	7	0	24
After Start of Heavy River Outflow (7/1/83-12/31/95)	E43	0	0	24
Before the Big Freeze of 1989 (1/1/78-12/1/89)	E47	9	0	24
After the Big Freeze of 1989 (1/1/90-12/31/95)	E51	1	0	24

Table 6. Summary of top temperature trends. Numbers of stations at which positive and negative trends were detected with probability greater than 0.95, and total number of stations analyzed for trend, for each time period.

Description of Time Period	table	+	-	total
Entire Study Period (1/1/78-12/31/95)	E4	4	0	24
Before 1985 Hurricane Season (1/1/78-12/31/84)	E8	0	0	24
After 1985 Hurricane Season (1/1/86-12/31/95)	E12	0	0	24
Before Year of No Brine Discharge (1/1/78-12/31/89)	E16	4	0	24
After Year of No Brine Discharge (1/1/90-12/31/95	E20	4	0	24
Before Hurricane Andrew (1/1/78-8/10/92)	E24	6	0	24
After Hurricane Andrew (8/30/92-12/31/95)	E28	5	0	24
Before Start of Heavy Brine Disposal (1/1/78-3/31/80)	E32	0	0	12
After Heavy Brine Disposal Ceased (1/1/83-12/31/95)	E36	4	0	24
Period of Light River Outflow (1/1/78-12/31/82)	E40	0	0	24
After Start of Heavy River Outflow (7/1/83-12/31/95)	E44	4	0	24
Before the Big Freeze of 1989 (1/1/78-12/1/89)	E48	4	0	24
After the Big Freeze of 1989 (1/1/90-12/31/95)	E52	0	0	24

that the bottom warming may be a response to some other occurrence. Following Hurricane Andrew, ten upper estuary, lower estuary, nearshore, and offshore stations were found to have recorded significant increasing trends in near surface salinity, and it is possible that this could be a response to the severe effects of this particular hurricane across the study area.

Significant long term surface warming trends were reduced to insignificant levels at four station locations after the Big Freeze of late 1989 that heavily affected Louisiana coastal regions. One of these stations was a lower estuary station, and three were located in shallow upper estuary regions.

Following the major brine discharge period after LOOP construction, long term temperature and salinity values did not deviate appreciably from trends over the entire eighteen year period of data collection. Few significant long term trends were detected during the two years prior to this period of major brine discharge, and this finding may be attributed to the limited data collected before this event. None of the stations within a fairly broad region around the brine diffuser (21, 22, 35, 36, 502, 535) appeared to show any significant trend in upper layer salinity, and no significant long term trends in bottom salinity were found at these stations near the brine discharge region either before or after this major discharge period.

The cessation of brine discharge during the entire year of 1990 also did not appear to affect upper layer or bottom salinity in the brine discharge region. A trend of increasing bottom salinity appeared at station 36 following the cessation of brine discharge; however, a similar trend at station 22 before became insignificant following 1990. No long term trends in upper layer salinity were found for the six stations in the brine discharge region, either before or after the period of major brine discharges from 1980-1982.

In 1983, mean Mississippi River flow reached its highest peak for the eighteen year study period (Figure 10). The hypothesis that long term trends at offshore stations (52, 53, 54, 55, 704, 706, 708) would shift towards significantly decreasing salinity was not confirmed. In fact, bottom salinities at stations 52, 53, and 706 shifted in the opposite direction, towards significantly increasing salinity, after 1983, and none of these seven offshore stations exhibited any significant surface salinity trends either before or after the increase in Mississippi River flow.

Not only did 1983 present the largest observed daily discharge during the study period, it also followed a period of three years of rather low annual mean discharge. Subsequent annual

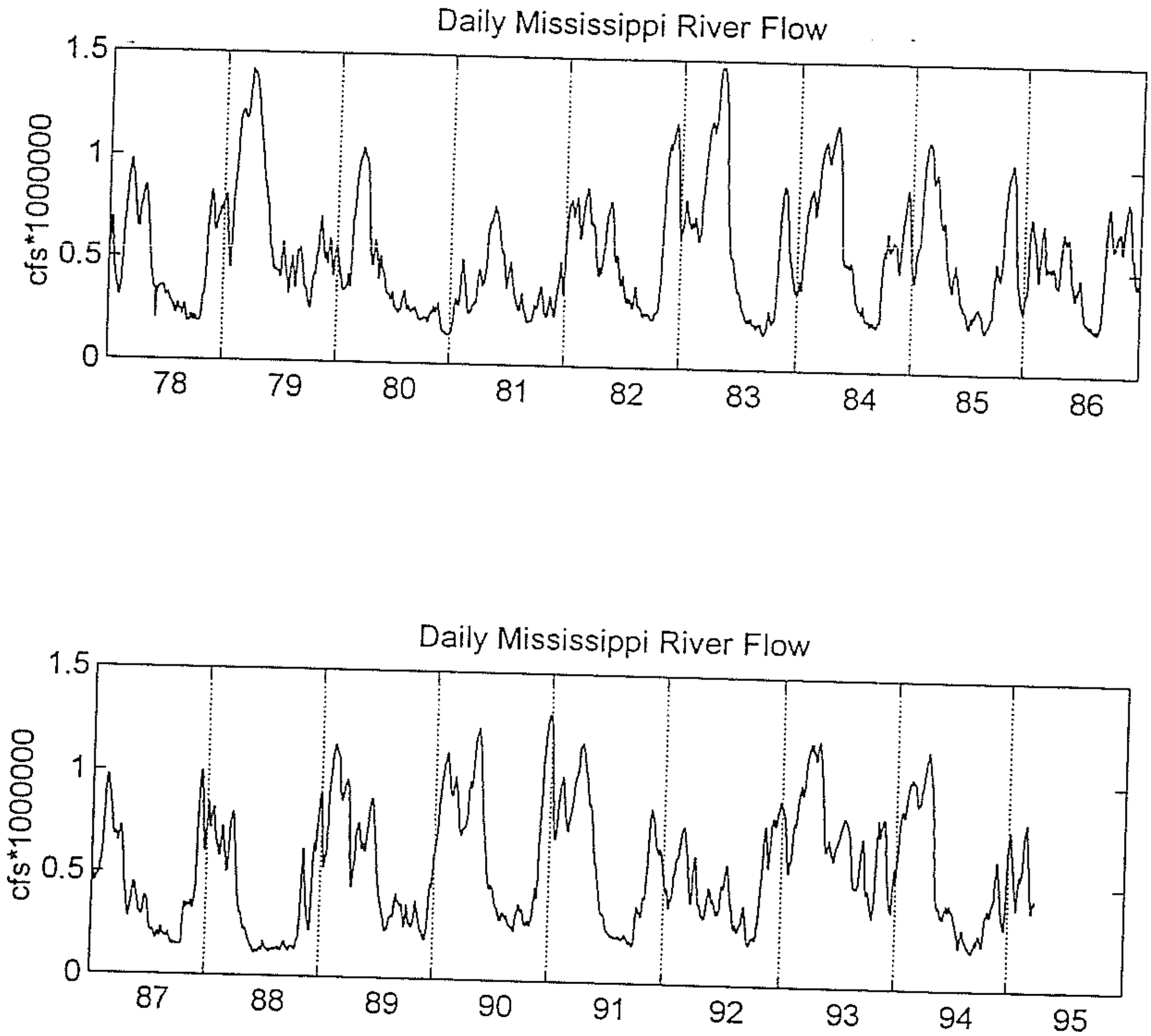

Figure 10. Daily volume of Mississippi River outflow, 1978-1995; data obtained from the Army Corps of Engineers, New Orleans District.

mean discharge was generally high (except in 1988) and very high in the early 1990s. The added density differences due to the river discharge may have prevented enough vertical mixing to increase bottom salinity noticeably at stations 52, 53, and 706 at certain times of the year. It is unclear whether the lack of a similar signal at nearby stations reflects the fallacy of this hypothesis or sampling variability.

The most interesting and definitive result derived from the trend analysis was not related to specific events, but instead a description of overall decadal scale trends in the region. Long term trend analyses demonstrate no significant trends in surface salinity; and bottom salinity trends are significant at only five stations (29 percent), and these are increasing trends. Surface temperature trends indicated significant increases at four station locations, and decreases at none; bottom temperatures increased significantly at six station locations and decreased at none. Significantly increasing surface temperatures are occurring at 17 percent of stations, and significantly increasing bottom temperatures at 35 percent of stations.

Three of the four stations experiencing an increase in near surface temperatures are in the offshore region. Physically, stronger stratification due to greater buoyancy flux from the river would indicate higher offshore surface temperatures. The one estuarine station exhibiting an increasing temperature trend is problematic and may simply be due to sampling variability. The increasing near bottom temperatures at the offshore stations are spatially coherent and may result from processes associated with the buoyancy flux from the river and the expected stratification increase. An alternative explanation for both the higher salinities and the higher temperatures in the region in recent years is the interannual variability of shelf interaction with Loop Current rings.

The Loop Current, part of the Gulf Stream system (Stommel 1965), is arguably the most important oceanographic feature in the Gulf of Mexico (Leipper 1970). It enters the Gulf through the Yucatan Channel, turns anticyclonically (clockwise), and leaves the Gulf through the Straits of Florida. Aperiodically, it penetrates northward and sheds a large eddy with a diameter measured in hundreds of kilometers. These eddies or rings constitute the oceanographic equivalent of storm systems. They propagate westward across the Gulf and dissipate as they interact with the continental slope of the western Gulf (Smith 1986; Brooks 1984). Occasionally, these features propagate into the vicinity of the region of study. Such events have been documented by Huh et al. (1990), and their influences on currents and water properties near the Mississippi delta have been suggested by Ebbesmeyer et al. (1982) and Wiseman and Dinnel (1988). Anecdotal evidence of their occurrence is suggested by reports of exotic (tropical) fish species caught in the region immediately west of the Mississippi River delta (M. Brown, personal communication). The water mass characteristics of these features are warm temperatures and high salinities.

The occurrence of a Loop Current ring in the study area is a relatively rare phenomenon (Wiseman and Dinnel 1988). The intrusion of such features could bias estimates of long term trends of both temperature and salinity and explain the significance of the trends observed in near-bottom temperature and salinity at offshore stations. We have not yet been able to identify an accurate long-term time series of the occurrence of rings in the region of study. Statistically, though, fronts delineating warm oceanic waters from normal shelf waters are observed in the region at least 2.5 percent of the time (F. Vukovitch, personal communication). The U.S. Minerals Management Service is funding an ongoing study of the intrusion of such features onto the upper slope and shelf immediately east of the Mississippi River delta, and the results of this study should shed additional light on the frequency of events in the region.

Classification of the Project Area

The project area is a diverse mixture of Louisiana estuarine and inner continental shelf regimes, extending well into shallow bayou regions in which mean salinities as low as 1-3 ppt were recorded.

Temporal and Spatial Patterns

Spatial patterns that prevail in the region of study illustrate the differences between stations in continental shelf and lower and upper estuarine regimes. Mean surface salinity contours over the region of study for the months of January, April, July, and October (winter, spring, summer, and fall) are presented in Figure 11. Generalized lowering of salinity in Barataria Bay as well as in offshore regions by April can be attributed to spring rains and freshwater outflow from streams and rivers. Salinity contours in offshore regions do not parallel the coast, and this may be due to incursions of the freshwater Mississippi River plume. Increases in surface salinity by July, and further increases by October, can be attributed to the combination of reduced

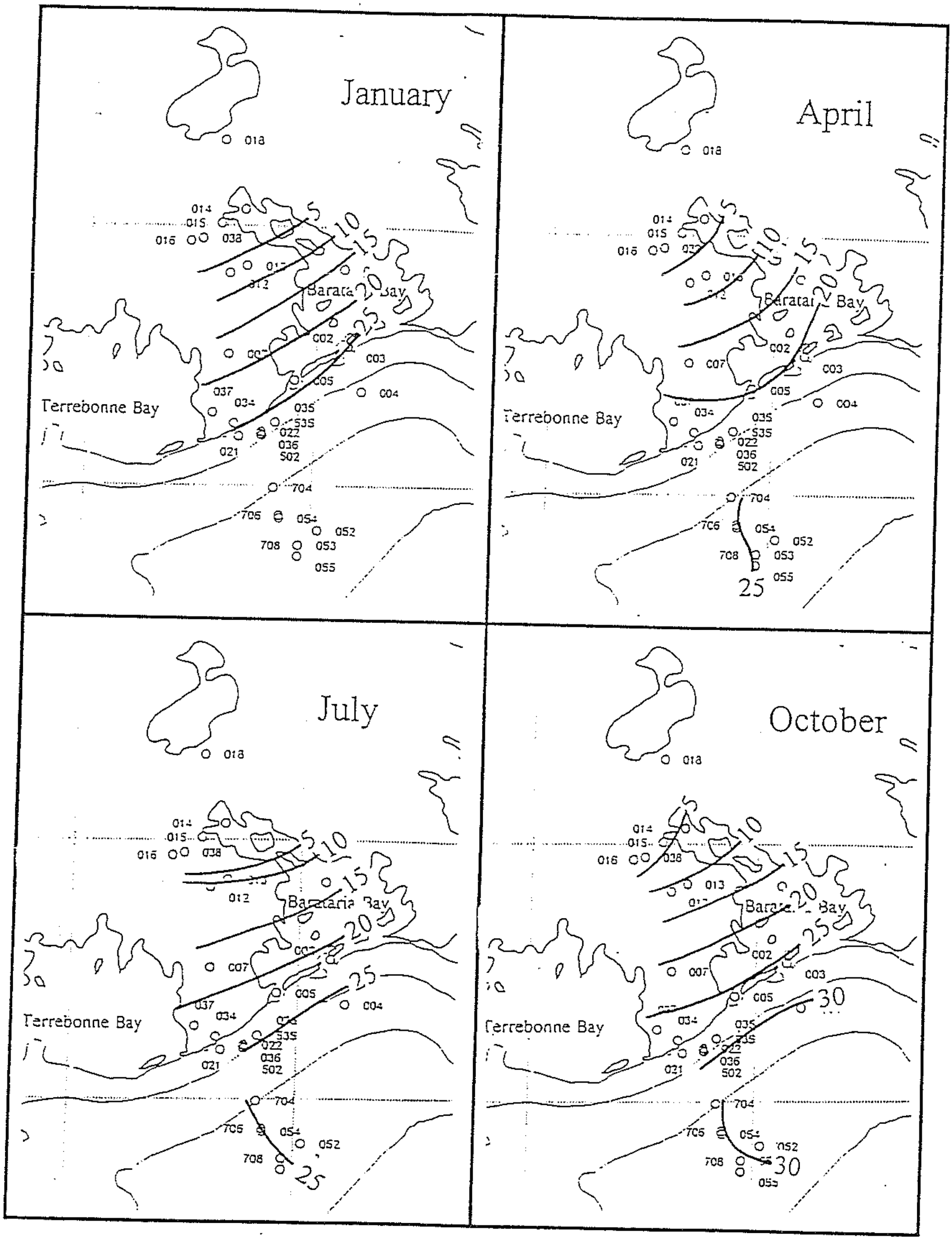

Figure 11. Seasonal surface salinity contours in the study region.

Mississippi River discharge, lower rainfall, and increased evaporation during the warm months of summer and early fall in this region.

Mean near surface temperature contour plots for spring, summer, fall, and winter seasons in the study area are available in Figure 12. These mean temperatures change from season to season, as is expected due to heat flux through the surface boundary. Contours for spring, summer, and fall suggest the predominance of these boundary effects on near surface temperature means during these seasons, due to the roughly uniform air temperatures throughout the study region (especially during the summer) and the relatively large scale of atmospheric thermal variability. Contours for the winter season indicate colder, shallower water in northern portions of the region during the winter. This suggests that the relative influence of surface heat flux during cold air outbreaks drops temperatures more in shallow water than in deep water.

Identification of Natural Variability

The effect of Mississippi river outflow is thought to be strong in the region of study, particularly in offshore areas. The time scales at which the river outflow affects local salinity are of interest and are addressed here by means of squared coherence between weekly mean volume of river outflow and weekly mean salinity times series at the high resolution time series stations; and squared coherence between monthly mean volume of river outflow and monthly means at these stations, or monthly measurements at offshore stations (appendix F).

The coherence squared represents a correlation coefficient between two time series as a function of time scale. We compare salinity time series and river discharge series using this technique to determine at which scales the river discharge events might influence the local salinities. The river gauging station at Tarbert Landing, Mississippi is upstream of Baton Rouge.

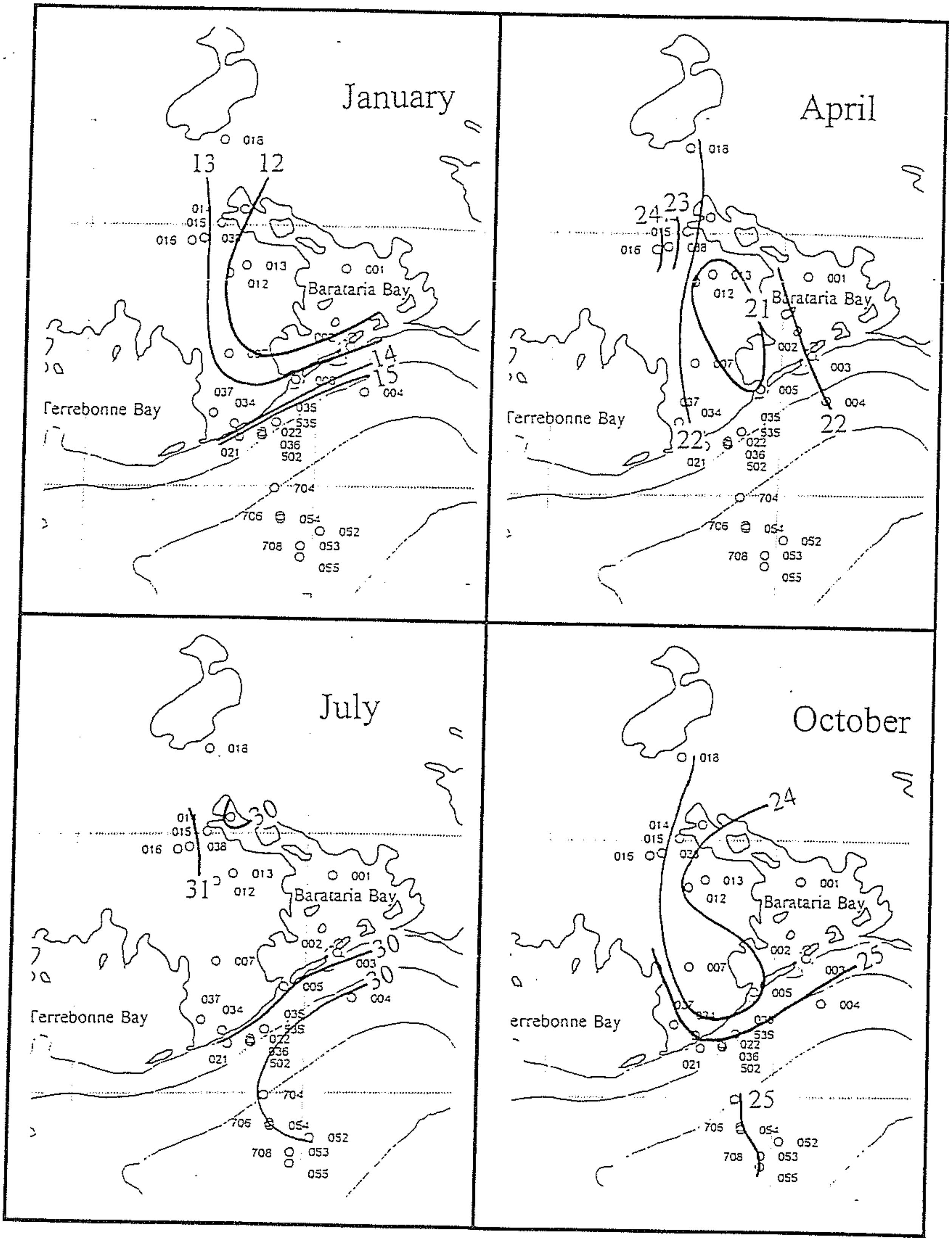

Figure 12. Seasonal surface temperature contours in the study region.

The time required for water measured at Tarbert Landing to reach the mouth of the river is variable and depends upon river stage. The time lag is shorter at high river stage and longer at low stage. It has been estimated to vary between a few days at high stage and 1.5-2 weeks at low stage. There is no reliable method for eliminating this level of uncertainty in the available data set, and therefore no effort was made to lag river discharge to account for the run from Tarbert's Landing to the mouth of the river. Consequently, we cannot hope to resolve the phase lag between river discharge and salinity time series to better than a few weeks nor to determine reliable coherence estimates for time scales shorter than a few weeks. Fortunately, most of the variance in river discharge occurs at time scales longer than a few weeks, and, consequently, we expect the associated response to occur at similar scales.

Squared coherence estimates are plotted by frequency for each offshore station in appendix F. It appears that coherence is greatest at annual frequencies, as might be expected due to the substantial seasonal changes that occur in river flow. Coherence of salinity at station 14 (an estuarine station) with river flow was also plotted; and coherence at annual periods at this station appears to be relatively small as is coherence with bottom measurements of salinity at offshore stations. This indicates lesser river influence on salinity at estuarine than at offshore stations, as well as lesser influence of the Mississippi River plume on the bottom than at the top of the water column.

Wind driven mixing of coastal ocean waters can allow the lower salinities of the freshwater plume to penetrate deeper waters. In coastal ocean waters with significant density stratification, such mixing requires relatively greater energy input from wind forcing than is required in less stratified waters. Therefore, in the former case, the deeper waters can be isolated to some degree from the influence of the freshwater river plume, and lower coherence of salinity with Mississippi River outflow is to be expected.

Estuarine waters are affected less by the riverine signal than are coastal ocean waters in the study region. This reflects the fact that the influence of the coastal ocean, and thus the freshwater plume, on estuarine waters occurs as they disperse up the estuary from the Gulf. This mixing process will result in reduced coherence with the river discharge as one moves further up-estuary from the source of Mississippi River water.

River outflow is indirectly influenced by cumulative rainfall, especially in upstream areas. The direct influence of heavy local rainfall on local surface salinities is of interest also. Plots of salinity time series at stations 5, 21, 22, 35, 36, 37,52, 53, 54, 55, 502, 704, 706, 708, and others depict a distinct local salinity minimum in late spring, 1991 (Figures B5, B13-B14, B16-B18, B20-B23, B26-B28). This occurred during a time of heavy rainfall in this part of Louisiana. Intense local rainfall influences surface salinities at higher frequencies than the annual. Rain data that lies within the LOOP study region is especially valuable for determining the effect of local rainfall on surface salinity. However, the previously unverified rain data collected by LDWF within the study region appears to be unsuited for this purpose in the present study due to the method of collection, which apparently allowed evaporation to substantially affect cumulative rainfall records, and due to the relatively short time period over which it was collected (1978-1980).

A local maximum in surface salinities appears in 1981 at numerous stations (for example, station 1). The reason for this maximum is unknown, but may be attributable to the dual effect of relatively low Mississippi River discharge and low rainfall in the region at that time.

Impacts and Possible Causes

A BACI analysis was performed on the LDWF-LOOP salinity and temperature data from the monthly measurements of the physical hydrography data set. No statistically significant results were obtained in the analysis for impact of those LOOP activities considered on these variables.

The surface salinity results (Table 7) indicate that there were no impacts for any of the events analyzed (none of the interaction terms were significant). The results for the bottom salinity analyses indicate no impacts of the construction, the brine pumping, or the Clovelly Dome oil spills. The offshore data show a significant interaction when considering oil spills, however the oil covariate is not significant. This indicates that there was some sort of an impact over the time period analyzed, but suggests that it cannot be directly attributed to the oil spills.

Table 7. Results of before:after, control:impact (BACI) analyses of loop physical hydrography salinity data. Listed for each BACI model is the F value and the probability for (1) the Before:After, (2) the Control:Impact, and (3) the interaction of the Before:After and Control:Impact portions of the model. In the case of the oil spills, the F value and the probability is also given for the oil spill covariate used in the model. Results are given for surface and bottom salinity. Details of the parameters used in the BACI model are listed in Table 2. The symbol *nd* indicates that there were not enough data points to run the model, and the symbol *na* indicates the model term was not applicable. Bold face indicates a result significant at the 0.05 level.

Surface Salinity

Type of Impact	Before:After F	Before:After P>F	Control:Impact F	Control:Impact P>F	Interaction F	Interaction P>F	Oil Spill Covariate F	Oil Spill Covariate P>F
Construction	0.695	0.514	1.633	0.302	1.133	0.345	.na	.na
Brine Discharge	1.837	0.186	0.242	0.627	0.506	0.604	.na	.na
Oil Spills								
Clovelly Dome	1.137	0.343	37.807	0.193	4.533	0.016	0.278	0.598
Offshore Terminal 1	1.066	0.366	0.072	0.789	1.410	0.245	1.954	0.162
Offshore Terminal 2	0.996	0.391	**3.116**	**0.046**	1.462	0.212	1.954	0.165

Bottom Salinity

Type of Impact	Before:After F	Before:After P>F	Control:Impact F	Control:Impact P>F	Interaction F	Interaction P>F	Oil Spill Covariate F	Oil Spill Covariate P>F
Construction	.nd	.nd	.nd	.nd	.nd	.nd	.na	.na
Brine Discharge	**5.712**	**0.011**	0.230	0.661	1.047	0.352	.na	.na
Oil Spills								
Clovelly Dome	2.258	0.135	1.379	0.344	0.485	0.492	0.250	0.617
Offshore Terminal 1	0.419	0.664	**13.379**	**0.004**	**5.609**	**0.004**	1.029	0.311
Offshore Terminal 2	0.177	0.839	**4.804**	**0.050**	**3.364**	**0.010**	1.029	0.311

Table 8. Results of before:after, control:impact (BACI) analyses of loop physical hydrography temperature data. Listed for each BACI model is the F value and the probability for (1) the Before:After, (2) the Control:Impact, and (3) the interaction of the Before:After and Control:Impact portions of the model. In the case of the oil spills, the F value and the probability is also given for the oil spill covariate used in the model. Results are given for surface and bottom temperature. Details of the parameters used in the BACI model are listed in Table 2. The symbol nd indicates that there were not enough data points to run the model, and the symbol na indicates the model term was not applicable. Bold face indicates a result significant at the 0.05 level.

Surface Temperature

Type of Impact	Before:After F	Before:After P>F	Control:Impact F	Control:Impact P>F	Interaction F	Interaction P>F	Oil Spill Covariate F	Oil Spill Covariate P>F
Construction	2.717	0.089	1.112	0.352	0.869	0.483	.na	.na
Brine Discharge	**4.510**	**0.021**	0.074	0.788	0.025	0.975	.na	.na
Oil Spills								
Clovelly Dome	1.409	0.268	1.481	0.370	0.528	0.590	**7.635**	**0.006**
Offshore Terminal 1	1.731	0.205	1.231	0.268	0.971	0.379	0.732	0.394
Offshore Terminal 2	2.074	0.156	0.847	0.430	0.791	0.531	0.732	0.392

Bottom Temperature

Type of Impact	Before:After F	Before:After P>F	Control:Impact F	Control:Impact P>F	Interaction F	Interaction P>F	Oil Spill Covariate F	Oil Spill Covariate P>F
Construction	.nd	.nd	.nd	.nd	.nd	.nd	.na	.na
Brine Discharge	**4.479**	**0.022**	0.884	0.3519	0.019	0.982	.na	.na
Oil Spills								
Clovelly Dome	.nd	.nd	.nd	.nd	.nd	.nd.	.nd	.nd
Offshore Terminal 1	3.971	0.037	0.313	0.577	0.102	0.903	0.009	0.924
Offshore Terminal 2	**4.368**	**0.029**	0.484	0.619	0.347	0.846	0.009	0.924

analyzed except the surface temperature at Clovelly Dome which showed a significant oil spill term, indicating that there was a change in surface temperature that was correlated with oil. The temperature for the control class increased from 21.97°C to 22.71°C, and the temperature in the impact class decreased from 23.67°C to 23.56°C. Although these changes are statistically significant, they are not ecologically significant (R. E. Turner, personal communication).

Although markedly increased salinities are apparent in the data taken in the immediate proximity of the brine diffuser site during brine disposal, these do not appear to have long-lasting or widespread effects on the physical hydrography of the region or to cause a clear impact on the region, and this is apparent in results from trend analysis and BACI testing.

CONCLUSIONS

Offshore Hydrography

Temperature-salinity characteristics at offshore stations were similar to available historical information obtained from this region (Wiseman et al. 1982). Offshore stations 52, 53, 54, 55, 704, 706, and 708 had the most complete physical hydrography record of any offshore stations, and study of the offshore regime focused primarily on these stations. Interannual variability in temperature is less than the intra-annual variability at these offshore stations for near surface, mid-depth, and near bottom records (Figures B20-B23, B26-B35, B45-B48, and B51-B53).

Coherence of surface salinity records at all offshore stations with Mississippi river outflow was high at annual periods (appendix F). This coherence did not extend to the near bottom salinity records at these stations except at station 704 where there was some coherence at annual periods for unknown reasons. Phase was consistent with the formulated hypothesis which states that river forcing primarily contributes to the near annual period response in near surface salinity records in the offshore region.

Tables E1-E4 list the results of trend analyses for a number of stations including the seven offshore stations listed. Significant increasing long term trends in temperature occurred near the bottom at six of these seven stations and near the surface at four of the seven stations. Near the bottom, significant increasing salinity trends occurred from 1978-1995 at five of the seven offshore stations, although there were no significant trends in near surface salinity over this time period.

The causes for these significant increasing trends in temperature and salinity in the offshore regime are unknown. It is doubtful that the increasing temperature trends are due to changes in atmospheric climate. The large spatial scales of atmospheric thermal variability would suggest that if this were indeed the case (which it is not), significant increasing temperature trends would occur at nearshore and estuarine stations.

Nearshore Hydrography

Nearshore stations 21, 22, 35, 36, 502, and 535 provided the most complete physical hydrography record of the nearshore stations at which monthly measurements were obtained. The nearshore region was also the location of stations 306, 318, 319, and 335, where constant recorders measured temperature, salinity, and current speed and direction. These ten stations were the primary focus of study for the nearshore region. Intra-annual variability is larger than interannual temperature and salinity variability in the nearshore regime (appendices B and D). Temperature-salinity characteristics at nearshore stations were consistent with historical hydrographic findings in the region. Monthly temperature and salinity means and variances were computed for the constant recorder stations, and these were plotted as time series to illustrate seasonal patterns of these moments. Summer heating and winter cooling are reflected in the temperature means at station 315 illustrated in Figure D1, as are increases in temperature variance during winter months, presumably as a response to cold fronts and other storms during that season. Despite gaps in the current meter records, months in which a meaningful monthly mean and variance could be computed were identified and these statistical moments were also plotted as times series (appendix D). Mean east and north velocities were not statistically different from zero (Tables A12-A13); current velocity was highly variable. Although mean current velocity at stations 306, 318, and 319 was towards the southwest, mean currents were towards the northeast at station 335 (which is further east than stations 306, 318, and 319). The cause for this opposing mean current direction at station 335 is not known, but it is possibly due to bifurcation of the Mississippi River plume as it merges with the Louisiana Coastal Current (Rouse and Coleman 1976). Salinity records were not long enough to estimate coherence at annual frequencies between salinities at these fixed stations and Mississippi River outflow (appendix F), though salinities would be expected to respond to annual scale riverine discharge patterns which influence salinity in both offshore and estuarine regimes.

No significant long term trends in salinity or temperature were detected in the nearshore region. Significant temperature increases at stations 318, 319, and 335, and significant salinity increase at station 319 occurred over the relatively brief periods of operation of these stations (Tables E61-E62). However, no significant temperature or salinity trends were observed at the six nearshore stations having very long time series of monthly measurements (Tables E1-E4).

Thus, the trends at stations 318, 319, and 335 are attributed to sampling variability rather than to a true long term trend.

BACI impact analyses detected no significant impact on physical hydrography data sets in this region that could be attributed to LOOP activities, including construction and brine pumping. It is noted, though, that the sled data (LDWF 1995), which was not analyzed in this report, clearly demonstrated the local increase of near-bottom salinities due to brine pumping.

Hydrography in the Lower Estuary

The lower estuarine regime includes marsh stations such as stations 34, 37, and 7 and station 5 which is located in Caminada Pass. Constant recorder stations 315 (Grand Terre), 317 (St. Mary's Point), 322 (Caminada Pass), and 323(Lake Palourde and Bay Macoin Channel) are also located in the lower estuary. These eight stations provided the most complete physical hydrography time series of the lower estuarine region, and study of this area centered on their records. Seasonal variability in temperature in the lower estuary is consistent with historical observations for this region. Intra-annual variability is larger than interannual variability in this region, as has been described above for the offshore and nearshore regions.

No significant trends in temperature or salinity from 1978-1995 were detected by seasonal Kendall tau tests for trend at stations 5, 7, 34, and 37. There were no significant long term trends in temperature or salinity at these stations before or after heavy brine disposal associated with LOOP construction in 1980-1982. Significant trends in temperature data were detected at fixed stations 315 and 317(increasing), and 323(decreasing). The source of the decreasing trend is not clear but is probably due to the short record. The lack of spatial coherence of increasing trends is disconcerting. The logical source of a temperature trend is air/sea interaction. Such processes have large spatial scales and should affect all estuarine stations. While the source of the apparent temperature increase at stations 315 and 317 is unresolved, it is consistent with the trends observed offshore. Significant trends of decreasing salinity existed at stations 317 and 323. Stations 315 and 317 have very long temperature and salinity records. However, the salinity trend at station 317 was not accompanied by a similarly decreasing significant salinity trend at station 315. This decrease at station 317 may be in response to increased precipitation upstream of St. Mary's Point from 1978-1995, although precipitation data sufficiently near this location to test this hypothesis are not available. Increased discharge from river diversions into Barataria Basin could also lead to decreasing salinity trends at St. Mary's Point, although there is not sufficient data available to suggest that this is the case. Although significant decreasing salinity trends were not observed at Grand Terre, it is possible that changes in Mississippi River outflow volume could still be responsible for the decreasing salinity at St. Mary's point. This would assume a major route of freshwater encroachment into Barataria Bay by the Mississippi River plume that does not pass station 315, e.g. through Pass Abel or Quatre Bayous Pass.

No significant impact of LOOP activities on temperatures or salinities in the lower estuary was detected by BACI analyses.

Hydrography in the Upper Estuary

Upper estuary stations included stations 12, 13, 14, 15, 16, 18, and 38, at which monthly samples were taken, and 320, 321, 324, 325, and 326 which were fixed recorder stations. These stations were taken to represent upper estuarine conditions. Although very little historical temperature or salinity data is available for the upper estuary region, the low salinities and seasonal variability appear typical when compared with sparse previous data from this region.

There were no significant trends in salinity or temperature for the period from 1978-1995, except for an anomalous trend of increasing surface temperature at station 16. The reasons for this trend are unknown. We have no hypothesis beyond normal sampling variability for a possible mechanism behind this trend. This temperature trend at station 16 is increasing, as are the other significant temperature trends that were all identified in areas further seaward.

BACI testing detected no significant impact of LOOP construction or oil spills on temperature or salinity at Clovelly Dome in the upper estuary.

Overall Conclusions

Construction of the Louisiana Offshore Oil Port (LOOP) facilities and brine disposal operations did not clearly impact the physical hydrography in the study area. Long term trends in temperature and salinity time series do not appear to have been affected by the major 1980-1982 brine discharges or by the one year cessation of brine discharge in 1990.

The long term characterization of regional physical hydrography presented herein contributes to an understanding of the regional physical hydrography of Barataria Bay and nearby estuarine and offshore locations. As such, it will provide a useful baseline from which to assess any alleged environmental effects of future LOOP activities.

REFERENCES

1. Barrett, B. B., 1971, *Cooperative Gulf of Mexico estuarine inventory and study, Louisiana, phase II, hydrology, and phase III, sedimentology*, Louisiana Wild Life and Fisheries Commission, New Orleans, LA, 191 pp.

2. Brooks, D. A., 1984, Current and hydrographic variability in the northwestern Gulf of Mexico, *J. Geophys. Res.* 89, pp. 8022-8032.

3. Byrne, P., Borengasser, M., Grew, A., Miller, R. A., Smith, B. L. Jr., and Wax, C., 1976, *Barataria basin: hydrologic and climatologic processes*, Sea Grant Publ. LSU-T-76-010, Center for Wetland Resources, Louisiana State University, Baton Rouge, LA, 176 pp.

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

5. Condrey, R, Kemp, P., Visser, J., Gosselink, J., Lindstedt, J., Melancon, E. Jr., Peterson, G., and Thompson, B., *Characterization of the current status, trends, and probable causes of change in living resources in the Barataria-Terrebonne estuarine system*, BTNEP Publ. No. 21, Barataria-Terrebonne National Estuarine Program, Thibodaux, Louisiana.

6. Csanady, G. T., 1981, Circulation in the coastal ocean, *Advances in Geophysics* 23, 101-183.

7. Daddio, E., Wiseman, W. J. Jr., and Murray, S. P., 1978, Inertial currents over the inner shelf near 30 N., *J. Phys. Oceanogr.* 8(4), 728-733.

8. Dinnel, S. P., and Wiseman, W. J. Jr., 1986, Fresh water on the Louisiana and Texas shelves. *Cont. Shelf Res.* 6(6), pp. 765-784.

9. Dinnel, S. P., Wiseman, W. J. Jr., and Rouse, L. J. Jr., 1997, *Coastal currents in the northern Gulf of Mexico*. OCS Study MMS 97-0005, U. S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 113 pp.

10. Ebbesmeyer, C. C., Williams, G. N., Hamilton, R. C., Abbott, C. E., Collipp, B. G., and McFarlane, C. F., 1982, *Strong persistent currents observed at depth off the Mississippi River Delta*, Proc. 14th Int. Offshore Tech. Conf., Houston, pp. 259-267.

11. Gill, A. E., 1982, *Atmosphere-Ocean Dynamics*, Academic Press, San Diego, 662 pp.

12. Gosselink, J. G., Miller, R. R., Hood, M., and Bahr, L. M. Jr. 1976, *Louisiana Offshore Oil Port Environmental Baseline Study*, Report prepared for LOOP, INC, New Orleans, Louisiana.

13. Hacker, S., 1973, *Transport phenomena in estuaries*, Louisiana State University, Dept. Chem. Eng., Ph.D. Dissertation, 335 pp.

14. Hirsch, R. M., J. R. Slack, and R. A. Smith, 1982, Techniques of trend analysis for monthly water quality data, *Water Res. Research* Vol. 18, No. 1, pp. 107-121.

15. Hitchcock, G.L., Wiseman, W. J. Jr., Boicourt, W. C., Mariano, A. J., Walker, N., Nelson, T. A., and Ryan, E., 1997, Property fields in an effluent plume of the Mississippi River. *J. Mar. Sys.* 12:109-126.

16. Huh, O. K., and Schaudt, K. J., 1990, Satellite imagery tracks currents in Gulf of Mexico, *Oil & Gas Journal*, May 7, pp. 70-76.

17. Jochens, A. E., and Nowlin, W. D., eds., 1994: *Texas-Louisiana shelf circulation and transport processes study: year 1, annual report, volume II: Technical Report*. MMS 94-0030, U. S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, LA, 207 pp.

18. Kendall, M. G., 1938, A new measure of rank correlation, *Biometrika*, Vol. 30, pp. 81-93.

19. Kjerfve, B., 1973, *Dynamics of the water surface in a bar-built estuary*, Louisiana State University, Dept. Mar. Sci., Ph.D. Dissertation, 91 pp.

20. Kjerfve, B., 1975, Tide and fair-weather wind effects in a bar-built Louisiana estuary, in *Estuarine Res., Vol. 11*, Academic Press, New York, pp. 47-62.

21. Leipper, D. F., 1970, A sequence of current patterns in the Gulf of Mexico, *J. Geophys. Res.* 75, pp. 637-657.

22. Louisiana Department of Wildlife and Fisheries, 1995, *Environmental monitoring of the Louisiana Offshore Oil Port (LOOP, Inc.) 1978-1994, Brine Monitoring, Part 1*. Draft report prepared for LOTA Program Review Committee, 58 pp.

23. Marmer, H. A., 1954, Tides and sea level in the Gulf of Mexico, *Fish. Bull.* 89, 101-118.

24. McKee, B., Wiseman, W. J. Jr., and Inoue, M., 1994, Salt flux and sediment residence times in a bar-built estuary, in *Mixing Processes in Estuaries and Coastal Seas*, C. Pattiaratchi (ed.), AGU, Washington, D.C., pp. 157-170.

25. McKenzie, L. C. III, Wascom, M. W., Keithly, W. R., Emmer, R. E., Hudnall, W. H., Johnson, M. T. C., Niami, F., and Touchet, B. A., 1995, *Land use and socioeconomic status and trends in the Barataria-Terrebonne estuarine system*, BTNEP Publ. No. 23, Barataria-Terrebonne National Estuarine Program, Thibodaux, Louisiana.

26. NMFS, 1997, Personal communication from the National Marine Fisheries Service, Fisheries Statistics and Economics Division (http://remora.ssp.nmfs.gov)

27. Pritchard, D. W., 1967, Observations of circulation in coastal plain estuaries, in *Estuaries*, Lauff, G. H. (ed.), Am. Assoc. Adv. Sci., pp. 37-44.

28. Pritchard, D. W., and Bunce, R. E., 1959, *Physical and chemical hydrography of the Magothy River*, Tech. Rep. XVII, Ref. 59-2, Chesapeake Bay Inst., Johns Hopkins University, Baltimore.

29. Rabalais, N. N., Turner, R. E., Wiseman, W. J. Jr., and Boesch, D. F., 1991, A brief summary of hypoxia on the northern Gulf of Mexico continental shelf: 1985-1988, in *Modern and Ancient Continental Shelf Anoxia*, R. V. Tyson and T. H. Pearson (eds.), Geological Society Special Publication No. 58, pp. 35-47.

30. Rouse, L. J. Jr., 1997, *Circulation and hydrographic structure in the vicinity of the Mississippi River Delta, in an observational study of the Mississippi-Atchafalaya coastal plume*, U. S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, pp. 121-138.

31. Rouse, L. J. Jr., and Coleman, J. M., 1976, Circulation observations in the Louisiana Bight using LANDSAT imagery, *Rem. Sens. Environ.* 5, pp. 55-66.

32. SAS, 1990a, *SAS Procedures Guide*, Version 6, Third Edition. SAS Institute, Inc., Cary, North Carolina. 705 pp.

33. SAS, 1990b, *SAS Language Reference*, Version 6, First Edition. SAS Institute, Inc., Cary, North Carolina. 1042 pp.

34. SAS, 1990c, *SAS/Graph Software Reference*, Version 6 First Edition, Volume 1. SAS Institute, Inc., Cary, North Carolina. 1341 pp.

35. SAS, 1990d, *SAS/Graph Software Reference*, Version 6 First Edition, Volume 2. SAS Institute, Inc., Cary, North Carolina. 605 pp.

36. Sasser, C. E., Gosselink, J. G., Peterson, G. W., Heikamp, A. J. Jr., and Webb, J. C., 1982, Environmental management analysis of the Louisiana Offshore Oilport, *Wetlands* Vol. 2, pp. 249-261.

37. Schroeder, W. W., and Wiseman, W. J. Jr., 1986, Low-frequency shelf-estuarine exchange processes in Mobile Bayand other estuarine systems on the northern Gulf of Mexico, in *Estuarine Variability*, D. Wolfe (ed.), Academic Press, New York, pp. 355-367.

38. Smith, D. C., 1986, Numerical study of Loop Current eddy interaction with topography in the western Gulf of Mexico, *J. Phys. Oceanogr.* 16, pp. 1260-1272.

39. Stommel, H. M., 1965, *The Gulf Stream: A Physical and Dynamical Description*, University of California Press, Berkeley, 248 pp.

40. Temple, R. F., Harrington, D. L., and Martin, J. A., 1977, *Monthly temperature and salinity measurements of continental shelf waters of the north-western Gulf of Mexico, 1963-1965*, NOAA Rep., NMFS, SSFR-707, 26 pp.

41. Turner, R. E., and Allen, R., 1982, Bottom water oxygen concentration in the Mississippis River Delta Bight, *Contrib. Mar. Sci.* 25, 161-172.

42. Underwood, A. J., 1994, On beyond BACI: Sampling designs that might reliably detect environmental disturbances. *Ecol. Applic.* Vol. 4, pp. 3-15.

43. Von Arx, 1949, unpublished report to the Freeport Sulphur Company.

44. Walker, N. D., 1996, Satellite assessment of Mississippi River plume variability: causes and predictability. *Rem Sens. Environ.* 58, pp. 21-35.

45. Wax, C. L., Borengasser, M. J., and Muller, R. A., 1978, *Barataria Basin: synoptic weather types and environmental responses*, Center for Wetlands Resources, Louisiana State University, Sea Grant pub. no. LSU-T-78-001, 60 pp.

46. Weisberg, S., *Applied Linear Regression*, 1985, Wiley, New York, Chapter 1, pp. 1-27.

47. Whitaker, R. E., 1971, *Seasonal variations of steric and recorded sea level of the Gulf of Mexico.* M.S. thesis, Texas A&M University, College Station, 111 pp.

48. Wiseman, W. J. Jr., Bane, J. M., Murray, S. P., and Tubman, M. W., 1975a, Small-scale temperature and salinity structure west of the Mississippi River Delta, in *Memoires de la societe royale des sciences de Liege* X, pp. 277-285.

49. Wiseman, W. J. Jr., and Dinnel, S. P., 1988, Shelf currents near the mouth of the Mississippi River, *J. Phys. Oceanogr.* 18, pp. 1287-1291.

50. Wiseman, W. J. Jr., and Inoue, M., 1993, Salinity variations in two Louisiana estuaries, *Coastal Zone '93, Proceedings of the eighth symposium on coastal and ocean management*, Magoon, O. T., Wilson, W. S., Converse, H., and Tobin, L. T. (eds.), Vol. 1, pp. 1230-1242.

51. Wiseman, W. J. Jr., and F. J. Kelly, 1994, Salinity variability within the Louisiana Coastal Current during the 1982 flood season. *Estuaries* 17(4):732-739, 1994

52. Wiseman, W. J. Jr., Murray, S. P., Bane, J. M., and Tubman, M. W., 1975b, *Offshore physical oceanography, in Environmental Assessment of a Louisiana Offshore Oil Port and Appertinent Storage and Pipeline Facilities, Vol. II*, Gosselink, J. G., Miller, R. R., Hood, M., and Bahr, L. M. Jr. (eds.), Louisiana Offshore Oil Port, Inc., pp. 1-162.

53. Wiseman, W. J. Jr., Murray, S. P., Bane, J. M., and Tubman, M. W., 1982, Physical environment of the Louisiana Bight, *Contrib. Mar. Sci.* 25, pp. 85-90.

54. Wiseman, W. J. Jr., and Swenson, E. M., 1989, Modelling the effects of produced water discharges on estuarine salinity, in *Environmental Impact of Produced Water Discharges in Coastal Louisiana*, Boesch, D. F. and Rabalais, N. N (eds.), Prepared by the Louisiana Universities Marine Consortium in collaboration with Louisiana State University and A&M College and Aero-Data Corporation, pp. 23-54.

55. Wiseman, W. J. Jr., Swenson, E. M., and Kelly, F. J., 1990a, Control of estuarine salinities by coastal ocean salinity, in *Coastal and Estuarine Studies, Vol. 38*, R. T. Cheng (ed.), Springer-Verlag, New York, pp. 184-193.

56. Wiseman, W. J. Jr., Swenson, E. M., and Power, J., 1990b, Salinity trends in Louisiana estuaries. *Estuaries* Vol. 13, No. 3, pp. 265-271.

57. Wiseman, W. J. Jr., Rabalais, N. N., Turner, R. E., Dinnel, S. P., and MacNaughton, A., 1997, Seasonal and interannual variability within the Louisiana coastal current: stratification and hypoxia. *J. Mar. Sys.* Vol. 12, pp. 237-248.

APPENDIX A

TABLES OF TEMPERATURE AND SALINITY STATISTICS

Table A1. Temperature statistics for monthly physical hydrography samples: surface samples 1/1/78-12/31/95. General descriptive statistics for selected stations (Sta). Mean measured seafloor depth at the station ($z_{seafloor}$) is listed in meters, as is mean sampling depth (z_{sample}). Mean (μ), standard deviation from the mean (σ), maximum (Max), and minimum (Min) are listed in °C. The number of measurements used to compute these statistics is n.

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
1	1.91	0.30	22.272	7.325	33.600	7.100	75
2	2.07	0.30	22.545	7.041	32.000	7.500	75
3	2.54	0.30	22.684	6.835	32.700	9.900	74
4	11.82	0.30	23.359	6.357	32.400	10.900	64
5	4.10	0.29	22.910	6.420	33.000	7.900	208
6	2.19	0.30	22.485	7.270	32.600	8.000	46
7	1.64	0.29	22.607	6.893	32.500	5.300	205
8	1.67	0.30	23.021	7.351	34.100	7.900	60
9	2.00	0.30	23.252	7.140	36.500	8.900	44
10	2.04	0.32	22.781	7.122	32.900	7.500	56
11	2.62	0.30	22.450	6.797	34.300	10.300	38
12	1.68	0.29	22.366	7.014	32.200	5.570	130
13	1.52	0.29	22.700	7.213	32.900	5.600	181
14	1.91	0.29	21.884	7.100	32.500	2.100	202
15	1.82	0.30	22.371	7.173	33.100	5.700	200
16	2.22	0.29	23.611	7.017	34.100	6.900	177
17	1.57	0.30	21.954	7.406	32.100	9.200	41
18	3.28	0.30	22.494	6.899	32.800	8.900	197
19	1.92	0.30	21.945	7.695	33.300	8.500	40
21	7.87	0.42	23.018	5.587	31.500	9.100	196
22	10.51	0.40	23.254	5.478	31.500	9.900	192
31	3.29	0.30	22.502	6.146	30.800	9.100	41
32	2.40	0.30	22.984	6.425	36.100	9.800	32
33	2.80	0.30	24.476	6.406	37.700	12.900	34
34	1.76	0.28	23.169	7.078	34.500	6.400	195
35	10.49	0.44	23.124	5.397	32.200	12.100	188
36	10.86	0.44	23.456	5.408	31.600	10.000	181
37	3.21	0.34	23.463	6.291	32.600	9.000	181
38	1.84	0.30	23.642	6.979	34.400	6.100	184
39	1.71	0.29	24.396	6.488	33.940	10.700	114
40	1.72	0.28	23.928	6.548	33.090	8.000	51
52	32.98	0.44	23.464	5.455	31.250	11.900	151
53	32.98	0.45	23.548	5.411	31.500	12.800	162
54	26.93	0.50	23.799	5.474	31.700	12.200	156
55	33.90	0.44	23.477	5.343	31.170	12.000	153

(Table A1, cont.)

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
407	1.33	0.27	22.606	7.086	33.600	10.300	35
435	9.63	0.40	23.902	5.204	32.600	13.500	58
461	0.91	0.29	23.016	6.785	33.100	10.600	37
462	0.91	0.26	22.129	7.164	32.200	8.700	38
463	1.73	0.27	23.654	6.868	32.300	9.900	35
464	1.96	0.26	21.978	7.126	33.100	9.820	37
473	9.38	0.38	23.833	5.307	32.950	14.700	58
474	9.49	0.39	23.684	5.317	33.250	14.300	55
475	9.58	0.42	23.800	5.392	33.400	14.500	57
481	31.88	0.44	23.949	5.125	31.600	14.600	59
482	33.01	0.37	23.441	5.172	31.900	15.500	56
484	31.69	0.44	23.486	5.402	31.200	12.600	55
500	10.67	0.30	23.542	5.618	31.100	14.300	24
501	10.67	0.30	23.721	5.484	31.100	14.700	24
502	10.73	0.41	23.448	5.500	31.700	12.600	161
505	10.67	0.30	24.158	5.476	31.700	15.200	24
506	10.67	0.30	24.622	5.449	32.200	15.200	23
507	10.67	0.30	23.593	5.493	32.100	13.700	54
535	11.09	0.42	23.322	5.677	31.630	12.900	129
601	1.64	0.30	26.443	5.040	33.900	12.500	30
602	1.00	0.30	25.147	6.144	33.400	11.600	36
604	0.68	0.27	25.087	6.180	32.650	11.900	33
605	0.53	0.29	25.699	5.763	33.200	12.600	30
607	1.71	0.31	25.357	5.504	34.500	12.200	35
608	1.24	0.31	25.021	5.948	33.190	11.600	36
609	0.88	0.30	25.051	6.190	33.000	11.300	37
610	1.38	0.29	24.000	6.410	33.070	10.700	44
611	1.55	0.30	23.918	6.080	32.170	10.700	36
612	0.97	0.28	24.139	6.681	33.500	9.900	32
613	1.11	0.27	23.289	6.439	31.800	8.800	25
614	0.48	0.31	23.287	5.705	32.400	10.900	31
615	0.58	0.29	23.077	6.212	32.600	9.500	30
616	0.72	0.32	24.150	4.885	32.900	13.500	26
617	1.08	0.27	23.623	5.726	31.800	12.500	38
618	1.17	0.28	22.960	5.754	31.200	11.200	43
619	1.74	0.28	23.227	5.520	32.110	12.300	38
620	1.00	0.28	23.400	5.566	31.320	11.840	33
621	1.09	0.29	23.668	5.598	32.090	13.000	32
622	0.58	0.29	24.415	6.641	46.200	12.900	33
623	0.84	0.28	25.433	6.205	33.890	12.700	31
624	0.64	0.26	23.665	6.598	32.400	9.900	33

(Table A1, cont.)

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
625	0.89	0.27	23.530	6.650	32.900	7.300	30
630	0.45	0.29	24.916	5.681	34.500	11.000	23
701	10.17	0.30	24.929	4.486	31.200	17.200	34
703	15.78	0.50	23.950	5.230	31.500	14.400	85
704	19.55	0.42	23.789	5.330	31.600	12.270	155
706	25.94	0.44	23.567	5.155	31.300	13.400	156
708	32.13	0.47	23.684	5.156	31.130	13.300	153
711	33.18	0.30	24.823	4.990	31.200	16.500	22
713	27.31	0.30	25.087	4.927	30.900	16.100	23
715	21.81	0.30	24.468	5.155	30.700	16.000	25
717	15.41	0.30	24.368	5.184	30.700	16.200	25
719	9.69	0.30	24.432	5.744	31.000	11.200	25
857	10.55	0.65	25.639	3.204	31.040	19.690	25

Table A2. Temperature statistics for monthly physical hydrography samples: mid-depth samples 1/1/78-12/31/95. General descriptive statistics for selected stations (Sta). Mean measured seafloor depth at the station ($z_{seafloor}$) is listed in meters, as is mean sampling depth (z_{sample}). Mean (μ), standard deviation from the mean (σ), maximum (Max), and minimum (Min) are listed in °C. The number of measurements used to compute these statistics is n.

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
52	32.98	16.42	23.302	3.825	30.500	13.800	156
53	32.98	16.45	23.373	3.775	30.500	14.000	162
54	26.93	13.50	23.363	4.066	30.700	13.800	155
55	33.90	16.82	23.335	3.667	29.800	13.900	153
481	31.13	15.39	23.253	3.437	29.600	17.000	44
482	31.49	15.58	23.110	3.785	30.100	16.300	43
484	30.85	15.20	23.395	3.274	29.990	17.700	41
500	10.67	5.18	23.263	5.397	30.400	14.300	24
501	10.67	5.18	23.583	5.574	31.000	14.500	24
502	10.62	5.19	23.723	5.210	31.300	14.700	26
505	10.67	5.18	23.542	5.206	30.600	14.500	24
506	10.67	5.18	23.722	5.005	30.700	14.400	23
507	10.67	5.18	23.724	5.192	30.800	14.700	25
535	10.40	5.16	24.169	4.865	31.300	14.500	21
703	15.76	7.78	23.784	4.736	30.700	15.400	81
704	19.50	9.74	23.276	4.398	30.900	14.500	153
706	25.87	13.00	23.221	4.000	31.000	14.700	148
708	32.11	16.04	23.465	3.598	30.900	15.100	150
713	27.30	13.57	24.471	4.120	29.500	16.900	21
715	21.81	10.96	23.852	4.655	29.600	16.300	25
717	15.41	7.96	24.092	4.520	30.300	16.300	25

Table A3. Temperature statistics for monthly physical hydrography samples: bottom samples 1/1/78-12/31/95. General descriptive statistics for selected stations (Sta). Mean measured seafloor depth at the station ($z_{seafloor}$) is listed in meters, as is mean sampling depth (z_{sample}). Mean (μ), standard deviation from the mean (σ), maximum (Max), and minimum (Min) are listed in °C. The number of measurements used to compute these statistics is n.

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
4	11.82	11.82	22.598	5.251	31.200	10.900	64
5	4.11	4.11	22.817	6.269	32.900	7.700	203
18	3.30	3.29	22.408	6.780	32.600	8.500	168
21	7.87	7.87	22.793	4.960	31.200	11.200	196
22	10.51	10.51	22.698	4.583	30.900	12.300	192
35	10.49	10.49	22.762	4.487	31.900	12.500	188
36	10.86	10.86	22.675	4.429	30.800	11.800	181
37	3.19	3.05	23.303	6.236	32.400	8.600	177
38	1.84	1.83	22.994	6.595	33.400	6.100	177
52	32.98	32.97	22.593	2.750	31.600	15.600	156
53	32.98	32.98	22.441	2.676	29.800	15.500	161
54	26.93	26.87	22.781	3.042	30.100	14.100	156
55	33.90	33.89	22.512	2.698	30.000	15.700	153
407	1.37	1.35	22.182	6.945	33.200	9.270	56
435	10.30	10.30	23.043	4.288	30.300	16.000	53
461	1.08	1.04	22.283	7.293	32.900	9.100	45
462	0.93	0.92	22.037	6.741	31.800	8.710	56
463	1.67	1.56	22.819	7.314	32.900	6.800	54
464	2.10	2.06	22.107	7.288	32.400	6.000	49
473	9.62	9.62	22.771	4.327	30.900	15.200	55
474	9.75	9.75	22.707	4.169	30.400	15.700	52
475	9.84	9.84	22.700	4.329	30.600	15.800	53
481	33.44	33.41	22.105	2.153	27.700	17.900	54
482	33.80	33.79	22.048	2.268	28.500	18.000	53
484	33.39	33.39	21.974	2.081	26.200	17.800	50
500	10.67	10.67	23.212	4.821	30.400	15.600	24
501	10.67	10.67	23.342	4.701	29.400	15.500	24
502	10.73	10.73	22.854	4.237	30.800	13.800	161
505	10.67	10.67	23.137	4.585	30.300	15.000	24
506	10.67	10.67	23.539	4.523	30.400	15.800	23
507	10.67	10.67	22.598	4.253	30.300	14.000	54
535	11.15	10.40	22.563	4.328	29.800	13.800	127
602	1.13	1.13	24.700	5.332	33.940	16.290	23
607	1.67	1.59	24.435	5.904	35.900	14.860	25
608	1.22	1.19	23.662	5.908	32.000	12.280	24

(Table A3, cont.)

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
609	0.86	0.85	22.583	6.770	33.100	10.670	22
610	1.34	1.34	23.525	6.335	31.200	12.220	23
611	1.51	1.50	23.057	5.710	31.500	12.790	31
615	0.49	0.49	23.100	6.571	32.490	8.580	22
617	1.02	0.99	21.597	7.195	31.000	8.950	23
618	1.35	1.33	21.897	6.538	31.000	11.500	30
619	1.42	1.42	21.530	6.376	30.970	9.870	25
620	0.82	0.82	21.794	6.379	31.300	9.620	31
621	0.61	0.63	21.864	6.317	30.400	9.300	24
701	10.17	7.70	24.279	3.948	30.900	17.100	34
703	15.79	15.72	23.225	3.538	30.800	16.300	84
704	19.55	19.47	22.927	3.138	30.500	14.500	155
706	25.93	25.67	22.782	2.755	29.800	16.700	155
708	32.13	32.13	22.650	2.650	31.400	16.700	153
713	27.31	27.24	22.968	2.547	27.100	18.300	22
715	22.65	22.65	23.461	2.995	28.000	18.600	23
717	16.46	16.44	24.200	3.747	29.000	17.700	21
719	9.69	9.33	23.620	4.811	31.000	16.000	25
857	10.55	10.15	24.228	3.171	30.330	19.380	25

Table A4. Salinity statistics for monthly physical hydrography samples: surface samples 1/1/78-12/31/95. General descriptive statistics for selected stations (Sta). Mean measured seafloor depth at the station ($z_{seafloor}$) is listed in meters, as is mean sampling depth (z_{sample}). Mean (μ), standard deviation from the mean (σ), maximum (Max), and minimum (Min) are listed in ppt. The number of measurements used to compute these statistics is n.

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
1	1.91	0.30	13.297	6.753	36.800	0.900	72
2	2.07	0.30	19.896	6.522	32.600	5.600	71
3	2.54	0.30	20.794	6.882	32.700	5.900	70
4	11.82	0.30	23.860	6.188	33.700	10.200	62
5	4.10	0.29	21.790	6.090	35.900	8.110	204
6	2.19	0.30	21.726	5.341	30.100	10.200	43
7	1.64	0.29	17.434	5.031	29.200	4.900	199
8	1.67	0.30	18.248	5.140	29.500	6.900	57
9	2.00	0.30	18.062	5.231	29.400	8.700	40
10	2.04	0.32	17.811	4.634	27.000	7.700	56
11	2.62	0.30	10.800	5.904	24.300	0.400	36
12	1.68	0.29	9.587	4.757	21.900	0.700	127
13	1.52	0.29	8.710	4.889	23.100	0.500	177
14	1.91	0.29	3.775	4.081	18.600	0.100	196
15	1.82	0.30	3.480	2.986	15.700	0.100	198
16	2.22	0.29	2.044	2.404	12.800	0.100	175
17	1.57	0.30	2.428	2.370	11.600	0.100	43
18	3.28	0.30	1.035	1.520	8.700	0.100	182
19	1.92	0.30	2.071	1.777	6.300	0.200	42
21	7.87	0.42	25.821	5.184	36.300	11.100	188
22	10.51	0.40	26.219	5.167	36.000	11.000	179
31	3.29	0.30	25.666	6.137	36.900	10.900	38
32	2.40	0.30	19.966	4.980	28.200	10.000	32
33	2.80	0.30	23.856	4.836	31.900	11.900	34
34	1.76	0.28	23.936	5.057	33.900	1.400	183
35	10.49	0.44	25.889	5.338	35.700	5.480	182
36	10.86	0.44	26.037	5.182	36.100	11.600	176
37	3.21	0.34	24.665	4.174	32.870	12.800	170
38	1.84	0.30	2.952	2.483	12.900	0.100	181
39	1.71	0.29	2.740	2.270	11.700	0.160	114
40	1.72	0.28	10.382	4.679	19.400	1.600	50
52	32.98	0.44	26.185	5.251	36.670	9.300	151
53	32.98	0.45	26.603	5.200	35.400	9.200	156
54	26.93	0.50	26.099	5.084	34.090	9.100	150
55	33.90	0.44	26.669	5.202	35.400	9.700	149

(Table A4, cont.)

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
407	1.33	0.27	16.882	5.103	27.400	5.200	35
435	9.63	0.40	24.917	5.317	35.300	13.400	58
461	0.91	0.29	2.358	2.153	8.500	0.300	37
462	0.91	0.26	16.918	5.003	25.900	5.400	38
463	1.73	0.27	2.704	2.494	10.200	0.100	35
464	1.96	0.26	2.806	2.795	11.800	0.100	34
473	9.38	0.38	24.334	5.055	31.900	11.900	58
474	9.49	0.39	24.138	5.272	31.900	12.600	55
475	9.58	0.42	24.451	5.015	34.000	11.900	57
481	31.88	0.44	26.129	5.621	36.700	9.400	59
482	33.01	0.37	25.650	6.189	36.100	9.290	59
484	31.69	0.44	26.910	5.391	35.600	12.100	54
500	10.67	0.30	25.383	5.506	31.700	8.200	24
501	10.67	0.30	25.808	5.192	31.600	8.600	24
502	10.73	0.41	25.572	5.352	35.100	7.800	160
505	10.67	0.30	26.571	5.239	32.500	9.500	24
506	10.67	0.30	26.143	5.475	32.000	9.500	23
507	10.67	0.30	26.340	5.378	33.300	8.800	53
535	11.09	0.42	25.378	5.585	40.920	8.200	126
601	1.64	0.30	2.685	2.529	8.800	0.200	27
602	1.00	0.30	2.836	2.295	11.700	0.300	34
604	0.68	0.27	3.421	2.534	11.300	0.200	31
605	0.53	0.29	3.342	2.379	12.500	0.200	30
607	1.71	0.31	2.944	2.410	12.700	0.200	33
608	1.24	0.31	3.097	2.466	12.300	0.200	35
609	0.88	0.30	3.249	2.616	11.500	0.200	36
610	1.38	0.29	3.597	3.069	13.700	0.200	43
611	1.55	0.30	4.298	3.922	13.600	0.210	31
612	0.97	0.28	4.898	3.920	14.600	0.400	29
613	1.11	0.27	9.178	4.278	21.900	0.700	24
614	0.48	0.31	22.702	4.907	31.800	11.200	31
615	0.58	0.29	22.720	5.274	30.400	10.600	30
616	0.72	0.32	22.191	5.803	30.300	9.800	26
617	1.08	0.27	22.363	5.329	30.000	11.000	38
618	1.17	0.28	22.269	5.077	31.190	10.900	43
619	1.74	0.28	22.467	4.969	30.800	10.300	38
620	1.00	0.28	23.392	5.504	31.300	10.100	33
621	1.09	0.29	22.772	4.802	30.600	11.000	32
622	0.58	0.29	22.771	4.930	30.700	10.500	33
623	0.84	0.28	3.596	2.106	10.200	0.300	30
624	0.64	0.26	6.139	4.826	17.900	0.360	31

(Table A4, cont.)

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
625	0.89	0.27	8.019	4.945	23.100	1.000	29
630	0.45	0.29	22.993	6.234	30.600	10.000	23
701	10.17	0.30	25.947	5.256	32.300	15.200	34
703	15.78	0.50	26.706	4.860	33.800	14.320	85
704	19.55	0.42	26.153	5.088	35.420	13.400	154
706	25.94	0.44	26.630	5.224	34.500	13.500	155
708	32.13	0.47	26.656	5.419	35.600	12.500	152
711	33.18	0.30	26.500	5.079	35.100	13.400	22
713	27.31	0.30	26.548	5.264	34.600	13.900	23
715	21.81	0.30	26.132	4.892	34.400	13.800	25
717	15.41	0.30	26.276	4.843	34.200	13.000	25
719	9.69	0.30	25.888	4.949	32.400	10.200	25
857	10.55	0.65	21.380	5.479	28.790	11.890	25

Table A5. Salinity statistics for monthly physical hydrography samples: mid-depth samples 1/1/78-12/31/95. General descriptive statistics for selected stations (Sta). Mean measured seafloor depth at the station ($z_{seafloor}$) is listed in meters, as is mean sampling depth (z_{sample}). Mean (μ), standard deviation from the mean (σ), maximum (Max), and minimum (Min) are listed in ppt. The number of measurements used to compute these statistics is n.

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
52	32.98	16.42	33.906	1.788	36.600	28.000	146
53	32.98	16.45	34.003	1.801	36.600	26.300	150
54	26.93	13.50	33.077	2.193	36.300	23.500	145
55	33.90	16.82	34.184	1.684	36.700	27.200	143
481	31.13	15.39	34.369	1.708	36.600	30.500	40
482	31.49	15.58	34.106	2.051	36.500	25.800	39
484	30.85	15.20	34.426	1.403	36.240	31.500	35
500	10.67	5.18	28.737	2.724	33.100	21.500	24
501	10.67	5.18	28.083	4.026	32.200	12.400	24
502	10.62	5.19	27.480	4.641	32.200	13.000	26
505	10.67	5.18	29.679	2.567	34.600	24.200	24
506	10.67	5.18	29.709	2.601	35.200	24.600	23
507	10.67	5.18	28.608	3.419	32.400	19.200	25
535	10.40	5.16	27.652	4.631	32.400	13.600	21
703	15.76	7.78	30.155	2.991	34.980	21.990	81
704	19.50	9.74	31.597	2.629	35.900	20.500	152
706	25.87	13.00	33.116	2.188	36.400	23.000	147
708	32.11	16.04	33.949	1.961	36.600	27.400	149
713	27.30	13.57	32.967	2.386	35.000	23.900	21
715	21.81	10.96	31.724	2.954	35.100	21.500	25
717	15.41	7.96	30.528	3.401	34.200	17.800	25

Table A6. Salinity statistics for monthly physical hydrography samples: bottom samples 1/1/78-12/31/95. General descriptive statistics for selected stations (Sta). Mean measured seafloor depth at the station ($z_{seafloor}$) is listed in meters, as is mean sampling depth (z_{sample}). Mean (μ), standard deviation from the mean (σ), maximum (Max), and minimum (Min) are listed in ppt. The number of measurements used to compute these statistics is n.

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
4	11.82	11.82	30.840	4.275	38.700	15.600	62
5	4.11	4.11	22.594	6.061	36.000	9.100	200
18	3.30	3.29	1.270	1.838	9.400	0.100	156
21	7.87	7.87	29.749	3.652	37.600	12.800	187
22	10.51	10.51	31.328	3.292	37.800	17.300	179
35	10.49	10.49	31.361	2.992	37.900	19.000	183
36	10.86	10.86	31.840	2.961	39.900	21.700	175
37	3.19	3.05	25.074	4.052	32.850	12.600	168
38	1.84	1.83	3.091	2.478	12.500	0.100	174
52	32.98	32.97	35.612	0.817	36.700	31.900	137
53	32.98	32.98	35.626	0.805	36.700	32.100	144
54	26.93	26.87	35.194	1.212	36.700	28.700	141
55	33.90	33.89	35.668	0.827	36.600	30.000	134
407	1.37	1.35	17.627	4.692	26.800	5.700	56
435	10.30	10.30	31.084	3.194	36.300	18.300	53
461	1.08	1.04	2.861	2.192	9.800	0.500	44
462	0.93	0.92	17.735	4.602	25.600	5.200	57
463	1.67	1.56	2.664	2.296	10.400	0.100	53
464	2.10	2.06	2.933	2.488	10.100	0.100	46
473	9.62	9.62	31.155	4.152	40.500	16.700	55
474	9.75	9.75	31.478	3.625	40.600	18.300	52
475	9.84	9.84	31.482	2.959	40.000	23.550	53
481	33.44	33.41	35.564	0.846	36.600	32.190	45
482	33.80	33.79	35.409	0.998	36.400	31.830	48
484	33.39	33.39	35.303	1.197	36.600	30.800	44
500	10.67	10.67	31.617	2.516	36.000	25.800	23
501	10.67	10.67	31.504	2.617	36.000	25.800	24
502	10.73	10.73	31.833	2.905	36.500	18.200	160
505	10.67	10.67	31.750	3.709	35.100	18.500	24
506	10.67	10.67	31.617	3.982	36.000	18.400	23
507	10.67	10.67	32.140	3.568	37.900	18.000	53
535	11.15	10.40	30.989	3.520	36.100	17.900	124
602	1.13	1.13	2.392	1.686	5.200	0.300	23
607	1.67	1.59	2.100	1.569	5.500	0.300	25
608	1.22	1.19	2.312	1.682	5.700	0.200	24

(Table A6, cont.)

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
609	0.86	0.85	2.063	1.586	5.300	0.200	22
610	1.34	1.34	2.498	1.983	6.400	0.200	23
611	1.51	1.50	3.430	3.423	10.700	0.210	26
615	0.49	0.49	17.464	6.092	30.700	0.070	21
617	1.02	0.99	20.580	4.960	28.780	12.100	23
618	1.35	1.33	21.153	4.891	31.570	11.000	30
619	1.42	1.42	21.941	5.402	32.280	13.560	24
620	0.82	0.82	22.861	4.998	31.990	13.380	31
621	0.61	0.63	21.587	5.032	32.530	13.510	24
701	10.17	7.70	31.130	4.639	47.400	22.000	33
703	15.79	15.72	33.880	1.535	36.100	30.000	83
704	19.55	19.47	34.492	1.432	36.600	30.700	152
706	25.93	25.67	35.120	1.137	36.600	29.330	149
708	32.13	32.13	35.528	1.000	36.600	30.210	145
713	27.31	27.24	35.082	0.798	36.200	33.200	22
715	22.65	22.65	34.557	0.758	36.100	33.100	23
717	16.46	16.44	33.733	1.022	35.200	31.500	21
719	9.69	9.33	31.344	2.332	34.500	24.900	25
857	10.55	10.15	30.553	2.008	34.150	27.680	25

Table A7. Salinity statistics for monthly water chemistry samples: surface samples 1/1/78-12/31/95. General descriptive statistics for selected stations (Sta). Mean measured seafloor depth at the station ($z_{seafloor}$) is listed in meters, as is mean sampling depth (z_{sample}). Mean (μ), standard deviation from the mean (σ), maximum (Max), and minimum (Min) are listed in ppt. The number of measurements used to compute these statistics is n.

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
1	1.96	0.30	14.851	6.275	36.800	0.700	65
2	2.19	0.30	21.518	5.924	37.600	7.000	65
3	2.67	0.30	23.292	6.586	37.100	6.000	66
4	10.47	0.30	25.560	5.855	37.600	13.400	52
5	4.09	0.30	22.015	5.605	33.300	9.800	103
6	2.28	0.30	21.257	4.741	28.100	12.600	23
7	1.65	0.29	18.116	4.209	27.500	5.800	101
8	1.67	0.31	17.943	5.312	27.900	8.700	30
9	1.83	0.30	17.418	5.023	27.000	10.500	22
10	2.12	0.32	17.499	5.597	26.300	7.800	27
11	2.61	0.30	10.581	5.392	25.100	1.500	21
12	1.72	0.29	9.725	4.241	21.400	1.860	69
13	1.50	0.30	8.188	4.299	22.700	1.400	91
14	1.91	0.28	3.833	4.315	16.800	0.160	99
15	1.83	0.30	3.484	3.149	15.000	0.360	102
16	2.26	0.30	1.958	2.267	12.000	0.100	43
18	3.26	0.31	1.075	1.650	8.500	0.100	97
19	1.90	0.30	2.150	1.854	5.800	0.100	22
21	7.83	0.45	26.330	4.881	36.500	15.000	94
22	10.48	0.43	26.488	5.119	35.200	12.800	97
34	1.78	0.29	23.914	4.256	33.300	12.600	94
35	10.51	0.42	26.226	4.797	35.200	13.300	92
36	10.87	0.45	25.995	5.641	34.600	11.940	92
37	3.05	0.35	24.453	4.186	33.100	14.650	92
38	1.86	0.30	2.869	2.434	11.400	0.500	90
39	1.71	0.29	2.884	2.897	18.100	0.560	57
52	33.12	0.45	26.409	5.656	36.200	8.300	75
53	33.12	0.41	26.363	5.513	35.900	9.000	78
54	27.17	0.36	26.644	4.876	34.600	12.500	75
55	33.63	0.45	27.131	5.560	35.900	8.600	75
435	9.67	0.39	25.519	5.638	34.400	11.800	26
473	9.63	0.43	23.651	4.560	32.300	16.260	30
474	9.22	0.36	24.460	5.660	33.300	12.500	24
475	9.28	0.31	24.827	5.774	33.800	12.200	30
481	31.30	0.41	24.745	5.408	36.000	16.600	26

(Table A7, cont.)

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
482	31.99	0.42	24.532	5.696	35.700	14.900	28
484	31.44	0.46	27.549	5.098	36.300	17.900	21
502	10.74	0.41	25.620	6.059	34.600	8.600	76
507	10.67	0.30	26.150	6.012	34.300	8.800	24
535	10.27	0.41	25.010	6.067	32.960	7.700	64
704	19.62	0.52	26.149	5.162	34.900	15.190	62
706	26.01	0.48	26.621	5.873	35.900	13.930	66
708	32.45	0.49	27.561	5.971	38.400	13.400	65

Table A8. Salinity statistics for monthly water chemistry samples: mid-depth samples 1/1/78-12/31/95. General descriptive statistics for selected stations (Sta). Mean measured seafloor depth at the station ($z_{seafloor}$) is listed in meters, as is mean sampling depth (z_{sample}). Mean (μ), standard deviation from the mean (σ), maximum (Max), and minimum (Min) are listed in ppt. The number of measurements used to compute these statistics is n.

