Technical Report CHL-98-14
May 1998

US Army Corps
of Engineers
Waterways Experiment
Station

Annual Data Summary for 1995 CHL Field Research Facility

Volume I: Main Text and Appendixes A and B

by Michael W. Leffler, Clifford F. Baron, Brian L. Scarborough,
Paul R. Hodges, C. Ray Townsend

WES

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Prepared for Headquarters, U.S. Army Corps of Engineers

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Final report

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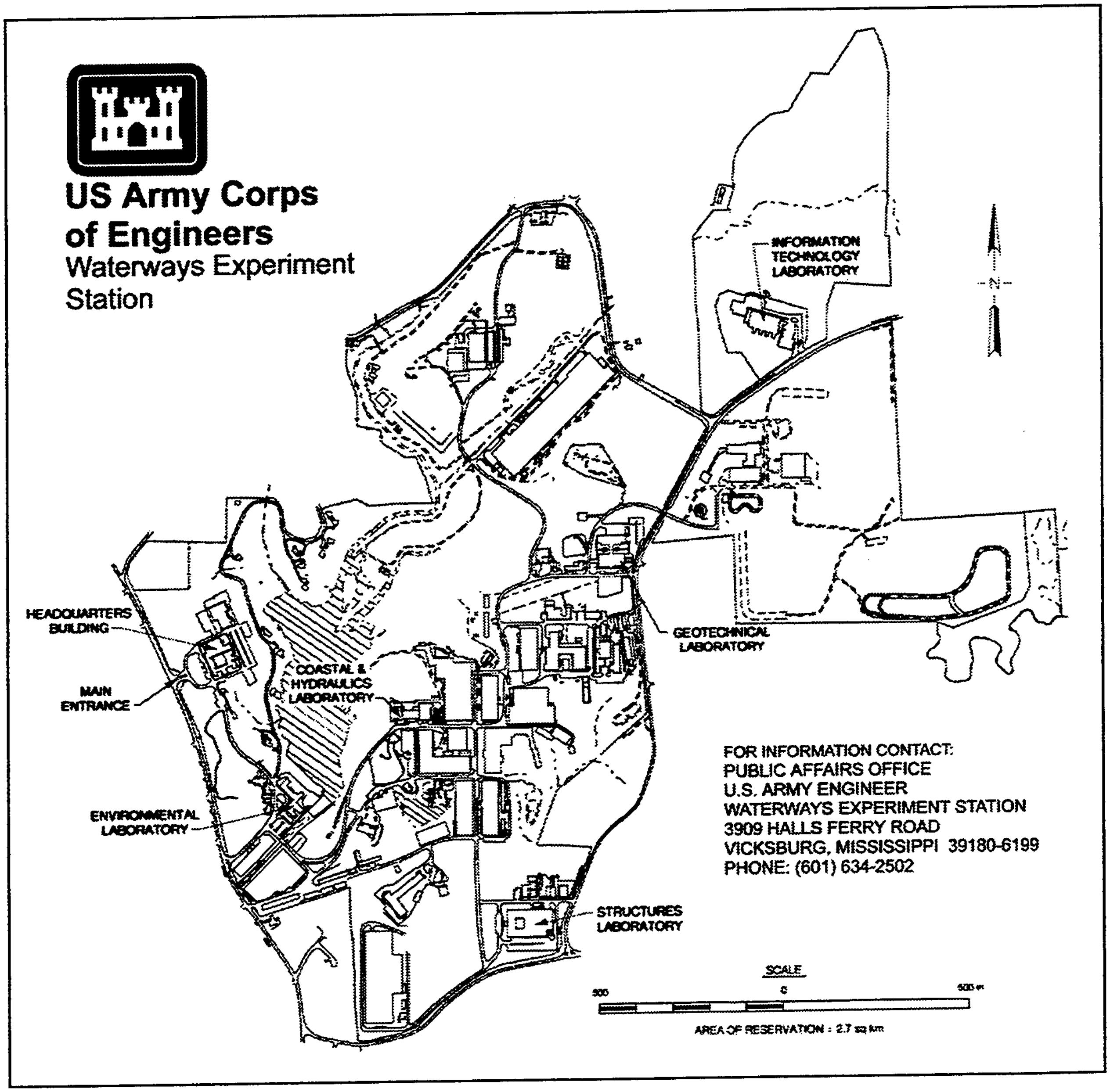

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Contents

[1] A limited number of copies of Appendixes C-E (Volume II) were published under separate cover. Copies are available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

Preface

This report is the 17th in a series of annual data summaries authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), under the Civil Works Research and Development Program, Work Unit 32525, "Field Research Facility Analysis." Funds were provided through the U.S. Army Engineer Waterways Experiment Station (WES), Coastal and Hydraulics Laboratory (CHL), under the program management of Ms. Carolyn M. Holmes. The HQUSACE Technical Monitors were Messrs. John H. Lockhart, Jr., Charles Chesnutt, and Barry W. Holliday.

Data for the report were collected and analyzed at the WES/CHL Field Research Facility (FRF) in Duck, NC. The report was prepared by Mr. Michael W. Leffler, FRF, under the direct supervision of Mr. William A. Birkemeier, Chief, FRF Group, Engineering Development Division (EDD), and Mr. Thomas W. Richardson, Chief, EDD; and under the general supervision of Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Director and Assistant Director, CHL, respectively. Messrs. Kent K. Hathaway and Paul Hodges assisted with instrumentation. Messrs. Brian L. Scarborough and C. Raymond Townsend, FRF, with Messrs. Christopher Goshow and Kevin M. Kremkau assisted with data collection. Mr. Clifford F. Baron assisted with data analysis. The National Oceanic and Atmospheric Administration/National Ocean Service maintained the tide gauge and provided statistics for summarization.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

1 Introduction

Background

The U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory's[1] (CHL), Field Research Facility (FRF), located on 0.7 km^2 at Duck, NC (Figure 1), consists of a 561-m-long research pier and accompanying office and field support buildings. The FRF is located near the middle of Currituck Spit along a 100-km unbroken stretch of shoreline extending south of Rudee Inlet, VA, to Oregon Inlet, NC. The FRF is bordered by the Atlantic Ocean to the east and Currituck Sound to the west. The facility is designed to (a) provide a rigid platform from which waves, currents, water levels, and bottom elevations can be measured, especially during severe storms; (b) provide CHL with field experience and data to complement laboratory and analytical studies and numerical models; (c) provide a manned field facility for testing new instrumentation; and (d) serve as a permanent field base of operations for physical and biological studies of the site and adjacent region.

The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The piles are embedded approximately 20 m below the ocean bottom. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.8 m above the National Geodetic Vertical Datum (NGVD). The pilings are protected against sand abrasion by concrete erosion collars and against corrosion by a cathodic system.

An FRF Measurements and Analysis Program has been established to collect basic oceanographic and meteorological data at the site, reduce and analyze these data, and publish the results.

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[1] Formerly the Coastal Engineering Research Center

This report, which summarizes data for 1995, continues a series of reports begun in 1977.

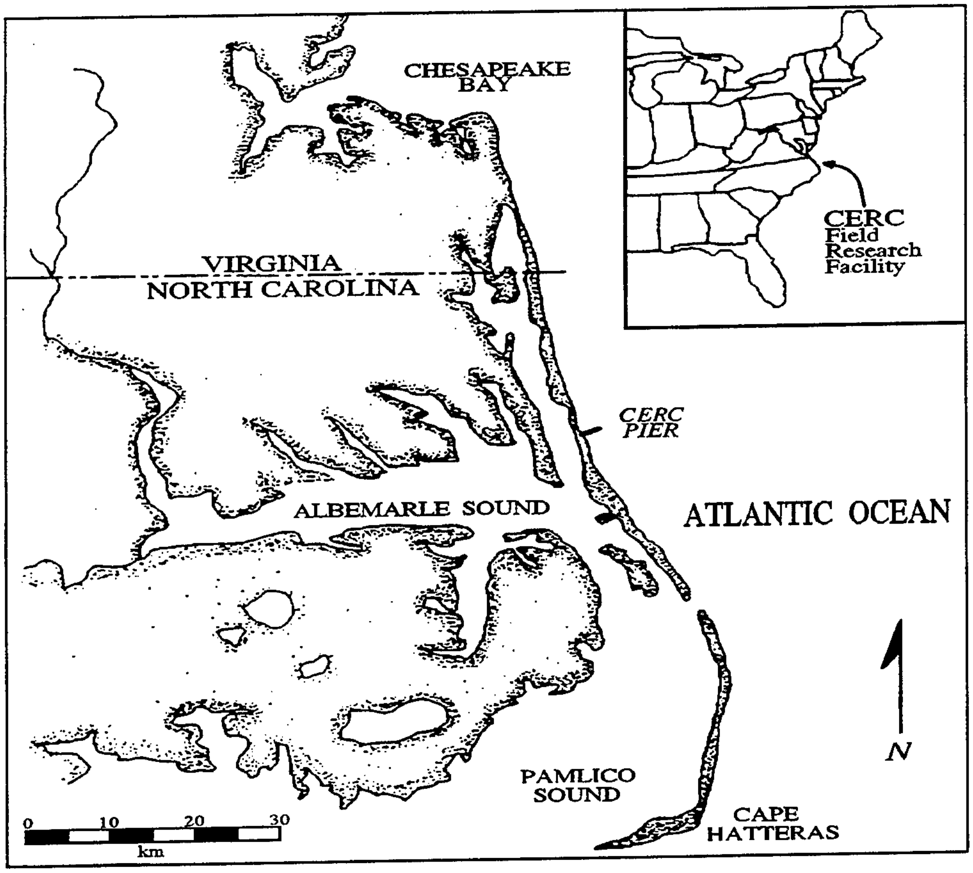

Figure 1. FRF location map

Organization of Report

This report is organized into nine chapters and five appendixes. Chapter 1 is an introduction; Chapters 2 through 8 discuss the various data collected during the year; and Chapter 9 describes the storms that occurred. Appendix A presents the bathymetric surveys, Appendix B summarizes deepwater wave statistics, and Appendixes C through E (published under separate cover as Volume II) contain summary statistics for other gauges.

In each chapter of this report, the respective instruments used for monitoring the meteorological or oceanographic conditions are briefly described, along with data collection and analysis procedures and data results. The instruments were interfaced with the primary data acquisition system, a Digital Equipment Corporation (Maynard, MA) VAX-11/750 minicomputer until June 1994 when it was replaced with a Digital Equipment Corporation VAXstation 4000 located in the FRF laboratory building. More detailed explanations of the design and the operation of the instruments may be found in Miller (1980). Readers' comments on the format and usefulness of the data presented are encouraged.

Availability of Data

Table 1 summarizes the available data. In addition to the wave data summaries in the main text, more extensive summaries for each of the wave gauges are provided in Appendixes B through E.

Table 1
1995 Data Availability

	Gauge	Jan					Feb				Mar				Apr					May				Jun				Jul					Aug				Sep				Oct					Nov				Dec			
	ID	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4
Weather																																																					
Anemometer	932	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Atm Pres.	616	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Air Temp	624	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Precip.	604	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Waves																																																					
Waverider	630	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	*	/	-	/	*	*	*	*	*	*	*	*	*	*	*	*
8m Press.	111	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
EOP Press.	625	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Pier Nshre	641	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Currents																																																					
Pier End		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Pier Nrshre		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Beach		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
EOP Tide Gauge		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*
Water Characteristics																																																					
Temperature		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Visibility		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Density		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bathymetry						*											*								*								*			*					*										*		
Photography																																																					
Beach		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Aerial																																											*										

Notes: * Full week of data obtained.
/ Less than 7 days of data obtained.
- No data obtained.

The annual data summary herein summarizes daily observations by month and year to provide basic data for analysis by users. Daily measurements and observations have already been reported in a series of monthly Preliminary Data Summaries (FRF 1995). If individual data for the present year are needed, the user can obtain detailed information (as well as the monthly and previous annual reports) from the following address:

USAE Waterways Experiment Station
Field Research Facility
1261 Duck Rd.
Kitty Hawk, NC 27949-4472

Much of this data is now also available via the World Wide Web at:

http://www.frf.usace.army.mil

Although the data collected at the FRF are designed primarily to support ongoing CHL research, use of the data by others is encouraged. Tidal data other than the summaries in this report can be obtained directly from the following address:

National Oceanic and Atmospheric Administration
National Ocean Service
ATTN: Tide Analysis Branch
Rockville, MD 20852

A complete explanation of the exact data desired for specific dates and times will expedite filling any request; an explanation of how the data will be used will help CHL or the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) determine whether other relevant data are available. For information regarding the availability of data for all years, contact the FRF at (252) 261-3511. Costs for collecting, copying, and mailing will be borne by the requester.

2 Meteorology

This chapter summarizes the meteorological measurements made during the current year and in combination with all previous years. Meteorological measurements during storms are given in Chapter 9.

Mean air temperature, atmospheric pressure, and wind speed and direction were computed for each data file, which consisted of data sampled two times per second for 34 min every 6 hr beginning at or about 0100, 0700, 1300, and 1900 hr eastern standard time (EST); these hours correspond to the time that the National Weather Service (NWS) creates daily synoptic weather maps. During storms, data recordings were made more frequently. Meteorological data are summarized in Table 2.

Table 2
Meteorological Statistics

	Mean Air Temperature deg C		Mean Atmospheric Pres. mb		Precipitation, mm				Wind Resultants			
					1995	1978-1995			1995		1980-1995	
Month	1995	1983-1995	1995	1983-1995	Total	Mean	Maxima	Minima	Speed m/sec	Direction deg	Speed m/sec	Direction deg
Jan	7.1	6.2	1016.1	1017.8	76	110	210	44	1.9	316	2.2	331
Feb	4.8	6.6	1016.0	1017.3	123	74	123	20	2.4	309	1.9	341
Mar	9.5	9.5	1018.7	1016.0	43	106	231	35	2.9	5	1.3	351
Apr	14.5	14.0	1015.1	1014.2	39	90	182	0	0.7	77	0.2	320
May	19.0	18.7	1014.8	1015.7	122	79	239	20	0.5	136	0.3	150
Jun	23.5	23.7	1015.3	1015.1	142	91	142	27	1.5	65	1.0	184
Jul	26.8	26.5	1016.2	1015.9	91	96	275	19	2.2	181	2.0	206
Aug	25.1	25.5	1015.6	1016.3	122	111	253	30	2.8	30	0.5	84
Sep	22.4	22.8	1017.3	1017.6	92	82	226	5	4.4	43	2.0	39
Oct	19.3	18.0	1017.2	1018.6	193	82	193	17	0.5	68	2.3	26
Nov	9.4	13.2	1018.0	1018.4	146	93	146	26	3.1	293	1.7	347
Dec	4.4	7.9	1018.6	1019.2	67	68	131	4	2.9	322	2.4	331
Mean	15.5	16.0	1016.6	1016.8	105	90			1.1	359	0.8	351
Total					1256	1082						

Air Temperature

The FRF enjoys a typical marine climate that moderates the temperature extremes of both summer and winter.

Measurement instruments

A Yellow Springs Instrument Company, Inc. (YSI) (Yellow Springs, OH), electronic temperature probe with analog output interfaced to the FRF's computer was operated beside the NWS's meteorological instrument shelter located 43 m behind the dune (Figure 2). To ensure proper temperature readings,

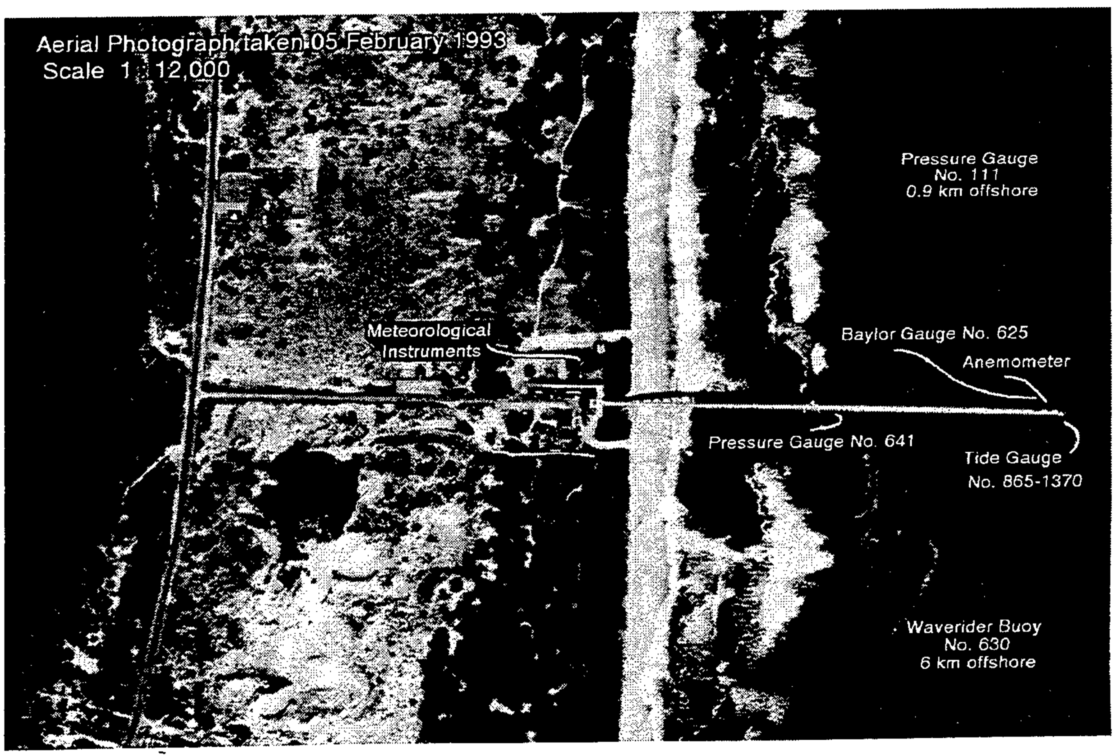

Figure 2 . FRF gauge locations

the probe was installed 3 m above ground inside a protective cover to shade it from direct sun, yet provide proper ventilation.