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
52	33.12	16.49	33.468	3.377	40.000	15.000	75
53	33.12	16.50	33.872	3.067	37.200	15.700	79
54	27.16	13.62	32.807	2.650	37.030	19.430	76
55	33.59	16.78	33.874	2.440	37.750	20.000	72
704	19.62	9.86	31.877	2.726	36.130	23.860	62
706	25.98	13.06	33.650	2.211	37.500	26.700	64
708	32.44	16.24	34.577	1.907	37.800	29.300	64

Table A9. Salinity statistics for monthly water chemistry samples: bottom samples 1/1/78-12/31/95. General descriptive statistics for selected stations (Sta). Mean measured seafloor depth at the station ($z_{seafloor}$) is listed in meters, as is mean sampling depth (z_{sample}). Mean (μ), standard deviation from the mean (σ), maximum (Max), and minimum (Min) are listed in ppt. The number of measurements used to compute these statistics is n.

Sta	$z_{seafloor}$	z_{sample}	μ	σ	Max	Min	n
4	10.30	10.30	29.660	3.771	37.600	21.000	43
5	4.14	4.13	22.864	5.539	33.100	9.600	100
18	3.29	3.28	1.271	1.886	9.200	0.100	85
21	7.86	7.78	29.413	3.509	35.700	19.300	91
22	10.57	10.56	31.128	3.083	36.200	19.100	94
35	10.51	10.49	30.816	3.199	35.900	19.100	93
36	10.87	10.87	30.645	3.703	35.770	19.100	91
37	3.03	3.03	24.821	4.004	33.500	14.800	91
38	1.87	1.85	2.962	2.526	12.300	0.400	90
52	33.11	33.07	35.475	1.473	38.660	29.100	74
53	33.12	33.12	35.672	1.256	38.300	32.300	78
54	27.17	27.17	34.992	1.681	37.570	25.900	74
55	33.62	33.56	35.678	1.212	38.840	32.300	74
407	1.40	1.40	19.606	3.068	25.100	12.300	27
435	10.21	10.21	31.299	3.347	37.000	19.700	26
461	1.01	1.01	2.851	2.190	9.000	0.500	27
462	0.92	0.91	18.206	4.251	25.900	8.600	29
463	1.55	1.51	2.932	2.430	9.500	0.700	27
464	1.97	1.96	3.044	3.086	13.300	0.500	27
473	9.66	9.66	30.042	3.709	35.400	18.100	29
474	9.82	9.79	31.598	3.677	40.800	23.130	24
475	9.75	9.75	31.314	3.313	36.800	23.000	26
481	33.03	32.97	35.524	1.279	37.000	30.700	22
482	33.69	33.59	35.757	1.965	42.200	30.700	25
502	10.74	10.74	31.731	2.883	35.700	18.700	78
507	10.67	10.67	31.484	3.188	35.300	22.400	25
535	10.27	10.27	30.485	3.737	35.700	17.900	64
704	19.62	19.62	34.810	1.602	39.380	29.270	62
706	26.01	26.01	35.219	1.614	37.600	27.500	66
708	32.45	32.45	35.694	1.297	38.380	30.000	65

Table A10. Temperature statistics at fixed stations. General descriptive statistics for measurements taken at fixed stations. Mean (μ), standard deviation from the mean (σ), maximum, and minimum are listed in units of °C.

Station	Timespan*	μ	σ	Maximum	Minimum
306	4/20/81-6/17/81	24.5052	1.8118	28.8000	21.3000
315	2/1/78-12/31/95	22.5689	6.5807	36.2200	2.8000
317	5/10/78-11/4/95	22.4801	6.1777	32.9600	3.7700
318	6/18/81-1/23/86	24.7698	4.0466	35.0000	14.6000
318	5/24/78-6/18/80	24.0938	2.4440	28.9000	20.6500
319	4/28/81-1/23/86	24.9349	5.1881	34.2000	9.4200
319	5/25/78-6/13/80	21.6426	5.0407	31.9000	11.0500
320	5/11/78-5/28/80	21.7561	2.5766	25.4500	15.9500
321	5/27/78-5/28/80	N/A	N/A	N/A	N/A
323	9/6/78-6/14/80	16.5064	4.1546	24.0500	5.9500
323	3/30/81-5/11/88	23.2963	6.4802	34.0000	3.5000
323	5/11/88-2/6/92	22.9520	6.3238	33.8700	4.1730
324	12/15/78-7/29/79	N/A	N/A	N/A	N/A
325	2/20/90-12/31/95	22.9224	6.8861	38.1000	2.3700
326	5/22/81-9/3/87	21.6961	7.1270	38.2000	0.5000
326	7/28/88-12/31/95	22.0407	6.4844	36.8600	2.4800
335	3/11/82-12/2/85	24.5725	3.2791	33.4000	14.4600

* Statistics for individual stations are found separately for time periods when different instruments were known to be used; see Figure 1 for instruments, and Figure 2 for location of stations.

Table A11. Salinity statistics at fixed stations. General descriptive statistics for measurements taken at fixed stations. Mean (μ), standard deviation from the mean (σ), maximum, and minimum are listed in units of ppt.

Station	Timespan*	μ	σ	Maximum	Minimum
306	4/20/81-6/17/81	30.5839	2.5828	35.2400	23.5600
315	2/1/78-12/31/95	19.2884	5.6141	36.1000	2.4990
317	5/10/78-11/4/95	13.0936	6.2869	31.6980	0.2000
318	5/24/78-6/18/80	27.9325	2.6336	33.9600	19.0900
318	6/18/81-1/23/86	27.3489	4.4835	37.5940	13.9700
319	5/25/78-6/13/80	21.2231	6.5830	34.5700	6.6200
319	4/28/81-1/23/86	27.2142	4.7469	41.9200	12.4940
320	5/11/78-5/28/80	1.7604	1.7466	7.8300	0.0600
321	5/27/78-5/28/80	3.3822	1.3102	7.5900	0.1200
323	9/6/78-6/14/80	18.8444	5.6484	34.1900	6.0400
323	3/30/81-5/11/88	20.2641	4.7773	33.2700	5.3640
323	5/11/88-2/6/92	20.2888	5.5293	34.6990	3.7990
324	12/15/78-7/29/79	0.1108	0.1290	0.9800	0.0600
325	2/20/90-12/31/95	2.9384	1.9419	9.3020	0.3000
326	5/22/81-9/3/87	4.8886	2.8049	15.3320	0.1900
326	7/28/88-12/31/95	2.1448	2.1250	10.2000	0.1000
335	3/11/82-12/2/85	28.4266	4.6802	41.4700	14.2620

* Statistics for individual stations are found separately for time periods when different instruments were known to be used; see Figure 1 for instruments, and Figure 2 for location of stations.

Table A12. East velocity statistics-at fixed stations. General descriptive statistics for measurements taken at fixed stations. Mean (μ), standard deviation from the mean (σ), maximum, and minimum are listed in meters per second.

Station	Timespan*	μ	σ	Maximum	Minimum
306	4/20/81-6/17/81	-0.0267	0.0844	0.2288	-0.2830
318	6/18/81-1/23/86	-0.0060	0.0968	0.3023	-0.3156
319	4/28/81-1/23/86	-0.0276	0.1305	0.3964	-0.4543
335	3/11/82-12/2/85	0.0163	0.1173	0.4001	-0.3645

Table A13. North velocity statistics at fixed stations. General descriptive statistics for measurements taken at fixed stations. Mean (μ), standard deviation from the mean (σ), maximum, and minimum are listed in meters per second.

Station	Timespan*	μ	σ	Maximum	Minimum
306	4/20/81-6/17/81	-0.0134	0.0834	0.2465	-0.2747
318	6/18/81-1/23/86	-0.0128	0.0940	0.2888	-0.3210
319	4/28/81-1/23/86	-0.0291	0.0925	0.2861	-0.3468
335	3/11/82-12/2/85	0.0059	0.0910	0.2947	-0.2861

APPENDIX B

PHYSICAL HYDROGRAPHY PLOTS

OF MONTHLY TEMPERATURE AND SALINITY OBSERVATIONS

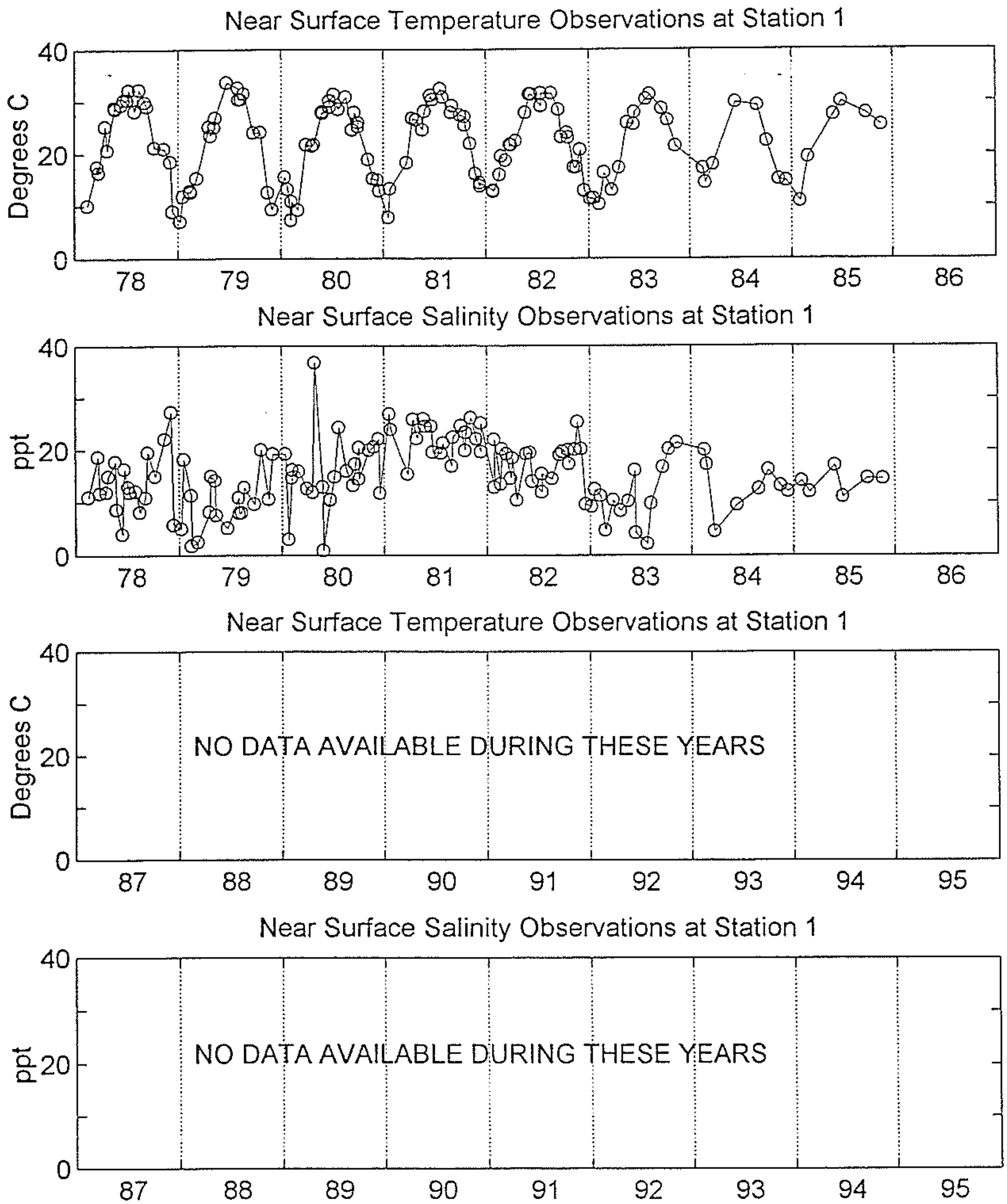

Figure B1. Station 1 monthly physical hydrography data: top temperatures and salinities.

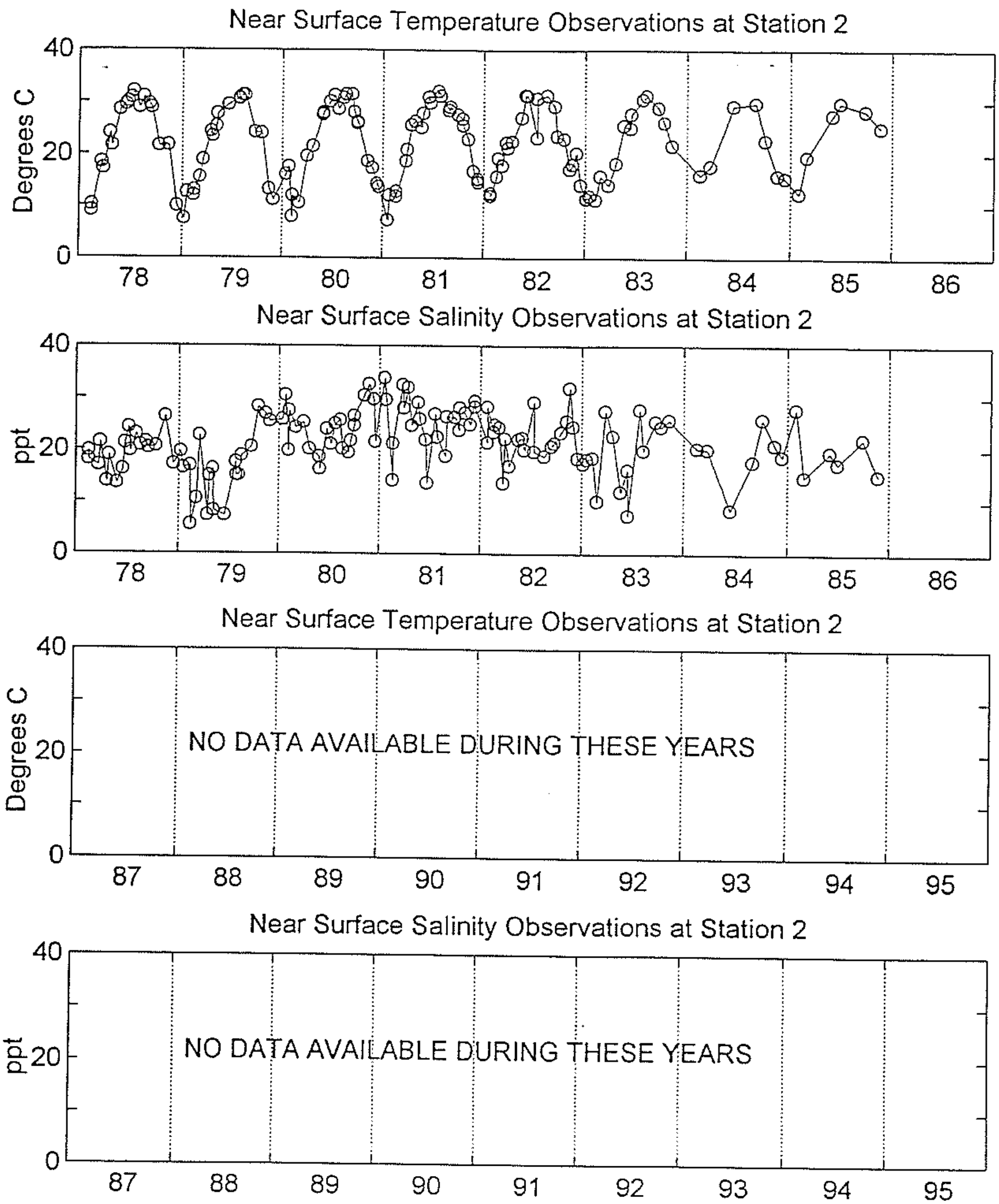

Figure B2. Station 2 monthly physical hydrography data: top temperatures and salinities.

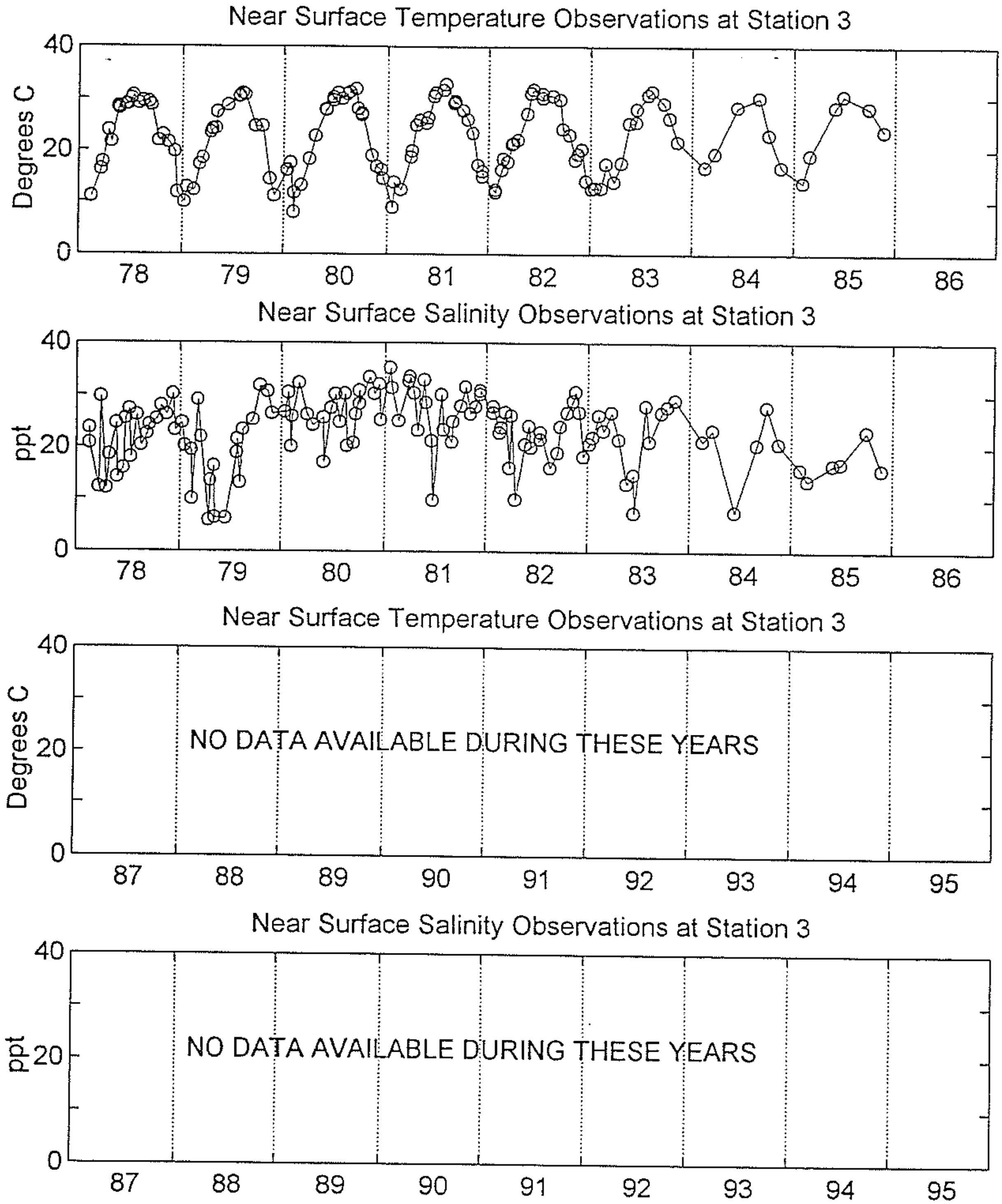

Figure B3. Station 3 monthly physical hydrography data: top temperatures and salinities.

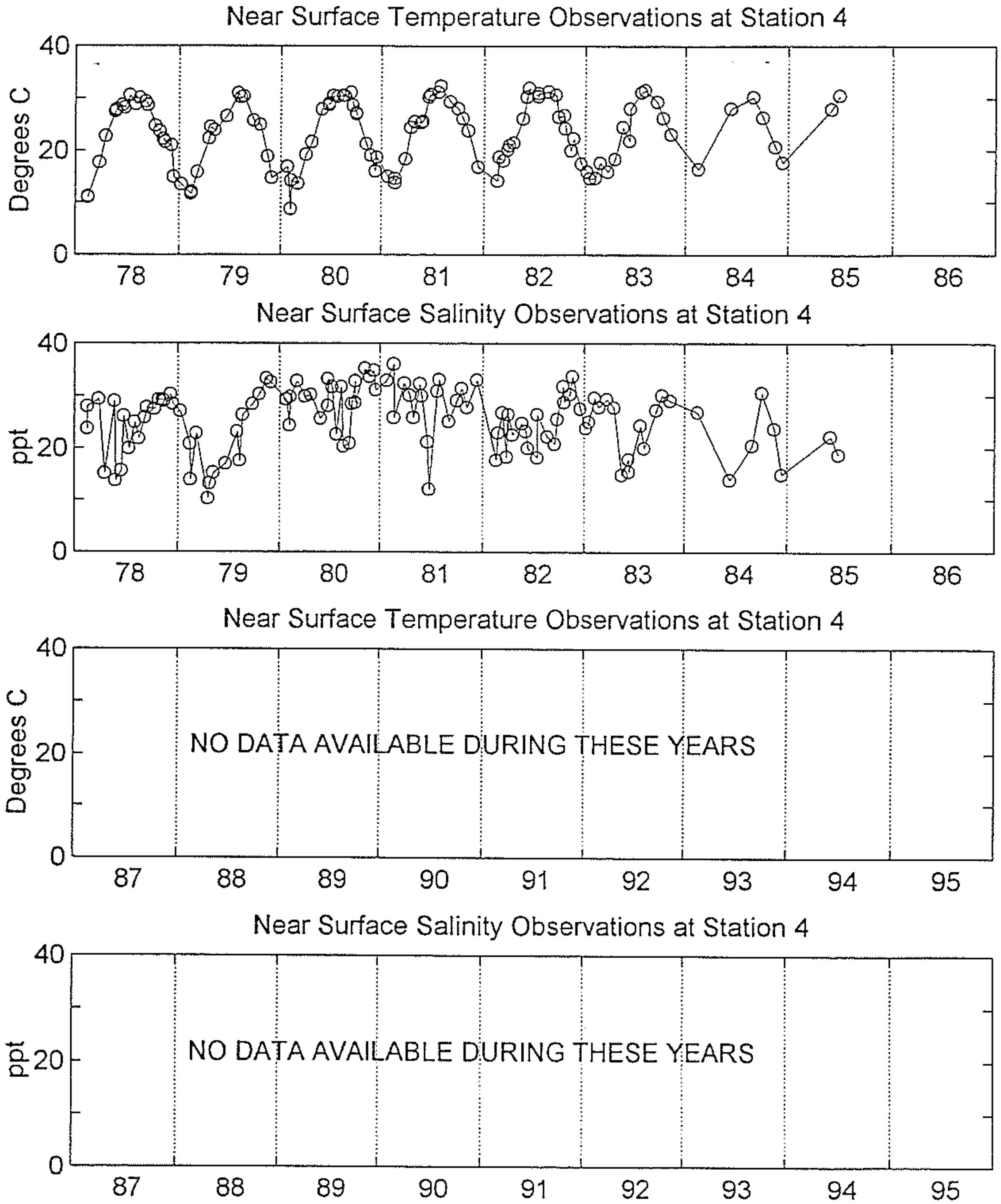

Figure B4. Station 4 monthly physical hydrography data: top temperatures and salinities.

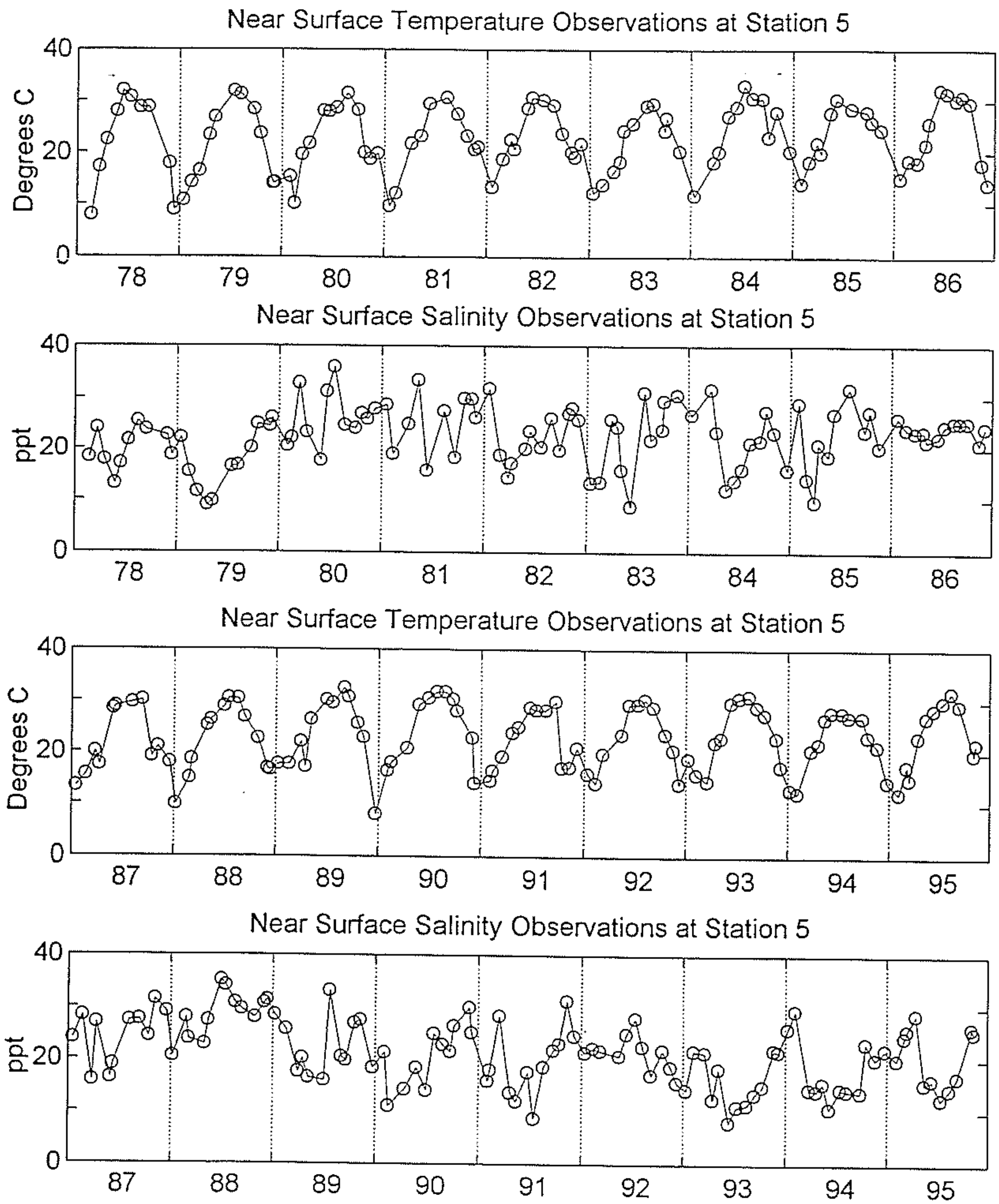

Figure B5. Station 5 monthly physical hydrography data: top temperatures and salinities.

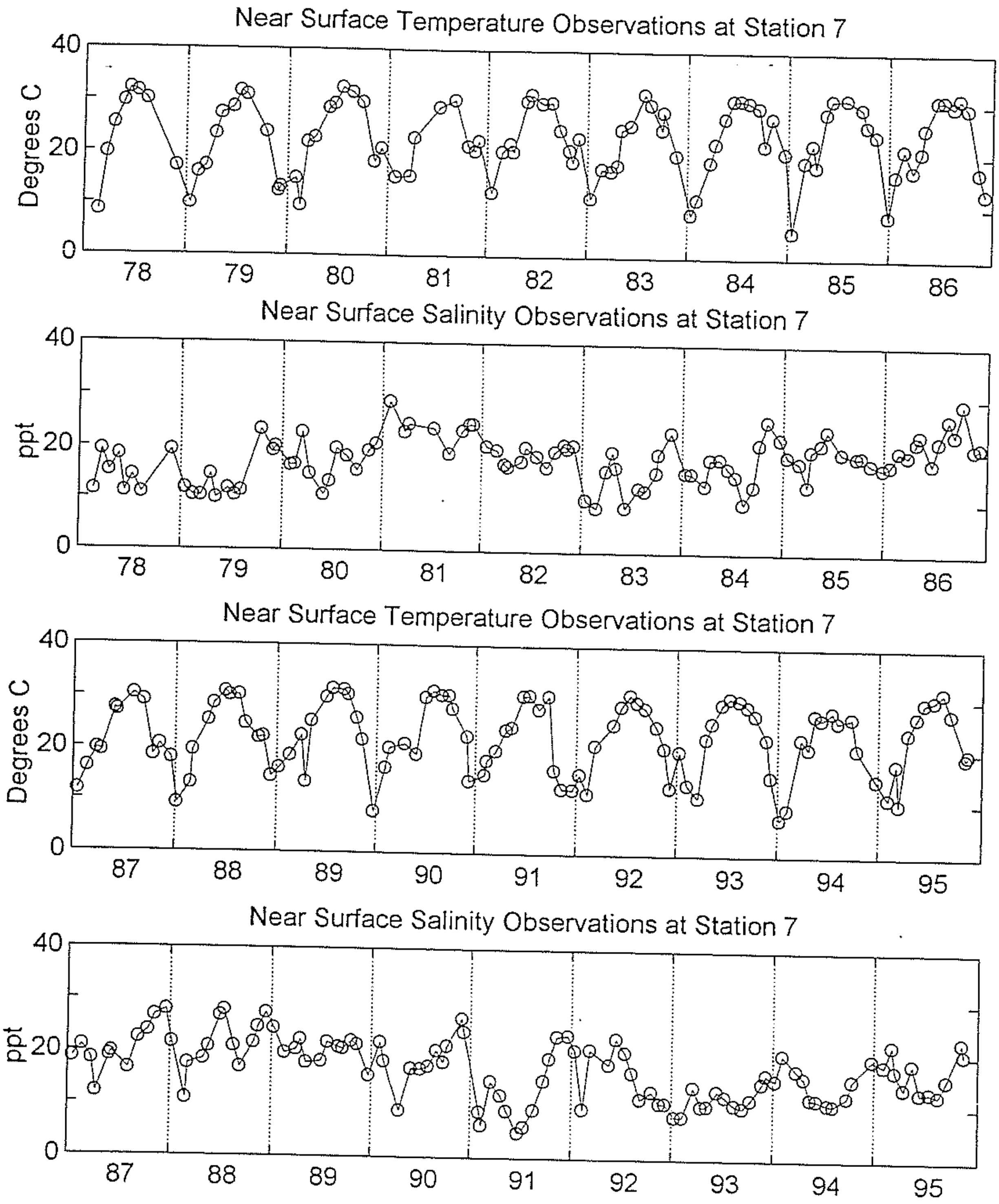

Figure B6. Station 7 monthly physical hydrography data: top temperatures and salinities.

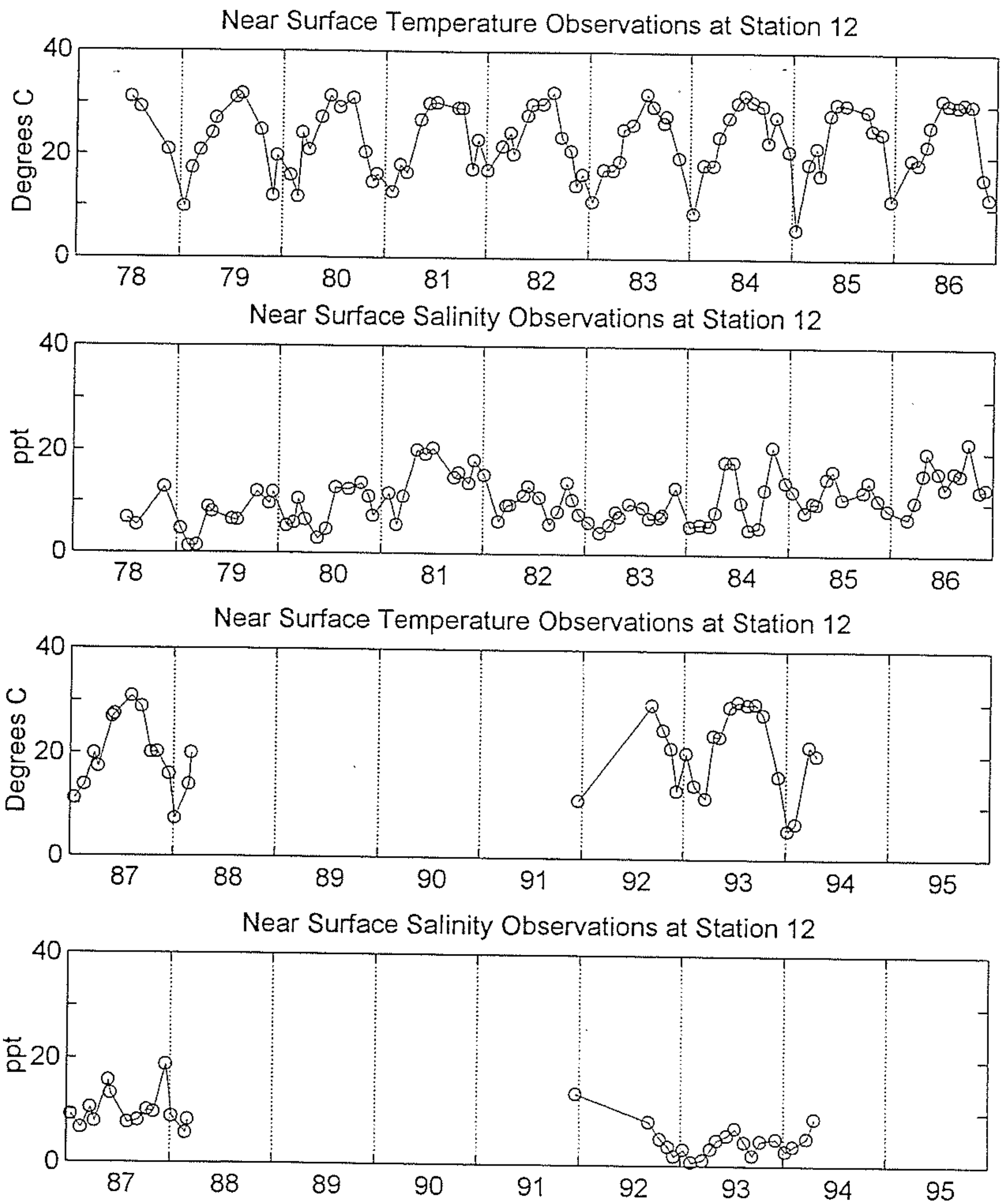

Figure B7. Station 12 monthly physical hydrography data: top temperatures and salinities.

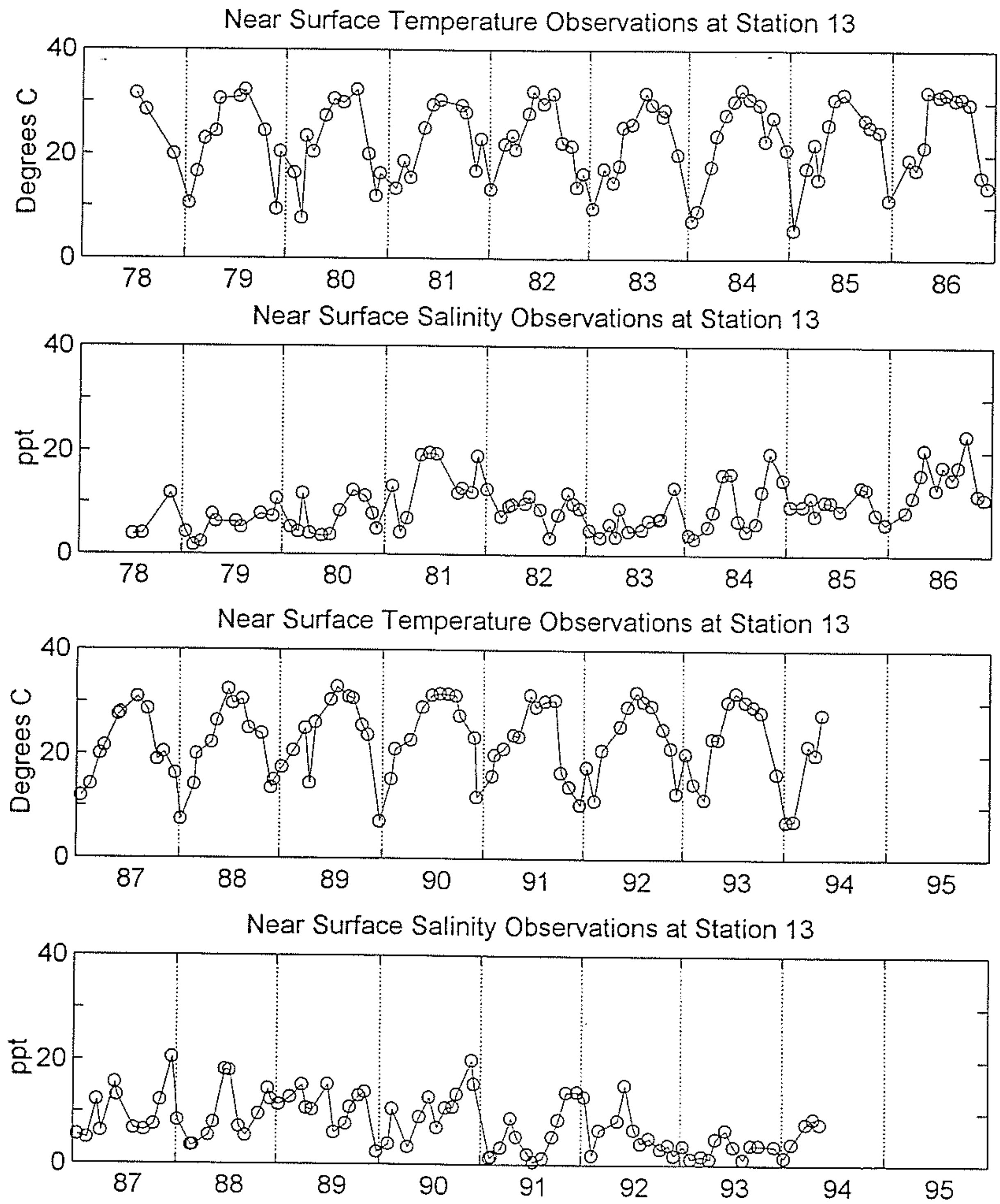

Figure B8. Station 13 monthly physical hydrography data: top temperatures and salinities.

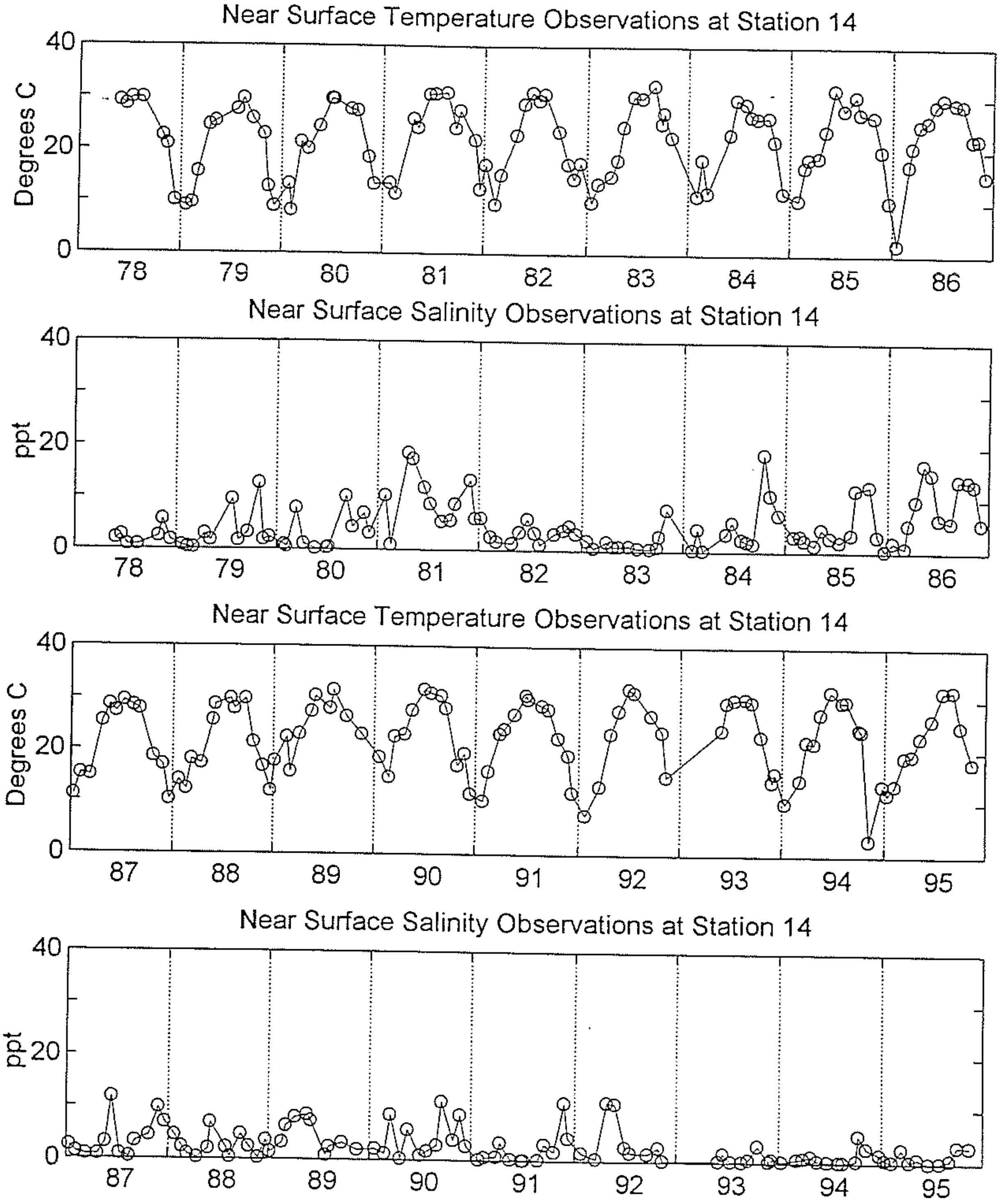

Figure B9. Station 14 monthly physical hydrography data: top temperatures and salinities.

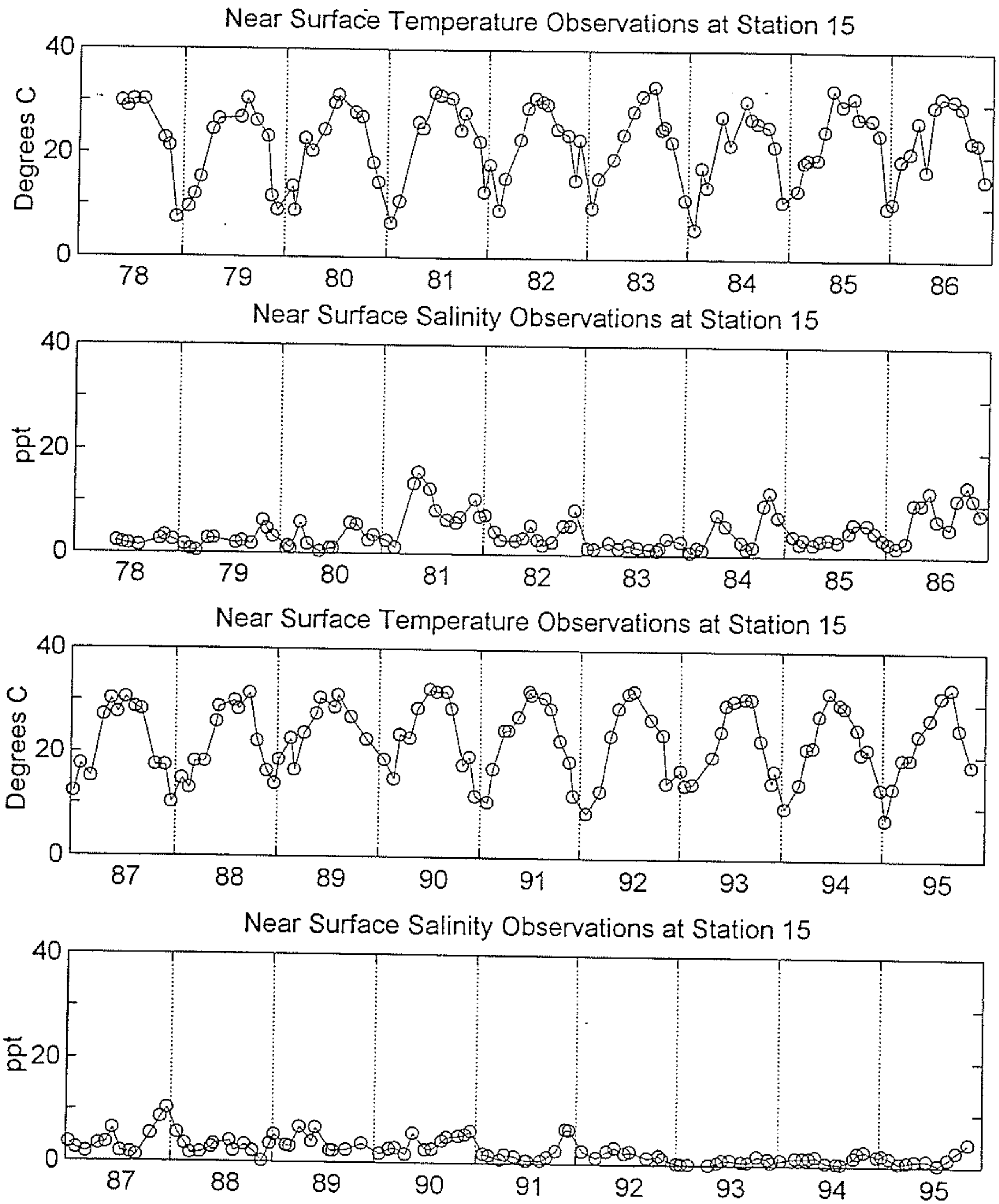

Figure B10. Station 15 monthly physical hydrography data: top temperatures and salinities.

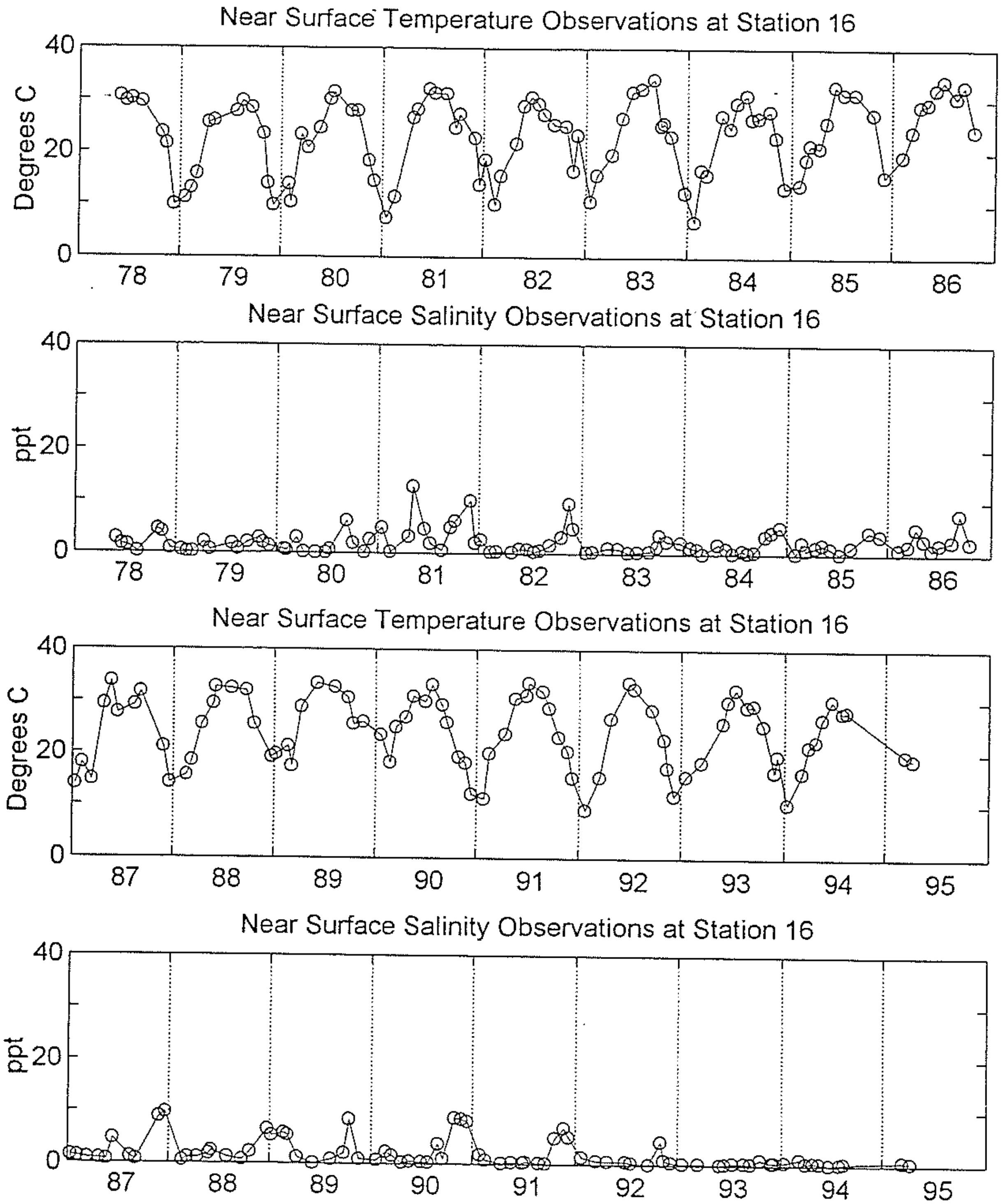

Figure B11. Station 16 monthly physical hydrography data: top temperatures and salinities.

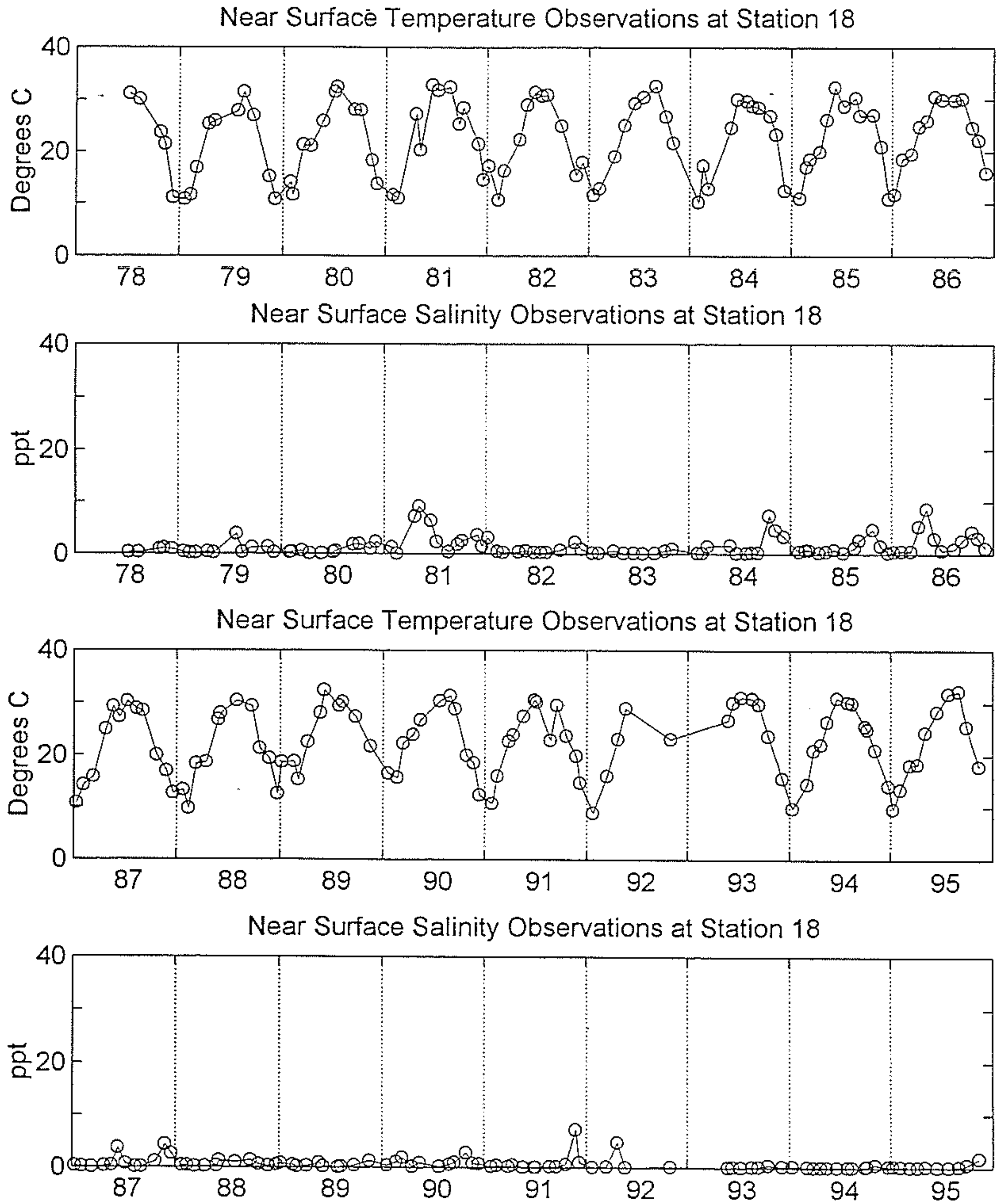

Figure B12. Station 18 monthly physical hydrography data: top temperatures and salinities.

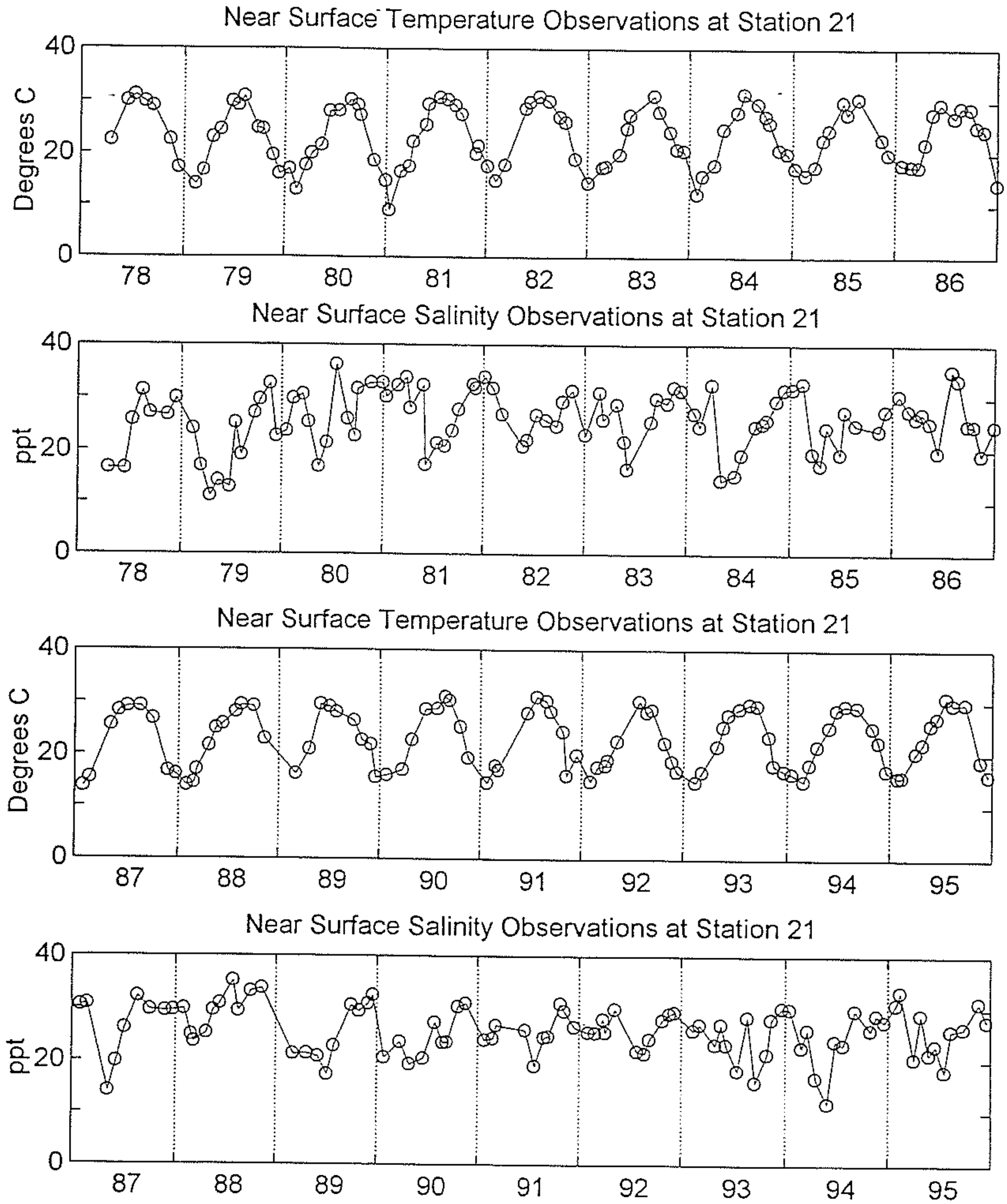

Figure B13. Station 21 monthly physical hydrography data: top temperatures and salinities.

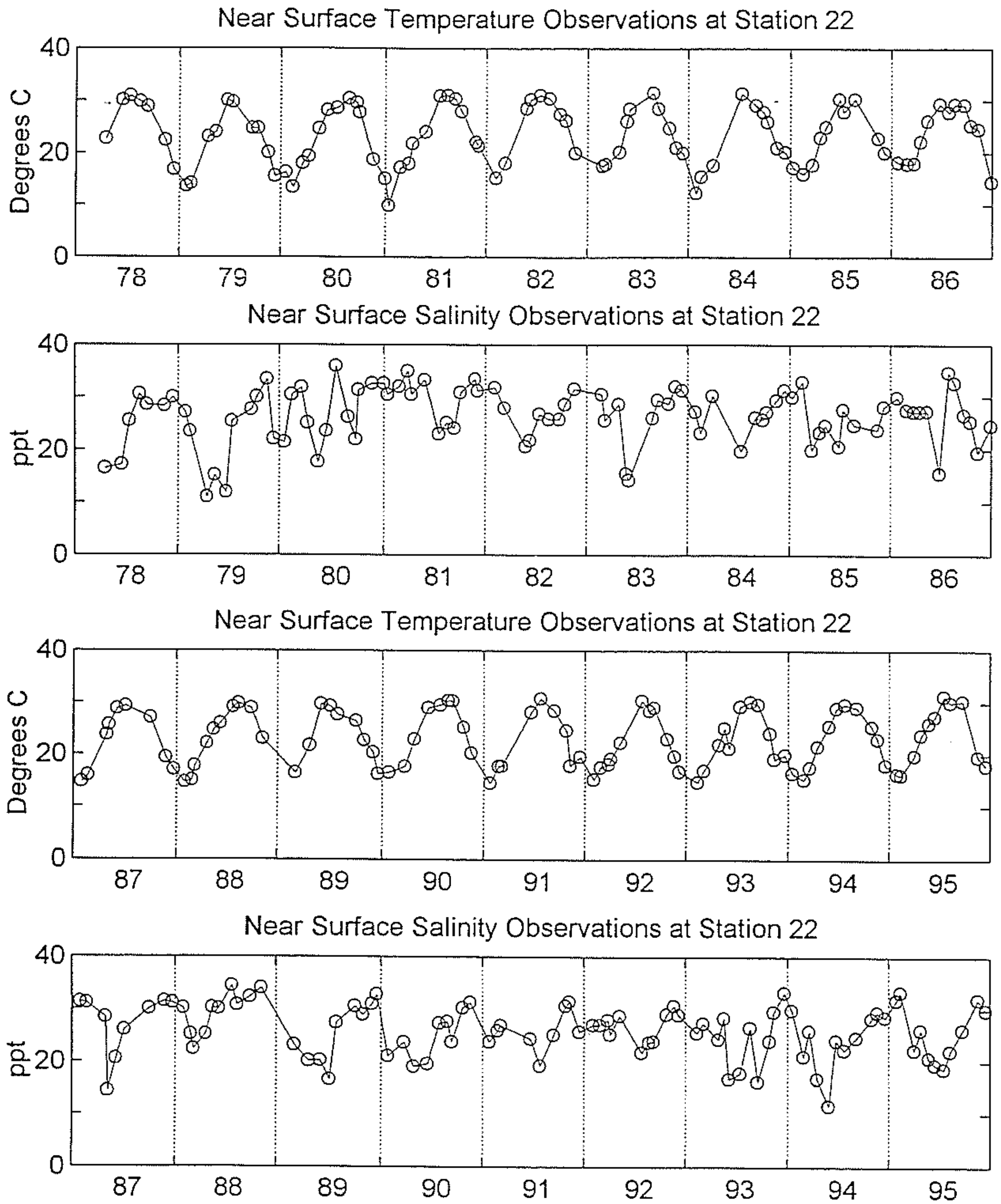

Figure B14. Station 22 monthly physical hydrography data: top temperatures and salinities.

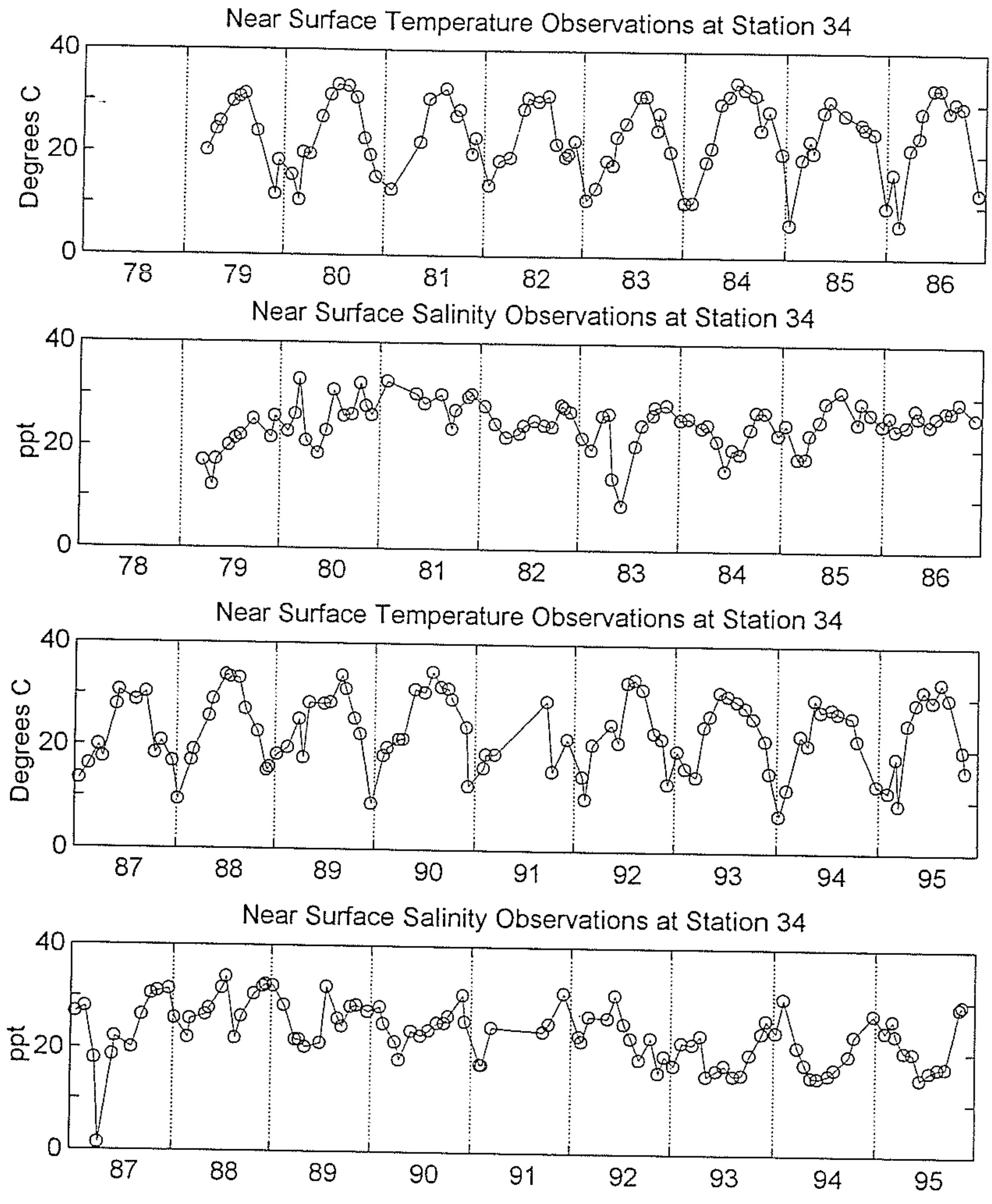

Figure B15. Station 34 monthly physical hydrography data: top temperatures and salinities.

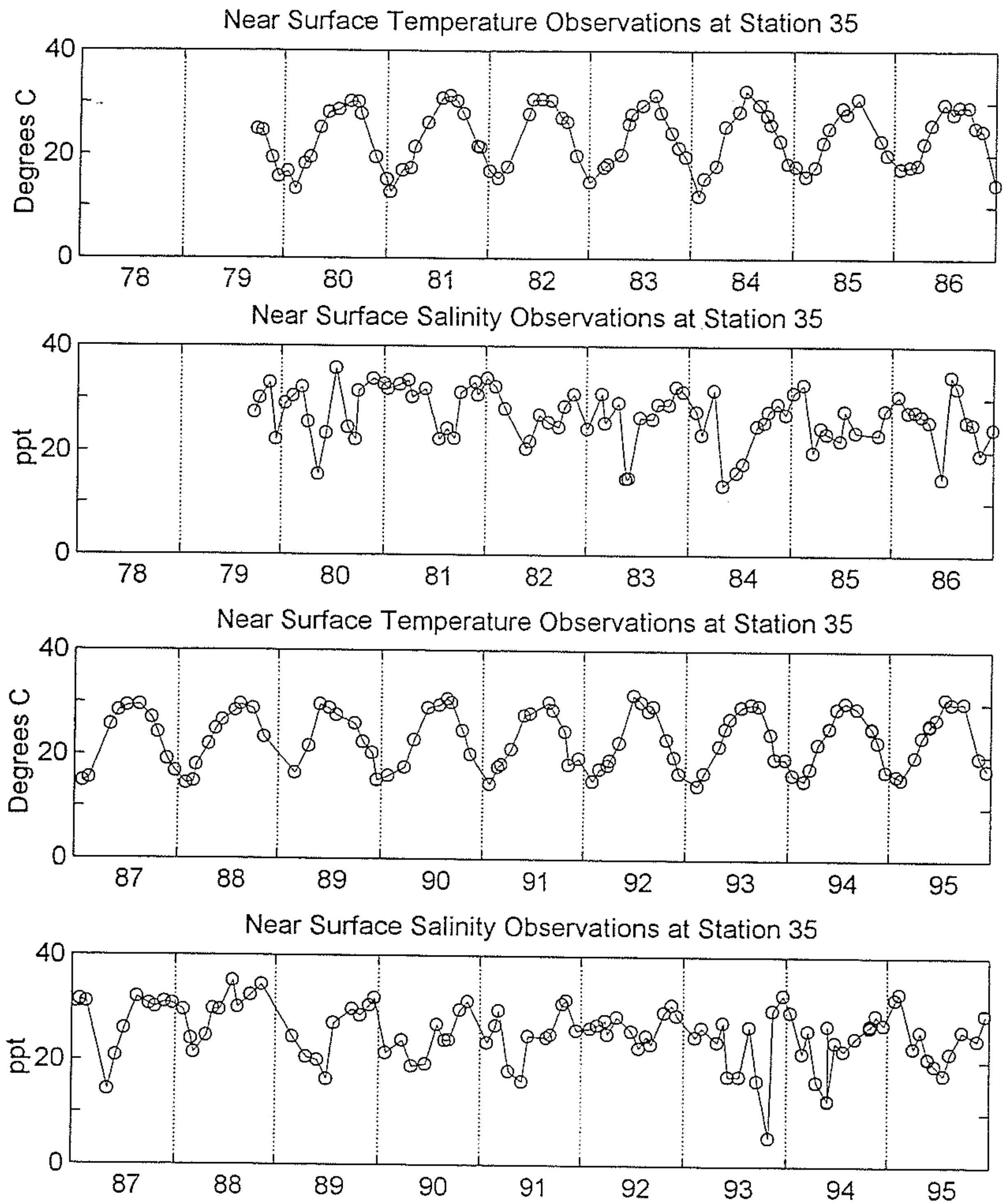

Figure B16. Station 35 monthly physical hydrography data: top temperatures and salinities.

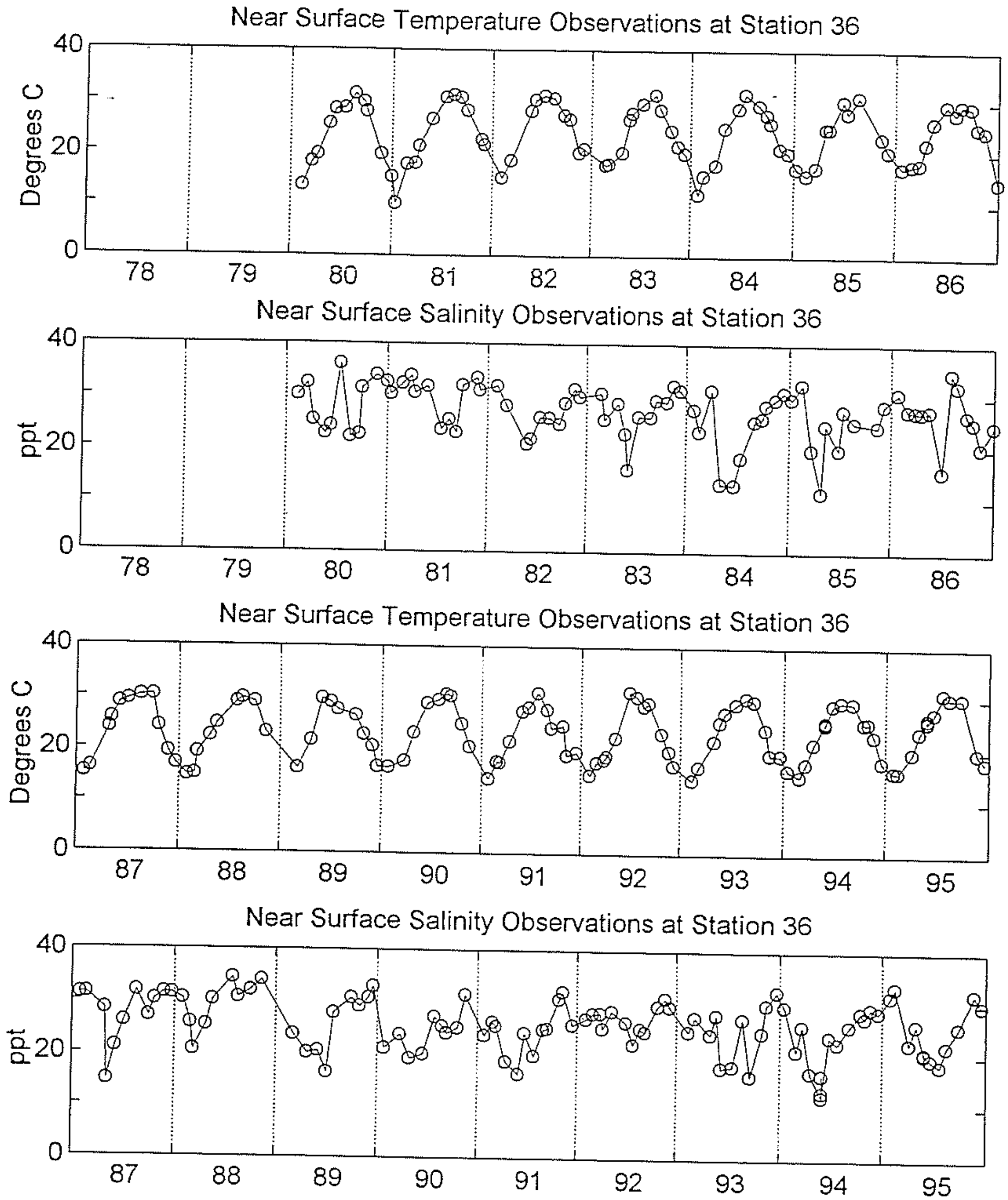

Figure B17. Station 36 monthly physical hydrography data: top temperatures and salinities.

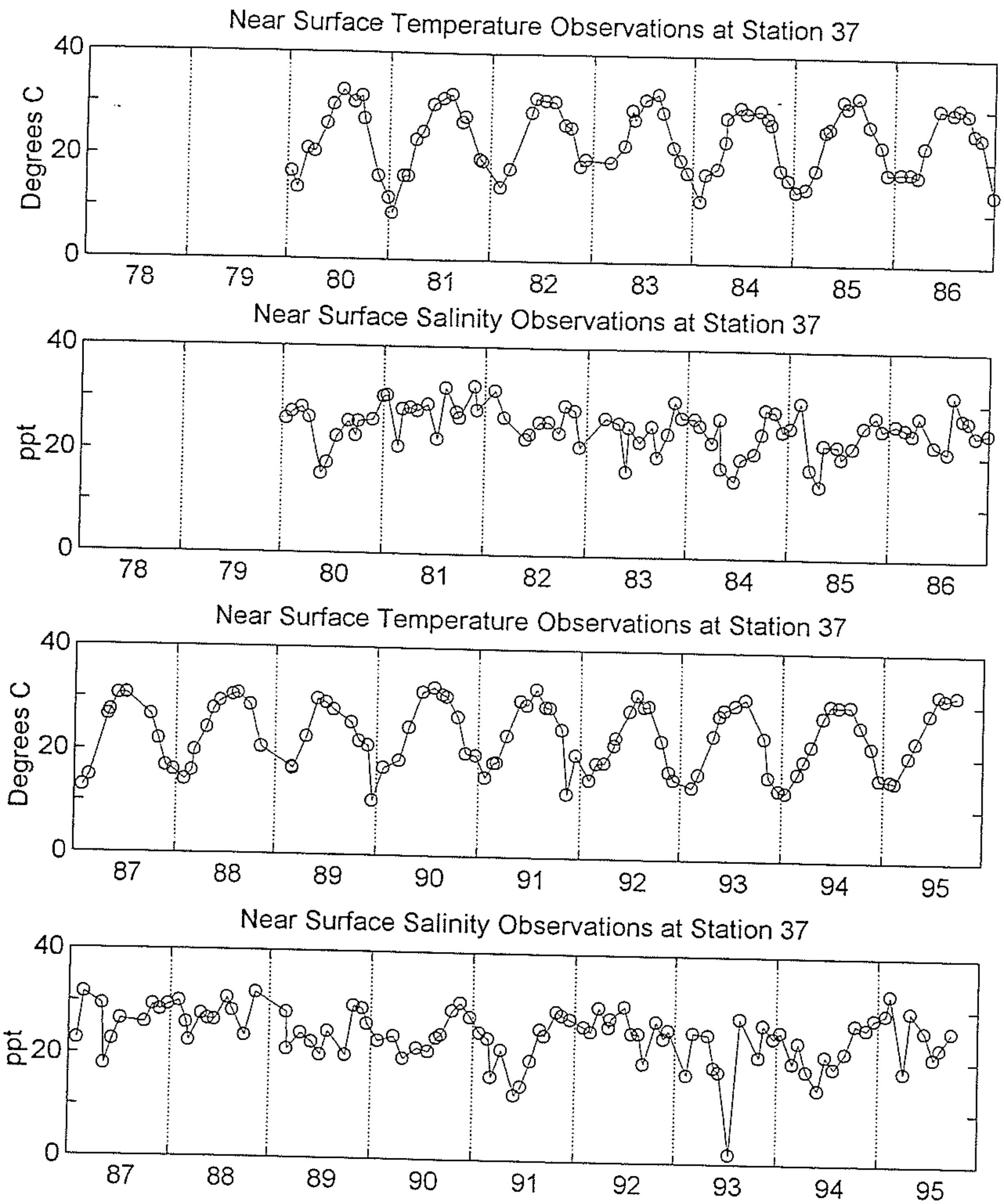

Figure B18. Station 37 monthly physical hydrography data: top temperatures and salinities.

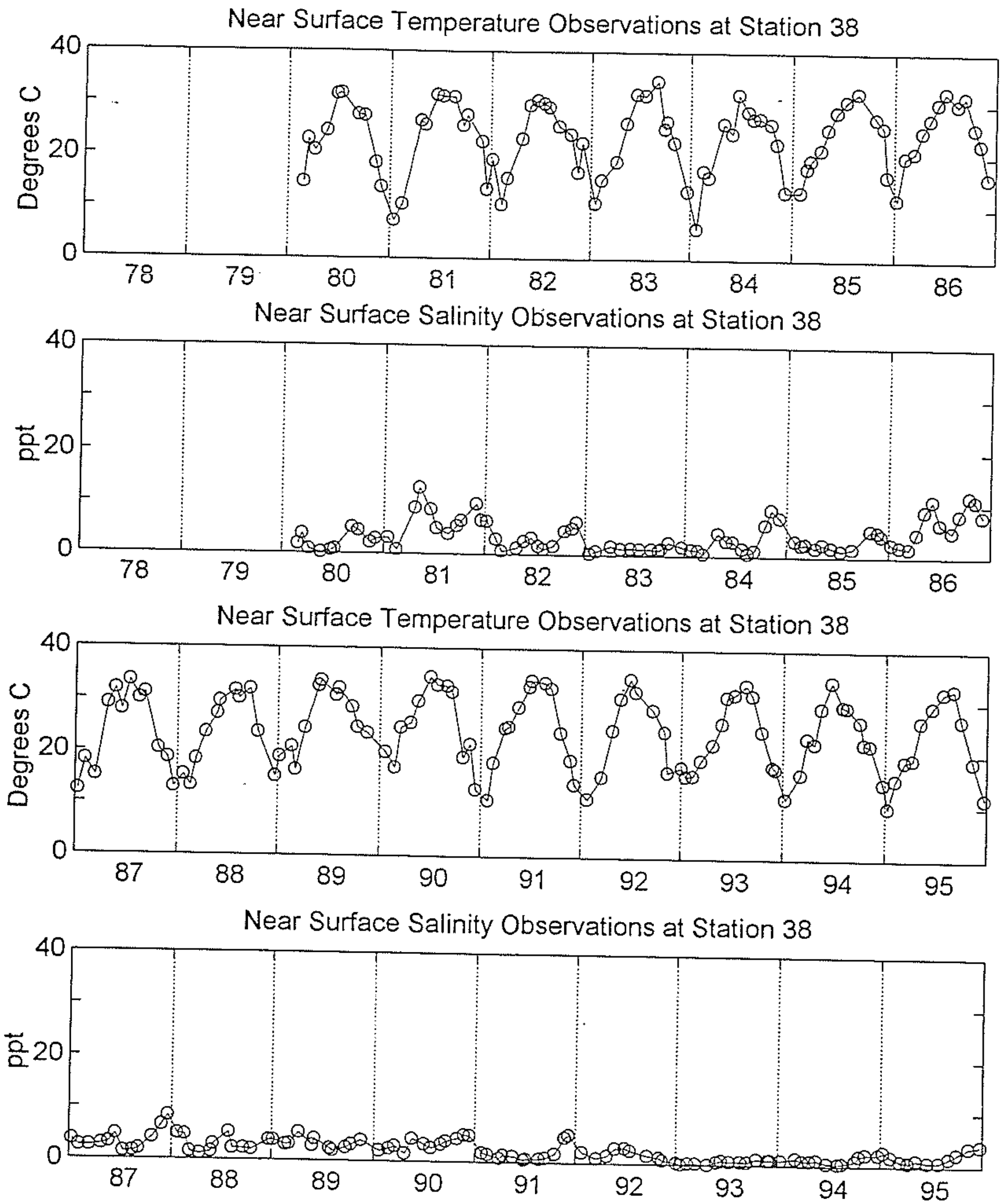

Figure B19. Station 38 monthly physical hydrography data: top temperatures and salinities.

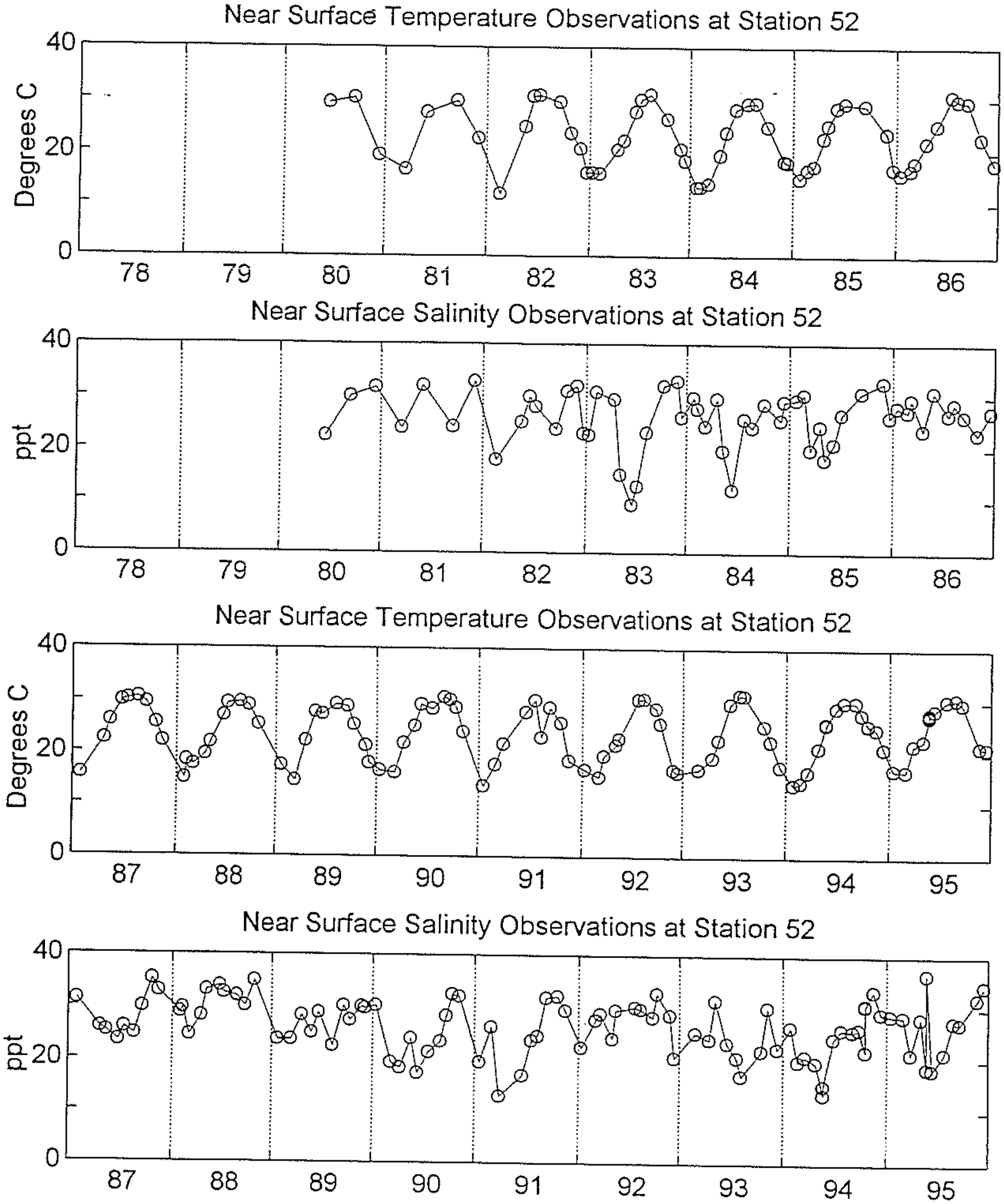

Figure B20. Station 52 monthly physical hydrography data: top temperatures and salinities.

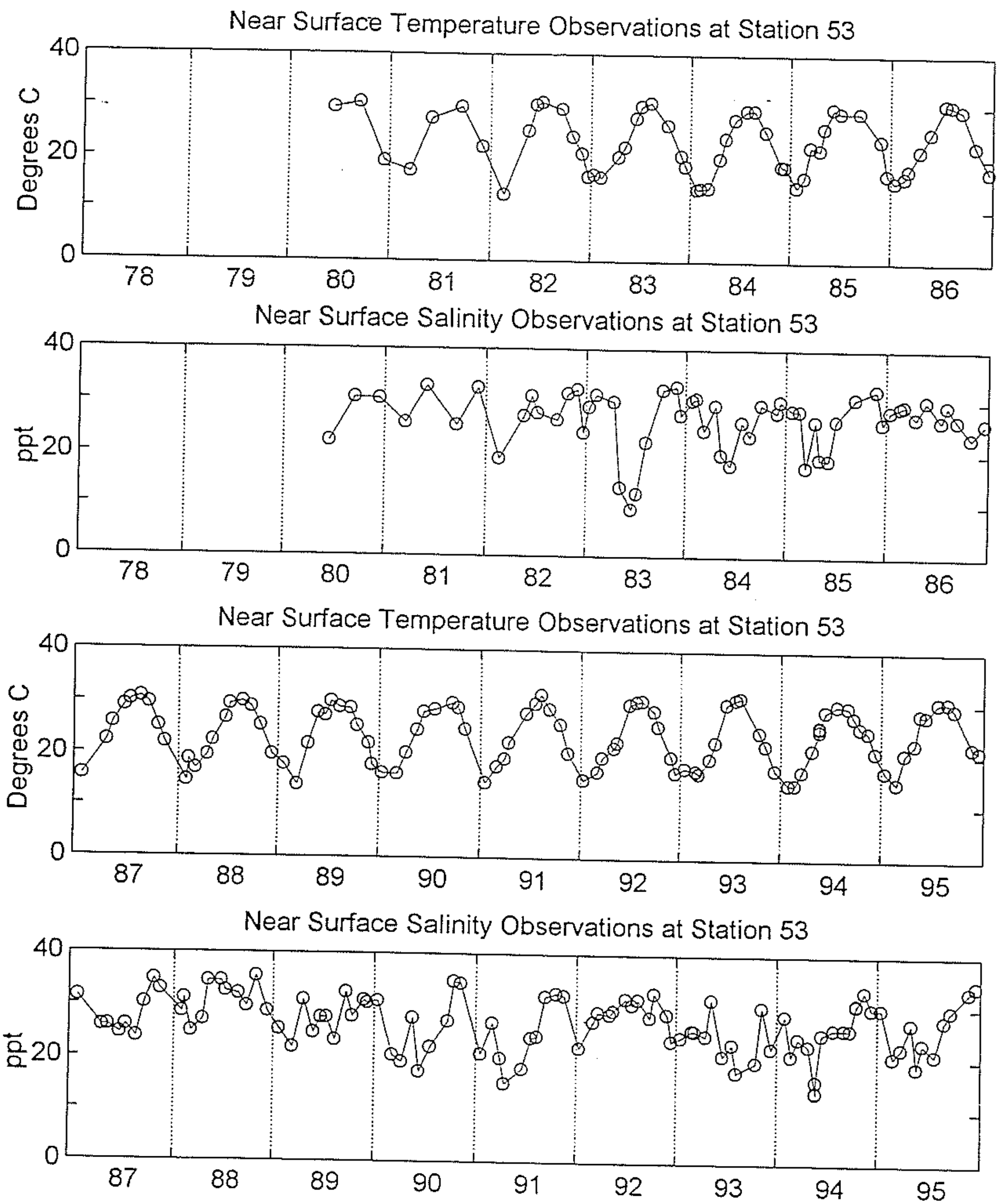

Figure B21. Station 53 monthly physical hydrography data: top temperatures and salinities.

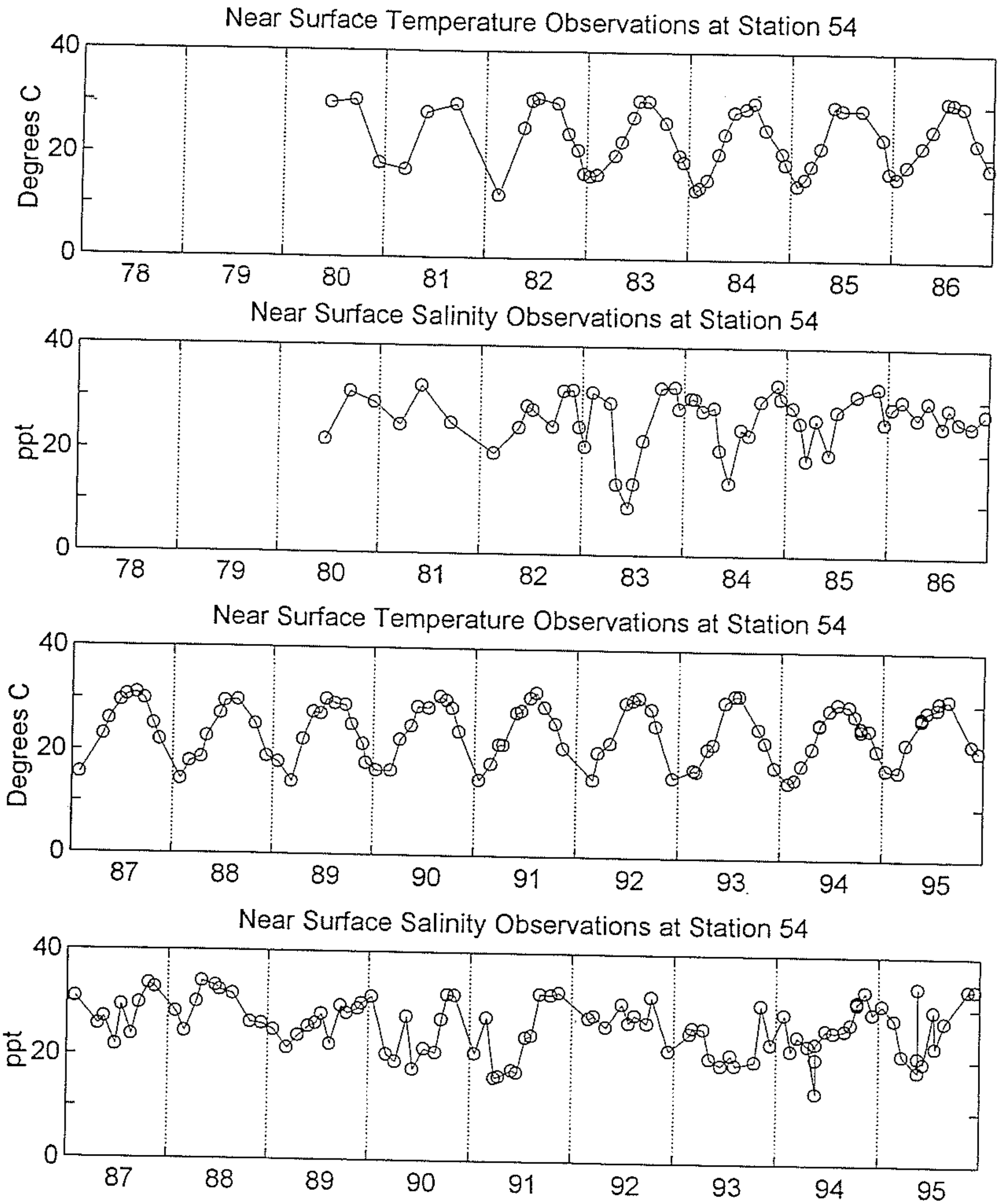

Figure B22. Station 54 monthly physical hydrography data: top temperatures and salinities.

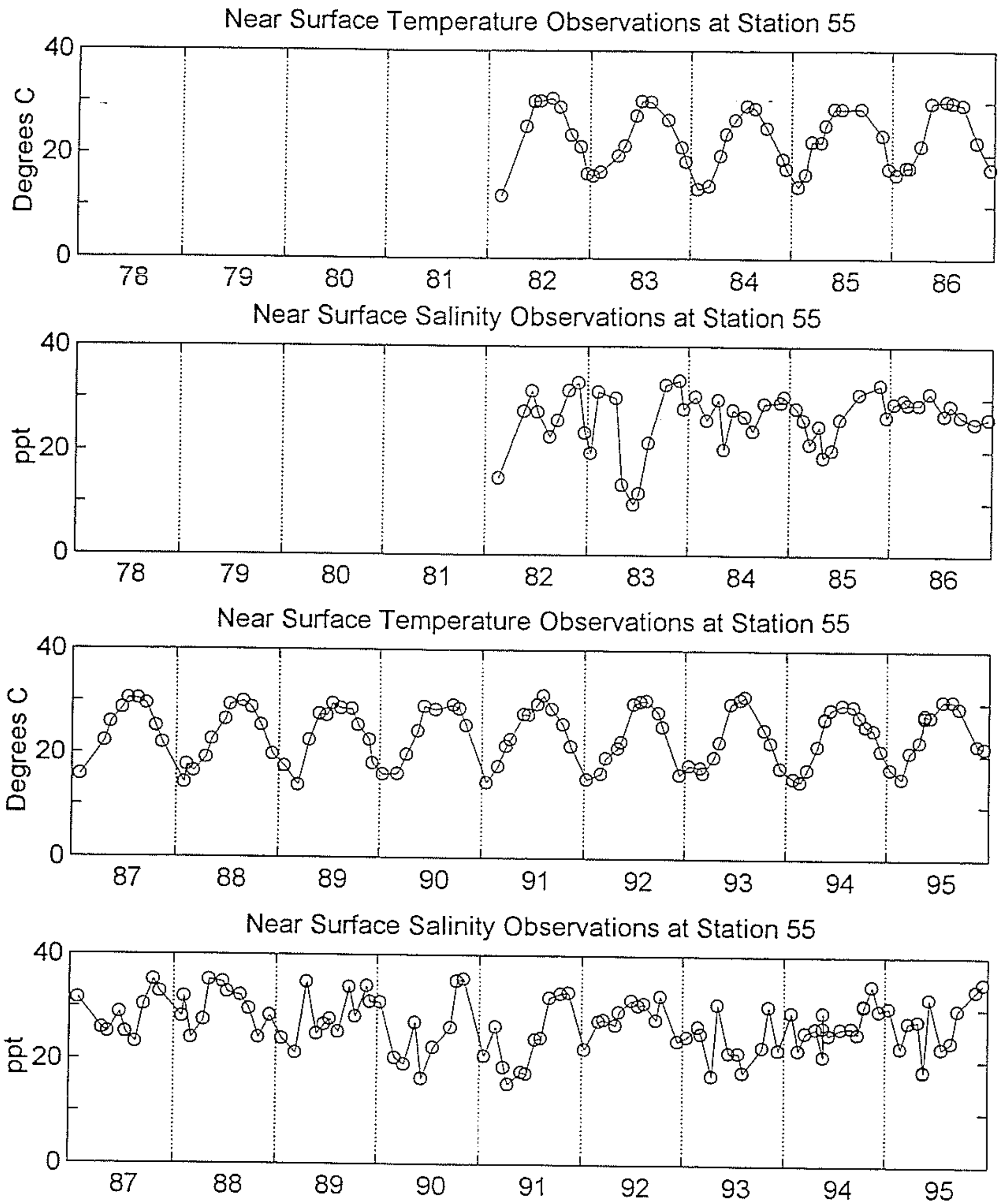

Figure B23. Station 55 monthly physical hydrography data: top temperatures and salinities.

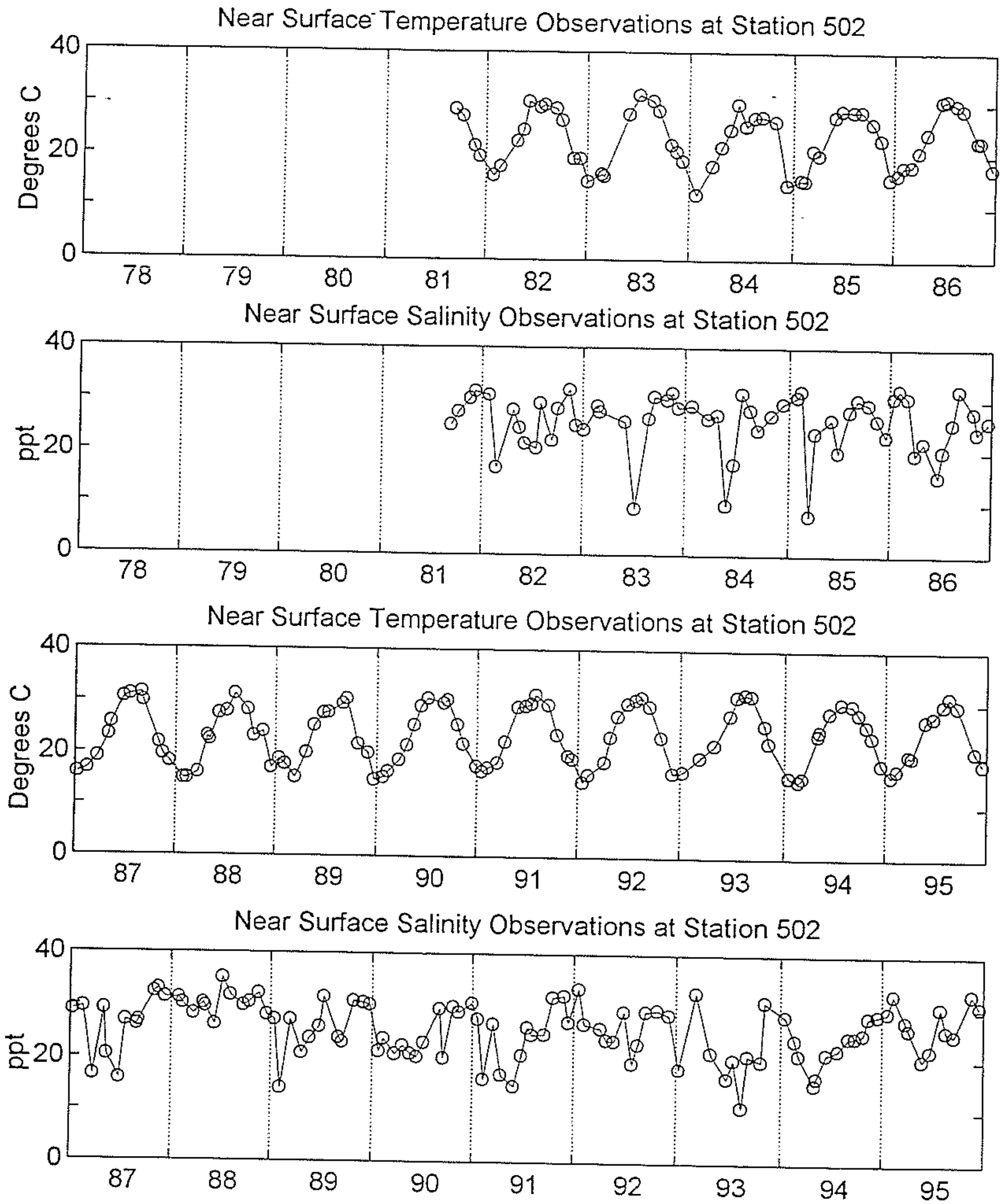

Figure B24. Station 502 monthly physical hydrography data: top temperatures and salinities.

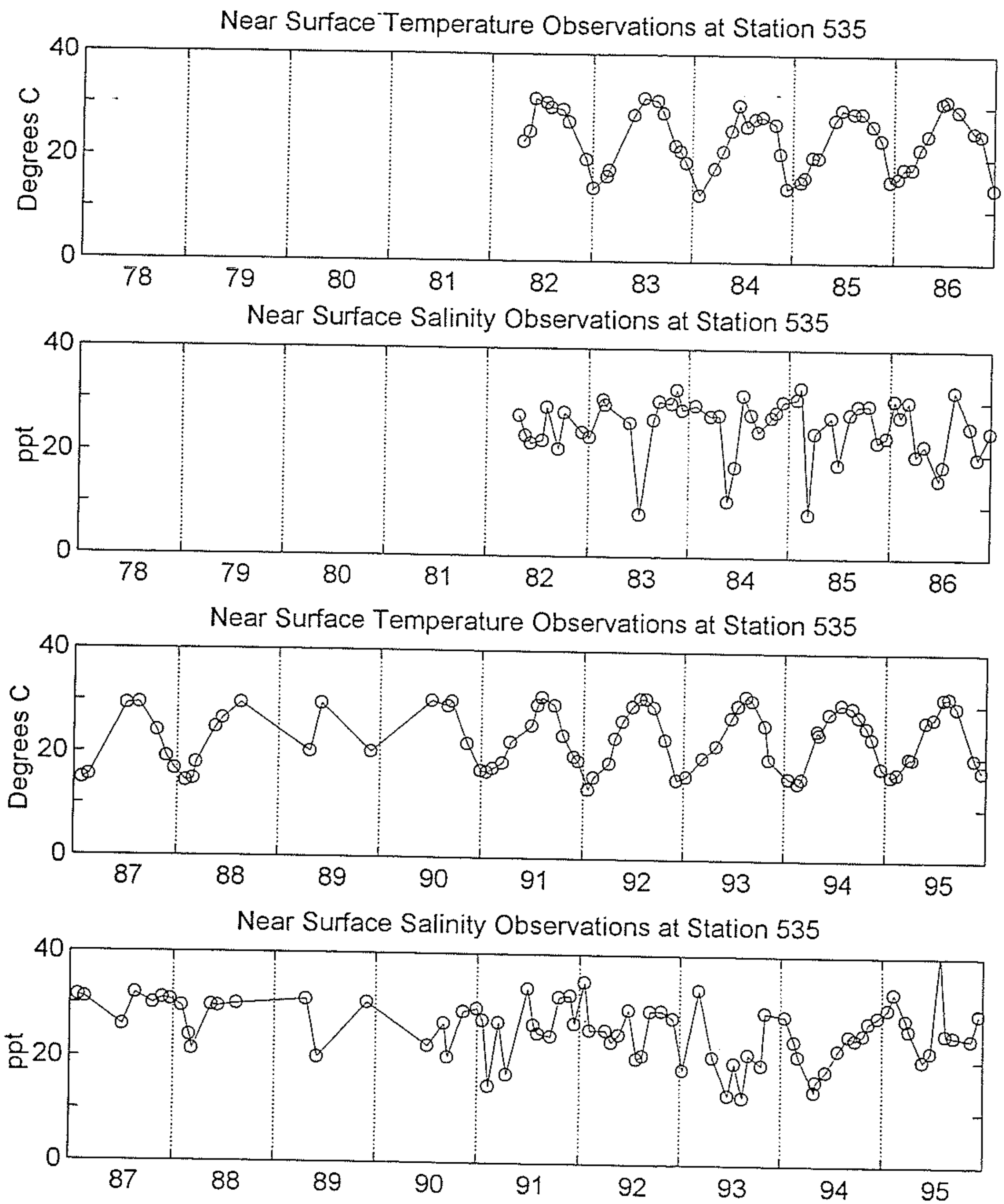

Figure B25. Station 535 monthly physical hydrography data: top temperatures and salinities.

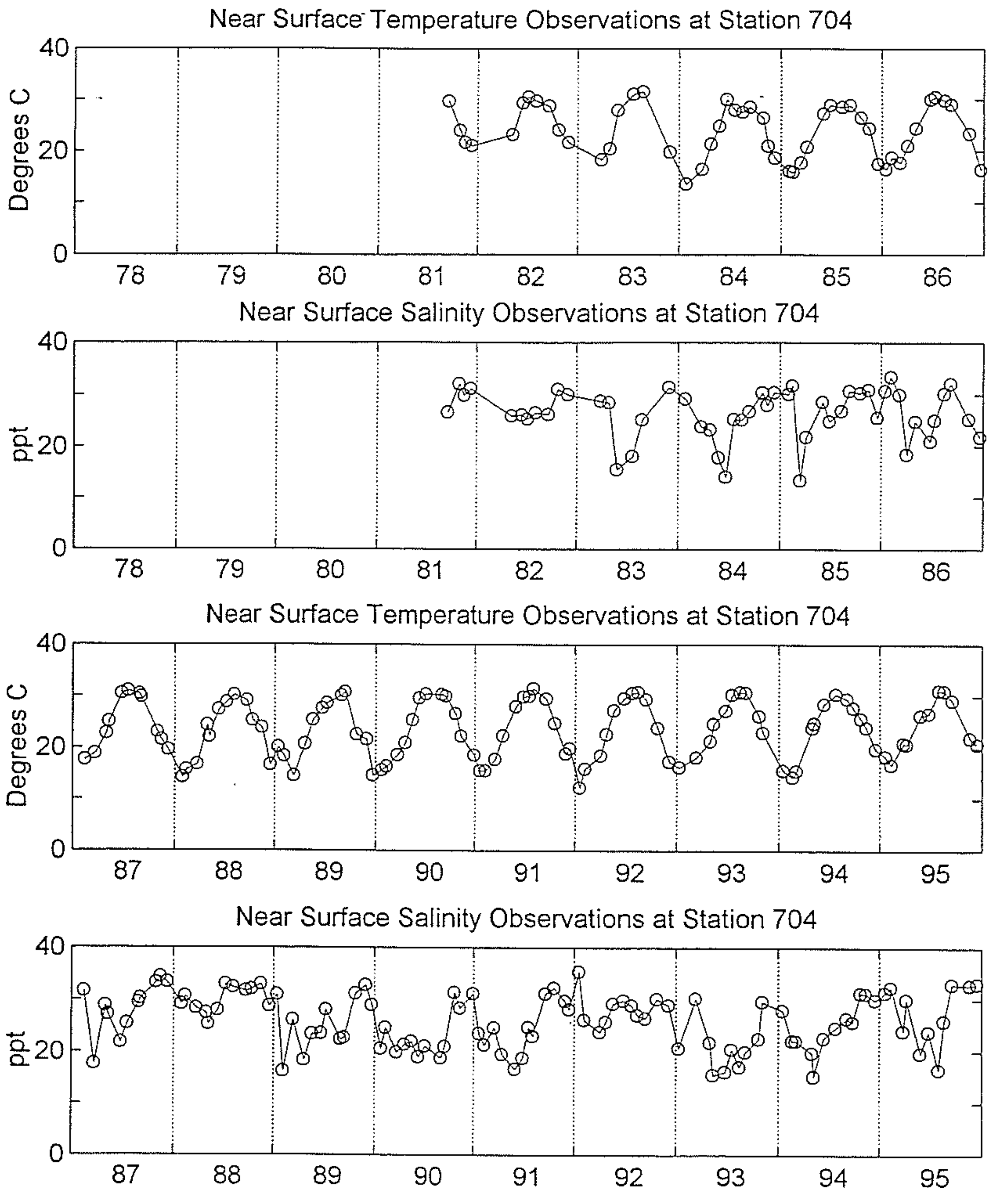

Figure B26. Station 704 monthly physical hydrography data: top temperatures and salinities.

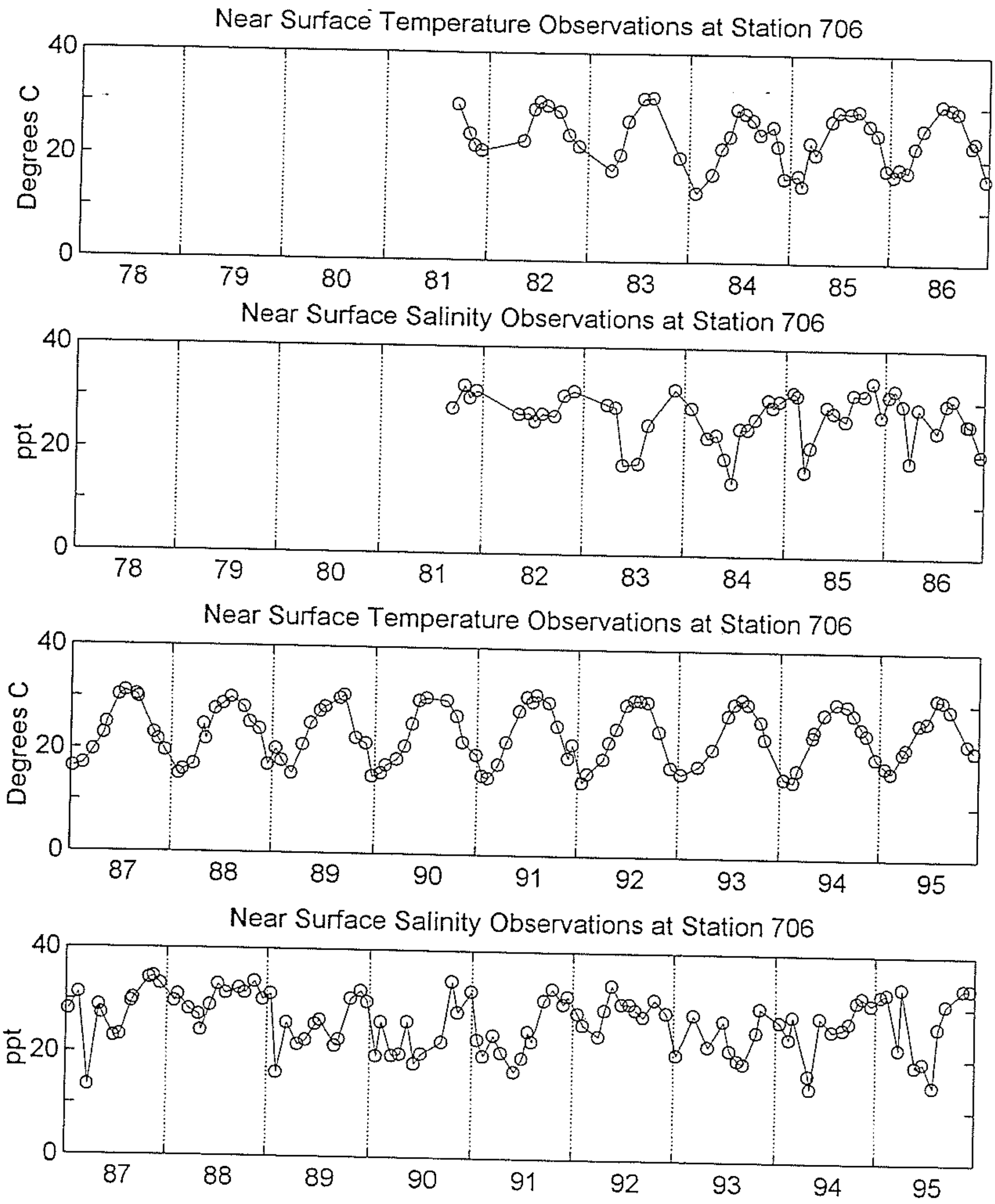

Figure B27. Station 706 monthly physical hydrography data: top temperatures and salinities.

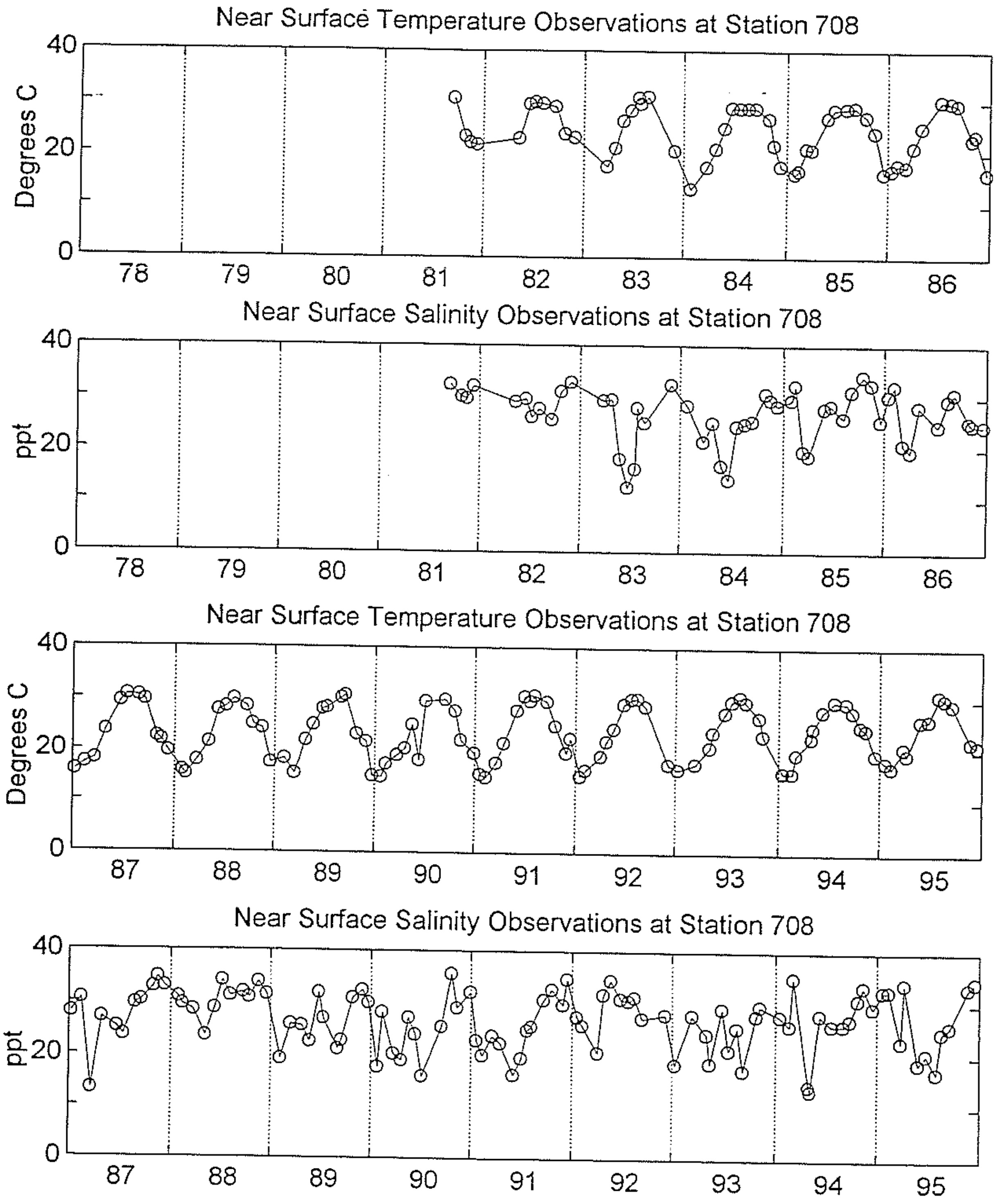

Figure B28. Station 708 monthly physical hydrography data: top temperatures and salinities.

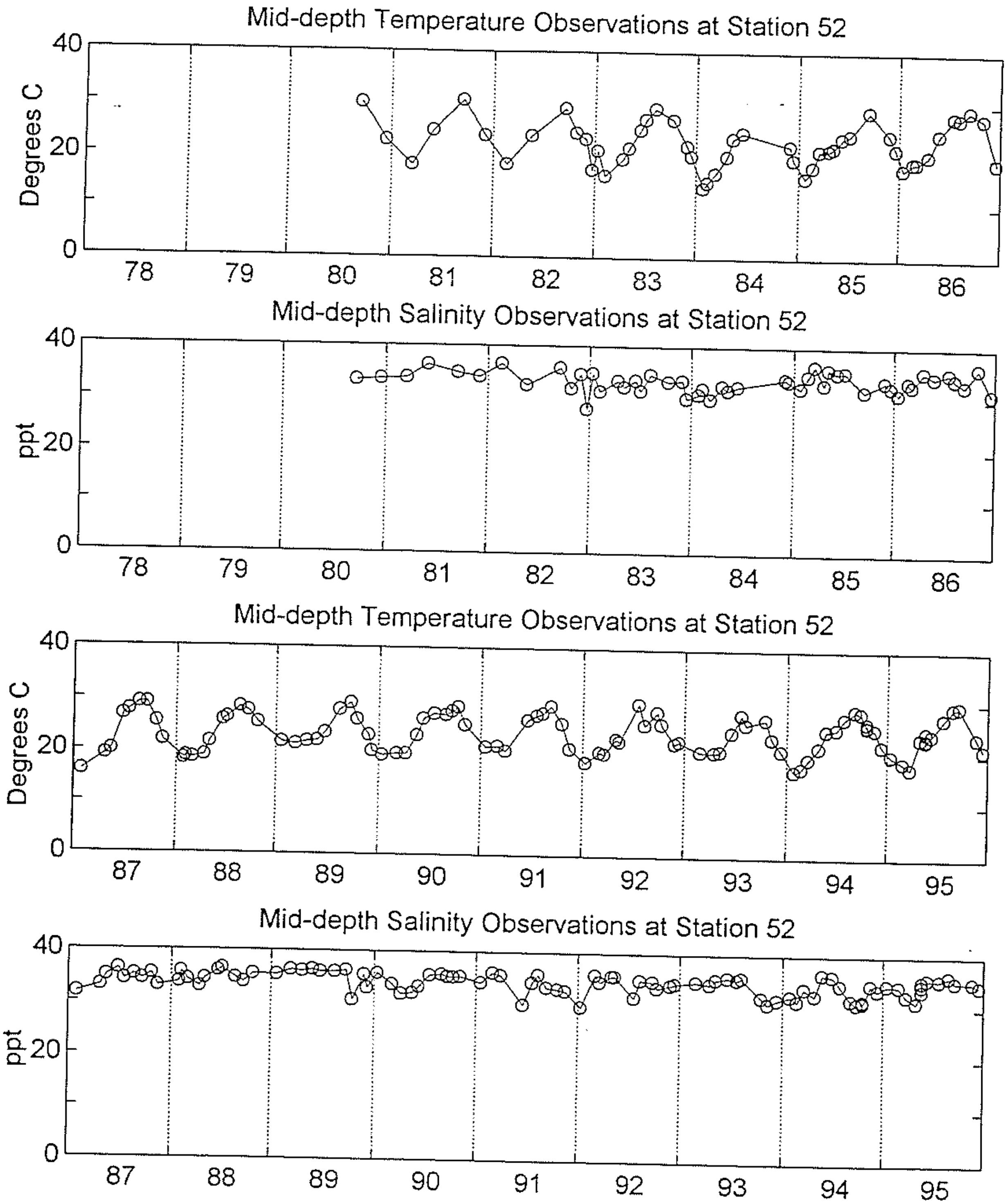

Figure B29. Station 52 monthly physical hydrography data: middle temperatures and salinities.

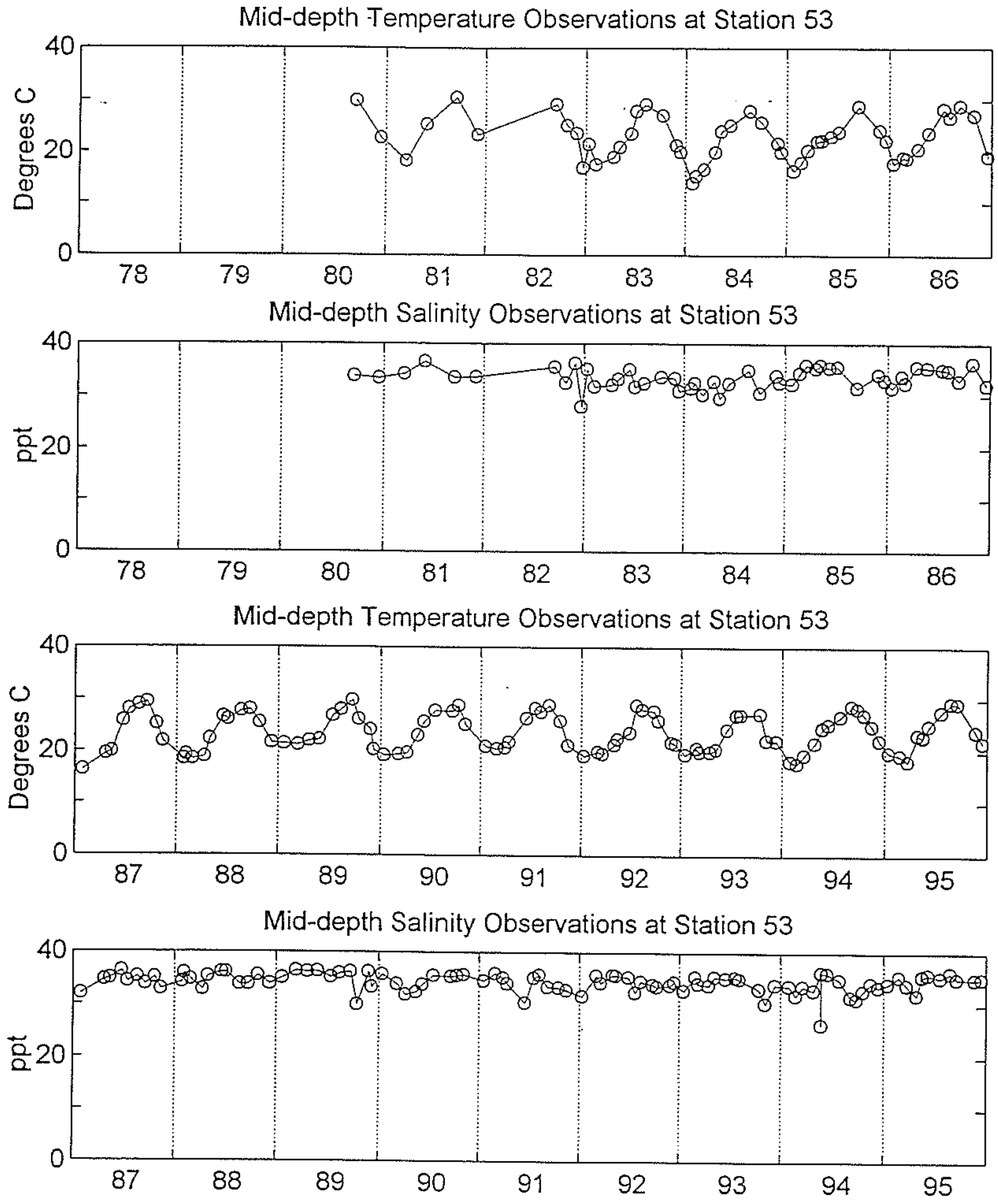

Figure B30. Station 53 monthly physical hydrography data: middle temperatures and salinities.

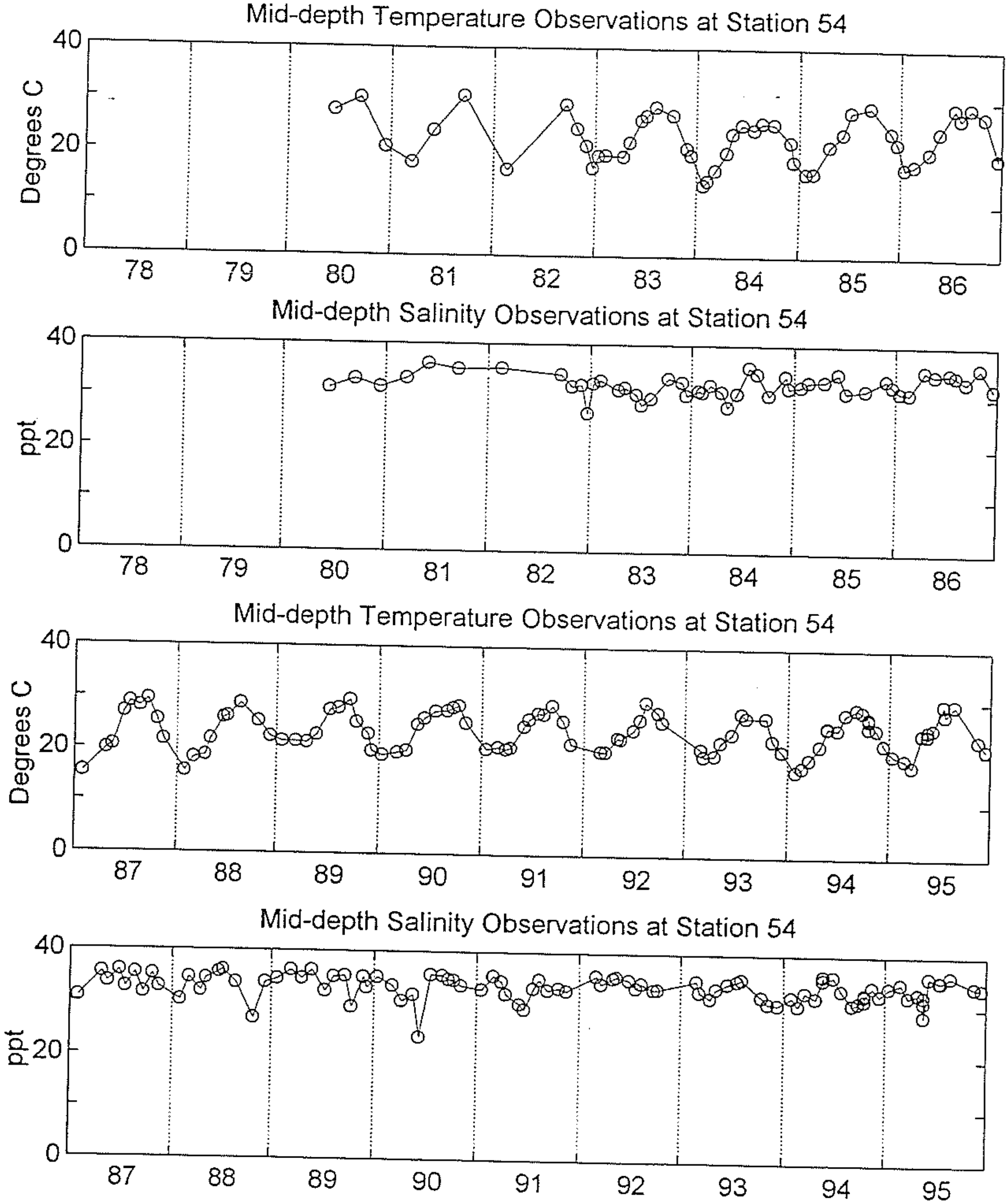

Figure B31. Station 54 monthly physical hydrography data: middle temperatures and salinities.

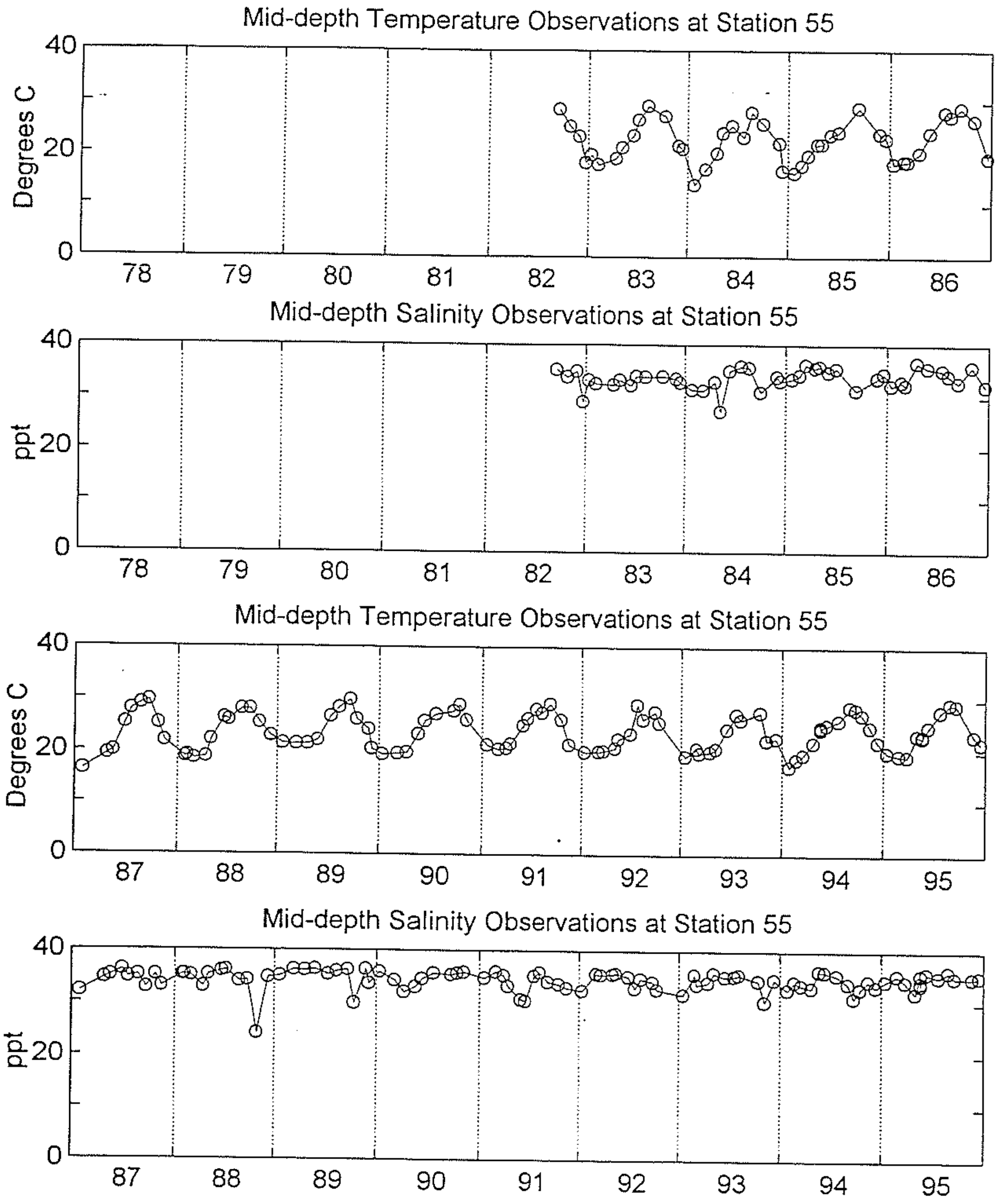

Figure B32. Station 55 monthly physical hydrography data: middle temperatures and salinities.

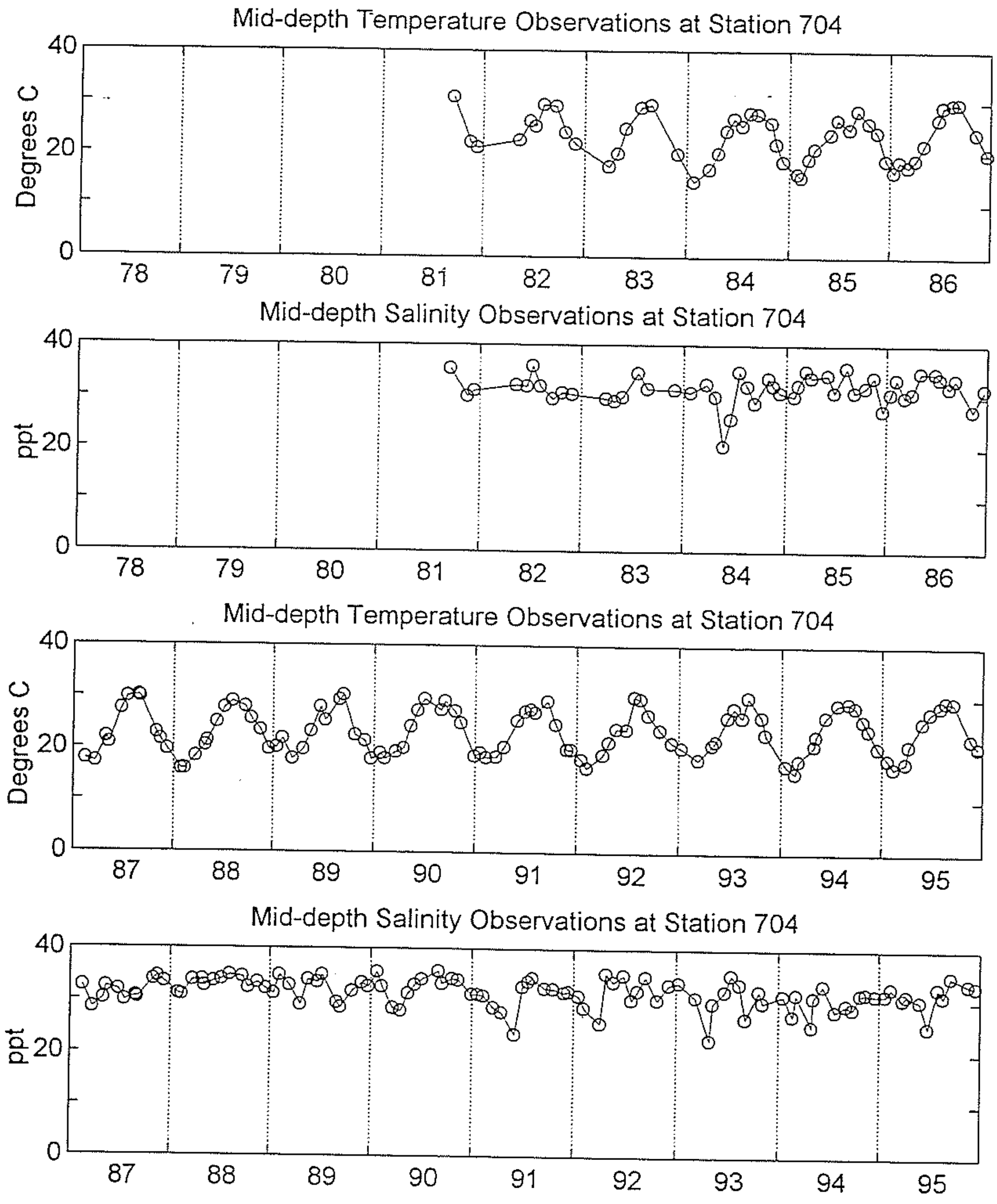

Figure B33. Station 704 monthly physical hydrography data: middle temperatures and salinities.

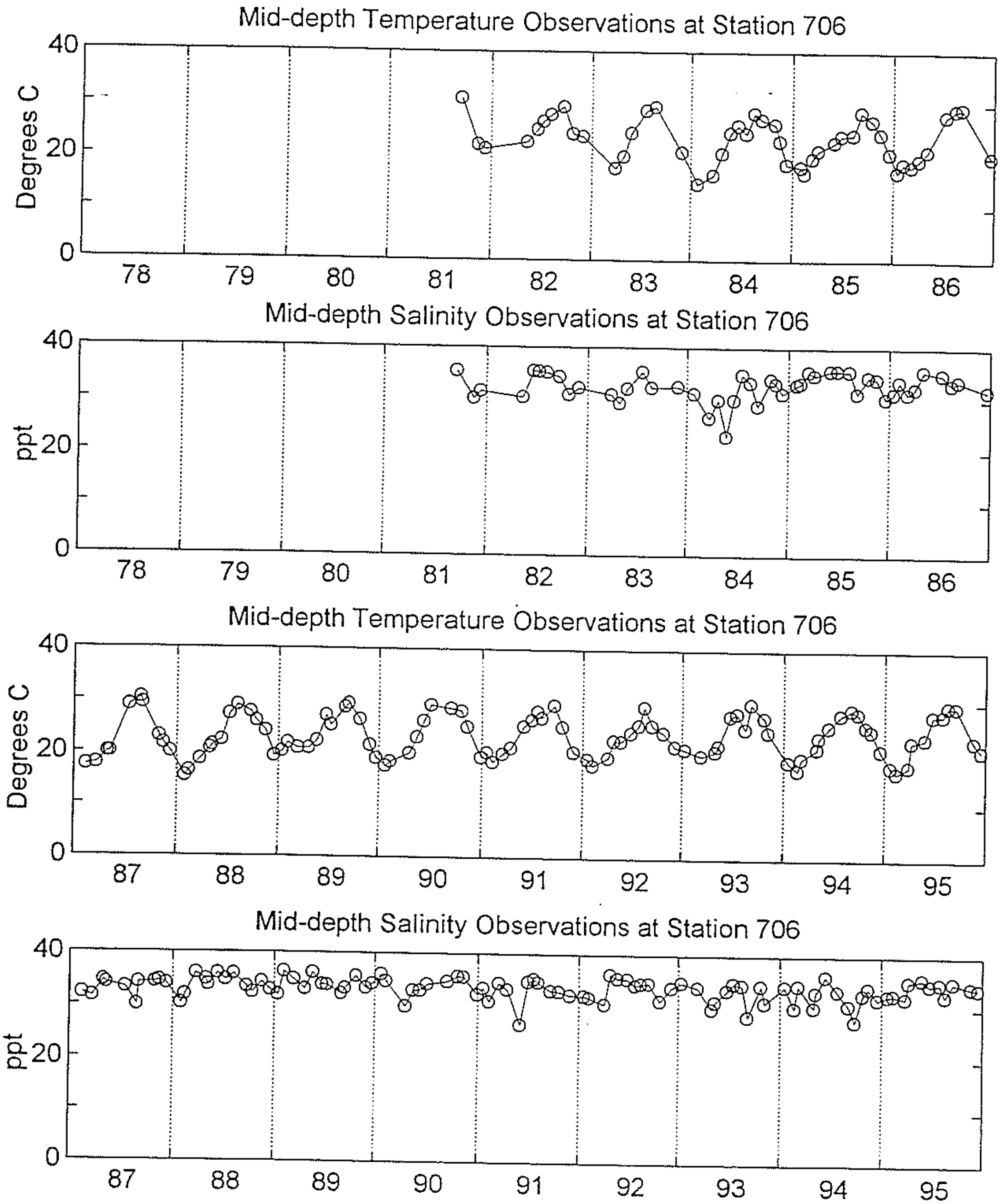

Figure B34. Station 706 monthly physical hydrography data: middle temperatures and salinities.

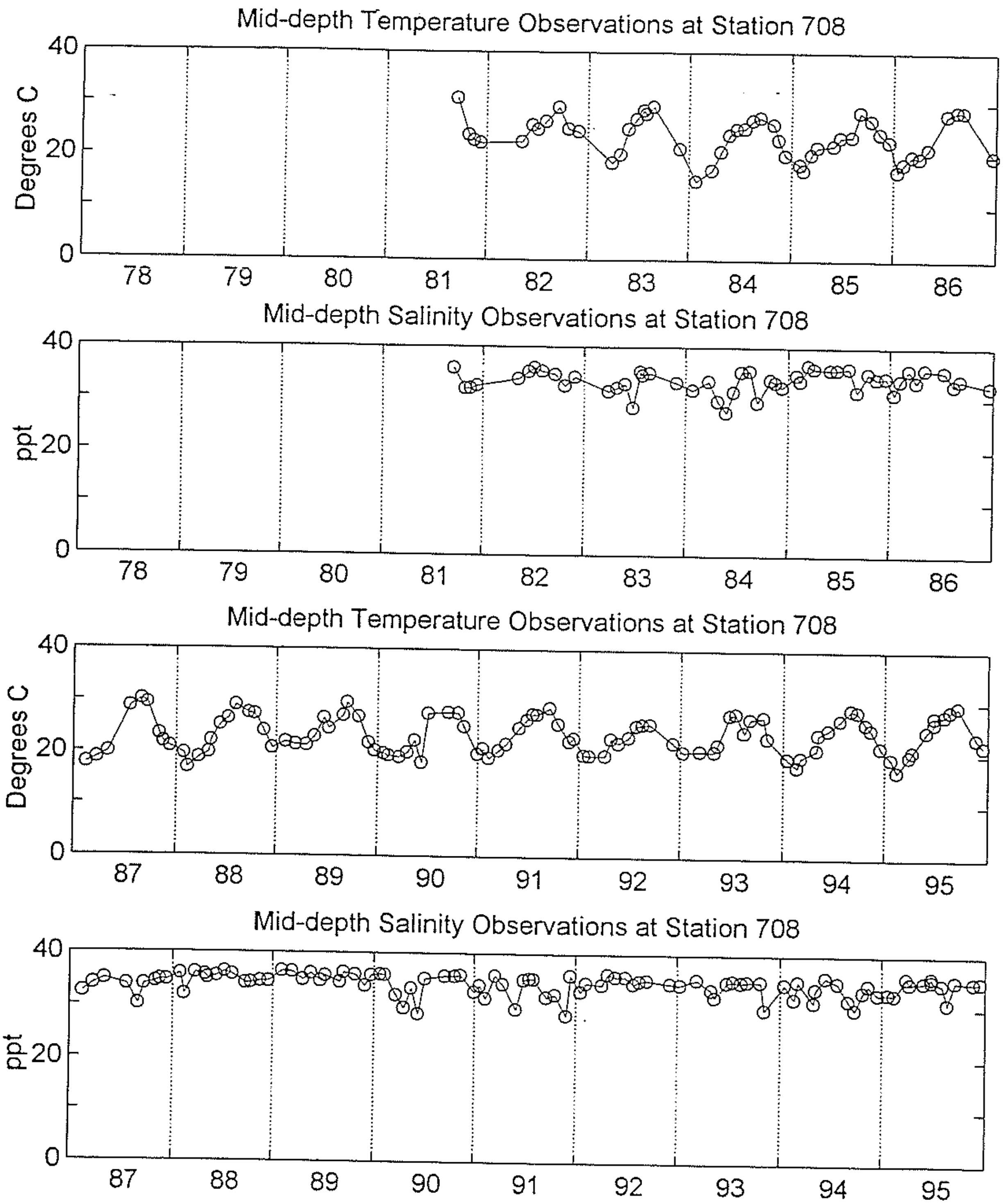

Figure B35. Station 708 monthly physical hydrography data: middle temperatures and salinities.

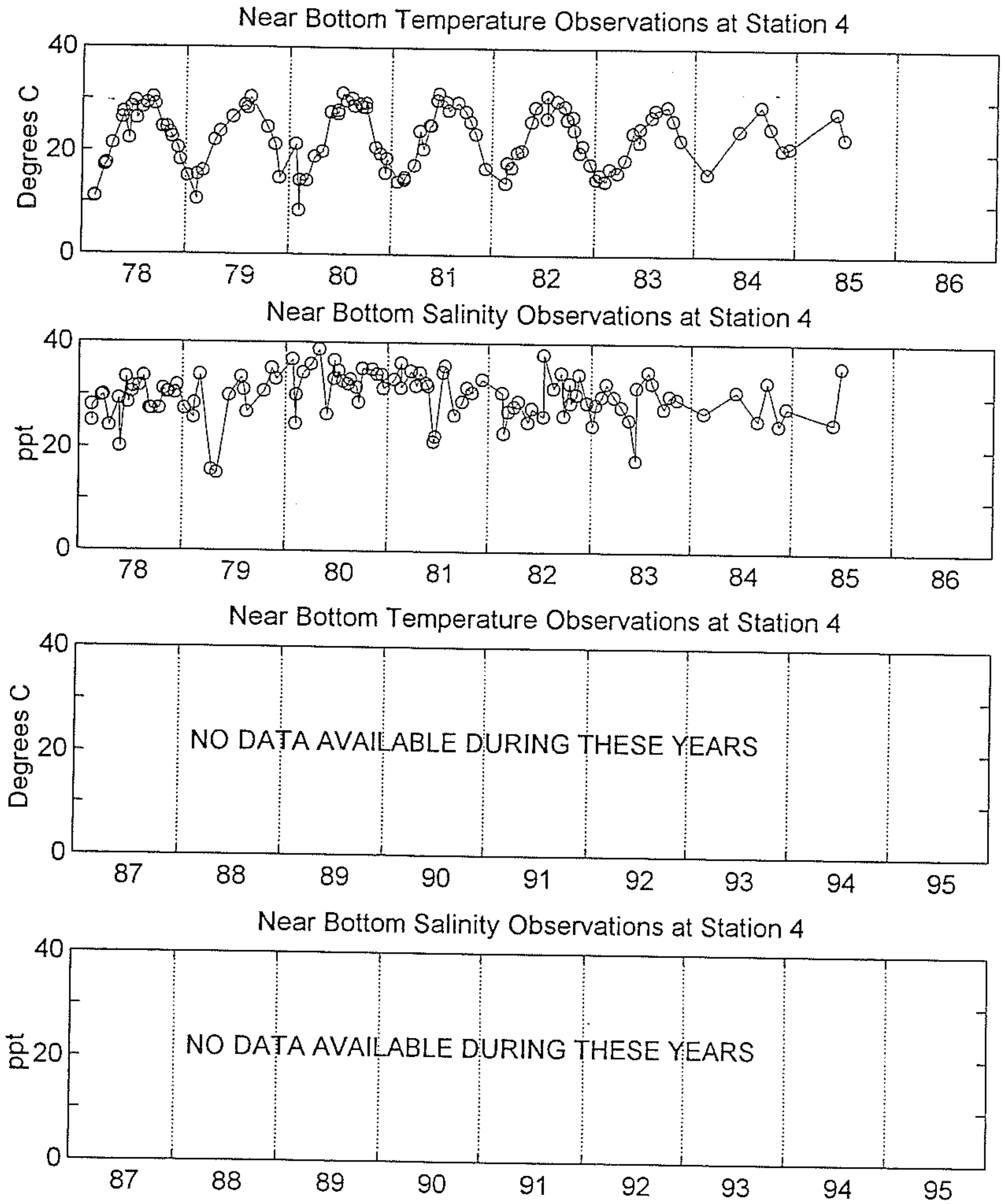

Figure B36. Station 4 monthly physical hydrography data: bottom temperatures and salinities.

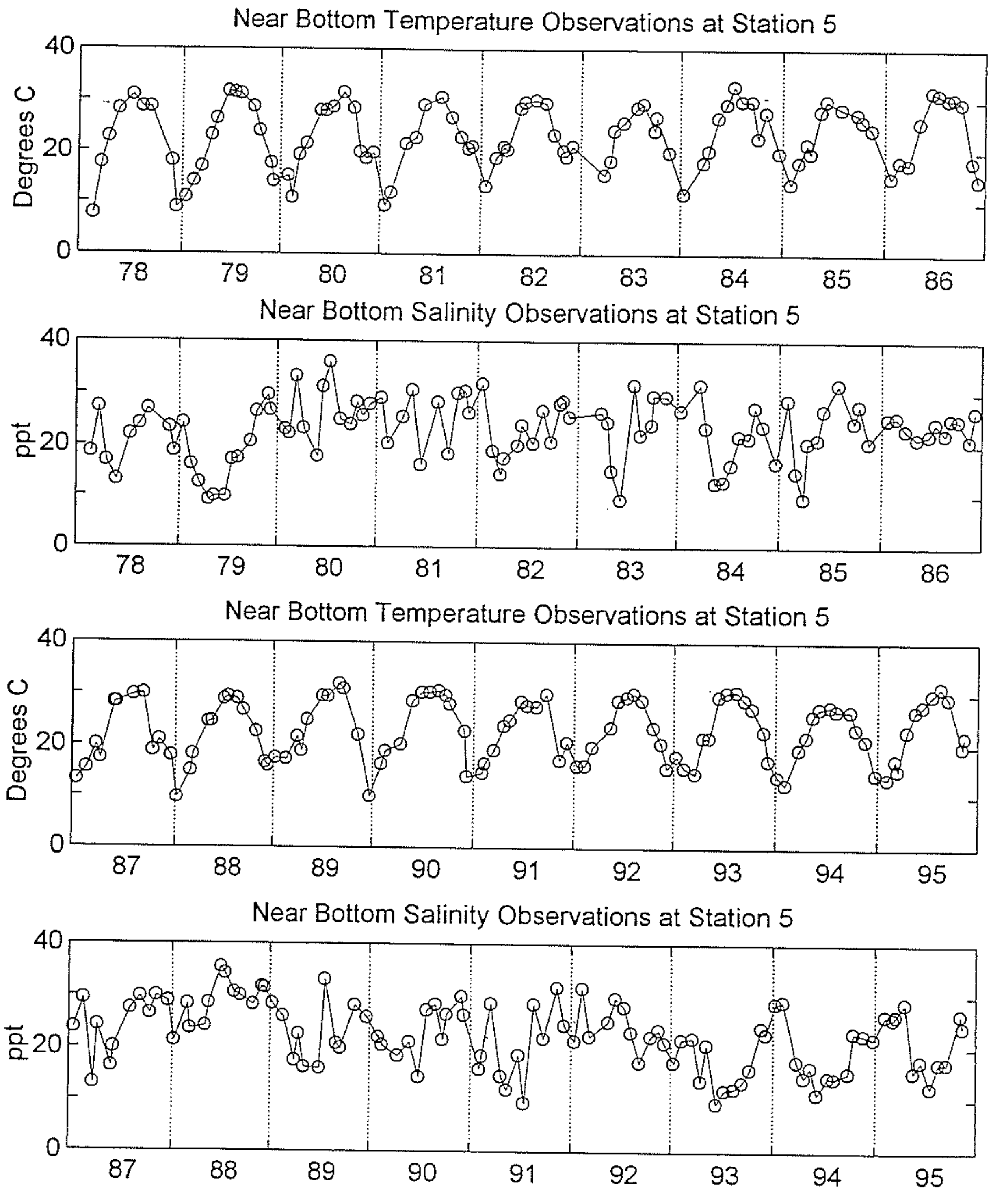

Figure B37. Station 5 monthly physical hydrography data: bottom temperatures and salinities.

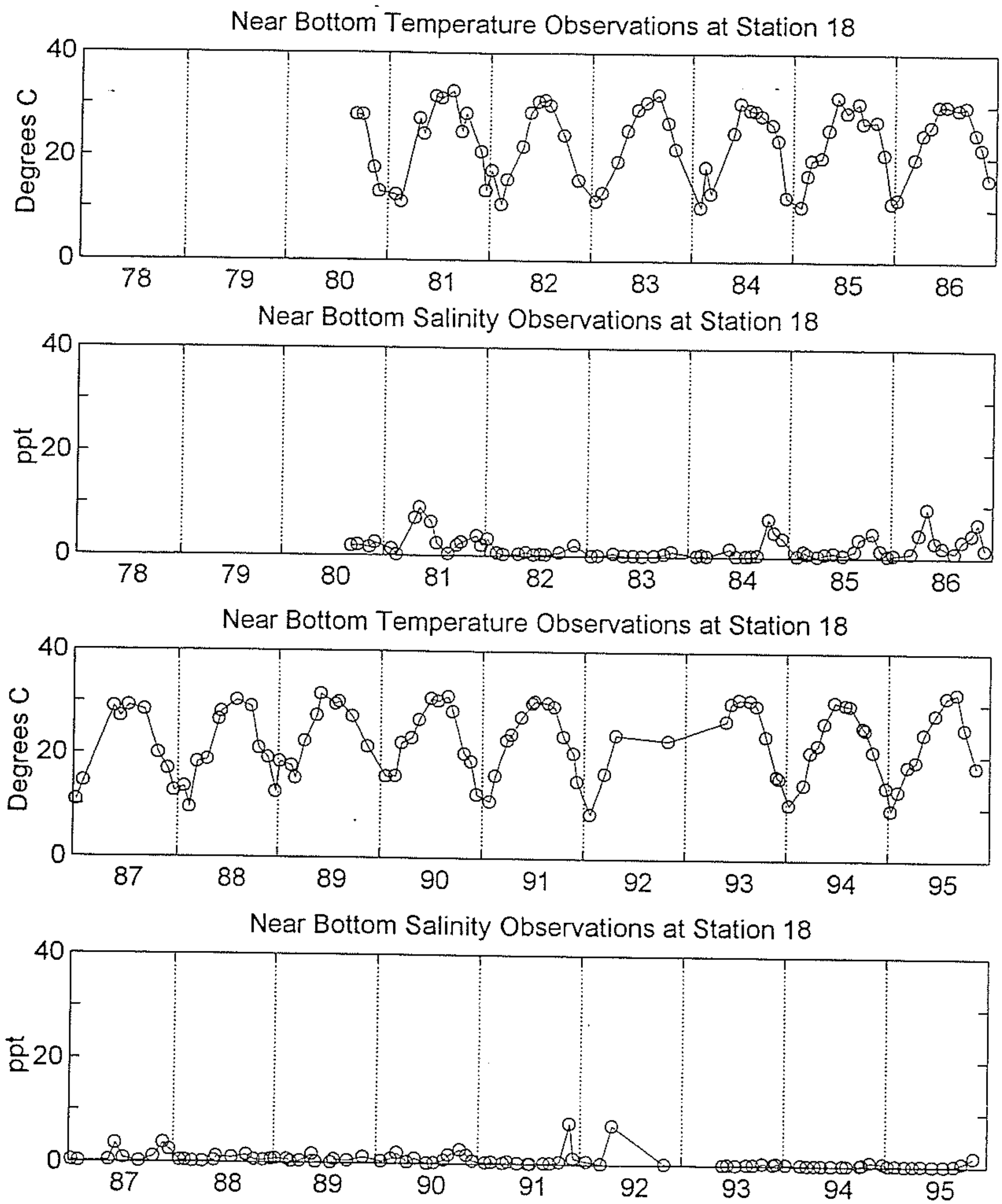

Figure B38. Station 18 monthly physical hydrography data: bottom temperatures and salinities.