Results

Daily and average air temperature values are tabulated in Table 2 and shown in Figure 3.

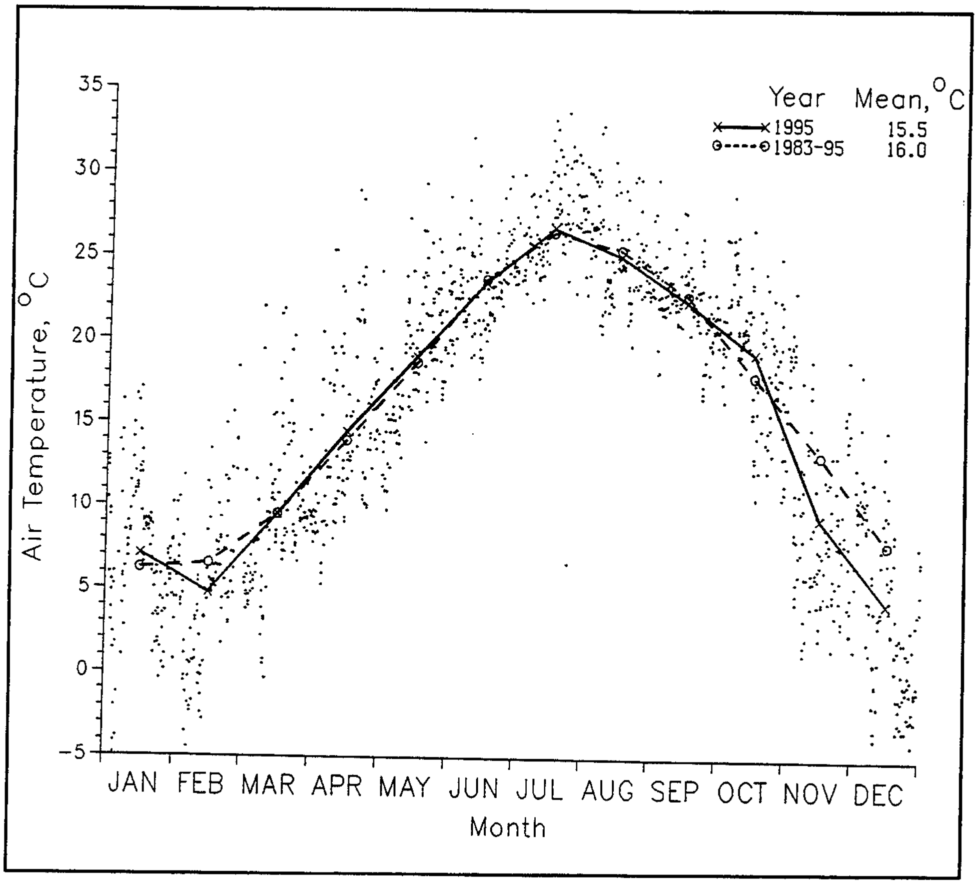

Figure 3. Daily air temperature values with monthly means

Atmospheric Pressure

Measurement instruments

Electronic atmospheric pressure sensor. Atmospheric pressure was measured with a YSI electronic sensor with analog output located in the laboratory building at 9 m above NGVD. Data were recorded on the FRF computer. Data from this gauge were compared with those from an NWS aneroid barometer to ensure proper operation.

Microbarograph. A Weathertronics, Incorporated (Sacramento, CA), recording aneroid sensor (microbarograph) located in the laboratory building was also used to continuously record atmospheric pressure variation.

The microbarograph was compared daily with the NWS aneroid barometer, and adjustments were made as necessary. Maintenance of the microbarograph consisted of inking the pen, changing the chart paper, and winding the clock every 7 days. During the summer, a meteorologist from the NWS checked and verified the operation of the barometer.

The microbarograph was read and inspected daily using the following procedure:

a. The pen was zeroed (where applicable).
b. The chart time was checked and corrected, if necessary.
c. The daily reading was marked on the chart for reference.
d. The starting and ending chart times were recorded, as necessary.
e. New charts were installed, when needed.

Results

Daily and average atmospheric pressure values are presented in Figure 4, and summary statistics are presented in Table 2.

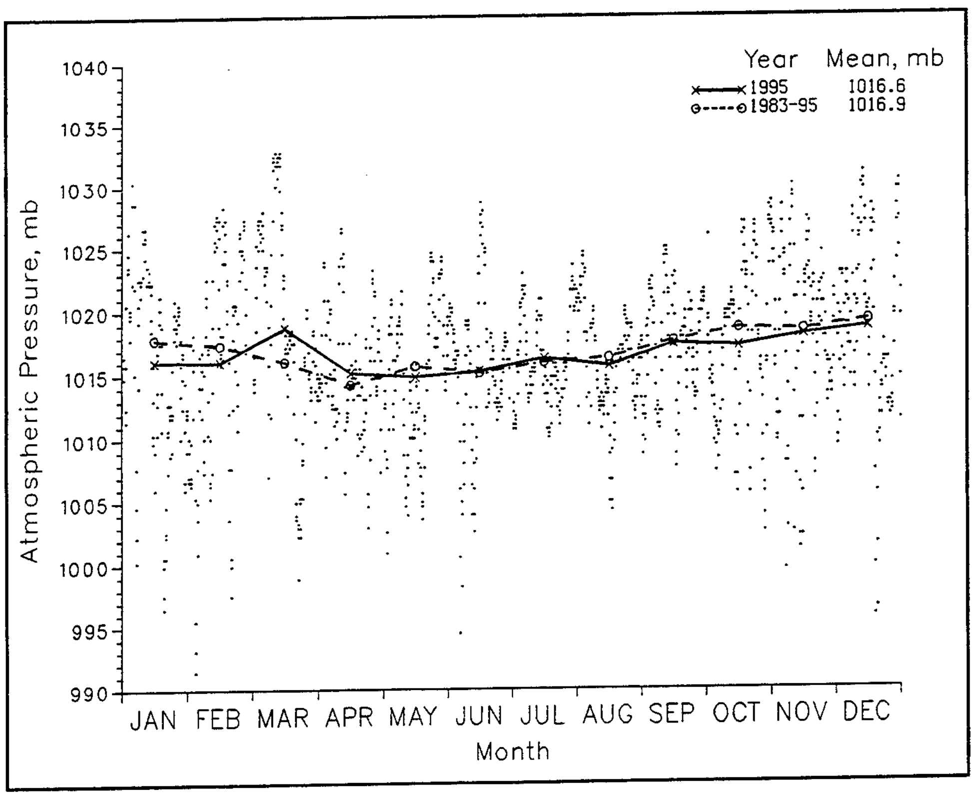

Figure 4. Daily barometric pressure values with monthly means

Precipitation

Precipitation is generally well distributed throughout the year. Precipitation from mid-latitude cyclones (northeasters) predominates in the winter, whereas local convection (thunderstorms) accounts for most of the summer rainfall.

Measurement instruments

Electronic rain gauge. A Belfort Instrument Company (Baltimore, MD) 30-cm weighing rain gauge, located near the instrument shelter 47 m behind the dune, measured daily precipitation. According to the manufacturer, the instrument's accuracy was 0.5 percent for precipitation amounts less than 15 cm and 1.0 percent for amounts greater than 15 cm.

The rain gauge was inspected daily; however, the analog chart recorder was inoperable the entire year.

Plastic rain gauge. An Edwards Manufacturing Company (Alberta Lea, MN) True Check 15-cm-capacity clear plastic rain gauge with a 0.025-cm resolution was used to monitor the performance of the weighing rain gauge. This gauge was located near the weighing gauge, and the gauges were compared on a daily basis. Very few discrepancies were identified during the year.

Results

Daily and monthly average precipitation values are shown in Figure 5. Statistics of total precipitation for each month during this year and average totals for all years combined are presented in Table 2.

Wind Speed and Direction

Winds at the FRF are dominated by tropical maritime air masses that create low to moderate, warm southern breezes; arctic and polar air masses that produce cold winds from northerly directions; and smaller scale cyclonic, low pressure systems, which originate either in the tropics (and move north along the coast) or on land (and move eastward offshore). The dominant wind direction changes with the season, being generally from northern directions in the fall and winter and from southern directions in the spring and summer. It is common for fall and winter storms (northeasters) to produce winds with average speeds in excess of 15 m/sec.

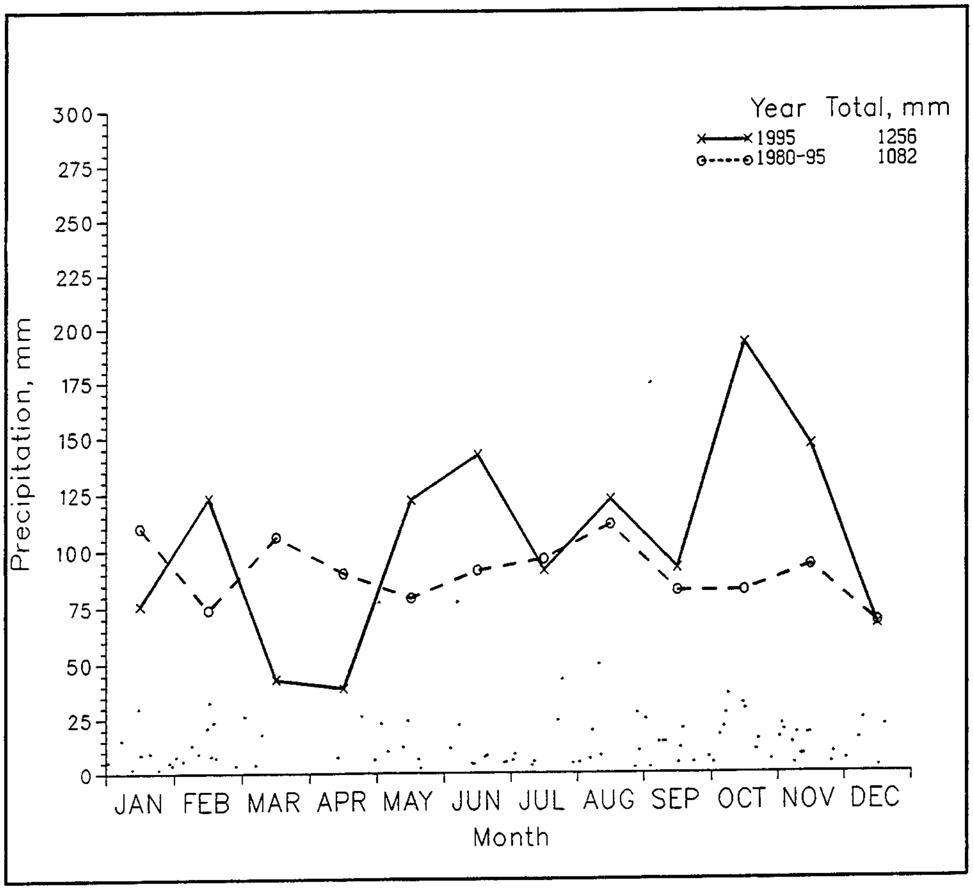

Figure 5. Daily precipitation values with monthly totals

Measurement instrument

Winds were measured at the seaward end of the pier at an elevation of 19.1 m (Figure 2) using a Weather Measure Corporation (Sacramento, CA) Skyvane Model W102P anemometer. Wind speed and direction data were collected on the FRF computer. The anemometer manufacturer specifies an accuracy of ±0.45 m/sec below 13 m/sec and 3 percent at speeds above 13 m/sec, with a threshold of 0.9 m/sec. Wind direction accuracy is ±2 deg, with a resolution of less than 1 deg. The anemometer is calibrated annually at the National Bureau of Standards in Gaithersburg, MD, and is within the manufacturer's specifications.

Results

Annual and monthly joint probability distributions of wind speed versus direction were computed. Wind speeds were resolved into 3-m/sec intervals, whereas the directions were at 22.5-deg intervals (i.e., 16-point compass direction specifications). These distributions are presented as wind "roses," such that the length of the petal represents the frequency of occurrence of wind blowing from the specified direction, and the width of the petal is indicative of the speed. Resultant directions and speeds were also determined by vector-averaging the data (see Table 2). Wind statistics are presented in Figures 6-8.

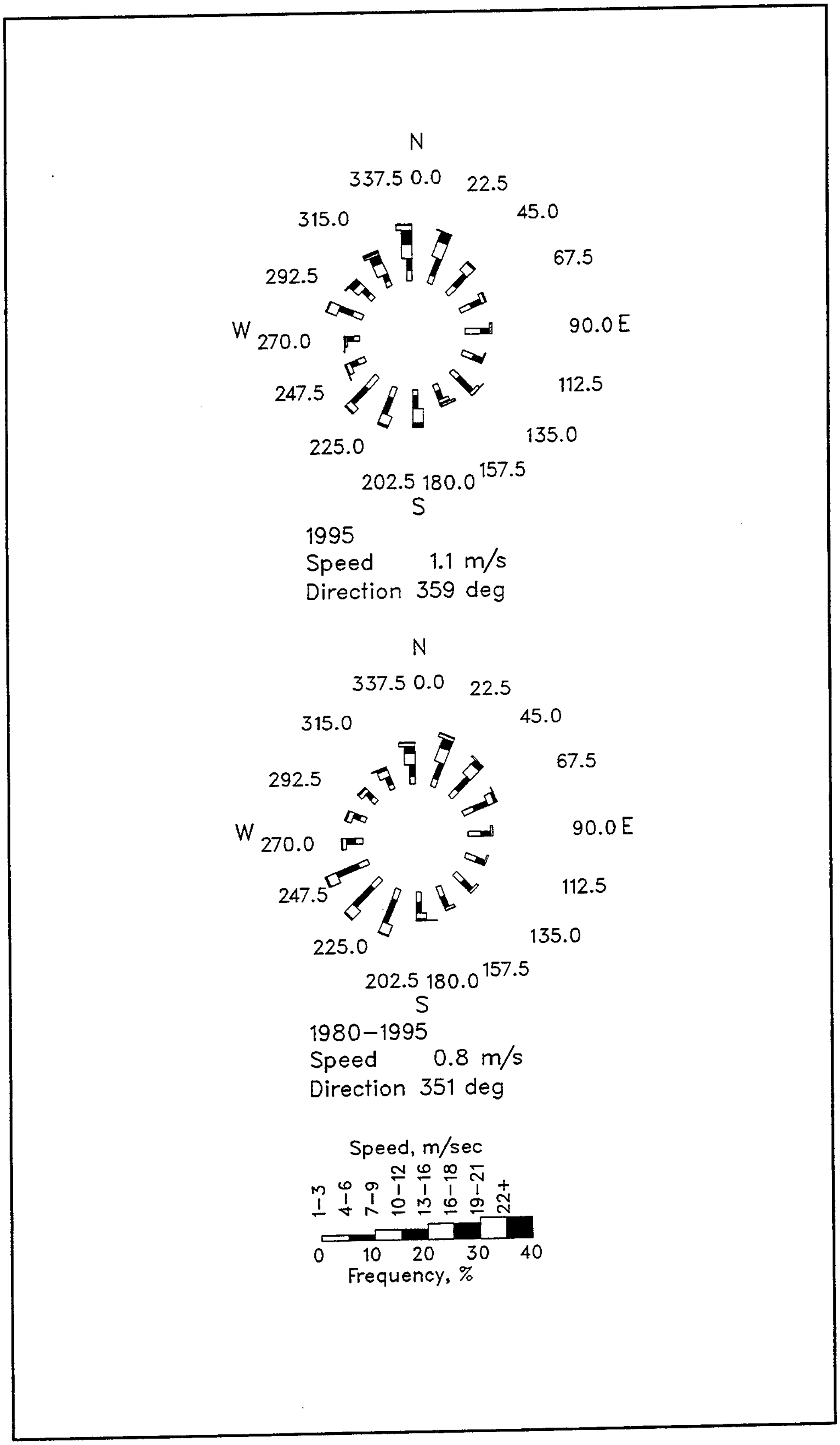

Figure 6. Annual wind roses

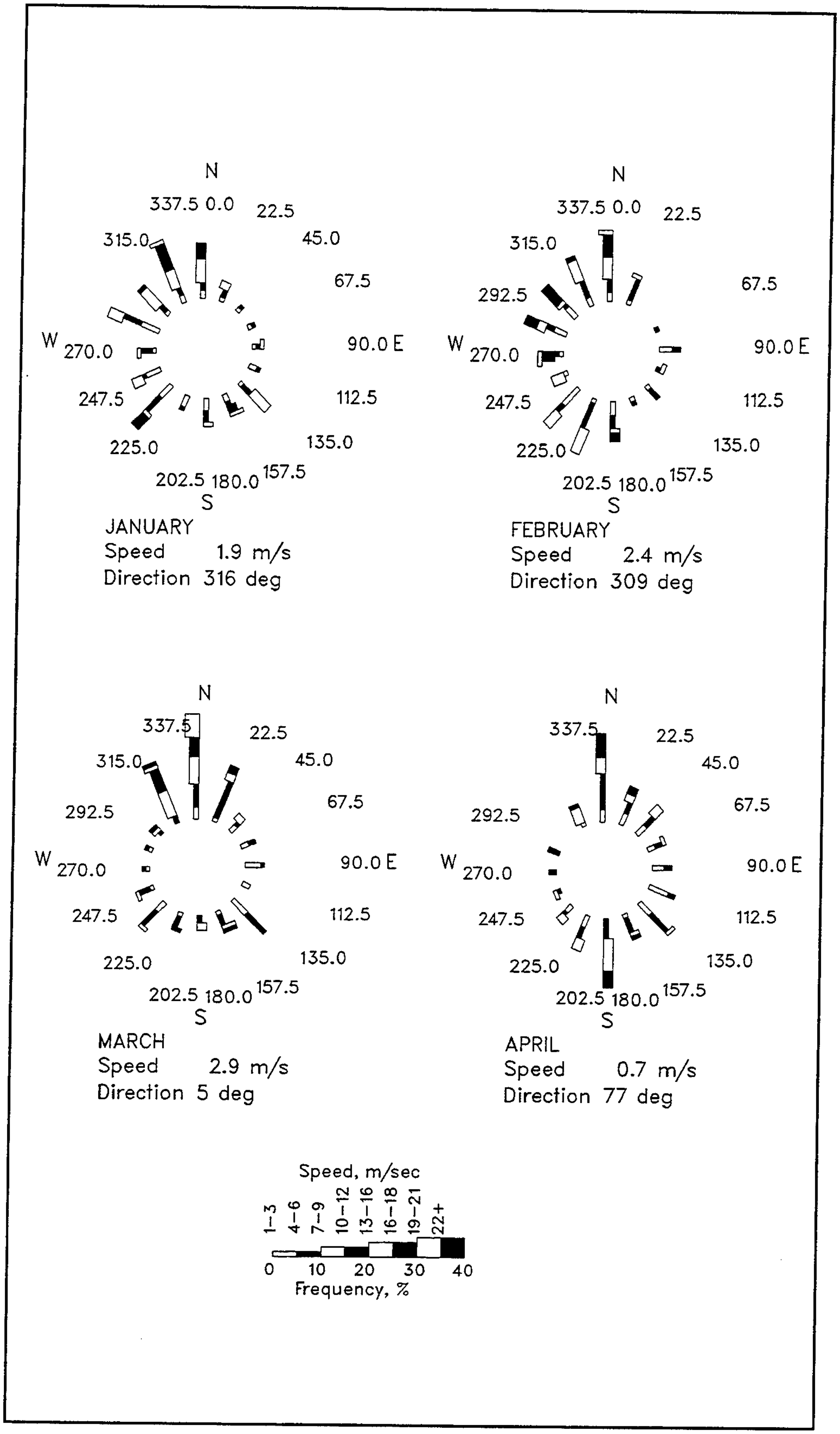

Figure 7. Monthly wind roses for 1995 (Sheet 1 of 3)