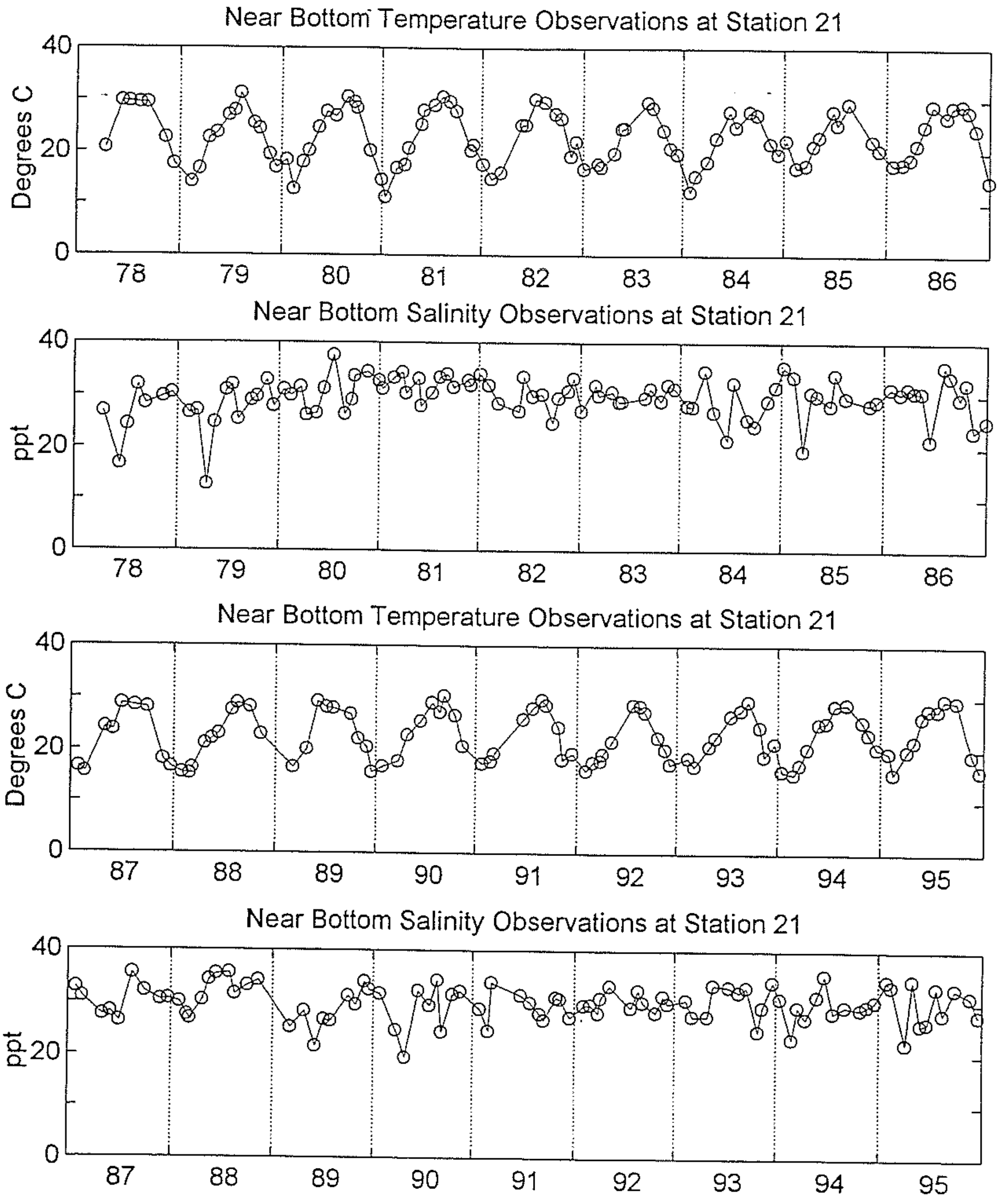

Figure B39. Station 21 monthly physical hydrography data: bottom temperatures and salinities.

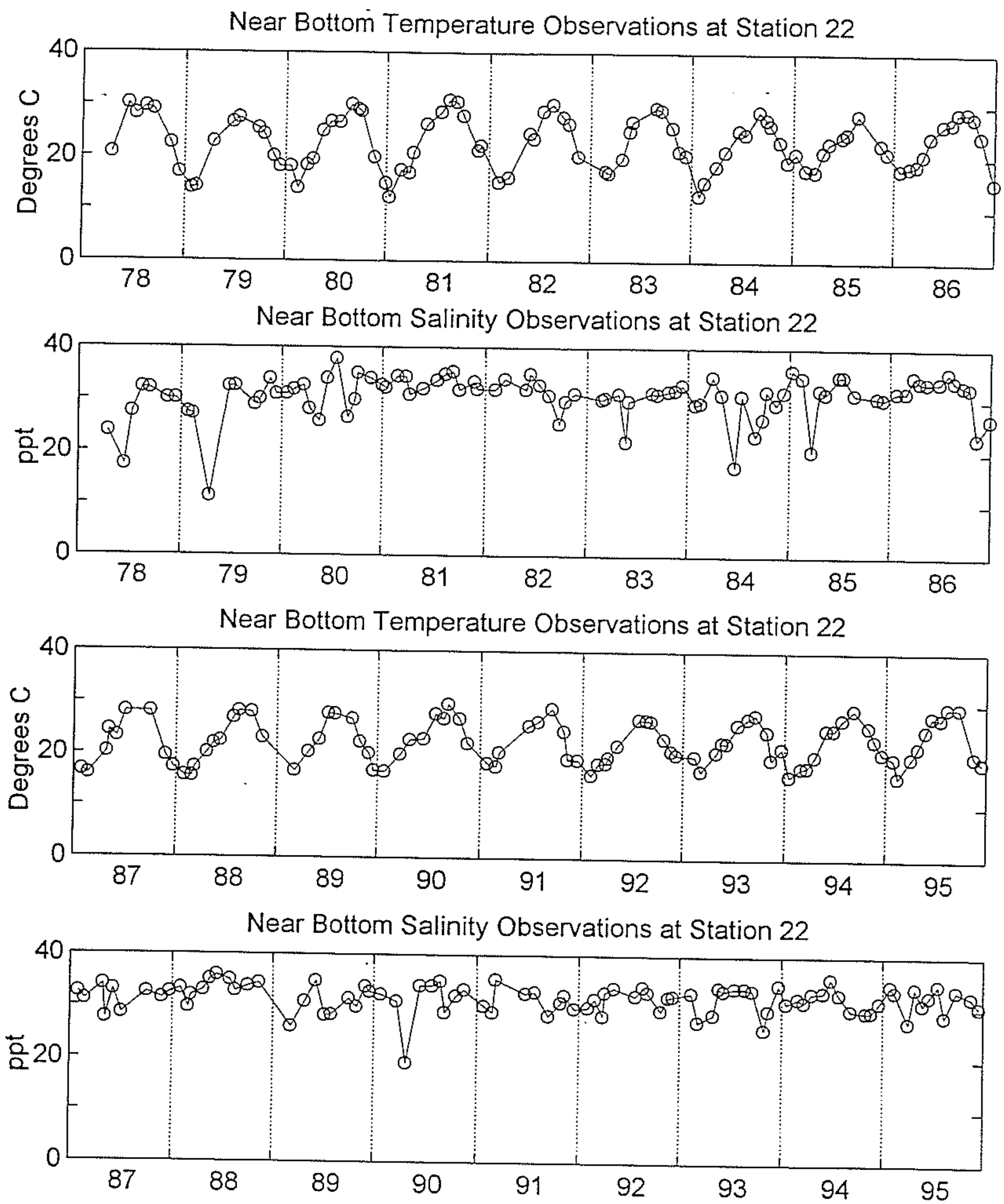

Figure B40. Station 22 monthly physical hydrography data: bottom temperatures and salinities.

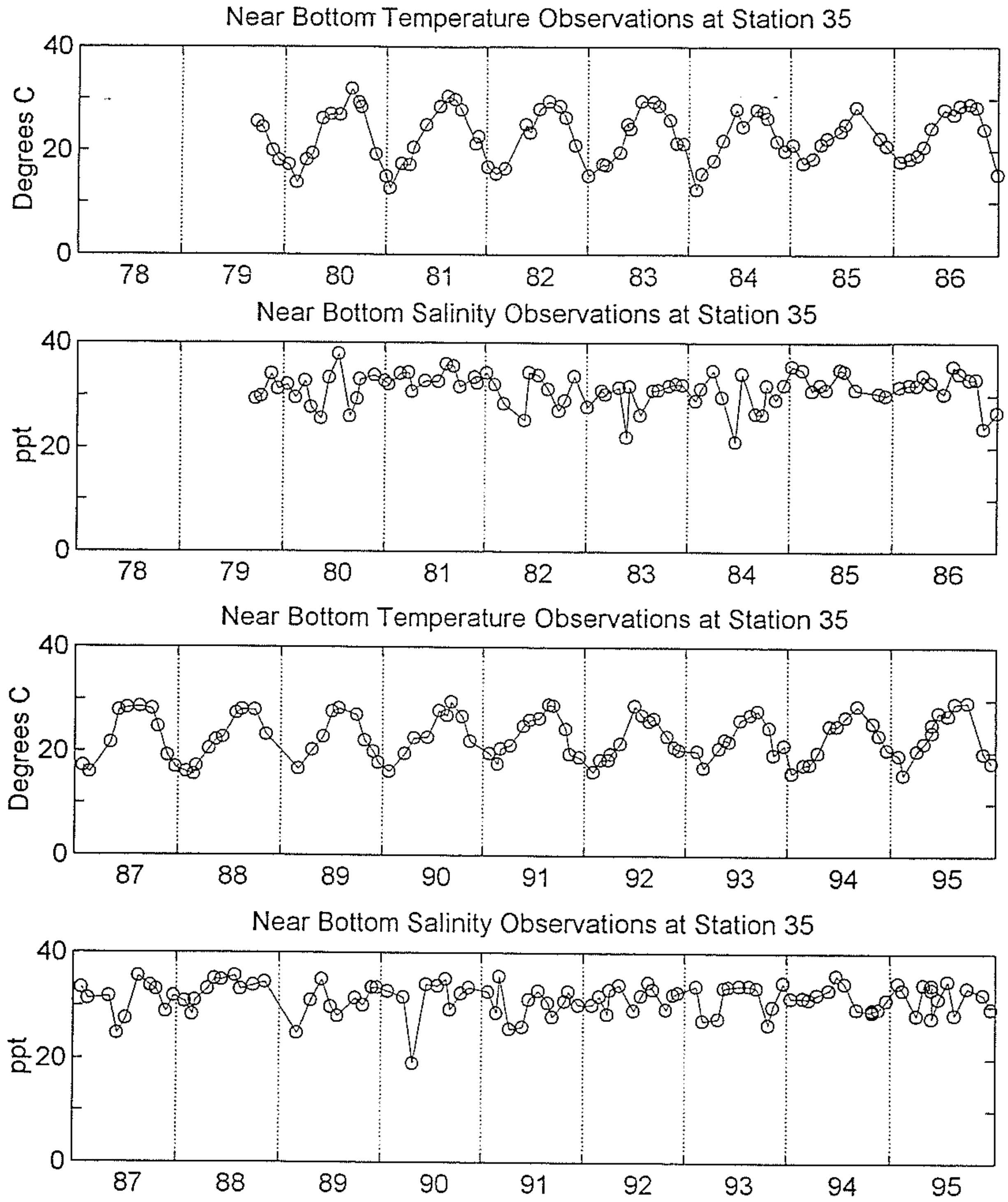

Figure B41. Station 35 monthly physical hydrography data: bottom temperatures and salinities.

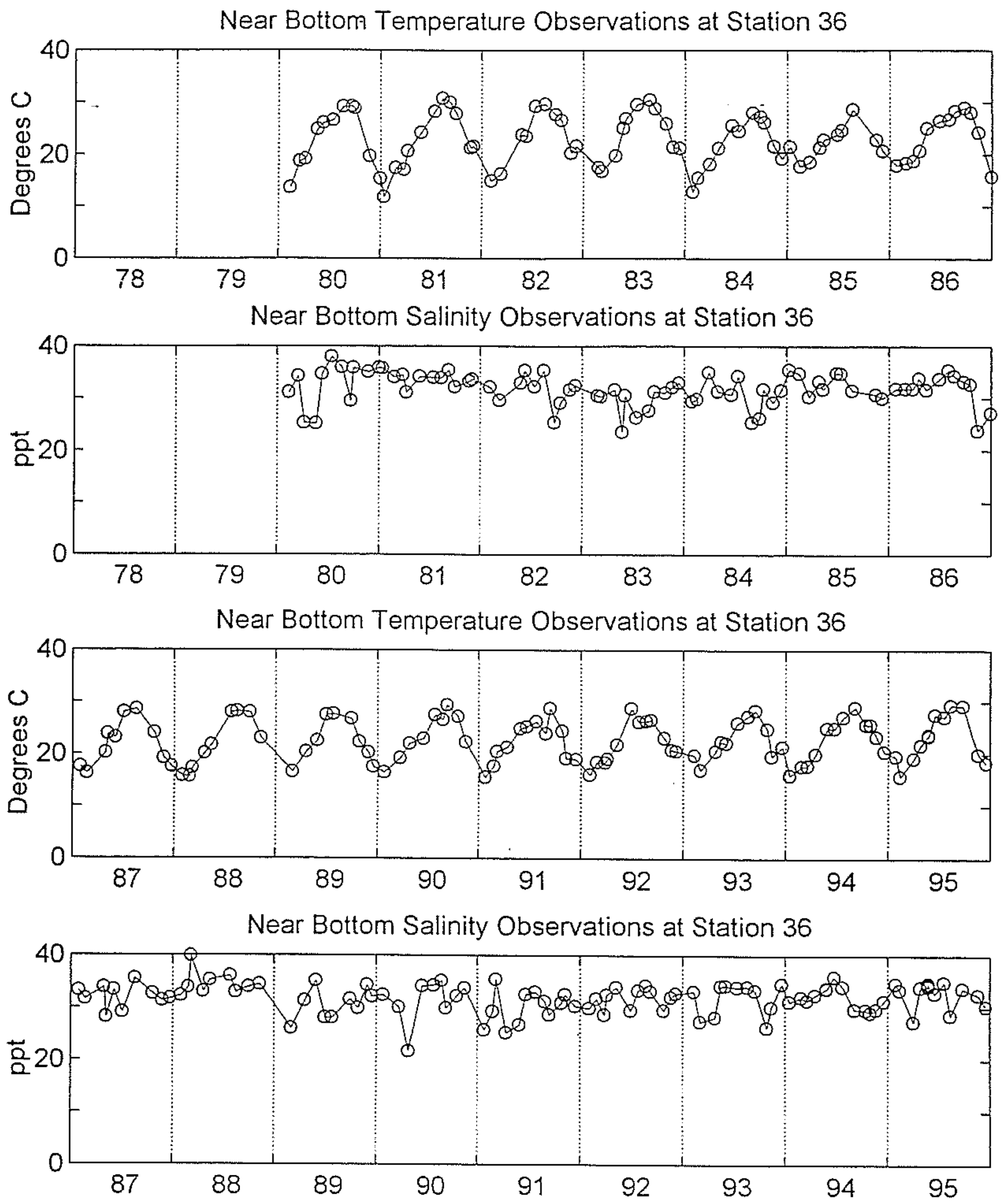

Figure B42. Station 36 monthly physical hydrography data: bottom temperatures and salinities.

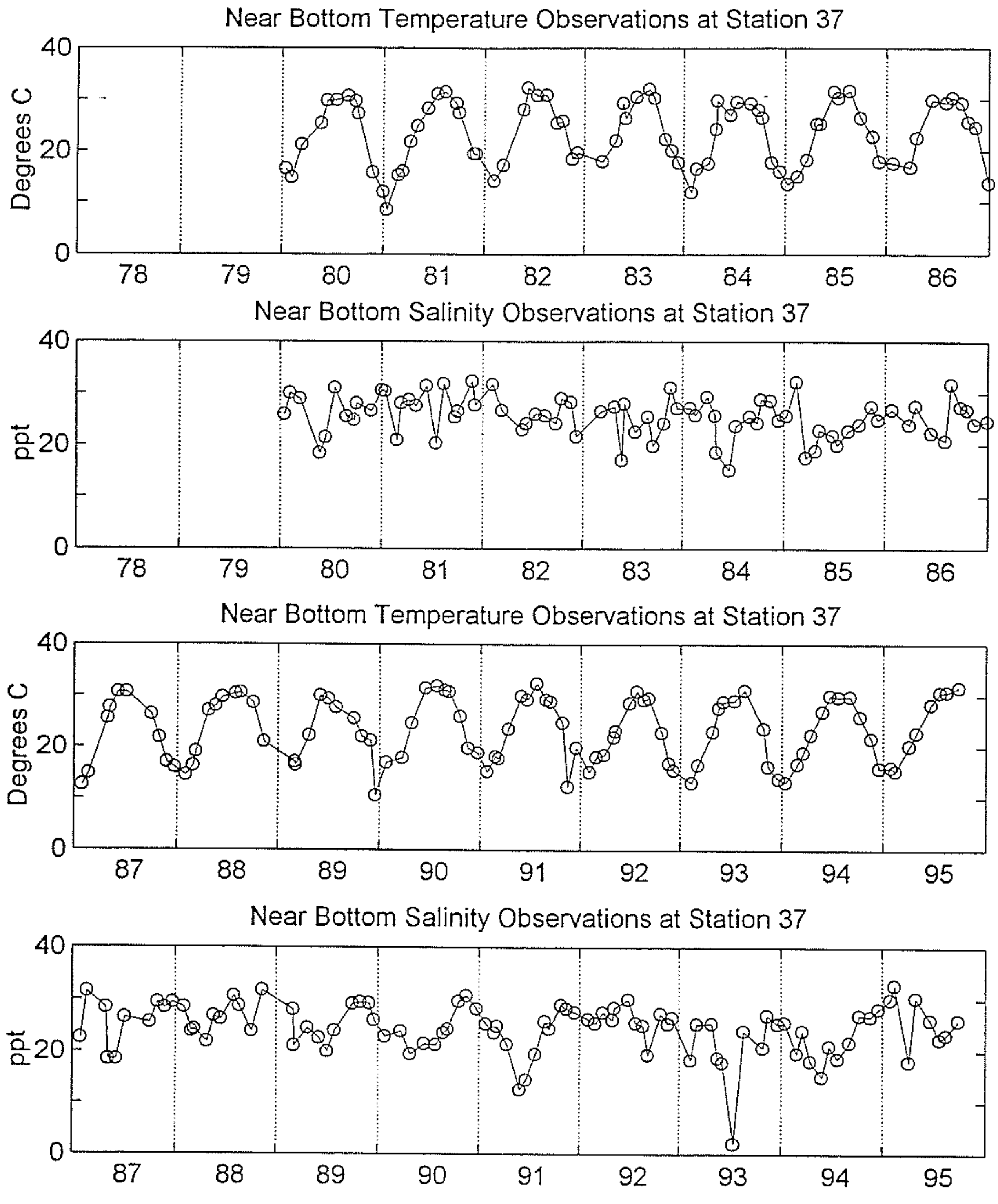

Figure B43. Station 37 monthly physical hydrography data: bottom temperatures and salinities.

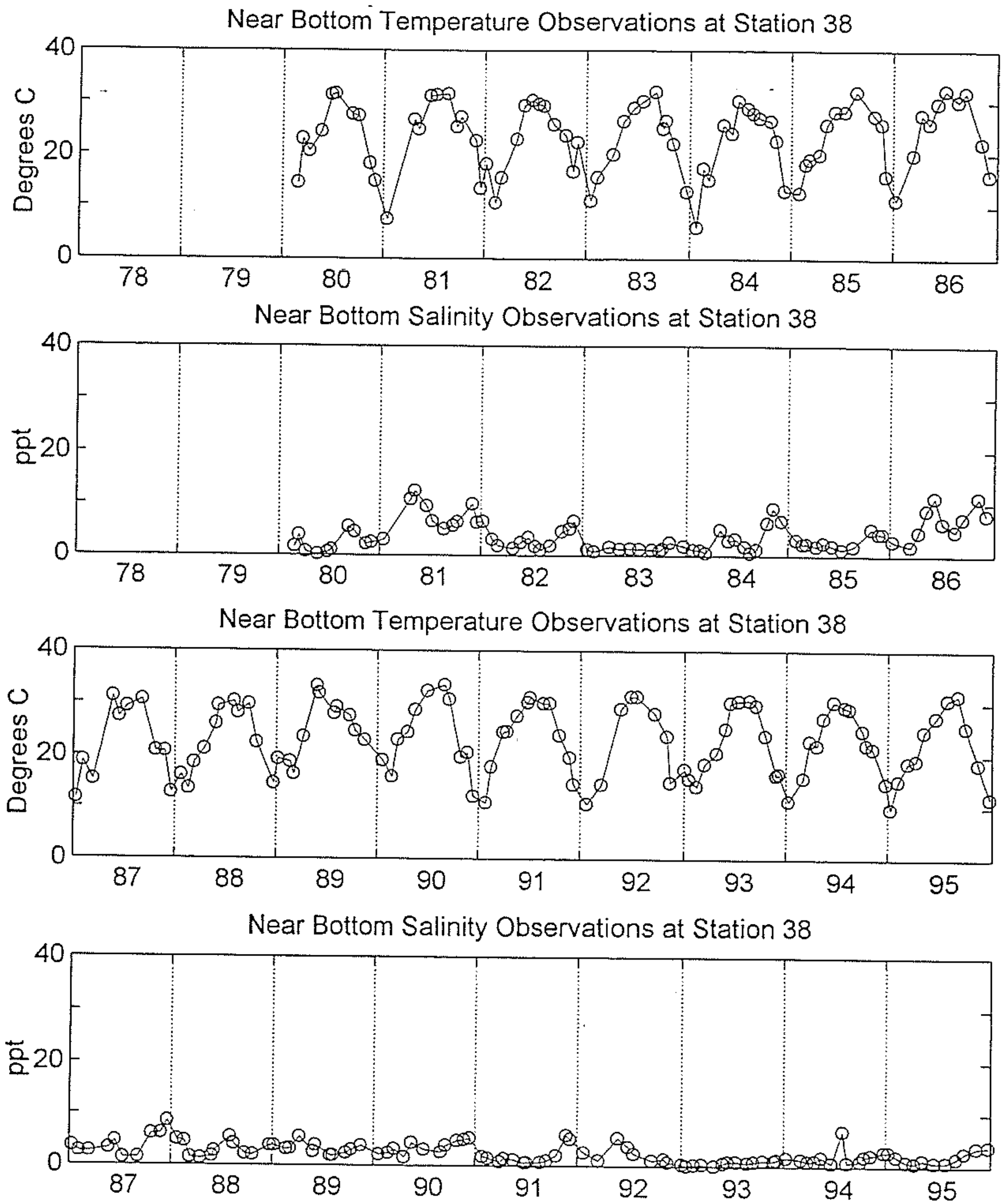

Figure B44. Station 38 monthly physical hydrography data: bottom temperatures and salinities.

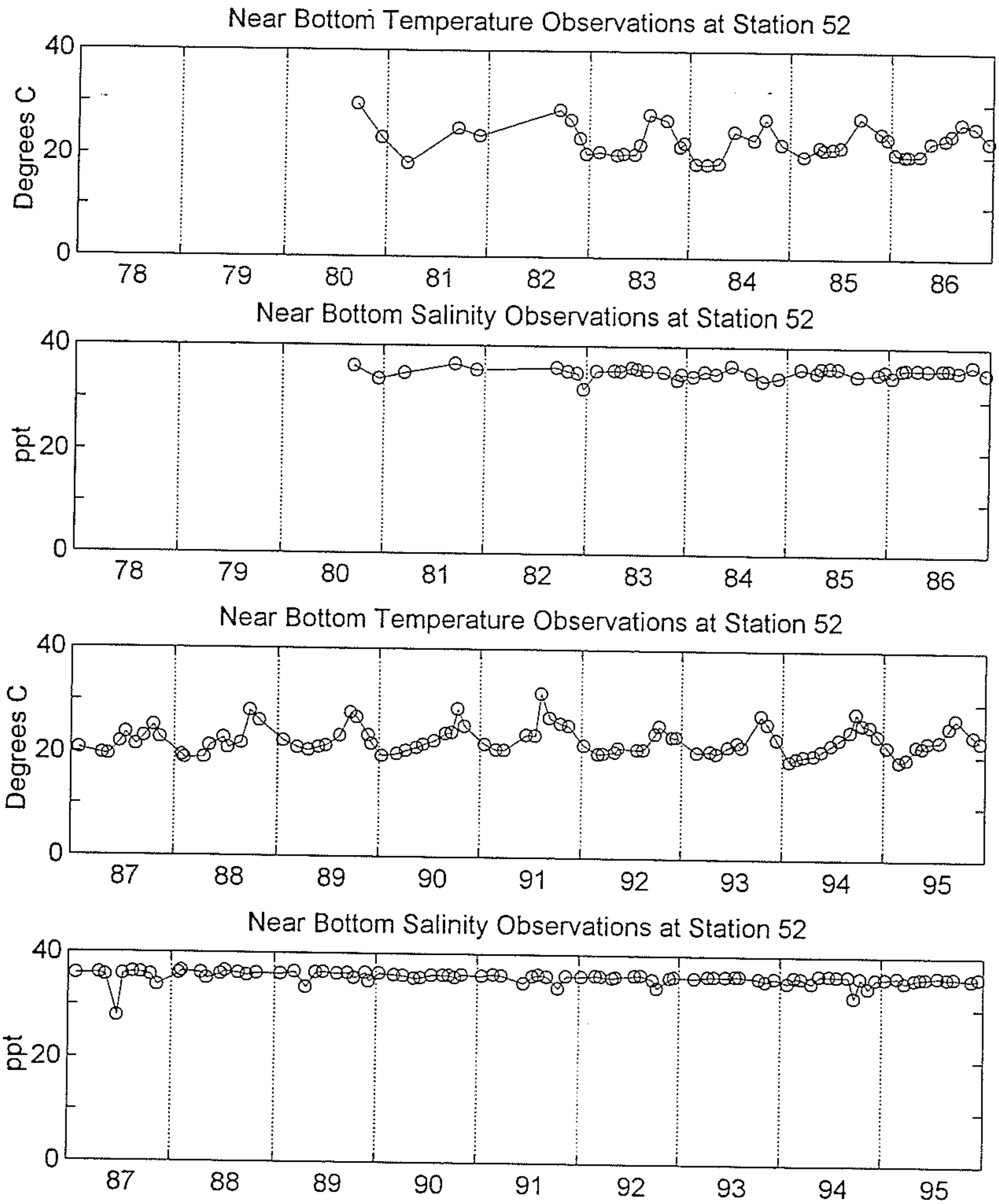

Figure B45. Station 52 monthly physical hydrography data: bottom temperatures and salinities.

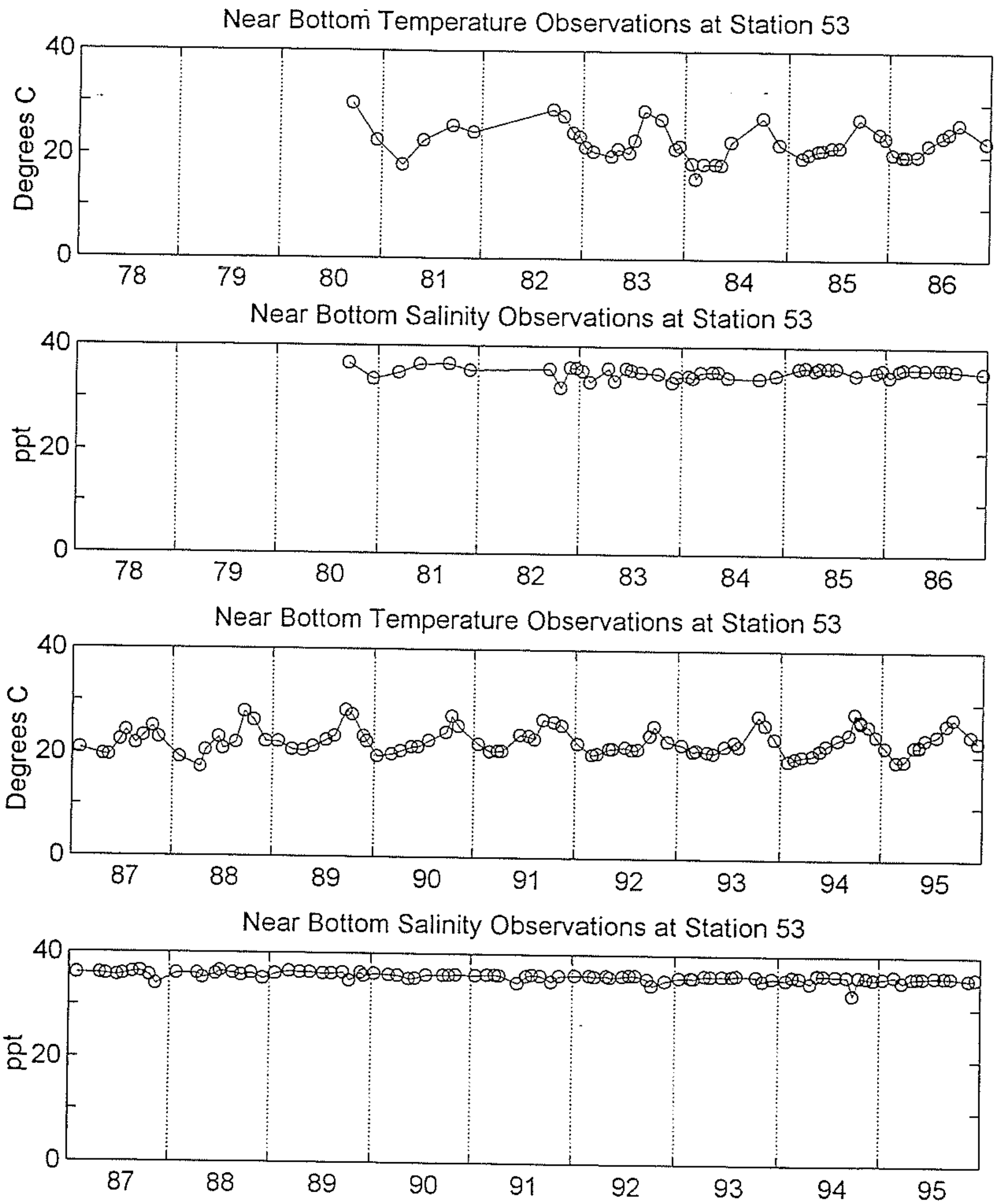

Figure B46. Station 53 monthly physical hydrography data: bottom temperatures and salinities.

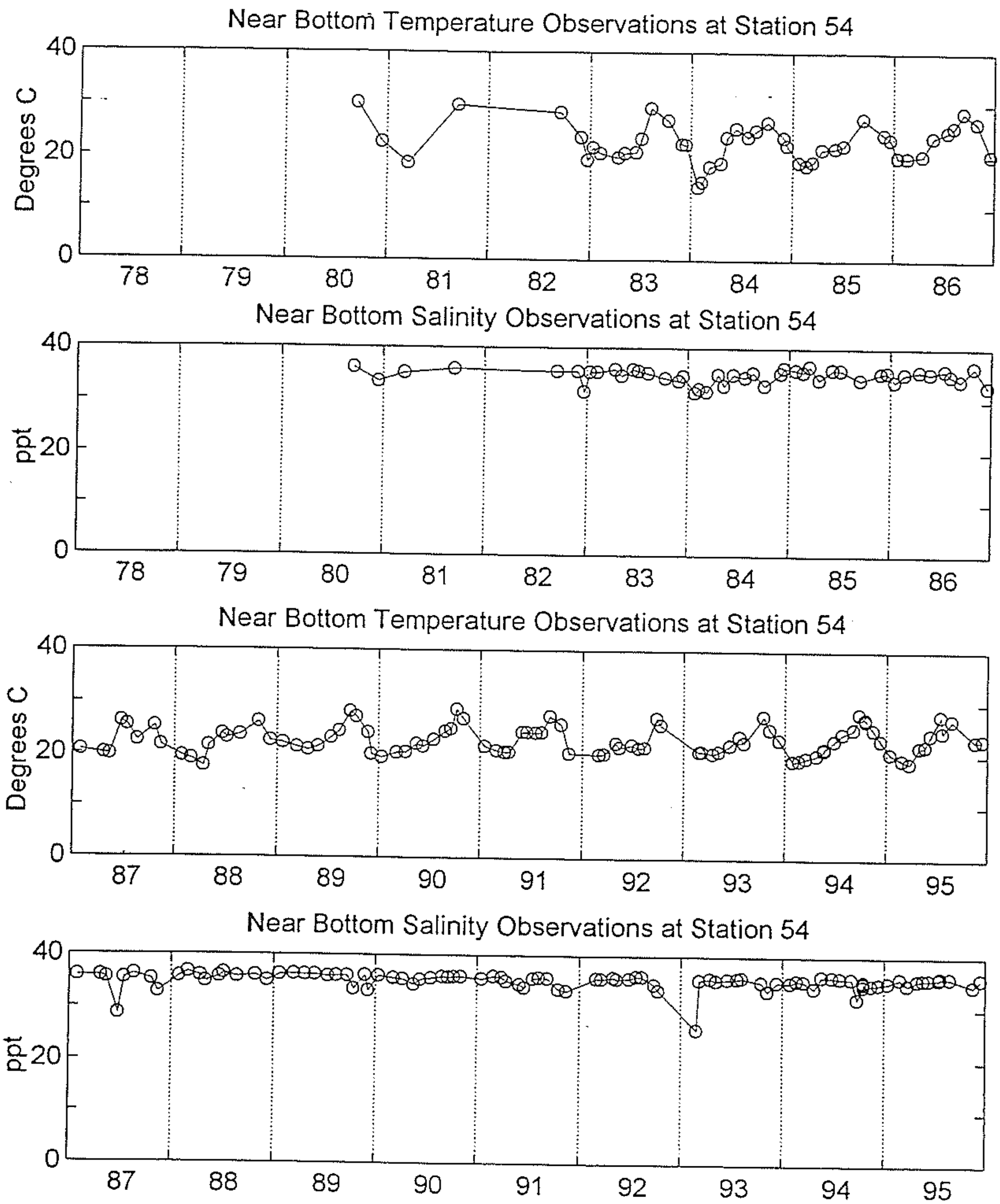

Figure B47. Station 54 monthly physical hydrography data: bottom temperatures and salinities.

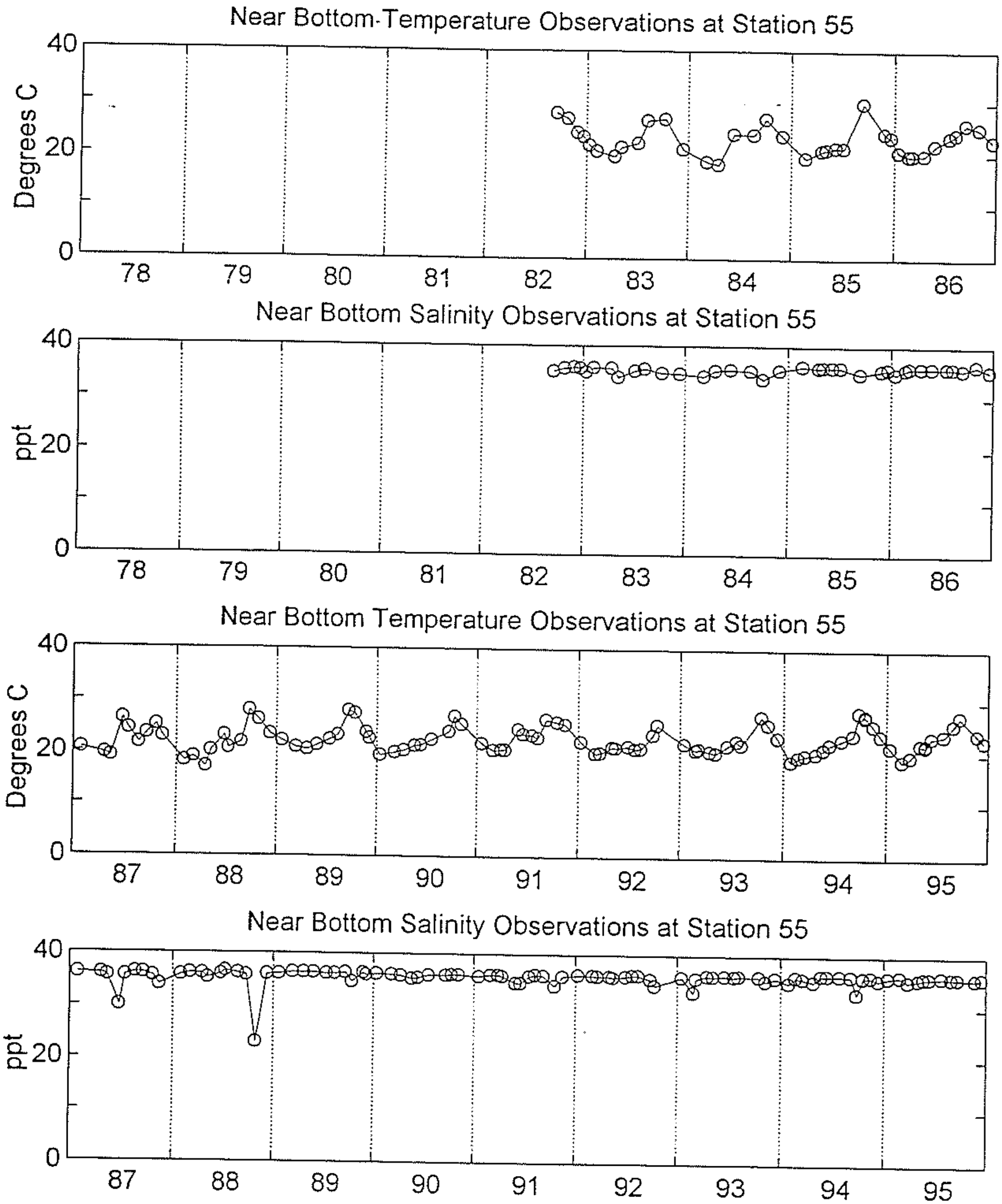

Figure B48. Station 55 monthly physical hydrography data: bottom temperatures and salinities.

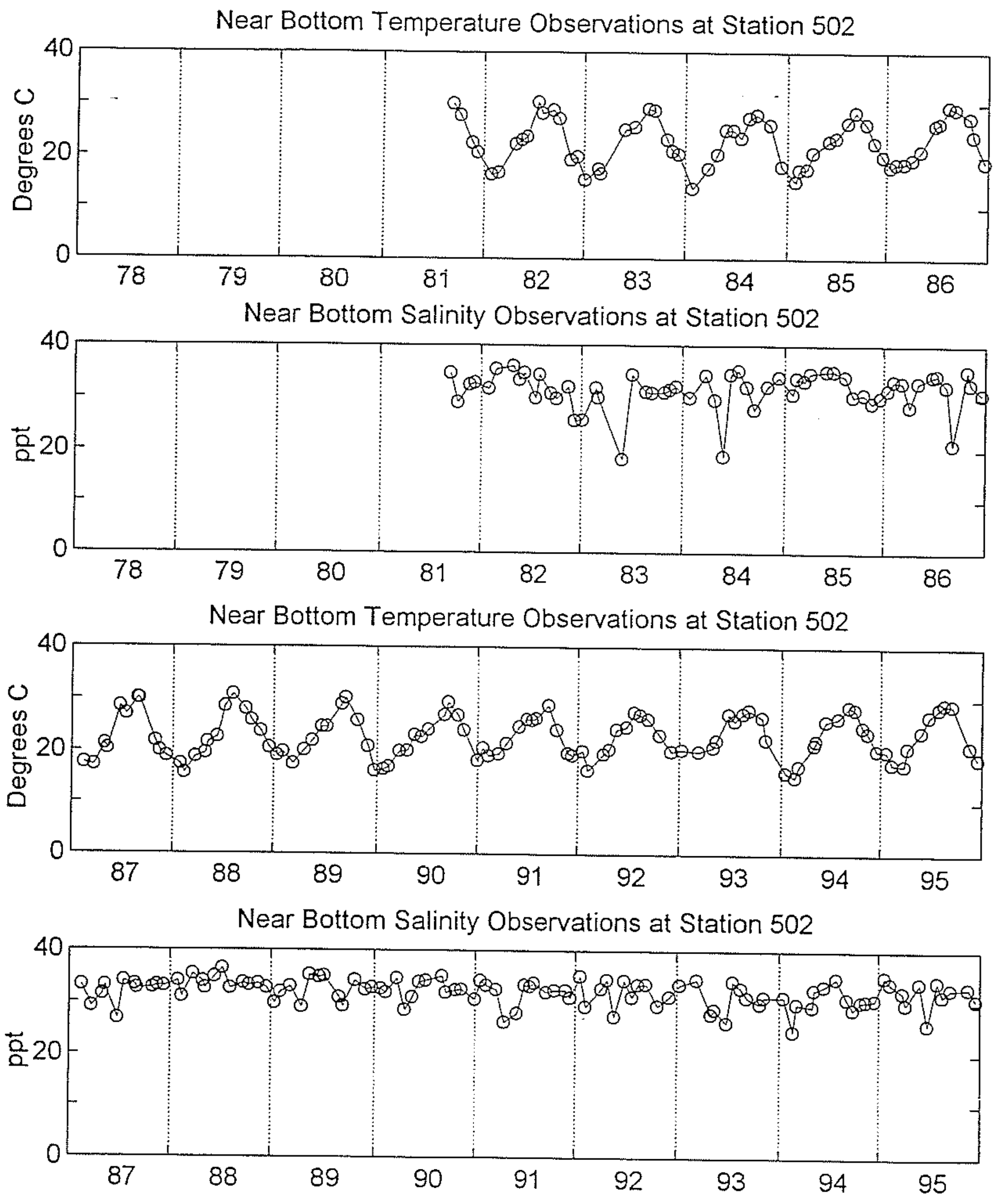

Figure B49. Station 502 monthly physical hydrography data: bottom temperatures and salinities.

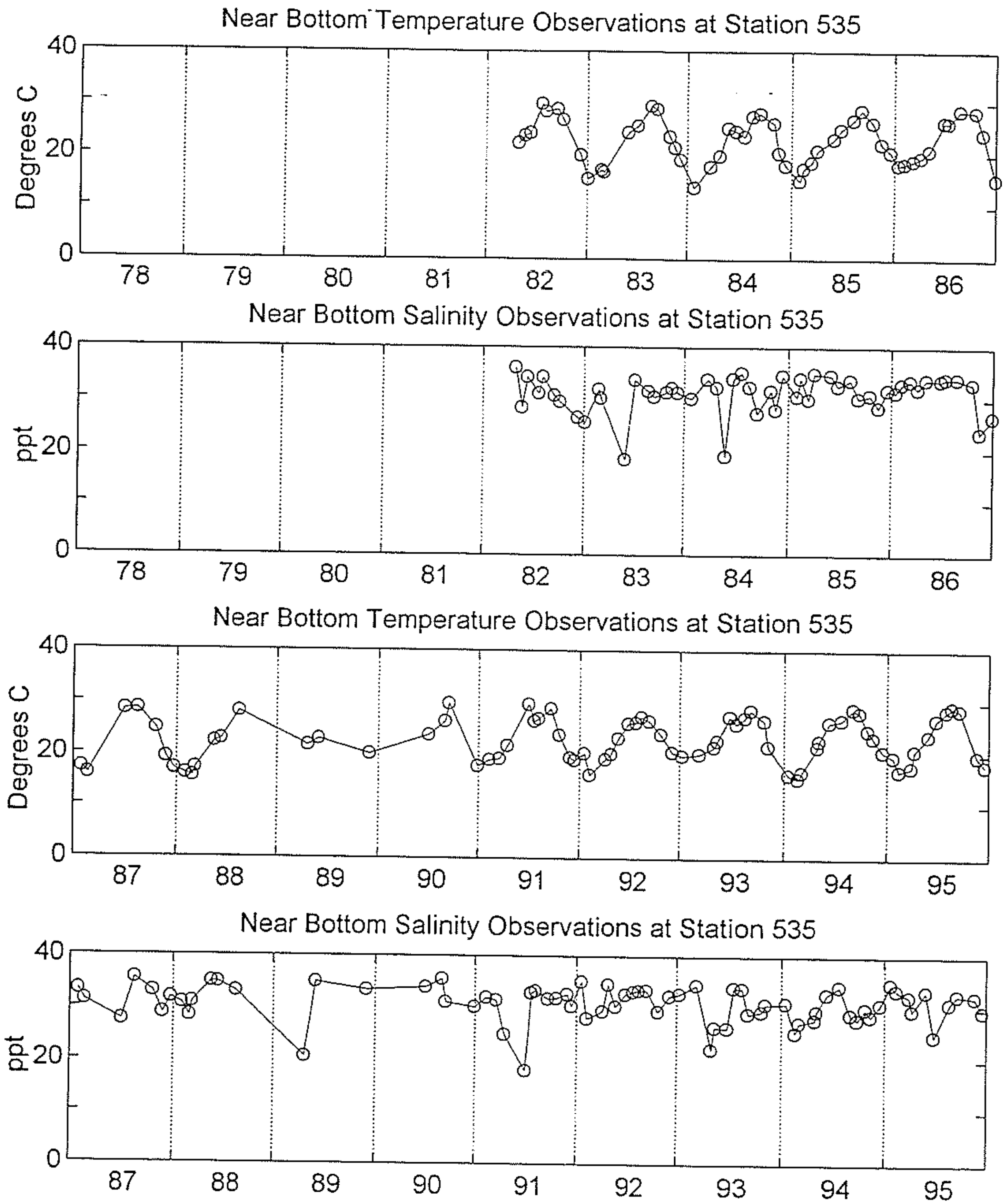

Figure B50. Station 535 monthly physical hydrography data: bottom temperatures and salinities.

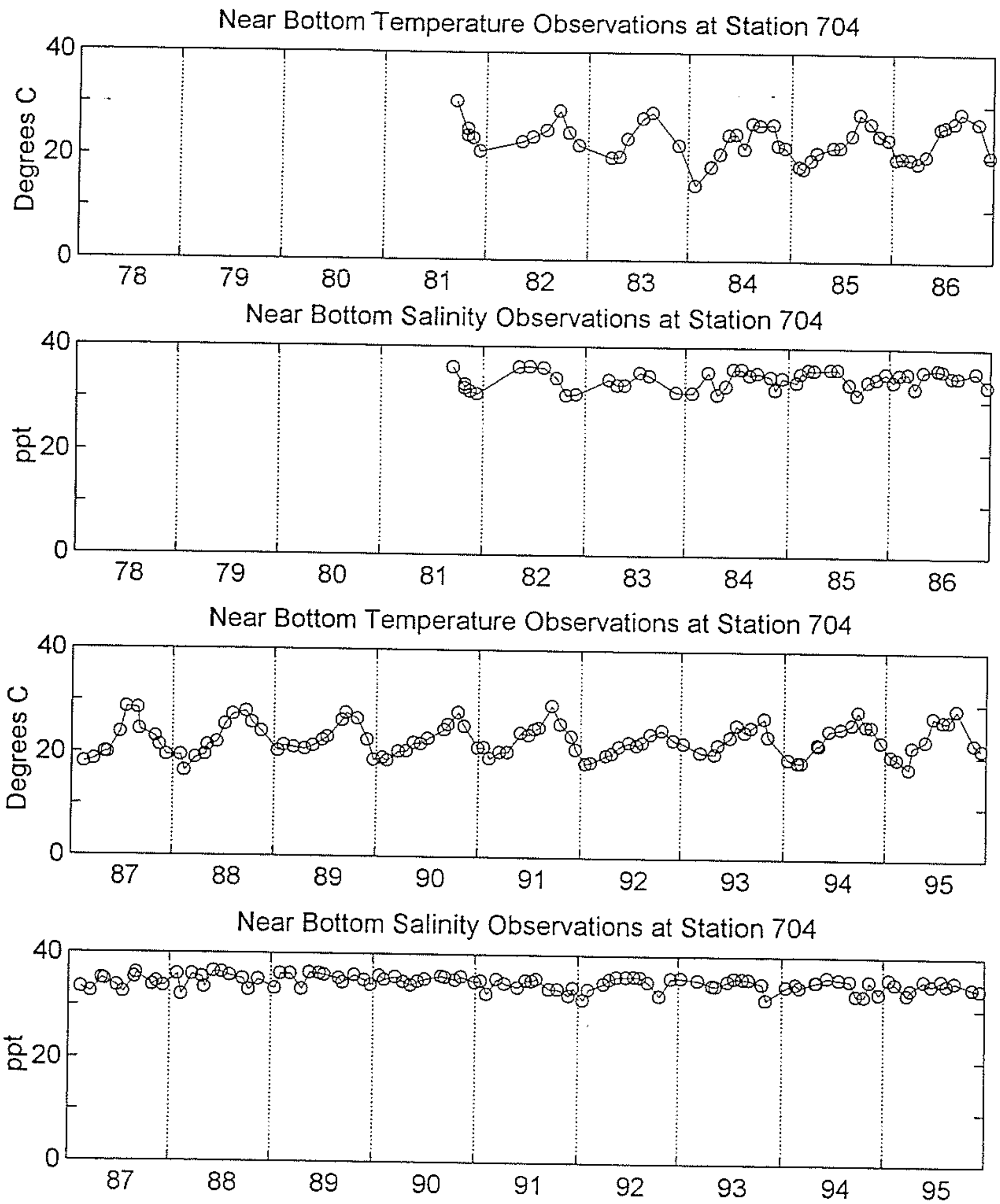

Figure B51. Station 704 monthly physical hydrography data: bottom temperatures and salinities.

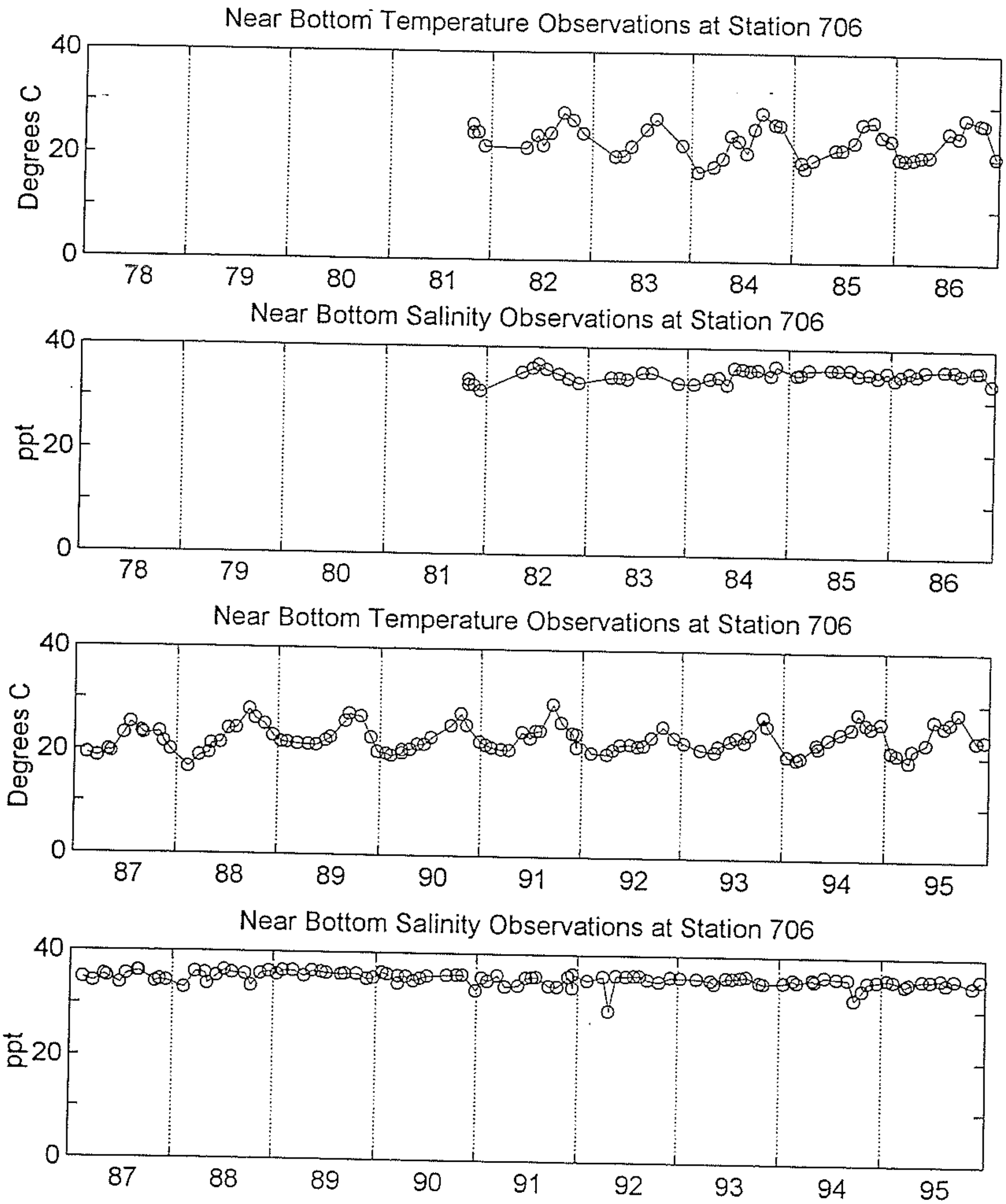

Figure B52. Station 706 monthly physical hydrography data: bottom temperatures and salinities.

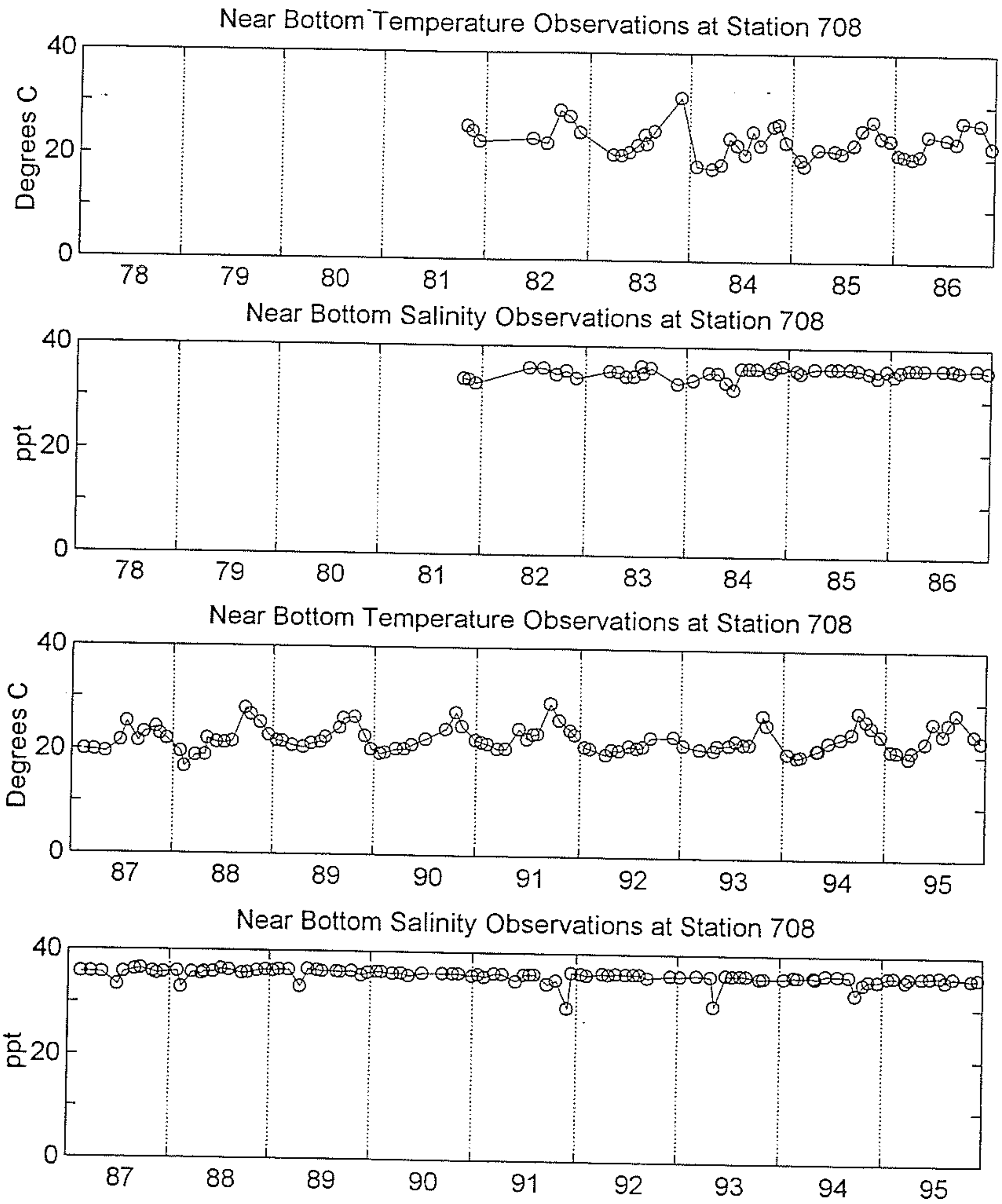

Figure B53. Station 708 monthly physical hydrography data: bottom temperatures and salinities.

APPENDIX C

WATER CHEMISTRY PLOTS OF MONTHLY SALINITY OBSERVATIONS

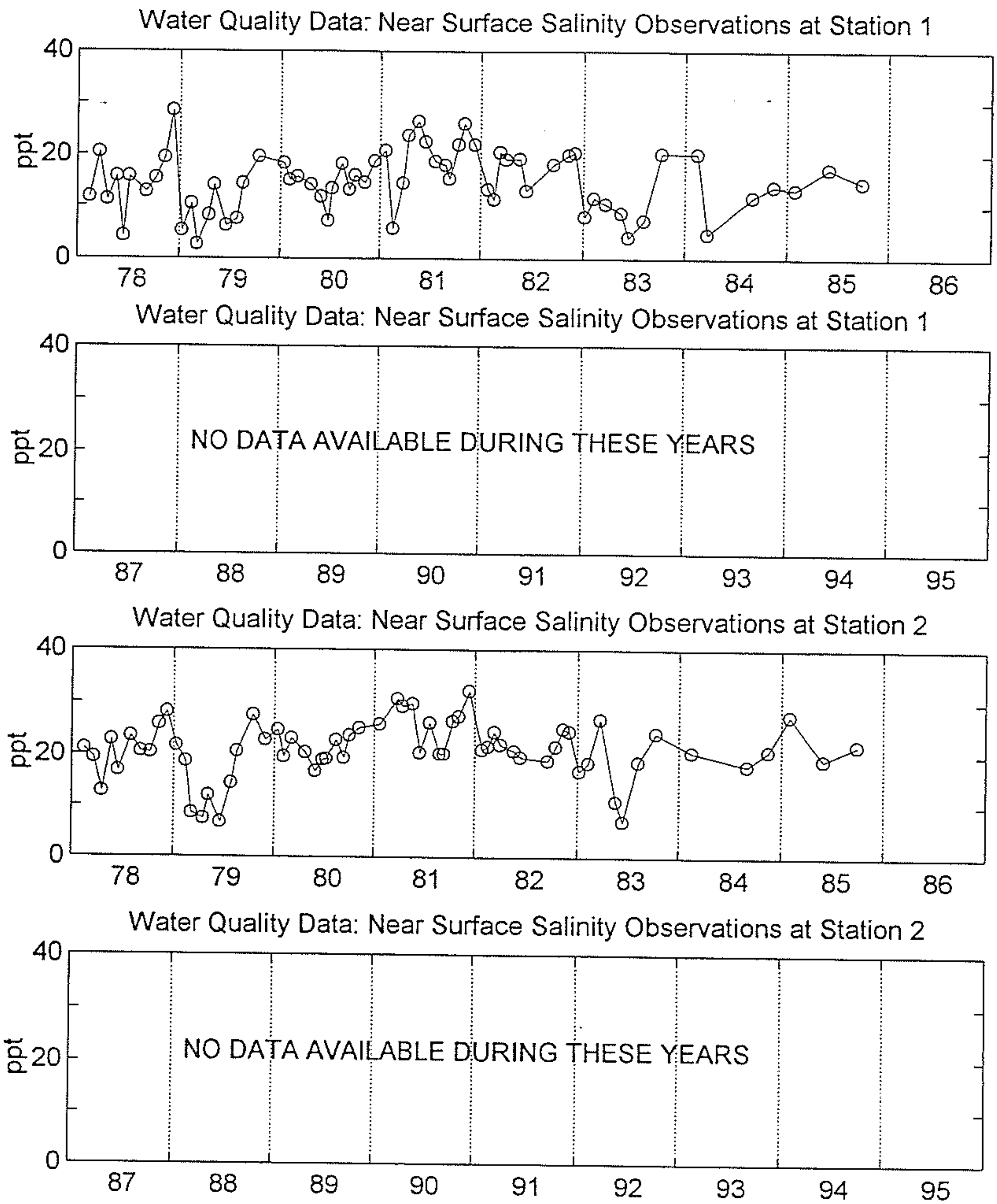

Figure C1. Monthly water chemistry data: top salinities, stations 1 and 2.

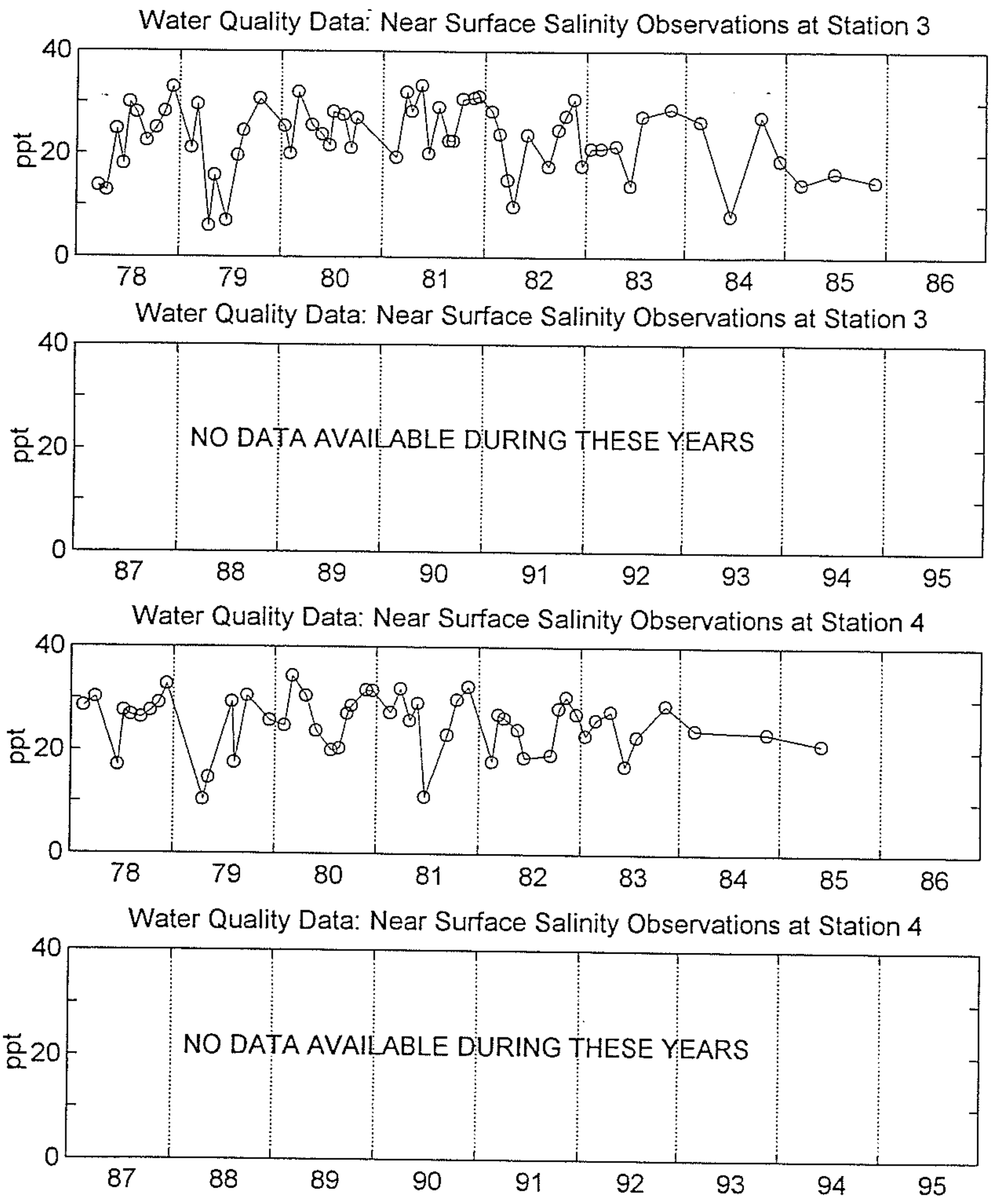

Figure C2. Monthly water chemistry data: top salinities, stations 3 and 4.

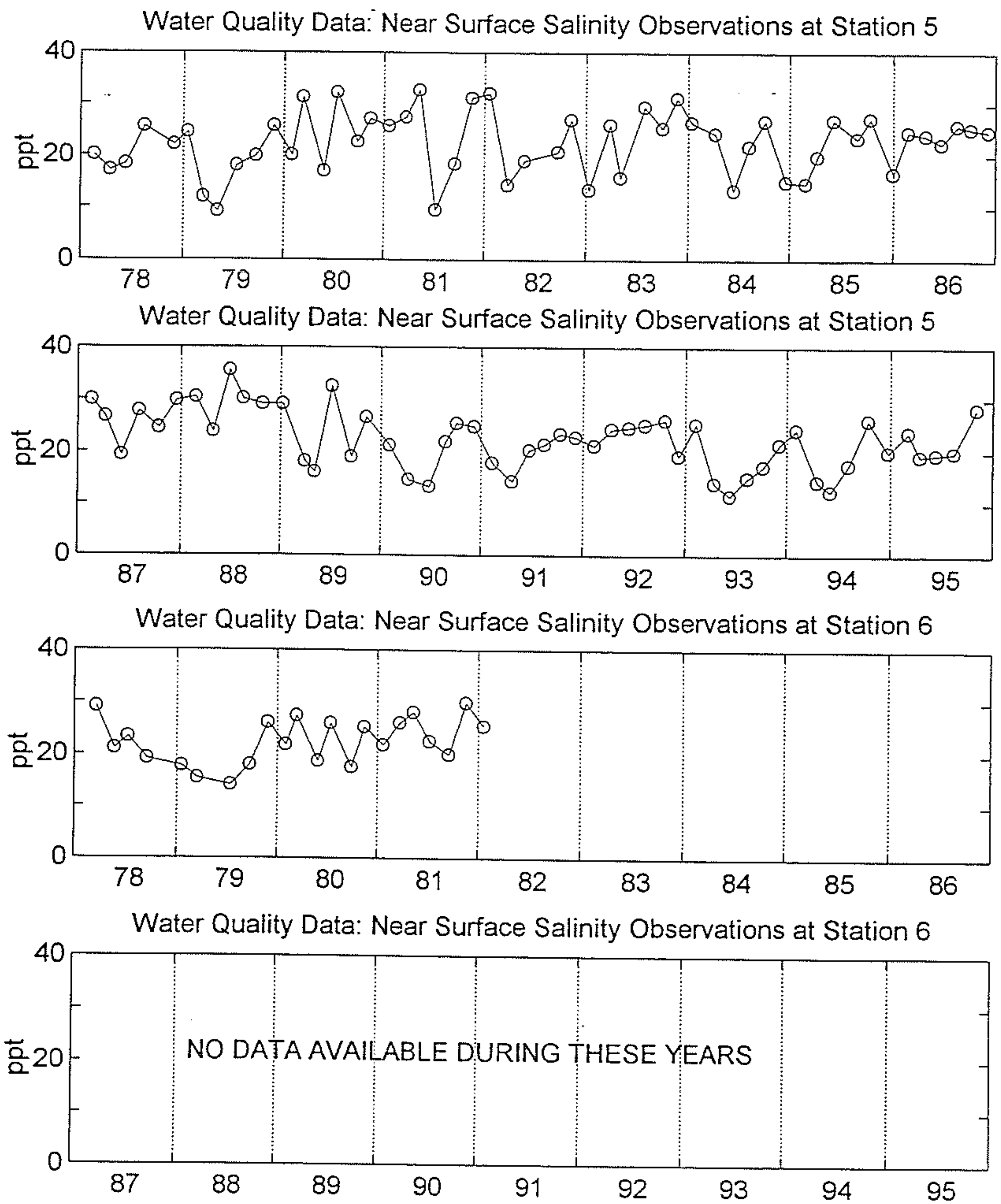

Figure C3. Monthly water chemistry data: top salinities, stations 5 and 6.

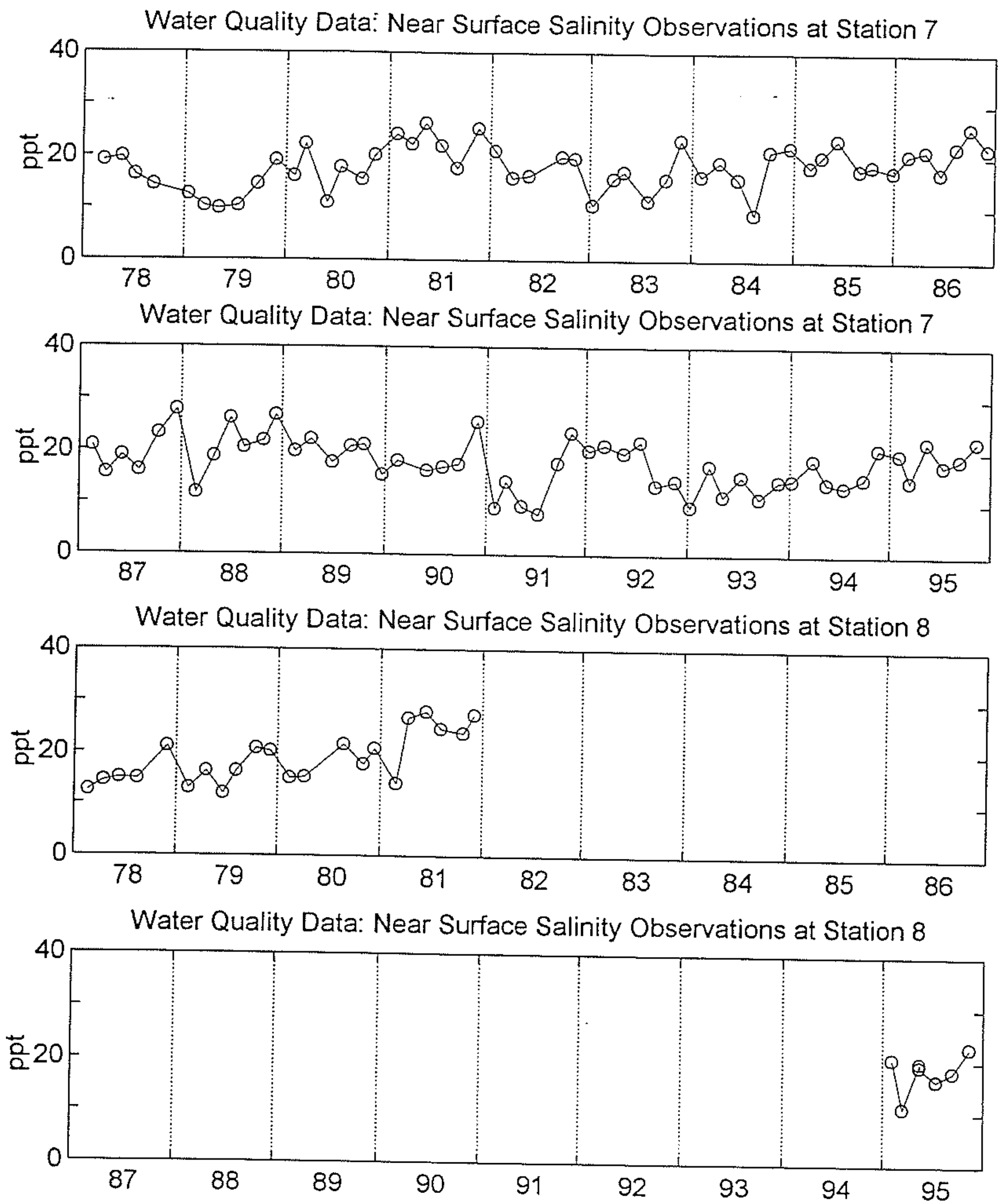

Figure C4. Monthly water chemistry data: top salinities, stations 7 and 8.

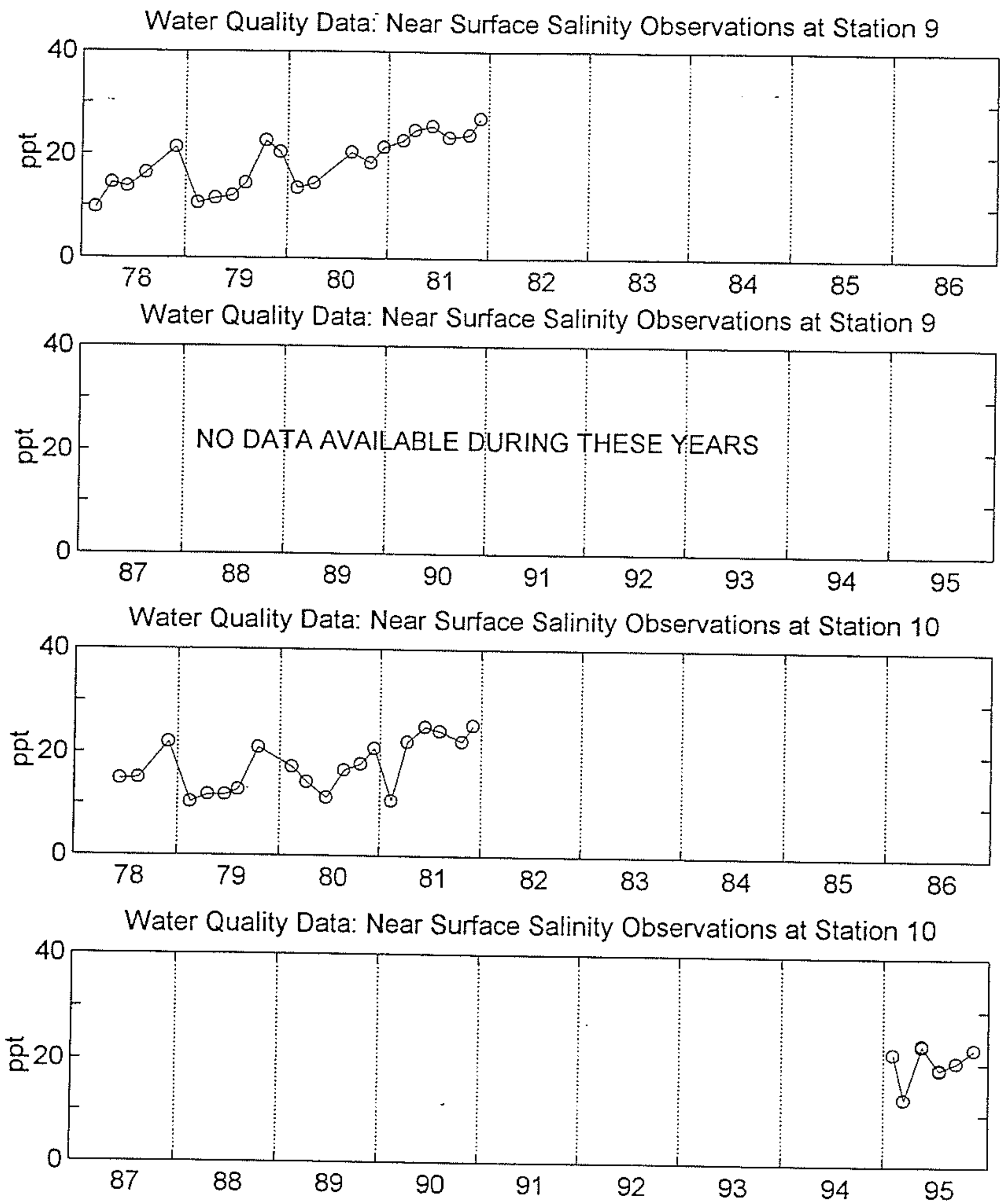

Figure C5. Monthly water chemistry data: top salinities, stations 9 and 10.