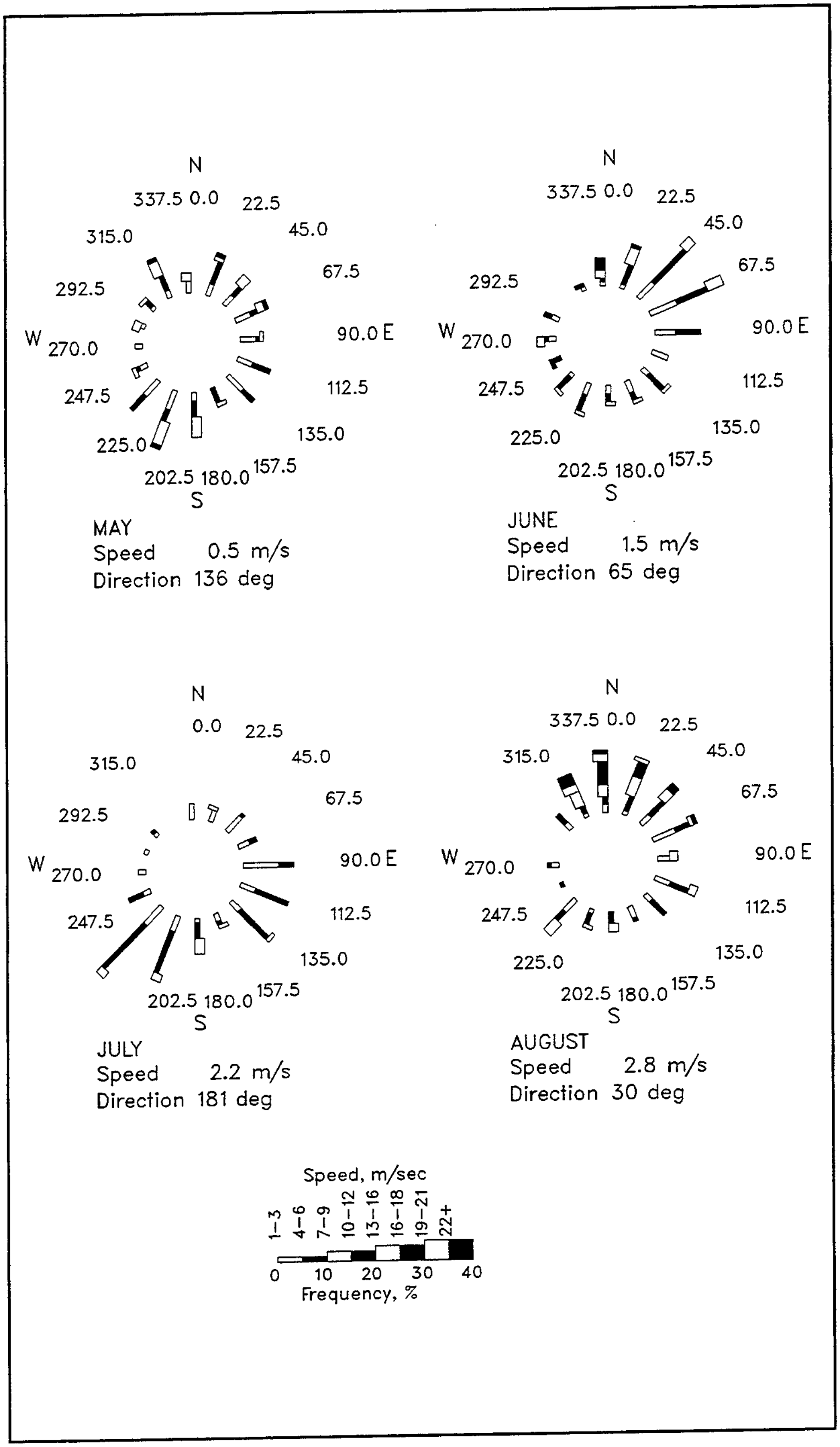

Figure 7. (Sheet 2 of 3)

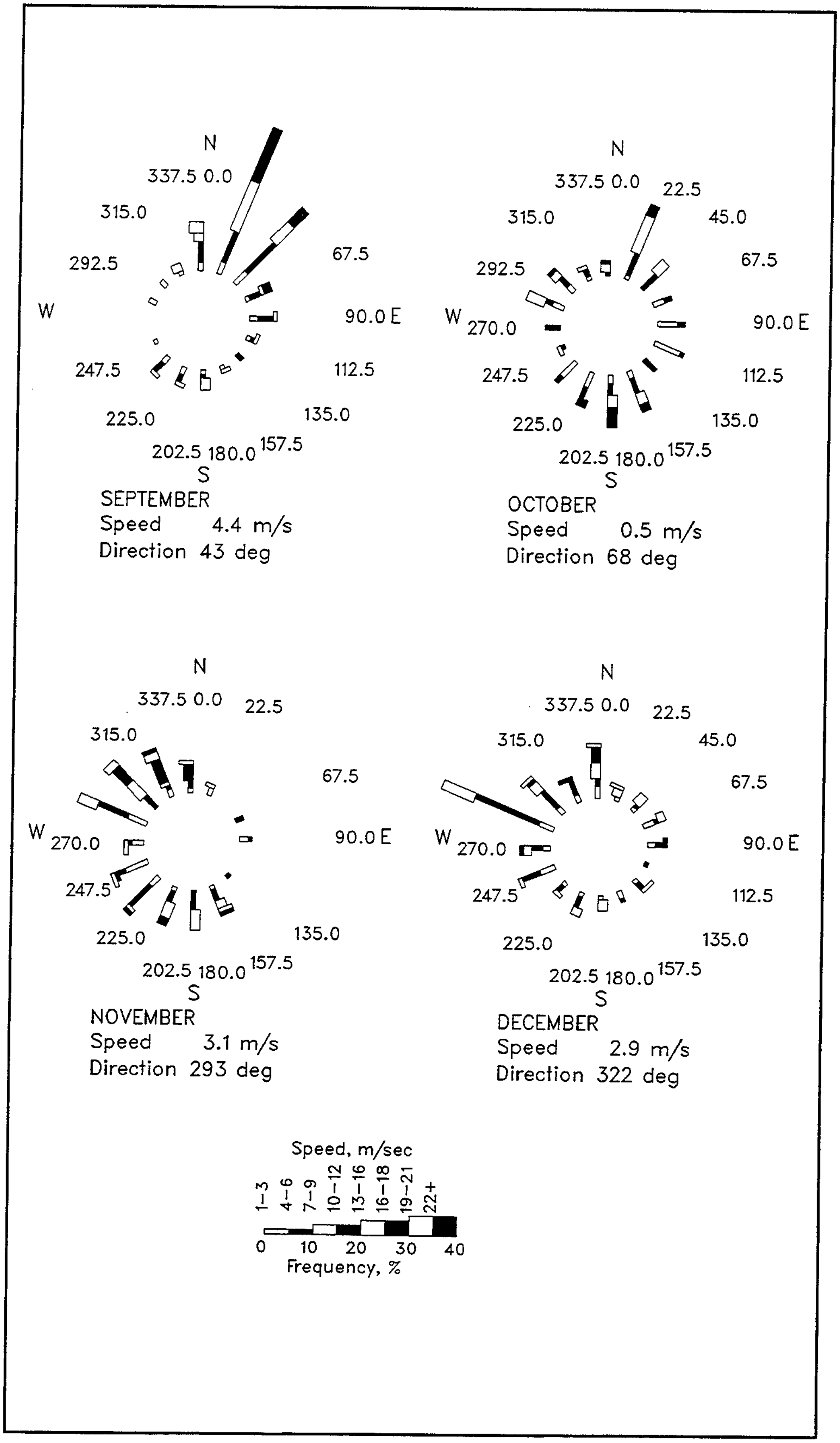

Figure 7. (Sheet 3 of 3)

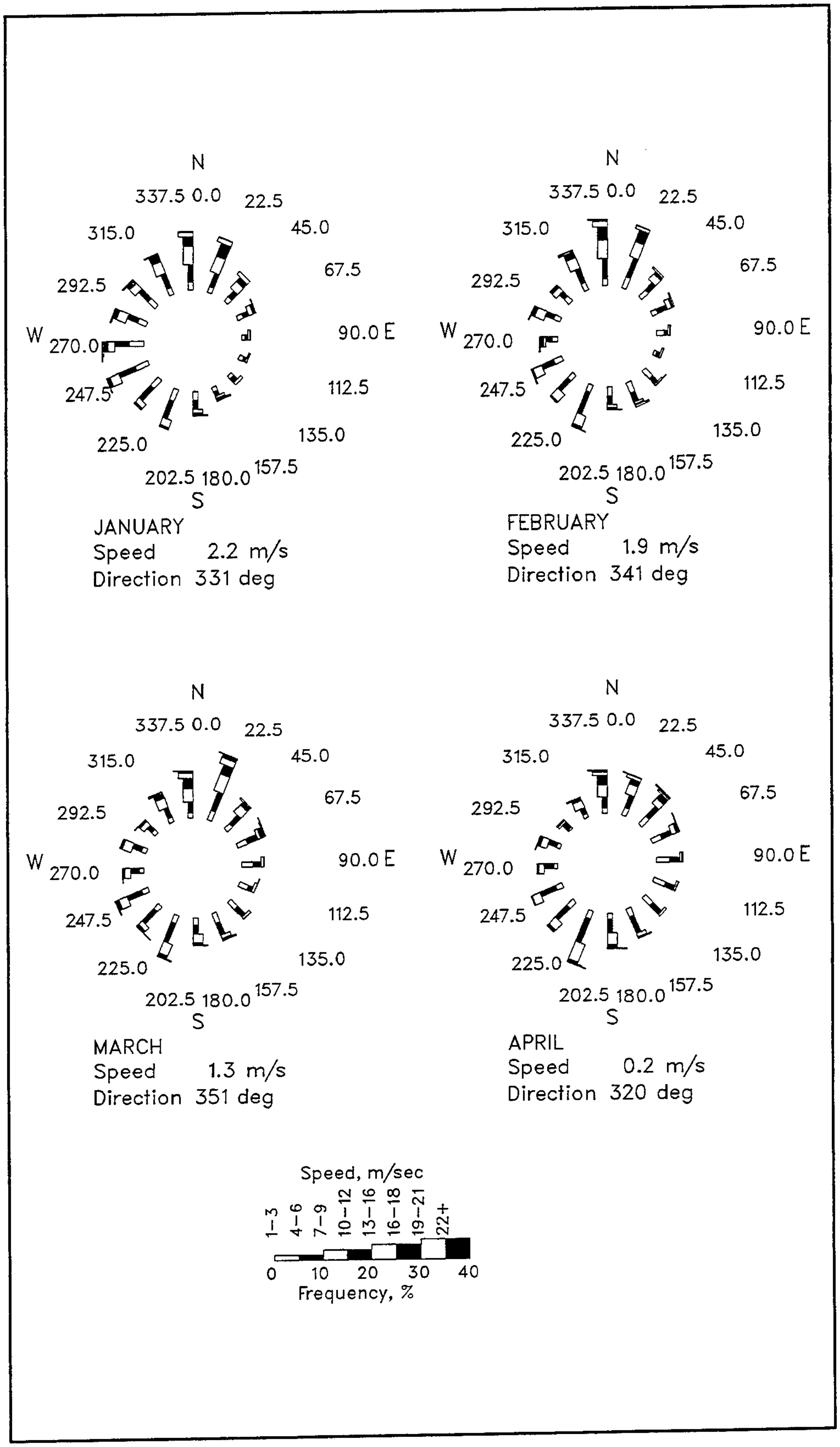

Figure 8. Monthly wind roses for 1980 through 1995 (Sheet 1 of 3)

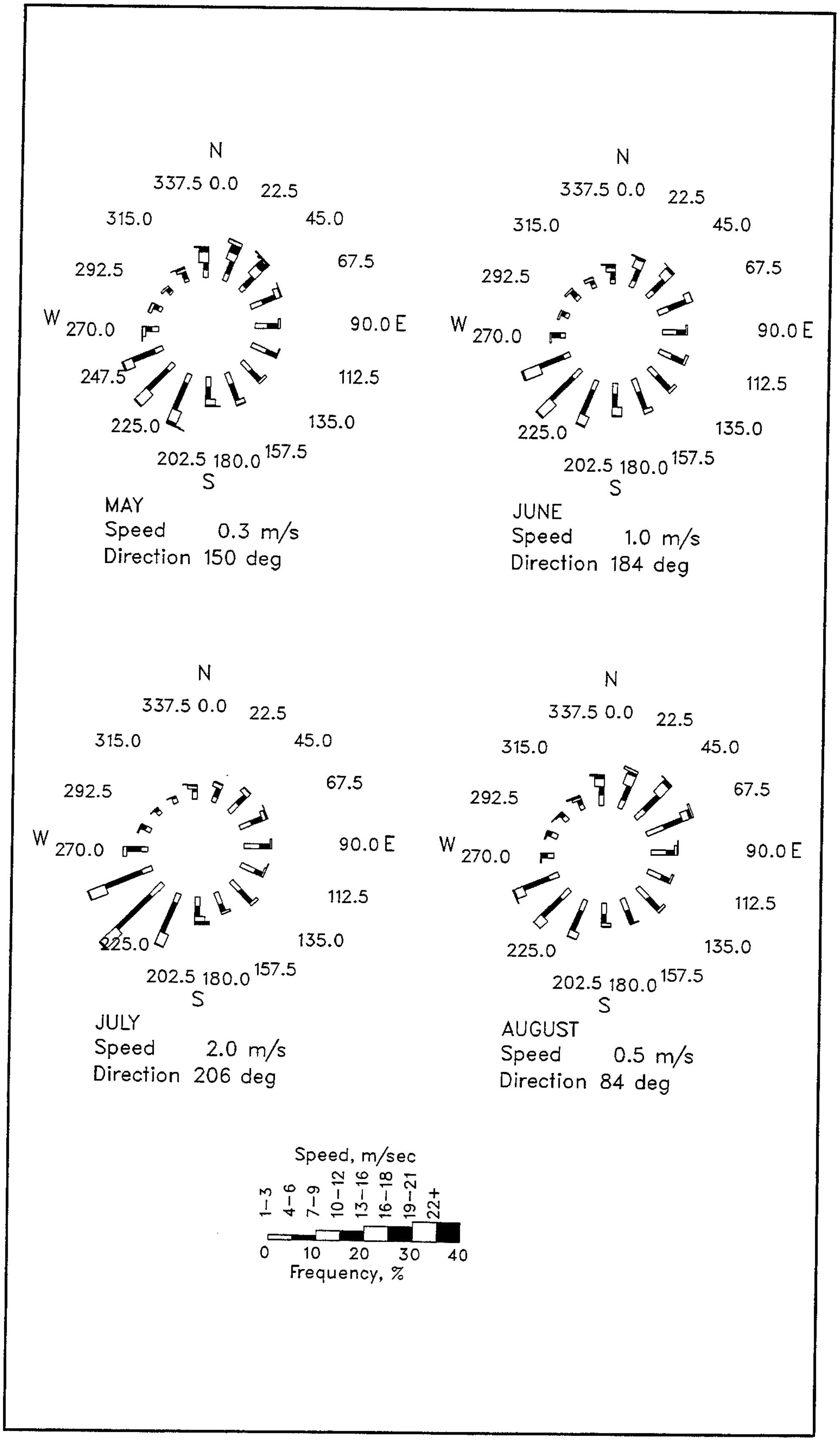

Figure 8. (Sheet 2 of 3)