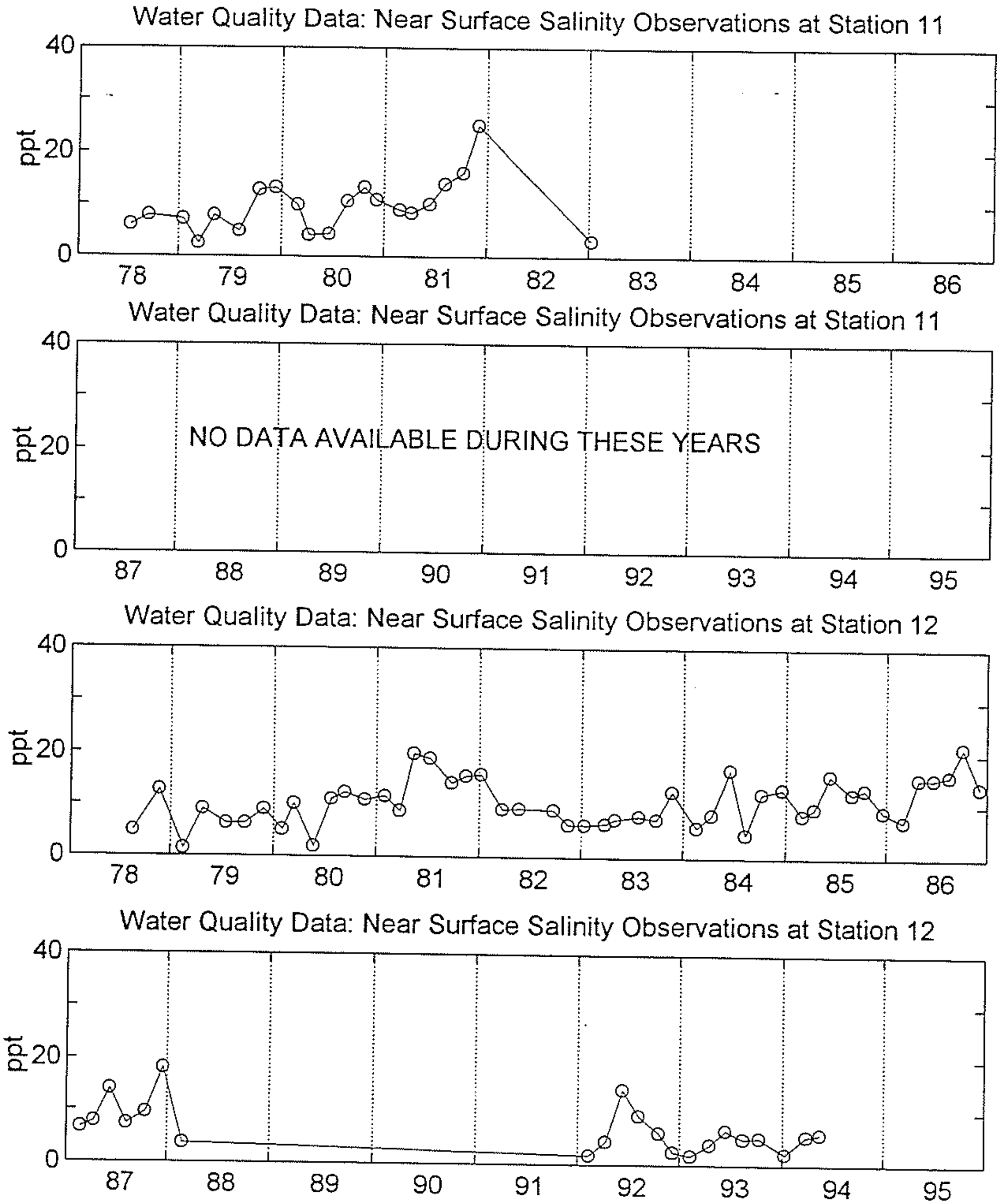

Figure C6. Monthly water chemistry data: top salinities, stations 11 and 12.

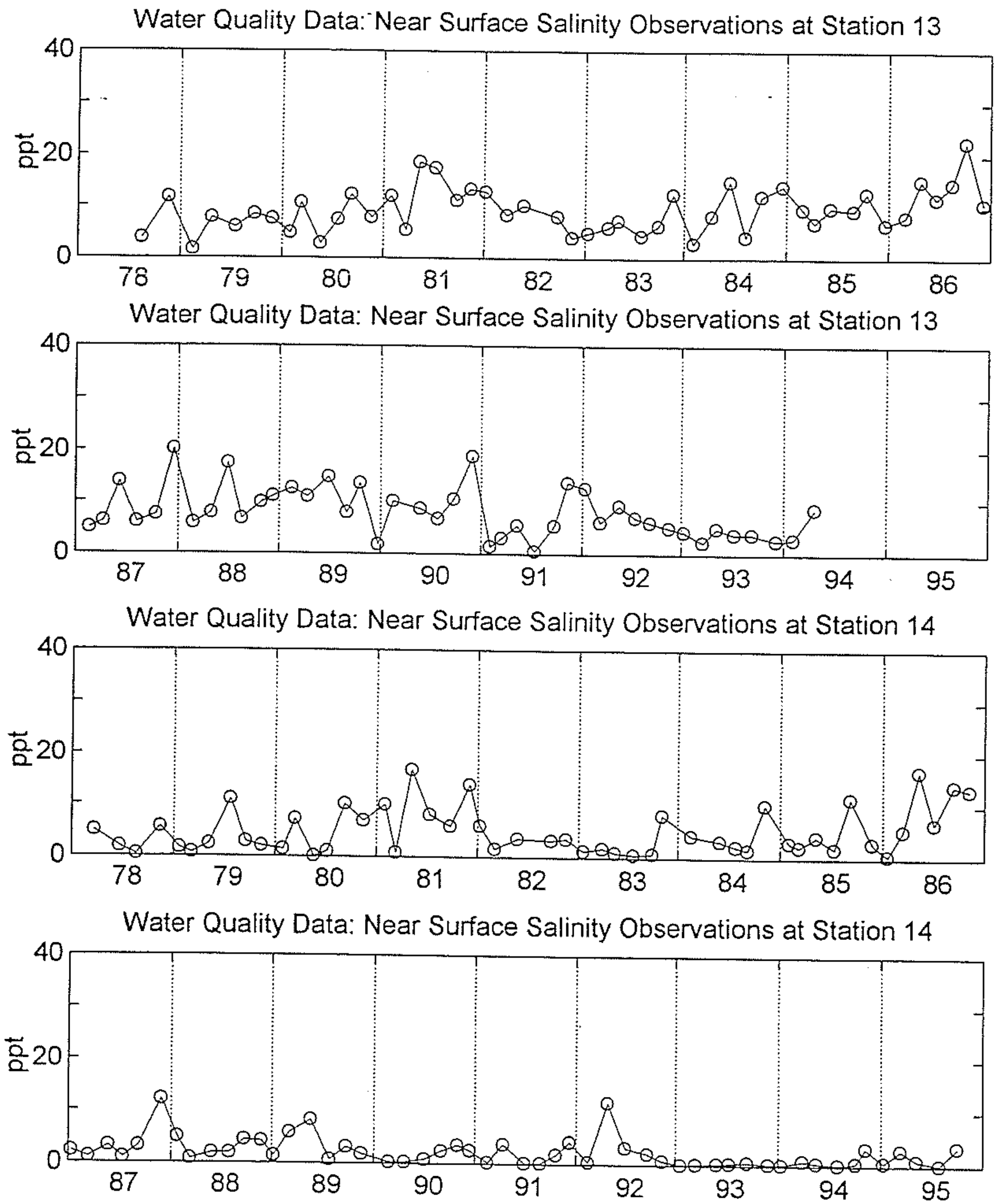

Figure C7. Monthly water chemistry data: top salinities, stations 13 and 14.

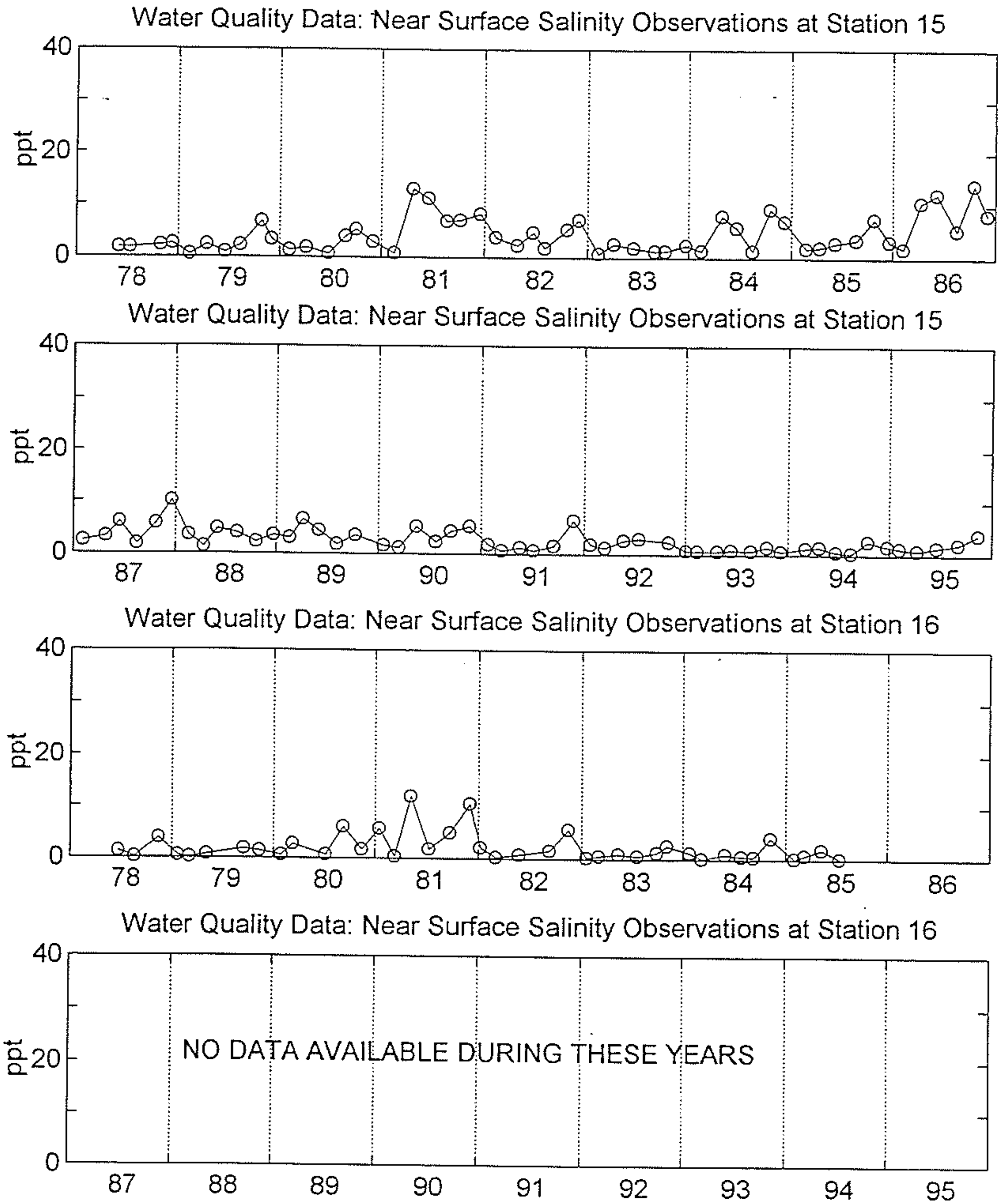

Figure C8. Monthly water chemistry data: top salinities, stations 15 and 16.

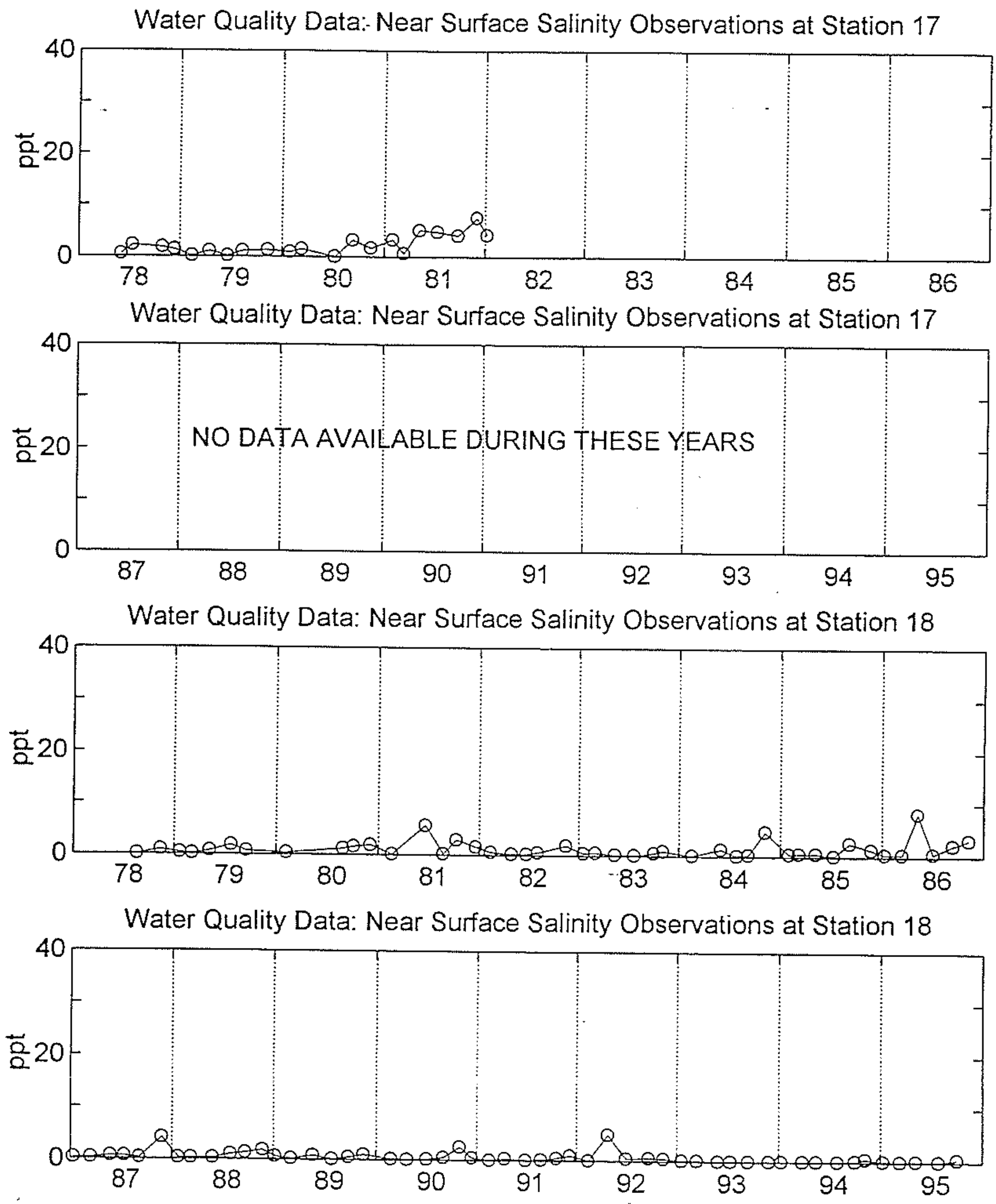

Figure C9. Monthly water chemistry data: top salinities, stations 17 and 18.

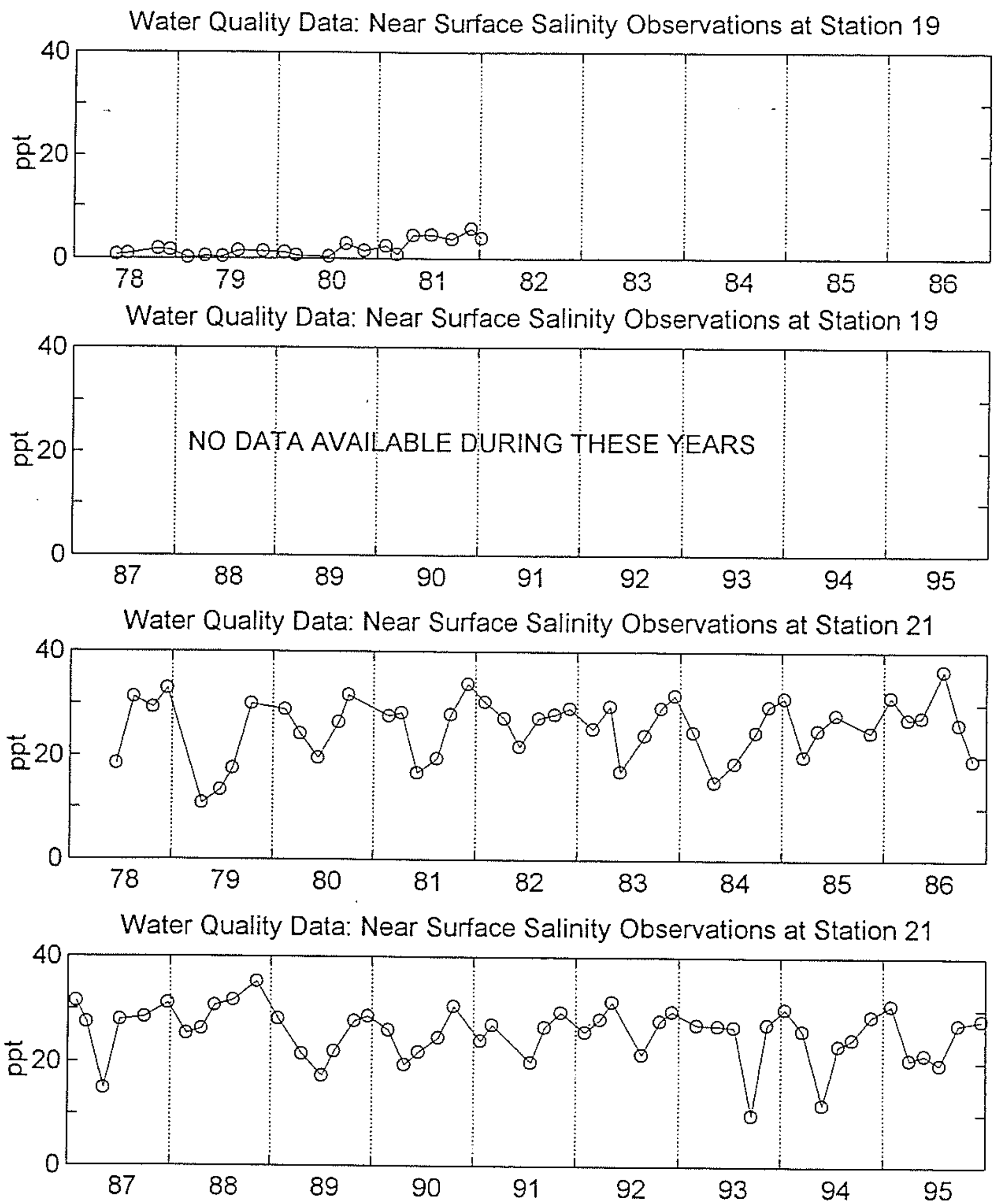

Figure C10. Monthly water chemistry data: top salinities, stations 19 and 21.

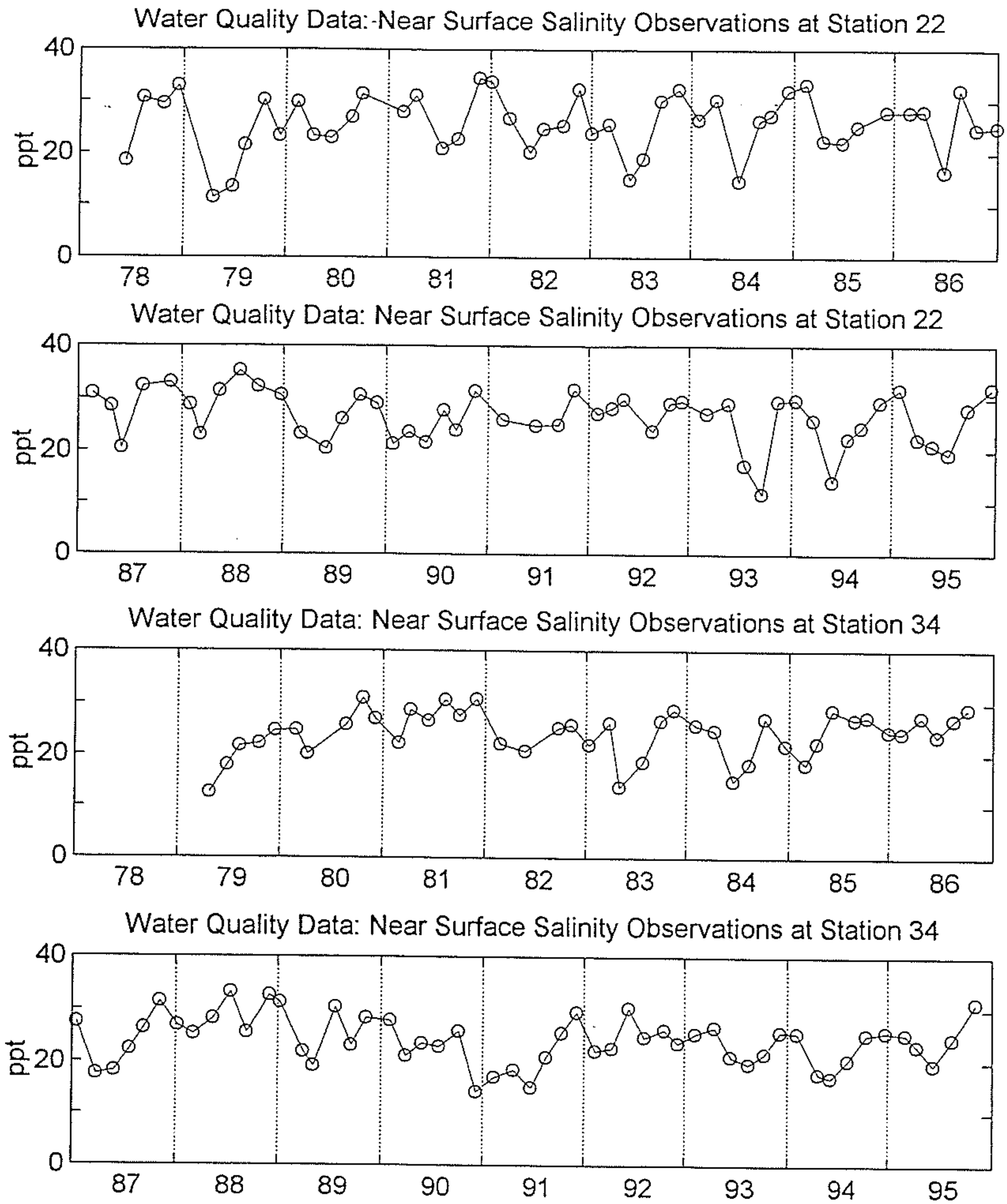

Figure C11. Monthly water chemistry data: top salinities, stations 22 and 34.

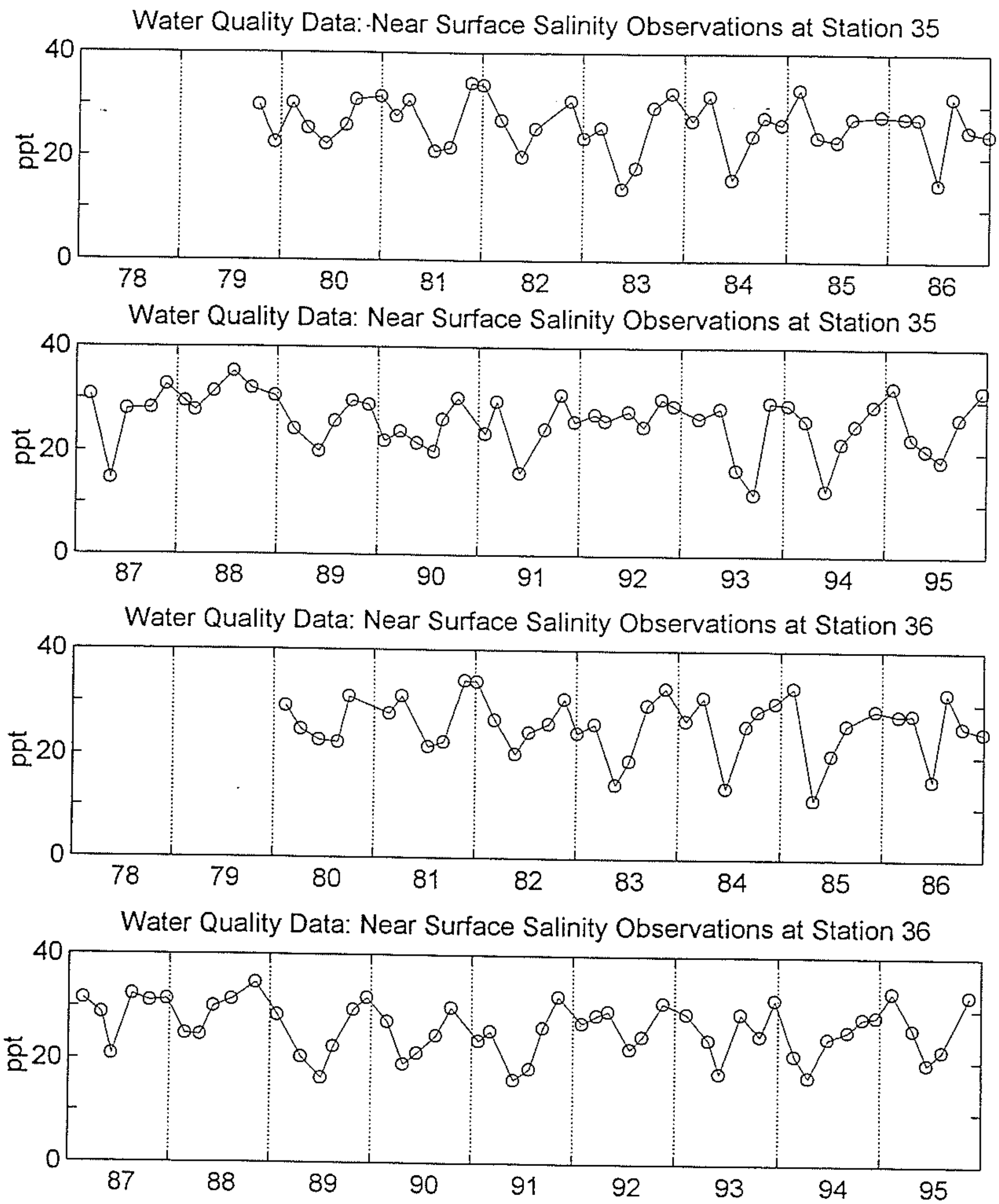

Figure C12. Monthly water chemistry data: top salinities, stations 35 and 36.

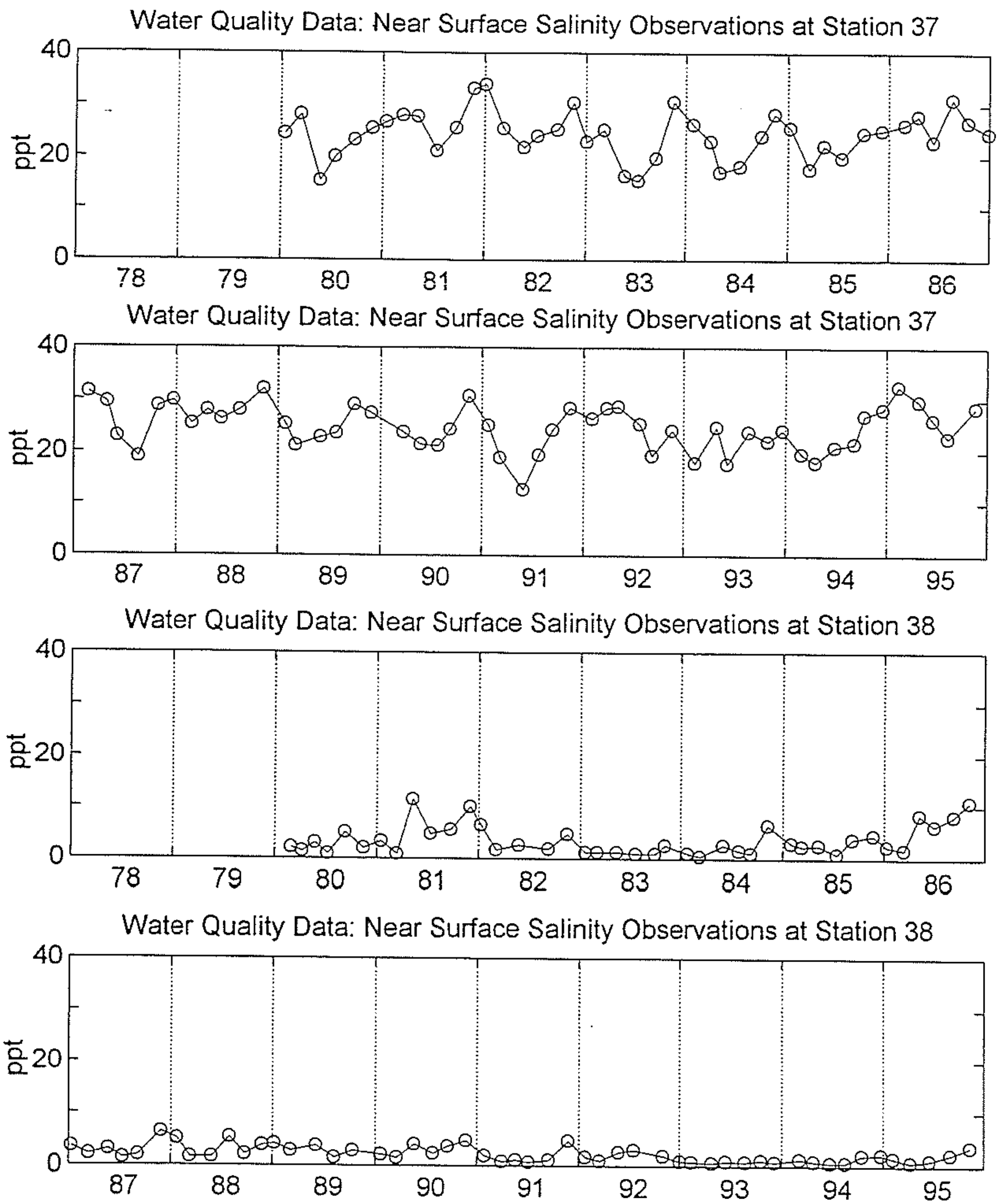

Figure C13. Monthly water chemistry data: top salinities, stations 37 and 38.

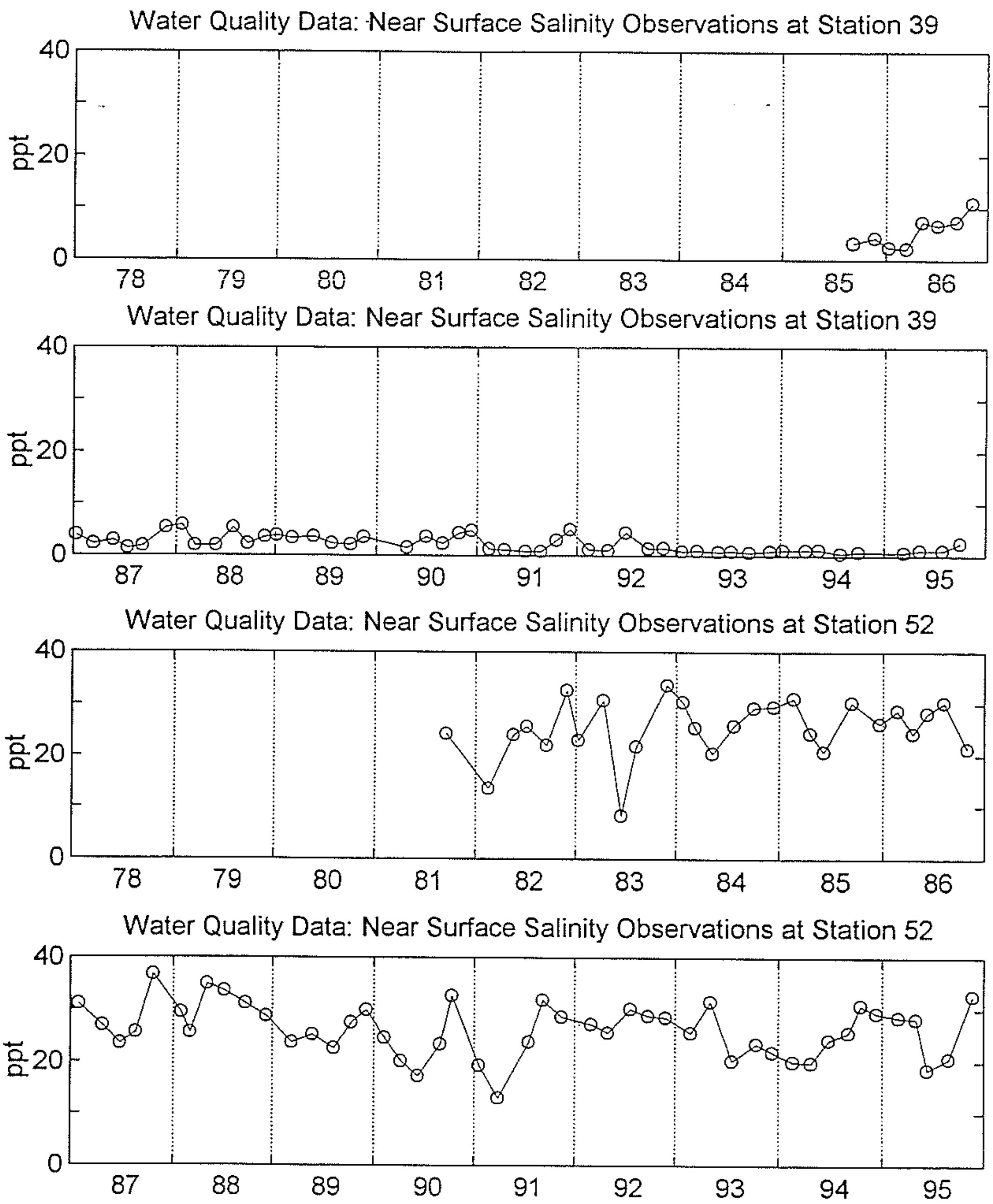

Figure C14. Monthly water chemistry data: top salinities, stations 39 and 52.

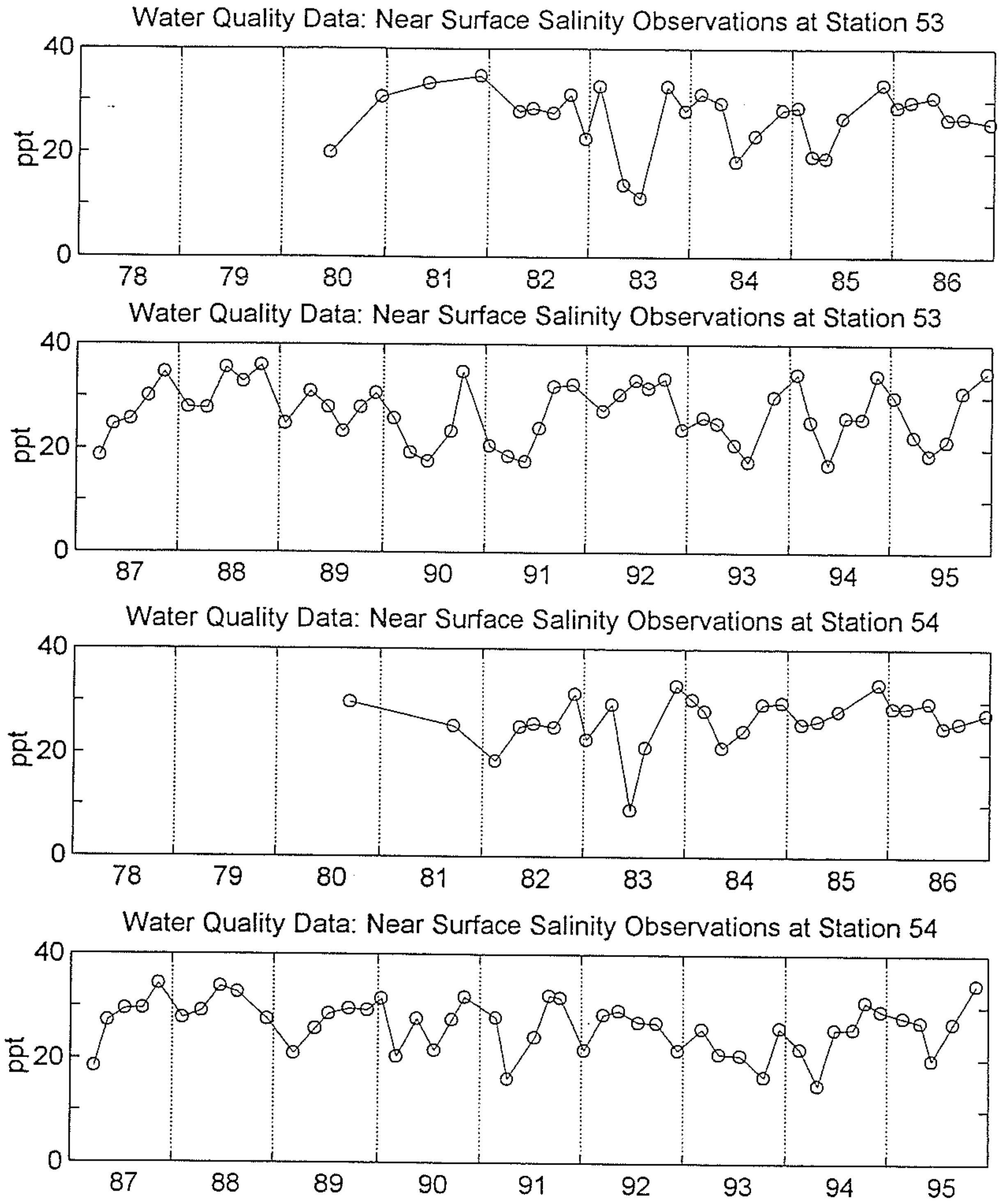

Figure C15. Monthly water chemistry data: top salinities, stations 53 and 54.

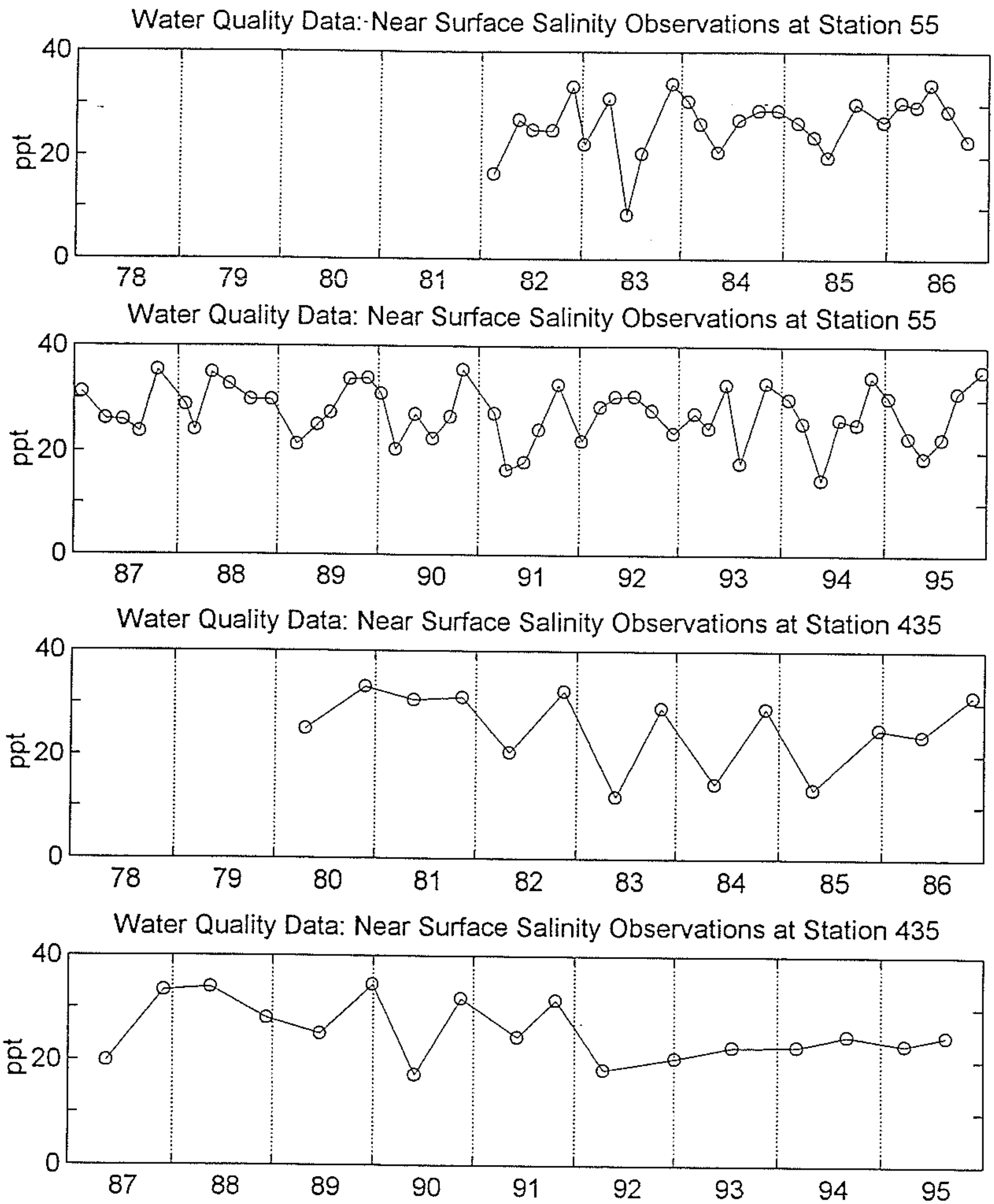

Figure C16. Monthly water chemistry data: top salinities, stations 55 and 435.

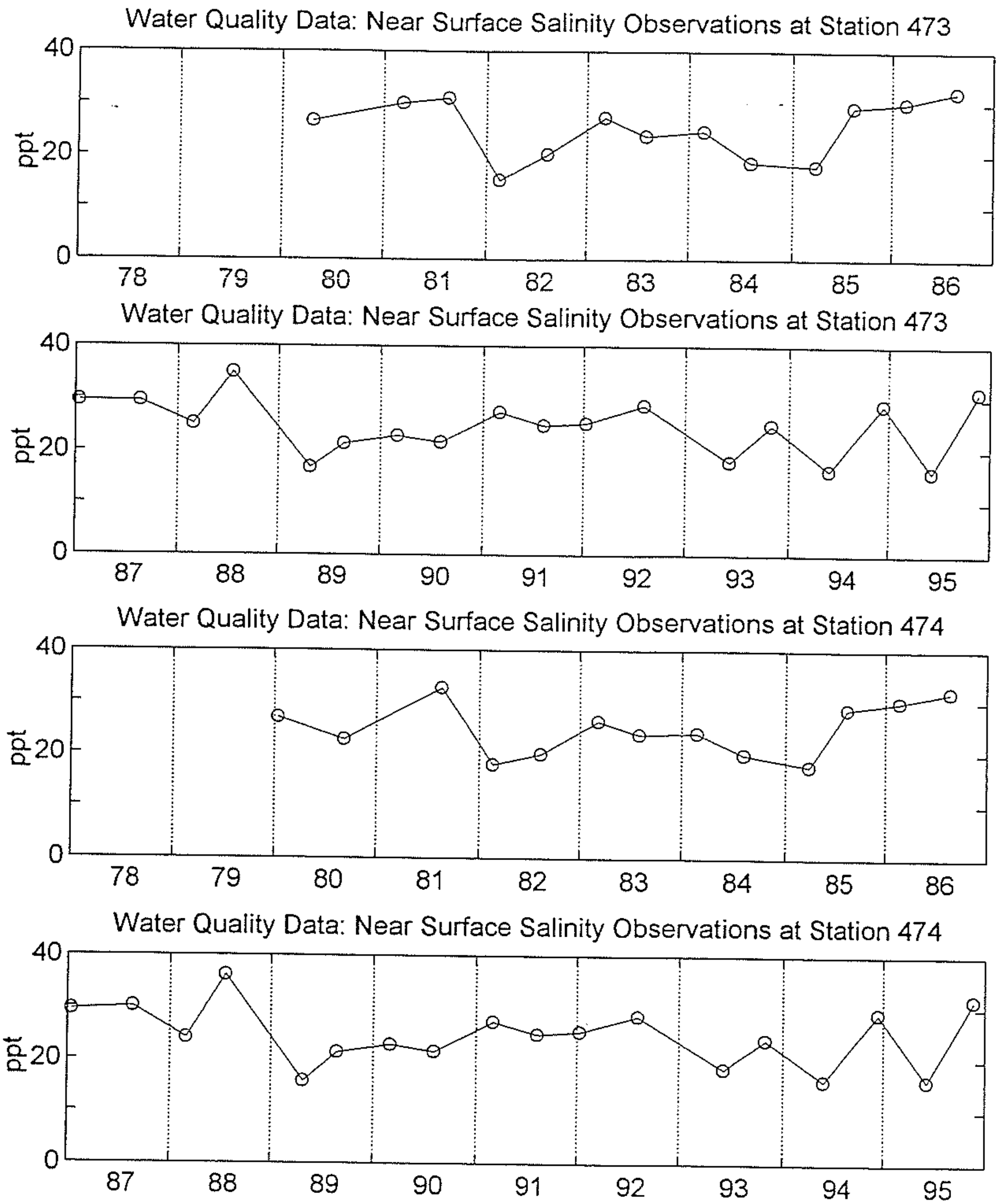

Figure C17. Monthly water chemistry data: top salinities, stations 473 and 474.

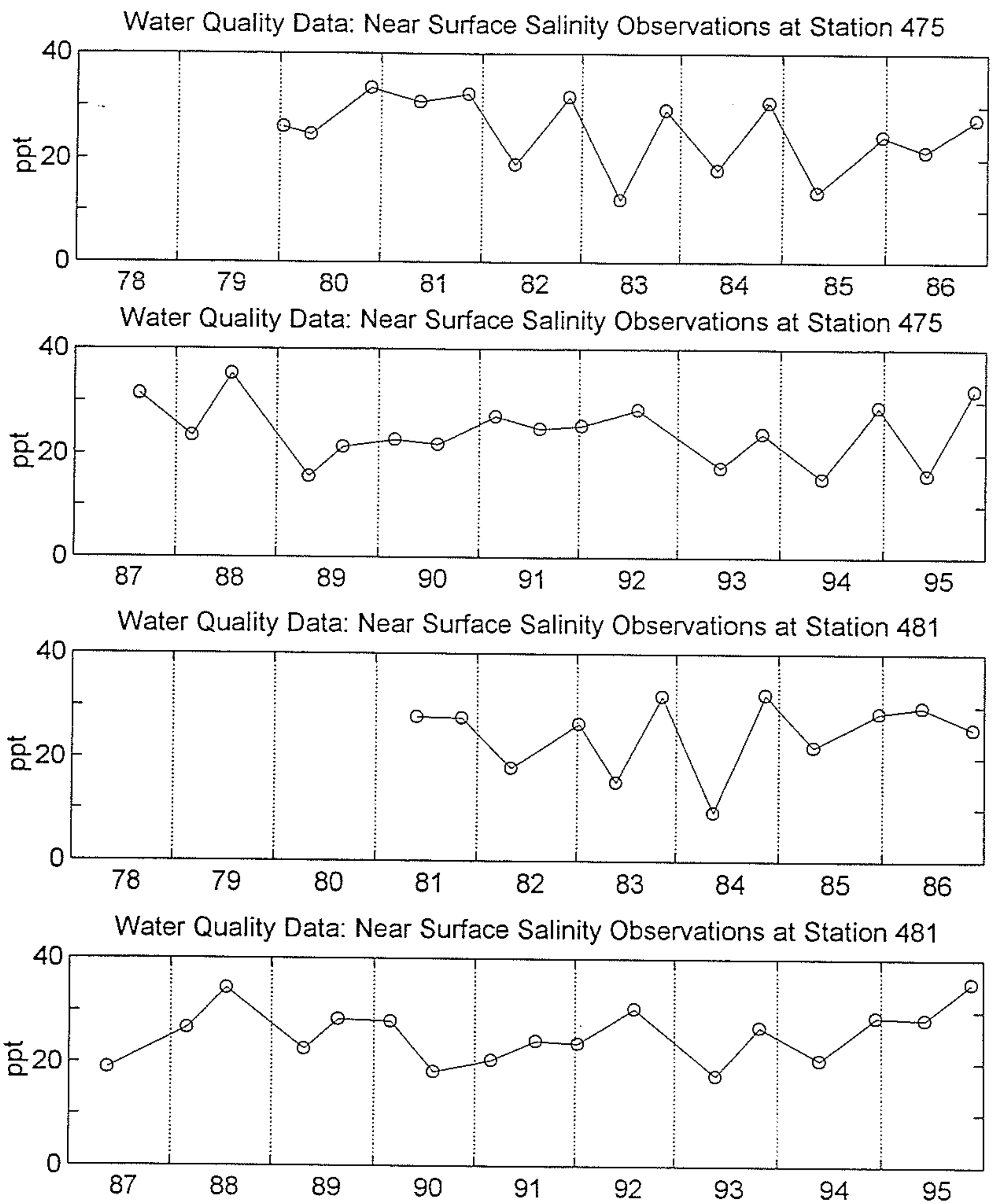

Figure C18. Monthly water chemistry data: top salinities, stations 475 and 481.

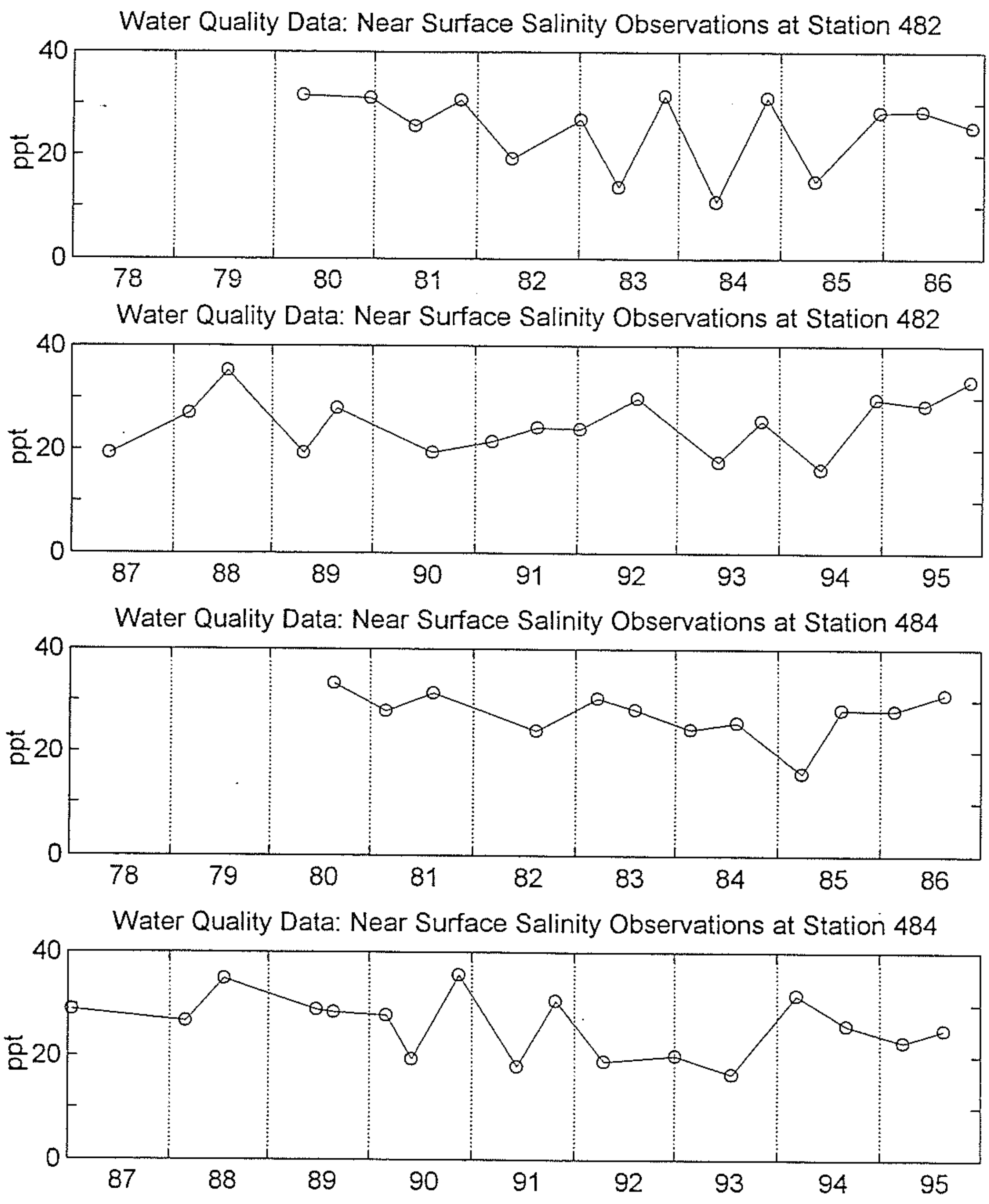

Figure C19. Monthly water chemistry data: top salinities, stations 482 and 484.

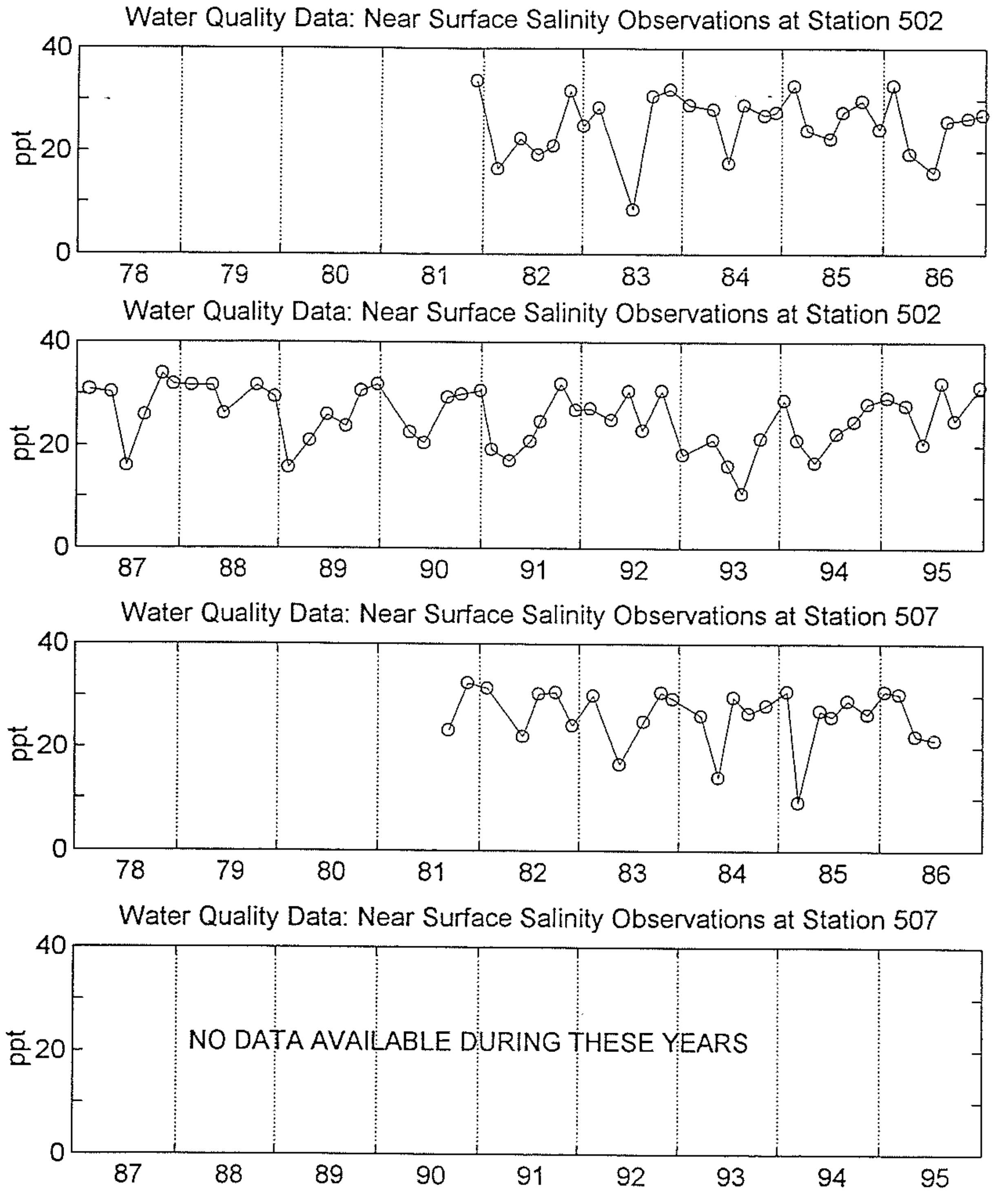

Figure C20. Monthly water chemistry data: top salinities, stations 502 and 507.

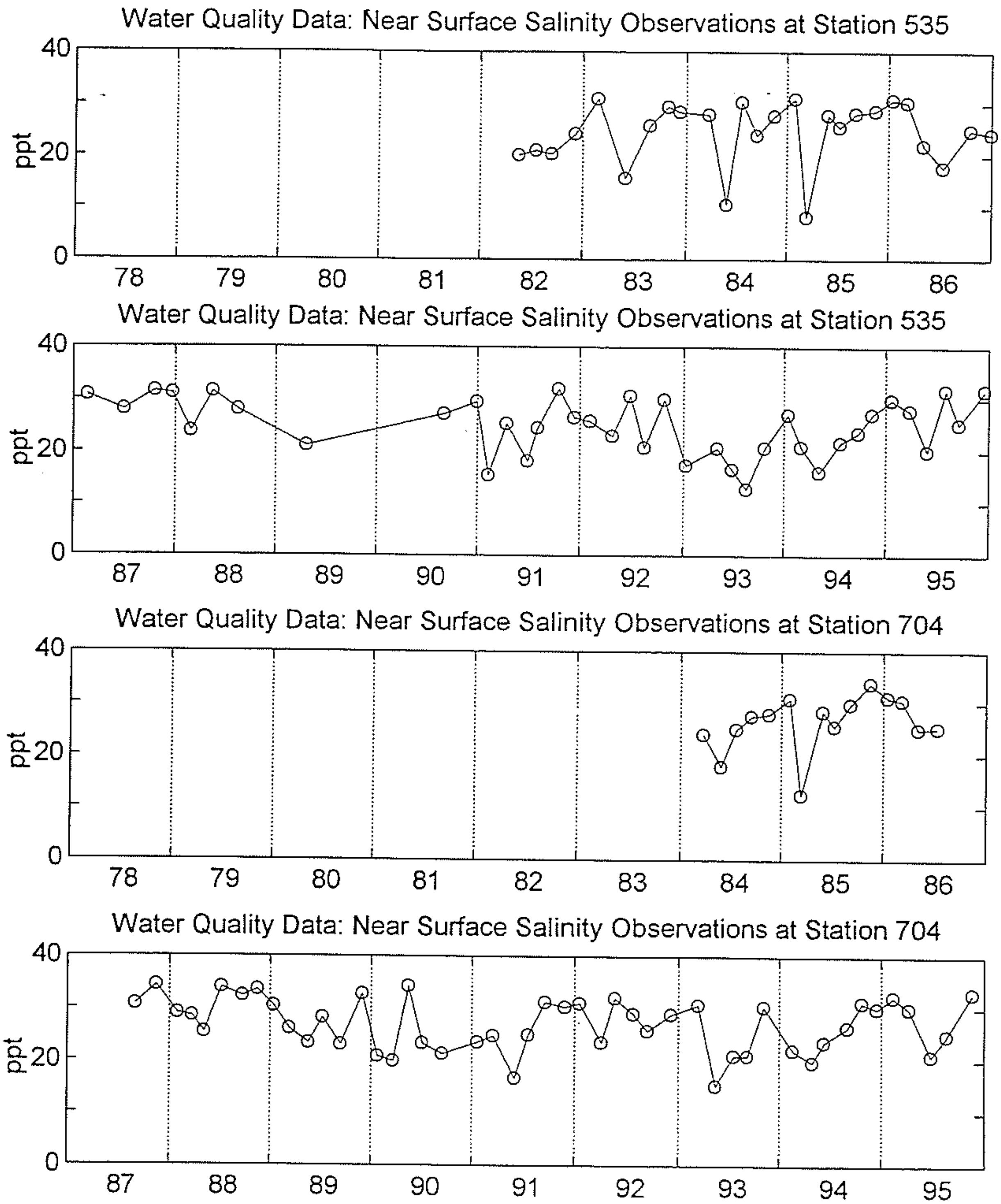

Figure C21. Monthly water chemistry data: top salinities, stations 535 and 704.

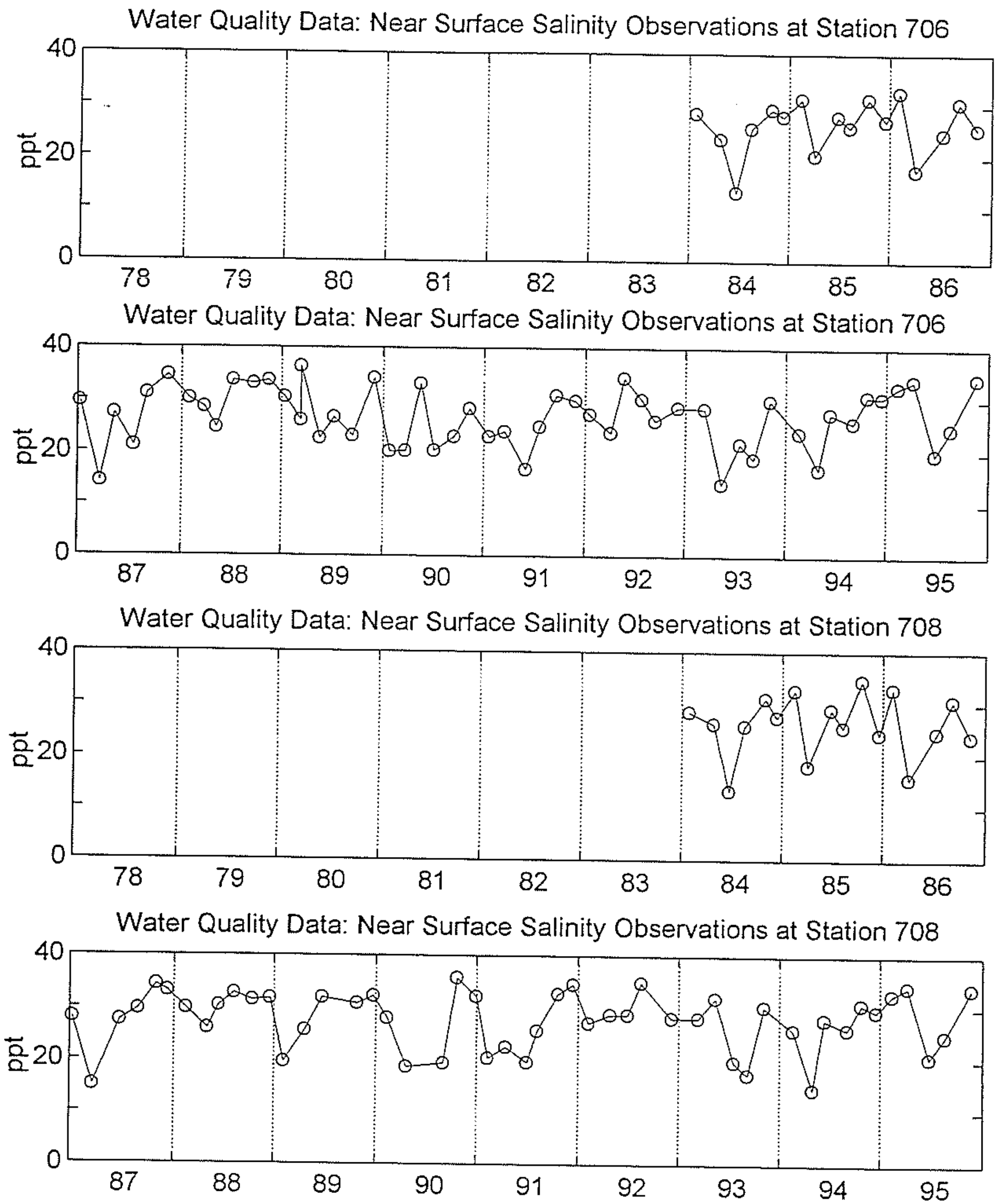

Figure C22. Monthly water chemistry data: top salinities, stations 706 and 708.

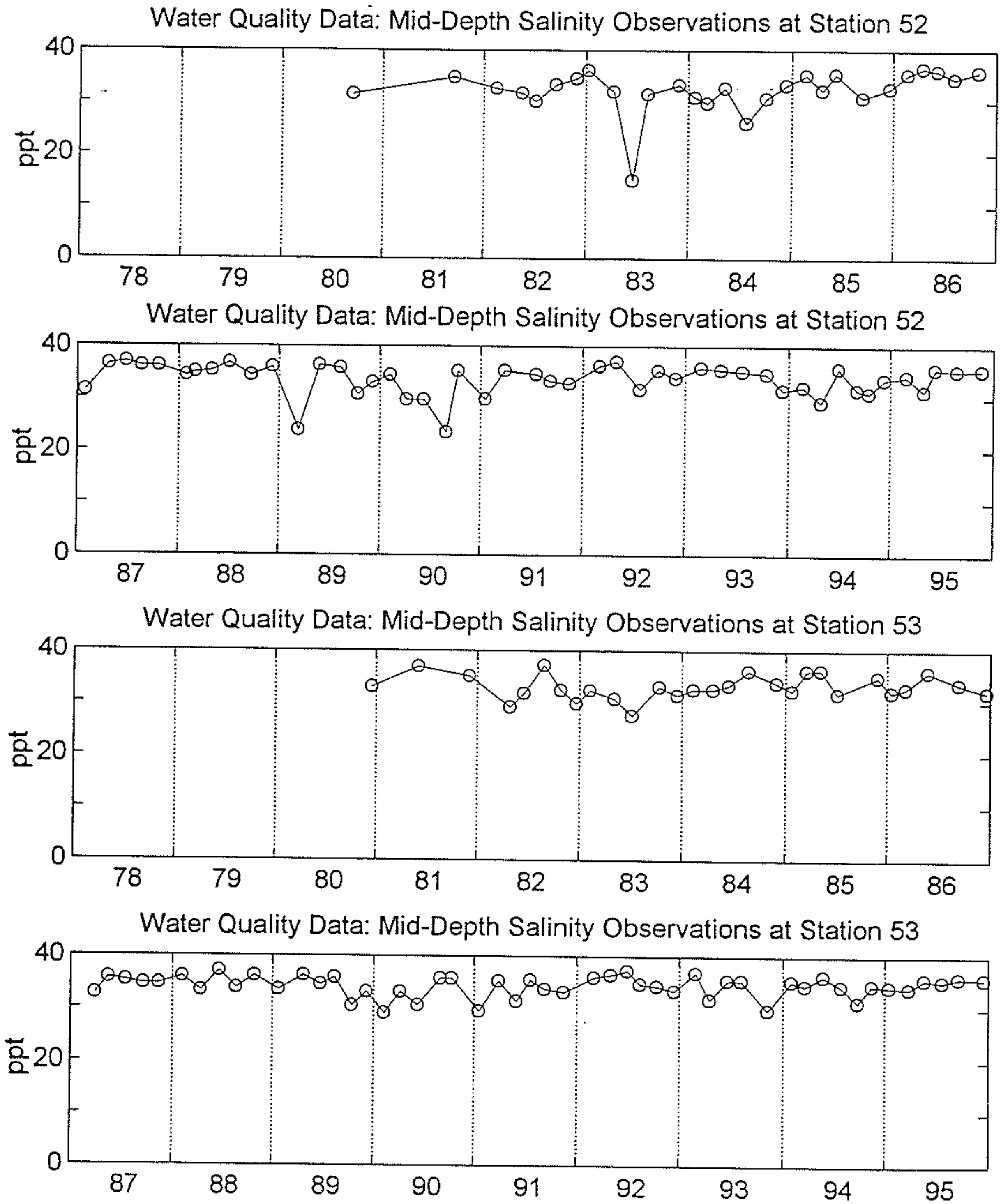

Figure C23. Monthly water chemistry data: middle salinities, stations 52 and 53.

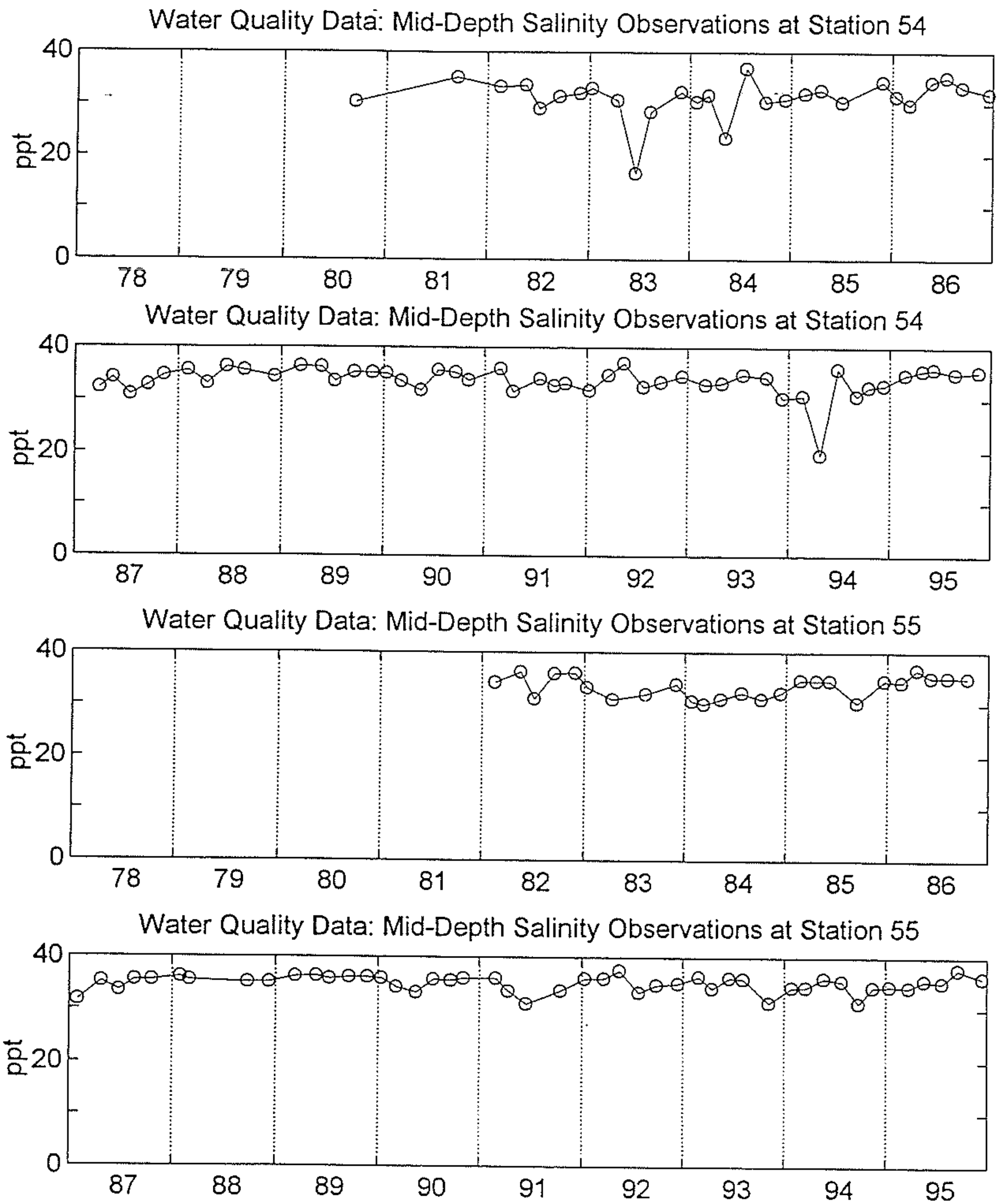

Figure C24. Monthly water chemistry data: middle salinities, stations 54 and 55.

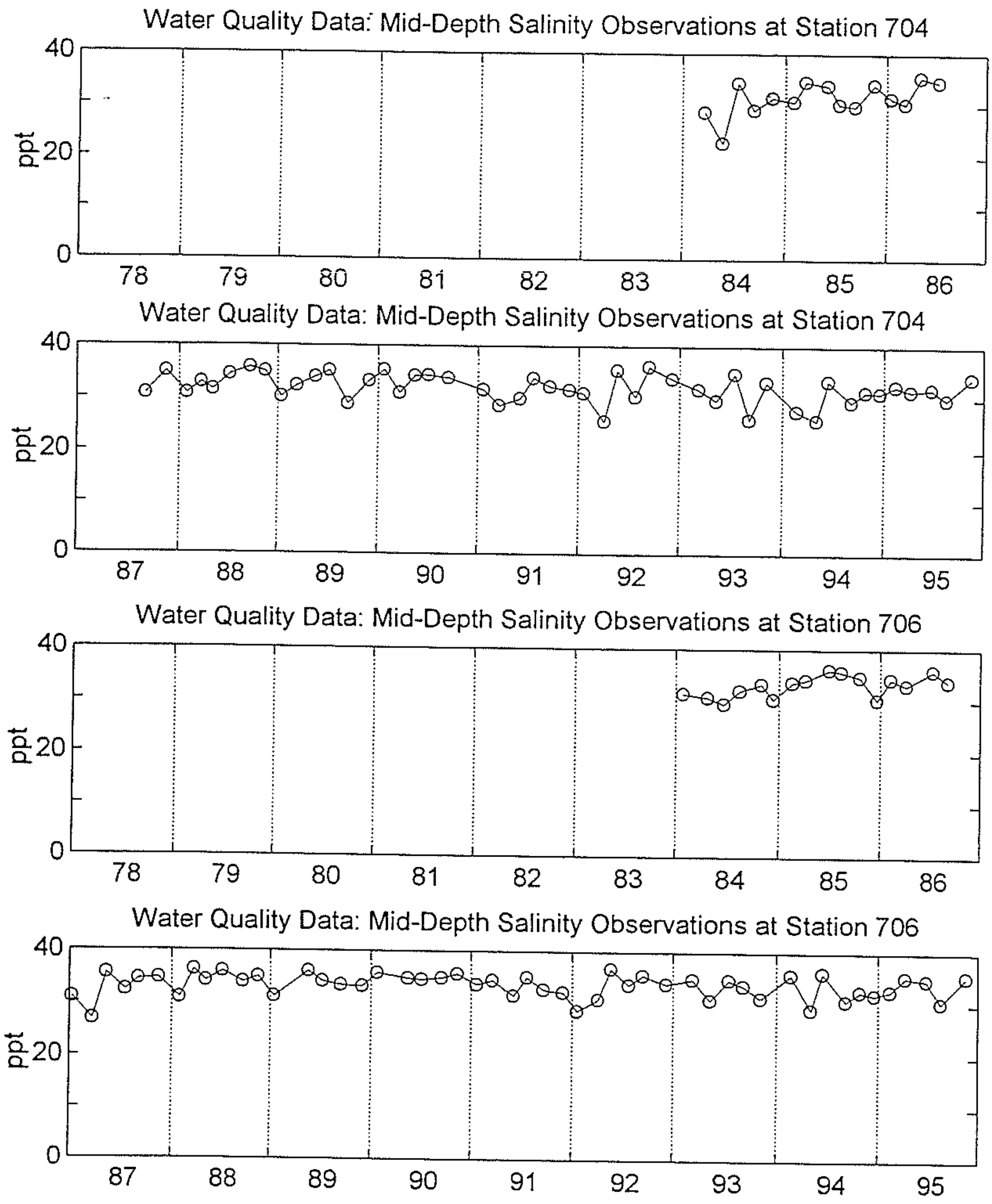

Figure C25. Monthly water chemistry data: middle salinities, stations 704 and 706.