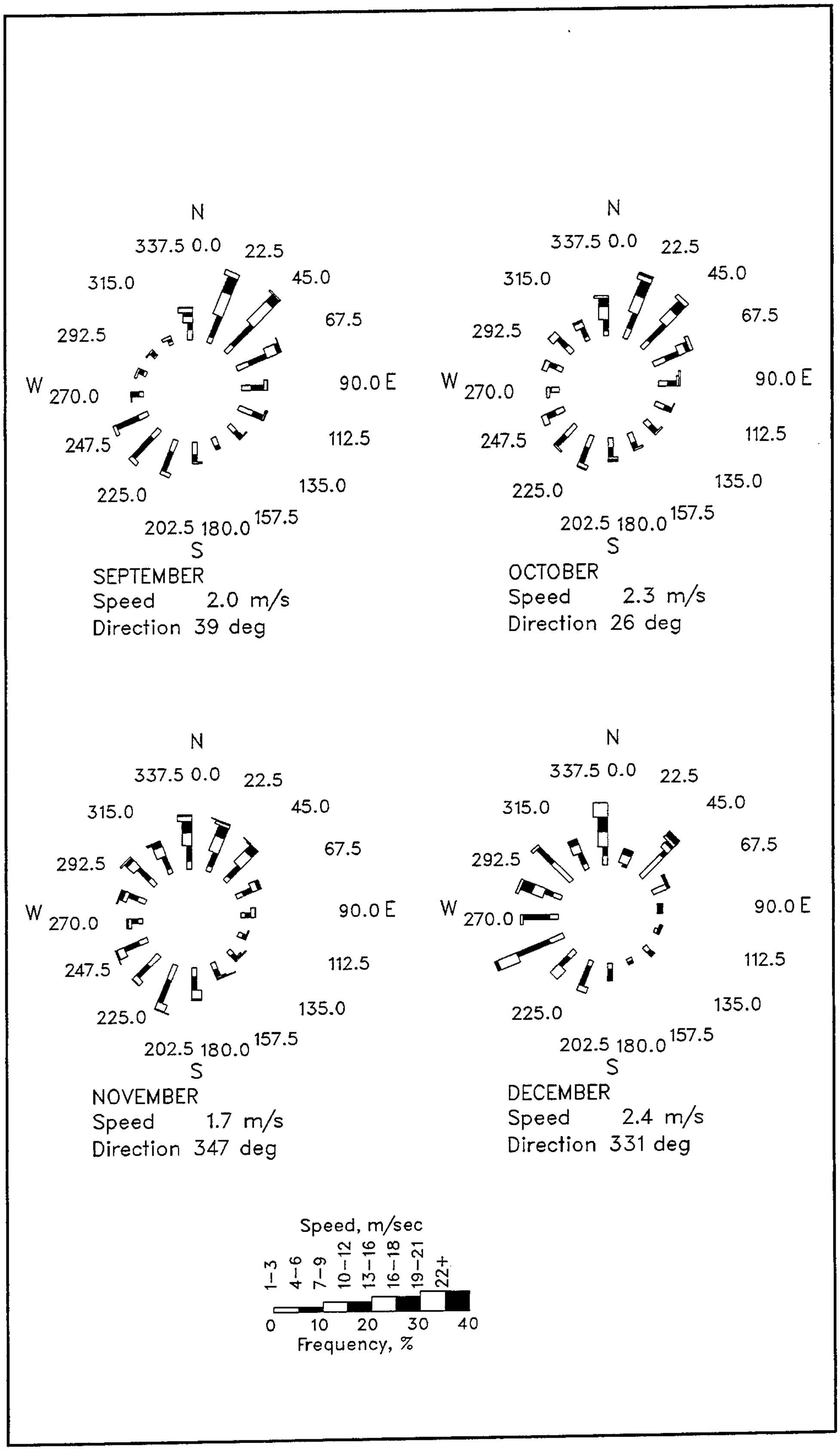

Figure 8. (Sheet 3 of 3)

3 Waves

This chapter presents summaries of the wave data. A discussion of individual major storms is given in Chapter 9 and contains additional wave data for times when wave heights exceeded 2 m at the seaward end of the FRF pier. Appendixes B through E provide more extensive data summaries for each gauge, including height and period distributions, wave direction distributions, persistence tables, and spectra during storms.

Wave directions (similar to wind directions) at the FRF are seasonally distributed. Waves approach most frequently from north of the pier in the fall and winter and south of the pier in the summer, with the exception of storm waves that approach twice as frequently from north of the pier. Annually, waves are approximately evenly distributed between north and south (resultant wave direction being almost shore-normal).

Measurement Instruments

The wave gauges included one wave staff gauge (Gauge 625), one buoy gauge (Gauge 630), and two pressure gauges (Gauges 111 and 641) as shown in Figure 2. Staff gauge 645 failed in May 1992 and was replaced by pressure gauge 641 at the same location. The gauges were located as follows:

Gauge Type/Number	Distance Offshore from Baseline	Water Depth m	Operational Period
Continuous wire (645)	238 m	3.5	11/84-05/92
Pressure Gauge (641)	238 m	3.5	11/92-12/95
Continuous wire (625)	567 m	8	11/78-12/95
Accelerometer buoy (630)	6 km	18	11/78-12/95

Staff gauges

One Baylor Company (Houston, TX) parallel cable inductance wave gauge (Gauge 625 at sta 18+60 (Figure 2)) was mounted on the FRF pier. Rugged and reliable, this gauge requires little maintenance except to keep tension on the cables and to remove any material that may cause an electrical short between them. It was calibrated prior to installation by creating an electrical short between the two cables at known distances along the cable and recording the voltage output. Electronic signal conditioning amplifiers are used to ensure that the output signals from the gauge are within a 0- to 5-V range. Manufacturer-stated gauge accuracy is about 1.0 percent, with a 0.1-percent full-scale resolution; full scale is 14 m for Gauge 625. This gauge is susceptible to lightning damage, but protective measures have been taken to minimize such occurrences. A more complete description of the gauges' operational characteristics is given by Grogg (1986).

Buoy gauge

One Datawell Laboratory for Instrumentation (Haarlem, The Netherlands) Waverider buoy gauge (Gauge 630) measures the vertical acceleration produced by the passage of a wave. The acceleration signal is double-integrated to produce a displacement signal transmitted by radio to an onshore receiver. The manufacturer stated that wave amplitudes are correct to within 3 percent of their actual value for wave frequencies between 0.065 and 0.500 Hz (corresponding to 15- to 2-sec wave periods). The manufacturer also specified that the error gradually increased to 10 percent for wave periods in excess of 20 sec. The results in this report were not corrected for the manufacturer's specified amplitude errors. However, the buoy was calibrated semiannually to ensure that it was within the manufacturer's specification.

Pressure gauges

One Senso-Metrics, Incorporated (Simi Valley, CA), pressure transduction gauge (Gauge 111) installed near the ocean bottom measures the pressure changes produced by the passage of waves creating an output signal that is linear and proportional to pressure when operated within its design limits. Predeployment and postdeployment calibrations are performed at the FRF using a static deadweight tester. The sensor's range is 0 to 25 psi (equivalent to 0 to 17 m of seawater) above atmospheric pressure with a manufacturer-stated accuracy of ± 0.25 percent. Copper scouring pads are installed at the sensor's diaphragm to reduce biological fouling, and the system is periodically cleaned by divers.

One Paroscientific, Incorporated (Redmond, WA) pressure transduction gauge (Gauge 641) was installed near the ocean bottom on an instrument pile under the pier at station 7+80. Calibration is similar to that performed on Gauge 111. The sensor's range is 0 to 45 psia (equivalent to 0 to 30 m of seawater) with a manufacturer-stated accuracy of ± 0.01 percent. A perforated copper/nickel plate protects the sensor's diaphragm from biological fouling, and the system is periodically cleaned by divers.

Digital Data Analysis and Summarization

The data were collected, analyzed, and then archived on optical disk using the FRF's VAX computer. Data sets were normally collected every 3 hr. For each gauge, a data set consisted of five contiguous records of 4,096 points recorded at 0.5 Hz (approximately 34-min long), for a total of 2 hr and 50 minutes, resulting in only a 10-min gap between data sets. Analysis was performed on individual 34-min records.

The analysis program computes the first moment (mean) and the second moment about the mean (variance) and then edits the data by checking for "jumps," "spikes," and points exceeding the voltage limit of the gauge. A jump is defined as a data value greater than five standard deviations from the previous data value, whereas a spike is a data value more than five standard deviations from the mean. If less than five consecutive jumps or spikes are found, the program linearly interpolates between acceptable data and replaces the erroneous data values. The editing stops if the program finds more than five consecutive jumps or spikes, or more than a total of 100 bad points, or the variance of the voltage is below 1×10^{-5} squared volts. The statistics and diagnostics from the analysis are saved.

Sea surface energy spectra are computed from the edited time series. Spectral estimates are computed from smaller data segments obtained by dividing the 4,096-point record into several 512-point segments. The estimates are then ensemble-averaged to produce a more accurate spectrum. These data segments are overlapped by 50 percent (known as the Welch (1967) method) which has been shown to produce better statistical properties than nonoverlapped segments. The mean and linear trends are removed from each segment prior to spectral analysis. To reduce side-lobe leakage in the spectral estimates, a data window was applied. The first and last 10 percent of data points were multiplied by a cosine bell (Bingham, Godfrey, and Tukey 1967). Spectra were computed from each segment with a discrete Fast Fourier Transform and then ensemble-averaged. Sea surface spectra from subsurface pressure gauges were obtained by applying the linear wave theory transfer function.

Unless otherwise stated, wave height in this report refers to the energy-based parameter H_{mo} defined as four times the zeroth moment wave height of the estimated sea surface spectrum (i.e., four times the square root of the variance) computed from the spectrum passband. Energy computations from the spectra are limited to a passband between 0.05 and 0.50 Hz for surface gauges and between 0.05 Hz and a high-frequency cutoff for subsurface gauges. This high-frequency limit is imposed to eliminate aliased energy and noise measurements from biasing the computation of H_{mo} and is defined as the frequency where the linear theory transfer function is less than 0.1 (spectral values are multiplied by 100 or more). Smoother and more statistically significant spectral estimates are obtained by band-averaging contiguous spectral components (three components are averaged per band, producing a frequency band width of 0.0117 Hz).

Wave period T_p is defined as the period associated with the maximum energy band in the spectrum, which is computed using a 3-point running average band on the spectrum. The peak period is reported as the reciprocal of the center frequency (i.e., T_p = 1/frequency) of the spectral band with the highest energy. A detailed description of the analysis techniques is presented in an unpublished report by Andrews (1987).[1]

Results

The wave conditions for the year are shown in Figure 9. For all four gauges, the distributions of wave height for the current year and all years combined are presented in Figures 10 and 11, respectively. Distributions of wave period are presented in Figure 12.

Multiple-year comparisons of data for Gauge 111 actually incorporate data for 1985 and 1986 from Gauge 640 (a discontinued Waverider buoy previously located at the approximate depth and distance offshore of Gauge 111) and data for 1987 from Gauge 141, located 30 m south of Gauge 111. In addition, Gauge 511 was used from January through October 1993. Multiple-year data for Gauge 641 also include data from Gauge 645 (a Baylor staff gauge) which was mounted at the same location as Gauge 641 from November 1984 until May 1992, when it failed.

Refraction, bottom friction, and wave breaking contribute to the observed differences in height and period. During the most severe storms when the wave heights exceed 3 m at the seaward end of the pier, the surf zone (wave breaking) has been observed to extend past the end of the pier and occasionally 1 km offshore. This occurrence is a major reason for the differences in the distributions between Gauge 630 and the inshore gauges. The wave height statistics for the pressure gauge (Gauge 641), located at the landward end of the pier, were considerably lower than those for the other gauges. In all but the calmest conditions, this gauge is within the breaker zone. Consequently, these statistics represent a lower energy wave climate.

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[1] M. E. Andrews. (1987). "Standard wave data analysis procedures for coastal engineering applications," unpublished report prepared for U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