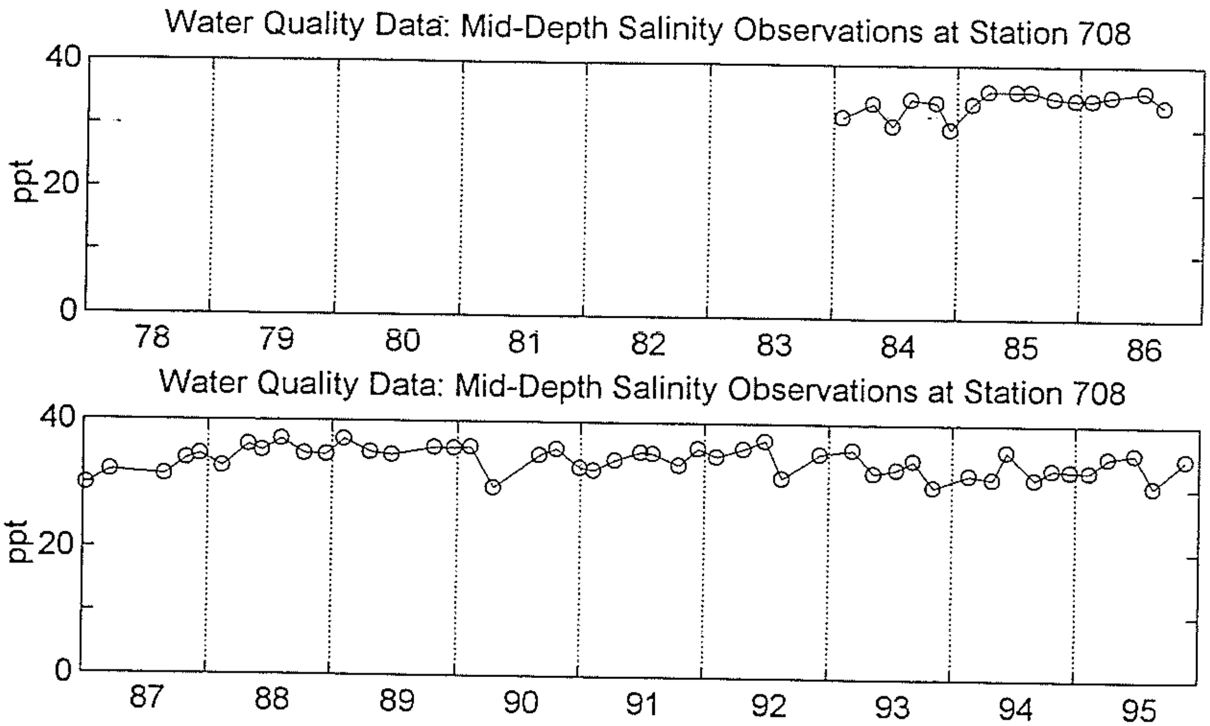

Figure C26. Monthly water chemistry data: middle salinities, station 708.

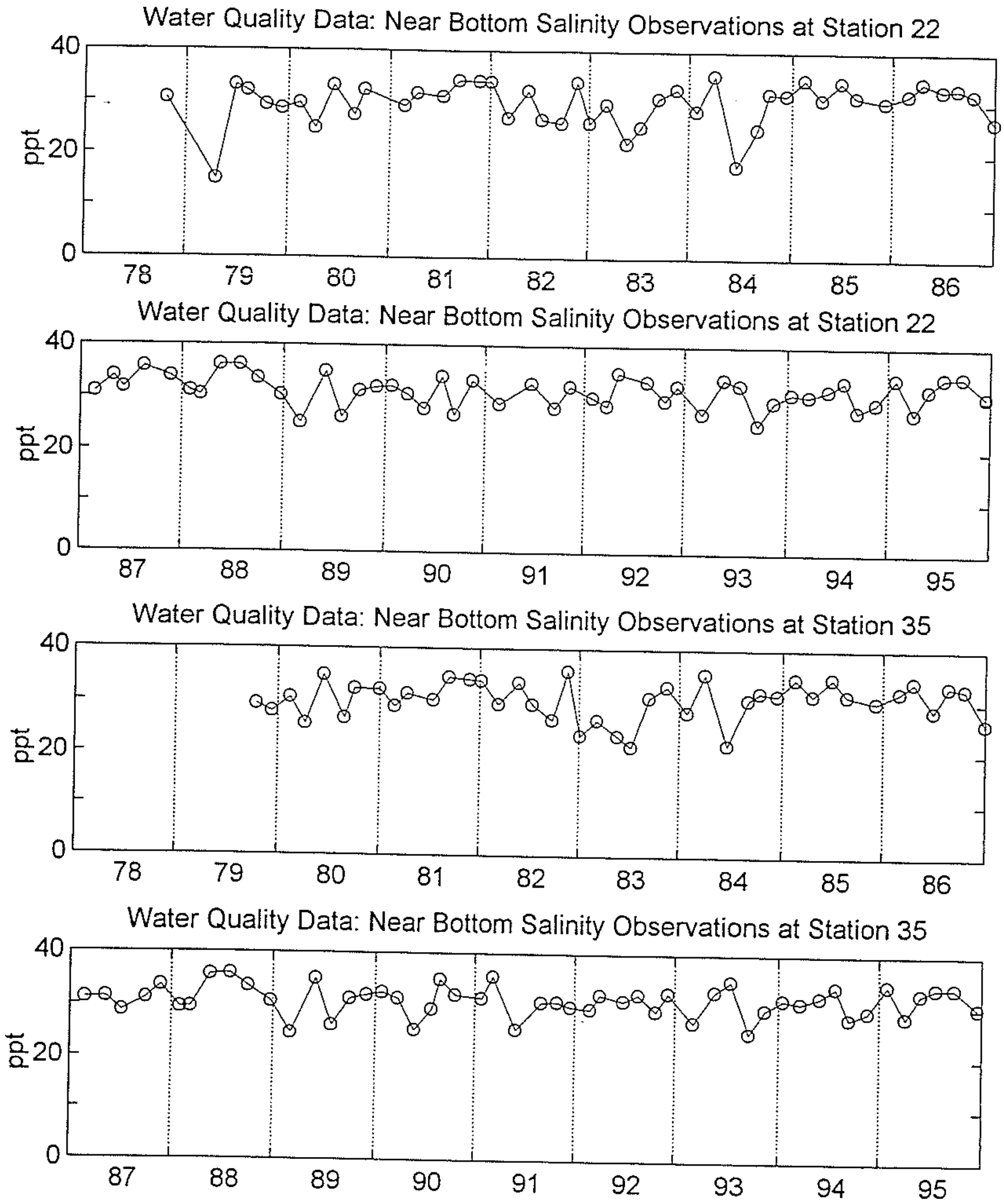

Figure C29. Monthly water chemistry data: bottom salinities, stations 22 and 35.

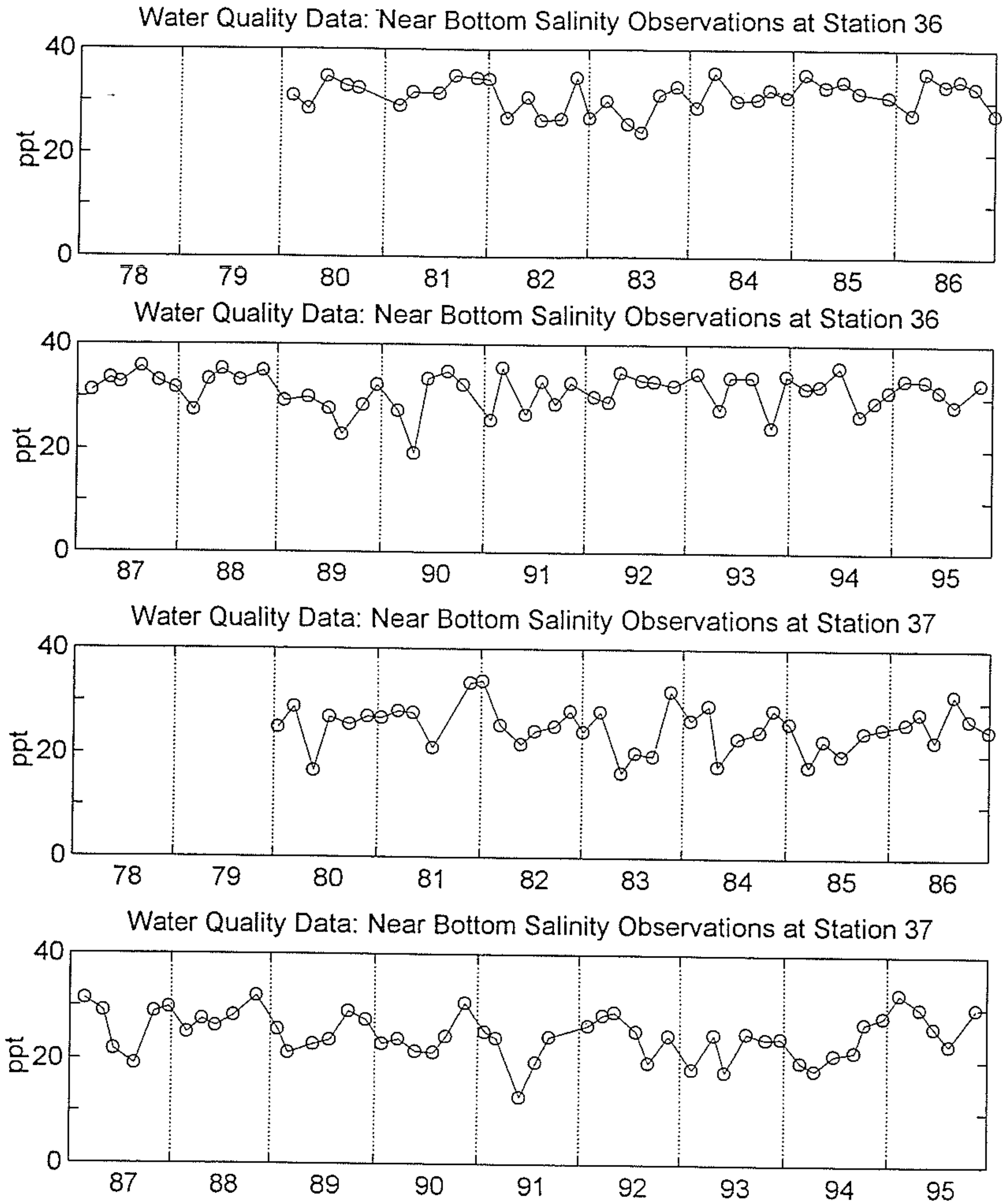

Figure C30. Monthly water chemistry data: bottom salinities, stations 36 and 37.

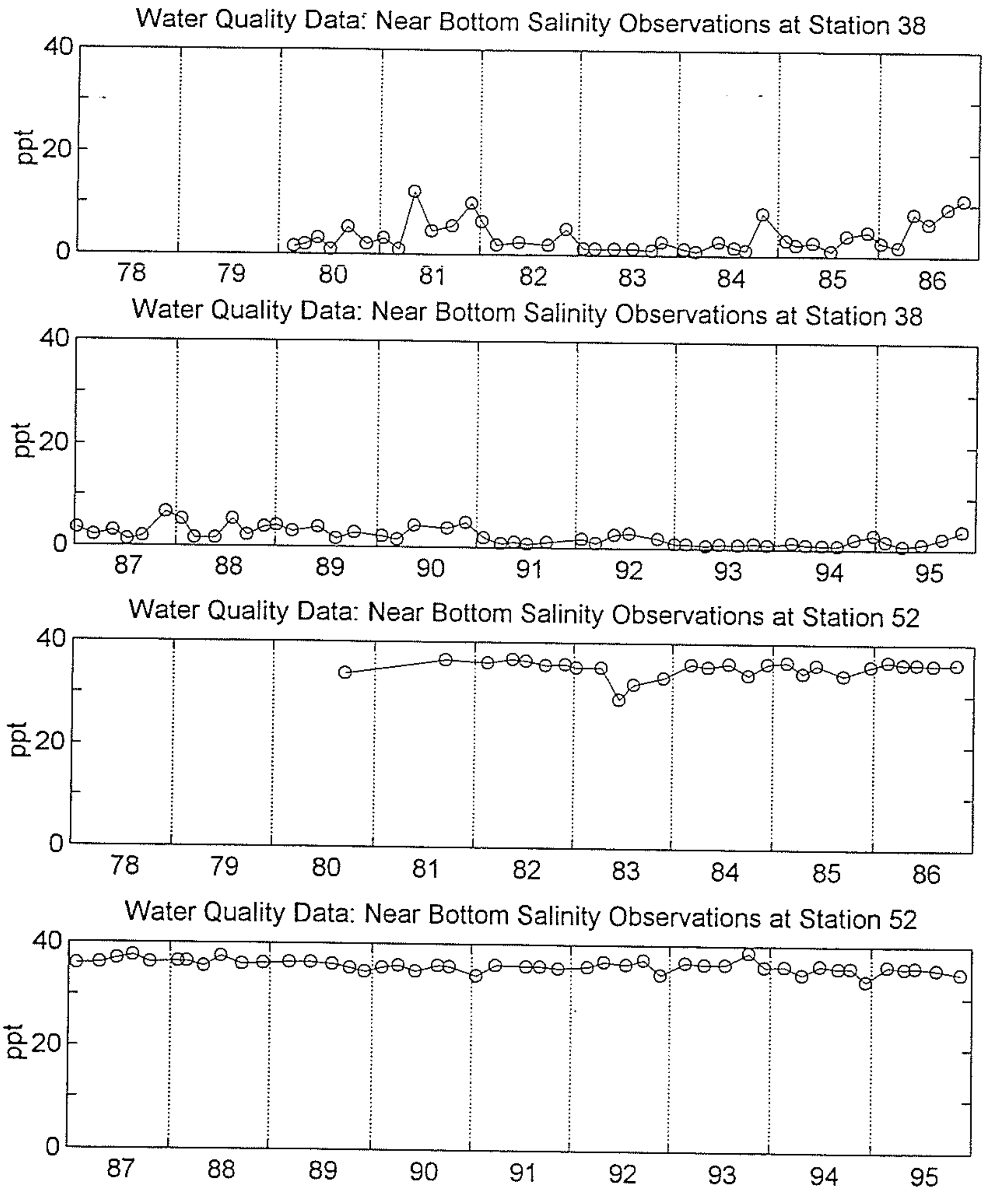

Figure C31. Monthly water chemistry data: bottom salinities, stations 38 and 52.

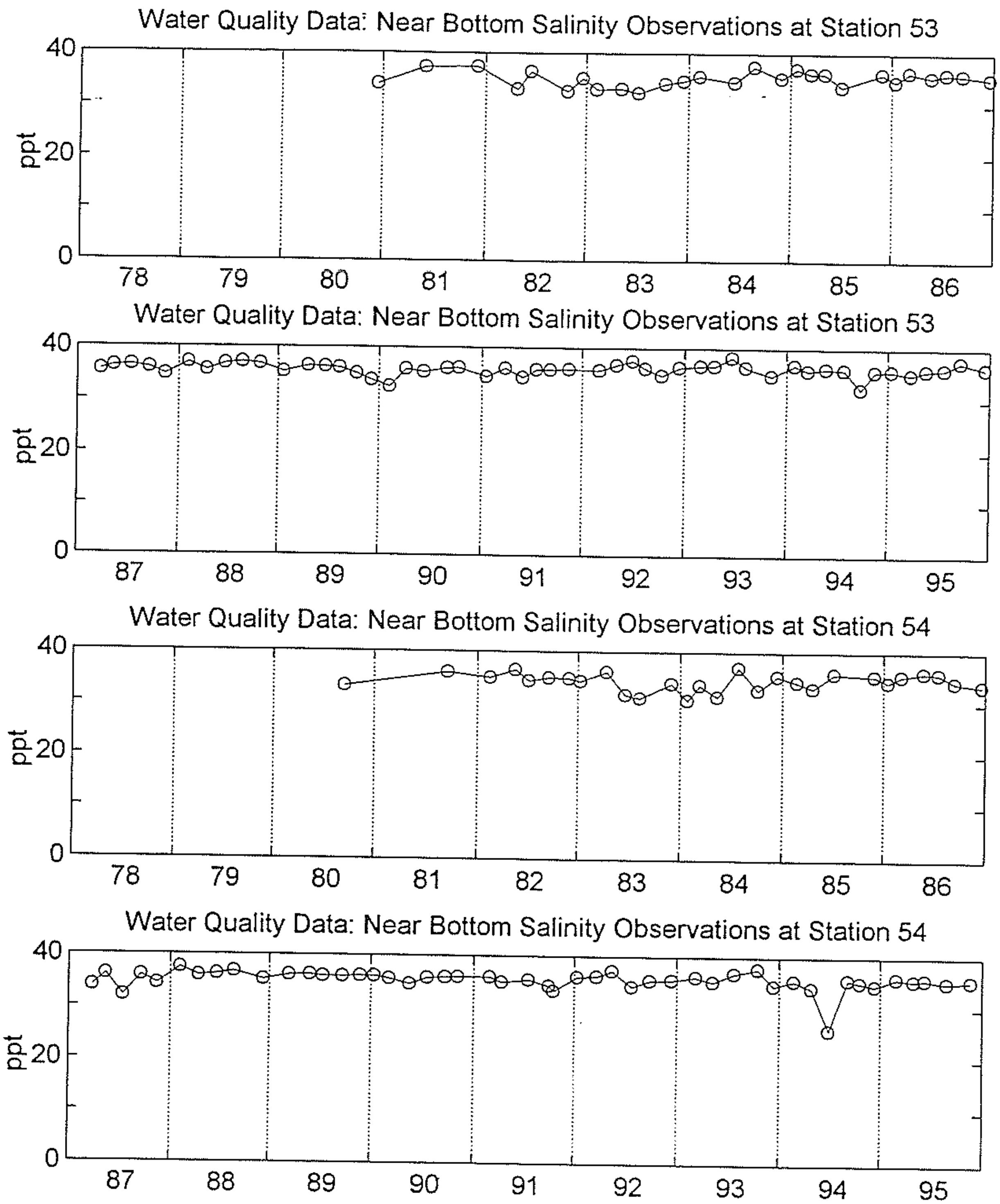

Figure C32. Monthly water chemistry data: bottom salinities, stations 53 and 54.

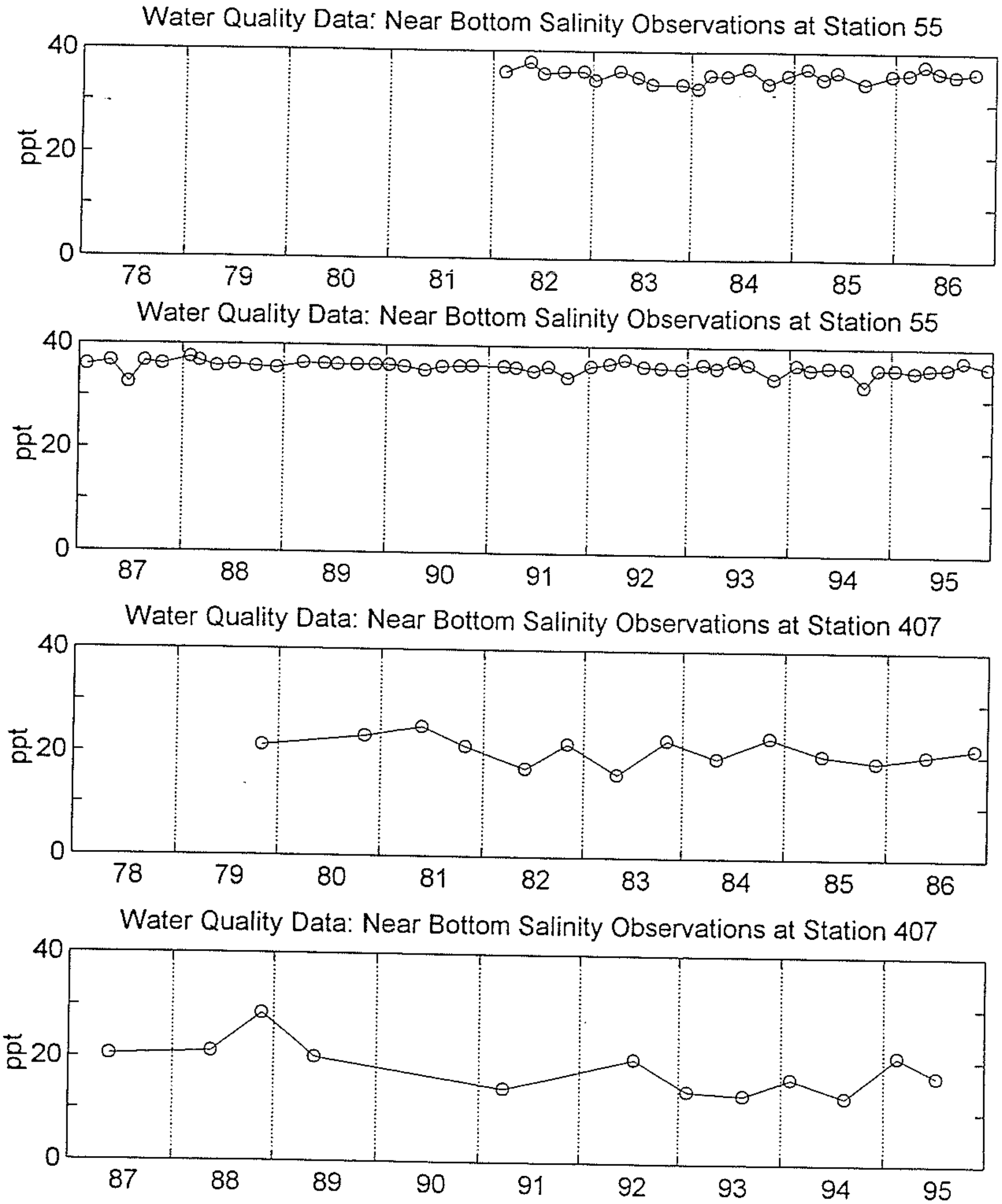

Figure C33. Monthly water chemistry data: bottom salinities, stations 55 and 407.

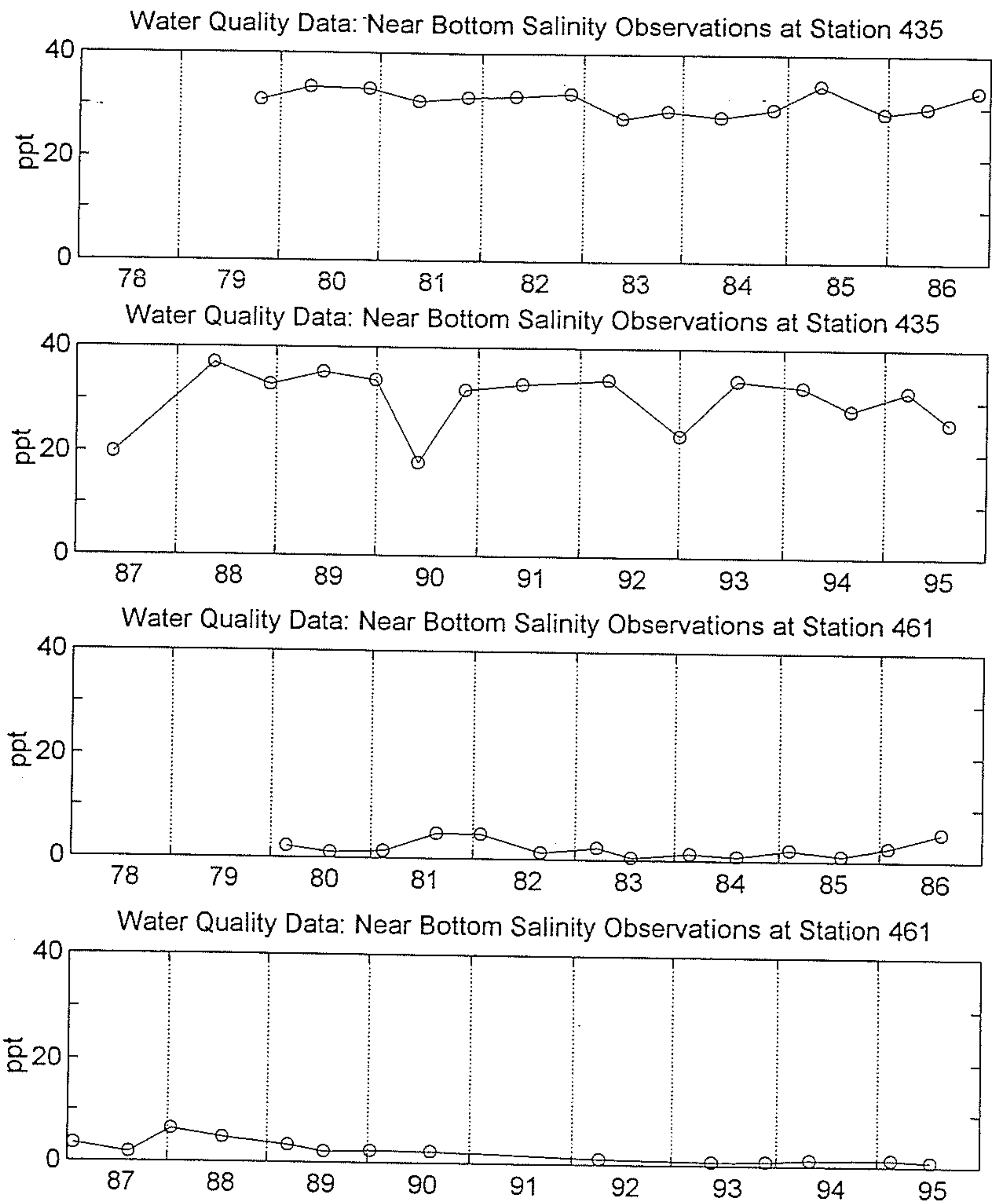

Figure C34. Monthly water chemistry data: bottom salinities, stations 435 and 461.

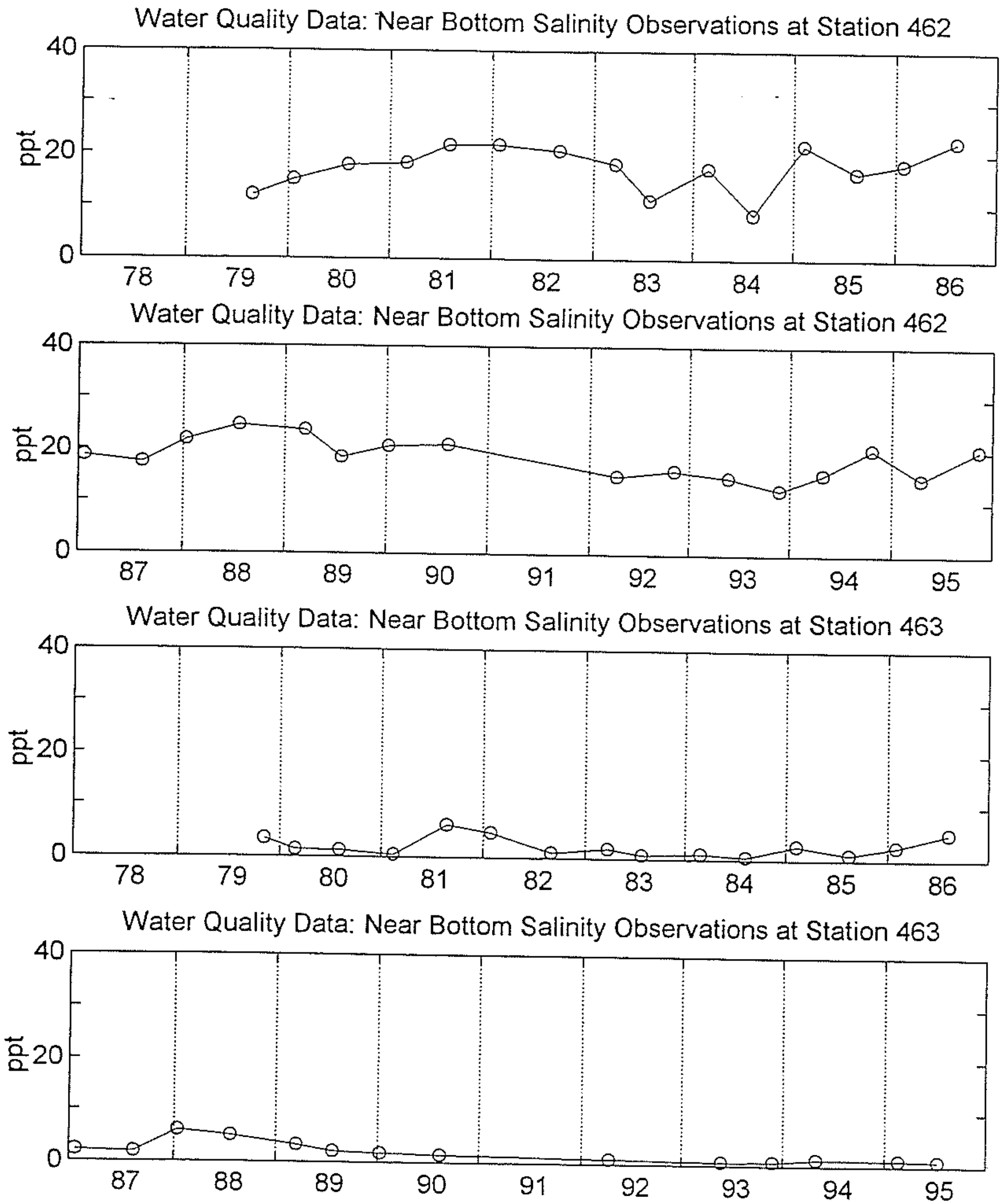

Figure C35. Monthly water chemistry data: bottom salinities, stations 462 and 463.

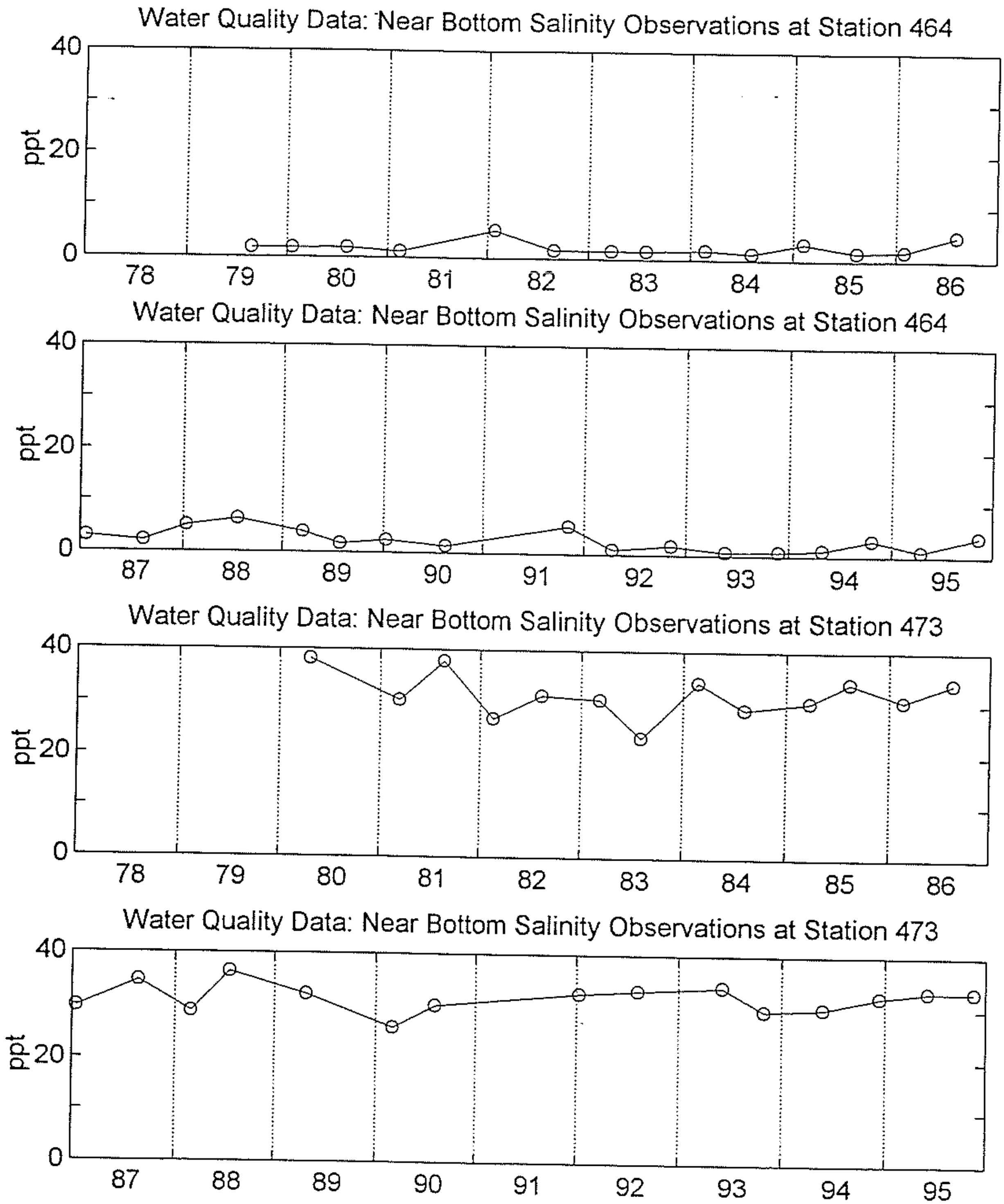

Figure C36. Monthly water chemistry data: bottom salinities, stations 464 and 473.

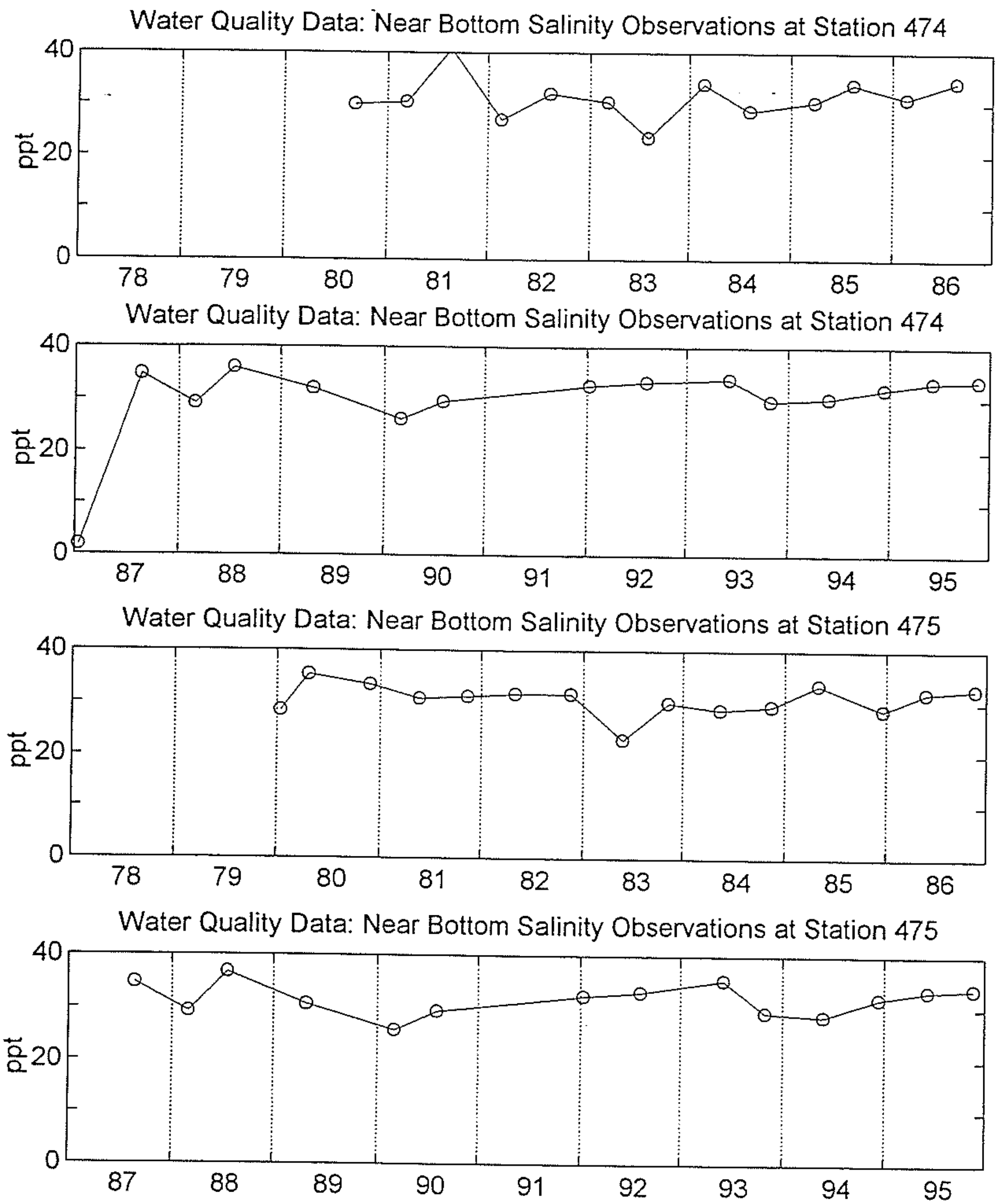

Figure C37. Monthly water chemistry data: bottom salinities, stations 474 and 475.

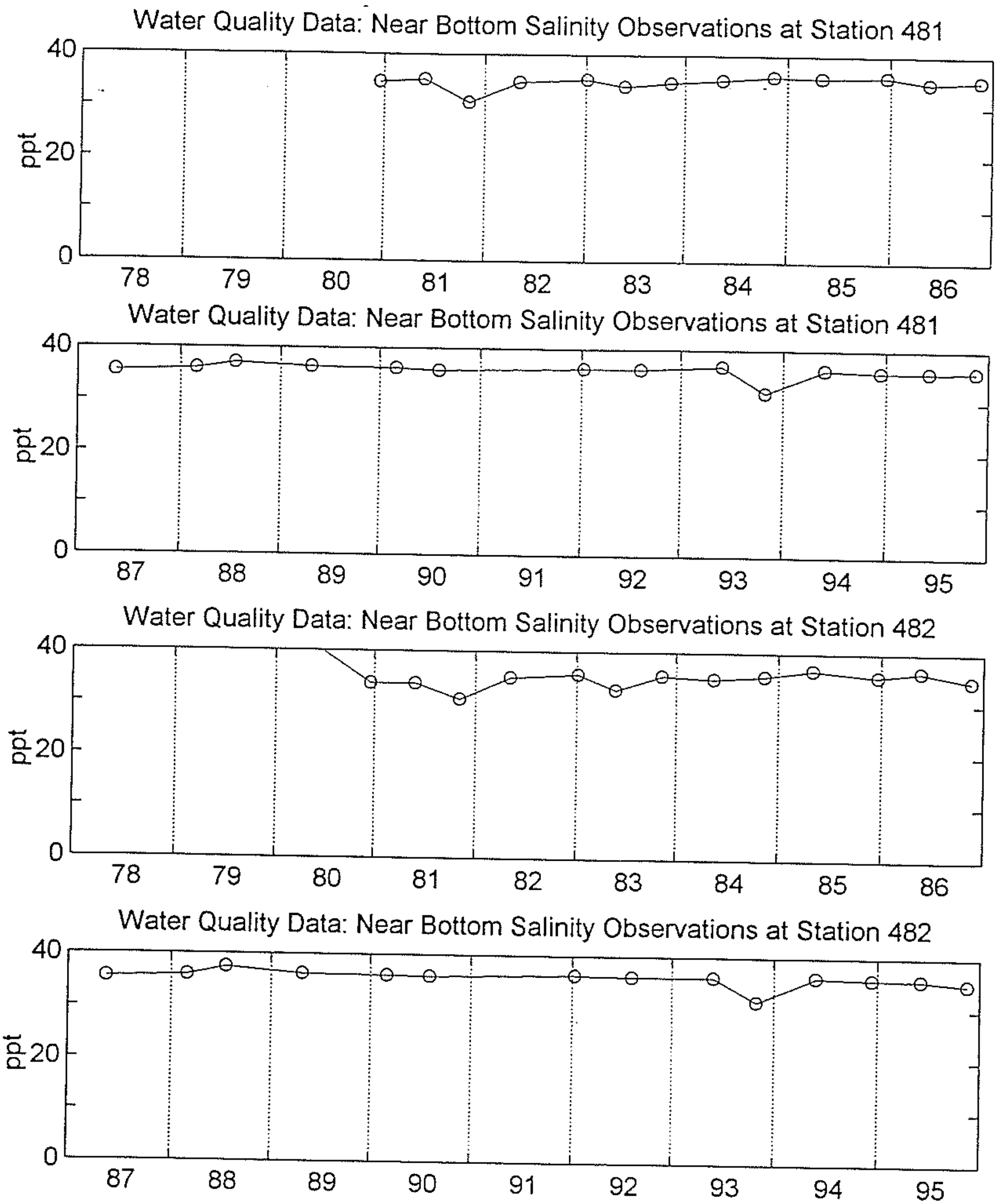

Figure C38. Monthly water chemistry data: bottom salinities, stations 481 and 482.

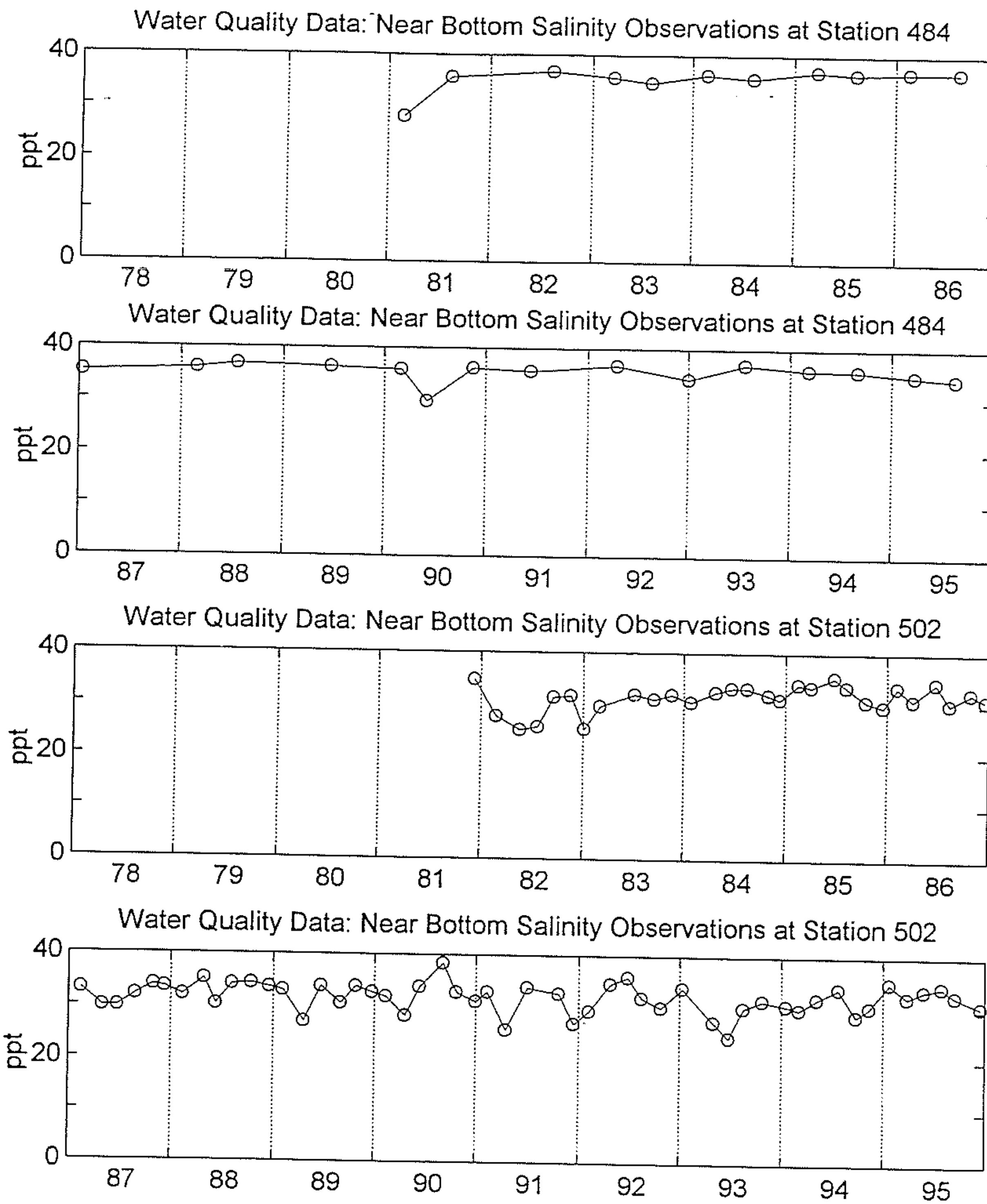

Figure C39. Monthly water chemistry data: bottom salinities, stations 484 and 502.

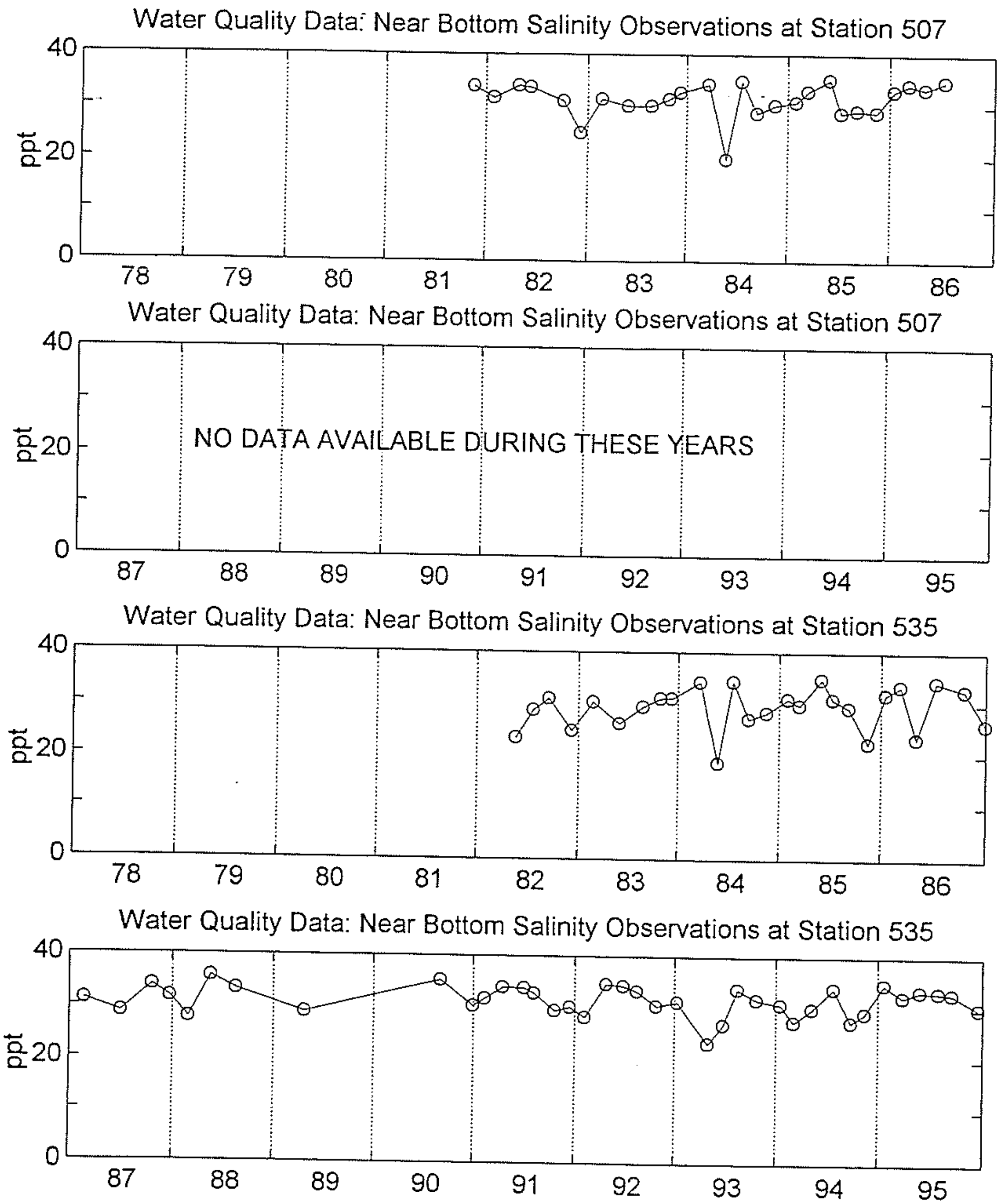

Figure C40. Monthly water chemistry data: bottom salinities, stations 507 and 535.

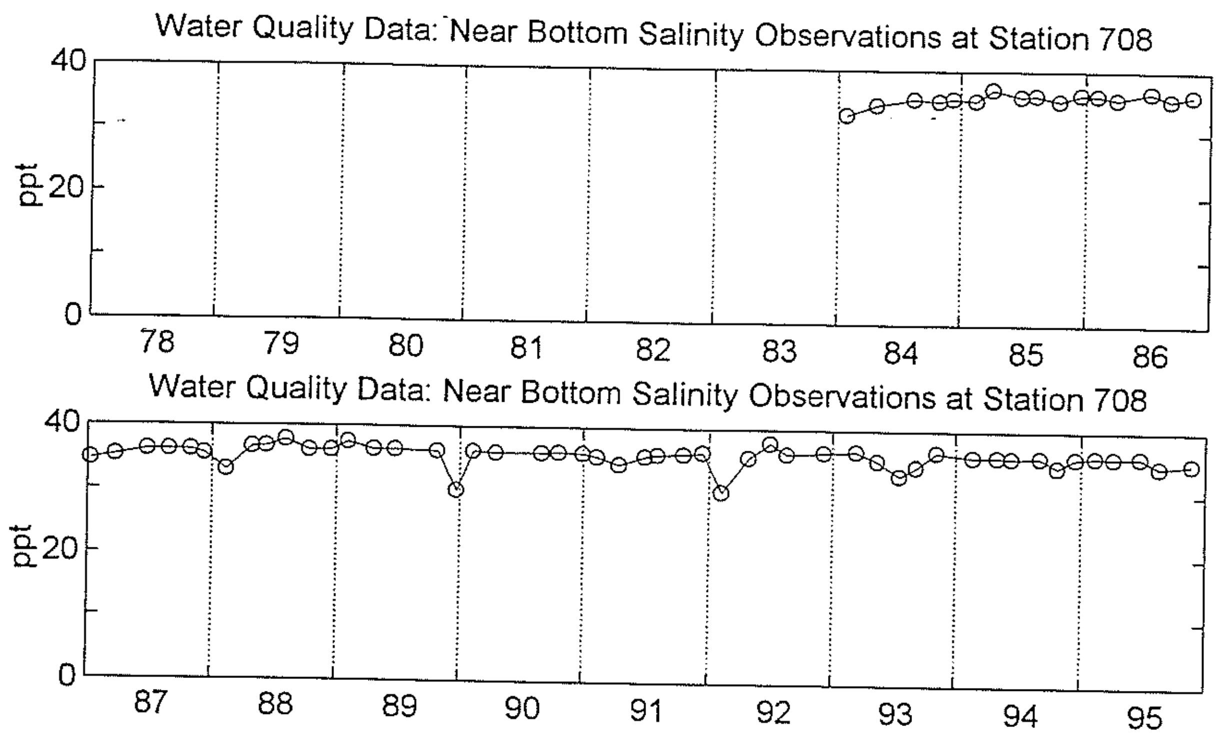

Figure C41. Monthly water chemistry data: bottom salinities, stations 704 and 706.

APPENDIX D

MONTHLY STATISTICAL MOMENTS AT FIXED STATIONS

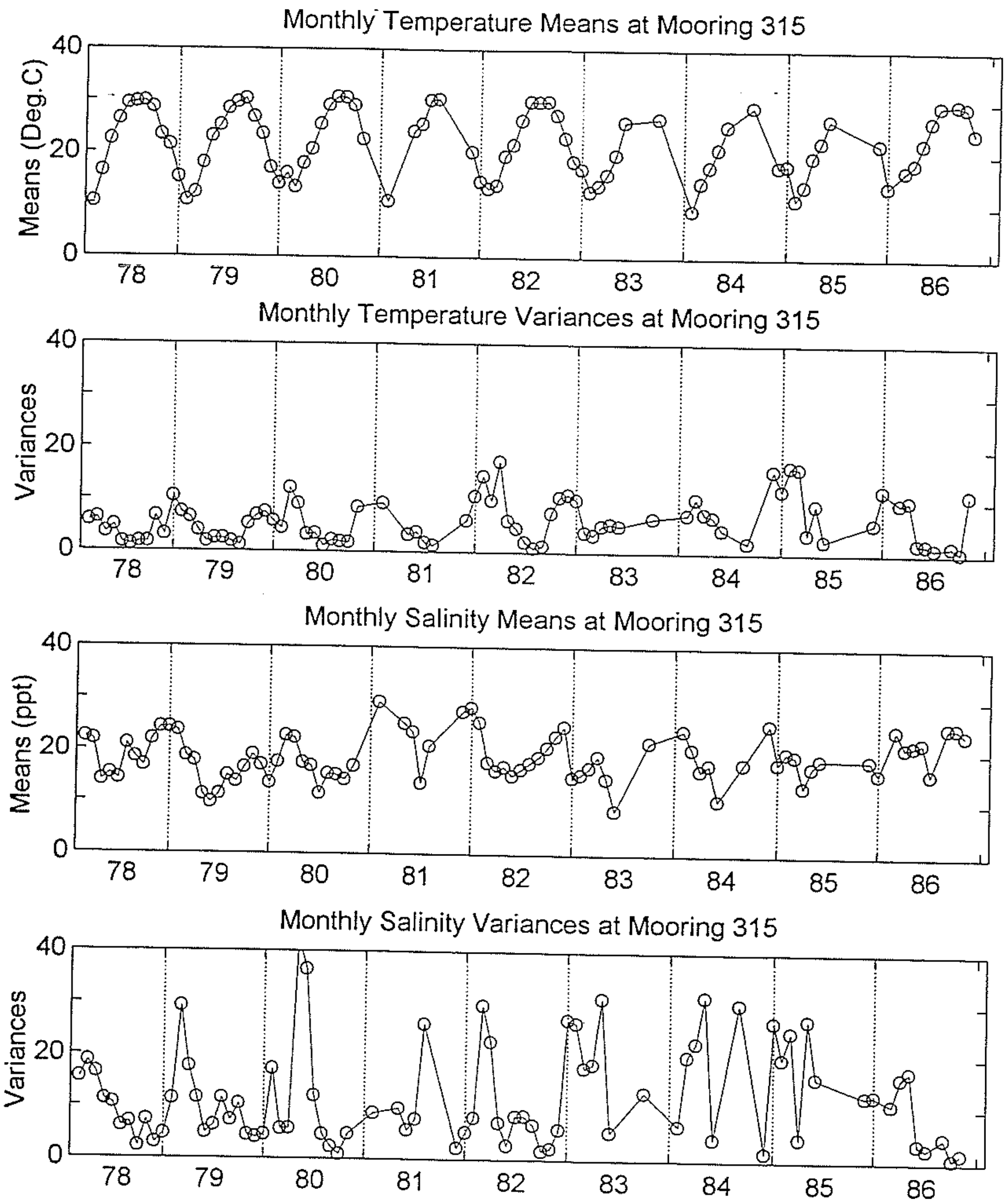

Figure D1. Monthly temperature and salinity means and variances at station 315, 1978-1986.

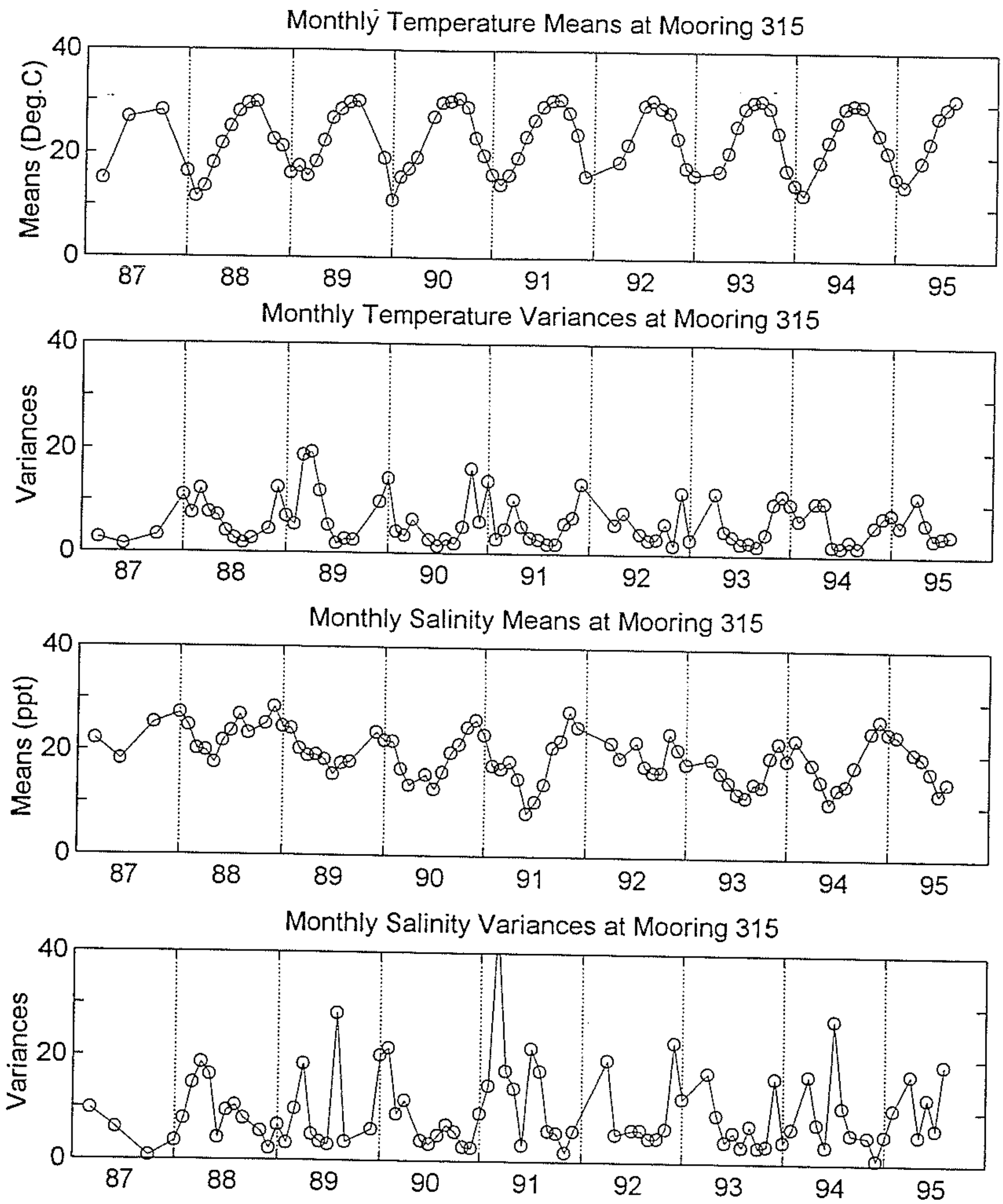

Figure D2. Monthly temperature and salinity means and variances at station 315, 1987-1995.

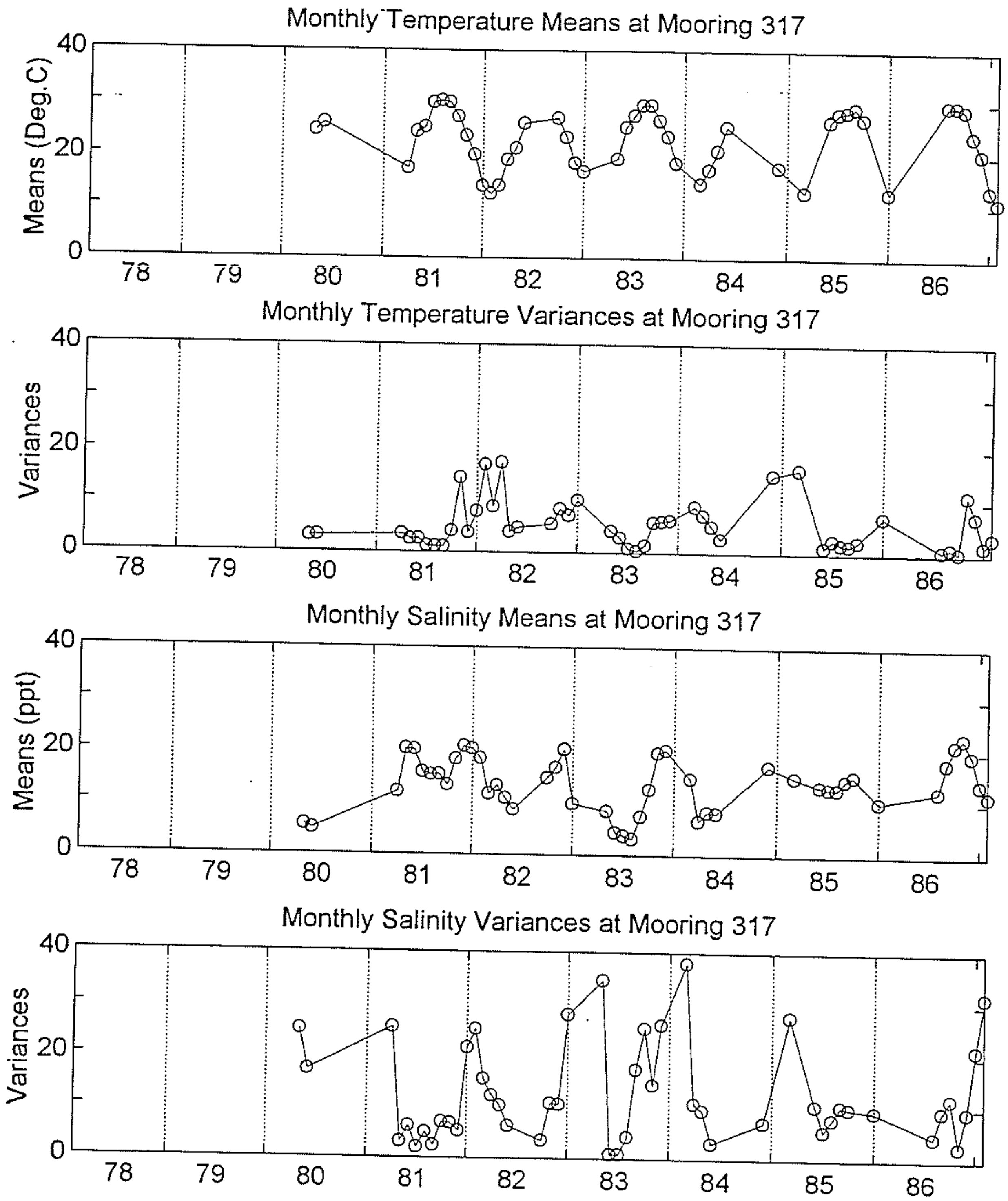

Figure D3. Monthly temperature and salinity means and variances at station 317, 1980-1986.

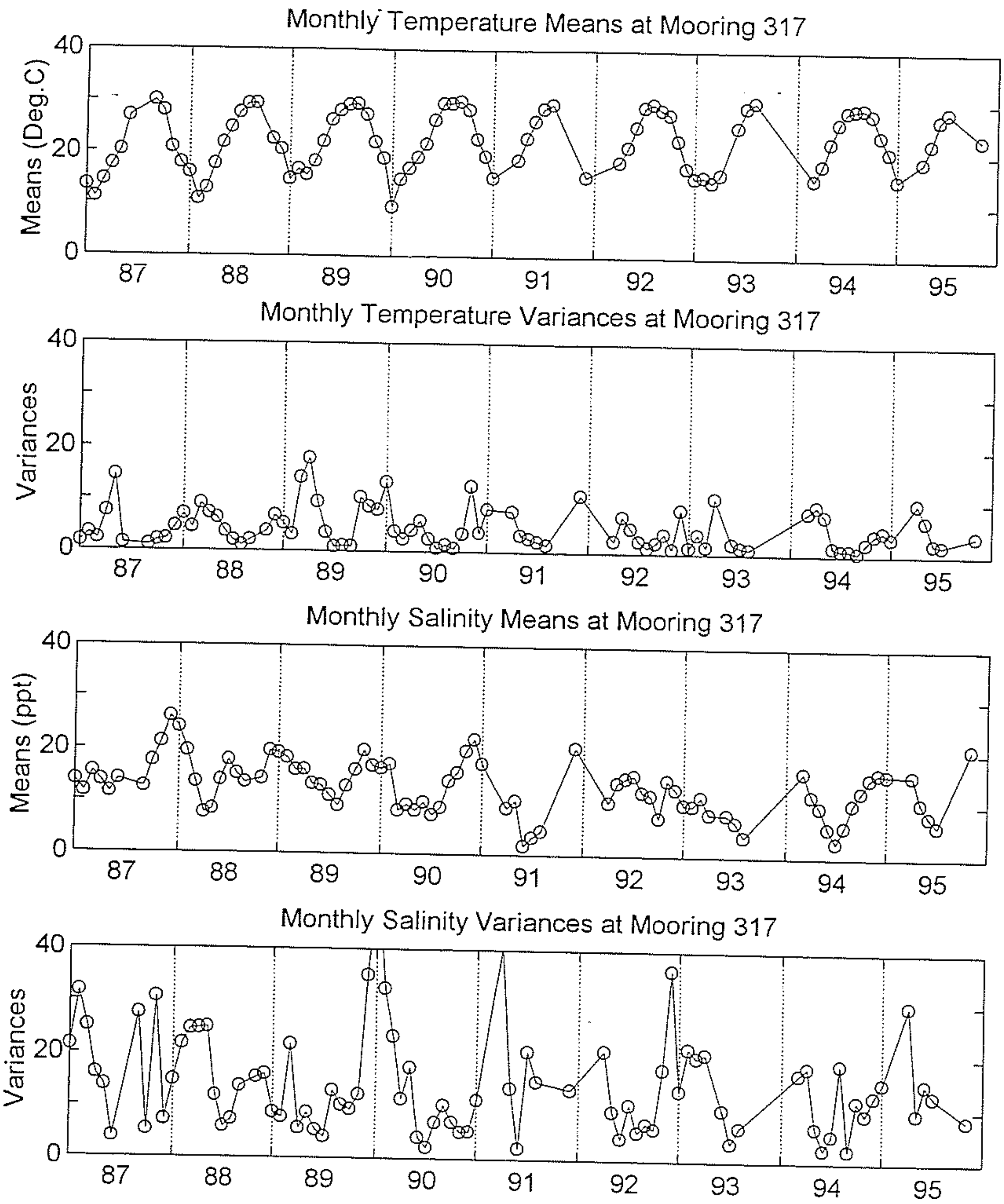

Figure D4. Monthly temperature and salinity means and variances at station 317, 1987-1995.

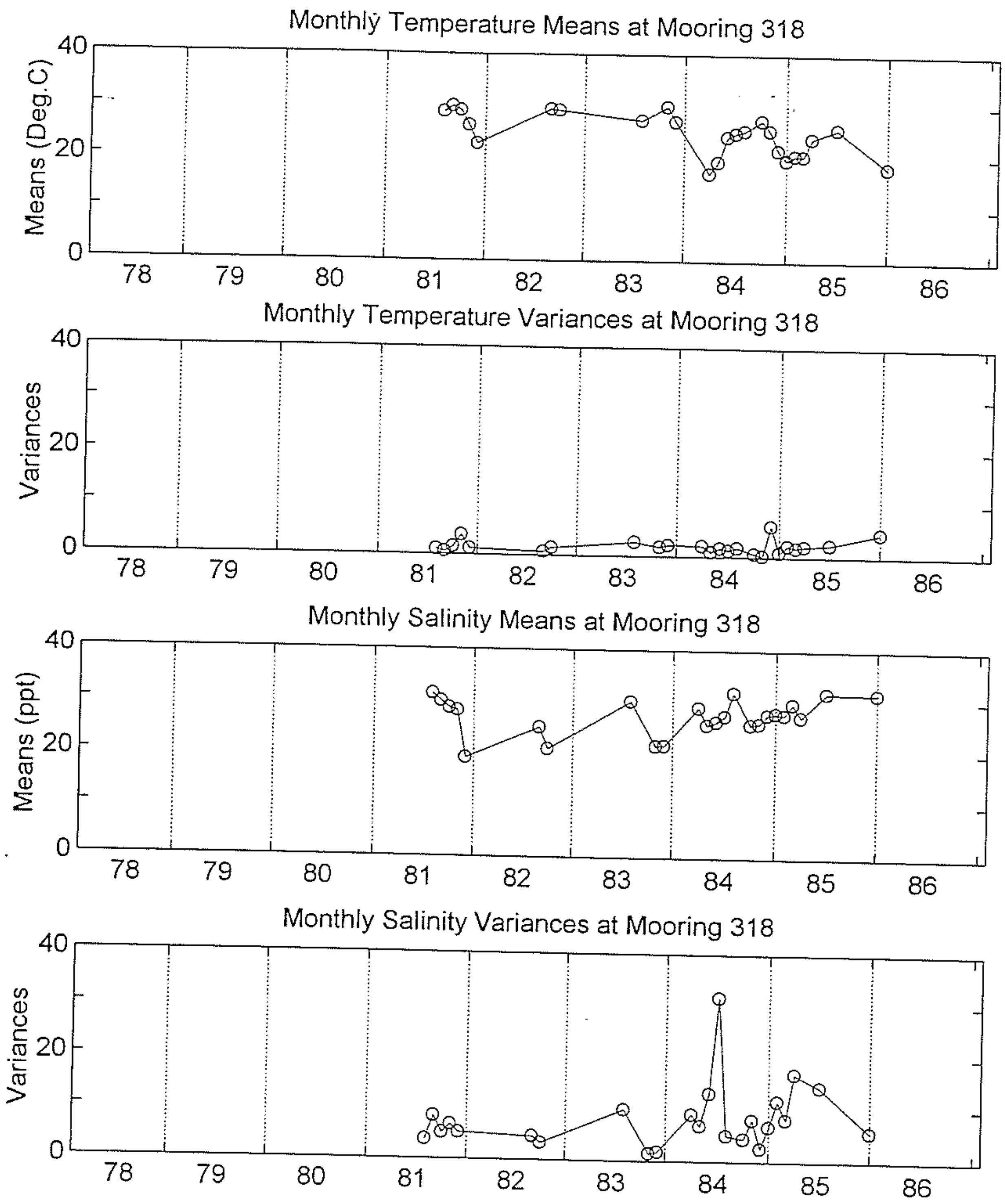

Figure D5. Monthly temperature and salinity means and variances at station 318.

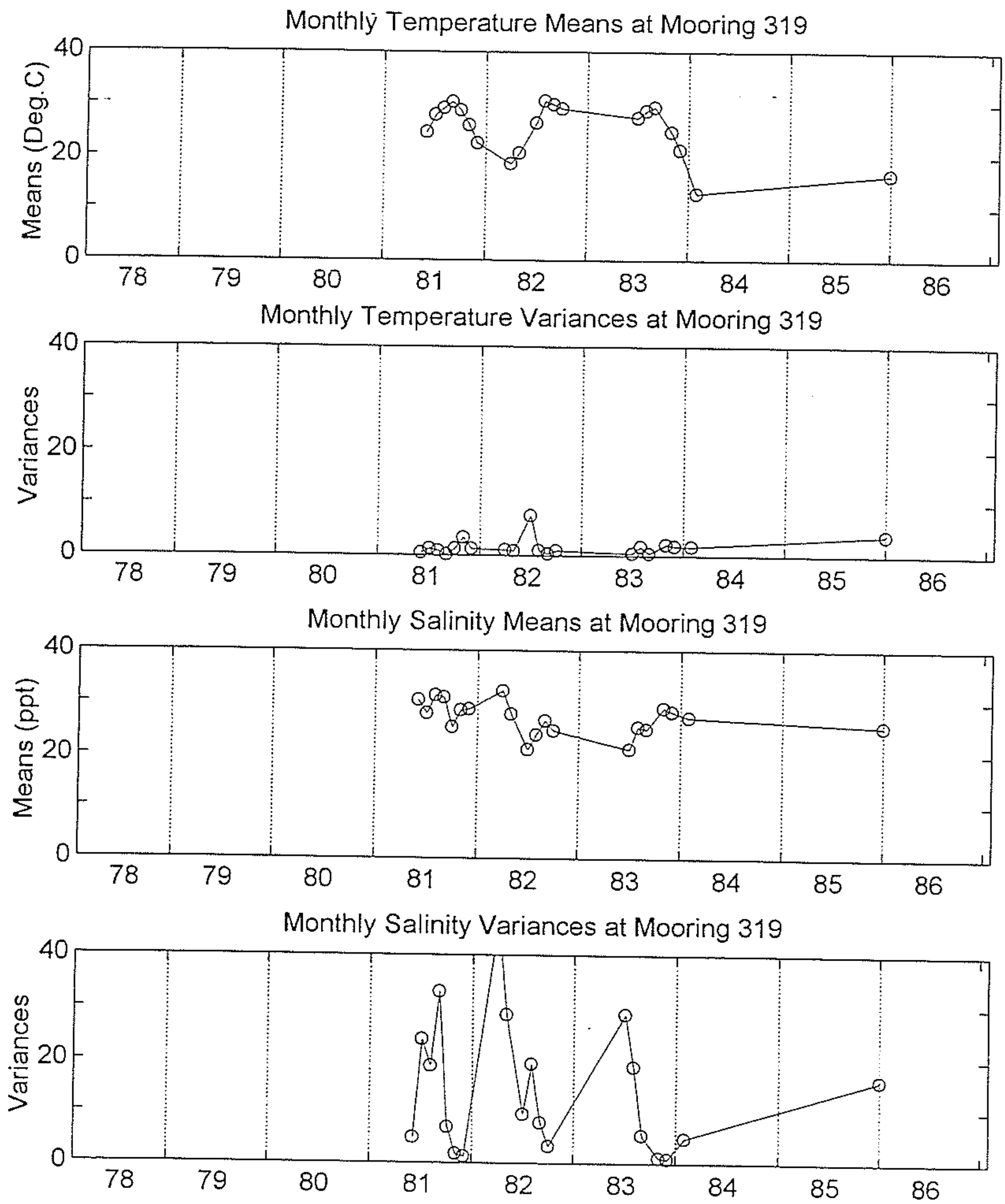

Figure D6. Monthly temperature and salinity means and variances at station 319.