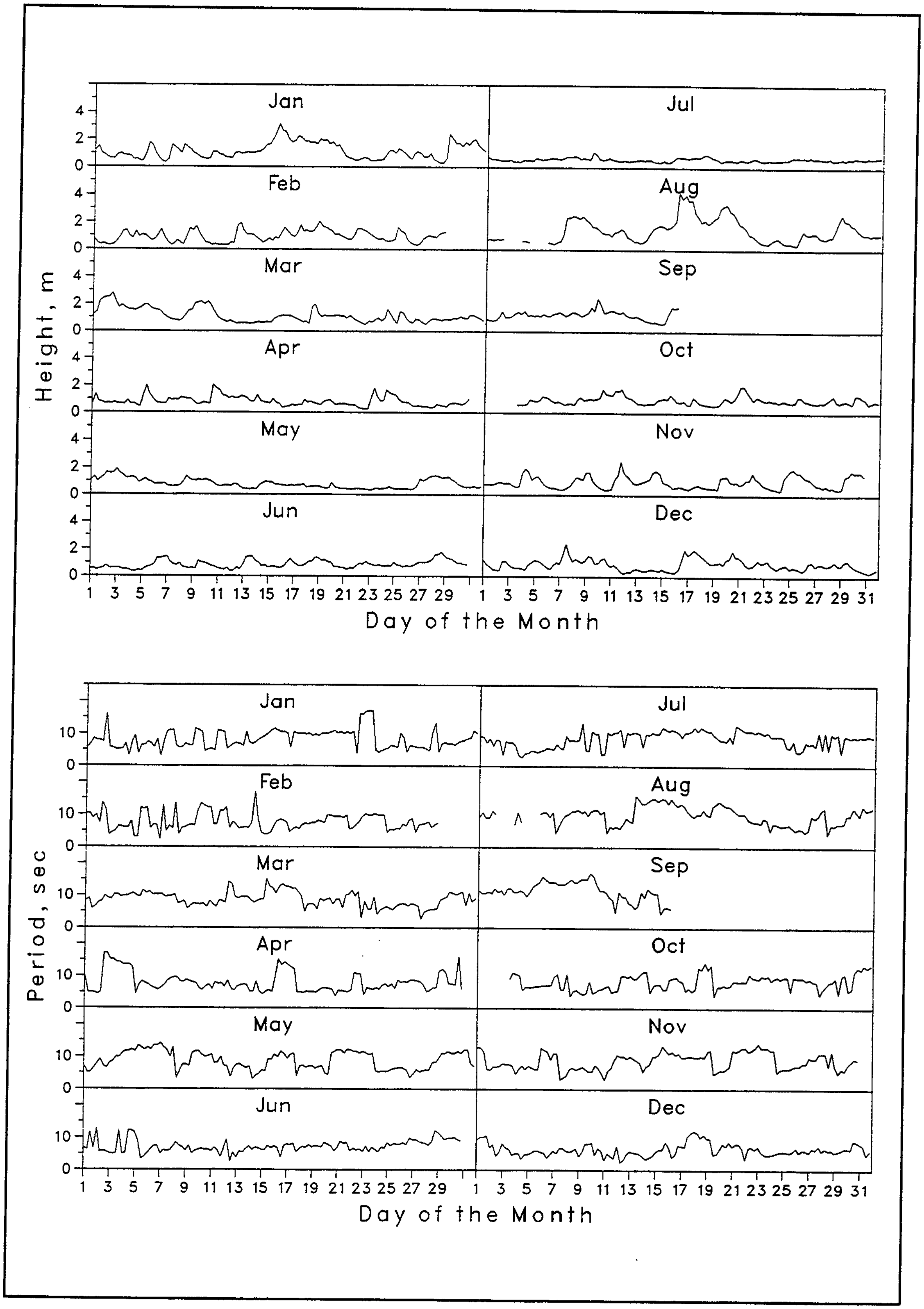

Figure 9. 1995 time-histories of wave height and period for Gauge 630

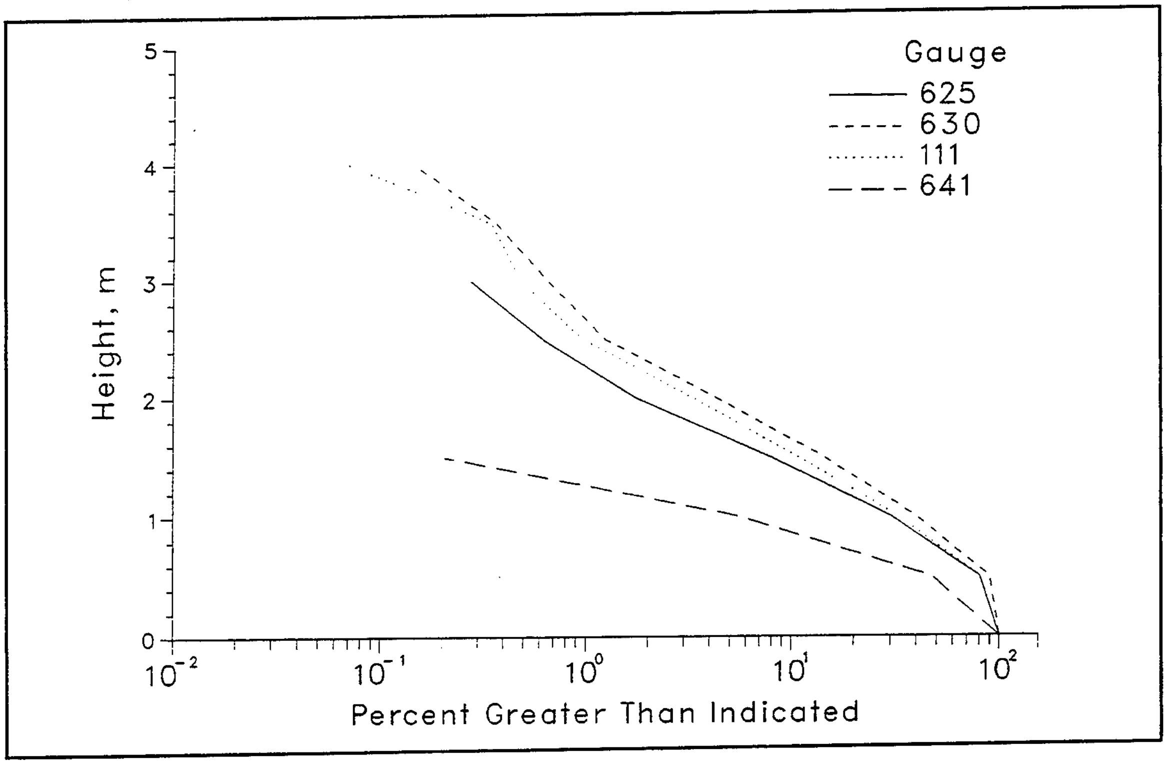

Figure 10. 1995 annual wave height distributions

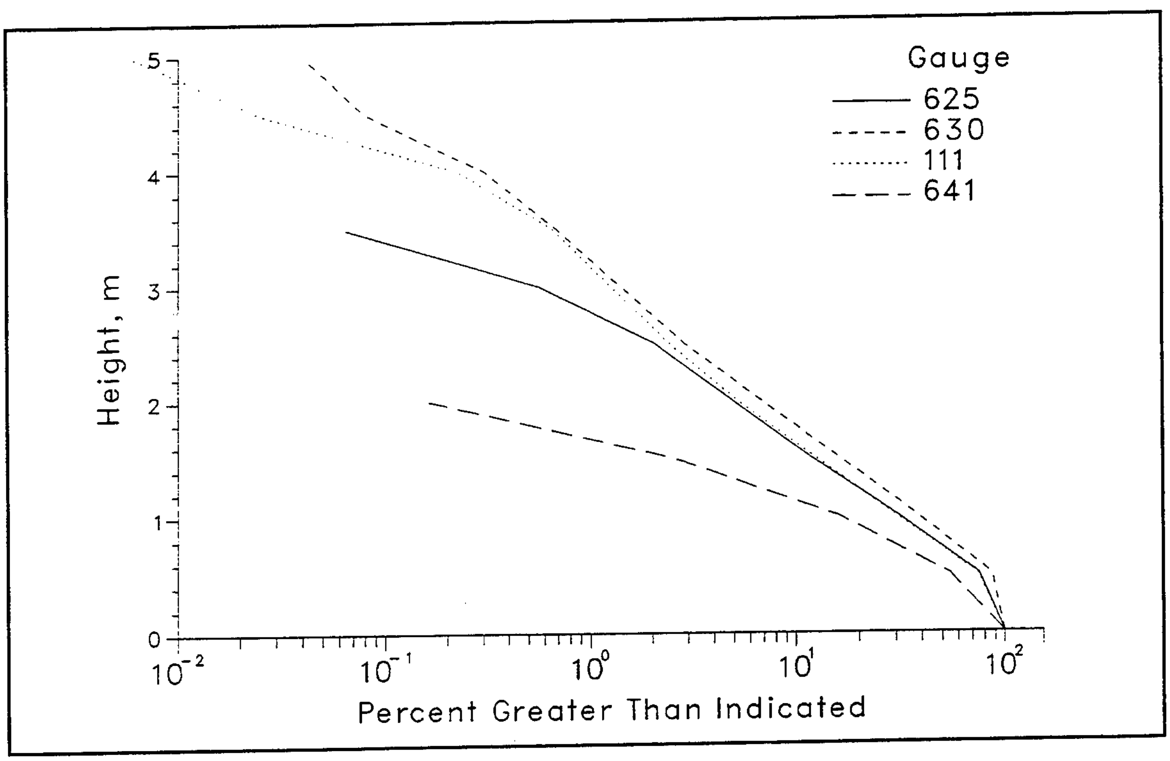

Figure 11. Annual distribution of wave heights for 1980 through 1995

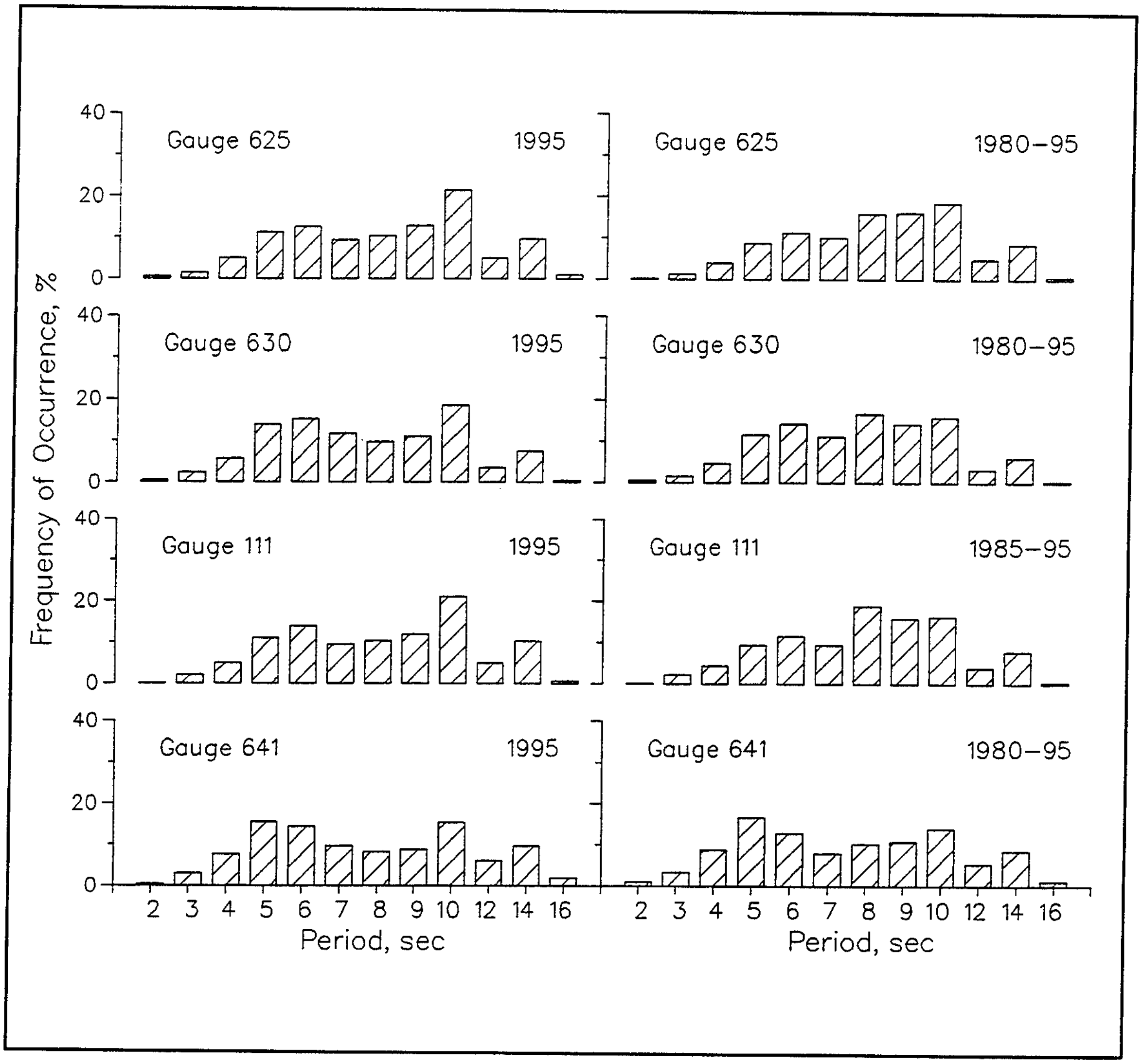

Figure 12. Annual wave period distributions for all gauges

Summary wave statistics for the current year and all years combined are presented for Gauge 630 in Table 3.

Table 3

Wave Statistics for Gauge 630

	1995							1980-1995						
	Height				Period			Height				Period		
Month	Mean m	Std. Dev. m	Extreme m	Date	Mean sec	Std. Dev. sec	Number Obs.	Mean m	Std. Dev. m	Extreme m	Date	Mean sec	Std. Dev. sec	Number Obs.
Jan	1.2	0.6	3.1	15	8.3	3.0	123	1.2	0.7	4.5	1983	8.1	2.7	1619
Feb	1.0	0.5	2.0	18	7.8	2.7	112	1.2	0.7	5.1	1987	8.4	2.5	1464
Mar	1.2	0.6	2.8	2	8.7	2.3	120	1.2	0.7	4.7	1983	8.6	2.6	1811
Apr	0.9	0.4	2.0	10	7.9	3.2	120	1.0	0.6	5.0	1988	8.6	2.7	1790
May	0.8	0.4	1.9	3	8.8	2.8	124	0.9	0.5	3.6	1992	8.2	2.5	1837
Jun	0.9	0.4	1.8	28	7.3	2.0	120	0.8	0.4	2.7	1991	7.9	2.2	1717
Jul	0.7	0.2	1.1	9	8.6	2.5	123	0.7	0.3	2.1	1985	8.1	2.4	1752
Aug	1.5	0.9	4.2	16	10.0	2.8	113	0.8	0.5	3.6	1981	8.3	2.5	1768
Sep	1.3	0.4	2.4	9	11.5	2.9	61	1.1	0.6	6.1	1985	8.7	2.7	1715
Oct	1.0	0.3	2.0	21	8.4	2.5	114	1.2	0.7	5.4	1991	8.6	2.8	1843
Nov	1.1	0.5	2.5	11	8.7	2.7	118	1.1	0.7	5.1	1994	8.1	2.7	1588
Dec	1.0	0.5	2.4	7	6.5	1.9	124	1.2	0.8	5.6	1980	8.3	2.9	1599
Annual	1.0	0.6	4.2	Aug	8.4	2.5	1372	1.0	0.6	6.1	Sep 1985	8.3	2.6	20503

Annual joint distributions of wave height versus wave period for Gauge 630 are presented for 1995 in Table 4, and for all years combined in Table 5. Similar distributions for the other gauges are included in Appendixes B-E.

Annual distributions of wave directions (relative to true north) based on daily observations of direction at the seaward end of the pier and height from Gauge 625 (or Gauge 111 when data for Gauge 625 were unavailable) are shown in Figure 13. Monthly wave roses for 1995 and all years combined are presented in Figures 14 and 15, respectively.

Table 4

Annual (1995) Joint Distribution of H_{mo} versus T_p for Gauge 630[1]

	Period, sec												
Height, m	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	29	14	22	65	43	115	459	416	244	158	108	.	1673
0.50 - 0.99	7	108	359	502	667	617	1055	861	581	57	273	14	5101
1.00 - 1.49	.	22	151	395	237	151	187	158	194	22	57	.	1574
1.50 - 1.99	.	.	.	172	273	115	57	36	136	29	57	.	875
2.00 - 2.49	.	.	.	14	143	86	36	29	50	7	50	.	415
2.50 - 2.99	.	.	.	.	14	50	36	22	22	7	36	.	187
3.00 - 3.49	.	.	.	.	.	7	7	14	50	7	.	.	85
3.50 - 3.99	.	.	.	.	.	.	.	22	22	.	.	.	44
4.00 - 4.49	.	.	.	.	.	.	.	.	7	14	7	.	28
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	14	.	14
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	7	.	7
Total	36	144	532	1148	1377	1141	1837	1558	1306	301	609	14	

[1] Percent occurrence (x100) of height and period.

Table 5

Annual (1980-1995) Joint Distribution of H_{mo} versus T_p for Gauge 630[1]

	Period, sec												
Height, m	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	25	15	28	63	80	123	356	293	194	68	119	4	1368
0.50 - 0.99	32	135	271	490	570	536	915	773	764	125	225	14	4850
1.00 - 1.49	.	10	147	405	404	237	274	216	318	39	112	3	2165
1.50 - 1.99	.	.	11	166	244	106	82	76	137	32	66	3	923
2.00 - 2.49	.	.	1	25	93	68	52	33	62	26	34	1	395
2.50 - 2.99	.	.	.	1	14	34	20	15	34	9	25	1	153
3.00 - 3.49	.	.	.	.	1	11	13	13	21	6	8	1	74
3.50 - 3.99	.	.	.	.	.	1	6	9	13	5	5	.	39
4.00 - 4.49	.	.	.	.	.	.	3	5	8	3	4	1	24
4.50 - 4.99	.	.	.	.	.	.	.	1	2	.	1	1	5
5.00 - Greater	.	.	.	.	.	.	1	.	1	1	1	1	5
Total	57	160	458	1150	1406	1116	1722	1434	1554	314	600	30	

[1] Percent occurrence (x100) of height and period.

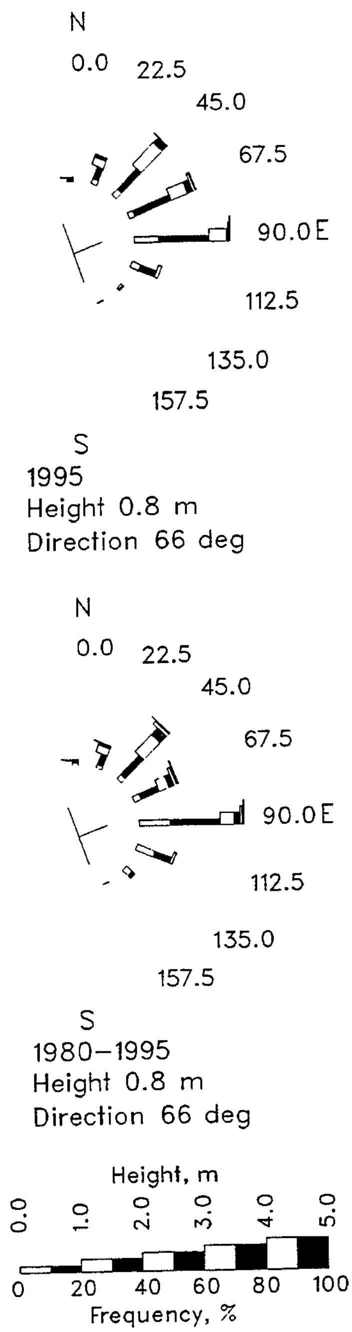

Figure 13. Annual wave roses

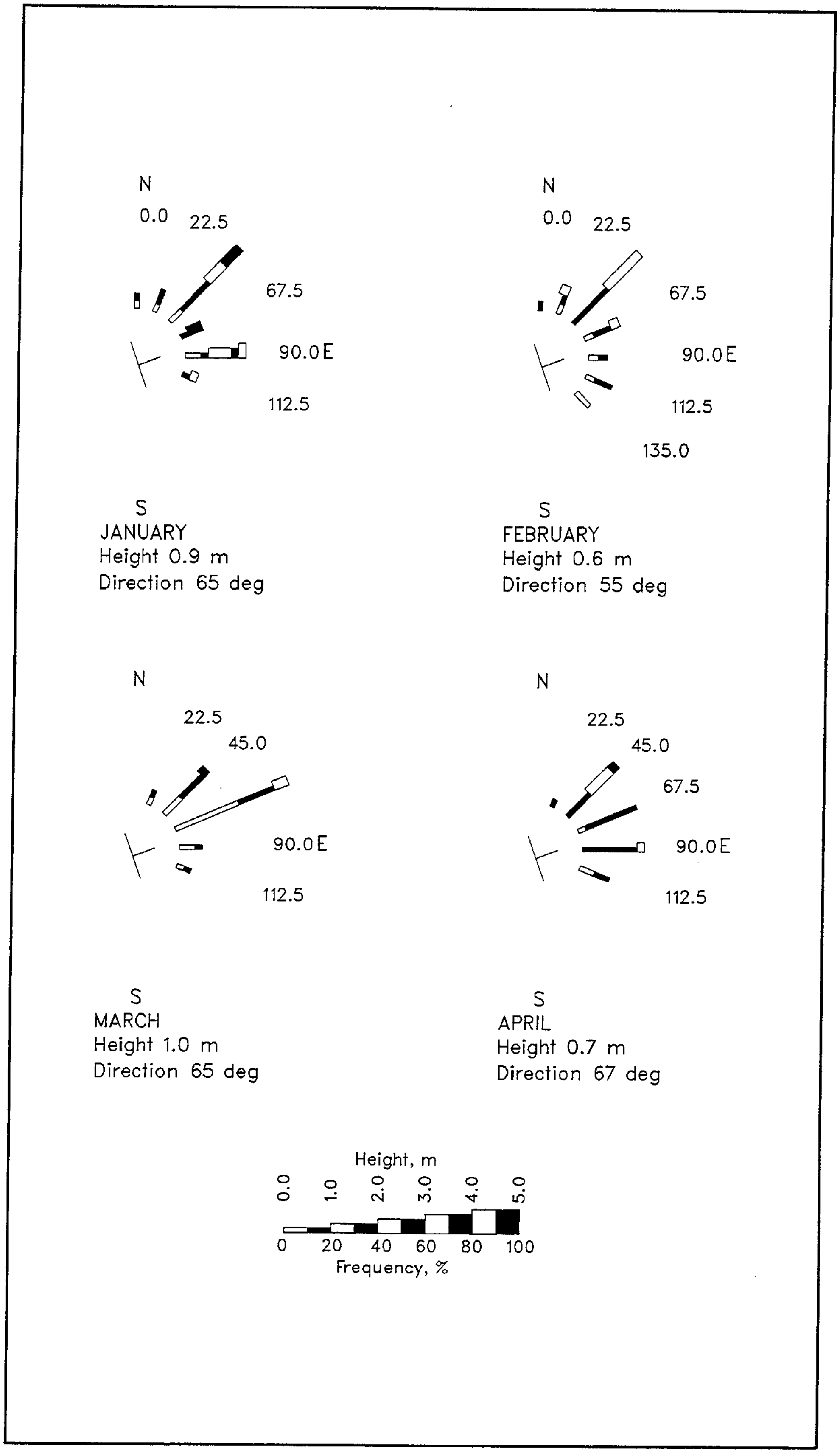

Figure 14. Monthly wave roses for 1995 (Sheet 1 of 3)