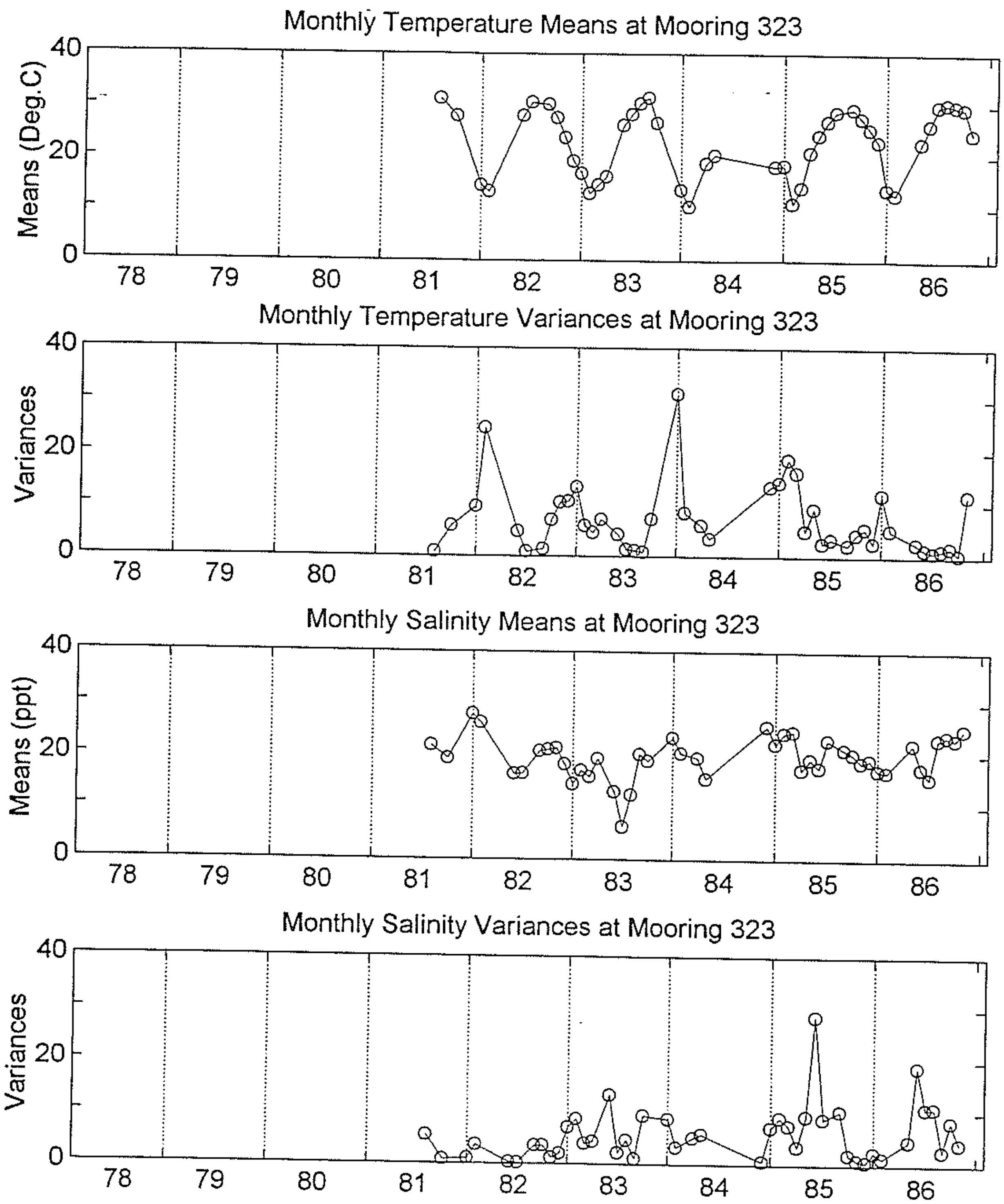

Figure D7. Monthly temperature and salinity means and variances at station 323, 1981-1986.

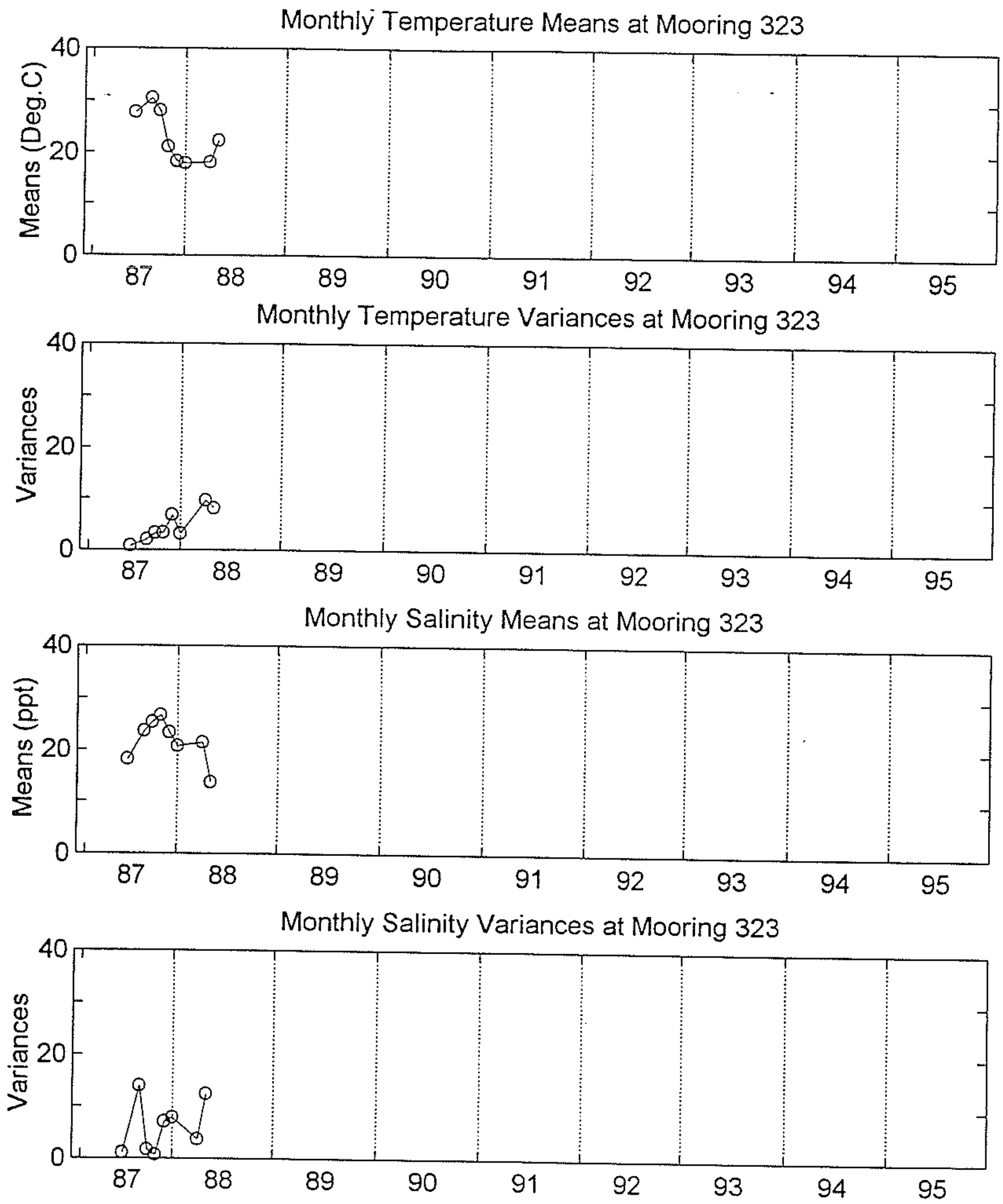

Figure D8. Monthly temperature and salinity means and variances at station 323, 1987-1988.

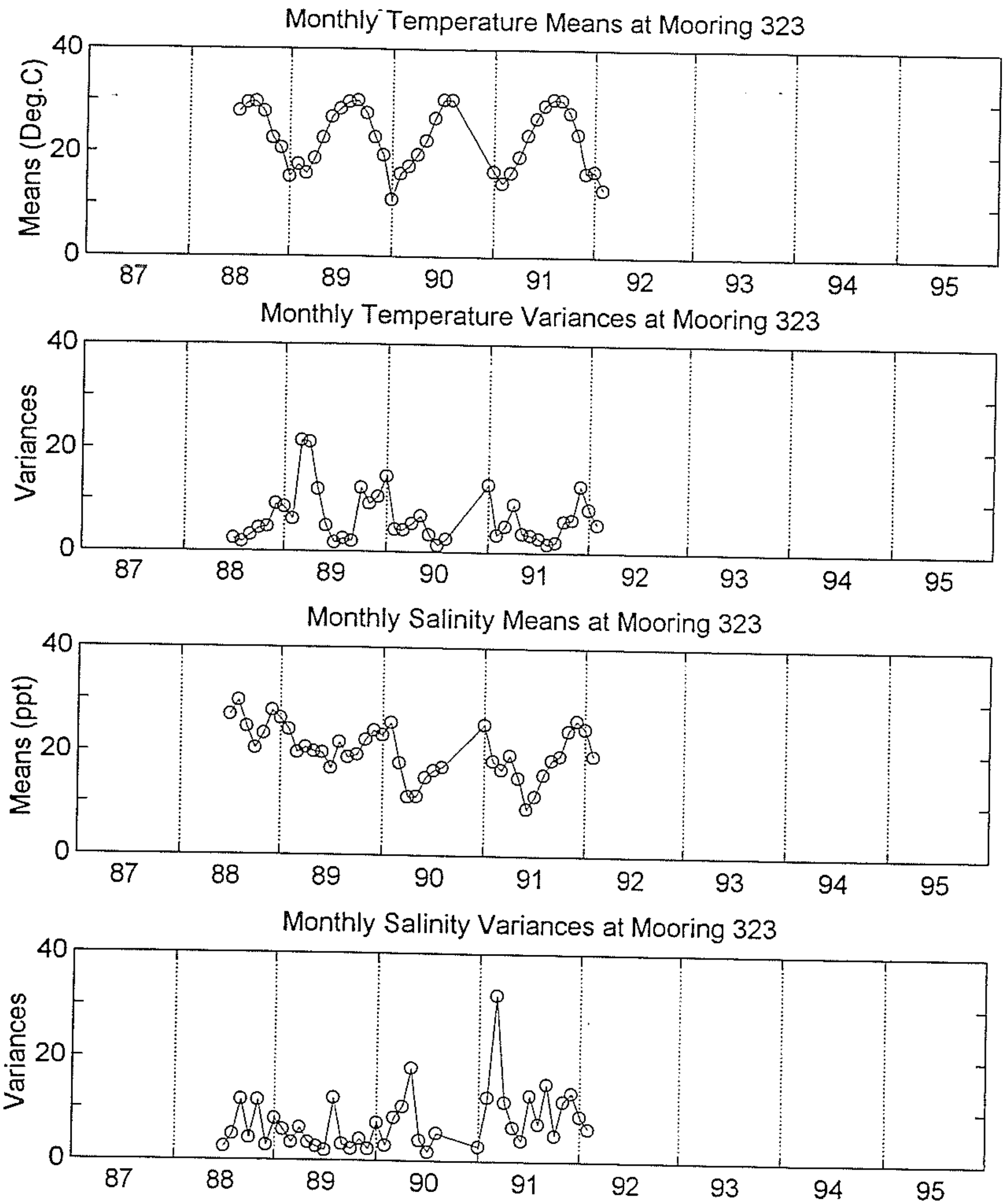

Figure D9. Monthly temperature and salinity means and variances at station 323, 1988-1992.

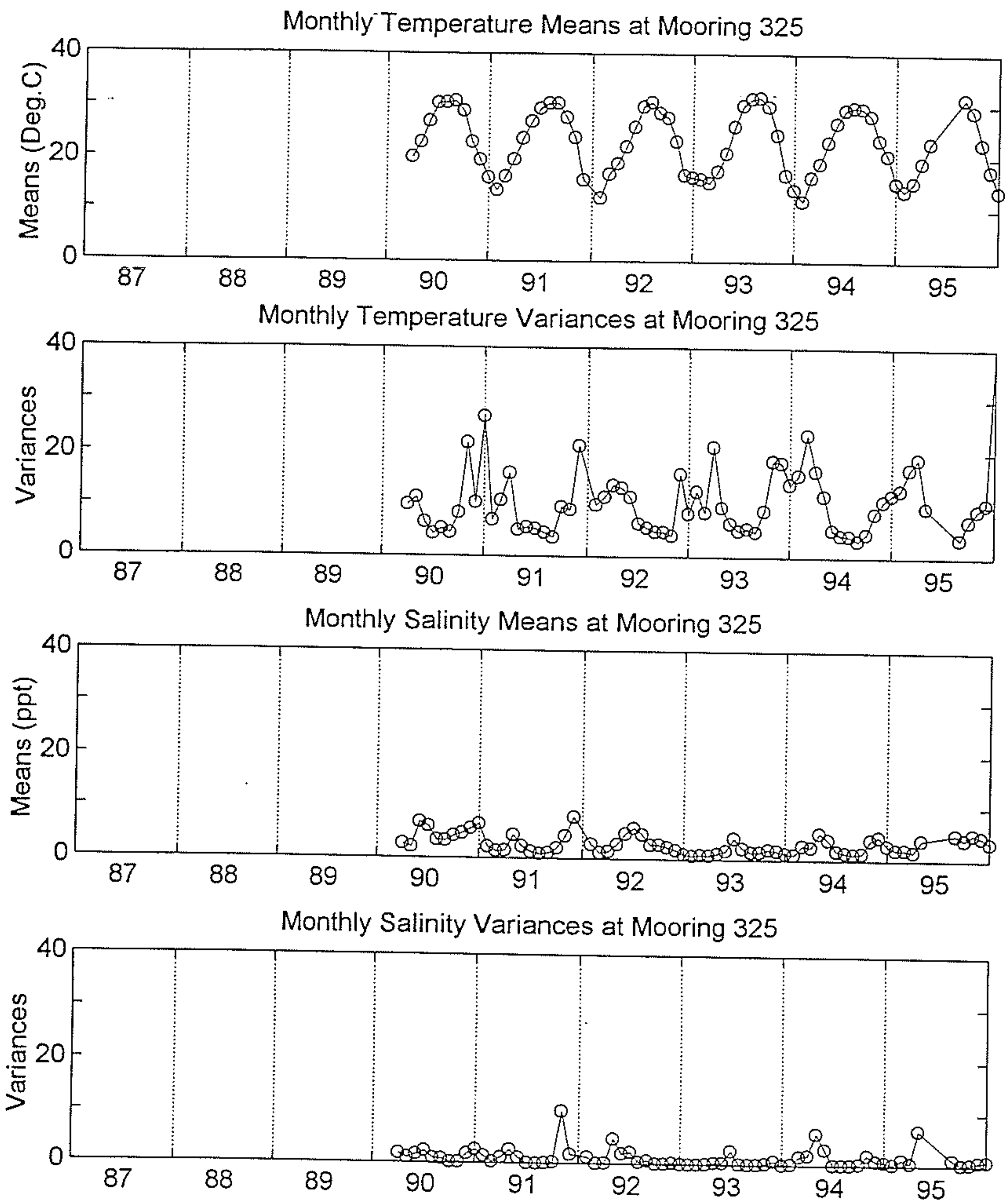

Figure D10. Monthly temperature and salinity means and variances at station 325.

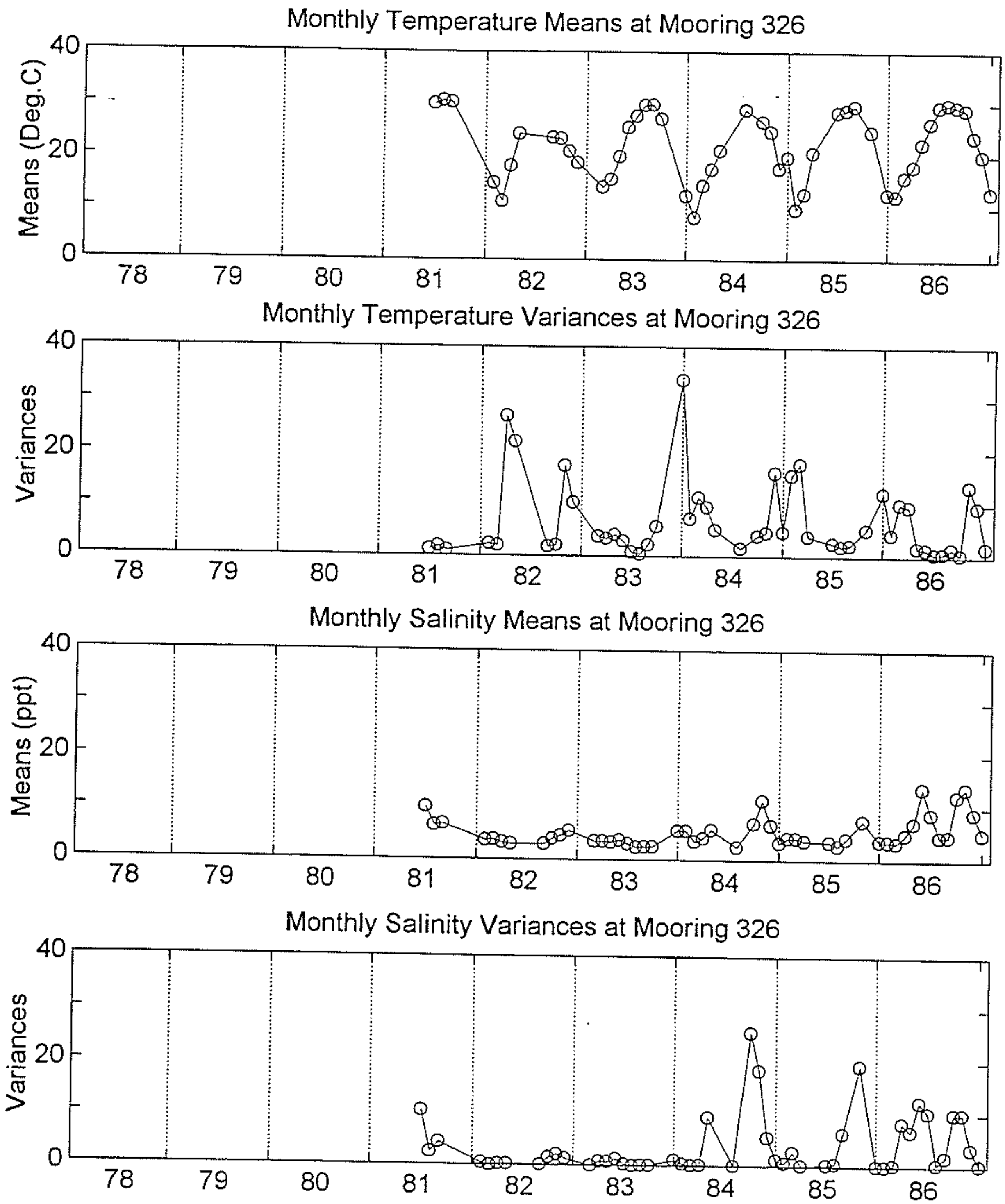

Figure D11. Monthly temperature and salinity means and variances at station 326, 1981-1986.

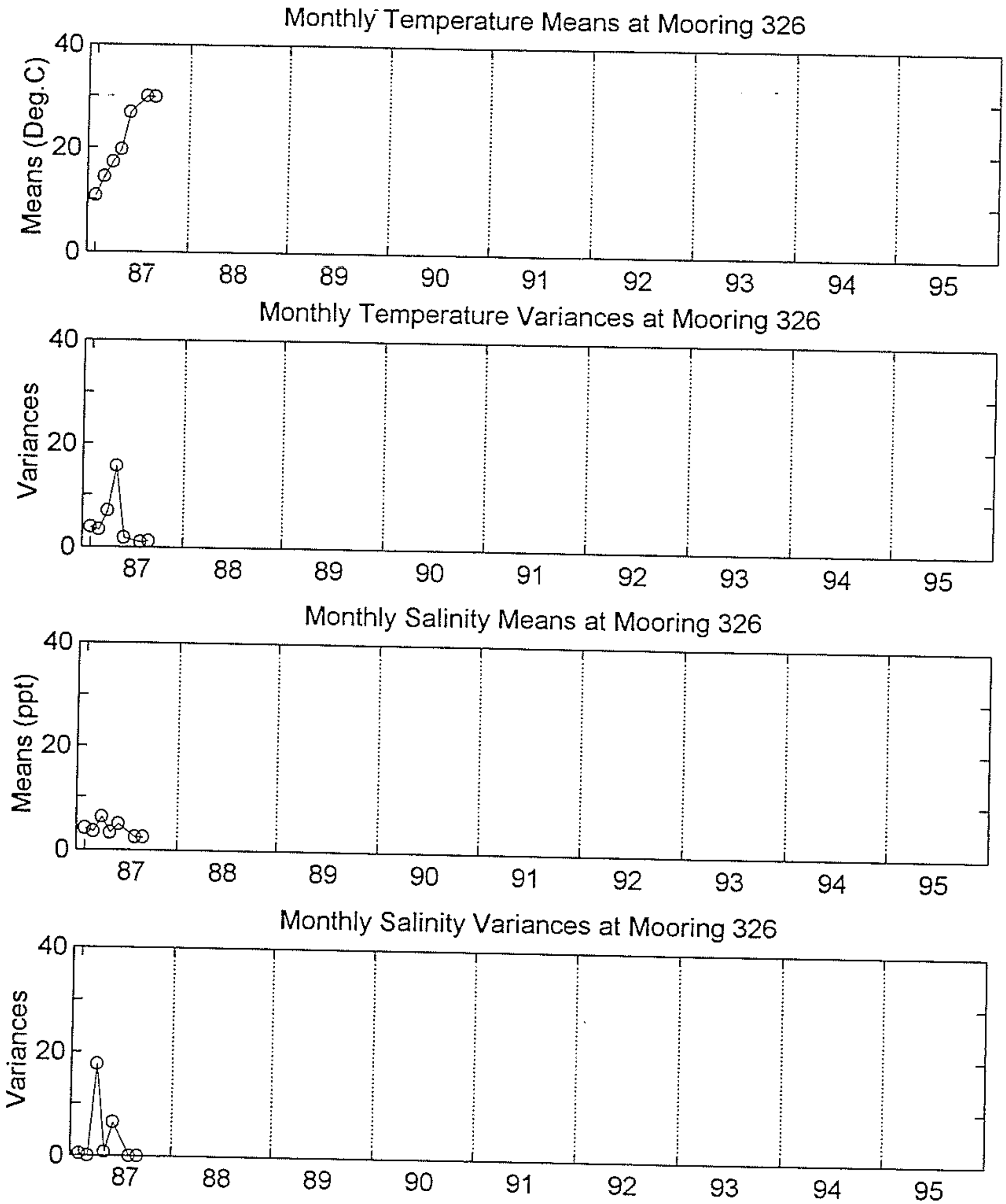

Figure D12. Monthly temperature and salinity means and variances at station 326, 1987.

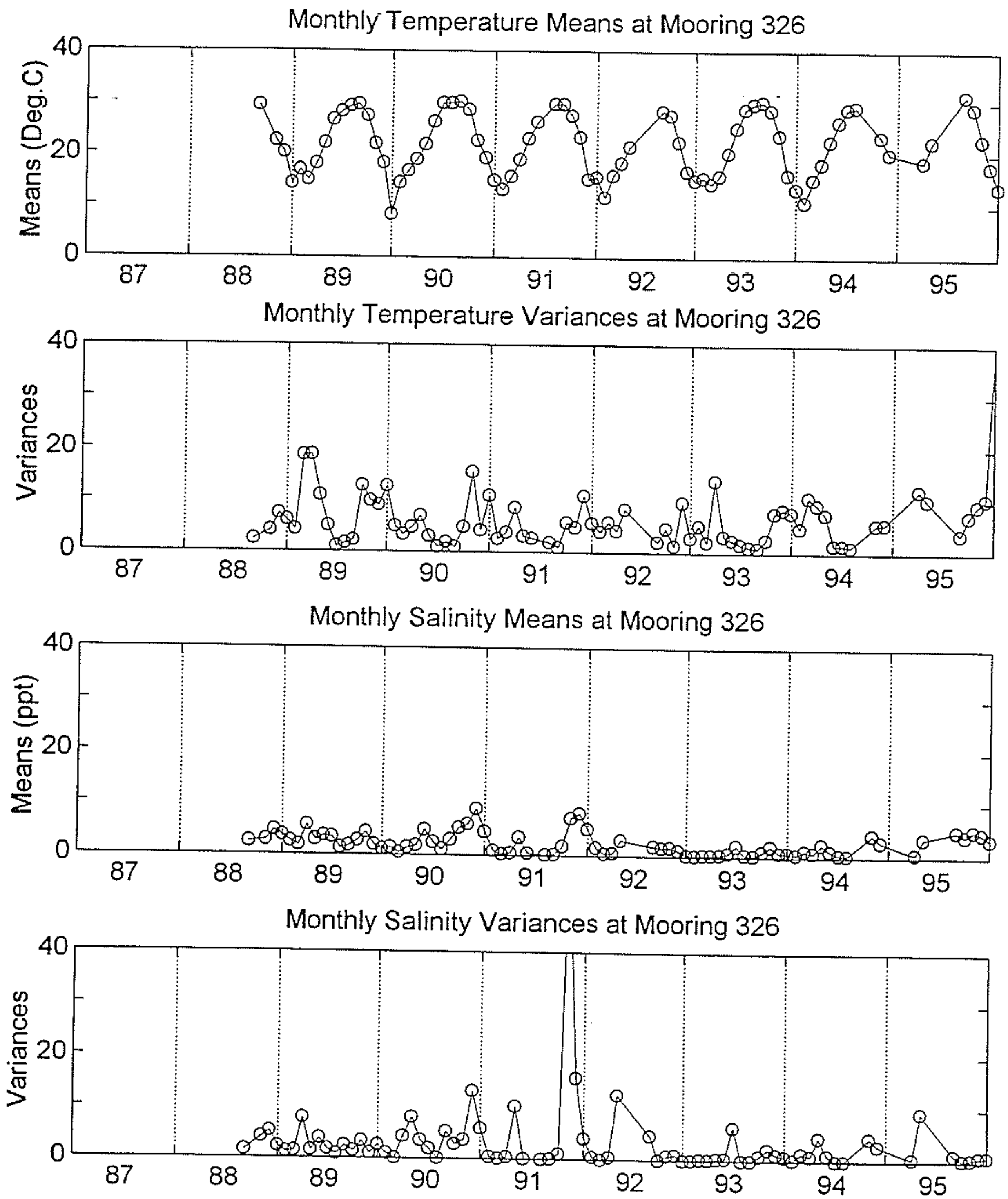

Figure D13. Monthly temperature and salinity means and variances at station 326, 1988-1995.

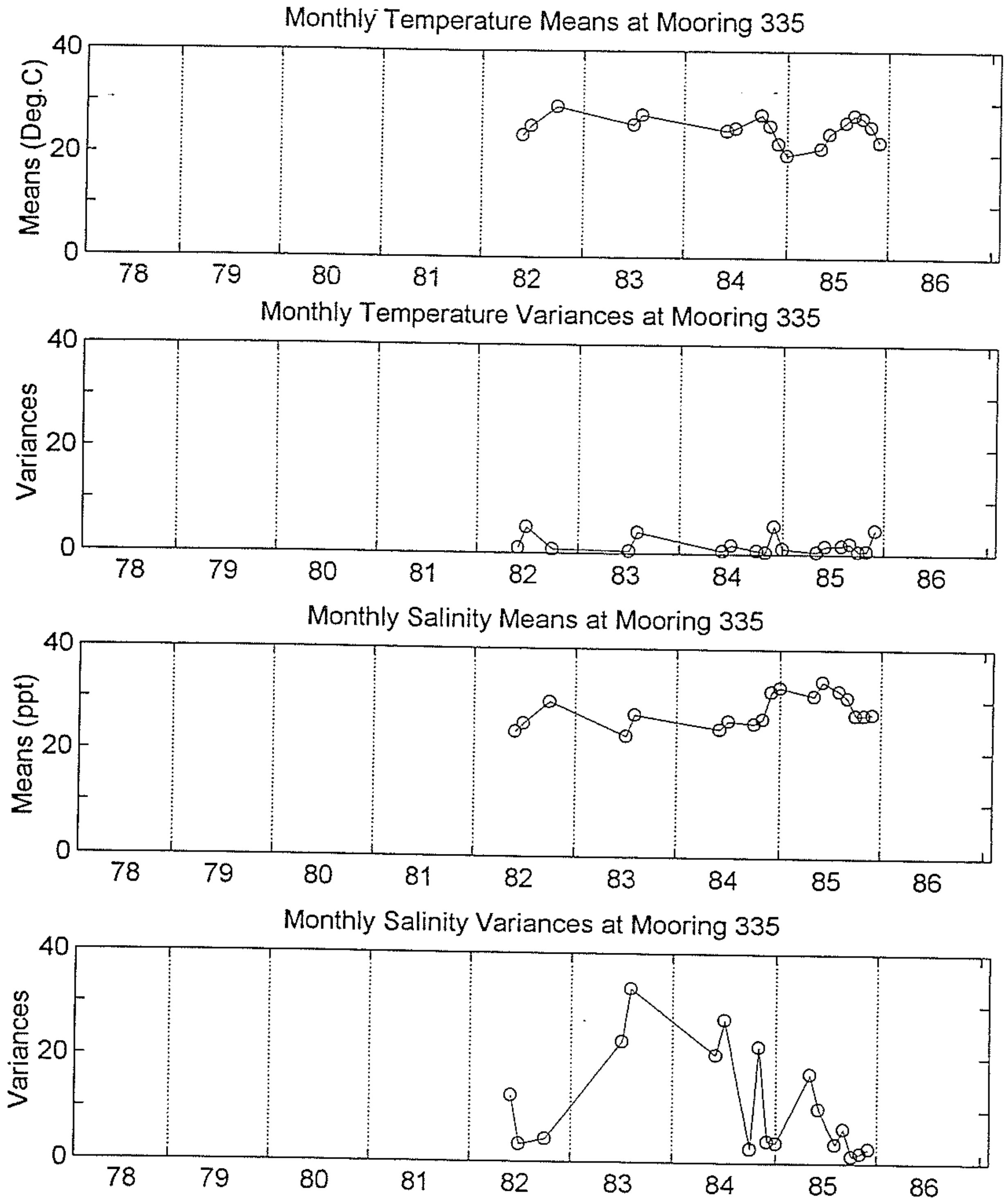

Figure D14. Monthly temperature and salinity means and variances at station 335.

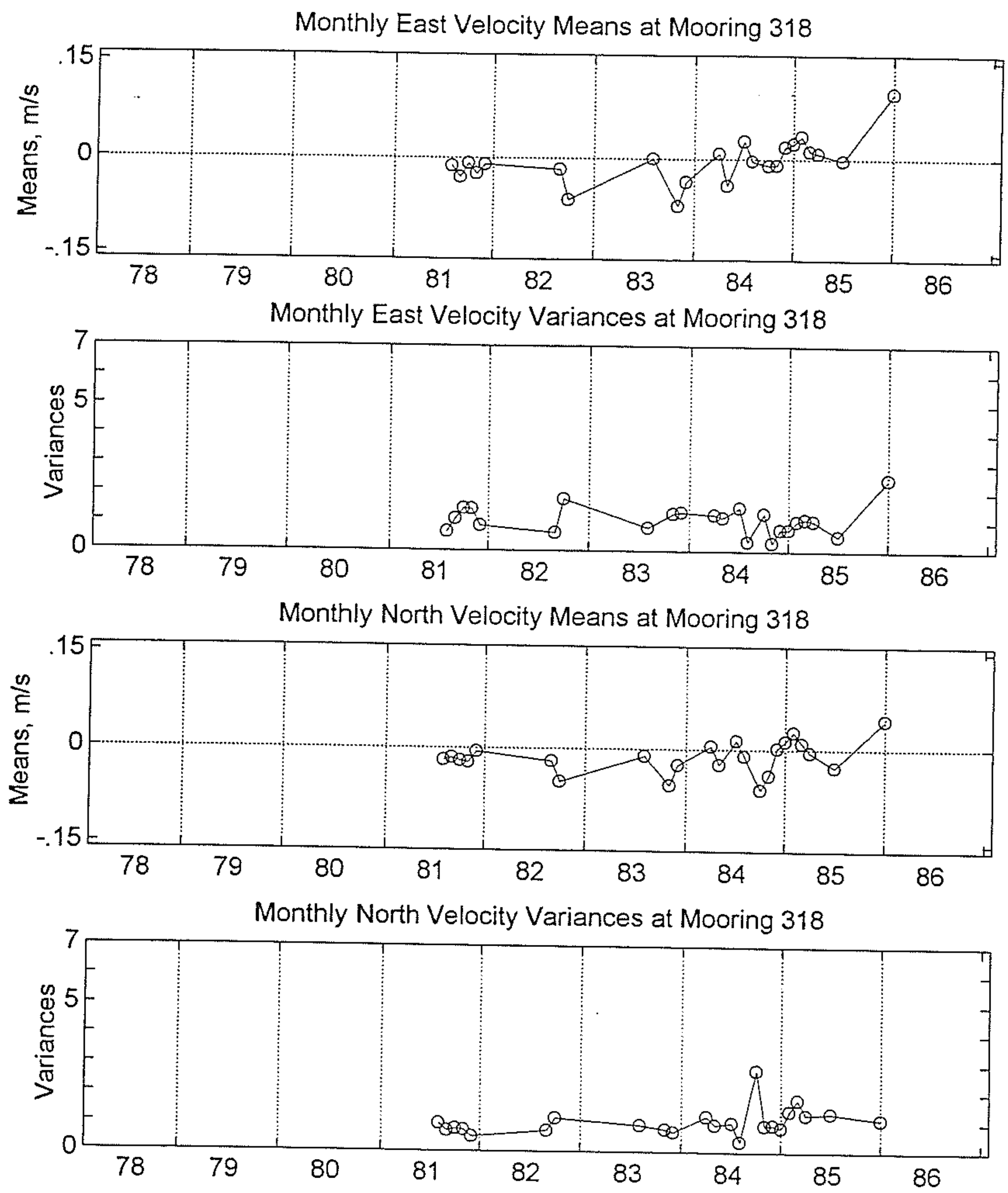

Figure D15. Monthly east and north velocity means and variances at station 318.

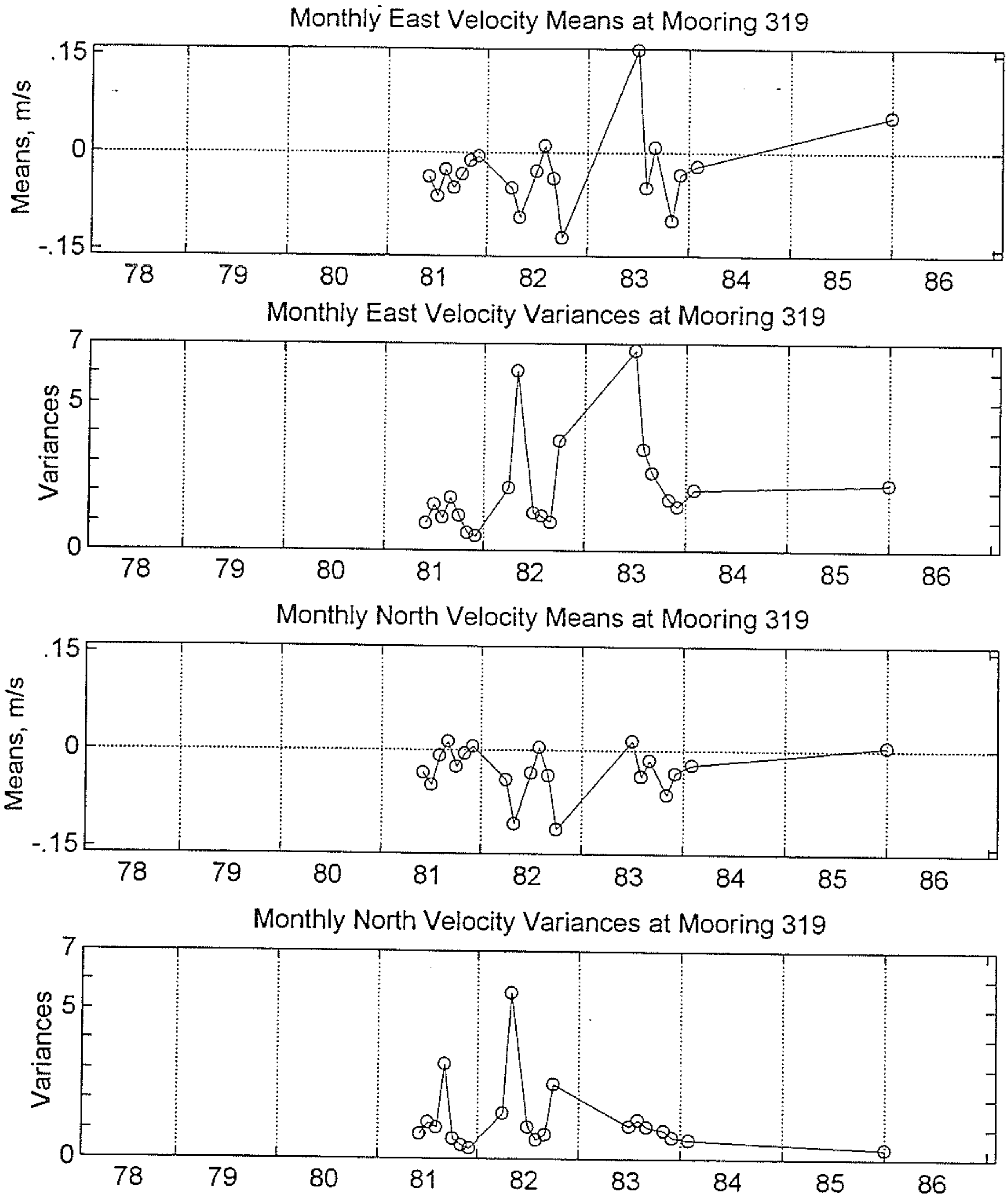

Figure D16. Monthly east and north velocity means and variances at station 319.

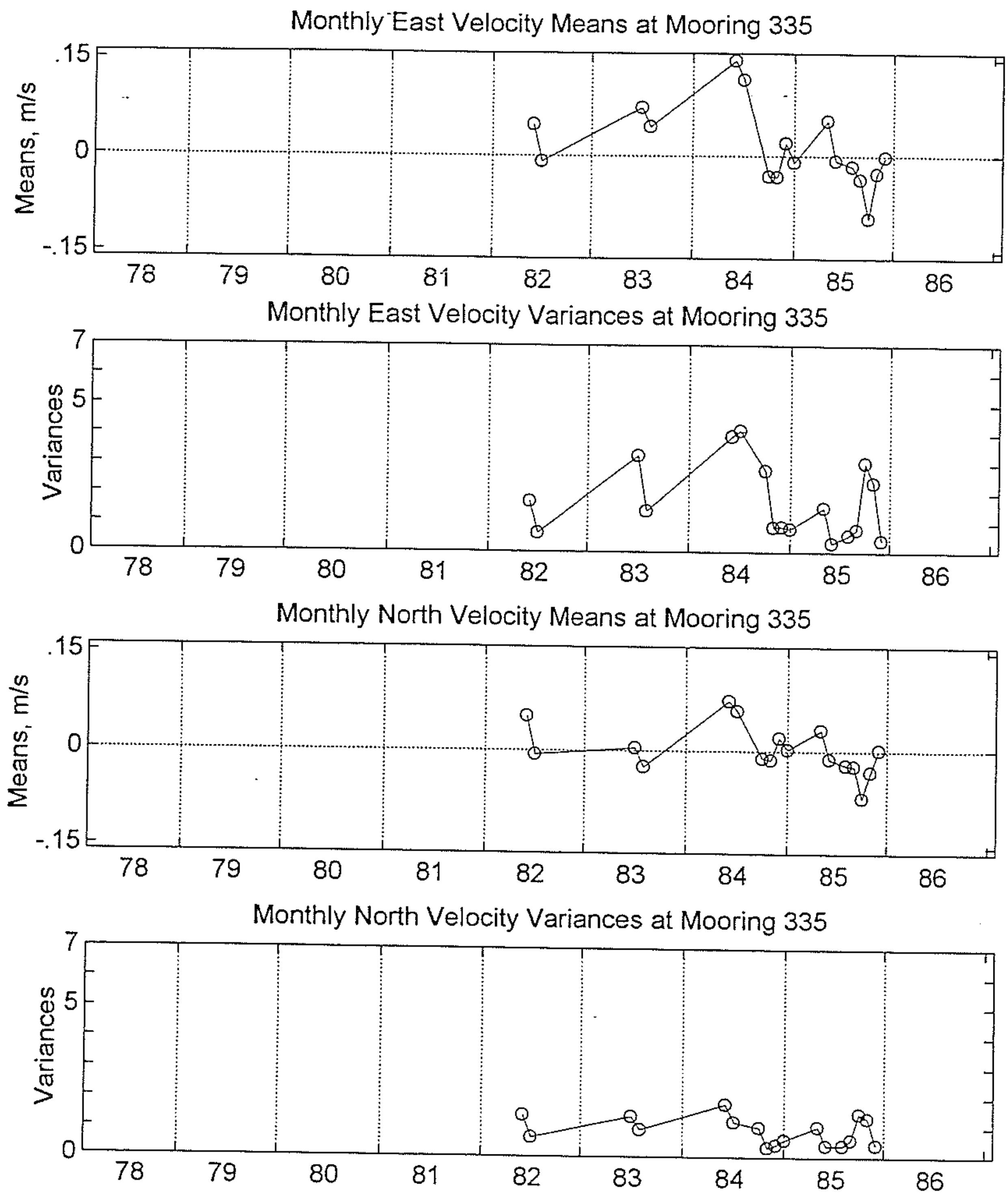

Figure D17. Monthly east and north velocity means and variances at station 335

APPENDIX E

TREND ANALYSIS TABLES

Table E1. Trend analysis for all monthly near bottom salinities 1/1/78-12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span.Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.1731	-0.1067	22.6462	6.0715	0.02	0.09	199
18	-0.0433	-0.1187	1.2697	1.8442	0.01	0.01	156
21	0.0076	0.0450	29.7569	3.6703	0.58	0.69	186
22	0.0800	0.1210	31.1897	3.6249	0.92	0.96	181
35	0.0020	0.0257	31.3611	2.9998	0.58	0.72	183
36	-0.0288	-0.0146	31.8404	2.9697	0.25	0.34	175
37	-0.1633	-0.1912	24.9380	4.4221	0.01	0.01	169
38	-0.1134	-0.1656	3.0842	2.4791	0.01	0.01	175
52	0.0360*	0.0461	35.6267	0.7967	0.99	0.99	138
53	0.0350*	0.0569	35.6575	0.7412	0.99	0.99	144
54	0.0250	0.0462	35.2598	1.0572	0.93	0.94	142
55	0.0268*	0.0360	35.7324	0.6389	0.98	0.99	135
502	-0.0496	0.0015	31.8349	2.9054	0.11	0.21	161
535	-0.0160	-0.0072	31.0886	3.6905	0.43	0.27	125
704	0.0225	0.0643	34.5680	1.3685	0.85	0.89	152
706	0.0489*	0.0709	35.2060	1.0037	0.99	0.99	152
708	0.0338*	0.0614	35.5754	0.9919	0.99	0.99	148

Table E2. Trend analysis for all monthly near bottom temperatures 1/1/78-12/31/95. Results of analysis for selected stations (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.0203	0.0275	22.8077	6.2201	0.79	0.54	199
18	-0.0200	0.0212	22.5976	6.8099	0.35	0.55	156
21	0.0000	-0.0157	22.7750	4.9987	0.45	0.36	186
22	-0.0158	-0.0177	22.6115	4.5769	0.27	0.34	181
35	0.0000	0.0435	22.7798	4.5021	0.56	0.69	183
36	-0.0156	0.0066	22.6899	4.4173	0.29	0.50	175
37	0.0049	-0.0005	23.3621	6.2233	0.57	0.47	169
38	-0.0313	-0.0343	23.0223	6.6050	0.20	0.37	175
52	0.0511*	0.0200	22.7058	2.7214	0.97	0.79	138
53	0.0567*	0.0278	22.5183	2.6992	0.96	0.82	144
54	0.0560*	0.0417	22.7775	3.0193	0.97	0.85	142
55	0.0400*	0.0074	22.6666	2.6312	0.96	0.66	135
502	0.0280	0.0389	22.8109	4.2514	0.81	0.76	161
535	0.0317	0.0475	22.6662	4.3466	0.77	0.72	125
704	0.0600*	0.0112	22.8924	3.1569	0.96	0.66	152
706	0.0589*	0.0313	22.8064	2.7176	0.98	0.77	152
708	0.0339	0.0091	22.6824	2.6185	0.92	0.60	148

Table E3. Trend analysis for all monthly near surface salinities 1/1/78-12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span.Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.2238	-0.1727	21.8226	6.0945	0.01	0.02	204
7	-0.1000	-0.1053	17.4242	5.0330	0.09	0.14	200
12	-0.1750	-0.2682	9.5735	4.7920	0.06	0.05	126
13	-0.1400	-0.1337	8.7191	4.9149	0.06	0.06	176
14	-0.1000	-0.1688	3.7817	4.0910	0.01	0.01	195
15	-0.0933	-0.1523	3.4588	2.9921	0.01	0.01	199
16	-0.0333	-0.0437	2.0401	2.4152	0.05	0.01	174
18	-0.0200	-0.0622	1.0849	1.6359	0.01	0.01	182
21	-0.0500	0.0003	25.8094	5.2099	0.25	0.33	187
22	-0.1239	-0.0671	26.2096	5.1686	0.02	0.10	180
34	-0.2183	-0.1782	23.9319	5.0572	0.01	0.01	184
35	-0.2027	-0.2563	25.8888	5.3533	0.01	0.01	182
36	-0.2050	-0.2418	26.0373	5.1965	0.01	0.01	176
37	-0.1400	-0.1361	24.5323	4.5220	0.01	0.06	171
38	-0.1200	-0.1740	2.9465	2.4843	0.01	0.01	182
52	-0.1500	-0.1014	26.0192	5.6350	0.08	0.18	152
53	-0.1244	-0.0779	26.6028	5.2163	0.06	0.13	156
54	-0.0500	-0.0478	26.0995	5.1007	0.25	0.22	150
55	-0.0333	0.0408	26.6527	5.2064	0.58	0.55	150
502	-0.0945	-0.0980	25.6114	5.3748	0.17	0.09	161
535	-0.1220	-0.0529	25.3783	5.6076	0.11	0.19	126
704	-0.0845	-0.1381	26.1527	5.1044	0.08	0.10	154
706	-0.0239	-0.0700	26.6139	5.2095	0.26	0.30	157
708	-0.0714	-0.0782	26.6451	5.4211	0.19	0.25	153

Table E4. Trend analysis for all monthly near surface temperatures 1/1/78-12/31/95. Results of analysis for selected stations (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.0292	0.0449	22.7975	6.4091	0.77	0.62	204
7	-0.0683	-0.0549	22.5832	6.9144	0.03	0.25	200
12	-0.0587	-0.1615	22.3280	6.9894	0.27	0.20	126
13	0.0111	0.0072	22.7050	7.2115	0.60	0.53	176
14	0.0400	0.0666	22.1139	7.1412	0.84	0.79	195
15	0.0400	0.0629	22.3868	7.1573	0.89	0.73	199
16	0.1273*	0.1125	23.6461	7.0119	0.98	0.84	174
18	0.0000	0.0600	22.5632	6.9301	0.46	0.67	182
21	-0.0250	-0.0315	23.0361	5.6372	0.14	0.31	187
22	-0.0200	-0.0206	23.1394	5.5076	0.19	0.36	180
34	0.0400	-0.0669	23.0612	7.1260	0.81	0.31	184
35	-0.0020	0.0437	23.1729	5.4158	0.40	0.70	182
36	-0.0367	0.0002	23.5048	5.4124	0.05	0.43	176
37	0.0045	-0.0023	23.4708	6.2522	0.56	0.43	171
38	0.0550	0.0590	23.6731	6.9941	0.84	0.71	182
52	0.0567*	0.1028	23.4929	5.4660	0.97	0.82	152
53	0.0425	0.0670	23.4462	5.3939	0.93	0.73	156
54	0.0693*	0.1277	23.9149	5.4909	0.99	0.86	150
55	0.0750*	0.1162	23.5321	5.3801	0.99	0.81	150
502	0.0105	0.0641	23.3915	5.5123	0.63	0.79	161
535	0.0050	0.0182	23.3748	5.7023	0.67	0.62	126
704	0.0200	-0.0192	23.7551	5.3483	0.78	0.49	154
706	0.0167	-0.0172	23.5841	5.1780	0.75	0.47	157
708	-0.0111	-0.0350	23.6967	5.1895	0.33	0.39	153

Table E5. Trend analysis for monthly near bottom salinity: measurements preceding the 1985 hurricane season 1/1/78-12/31/84. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.1125	0.3517	22.7147	6.3014	.67	.86	75
18	-0.1000	-0.3543	1.7067	2.1917	.06	.01	45
21	0.1250	0.3172	29.5365	3.8980	.76	.79	74
22	0.0500	0.1793	30.2913	4.4091	.52	.11	69
35	-0.3167	-0.4583	30.9250	3.2597	.11	.07	60
36	-1.2000	-0.8095	31.6389	3.3025	.01	.01	54
37	-0.2000	-0.5654	25.9273	3.8971	.13	.06	55
38	-0.1000	-0.2870	3.5582	2.9624	.38	.13	55
52	-0.3000	-0.1322	35.0240	1.0373	.27	.08	25
53	-0.3250	-0.2724	34.9042	0.9337	.41	.03	28
54	-0.3500	-0.2177	34.6654	1.3726	.20	.09	28
55	-0.9500	-0.4810	35.1438	0.6899	.03	.02	18
502	-0.2000	-0.6142	31.1257	4.0203	.50	.22	35
535	0.7000	-0.0142	30.5517	4.1690	.65	.67	29
704	-0.1000	0.1378	33.8120	1.8005	.42	.55	28
706	0.4000	0.4433	34.4880	1.3007	.95	.94	27
708	-0.1000	0.4480	34.8750	1.2546	.50	.96	27

Table E6. Trend analysis for monthly near bottom temperature: Measurements preceding the 1985 hurricane season 1/1/78-12/31/84. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.0800	0.5707	22.7493	6.4643	.61	.91	75
18	-0.4500	0.2785	22.7022	7.2349	.03	.50	45
21	-0.1500	-0.2016	22.8554	5.3516	.20	.26	74
22	-0.0500	0.0296	22.9116	5.2418	.41	.51	69
35	-0.1333	0.2720	22.6950	5.2230	.15	.72	60
36	-0.2000	0.2255	22.9389	5.2067	.24	.66	54
37	-0.1000	0.3178	23.4636	6.4031	.44	.63	55
38	-0.2750	-0.1623	22.9709	6.8248	.02	.32	55
52	-0.2667	-0.6150	22.8720	3.4263	.34	.17	25
53	-0.5500	-1.0043	22.5607	3.6911	.07	.02	28
54	-0.3000	-0.7057	22.7214	4.0996	.12	.48	28
55	-0.5000	-0.4855	23.2000	2.9902	.36	.21	18
502	-0.7000	-0.1610	22.9600	4.6691	.01	.47	35
535	-0.8000	-0.7083	23.0276	4.5767	.09	.28	29
704	0.1750	-0.6509	23.4286	3.3963	.81	.23	28
706	0.4000	-0.1541	23.4519	2.9842	.76	.59	27
708	0.0000	-0.5911	23.3111	3.1657	.50	.32	27

Table E7. Trend analysis for monthly near surface salinity: measurements preceding the 1985 hurricane season 1/1/78-12/31/84. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.1500	0.3466	22.1623	6.2093	.71	.88	77
7	0.2750	0.4050	17.0658	4.6707	.93	.90	73
12	0.2125	0.4918	9.7884	4.6365	.83	.84	69
13	0.2350	0.4993	8.5377	4.5733	.83	.93	69
14	0.1750	0.2234	4.2554	4.4152	.86	.71	74
15	0.1550	0.2950	3.9027	3.3668	.91	.79	74
16	0.0000	0.0249	2.0733	2.4069	.54	.55	75
18	0.0000	0.1089	1.3294	1.8744	.50	.50	68
21	-0.0250	0.4442	25.7635	5.9039	.50	.84	74
22	-0.0667	0.4731	26.5779	5.6387	.33	.85	68
34	-0.3000	-0.0633	24.1524	4.7810	.20	.47	63
35	-0.6000	-0.9298	26.9700	5.3901	.02	.03	60
36	-0.8500	-0.9628	27.2759	5.1195	.02	.05	54
37	-0.6500	-0.5183	25.0518	4.1008	.06	.08	56
38	-0.1500	-0.2012	3.3643	2.8794	.35	.24	56
52	-1.1750	-0.6860	25.5556	6.0915	.18	.23	36
53	-0.9000	-0.5439	26.3417	6.0416	.12	.23	36
54	-0.5000	-0.1105	25.7771	6.1246	.44	.57	35
55	0.0500	1.3393	25.5724	6.5484	.50	.67	29
502	-0.2667	-0.3192	25.8429	5.5552	.39	.54	35
535	0.3000	0.7112	25.4172	5.5696	.50	.91	29
704	-0.6167	-1.4073	26.3103	4.8037	.12	.06	29
706	-1.0000	-1.6994	26.5966	4.7450	.01	.03	29
708	-1.3000	-2.0008	26.2400	5.6413	.02	.01	30

Table E8. Trend analysis for monthly near surface temperature: Measurements preceding the 1985 hurricane season 1/1/78-12/31/84. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.1292	0.4878	22.5455	6.6517	.66	.86	77
7	-0.0500	0.2069	22.9781	6.7950	.42	.68	73
12	0.1083	0.2999	23.0986	6.4527	.71	.79	69
13	0.0000	0.1921	22.7029	7.1020	.50	.66	69
14	0.0900	0.1869	21.8135	7.2773	.66	.65	74
15	0.0833	0.0551	21.8581	7.6166	.76	.48	74
16	0.2333	0.1720	22.6080	7.3182	.80	.59	75
18	-0.0500	0.3205	22.4147	7.4139	.43	.73	68
21	0.0000	-0.0403	23.2703	5.8620	.50	.45	74
22	0.0250	0.0627	23.3676	5.8900	.65	.54	68
34	0.2000	0.2198	23.5540	6.8254	.86	.73	63
35	0.1000	0.4836	23.1283	5.7891	.75	.85	60
36	-0.1000	0.3221	23.7426	5.8411	.22	.66	54
37	0.1000	0.3335	23.6714	6.4080	.59	.64	56
38	-0.0667	0.0916	22.9893	7.2023	.18	.47	56
52	-0.5000	-0.8588	22.8889	6.0082	.03	.15	36
53	-0.5750	-0.8617	23.0028	5.7938	.02	.13	36
54	-0.2750	-0.7486	23.2286	6.0646	.24	.22	35
55	-0.7500	-0.5713	22.8345	5.8670	.05	.23	29
502	-0.8000	-0.1519	23.4343	5.5516	.01	.36	35
535	-0.7000	-1.2575	23.9655	5.7102	.03	.12	29
704	-0.1000	-0.5850	24.6207	4.8460	.43	.22	29
706	-0.0250	-0.8553	24.4276	4.8229	.43	.16	29
708	-0.2500	-0.6329	25.0033	4.8727	.07	.19	30

Table E9. Trend analysis for monthly near bottom salinity: measurements after the 1985 hurricane season 1/1/86-12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.8283	-0.6678	22.6035	5.9107	.01	.01	114
18	-0.0721	-0.2062	1.0644	1.6971	.01	.01	99
21	-0.2125	-0.0075	29.9117	3.4458	.16	.39	102
22	-0.1317	-0.0244	31.7581	2.7793	.07	.26	102
35	-0.1000	0.0162	31.4892	2.9004	.14	.49	113
36	-0.0650	-0.0071	31.8610	2.8722	.16	.60	111
37	-0.3000	-0.3069	24.5741	4.6436	.03	.06	103
38	-0.3659	-0.4217	2.8672	2.2793	.01	.01	109
52	0.0000	-0.0135	35.7821	0.6646	.44	.31	105
53	0.0000	-0.0007	35.8271	0.5889	.50	.48	107
54	0.0000	0.0041	35.3953	0.9291	.51	.34	105
55	0.0000	0.0014	35.8194	0.5956	.53	.52	109
502	-0.1267	-0.1290	31.9871	2.5242	.01	.03	115
535	-0.2050	-0.0904	31.1468	3.6803	.08	.08	85
704	-0.0088	0.0026	34.7334	1.1880	.36	.42	113
706	0.0160	0.0276	35.3493	0.8871	.84	.72	115
708	0.0000	-0.0002	35.7327	0.8885	.43	.54	111

Table E10. Trend analysis for monthly near bottom temperature: Measurements after the 1985 hurricane season 1/1/86-12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.1000	-0.0144	22.7565	6.1697	.21	.40	114
18	-0.0267	0.0689	22.5841	6.6451	.33	.67	99
21	0.0523	0.0222	22.7289	4.8588	.82	.59	102
22	0.0325	0.0760	22.4587	4.2171	.63	.72	102
35	0.0360	0.0608	22.8859	4.2089	.71	.66	113
36	0.0100	0.0901	22.6094	4.1160	.57	.77	111
37	-0.0500	0.0061	23.2999	6.1594	.33	.53	103
38	-0.1750	-0.1573	23.0477	6.5944	.01	.25	109
52	0.0600	0.1021	22.6733	2.5817	.97	.93	105
53	0.0833	0.1073	22.5340	2.4376	.98	.93	107
54	0.0557	0.0676	22.8725	2.6942	.90	.86	105
55	0.0850	0.0984	22.5724	2.5342	.99	.91	109
502	0.0367	0.0900	22.8543	4.1486	.81	.88	115
535	0.0829	0.2075	22.6044	4.3222	.84	.94	85
704	0.0950	0.1356	22.8030	3.0927	.92	.95	113
706	0.1000	0.1895	22.6920	2.6298	.99	.99	115
708	0.0667	0.1515	22.5559	2.4734	.98	.96	111

Table E11. Trend analysis for monthly near surface salinity: measurements after the 1985 hurricane season 1/1/86-12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.9000	-0.8045	21.5668	5.9904	.01	.01	117
7	-0.9373	-0.8555	17.5193	5.4107	.01	.01	116
12	-3.0000	-1.1905	8.7317	5.2785	.01	.01	46
13	-1.0617	-1.1651	8.7392	5.3768	.01	.01	96
14	-0.3633	-0.5878	3.4122	3.8744	.01	.01	109
15	-0.4187	-0.5542	3.1283	2.8288	.01	.01	113
16	-0.1925	-0.3016	2.0458	2.5281	.01	.01	89
18	-0.0500	-0.1635	0.9044	1.4831	.01	.01	102
21	-0.3420	-0.2262	25.9375	4.6952	.06	.11	103
22	-0.3250	-0.2656	26.0258	4.9611	.01	.06	102
34	-0.7500	-0.6149	23.7070	5.3062	.01	.01	110
35	-0.4140	-0.4184	25.3426	5.3811	.01	.01	112
36	-0.3417	-0.3643	25.5907	5.0939	.01	.02	112
37	-0.3694	-0.3565	24.4444	4.7134	.01	.03	104
38	-0.3571	-0.4637	2.7492	2.3466	.01	.01	115
52	-0.4013	-0.4257	26.1766	5.5699	.01	.03	106
53	-0.4567	-0.3731	26.7940	4.9552	.01	.03	110
54	-0.1990	-0.2474	26.1974	4.8033	.10	.12	106
55	-0.3375	-0.2539	27.0388	4.8558	.03	.09	111
502	-0.2050	-0.2262	25.5803	5.2214	.09	.06	115
535	-0.3775	-0.2088	25.4415	5.5146	.09	.06	86
704	-0.4160	-0.2417	26.0519	5.1879	.01	.10	114
706	-0.1700	-0.0519	26.4965	5.3518	.14	.37	117
708	-0.2454	-0.1679	26.6330	5.4220	.11	.24	112

Table E12. Trend analysis for monthly near surface temperature: Measurements after the 1985 hurricane season 1/1/86-12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.1200	-0.0339	22.8684	6.3719	.08	.36	117
7	-0.1535	-0.1195	22.3839	6.8557	.02	.30	116
12	0.1000	-0.1561	21.2746	7.4899	.58	.28	46
13	-0.0667	-0.1700	22.8519	7.2460	.24	.28	96
14	-0.0427	0.0599	22.3369	7.0961	.44	.70	109
15	-0.1559	-0.0185	22.6573	6.8914	.09	.58	113
16	-0.4785	-0.4520	24.4902	6.7262	.01	.05	89
18	-0.0560	0.1021	22.6696	6.6251	.26	.71	102
21	0.0600	-0.0001	22.8850	5.5492	.84	.60	103
22	0.0000	0.0198	23.0009	5.3095	.51	.64	102
34	-0.1800	-0.1358	22.8924	7.2879	.07	.34	110
35	0.0683	0.0712	23.2255	5.2764	.94	.77	112
36	0.0167	0.0581	23.4085	5.2317	.57	.72	112
37	-0.0200	0.0598	23.3433	6.1830	.43	.61	104
38	-0.1633	-0.1295	24.0227	6.9892	.02	.35	115
52	0.0461	0.1093	23.7945	5.2840	.88	.68	106
53	0.0514	0.0829	23.6374	5.2829	.90	.66	110
54	0.0659	0.1128	24.2957	5.2340	.94	.70	106
55	0.0449	0.0985	23.7875	5.2647	.95	.66	111
502	0.0100	0.1538	23.4333	5.5370	.62	.83	115
535	0.0462	0.2083	23.2305	5.7680	.79	.90	86
704	-0.0024	0.1153	23.6104	5.4786	.44	.73	114
706	0.0000	0.1689	23.3719	5.2788	.46	.81	117
708	-0.0075	0.2096	23.3848	5.2548	.38	.87	112

Table E13. Trend analysis for monthly near bottom salinity: measurements preceding 1990 cessation of brine discharge 1/1/78-12/31/89. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ= standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*). Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.2818	0.3732	23.5615	6.0107	.97	.99	130
18	-0.0250	-0.1197	1.5959	1.9843	.24	.17	98
21	0.1111	0.1281	29.7452	3.8561	.92	.85	124
22	0.2550	0.2357	30.9647	3.9988	.99	.98	119
35	0.1000	0.0359	31.3252	3.1039	.82	.72	111
36	-0.0764	-0.0280	31.9683	3.0824	.30	.29	104
37	-0.0429	-0.0840	25.6557	3.8487	.29	.22	106
38	0.1400	0.0023	3.7509	2.6938	.98	.86	108
52	0.1550	0.1425	35.5333	0.8821	.99	.99	71
53	0.2000	0.1507	35.5104	0.8482	.99	.99	74
54	0.1450	0.1234	35.1471	1.2202	.98	.99	73
55	0.1667	0.1294	35.6678	0.6704	.99	.99	65
502	0.1000	0.2213	31.9516	3.2017	.85	.91	93
535	0.2200	0.1539	31.2134	3.6668	.92	.88	67
704	0.2000	0.1973	34.4425	1.5360	.99	.99	84
706	0.2000	0.1977	35.0734	1.1042	.99	.99	83
708	0.1667	0.2132	35.4784	1.0043	.99	.99	81

Table E14. Trend analysis for monthly near bottom temperature: measurements preceding 1990 cessation of brine discharge 1/1/78-12/31/89. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.0778	0.1105	22.7838	6.3810	.85	.71	130
18	-0.0500	0.0129	22.5398	6.9000	.43	.46	98
21	-0.0750	-0.0491	22.7952	5.1519	.11	.29	124
22	-0.0937	-0.0711	22.6269	4.8567	.05	.24	119
35	-0.1000	0.0446	22.6523	4.8500	.09	.56	111
36	-0.1225	-0.0451	22.6615	4.7474	.10	.31	104
37	-0.0333	0.0126	23.3783	6.2656	.36	.44	106
38	0.0667	0.1106	23.2093	6.5829	.69	.68	108
52	0.0000	-0.0678	22.5845	2.7954	.48	.47	71
53	-0.0500	-0.0252	22.4446	2.9700	.48	.59	74
54	-0.0083	-0.0024	22.6397	3.3469	.50	.67	73
55	-0.1000	-0.0375	22.7123	2.8275	.22	.45	65
502	0.0000	0.0094	22.7419	4.5098	.46	.57	93
535	-0.1125	-0.3414	22.2881	4.5075	.30	.42	67
704	-0.0167	-0.1085	22.8833	3.3731	.47	.28	84
706	-0.0500	-0.1021	22.7289	2.8952	.24	.27	83
708	-0.1600	-0.1552	22.6481	2.7579	.13	.16	81

Table E15. Trend analysis for monthly near surface salinity: measurements preceding 1990 cessation of brine discharge 1/1/78-12/31/89. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_l = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*). Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_l	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.3375	0.3864	23.1067	5.9392	.99	.99	134
7	0.5600	0.5470	18.6244	4.6125	.99	.99	131
12	0.2600	0.4202	10.5314	4.5133	.99	.99	105
13	0.4000	0.3912	9.6421	4.7026	.99	.99	126
14	0.1063	0.0744	4.5045	4.3642	.97	.83	132
15	0.1523	0.1135	4.2053	3.2471	.99	.98	132
16	0.1000	0.0975	2.2762	2.4398	.99	.96	122
18	0.0000	-0.0130	1.3000	1.7661	.46	.40	125
21	0.2100	0.2363	26.1177	5.6219	.91	.90	124
22	0.1000	0.1627	26.7144	5.3673	.82	.81	118
34	0.2714	0.2726	24.9042	5.0010	.99	.99	120
35	-0.0800	-0.1201	26.8919	5.2281	.39	.21	111
36	-0.0375	-0.1336	27.0076	5.2425	.46	.29	105
37	0.0000	0.0392	25.1528	4.0061	.50	.56	108
38	0.1613	0.0406	3.6637	2.7374	.99	.94	113
52	0.2125	0.4313	26.8753	5.0342	.91	.95	85
53	0.1667	0.3743	27.3195	4.9955	.84	.87	87
54	0.1500	0.3154	26.7695	4.8877	.73	.83	82
55	0.6000	0.7061	27.1937	5.1844	.97	.97	80
502	0.2000	0.2803	26.3574	5.4609	.83	.90	94
535	0.5000	0.4769	25.8388	5.5776	.89	.96	67
704	0.2500	0.1526	27.0721	4.8560	.89	.81	86
706	0.0800	0.0528	27.1955	5.0022	.65	.70	88
708	0.0200	0.2108	27.2576	5.0842	.53	.81	85

Table E16. Trend analysis for monthly near surface temperature: measurements preceding 1990 cessation of brine discharge 1/1/78-12/31/89. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.1286	0.1518	22.7515	6.5245	.89	.77	134
7	0.0000	0.0057	22.7893	6.9065	.52	.52	131
12	-0.0500	-0.1547	22.6076	6.7810	.35	.33	105
13	0.0400	0.0545	22.6841	7.1911	.67	.65	126
14	0.0690	0.1202	21.9545	7.0970	.82	.72	132
15	0.1100	0.1623	22.2886	7.1681	.96	.75	132
16	0.4250	0.4226	23.6926	7.1090	.99	.98	122
18	0.0182	0.0980	22.4736	7.0657	.60	.66	125
21	-0.0750	-0.0281	23.1476	5.6840	.04	.32	124
22	-0.0500	-0.0055	23.2517	5.5912	.15	.39	118
34	0.1667	0.0136	23.2983	7.0802	.97	.53	120
35	-0.0750	0.0897	23.1090	5.5342	.08	.64	111
36	-0.1000	0.0093	23.5581	5.5667	.03	.38	105
37	-0.0556	-0.0244	23.4583	6.2817	.41	.35	108
38	0.1775	0.2835	23.6044	6.9003	.95	.88	113
52	-0.0071	0.1026	23.2118	5.6082	.35	.61	85
53	-0.0250	0.0916	23.3126	5.5096	.36	.62	87
54	0.0000	0.0854	23.4573	5.7213	.50	.59	82
55	0.0875	0.2054	23.2738	5.5460	.83	.72	80
502	-0.1500	-0.0804	23.1277	5.4770	.04	.40	94
535	-0.1500	-0.4021	23.1149	5.7000	.12	.13	67
704	0.0000	-0.2141	23.7547	5.2117	.52	.24	86
706	0.0000	-0.2294	23.6091	5.0707	.39	.21	88
708	-0.0750	-0.2873	23.8141	5.1964	.21	.12	85

Table E17. Trend analysis for monthly near bottom salinity: measurements after 1990 cessation of brine discharge 1/1/91-12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*). Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.0500	-0.1636	20.4724	5.9631	.44	.44	58
18	-0.0142	-0.1985	0.6387	1.5516	.90	.11	46
21	0.0838	0.0874	29.9300	2.9736	.60	.67	53
22	0.0850	0.1286	31.7175	2.2681	.63	.79	53
35	0.0483	0.2680	31.4441	2.5013	.64	.90	63
36	0.2200	0.5354	31.6769	2.6168	.99	.99	62
37	-0.1900	0.1689	23.5723	5.2714	.41	.56	53
38	0.0510	0.0538	1.7112	1.4778	.90	.90	56
52	0.0100	0.0349	35.7100	0.7323	.72	.75	57
53	0.0000	0.0160	35.7976	0.6197	.50	.63	61
54	0.0300	0.0619	35.3416	0.8910	.70	.79	59
55	0.0293	0.0629	35.7790	0.6422	.92	.83	61
502	0.1729	-0.1166	31.5129	2.5547	.70	.30	56
535	0.2925	0.2772	30.8163	3.8072	.71	.52	54
704	0.0533	0.0871	34.6155	1.2045	.65	.72	56
706	0.0587	0.0416	35.3722	0.8418	.73	.62	57
708	0.0325	0.0943	35.6481	1.0505	.89	.63	57

Table E18. Trend analysis for monthly near bottom temperature: measurements after 1990 cessation of brine discharge 1/1/91-12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.0133	-0.0028	22.5386	5.8897	.50	.56	58
18	-0.2200	0.1726	22.6485	6.8185	.18	.54	46
21	0.2075	0.3852	22.5066	4.6970	.85	.83	53
22	0.3150	0.5175	22.3602	3.9882	.98	.94	53
35	0.0987	0.3107	22.8637	3.8920	.91	.87	63
36	0.2000	0.4497	22.5942	3.8813	.93	.93	62
37	0.0658	0.4049	23.0394	6.2169	.50	.76	53
38	-0.3725	-0.2661	22.5446	6.6730	.02	.37	56
52	0.0425	0.0307	22.8667	2.6503	.69	.78	57
53	0.0904	0.2666	22.6285	2.3819	.83	.74	61
54	0.1020	0.2521	22.8917	2.6002	.94	.93	59
55	0.0857	0.2653	22.6621	2.4574	.75	.95	61
502	0.1663	0.2305	23.0188	3.8736	.84	.88	56
535	0.1308	0.1282	23.0161	4.1142	.68	.78	54
704	0.3450	0.4284	22.9882	2.9223	.99	.97	56
706	0.1400	0.3329	23.0716	2.4761	.77	.94	57
708	0.0950	0.3682	22.8175	2.4495	.84	.95	57

Table E19. Trend analysis for monthly near surface salinity: measurements after 1990 cessation of brine discharge 1/1/91-12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*). Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.2000	0.0316	19.0851	5.6128	.56	.55	59
7	0.9133	0.9369	14.3921	4.7925	.97	.99	58
12	0.1875	-1.1930	4.7838	2.9489	.62	.67	21
13	-0.1500	-0.2355	5.1836	3.9396	.40	.50	39
14	0.0283	-0.3355	1.8280	2.6371	.75	.36	51
15	-0.0050	-0.0856	1.5909	1.3179	.47	.44	55
16	-0.0850	-0.3877	1.0195	1.5720	.03	.15	40
18	-0.0050	-0.1459	0.5293	1.2603	.38	.29	46
21	0.0700	0.0008	25.3326	4.2867	.50	.64	54
22	-0.1700	-0.1996	25.3175	4.7192	.37	.49	53
34	0.1000	-0.1974	21.5206	4.7839	.63	.25	52
35	-0.6680	-0.4149	24.3237	5.3475	.08	.20	62
36	0.0000	-0.1439	24.6800	4.9639	.50	.48	62
37	0.4188	0.2778	23.3023	5.4133	.66	.67	53
38	0.0188	0.0134	1.4239	1.1082	.59	.73	57
52	0.5438	0.0700	24.9740	6.3040	.84	.64	57
53	0.1050	0.2140	25.6623	5.2542	.50	.66	60
54	0.3867	0.7349	25.3607	5.2450	.92	.95	58
55	0.1350	0.7786	26.0674	4.9690	.68	.95	61
502	0.7050	0.4698	24.6262	5.3239	.93	.88	55
535	0.1950	0.0180	24.7957	5.7915	.56	.43	54
704	0.3667	0.4585	25.3611	5.2958	.70	.92	56
706	0.6367	0.4830	26.3016	5.3526	.77	.89	57
708	0.0000	0.1834	26.0667	5.6982	.47	.71	57

Table E20. Trend analysis for monthly near surface temperature: measurements after 1990 cessation of brine discharge 1/1/91-12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.1400	0.0790	22.5085	6.1240	.61	.59	59
7	-0.0283	-0.0636	21.8747	7.0884	.47	.44	58
12	0.7650	0.9677	20.9300	7.9844	.64	.58	21
13	-0.0400	-0.3928	22.1072	7.3971	.35	.39	39
14	-0.2237	-0.1122	22.3278	7.4387	.27	.50	51
15	-0.4750	0.0063	22.3924	7.2481	.04	.51	55
16	-0.5800	-0.2716	23.2832	7.0484	.07	.32	40
18	-0.3333	0.2584	22.8413	6.8120	.16	.64	46
21	0.2333	0.3911	22.5565	5.5514	.87	.78	54
22	0.4600	0.6561	22.6357	5.3554	.95	.92	53
34	-0.5100	0.3914	21.9742	7.2400	.11	.72	52
35	0.1895	0.5471	23.1010	5.2248	.99	.92	62
36	0.2200	0.5300	23.2395	5.1878	.98	.91	62
37	0.2100	0.4496	23.1755	6.2818	.77	.78	53
38	-0.5125	-0.3399	23.4914	7.2358	.03	.33	57
52	0.2375	0.8003	23.6319	5.2942	.96	.92	57
53	0.1787	0.5203	23.5352	5.3018	.87	.84	60
54	-0.0092	0.3737	24.3559	5.2024	.48	.81	58
55	0.1100	0.4441	23.7854	5.2014	.92	.82	61
502	-0.0875	0.1990	23.8242	5.6048	.35	.73	55
535	0.0675	0.3693	23.4800	5.7303	.78	.81	54
704	-0.0033	0.3807	23.7730	5.5754	.50	.76	56
706	0.0200	0.3707	23.7160	5.3747	.62	.73	57
708	0.0000	0.4476	23.8404	5.2124	.47	.83	57

Table E21. Trend analysis for monthly near bottom salinity: measurements preceding the approach of hurricane Andrew 1/1/78-8/10/92. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.1437	0.1715	23.4235	5.9849	.88	.93	159
18	-0.0200	-0.0856	1.5105	1.9825	.08	.03	125
21	0.0400	0.0498	29.6783	3.7818	.66	.65	149
22	0.1000	0.1499	31.0114	3.8803	.88	.94	143
35	-0.0050	-0.0164	31.2315	3.1590	.41	.46	139
36	-0.1525	-0.1001	31.7330	3.1300	.03	.06	132
37	-0.0500	-0.1136	25.4168	3.9599	.18	.14	135
38	0.0155	-0.0782	3.5454	2.5503	.62	.35	136
52	0.0500	0.0849	35.5968	0.8135	.98	.99	97
53	0.0667	0.0992	35.6078	0.7641	.99	.99	101
54	0.0400	0.0809	35.2266	1.1139	.92	.99	101
55	0.0600	0.0609	35.6985	0.6357	.97	.99	93
502	0.0000	0.1117	31.9943	2.9901	.53	.75	124
535	0.1000	0.0357	31.1899	3.6982	.79	.74	88
704	0.0708	0.1047	34.5075	1.4375	.95	.93	115
706	0.1000	0.1081	35.1259	1.0575	.99	.99	114
708	0.0921	0.0950	35.5052	1.0830	.99	.99	110