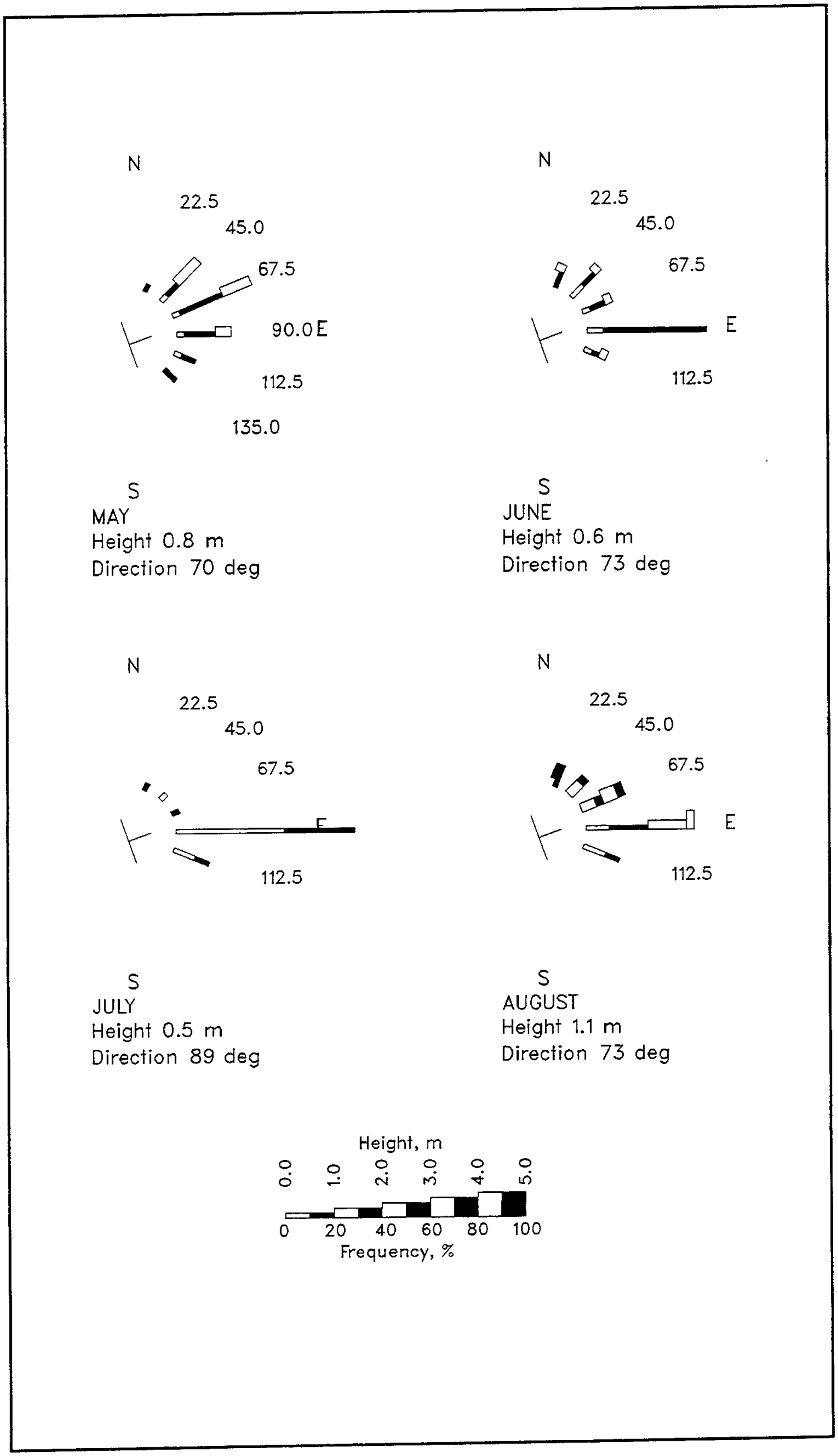

Figure 14. (Sheet 2 of 3)

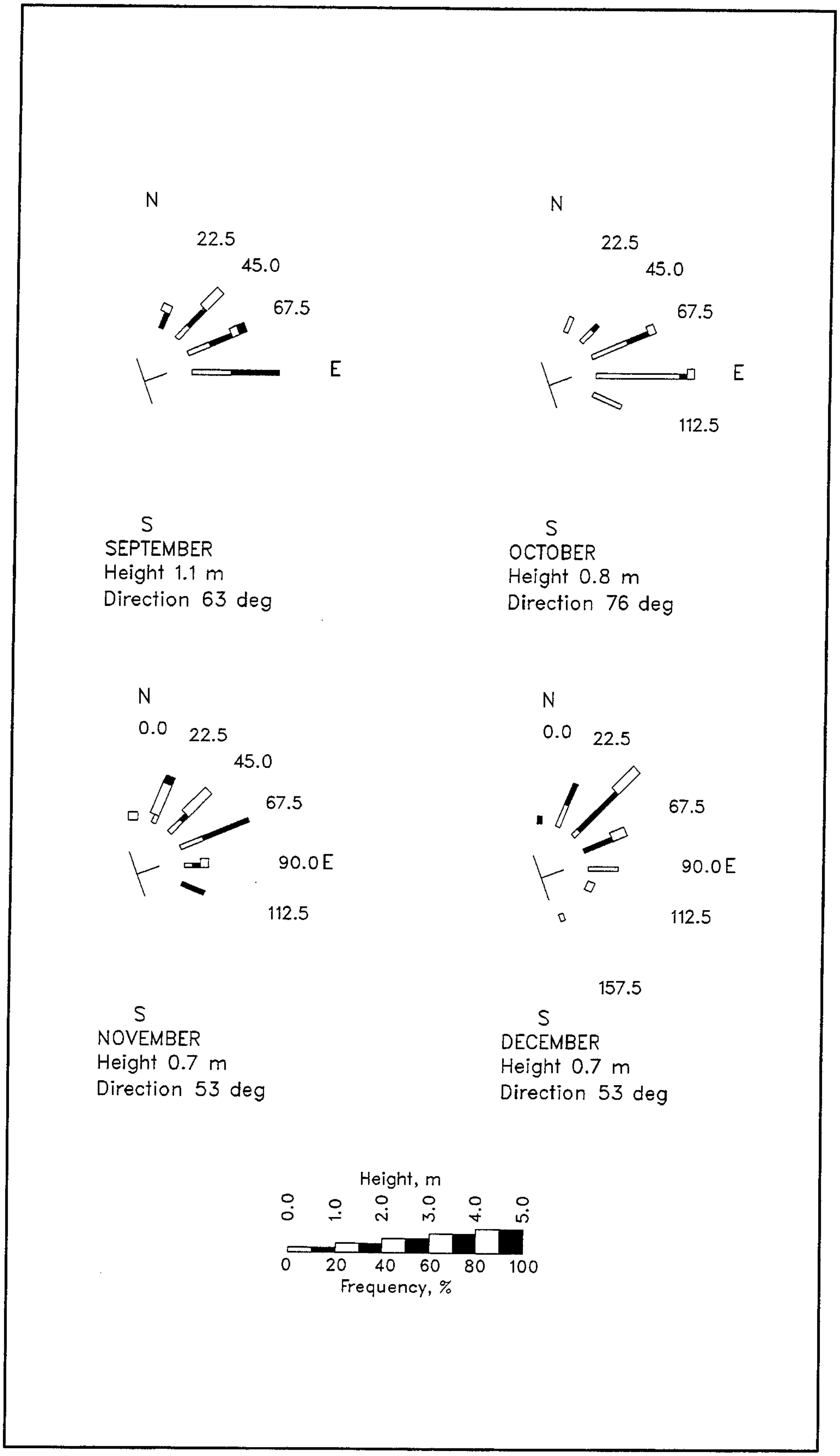

Figure 14. (Sheet 3 of 3)

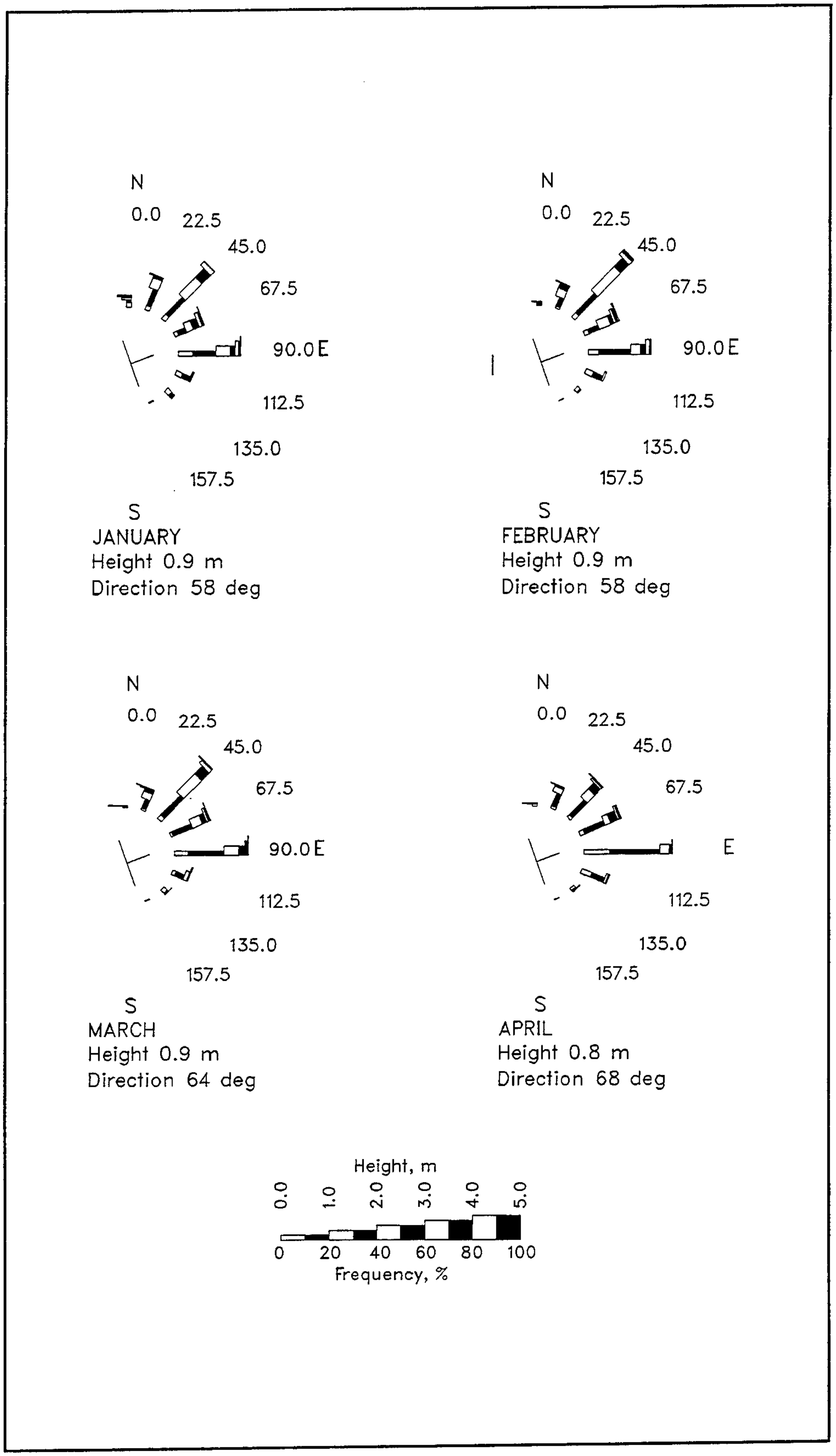

Figure 15. Monthly wave roses for 1980 through 1995 (Sheet 1 of 3)

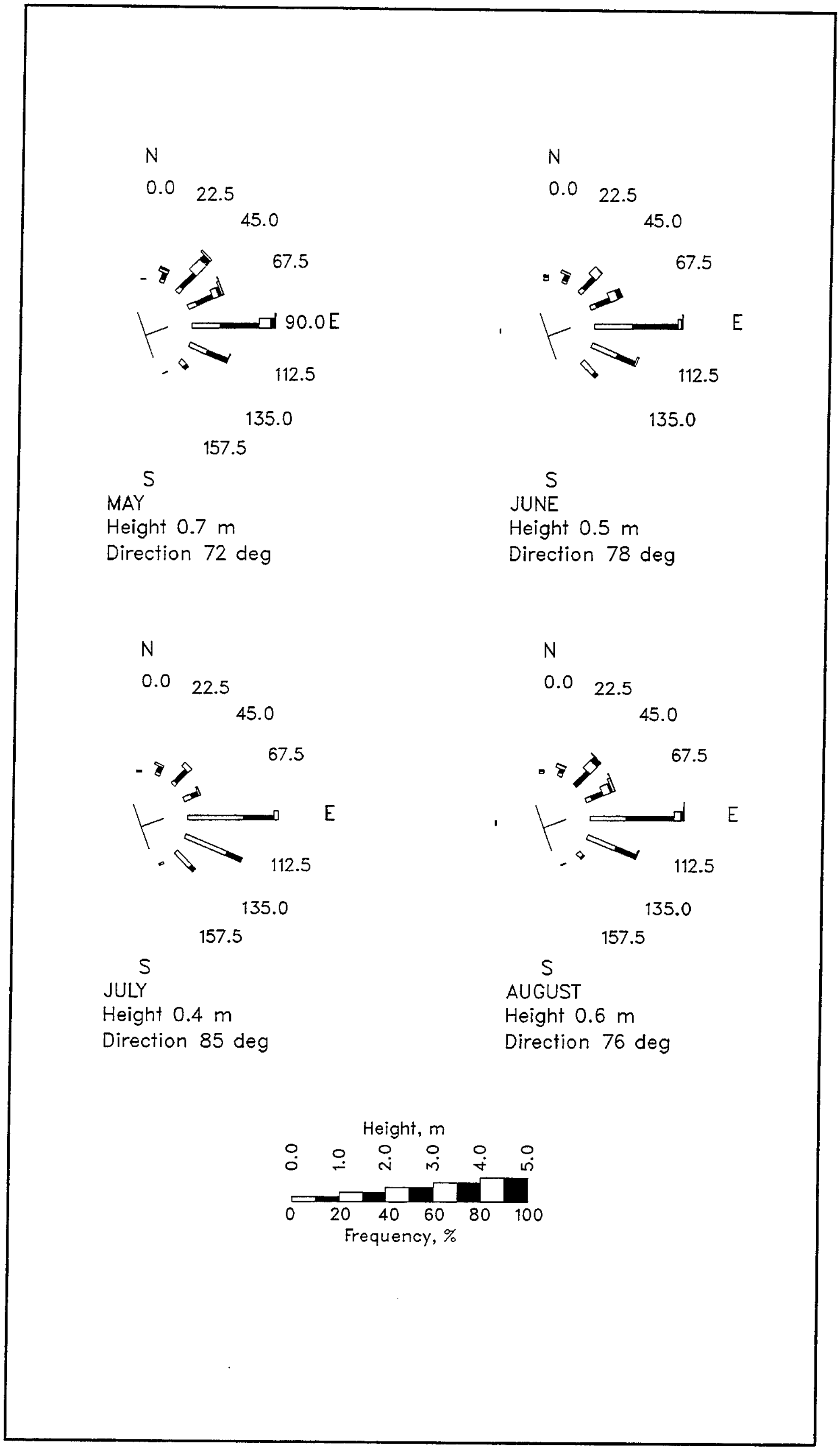

Figure 15. (Sheet 2 of 3)