Table E22. Trend analysis for monthly near bottom temperature: measurements preceding the approach of hurricane Andrew 1/1/78-8/10/92. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.0739	0.1118	22.9288	6.2691	.91	.77	159
18	0.0450	-0.0248	22.4822	6.8511	.63	.42	125
21	-0.0322	-0.0390	22.7705	5.0957	.28	.31	149
22	-0.0472	-0.0649	22.5693	4.7404	.15	.20	143
35	0.0000	0.0397	22.7012	4.7229	.45	.60	139
36	-0.0500	-0.0415	22.6099	4.6203	.19	.28	132
37	0.0500	0.0244	23.4379	6.2220	.79	.55	135
38	0.0950	0.0922	23.2922	6.6751	.85	.74	136
52	0.0450	-0.0087	22.6354	2.8330	.80	.52	97
53	0.0250	-0.0271	22.3992	2.7827	.70	.47	101
54	-0.0062	-0.0041	22.6391	3.1187	.49	.62	101
55	0.0000	-0.0626	22.5919	2.6430	.50	.28	93
502	0.0500	-0.0143	22.6734	4.3124	.82	.53	124
535	0.0033	-0.0462	22.4267	4.4204	.58	.34	88
704	0.0143	-0.1088	22.7268	3.2263	.65	.16	115
706	0.0431	-0.0705	22.6407	2.7695	.84	.24	114
708	0.0000	-0.0954	22.5702	2.6636	.48	.13	110

Table E23. Trend analysis for monthly near surface salinity: measurements preceding the approach of hurricane Andrew 1/1/78-8/10/92. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.0536	0.0852	22.6826	5.9442	.68	.83	164
7	0.2056	0.1627	18.2006	4.9816	.99	.99	161
12	0.2586	0.4157	10.5604	4.5016	.99	.99	106
13	0.1333	0.0968	9.3243	4.8292	.94	.90	156
14	0.0077	-0.0235	4.3122	4.2640	.59	.35	162
15	0.0317	-0.0272	3.9560	3.0810	.83	.52	162
16	0.0300	0.0453	2.2653	2.5072	.88	.66	150
18	-0.0091	-0.0246	1.2457	1.7408	.10	.09	152
21	0.0300	0.0875	25.9809	5.3233	.62	.62	149
22	-0.0156	0.0315	26.5270	5.1274	.44	.41	142
34	0.1100	0.1333	24.8265	4.7958	.92	.89	145
35	-0.1475	-0.1812	26.5376	5.0548	.10	.03	138
36	-0.1636	-0.2276	26.5368	5.0531	.07	.02	133
37	-0.0400	-0.0418	24.9466	4.1245	.29	.37	137
38	0.0183	-0.0753	3.4241	2.5664	.66	.39	143
52	0.0167	0.0751	26.4953	5.1741	.55	.64	111
53	0.0333	0.1018	27.0604	5.1562	.62	.66	114
54	-0.0250	0.0076	26.3427	5.0990	.48	.41	109
55	0.1500	0.1725	26.8081	5.4151	.82	.73	108
502	0.0236	-0.0338	25.9137	5.3508	.51	.25	125
535	0.3000	0.1575	25.8574	5.4017	.83	.78	90
704	-0.0033	-0.1111	26.4932	4.9449	.42	.19	117
706	0.0000	-0.1031	26.7285	5.1075	.53	.30	120
708	-0.0083	0.0022	26.9131	5.2672	.47	.50	115

Table E24. Trend analysis for monthly near surface temperature: measurements preceding the approach of hurricane Andrew 1/1/78-8/10/92. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.1000	0.1306	22.8913	6.4501	.90	.81	164
7	-0.0211	0.0071	22.7993	6.8425	.36	.50	161
12	-0.0725	-0.2538	22.4991	6.8406	.27	.25	106
13	0.0413	0.0862	22.8572	7.1508	.77	.74	156
14	0.1000	0.1149	22.0927	7.1230	.97	.82	162
15	0.1268	0.1515	22.4669	7.2355	.99	.87	162
16	0.2837	0.2561	23.8019	7.1317	.99	.97	150
18	0.0250	0.0269	22.4009	6.9629	.70	.53	152
21	-0.0400	-0.0419	23.0832	5.7081	.13	.32	149
22	-0.0268	-0.0439	23.1503	5.5887	.15	.31	142
34	0.1571	-0.0046	23.2819	7.0696	.99	.51	145
35	-0.0257	0.0355	23.0857	5.5400	.20	.62	138
36	-0.0800	-0.0272	23.4779	5.5383	.03	.34	133
37	0.0464	0.0114	23.5309	6.2323	.79	.49	137
38	0.2000	0.2445	23.8720	7.0567	.99	.95	143
52	0.0000	0.0897	23.3137	5.5773	.53	.68	111
53	0.0133	0.0979	23.4124	5.5023	.62	.72	114
54	0.0500	0.1836	23.7870	5.6662	.89	.85	109
55	0.0750	0.1722	23.4367	5.5138	.95	.81	108
502	-0.0279	0.0099	23.2082	5.5120	.35	.59	125
535	-0.0429	-0.0832	23.1967	5.7098	.32	.34	90
704	0.0400	-0.1245	23.6484	5.4012	.84	.29	117
706	0.0208	-0.1500	23.4371	5.2090	.70	.21	120
708	0.0000	-0.2115	23.5330	5.2968	.47	.12	115

Table E25. Trend analysis for monthly near bottom salinity: measurements following hurricane Andrew 8/30/92-12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.7000	1.1237	19.5567	5.4575	.95	.93	40
18	0.0100	0.1372	0.2990	0.3329	.81	.55	31
21	-0.4300	-0.0764	30.0075	3.2293	.29	.48	36
22	-0.1000	0.0848	31.8030	2.3620	.39	.61	37
35	-0.0113	-0.0202	31.7081	2.4086	.42	.52	43
36	0.1083	0.2725	32.1214	2.4226	.82	.84	42
37	2.4900	1.6062	22.9776	5.6628	.95	.90	33
38	0.6217	0.6450	1.4759	1.2731	.99	.99	39
52	0.0100	0.1121	35.7035	0.7570	.65	.83	41
53	0.0175	0.1174	35.7715	0.6813	.50	.77	43
54	-0.0225	0.1837	35.3453	0.9026	.42	.79	41
55	0.0100	0.1023	35.8079	0.6478	.70	.60	42
502	0.4750	0.3111	31.2392	2.5757	.94	.79	36
535	0.8725	0.7137	30.7753	3.7374	.84	.77	36
704	-0.1075	-0.0780	34.7150	1.1308	.24	.24	36
706	-0.0650	-0.0974	35.4219	0.7934	.24	.37	37
708	0.0000	-0.0367	35.7646	0.6481	.45	.65	37

Table E26. Trend analysis for monthly near bottom temperature: measurements following hurricane Andrew 8/30/92-12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.0700	0.1290	22.3265	6.0751	.50	.59	40
18	-0.2600	-0.7799	23.0629	6.7314	.36	.27	31
21	0.9000	0.7266	22.6319	4.6134	.92	.85	36
22	0.7500	0.6265	22.6643	3.9536	.95	.79	37
35	0.2963	0.6797	22.9612	3.7752	.97	.90	43
36	0.1592	0.5726	22.8540	3.7720	.76	.86	42
37	0.7767	1.6651	22.8755	6.3158	.90	.94	33
38	-0.7150	0.1499	22.0810	6.3478	.26	.61	39
52	0.2200	0.2663	22.8724	2.4624	.98	.81	41
53	0.2262	0.4907	22.7981	2.5010	.95	.95	43
54	0.2125	0.3187	23.1185	2.7660	.99	.91	41
55	0.2375	0.5916	22.8319	2.6291	.99	.97	42
502	0.6433	0.2624	23.1661	4.0692	.97	.78	36
535	0.4000	0.0596	23.1231	4.1708	.92	.68	36
704	0.6750	0.4190	23.4367	2.9479	.98	.81	36
706	0.5300	0.5547	23.3465	2.5463	.98	.92	37
708	0.6550	0.9223	23.0554	2.5054	.98	.97	37

Table E27. Trend analysis for monthly near surface salinity: measurements following hurricane Andrew 8/30/92-12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	1.5700	1.5733	18.2967	5.4586	.98	.96	40
7	2.3700	2.5166	14.2192	3.8819	.99	.99	39
12	0.3050	0.9722	4.3430	2.2041	.74	.87	20
13	0.8400	2.3312	3.9985	2.4033	.74	.95	20
14	0.2900	0.1962	1.1773	1.2519	.92	.68	33
15	0.4667	0.4547	1.2819	0.8960	.99	.99	37
16	0.0100	-0.3138	0.6325	0.8690	.61	.64	24
18	0.0000	0.1322	0.2703	0.3184	.50	.52	30
21	-0.0050	0.2358	25.2368	4.7697	.50	.60	37
22	0.2867	0.0340	25.0589	5.2846	.50	.51	37
34	1.6000	1.3526	20.6059	4.6475	.99	.93	39
35	-0.3625	-0.1696	23.8323	5.8662	.31	.28	43
36	0.2150	-0.2652	24.4764	5.4526	.66	.34	42
37	2.3600	1.5256	22.7982	5.7002	.95	.91	33
38	0.4975	0.5581	1.1951	0.8823	.99	.99	39
52	1.5400	0.2776	24.7302	6.6270	.97	.78	41
53	1.2600	0.7325	25.3607	5.2371	.78	.81	42
54	1.4000	1.5880	25.4529	5.1113	.98	.98	41
55	0.4975	1.2566	26.2533	4.6642	.70	.97	42
502	2.4400	1.4775	24.6103	5.4715	.99	.97	35
535	2.6850	1.4857	24.2777	6.0622	.95	.92	35
704	2.9567	1.8964	25.0225	5.5796	.99	.99	36
706	2.2300	1.2580	26.1639	5.6427	.98	.95	36
708	0.0000	0.8431	25.6851	5.8689	.50	.79	37

Table E28. Trend analysis for monthly near surface temperature: measurements following hurricane Andrew 8/30/92-12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.0900	0.0961	22.4130	6.3037	.50	.57	40
7	-0.2167	-0.0423	21.6908	7.2261	.31	.52	39
12	0.2500	-1.6118	21.4215	7.8592	.50	.41	20
13	-0.0400	-1.1879	21.5175	7.7576	.50	.34	20
14	-0.3200	-0.5665	22.2185	7.3406	.50	.46	33
15	-0.2700	0.7811	22.0362	6.8894	.25	.72	37
16	0.2200	0.5609	22.6729	6.2591	.50	.64	24
18	-0.3400	-1.0579	23.3853	6.8170	.23	.26	30
21	0.2600	0.5698	22.7092	5.4224	.95	.79	37
22	0.5100	0.8447	22.9549	5.2617	.97	.86	37
34	-0.4533	-0.2450	22.2408	7.3672	.13	.46	39
35	0.2325	0.7881	23.3302	5.0577	.99	.66	43
36	0.2200	0.8163	23.4688	5.0644	.99	.91	42
37	0.8500	1.7203	23.0458	6.4293	.95	.93	33
38	-0.4517	0.0743	22.9441	6.7988	.26	.61	39
52	0.5200	1.2630	23.9780	5.1879	.97	.91	41
53	0.5300	1.2717	23.5381	5.1514	.94	.91	42
54	0.2900	1.2514	24.2551	5.0459	.95	.93	41
55	0.3133	1.3035	23.7774	5.0760	.99	.92	42
502	0.0075	0.2836	23.8286	5.4915	.56	.64	35
535	0.3500	0.4050	23.6140	5.6868	.91	.72	35
704	0.5200	0.5446	23.9075	5.1854	.90	.73	36
706	0.3500	0.4926	23.8878	5.0785	.84	.66	36
708	0.0850	0.7250	24.0281	4.8446	.60	.82	37

Table E29. Trend analysis for monthly near bottom salinity: preconstruction measurements 1/1/78 - 3/31/80. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-1.8000	2.1761	20.3375	6.5474	.40	.83	24
21	3.1000	3.0534	27.5714	4.9543	.75	.98	21
22	3.7000	3.7343	28.5368	5.7015	.86	.98	19
35	0.0000	3.2571	31.2143	1.7883	.50	.82	7
36	0.0000	3.2571	31.2143	1.7883	.50	.82	3

Table E30. Trend analysis for monthly near bottom temperature: preconstruction measurements 1/1/78 - 3/31/80. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.7500	-0.4605	21.1083	7.8193	.90	.52	24
21	-1.3000	-4.1660	22.7048	5.6588	.25	.03	21
22	-0.4500	-3.8644	22.1000	5.4818	.36	.02	19
35	0.0000	-19.7571	19.5571	4.1259	.50	.02	7
36	0.0000	3.2571	31.2143	1.7883	.50	.82	3

Table E31. Trend analysis for monthly near surface salinity: preconstruction measurements 1/1/78 - 3/31/80. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_l = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_l	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-2.2000	2.1578	19.7208	5.6327	.40	.85	24
7	0.5000	2.0378	14.9545	4.3083	.60	.83	22
12	0.8000	1.8994	7.3188	3.4668	.66	.78	16
13	1.8500	2.2341	6.2812	3.0703	.89	.96	16
14	0.6000	1.6343	2.9714	3.2874	.87	.67	21
15	0.7000	1.0198	2.5000	1.5550	.98	.79	21
16	0.3000	-0.2243	1.5810	1.2372	.75	.46	21
18	0.2000	0.1349	0.7278	0.8498	.65	.66	18
21	-0.6000	2.6999	23.4429	6.6035	.37	.87	21
22	-3.1000	2.5715	24.4050	6.7934	.14	.84	20
34	15.9000	13.5709	22.0000	5.2796	.50	.99	12
35	0.0000	4.9714	29.1000	3.6185	.50	.82	7

Table E32. Trend analysis for monthly near surface temperature: preconstruction measurements 1/1/78 - 3/31/80. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	1.1500	-1.7515	20.9167	8.0063	.78	.29	24
7	0.2000	-2.8011	21.5818	8.0492	.50	.21	22
12	1.3000	-4.3819	21.9625	7.2006	.50	.18	16
13	-0.0500	-5.2869	21.8437	8.0117	.50	.17	16
14	-1.0000	-5.8093	20.2571	8.0738	.25	.02	21
15	0.3000	-5.7740	20.5333	8.2903	.50	.04	21
16	-0.2000	-5.4935	21.2762	7.7518	.25	.02	21
18	0.0000	-4.5281	20.4056	7.6803	.50	.18	18
21	-1.0000	-4.7671	22.9714	6.0759	.25	.03	21
22	-0.9500	-4.8356	22.4650	6.1403	.24	.03	20
34	-0.4000	-12.8722	21.8333	7.0484	.50	.07	12
35	0.0000	-19.1143	18.9429	4.3231	.50	.04	7

Table E33. Trend analysis for monthly near bottom salinity: postconstruction measurements 1/1/83 – 12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.4382	-0.3075	22.5632	6.0253	.01	.01	144
18	-0.0300	-0.0966	1.0960	1.6941	.01	.01	131
21	0.0000	0.0396	29.7819	3.4513	.47	.67	133
22	0.0575	0.1289	31.3724	3.2295	.76	.91	133
35	0.0710	0.0906	31.2848	3.0109	.82	.91	146
36	0.0729	0.0860	31.6424	2.8908	.80	.96	143
37	-0.0736	-0.1158	24.5113	4.5021	.12	.21	136
38	-0.1067	-0.1486	2.7981	2.2119	.01	.01	143
52	0.0350	0.0349	35.6750	0.7152	.99	.98	129
53	0.0400	0.0650	35.6669	0.7237	.99	.99	134
54	0.0279	0.0442	35.2855	1.0211	.95	.92	135
55	0.0300	0.0403	35.7307	0.6463	.99	.99	131
502	-0.0500	0.0259	31.7960	2.9246	.13	.31	146
535	-0.0450	0.0000	31.0725	3.7283	.39	.30	117
704	0.0256	0.0558	34.6113	1.2971	.88	.87	141
706	0.0333	0.0518	35.2726	0.9329	.99	.96	141
708	0.0210	0.0417	35.6295	0.9464	.97	.98	140

Table E34. Trend analysis for monthly near bottom temperature: postconstruction measurements 1/1/83 – 12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.0125	-0.0929	23.0183	6.0304	.43	.26	144
18	0.0111	0.0489	22.5621	6.7294	.57	.64	131
21	0.0400	0.0678	22.5974	4.7701	.81	.74	133
22	0.0000	0.0429	22.4488	4.2242	.50	.63	133
35	0.0220	0.0738	22.7720	4.2609	.72	.75	146
36	-0.0067	0.0372	22.6213	4.1639	.45	.67	143
37	-0.0150	-0.0267	23.3793	6.1104	.39	.43	136
38	-0.0315	-0.0165	22.9350	6.6082	.30	.47	143
52	0.0713	0.0879	22.5961	2.6208	.99	.95	129
53	0.0800	0.1215	22.3578	2.5838	.99	.99	134
54	0.0600	0.1028	22.6830	2.8882	.98	.94	135
55	0.0473	0.0558	22.5778	2.6008	.97	.87	131
502	0.0710	0.1060	22.7120	4.2104	.98	.91	146
535	0.0957	0.1353	22.4792	4.3466	.95	.93	117
704	0.0647	0.0902	22.7627	3.1545	.95	.91	141
706	0.0671	0.1082	22.6885	2.7305	.99	.97	141
708	0.0500	0.0790	22.5536	2.5847	.97	.92	140

Table E35. Trend analysis for monthly near surface salinity: postconstruction measurements 1/1/83 – 12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.4875	-0.3770	21.5881	6.1367	.01	.01	149
7	-0.3286	-0.3115	17.3696	5.1679	.01	.01	150
12	-0.6432	-0.5936	9.3195	4.8800	.01	.01	80
13	-0.3333	-0.4026	8.6935	5.0551	.01	.01	130
14	-0.1675	-0.2793	3.4911	3.9383	.01	.01	143
15	-0.2000	-0.2666	3.2000	2.7966	.01	.01	147
16	-0.0671	-0.0608	1.9089	2.2820	.01	.01	122
18	-0.0286	-0.0948	0.9735	1.5312	.01	.01	134
21	-0.0667	-0.0619	25.8034	4.8383	.21	.27	135
22	-0.1480	-0.1343	26.0514	4.8870	.06	.11	131
34	-0.3000	-0.2284	23.6137	5.1659	.01	.01	144
35	-0.1721	-0.1733	25.2998	5.3425	.09	.05	145
36	-0.1189	-0.1473	25.5115	5.2284	.09	.07	144
37	-0.0633	-0.0648	24.1753	4.6143	.28	.41	137
38	-0.1250	-0.1862	2.7031	2.2782	.01	.01	149
52	-0.1475	-0.0756	25.8899	5.7398	.11	.26	137
53	-0.1288	-0.0382	26.4655	5.3090	.09	.22	141
54	-0.0500	-0.0228	26.0141	5.2076	.30	.25	136
55	-0.0585	0.0365	26.6731	5.1967	.34	.43	141
502	-0.1227	-0.1004	25.5523	5.4689	.16	.08	146
535	-0.1444	-0.0913	25.4447	5.7441	.09	.07	118
704	-0.1050	-0.0678	25.9551	5.2153	.14	.28	142
706	-0.0050	0.0289	26.4068	5.3250	.34	.59	145
708	-0.0271	0.0269	26.4099	5.5212	.39	.60	142

Table E36. Trend analysis for monthly near surface temperature: postconstruction measurements 1/1/83 – 12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.0167	-0.0368	22.9946	6.2585	.37	.39	149
7	-0.0767	-0.0657	22.4489	6.9534	.06	.31	150
12	0.0312	-0.2155	22.0004	7.2873	.57	.21	80
13	0.0400	0.0001	22.7298	7.3205	.72	.47	130
14	0.0329	0.0626	22.2666	7.0645	.64	.74	143
15	-0.0050	0.0546	22.5216	6.9831	.44	.68	147
16	-0.0500	-0.0320	24.1314	6.8642	.21	.41	122
18	0.0000	0.0633	22.6597	6.7410	.53	.66	134
21	-0.0150	0.0243	22.8559	5.4949	.38	.64	135
22	-0.0375	0.0189	22.9953	5.3115	.11	.61	131
34	-0.0250	-0.0531	22.9074	7.3058	.36	.39	144
35	0.0000	0.0560	23.1825	5.3089	.51	.74	145
36	-0.0333	0.0232	23.4337	5.2606	.17	.61	144
37	-0.0273	-0.0228	23.4759	6.1396	.28	.44	137
38	0.0000	0.0341	23.7927	7.0030	.46	.61	149
52	0.0767	0.1894	23.4147	5.4054	.99	.93	137
53	0.0640	0.1491	23.3533	5.3455	.99	.89	141
54	0.0871*	0.2182	23.8474	5.4055	.99	.95	136
55	0.0760	0.1640	23.4852	5.3115	.99	.90	141
502	0.0433	0.1315	23.3064	5.5757	.90	.89	146
535	0.0650	0.1226	23.1400	5.7313	.88	.88	118
704	0.0180	0.0663	23.5922	5.4444	.72	.72	142
706	0.0176	0.0799	23.4028	5.2594	.72	.75	145
708	0.0000	0.0490	23.5183	5.2541	.44	.69	142

Table E37. Trend analysis for monthly near bottom salinity: measurements preceding years of heavy river flow 1/1/78 - 12/31/82. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.9000	1.3103	22.8636	6.2418	.97	.99	55
18	-0.5000	-1.2050	2.1800	2.3220	.31	.04	25
21	0.9000	1.2715	29.6943	4.2053	.99	.99	53
22	1.0000	1.3932	30.6833	4.5470	.98	.99	48
35	0.0000	0.1728	31.6622	2.9773	.50	.70	37
36	-1.4000	-0.3590	32.7250	3.1989	.09	.04	32
37	0.3500	-0.1374	26.6970	3.6312	.56	.40	33
38	0.3500	0.5663	4.3625	3.1658	.89	.84	32
52	-0.3500	-0.4327	34.9667	1.4379	.36	.17	9
53	0.2000	0.2266	35.4857	1.0715	.50	.50	10
54	-0.4250	-0.5263	34.7857	1.6211	.08	.23	7
55	0.0000	0.0000	35.8000	0.1732	.50	.50	4
502	-2.0000	-2.5315	32.2133	2.7785	.31	.13	15
535	0.0000	-9.5820	31.3250	3.2932	.50	.04	8
704	-0.5000	0.5138	33.9000	2.2034	.50	.38	11
706	0.6250	1.6594	34.3000	1.4825	.92	.64	11
708	1.6000	2.6601	34.3833	1.3075	.50	.71	8

Table E38. Trend analysis for monthly near bottom temperature: measurements preceding years of heavy river flow 1/1/78 - 12/31/82. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.1417	0.5201	22.2564	6.7181	.70	.76	55
18	-0.6000	1.0581	22.7840	7.3598	.16	.61	25
21	0.0000	-0.0275	23.2208	5.5543	.50	.51	53
22	0.0333	0.2814	23.0625	5.4618	.50	.68	48
35	-0.1333	1.0930	22.8108	5.4170	.50	.86	37
36	-0.5000	1.1386	22.9969	5.4758	.20	.86	32
37	-0.4500	1.1967	23.2909	6.7684	.21	.82	33
38	-0.6250	0.2299	23.4125	6.6816	.11	.42	32
52	-1.0000	-0.1677	24.2778	3.7366	.36	.27	9
53	-0.0750	0.7583	24.6700	3.4016	.50	.36	10
54	-1.1250	-0.9143	24.6000	4.8836	.08	.18	7
55	0.0000	-19.3200	25.5750	2.1235	.50	.04	4
502	-1.0500	0.1898	23.7733	4.6760	.07	.50	15
535	0.0000	-0.0481	25.4000	3.5315	.50	.64	8
704	-0.7000	-0.8640	24.5545	2.8101	.50	.27	11
706	1.0750	1.1719	24.3182	2.1061	.68	.71	11
708	0.8500	1.4850	24.9375	2.2772	.50	.50	8

Table E39. Trend analysis for monthly near surface salinity: measurements preceding years of heavy river flow 1/1/78 - 12/31/82. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_l = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_l	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	1.0125	1.3915	22.4582	5.9877	.98	.99	55
7	0.9250	1.7247	17.5880	4.6505	.99	.99	50
12	1.0625	1.5283	10.0152	4.6546	.99	.99	46
13	1.3167	1.5436	8.7913	4.5472	.99	.99	46
14	0.6000	0.8691	4.5808	4.4261	.98	.98	52
15	0.7500	1.0908	4.1904	3.4101	.99	.99	52
16	0.1000	0.4802	2.3481	2.7008	.84	.88	52
18	0.1000	0.2961	1.3958	1.8807	.93	.96	48
21	0.9000	1.5067	25.8250	6.1224	.96	.98	52
22	0.6750	1.3549	26.6327	5.8897	.81	.97	49
34	0.9000	1.6501	25.0775	4.5206	.95	.99	40
35	0.5000	-0.2865	28.1973	4.7999	.70	.36	37
36	-0.4000	-0.5925	28.4031	4.3910	.50	.22	32
37	1.1500	0.7014	25.9706	3.8644	.83	.78	34
38	0.4000	0.5864	4.0455	3.0633	.80	.88	33
52	-2.0000	0.0278	27.2000	4.5591	.27	.58	15
53	-1.8000	0.4316	27.8933	4.1736	.50	.50	15
54	-3.2500	0.2761	26.9286	3.9702	.24	.61	14
55	0.0000	11.0816	26.3333	5.6697	.50	.77	9
502	-1.0500	-0.9981	26.1867	4.4716	.50	.48	15
535	0.0000	0.2887	24.4000	2.9771	.50	.50	8
704	-0.4000	-2.2808	28.4917	2.6976	.34	.21	12
706	-0.9000	-2.2530	29.1167	2.5059	.34	.17	12
708	1.0000	-1.8220	29.6818	2.4400	.50	.20	11

Table E40. Trend analysis for monthly near surface temperature: measurements preceding years of heavy river flow 1/1/78 - 12/31/82. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.1542	0.5186	22.2636	6.8314	.73	.73	55
7	0.3150	0.3100	22.9860	6.8496	.82	.64	50
12	0.0500	0.1089	22.8978	6.4766	.50	.55	46
13	-0.2000	0.0023	22.6348	6.9725	.35	.44	46
14	0.4000	0.1470	21.6942	7.4017	.85	.60	52
15	0.3000	0.3484	22.0058	7.6865	.88	.60	52
16	0.3333	0.2130	22.5077	7.2875	.63	.50	52
18	0.2000	0.5190	22.2938	7.5008	.65	.76	48
21	0.0000	0.0979	23.5038	6.0214	.50	.59	52
22	0.0125	0.3971	23.5245	6.0419	.64	.73	49
34	0.2167	0.1177	23.6150	6.4935	.63	.49	40
35	0.3000	1.6455	23.1351	5.8933	.94	.95	37
36	0.2000	1.4715	23.8250	6.1305	.50	.84	32
37	-0.2000	1.1074	23.4500	6.7839	.38	.77	34
38	-0.5000	0.5110	23.1333	7.0361	.12	.43	33
52	-0.3500	-1.0555	24.2067	6.1488	.27	.31	15
53	-0.5500	-1.0998	24.3200	5.9557	.27	.24	15
54	-0.2500	-0.9740	24.5714	6.4516	.50	.27	14
55	0.0000	2.3732	24.2667	6.6905	.50	.30	9
502	-0.6000	1.1026	24.2200	4.9453	.31	.52	15
535	0.0000	-4.4962	26.8375	4.1210	.50	.27	8
704	0.0000	1.7483	25.6833	3.6764	.50	.50	12
706	-0.0500	1.5576	25.7750	3.5302	.20	.37	12
708	0.5000	1.5027	26.0000	3.7175	.50	.50	11

Table E41. Trend analysis for monthly near bottom salinity: measurements during years of heavy river flow 7/1/83-12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.5129	-0.3888	22.6714	5.9609	.01	.01	140
18	-0.0429	-0.1242	1.1292	1.7188	.01	.01	126
21	-0.0029	0.0400	29.7928	3.5158	.47	.60	127
22	0.0086	0.0946	31.4768	3.1777	.54	.76	128
35	0.0167	0.0555	31.3827	2.9536	.55	.76	140
36	0.0201	0.0549	31.7280	2.8528	.56	.89	138
37	-0.0625	-0.1239	24.5070	4.5037	.18	.23	132
38	-0.1558	-0.1918	2.8531	2.2318	.01	.01	138
52	0.0300	0.0362	35.6801	0.7240	.98	.97	125
53	0.0333	0.0536	35.7062	0.6710	.99	.99	129
54	0.0300	0.0538	35.2785	1.0372	.95	.93	130
55	0.0200	0.0341	35.7511	0.6336	.94	.97	127
502	-0.0750	-0.0481	31.9452	2.6808	.04	.09	142
535	-0.0929	-0.0675	31.2343	3.5562	.20	.10	113
704	0.0150	0.0412	34.6461	1.2878	.73	.75	138
706	0.0255	0.0402	35.3013	0.9231	.98	.89	138
708	0.0108	0.0309	35.6594	0.9418	.89	.90	136

Table E42. Trend analysis for monthly near bottom temperature: measurements during years of heavy river flow 7/1/83-12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.0750	-0.1327	23.0789	6.0641	.19	.18	140
18	-0.0200	-0.0075	22.6828	6.6991	.38	.50	126
21	0.0431	0.0175	22.7177	4.7948	.81	.56	127
22	0.0000	0.0233	22.4984	4.2249	.50	.53	128
35	0.0150	0.0181	22.9044	4.2339	.63	.50	140
36	0.0000	0.0151	22.6742	4.1591	.51	.56	138
37	-0.0500	-0.0225	23.3643	6.1563	.30	.43	132
38	-0.0800	-0.0663	23.0283	6.5901	.14	.35	138
52	0.0600	0.0587	22.6712	2.6277	.98	.85	125
53	0.0975	0.1048	22.4220	2.6096	.99	.96	129
54	0.0600	0.0780	22.7601	2.9134	.96	.85	130
55	0.0554	0.0325	22.6314	2.6195	.99	.77	127
502	0.0727	0.0552	22.8271	4.1645	.97	.79	142
535	0.0908	0.0844	22.6281	4.2991	.94	.82	113
704	0.0667	0.0752	22.8032	3.1667	.94	.87	138
706	0.0787	0.0925	22.7325	2.7405	.99	.95	138
708	0.0617	0.0624	22.6007	2.6045	.96	.84	136

Table E43. Trend analysis for monthly near surface salinity: measurements during years of heavy river flow 7/1/83-12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.5957	-0.5294	21.7841	6.0582	.01	.01	143
7	-0.4667	-0.4396	17.5413	5.1327	.01	.01	144
12	-1.0400	-0.7443	9.5157	4.9985	.01	.01	74
13	-0.5200	-0.5656	8.8650	5.0974	.01	.01	124
14	-0.2500	-0.3662	3.5915	3.9927	.01	.01	137
15	-0.2343	-0.3228	3.2549	2.8286	.01	.01	142
16	-0.1000	-0.0966	1.9639	2.3134	.01	.01	117
18	-0.0350	-0.1188	1.0004	1.5543	.01	.01	129
21	-0.0667	-0.1002	25.8664	4.8309	.21	.18	129
22	-0.1450	-0.2102	26.1748	4.7544	.06	.06	126
34	-0.3625	-0.3461	23.7976	5.0227	.01	.01	138
35	-0.1850	-0.2392	25.3912	5.2740	.06	.02	139
36	-0.1051	-0.1768	25.5407	5.2289	.14	.04	139
37	-0.0386	-0.0808	24.1971	4.6285	.32	.38	133
38	-0.1667	-0.2332	2.7581	2.2960	.01	.01	144
52	-0.1750	-0.1622	26.0562	5.5513	.07	.15	132
53	-0.1780	-0.1105	26.6076	5.0440	.07	.16	136
54	-0.0762	-0.1208	26.2108	4.9251	.20	.13	131
55	-0.1175	-0.0662	26.8883	4.8901	.19	.36	136
502	-0.1230	-0.0948	25.5235	5.5352	.16	.08	142
535	-0.1381	-0.0764	25.3892	5.8122	.09	.08	114
704	-0.1021	-0.0918	25.9915	5.1857	.17	.23	139
706	-0.0025	0.0153	26.4373	5.3201	.41	.55	142
708	-0.0250	-0.0281	26.5268	5.4122	.40	.48	138

Table E44. Trend analysis for monthly near surface temperature: measurements during years of heavy river flow 7/1/83-12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.0833	-0.1427	23.1860	6.2348	.09	.15	143
7	-0.1071	-0.1497	22.5940	6.9893	.01	.14	144
12	-0.0850	-0.3310	22.2274	7.3908	.36	.05	74
13	0.0000	-0.1279	22.9426	7.3250	.46	.23	124
14	-0.0200	-0.0125	22.4272	7.0275	.39	.57	137
15	-0.0700	0.0014	22.6351	6.9723	.19	.55	142
16	-0.2170	-0.1129	24.2738	6.8004	.07	.27	117
18	-0.0250	0.0087	22.7798	6.7090	.33	.52	129
21	-0.0225	-0.0336	22.9787	5.5048	.34	.45	129
22	-0.0367	0.0002	23.0356	5.3398	.16	.54	126
34	-0.1000	-0.1603	23.1084	7.3175	.11	.18	138
35	0.0105	0.0082	23.2940	5.3090	.69	.60	139
36	-0.0218	-0.0010	23.4874	5.2836	.28	.53	139
37	-0.0308	-0.0083	23.4406	6.1888	.26	.46	133
38	-0.0562	-0.0198	23.9035	6.9559	.21	.49	144
52	0.0667	0.1564	23.5267	5.4103	.98	.86	132
53	0.0575	0.1141	23.4560	5.3569	.97	.80	136
54	0.0750	0.1787	23.9782	5.4003	.99	.89	131
55	0.0667	0.1205	23.6074	5.3101	.99	.80	136
502	0.0420	0.0771	23.4326	5.5316	.88	.78	142
535	0.0586	0.0711	23.2844	5.6872	.84	.76	114
704	0.0200	0.0551	23.6215	5.4661	.72	.68	139
706	0.0055	0.0656	23.4395	5.2781	.64	.70	142
708	0.0000	0.0498	23.5239	5.2796	.46	.68	138

Table E45. Trend analysis for monthly near bottom salinity: measurements preceding the big freeze of 1989 1/1/78-12/1/89. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.3050	0.3730	23.5442	6.0309	.97	.99	129
18	-0.0250	-0.1197	1.5959	1.9843	.24	.17	98
21	0.1000	0.1190	29.7228	3.8638	.89	.81	123
22	0.2464	0.2336	30.9492	4.0123	.98	.97	118
35	0.0929	0.0253	31.3064	3.1117	.77	.67	110
36	-0.0833	-0.0298	31.9670	3.0975	.29	.28	103
37	-0.0464	-0.0886	25.6524	3.8670	.28	.22	105
38	0.1400	0.0023	3.7509	2.6938	.98	.86	108
52	0.1600	0.1567	35.5456	0.8827	.99	.99	70
53	0.2000	0.1549	35.5076	0.8544	.99	.99	73
54	0.1500	0.1479	35.1754	1.2059	.99	.99	72
55	0.1667	0.1309	35.6621	0.6748	.99	.99	64
502	0.1000	0.2216	31.9424	3.2180	.82	.91	92
535	0.2200	0.1539	31.2134	3.6668	.92	.88	67
704	0.2000	0.2069	34.4468	1.5454	.99	.99	83
706	0.2000	0.2032	35.0718	1.1112	.99	.99	82
708	0.1667	0.2171	35.4726	1.0100	.99	.99	80

Table E46. Trend analysis for monthly near bottom temperature: measurements preceding the big freeze of 1989 1/1/78-12/1/89. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.0800	0.1632	22.8837	6.3030	.12	.79	129
18	-0.0500	0.0129	22.5398	6.9000	.43	.46	98
21	-0.0613	-0.0176	22.8537	5.1314	.14	.37	123
22	-0.0845	-0.0455	22.6771	4.8463	.07	.31	118
35	-0.1000	0.0735	22.6964	4.8498	.10	.62	110
36	-0.1000	-0.0136	22.7117	4.7429	.12	.38	103
37	-0.0134	0.0909	23.5010	6.1664	.44	.55	105
38	0.0667	0.1106	23.2093	6.5829	.69	.68	108
52	0.0000	-0.0629	22.5957	2.8140	.52	.48	70
53	0.0083	-0.0248	22.4466	2.9905	.50	.59	73
54	0.0500	0.0238	22.6764	3.3556	.56	.74	72
55	-0.1000	-0.0389	22.7125	2.8499	.27	.44	64
502	0.0000	0.0606	22.8141	4.4801	.54	.68	92
535	-0.1125	-0.3414	22.2881	4.5075	.30	.12	67
704	0.0125	-0.0762	22.9337	3.3616	.52	.38	83
706	-0.0400	-0.0822	22.7622	2.8970	.31	.33	82
708	-0.1417	-0.1393	22.6775	2.7625	.19	.22	80

Table E47. Trend analysis for monthly near surface salinity: measurements preceding the big freeze of 1989 1/1/78-12/1/89. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.3556	0.4129	23.1429	5.9468	.99	.99	133
7	0.5804	0.5709	18.6485	4.6221	.99	.99	130
12	0.2600	0.4202	10.5314	4.5133	.99	.99	105
13	0.4000	0.4308	9.7000	4.6761	.99	.99	125
14	0.1063	0.0744	4.5045	4.3642	.97	.83	132
15	0.1523	0.1135	4.2053	3.2471	.99	.98	132
16	0.1000	0.0975	2.2762	2.4398	.99	.96	122
18	0.0000	-0.0130	1.3000	1.7661	.46	.40	125
21	0.1929	0.2137	26.0659	5.6150	.88	.86	123
22	0.0929	0.1391	26.6624	5.3605	.76	.74	117
34	0.2732	0.2682	24.8840	5.0172	.99	.99	119
35	-0.1250	-0.1521	26.8464	5.2299	.31	.15	110
36	-0.1000	-0.1750	26.9510	5.2354	.38	.21	104
37	0.0000	0.0348	25.1439	4.0239	.50	.54	107
38	0.1613	0.0406	3.6637	2.7374	.99	.94	113
52	0.2000	0.4225	26.8405	5.0541	.89	.95	84
53	0.1667	0.3620	27.2826	5.0128	.78	.84	86
54	0.0833	0.2990	26.7284	4.9039	.65	.79	81
55	0.5583	0.6957	27.1456	5.1995	.95	.96	79
502	0.1500	0.2596	26.3161	5.4757	.79	.88	93
535	0.5000	0.4769	25.8388	5.5776	.89	.96	67
704	0.2600	0.1416	27.0494	4.8802	.90	.81	85
706	0.0857	0.0317	27.1632	5.0220	.67	.67	87
708	0.0200	0.1941	27.2250	5.1058	.53	.79	84

Table E48. Trend analysis for monthly near surface temperature: measurements preceding the big freeze of 1989 1/1/78-12/1/89. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	0.1429	0.2104	22.8624	6.4211	.91	.84	133
7	0.0125	0.0628	22.9038	6.8072	.58	.62	130
12	-0.0500	-0.1547	22.6076	6.7810	.34	.33	105
13	0.0500	0.1217	22.8088	7.0820	.73	.74	125
14	0.0690	0.1202	21.9545	7.0970	.82	.72	132
15	0.1100	0.1623	22.2886	7.1681	.96	.75	132
16	0.4250	0.4226	23.6926	7.1090	.99	.98	122
18	0.0182	0.0980	22.4736	7.0657	.60	.65	125
21	-0.0708	0.0054	23.2089	5.6658	.06	.40	123
22	-0.0500	0.0268	23.3120	5.5766	.17	.47	117
34	0.1789	0.0805	23.4202	6.9827	.98	.63	119
35	-0.0667	0.1378	23.1818	5.5058	.10	.73	110
36	-0.1000	0.0534	23.6250	5.5510	.04	.47	104
37	-0.0167	0.0517	23.5794	6.1833	.49	.45	107
38	0.1775	0.2835	23.6044	6.9003	.95	.88	113
52	0.0000	0.1501	23.2750	5.6113	.37	.68	84
53	0.0000	0.1371	23.3767	5.5092	.39	.69	86
54	0.0000	0.1347	23.5272	5.7216	.50	.66	81
55	0.0675	0.2634	23.3405	5.5490	.81	.78	79
502	-0.1333	-0.0193	23.2172	5.4371	.07	.51	93
535	-0.1500	-0.4021	23.1149	5.7000	.12	.13	67
704	0.0250	-0.1457	23.8624	5.1455	.61	.33	85
706	0.0000	-0.1668	23.7080	5.0139	.48	.30	87
708	-0.0500	-0.2195	23.9202	5.1341	.28	.19	84

Table E49. Trend analysis for monthly near bottom salinity: measurements after the big freeze of 1989 1/1/90 - 12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.4950	-0.4375	20.9217	5.8463	.10	.21	69
18	-0.0300	-0.1595	0.7186	1.4338	.01	.01	58
21	-0.1180	0.2068	29.7805	3.2973	.47	.66	62
22	-0.0600	0.1815	31.6215	2.7481	.30	.67	62
35	-0.0500	0.2104	31.4164	2.8526	.36	.74	72
36	0.1100	0.3776	31.6531	2.8074	.88	.96	71
37	-0.1000	0.0077	23.7306	5.0537	.35	.58	63
38	-0.1350	-0.2046	2.0094	1.5934	.10	.12	67
52	0.0067	0.0025	35.7290	0.6836	.67	.71	67
53	0.0040	0.0054	35.8024	0.5893	.61	.70	70
54	0.0186	0.0041	35.3792	0.8441	.66	.64	69
55	0.0058	0.0292	35.7893	0.6092	.73	.81	70
502	-0.0217	-0.1981	31.6753	2.4574	.41	.16	68
535	0.1175	0.0677	30.9445	3.7444	.64	.32	58
704	-0.0417	-0.0302	34.7157	1.1340	.24	.36	68
706	0.0500	0.0274	35.3622	0.8525	.72	.61	69
708	0.0038	0.0237	35.6875	0.9731	.60	.51	67

Table E50. Trend analysis for monthly near bottom temperature: measurements after the big freeze of 1989 1/1/90 - 12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal}$ > 0.9500 for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.2308	-0.2516	22.8528	5.9507	.07	.28	69
18	-0.1650	0.0614	22.6953	6.7134	.15	.52	58
21	0.0350	0.0643	22.7347	4.7178	.53	.63	62
22	0.1100	0.1375	22.5821	4.0230	.70	.72	62
35	0.0375	0.1242	22.9765	3.9305	.60	.71	72
36	0.0100	0.1922	22.7315	3.9164	.58	.80	71
37	-0.2475	0.0062	23.3348	6.2016	.05	.42	63
38	-0.5633	-0.3062	22.7209	6.6791	.01	.27	67
52	0.0650	0.0752	22.8343	2.6557	.88	.85	67
53	0.0988	0.2180	22.5963	2.3988	.95	.96	70
54	0.0914	0.1506	22.9233	2.6456	.91	.90	69
55	0.0850	0.2241	22.6241	2.4548	.95	.96	70
502	0.1690	0.2621	22.9051	3.9014	.94	.92	68
535	0.2325	-0.0080	23.1029	4.1489	.98	.68	58
704	0.2300	0.3490	22.9035	2.8924	.99	.98	68
706	0.1587	0.3613	22.8997	2.5053	.98	.99	69
708	0.1125	0.3341	22.7239	2.4595	.97	.98	67

Table E51. Trend analysis for monthly near surface salinity: measurements after the big freeze of 1989 1/1/90 - 12/31/95. Results of analysis for selected stations (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.3200	-0.1565	19.3646	5.6525	.14	.40	70
7	-0.1600	-0.0437	15.1455	5.0411	.41	.65	69
12	0.1875	-1.1930	4.7838	2.9489	.62	.67	21
13	-0.9100	-1.2646	6.3932	4.7061	.01	.02	50
14	-0.1867	-0.5071	2.2671	2.9466	.10	.02	63
15	-0.2540	-0.3524	1.9881	1.6188	.01	.01	67
16	-0.1000	-0.5220	1.4862	2.2843	.01	.01	52
18	-0.0300	-0.1417	0.6132	1.1888	.01	.01	57
21	0.3288	0.1600	25.2025	4.2616	.67	.81	63
22	-0.1700	-0.0101	25.2489	4.6588	.35	.65	62
34	-0.4000	-0.5740	22.1089	4.6768	.14	.03	64
35	-0.3575	-0.2202	24.3207	5.2017	.13	.36	71
36	0.1400	0.0111	24.6023	4.8142	.60	.67	71
37	0.0400	0.0632	23.4686	5.1528	.50	.64	63
38	-0.2000	-0.2641	1.7719	1.3533	.01	.02	69
52	0.3625	0.1038	24.9331	6.1849	.79	.72	67
53	-0.0700	0.1243	25.6991	5.3829	.43	.64	69
54	0.1625	0.5058	25.2915	5.2694	.87	.93	68
55	0.0486	0.5431	26.0344	5.1994	.56	.93	70
502	0.4625	0.3657	24.5648	5.1095	.90	.89	67
535	-0.0600	-0.0322	24.8554	5.6432	.45	.38	59
704	0.6667	0.6066	24.9900	5.2082	.91	.98	68
706	0.7700	0.6760	25.8723	5.4083	.97	.98	69
708	0.1883	0.3187	25.8794	5.7614	.77	.83	68

Table E52. Trend analysis for monthly near surface temperature: measurements after the big freeze of 1989 1/1/90 - 12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
5	-0.2700	-0.2553	22.8857	6.2277	.05	.26	70
7	-0.2167	-0.2847	22.1917	6.9630	.06	.25	69
12	0.7650	0.9677	20.9300	7.9844	.62	.58	21
13	-0.5067	-0.8592	22.7576	7.3358	.05	.15	50
14	-0.2820	-0.1637	22.4479	7.2789	.07	.45	63
15	-0.4700	-0.1599	22.5803	7.1861	.01	.39	67
16	-0.4000	-0.4158	23.5371	6.8453	.04	.24	52
18	-0.2650	0.2075	22.7596	6.6800	.17	.66	57
21	-0.0225	0.0344	22.8167	5.5828	.45	.53	63
22	0.0525	0.1551	22.9256	5.3835	.63	.72	62
34	-1.0267	-0.3381	22.6166	7.2462	.01	.32	64
35	0.1210	0.2090	23.2727	5.2628	.94	.79	71
36	0.0600	0.1937	23.4261	5.2141	.80	.77	71
37	-0.2225	0.0166	23.4921	6.2514	.14	.46	63
38	-0.5300	-0.4429	23.7857	7.1948	.01	.18	69
52	0.1600	0.3012	23.8496	5.3005	.08	.22	67
53	0.1729	0.2864	23.6146	5.2797	.91	.81	69
54	0.0393	0.1648	24.4668	5.1877	.68	.72	68
55	0.1100	0.2831	23.8273	5.2082	.93	.80	70
502	-0.0233	0.2003	23.7616	5.5816	.50	.78	67
535	0.0700	0.0678	23.6698	5.7394	.80	.63	59
704	-0.0263	0.2740	23.7557	5.5552	.32	.74	68
706	0.0000	0.3853	23.5523	5.3489	.50	.84	69
708	0.0250	0.5425	23.5500	5.2157	.65	.94	68

Table E60. Trend analysis at fixed moorings for all monthly salinities, 1/1/78-12/31/95. Results of analysis monthly means from selected fixed moorings (Sta); B = trend (ppt/yr) found by seasonal Kendall Tau analysis; B_1 = trend (ppt/yr) found by linear regression; μ = mean salinity, ppt; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
315	0.0091	0.0584	19.5368	4.7286	0.56	0.79	209
317	-0.1774	-0.0990	13.3693	5.0674	0.99	0.91	168
318	0.4030	0.5545	27.3836	3.6805	0.81	0.83	36
319	-0.8910	-0.1404	27.1941	3.5376	0.99	0.72	31
323	0.5006	0.0922	20.1976	4.2329	0.88	0.74	66
326	0.0824	0.0781	5.3622	3.0429	0.82	0.73	69
335	0.7584	0.8732	28.8729	3.8050	0.94	0.98	30
319	-1.7032	-5.1215	21.5716	5.7800	0.93	0.97	16
323	-1.2631	-1.5713	20.5479	4.7863	0.99	0.99	46
325	-0.1067	-0.0868	3.0409	1.7895	0.84	0.60	70
326	-0.1425	-0.1029	2.3222	1.9276	0.86	0.93	87

Table E61. Trend analysis at fixed moorings for all monthly temperatures 1/1/78-12/31/95. Results of analysis for monthly means from selected fixed moorings (Sta); B = trend (°C /yr) found by seasonal Kendall Tau analysis; B_1 = trend (°C/yr) found by linear regression; μ = mean temperature, °C; σ = standard deviation; $p_{seasonal}$ is probability that a trend exists found by seasonal Kendall Tau test; $p_{nonseasonal}$ is probability that a trend exists found by standard (nonseasonal) Kendall Tau test; n = number of months during which data was collected at that station for this time span. Those B values associated with the probability $p_{seasonal} > 0.9500$ for existence of trend by the seasonal Kendall Tau method are followed by an asterisk (*).

Sta	B	B_1	μ	σ	$p_{seasonal}$	$p_{nonseasonal}$	n
315	0.0897	0.0926	22.4721	6.1517	0.99	0.88	209
317	0.0859	0.0022	22.4138	5.8598	0.99	0.54	168
318	-0.3871	-1.4011	25.1690	3.8959	0.96	0.99	36
319	-0.8514	-1.1423	24.2791	5.0747	0.99	0.96	31
323	-0.2874	0.0565	23.4521	6.0720	0.99	0.54	66
326	0.0535	0.0828	22.0900	6.5435	0.74	0.66	69
335	-0.4649	-0.4252	24.2457	4.0650	0.95	0.73	30
319	-0.5610	-0.0370	21.4648	5.1018	0.76	0.50	16
323	0.1565	-0.9063	22.9305	5.8964	0.82	0.81	46
325	-0.0565	-0.1444	22.8294	6.1247	0.77	0.64	70
326	0.0188	-0.0105	22.1959	6.1419	0.69	0.51	87

APPENDIX F

SQUARED COHERENCE BETWEEN MISSISSIPPI RIVER OUTFLOW

AND PHYSICAL HYDROGRAPHY SALINITY RECORDS

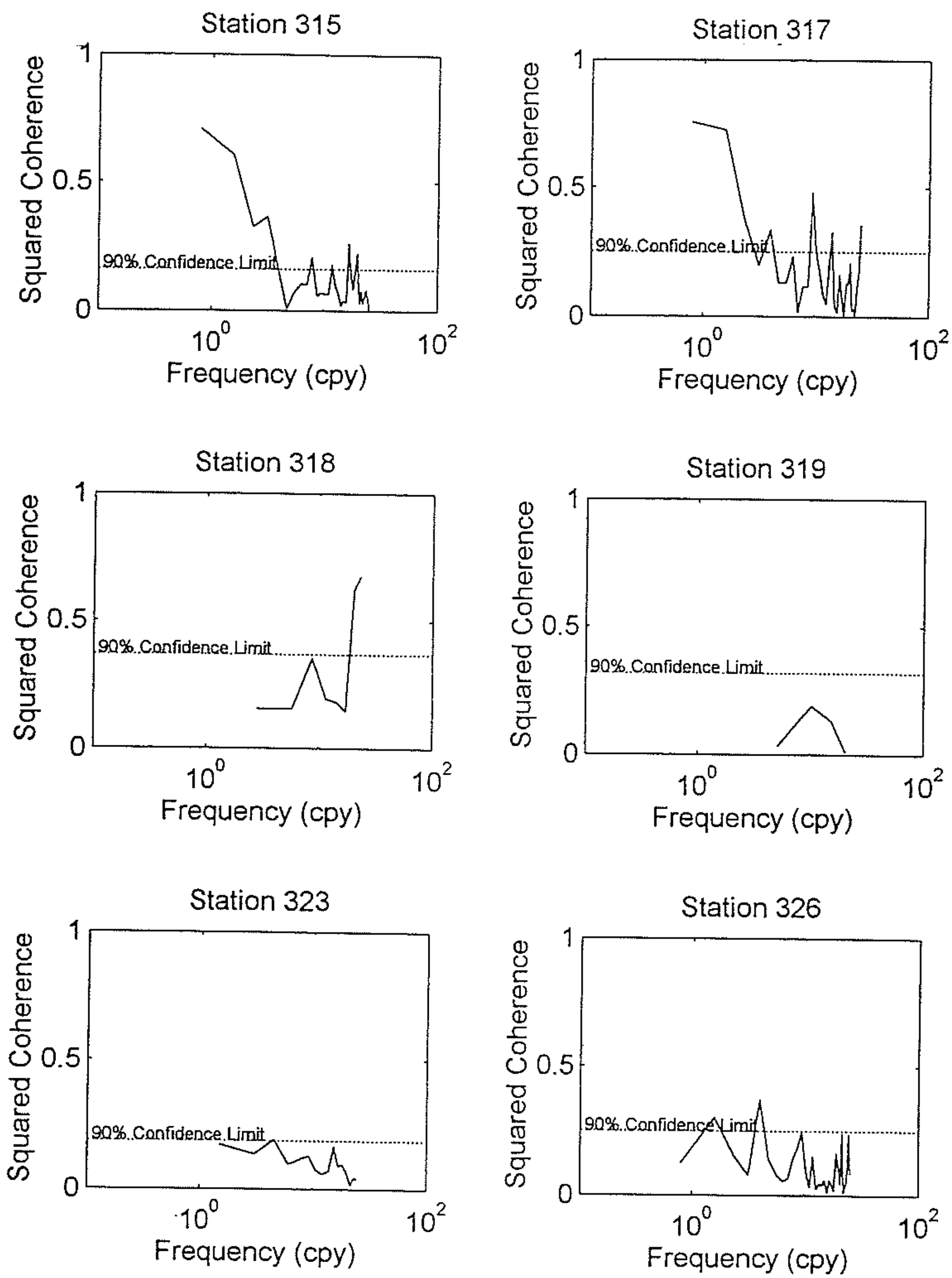

Figure F1. Coherence of weekly mean salinities at fixed stations and weekly mean Mississippi river discharge. Frequency is in units of cycles per year.

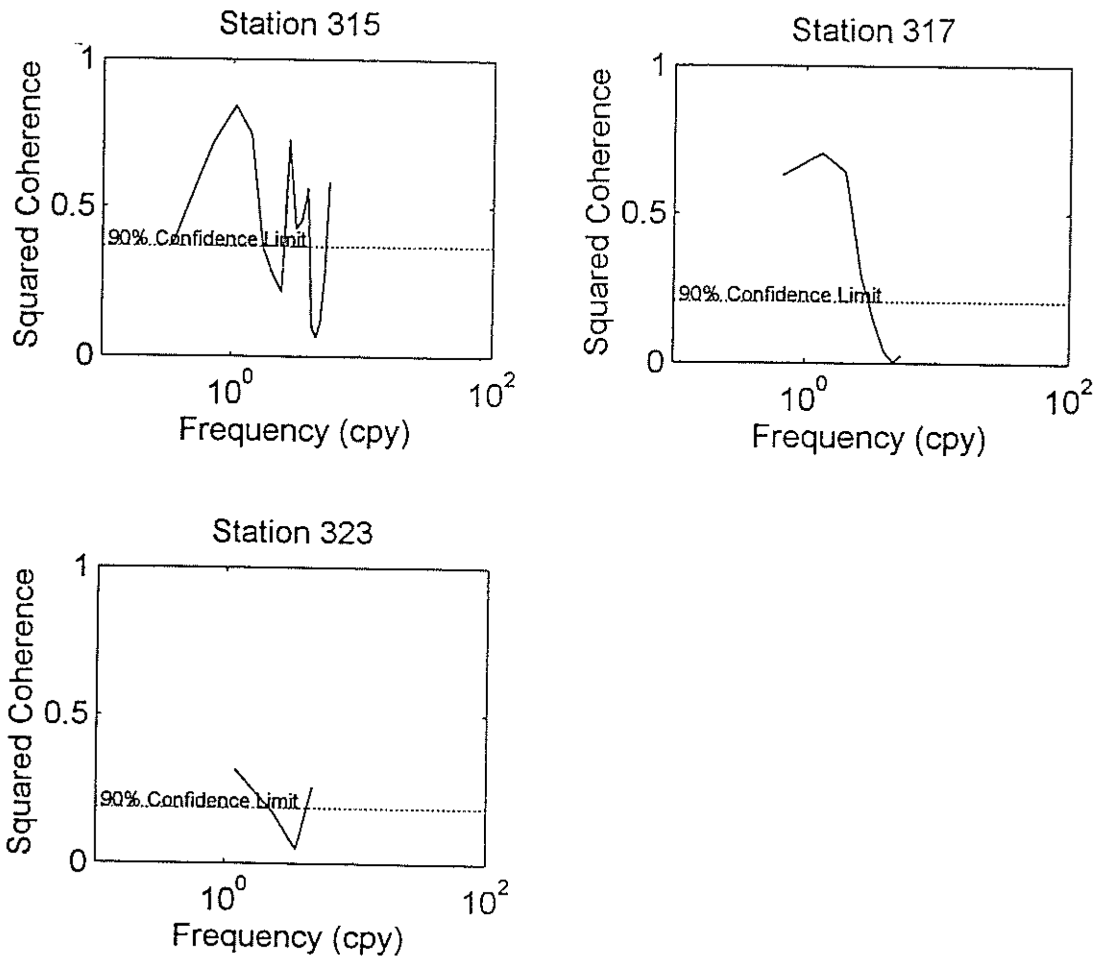

Figure F2. Coherence of monthly mean salinities at fixed stations and monthly mean Mississippi river discharge. Frequency is in units of cycles per year.

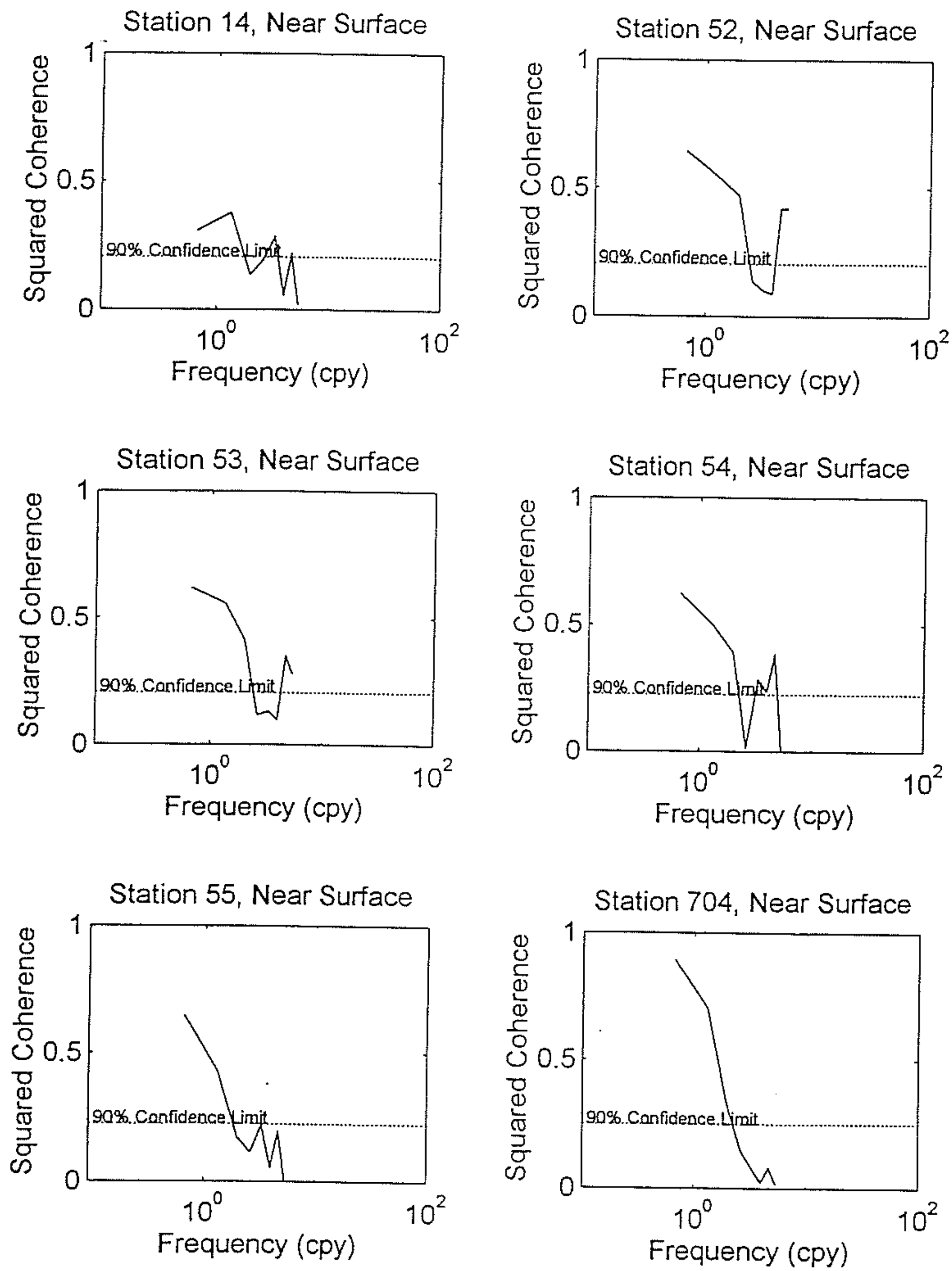

Figure F3. Coherence of monthly surface samples of salinity and monthly mean Mississippi river discharge. Frequency is in units of cycles per year.

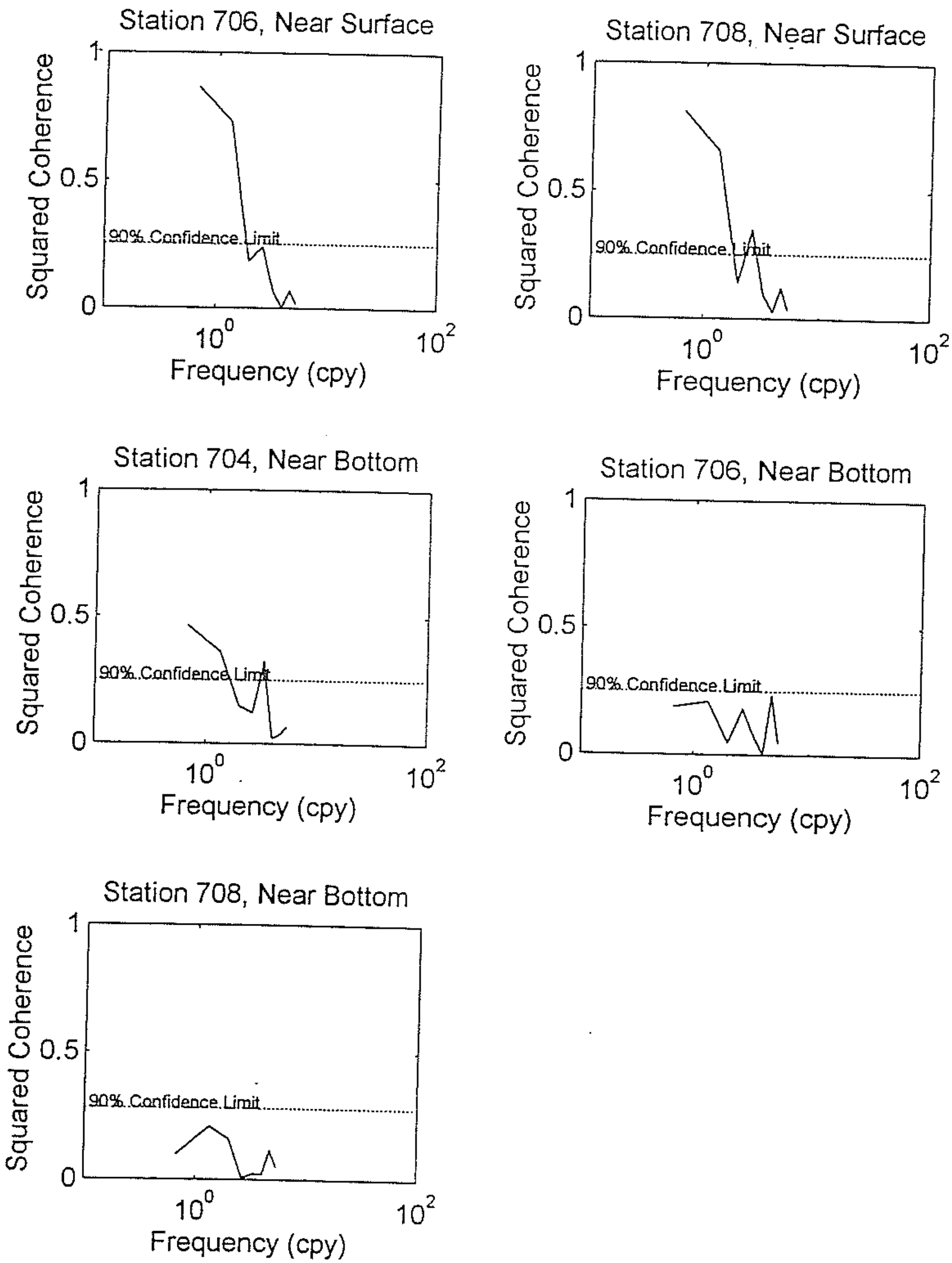

Figure F4. Coherence of monthly surface and bottom samples of salinity and monthly mean Mississippi river discharge. Frequency is in units of cycles per year.

TECHNICAL INFORMATION FOR THE LOOP MARINE AND ESTUARINE MONITORING PROGRAM REVISION:

by

William J. Wiseman, Jr.

Coastal Studies Institute
Center for Coastal, Energy, and Environmental Resources
Louisiana State University

RESULTS

Following the discussion in Chapter IV above, we subdivide the discussion of a revised sampling plan according to environmental region: offshore, nearshore, lower estuary and upper estuary.

Significant Results

Significant results are presented in Table 9.

Table 9. Significant results from the physical hydrography data analysis

Variable of interest	Temporal trends	Covariables	Impacts
Offshore temperature (surface)	increasing (stations 52, 53, 54, 55)	salinity	none
Offshore temperature (bottom)	increasing (stations 52, 53, 55, 704, 706, 708)	salinity	none
Offshore salinity (bottom)	increasing (stations 706, 708)	temperature river discharge rainfall	none
Upper estuary temperature	increasing station 16	salinity	none
Upper estuary salinity	decreasing station 317	temperature river discharge rainfall	none

Non-significant Results

We are unable to hypothesize a scenario whereby LOOP activities will significantly influence water temperature. Neither are we able to hypothesize a scenario whereby LOOP activities will affect salinity with the exception of two processes: brine diffusion and alterations of estuarine flow patterns. We did not analyze the sled data collected during monitoring of the brine diffuser plumes for reasons stated in our report at the end of Task 1. Never-the-less, it was clear from those data sets that brine discharge did alter the salinities very close to the sea bed. The full extent and duration of this change, as well as its sensitivity to external parameters such as current, ambient stratification, bottom slope, and turbulent intensity, are unknown. Any changes to estuarine flow regimes which may have resulted from LOOP construction activities in the estuarine environment were not detected in the analyses performed. Since it is unlikely that the natural flow of water through this environment was not altered in some fashion, it is concluded that natural variability and the effects of other anthropogenic alterations completely masked any changes in salinity and water temperature which may have arisen from LOOP activities.

RECOMMENDATIONS

Given the fact that we were unable to identify alterations to the temperature or salinity of the waters sampled (aside from the near bottom layer of abnormally high salinity associated with brine discharge), we assume that, in the absence of future construction, the role of hydrographic monitoring will be to provide a co-variate to be used in the analysis of biological data. A recurrent theme in the following recommendations is that monthly samples are too infrequent to properly define the sources of variability, while the number of stations presently sampled provide unnecessary redundancy. While it is impossible to estimate the effects of sampling less frequently than necessary at all stations, such effects are derivable for the stations with continuous recorders. For example, at station 317, 37 percent of the salinity variability in a nearly continuous 3.5 year subset of the record would have been missed by monthly sampling. Fewer samples, carefully situated in space, will allow improved resolution of the temporal variability, the means, and the variance structure. This, in turn, will allow better association of observed variations with their causes.

Offshore

- **Two moorings should be maintained with continuously recording temperature and salinity sensors at near-surface and near-bottom depths. One should be near the offshore terminal and the other should be approximately mid-way to the coast. These should sample at hourly intervals to resolve tidal and lower frequency signals. All other stations should be discontinued.**

The offshore region exhibited significant, spatially coherent trends in bottom salinity, bottom temperature and surface temperature. It is difficult to conceive of a process whereby LOOP operations could have been responsible for these trends. Furthermore, no BACI analyses indicated that LOOP operations had any negative effect on hydrographic properties in this region. Finally, it is difficult to attribute the thermal trends to atmospheric forcing since the scale of such forcing would require a similar (or enhanced) response in the shallow estuarine waters, a response which was not observed.

The most likely cause of the observed trends is intrusion of Loop Current rings, with the lack of a signal in surface salinity being due to the higher natural variability in this signal. Unfortunately, we have not yet been able to identify an adequate time series of Loop Current ring paths with which to test this hypothesis. It should be mentioned that the time scale of this phenomenon is very long. Rings are shed approximately once per year and existing records (of about 20 years) are not yet long enough to define the low-frequency variability of the signal. Thus, any conclusions concerning trends which were influenced by this process must be tempered by the assumption that the record is too short to properly define a reliable trend.

The analysis of offshore data was hampered by samples which were clearly erroneous (probably instrument error) and a process which was undersampled, i.e. important, deterministic and stochastic variability in the measured parameters which occurred on time scales much shorter than the sampling period was not resolved (wind-driven and tidal variability has time scales shorter than one month). On the other hand, the coherence length scales, distances over which the hydrographic properties varied in a coherent manner, for hydrographic parameters in this region are large, on the order of 10 to 20 km, at least. Mid-depth samples are not required, as the dominant stratification is defined by a strong halocline. Two stations located along a cross-shore transect will help define the large-scale mean spatial variability. Since the surface waters of this region are dominated by a river plume which is highly variable in space and time, additional moorings placed along isobaths would assist in defining the spatial patterns at any given instant in time. It is not clear that the added information provided by such moorings would warrant the cost of their deployment.

Nearshore

- **Two moorings, oriented along a cross-shore line, should be maintained with continuously recording temperature and salinity sensors at near-surface and near-bottom depths. These should sample at hourly intervals to resolve tidal and lower frequency signals. All other stations should be discontinued.**

The nearshore region exhibited no significant, spatially coherent temporal trends in either temperature or salinity. It is difficult to conceive of a process whereby LOOP operations could have been responsible for such trends, if they had been identified. Furthermore, no BACI analyses indicated that LOOP operations had any negative effect on hydrographic properties in this region. This is a region of strong cross-shelf gradients in properties, but smaller alongshelf gradients. Flow is strongly wind-driven and highly variable. Two moorings oriented cross-shelf will characterize the strong offshore gradients in water properties.

- **As an additional option, we suggest that two bottom-mounted acoustic Doppler current profilers which transmit data to shore in real time be deployed: one nearshore and one near the offshore terminal.**

The current meter records from this region were too short and too intermittent to be of great use in characterizing the region. Acquisition of accurate current meter data from such environments is notoriously difficult. It is not clear, now that construction and brine pumping are completed, whether such data are warranted. In the event of a spill, though, this information would permit accurate tracking of the potential region of impact. If significant further brine discharge is anticipated, this information from a site near the diffuser would assist brine plume tracking (see below).

Lower Estuary

- **Assuming that the stations 315 and 317 will be continued as part of LDWF's long-term monitoring program for other purposes, similar instrumentation should be deployed at two other sites in the lower estuary, stations 322 and 7. Sampling should occur, at least hourly. Other stations should be discontinued.**

The lower estuarine region exhibited no significant, spatially coherent trends in either temperature or salinity. Furthermore, no BACI analyses indicated that LOOP operations had any negative effect on hydrographic properties in this region. Spatial gradients are large in this region and time scales vary from the semi-diurnal to the interannual. Hourly recordings are necessary to adequately describe this variability, particularly in order to distinguish natural variability from possible LOOP-induced variability in case of events which impact the estuary. It is imperative that these stations be continued as proposed alterations in the amount of river water diverted from the Mississippi River to the Barataria Basin may invalidate all existing records as a basis against which to compare future potential impacts of LOOP activities.

- **A tide gauge should be deployed at the Clovelly Storage Dome.**

Water level is recorded by NOAA/NOS at Grand Isle. This identifies the apparent sea level rise at this location. It was unfortunate that a similar gauge was not deployed at LOOP facilities within the estuary (upper or lower) to identify possible construction-induced subsidence effects. While we are aware that a tide gauge was deployed in Little Lake and another south of the dome, we believe that these would have had to have been deployed within a few hundred meters or less of the construction in order to resolve the weak, but potentially important, signals expected from construction activity.

Upper Estuary

- **Stations 320, 324, and 12 should be continued and instrumented with hourly recording instruments similar to those recommended above. Other stations may be discontinued. An array of appropriate rainfall gauges would also be beneficial in helping to understand the salinity variability in the region.**

The upper estuarine region exhibited no significant, spatially coherent trends in either temperature or salinity. Furthermore, no BACI analyses indicated that LOOP operations had any negative effect on hydrographic properties in this region.

Spatial gradients are important in this region and time scales of variability range, again, from the semi-diurnal to the interannual. Never-the-less, spatial scales are larger than the existing station spacing in some cases, providing unnecessary redundancy. Again, proposed river diversions to the basin obviate the use of the existing data sets as controls against which to test for future changes in characteristics or against which to identify the cause of alterations to the environment. The complexity of the region suggests that deployment of current monitoring stations would not be cost effective in this area. The upper estuary consists of a few large open water bodies connected by multiple channels, tidal creeks, and bayous. The cost of placing current meters in these channels in sufficient number to define the flow regime is prohibitive. Furthermore, it is not clear scientifically exciting information that would be derived from such an investment is necessary for the monitoring that LOOP is tasked to maintain.

Brine Monitoring

- **In the event that significant brine monitoring should again take place, continuous recorders, deployed at increasing distances around the diffuser, should be used to delineate the temporal and partially delineate the spatial variability of the plume size and the strength of its associated salinity anomaly. A minimum of six bottom temperature and salinity sensors should be deployed uniformly around the diffuser. (An additional six at a greater distance would enhance the program.) Adaptive sampling of a predetermined grid of stations is recommended for brine plume mapping, in preference to towing a sled. Information concerning the preferred direction of plume advance should be derived from continuous monitoring of near-bottom currents and radio telemetry of the data to the sampling boat, thus requiring deployment of an appropriate near-bottom current meter and telemetry package.**

Plumes, both positively and negatively buoyant ones, are highly dynamic features. They respond to changes in sources strength and to ambient conditions of stratification, flow and mixing characteristics. Time scales on which these vary range from a few hours to seasons. Attempts to map the extent of a negatively buoyant plume must account for this space-time variability. The temporal variability can only be resolved through continuous monitoring. Records from the sled suggested that the sled structure may have been disturbing the interface between the brine plume and the ambient water. As an alternative, a salinity sensor could be carefully lowered to a specified distance above bottom at pre-specified grid stations. Stations could be added to or dropped from the sampling plan according to pre-decided criteria such as the absence of brine at two consecutive stations on a given transect. Continuous onboard monitoring of the shape of the brine patch using optimal interpolation and a laptop computer, or even hand contouring of the data, would allow stations to be added to the grid when the plume was observed to continue in a given direction. In order to understand the area of impact of the brine plume, such monitoring would need to include a variety of wind and stratification conditions and not be limited to fair-weather conditions.

General Discussion

The potential remains that past or future LOOP activities could modify flow patterns, particularly within the estuarine reaches of the study area, to an extent that they impact the hydrography and, consequently, the biology. In fact, alterations of the flow regime could impact the biology without a concomitant change in temperature or salinity. It has been mentioned above, that the cost of maintaining a long-term current monitoring program adequate to define the flow regime of the estuary would be high. One might ask whether or not modeling protocols could be developed or applied which would resolve the potential effects of slow, long-term changes in the estuarine environment such as rerouting of flows. Models of this region have been developed and the potential exists for developing others. A major missing parameter is an accurate bathymetry of the region. Mixing coefficients (engineering parameters which describe the effects of small scale flow features not resolvable on the model grid), adequate forcing (wind fields, rainfall fields, water levels at the tidal passes), and sufficient computing power to run the models in a realistic time frame are presently not available. Progress in this field of research can and is being made. The models presently in existence, though, might be indicative of potential responses, not definitively predictive. If it is suspected that such slow, long-term changes might be occurring, additional monitoring and modeling efforts are advisable. It seems unlikely that such changes would be clearly detected with the program recommended above. This is designed to capture changes in the large scale hydrographic fields occurring on time scales of a few days to years.