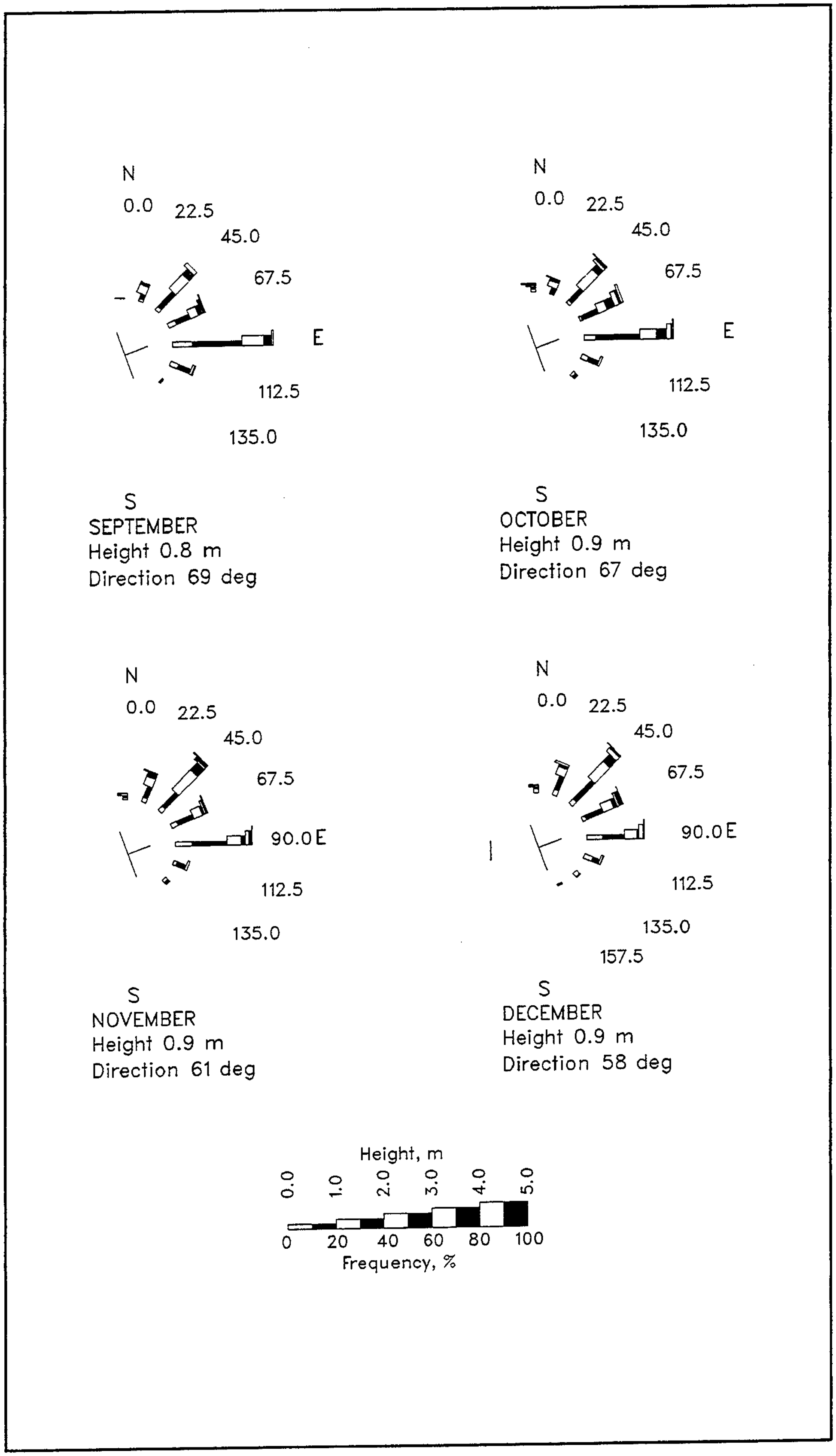

Figure 15. (Sheet 3 of 3)

4 Currents

Surface current speed and direction at the FRF are influenced by winds, waves, and, indirectly, by the bottom topography. The extent of the respective influences varies daily. However, winds tend to dominate the currents at the seaward end of the pier, whereas waves dominate within the surf zone.

Observations

Near 0700 EST, daily observations of surface current speed and direction were made at (a) the seaward end of the pier, (b) the midsurf position on the pier, and (c) 10 to 15 m from the beach 500 m updrift of the pier. Surface currents were determined by observing the movement of a small wooden block floating on the water surface.

Results

Annual mean and mean currents for 1980 through 1995 are presented in Table 6 and in Figure 16. Figure 16 shows the daily and average annual measurements at the beach, pier midsurf, and pier end locations. Since the relative influences of the winds and waves vary with position from shore, the current speeds and, to some extent, direction vary at the beach, midsurf, and pier end locations. Magnitudes generally are largest at the midsurf location and lowest at the end of the pier.

Table 6

Mean Longshore Surface Currents[1]

Month	Pier End, cm/sec 1995	Pier End, cm/sec 1980-1995	Pier Midsurf, cm/sec 1995	Pier Midsurf, cm/sec 1980-1995	Beach, cm/sec 1995	Beach, cm/sec 1980-1995
Jan	15	18	12	19	8	12
Feb	20	15	22	19	12	10
Mar	33	13	30	6	15	6
Apr	12	16	11	6	2	3
May	11	19	6	6	4	6
Jun	15	6	5	-8	-6	-3
Jul	10	5	-11	-6	-21	-5
Aug	14	12	2	-1	-3	-2
Sep	16	11	16	3	0	-1
Oct	3	10	6	7	-7	4
Nov	17	10	27	9	18	3
Dec	28	15	30	18	25	2
Annual	15	13	15	7	4	3

[1] + = southward; - = northward.

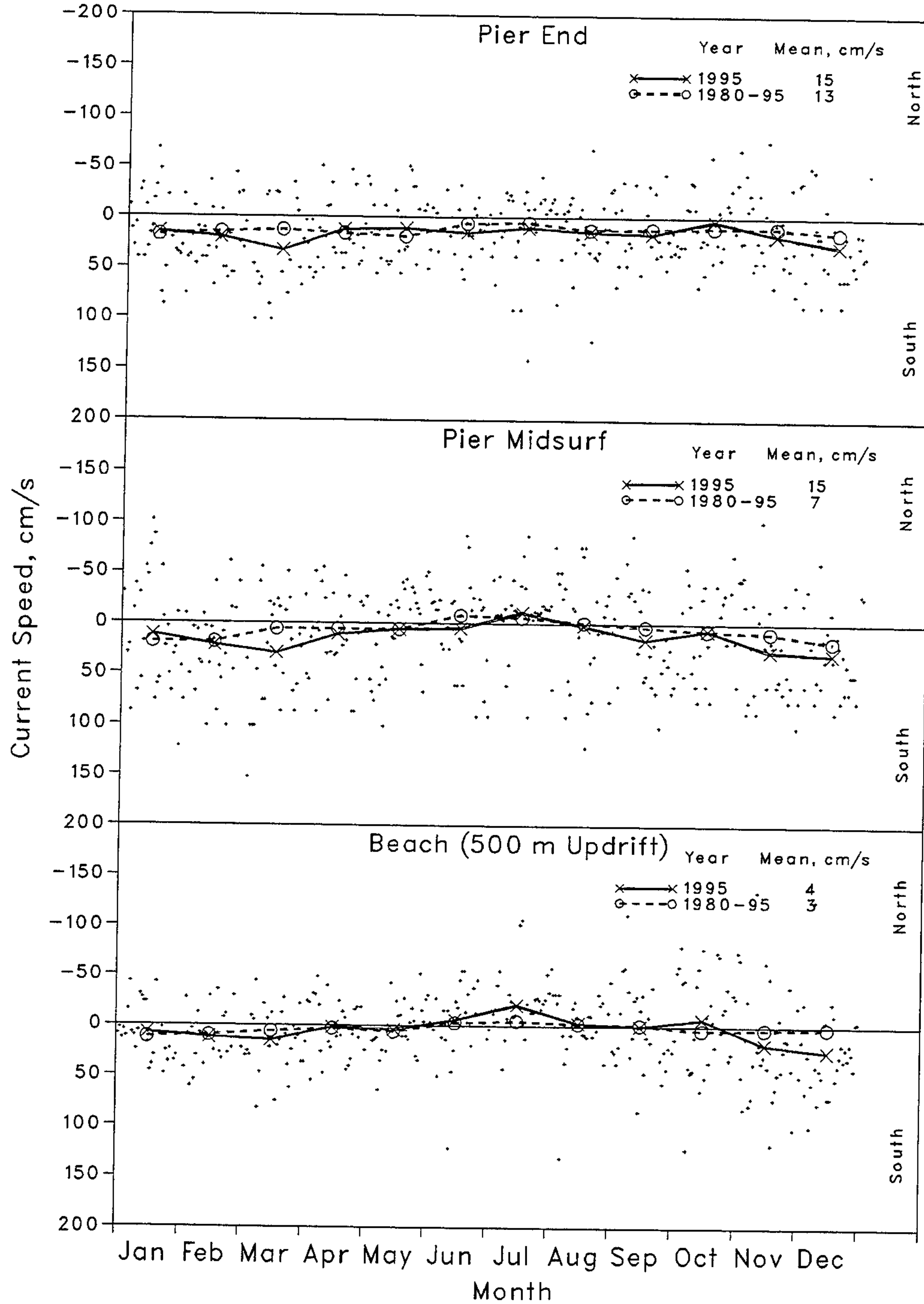

Figure 16. Daily current speeds and directions with monthly means for 1995

5 Tides and Water Levels

Measurement Instrument

From 1978 to June 1995 water level data were obtained from an NOAA/NOS control tide station (sta 865-1370) located at the seaward end of the research pier (Figure 2) by using a Leupold and Stevens, Inc. (Beaverton, OR), digital tide gauge. This analog-to-digital recorder is a float-activated, negator-spring, counterpoised instrument that mechanically converts the vertical motion of a float into a coded, punched paper tape record. The below-deck installation at pier sta 19+60 consisted of a 30.5-cm-diam stilling well with a 2.5-cm orifice and a 21.6-cm-diam float.

Operation and tending of the tide gauge conformed to NOS standards. The gauge was checked daily for proper operation of the punch mechanism and for accuracy of the time and water level information. The accuracy was determined by comparing the gauge level reading with a level read from a reference electric tape gauge. Once a week, a heavy metal rod was lowered down the stilling well and through the orifice to ensure free flow of water into the well. During the summer months, when biological growth was most severe, divers inspected and cleaned the orifice opening as required.

The tide station was inspected quarterly by an NOAA/NOS tide field group. Tide gauge elevation was checked using existing NOS control positions, and the equipment was checked and adjusted as needed. Both NOS and FRF personnel also reviewed procedures for tending the gauge and handling the data. Any specific comments on the previous months of data were discussed to ensure data accuracy.

Digital paper tape records of tide heights taken every 6 min were analyzed by the Tides Analysis Branch of NOS. An interpreter created a digital magnetic computer tape from the punch paper tape, which was then processed on a large computer. First, a listing of the instantaneous tidal height values was created for visual inspection. If errors were encountered, a computer program was used to fill in or recreate bad or missing data using correct values from the nearest

NOS tide station and accounting for known time lags and elevation anomalies. When the validity of the data had been confirmed, monthly tabulations of daily highs and lows, hourly heights (instantaneous height selected on the hour), and various extreme and/or mean water level statistics were computed.

Following a year of comparison tests at the FRF the Leupold and Stevens, Inc., digital tide gauge was replaced in June 1995 by an NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) located at pier sta 19+20.

The following brief discription of the NGWLMS was condensed from a paper found on the NOAA World Wide Web site (Gill 1990).

The NGWLMS system's primary sensor is a self-calibrating, downward-looking acoustic system that transmits a short acoustic pulse through a 1.3-cm-diameter sound tube to the water surface and to a calibration point referenced to the station's datum. Because the major potential source for errors is vertical temperature changes between the sensor and the water surface, sound tube air temperatures are monitored and accompany the transmitted data. The sensor takes 181 1-sec samples in 3-min periods centered every 6 min. A new mean value and standard deviation are computed every 6-minutes. Each NGWLMS also includes a less accurate, strain-gauge type sensor as a backup. The systems relay data every 3-hrs to NOAA's Geostationary Operational Environmental Satellite system. NOAA's NGWLMS Data Processing and Analysis System retrieves data on an hourly basis, decodes and then performs automated quality control checks.

Results

Tides at the FRF are semidiurnal with both daily high and low tides approximately equal. Tide height statistics are presented in Table 7. Figure 17 plots the monthly tide statistics for all available data, and Figure 18 compares the distribution of daily high and low water levels and hourly tide heights. The monthly or annual mean sea level (MSL) reported is the average of the hourly heights, whereas the mean tide level is midway between mean high water (MHW) and mean low water (MLW), which are the averages of the daily high- and low-water levels, respectively, relative to NGVD. Mean range (MR) is the difference between MHW and MLW levels, and the lowest water level for the month is the extreme low (EL) water, while the highest water level is the extreme high (EH) water level.

NOTE: Due to a mistake in converting feet to centimeters the tide height statistics from 1987 through 1993 (as published in the 1987 through 1993 Annual Data Summaries) found in Table 7 and Figure 17 were in error. These were corrected beginning with the 1994 report.

Table 7

Tide Height Statistics[1]

Month or Year	Mean High Water	Mean Tide Level	Mean Sea Level	Mean Low Water	Mean Range	Extreme High	Date	Extreme Low	Date
					1995				
Jan	58	6	6	-46	104	107	30	-79	7
Feb	48	-2	-2	-52	100	87	22	-83	26
Mar	64	14	14	-38	102	99	2	-60	1
Apr	57	7	7	-45	102	102	18	-66	17
May	66	17	17	-34	100	114	14	-64	30
Jun	66	16	16	-33	99	127	14	-62	12
Jul	61	11	12	-40	101	98	9	-70	30
Aug	79	28	29	-22	101	131	7	-54	5
Sep	80	30	30	-20	100	114	27	-45	1
Oct	71	19	20	-32	103	111	8	-61	25
Nov	68	16	16	-36	104	116	22	-76	24
Dec	63	13	13	-37	100	133	20	-75	22
1995	65	15	15	-36	101	133	Dec	-83	Feb
					Prior Years				
1994	62	12	12	-39	101	122	Nov	-95	Jan
1993	67	18	19	-31	98	150	Dec	-84	Nov
1992	66	17	17	-32	98	150	Dec	-84	Nov
1991	66	18	18	-31	97	150	Oct	-100	Dec
1990	59	11	11	-38	97	131	May	-94	Feb
1989	59	11	11	-37	96	239	Mar	-92	Apr
1988	55	7	7	-40	95	155	Apr	-86	Dec
1987	66	18	19	-29	95	136	Jan	-76	Nov
1986	60	13	13	-35	95	123	Dec	-108	Jan
1985	59	10	11	-37	96	136	Dec	-93	Apr
1984	64	16	16	-32	97	147	Oct	-77	Jul
1983	68	19	19	-30	98	143	Jan	-73	Mar
1982	58	8	9	-42	99	127	Oct	-108	Feb
1981	59	8	9	-42	101	149	Nov	-110	Apr
1980	59	8	8	-43	102	118	Mar	-119	Mar
1979	60	9	9	-43	103	121	Feb	-95	Sep
1979-1994	62	13	13	-36	98	239	Mar 1989	-119	Mar 1980

[1] Measurements are in centimeters.

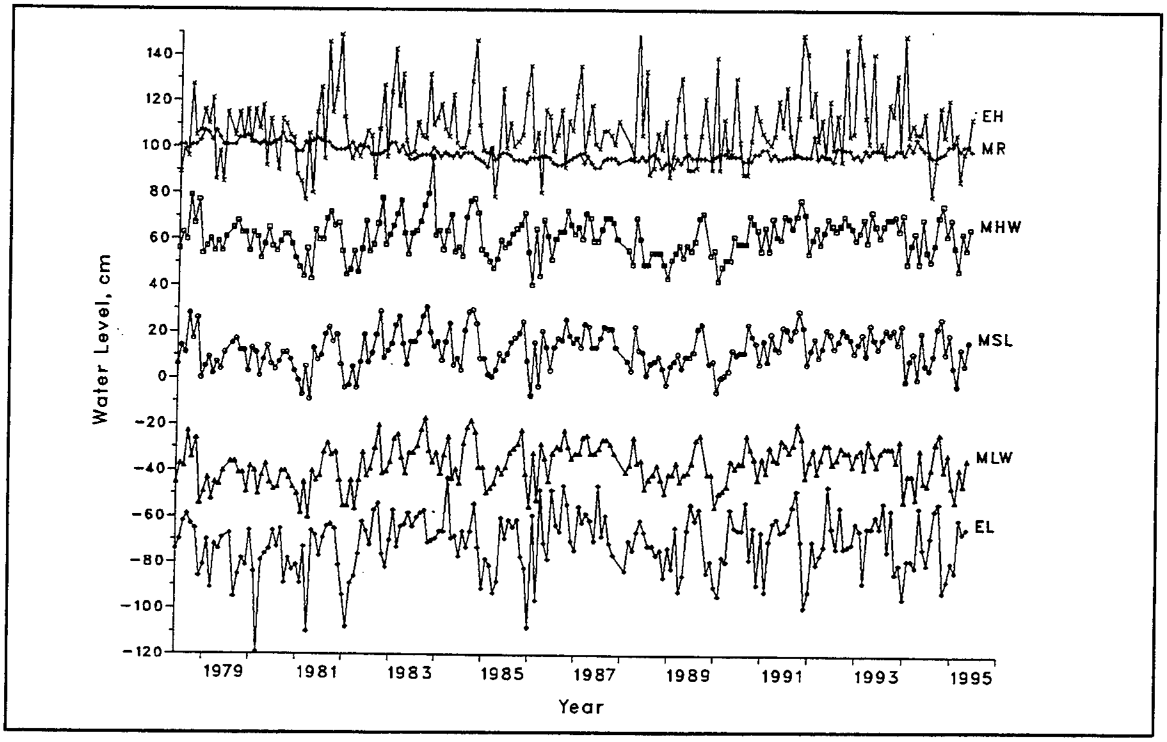

Figure 17. Monthly tide and water level statistics relative to NGVD

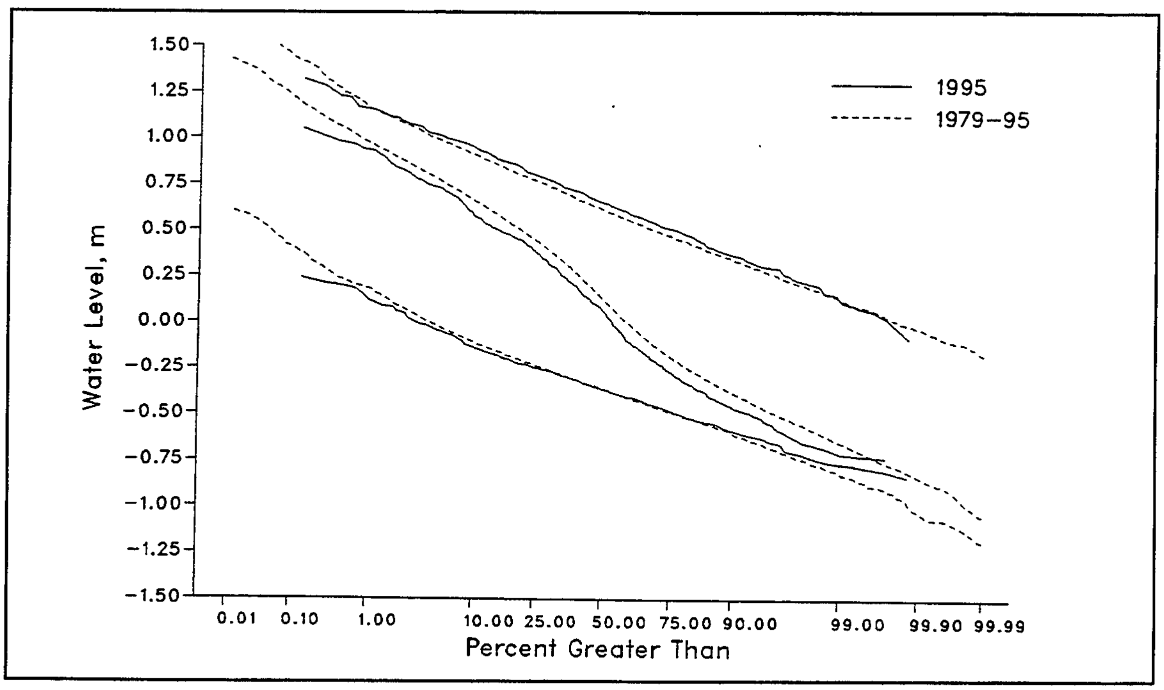

Figure 18. Distributions of hourly tide heights and high- and low-water levels

6 Water Characteristics

Monthly averages of daily measurements of surface water temperature, visibility, and density at the seaward end of the FRF pier are given in Table 8. The summaries represent single observations made near 0700 EST and, therefore, may not reflect daily average conditions since such characteristics can change within a 24-hr period. Large temperature variations were common when there were large differences between the air and water temperatures and variations in wind direction. From past experience, persistent onshore winds move warmer surface water toward the shoreline, although offshore winds cause colder bottom water to circulate shoreward, resulting in lower temperatures.

Table 8

Mean Surface Water Characteristics

	Temperature deg C		Visibility m		Density g/cm^3	
Month	1995	1980-1995	1995	1980-1995	1995	1980-1995
Jan	8.3	6.5	0.9	1.3	1.0247	1.0234
Feb	5.9	5.6	1.9	1.8	1.0251	1.0231
Mar	7.7	7.1	2.5	1.6	1.0234	1.0227
Apr	11.3	11.0	2.5	1.9	1.0243	1.0223
May	15.7	15.4	3.0	2.3	1.0233	1.0218
Jun	21.8	19.6	3.5	3.3	1.0213	1.0212
Jul	23.0	21.9	4.1	3.8	1.0226	1.0215
Aug	23.8	23.4	1.6	3.1	1.0224	1.0207
Sep	24.0	23.1	1.1	2.2	1.0214	1.0209
Oct	21.6	19.4	0.9	1.4	1.0234	1.0219
Nov	14.9	14.9	1.1	1.1	1.0246	1.0230
Dec	8.5	10.0	1.0	1.1	1.0248	1.0235
Annual	15.6	14.8	2.0	2.1	1.0234	1.0221

Temperature

Daily sea surface water temperatures (Figure 19) were measured with an NOS water sampler and thermometer. Monthly mean water temperatures (Table 8) varied with the air temperatures (see Table 2).

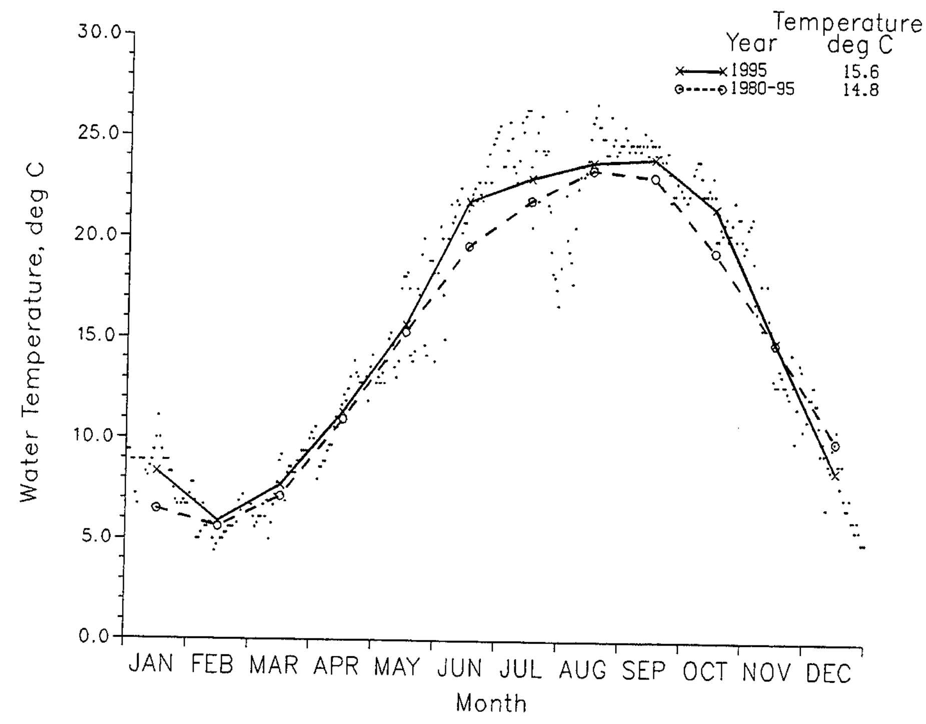

Figure 19. Daily water temperature values with monthly means

Visibility

Visibility in coastal nearshore waters depends on the amount of salts, soluble organic material, detritus, living organisms, and inorganic particles in the water. These dissolved and suspended materials change the absorption and attenuation characteristics of the water that vary daily and yearly.

Visibility was measured with a 0.3-m-diam Secchi disk, and similar to water temperature, variation was related to onshore and offshore winds. Onshore winds moved warm clear surface water toward shore, whereas offshore winds brought up colder bottom water with large concentrations of suspended matter. Figure 20 shows the daily and monthly mean surface visibility values for the year. Large variations were common, and visibility less than 1 m was expected in any month. Monthly means are given inTable 8.

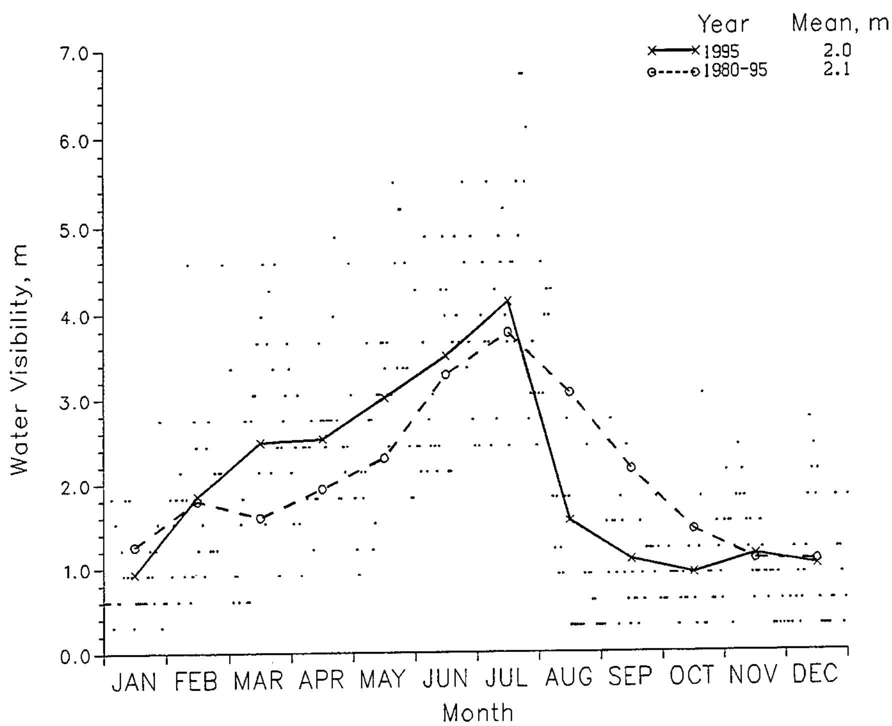

Figure 20. Daily water visibility values with monthly means

Density

Daily and monthly mean surface density values, plotted in Figure 21, were measured with a hydrometer. Monthly means are also given in Table 8. These values are direct readings from the hydrometer. Corrections for differences between ocean water temperature and jar water temperature, as well as use of uncalibrated hydrometers and other factors, could produce an error amounting to a couple of percent in the direct hydrometer readings.

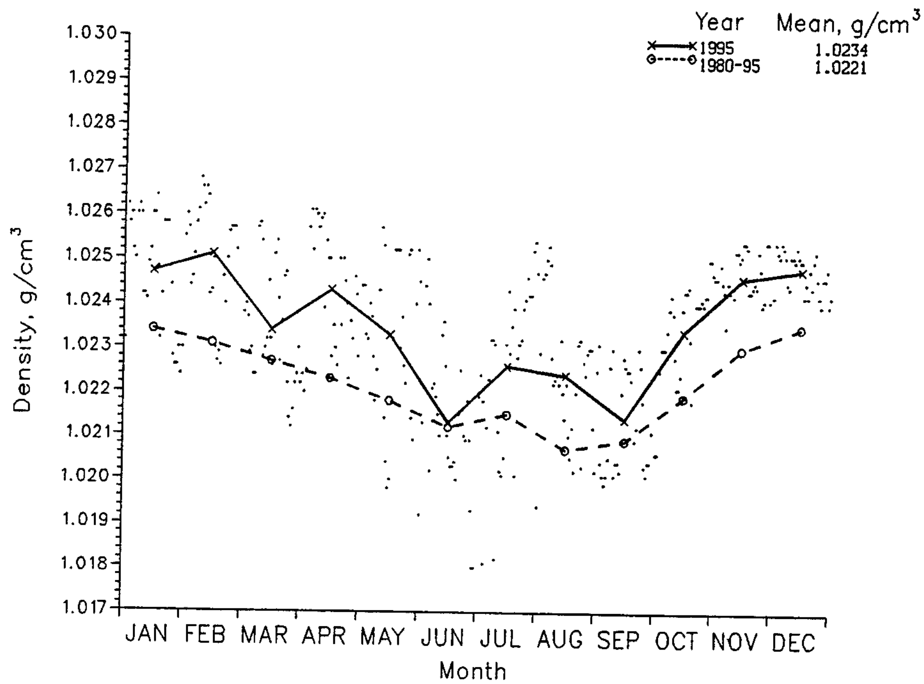

Figure 21. Daily water density values with monthly means

7 Surveys

Waves and currents interacting with bottom sediments produce changes in the beach and nearshore bathymetry. These changes can occur very rapidly in response to storms, or slowly as a result of persistent but less forceful seasonal variations in wave and current conditions.

Nearshore bathymetry at the FRF is characterized by regular shore-parallel contours, a moderate slope, and a barred surf zone (usually an outer storm bar in water depths of about 4.5 m and an inner bar in water depths between 1.0 and 2.0 m). This pattern is interrupted in the immediate vicinity of the pier where a permanent trough runs under much of the pier, ending in a scour hole where depths can be up to 3.0 m greater than the adjacent bottom (Figure 22). This trough, which apparently is the result of the interaction of waves and currents with the pilings, varies in shape and depth with changing wave and current conditions.

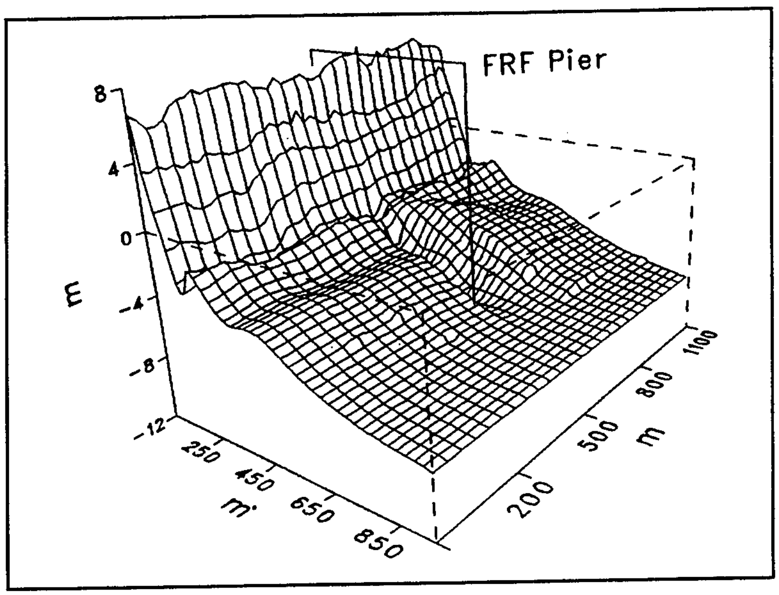

Figure 22. Permanent trough under the FRF pier, 25 January 1995

The effect of the pier on shore-parallel contours occurs as far as 300 m away, and the shoreline may be affected up to 350 m from the pier (Miller, Birkemeier, and DeWall 1983).

Approximately once a month, surveys were conducted of an area extending 600 m north and south of the pier and approximately 950 m offshore. These surveys were conducted to document the temporal and spatial variability in bathymetry. Contour maps resulting from these surveys, along with plots of change in elevation between surveys, are given in Appendix A.

All surveys used the Coastal Research Amphibious Buggy, a 10.7-m-tall amphibious tripod described by Birkemeier and Mason (1984), in combination with a Geodimeter 140-T self-tracking, electronic theodolite, distance meter. Profile locations are shown in each figure in Appendix A. Monthly soundings along both sides of the FRF pier were collected by lowering a weighted measuring tape to the bottom and recording the distance below the pier deck. Soundings were taken midway between the pier pilings to minimize errors caused by scour near the pilings.

A history of bottom elevations below Gauges 645 and 625 is presented in Figure 23 for pier stations 7+80 (238 m) and 18+60 (567 m), along with intermediate locations, 323 and 433 m.

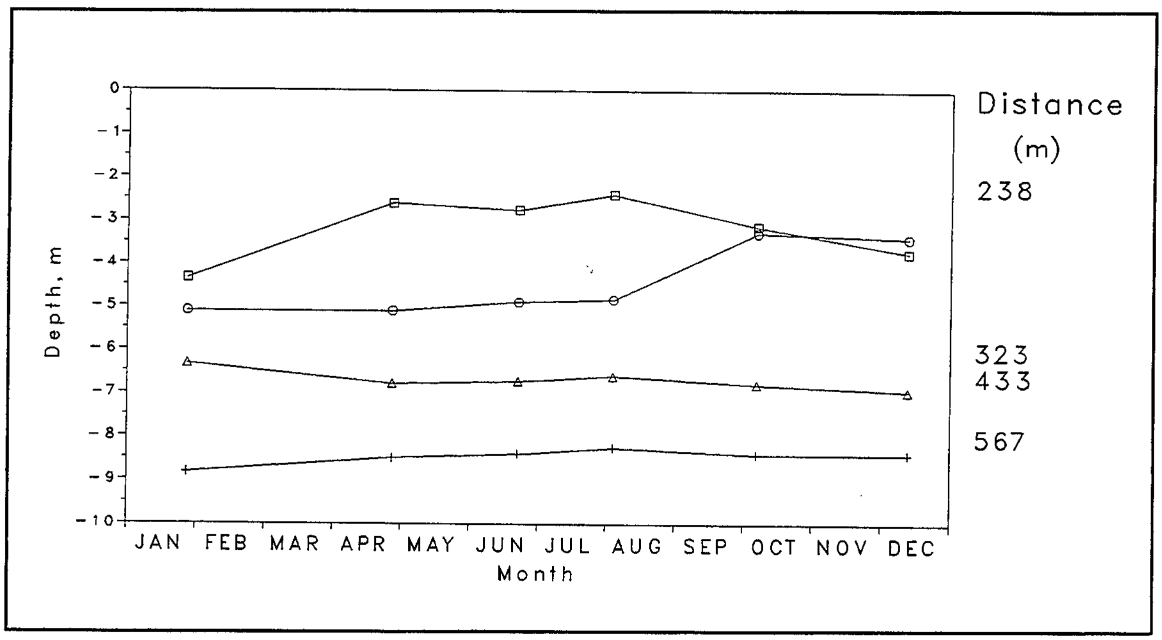

Figure 23. Time-history of bottom elevations at selected locations under the FRF pier

8 Photography

Aerial Photographs

Aerial photographs are taken annually using a 23-cm aerial mapping camera at a scale of 1:12,000. All coverage was at least 60-percent overlap, with flights flown as closely as possible to low tide between 1000 and 1400 EST with less than 10-percent cloud cover. The flight lines covered are shown in Figure 24. Figure 25 is a sample of the imagery obtained on 14 January 1991; the available aerial photographs for the year are:

Date	Flight Lines	Format
18 October	1	Black/White
	2	Color

Beach Photographs

Daily color slides of the beach were taken using a 35-mm camera from the same location on the pier looking north and south (Figure 26). The location from which each picture was taken, as well as the date, time, and a brief description of the picture, were marked on each of the slides.

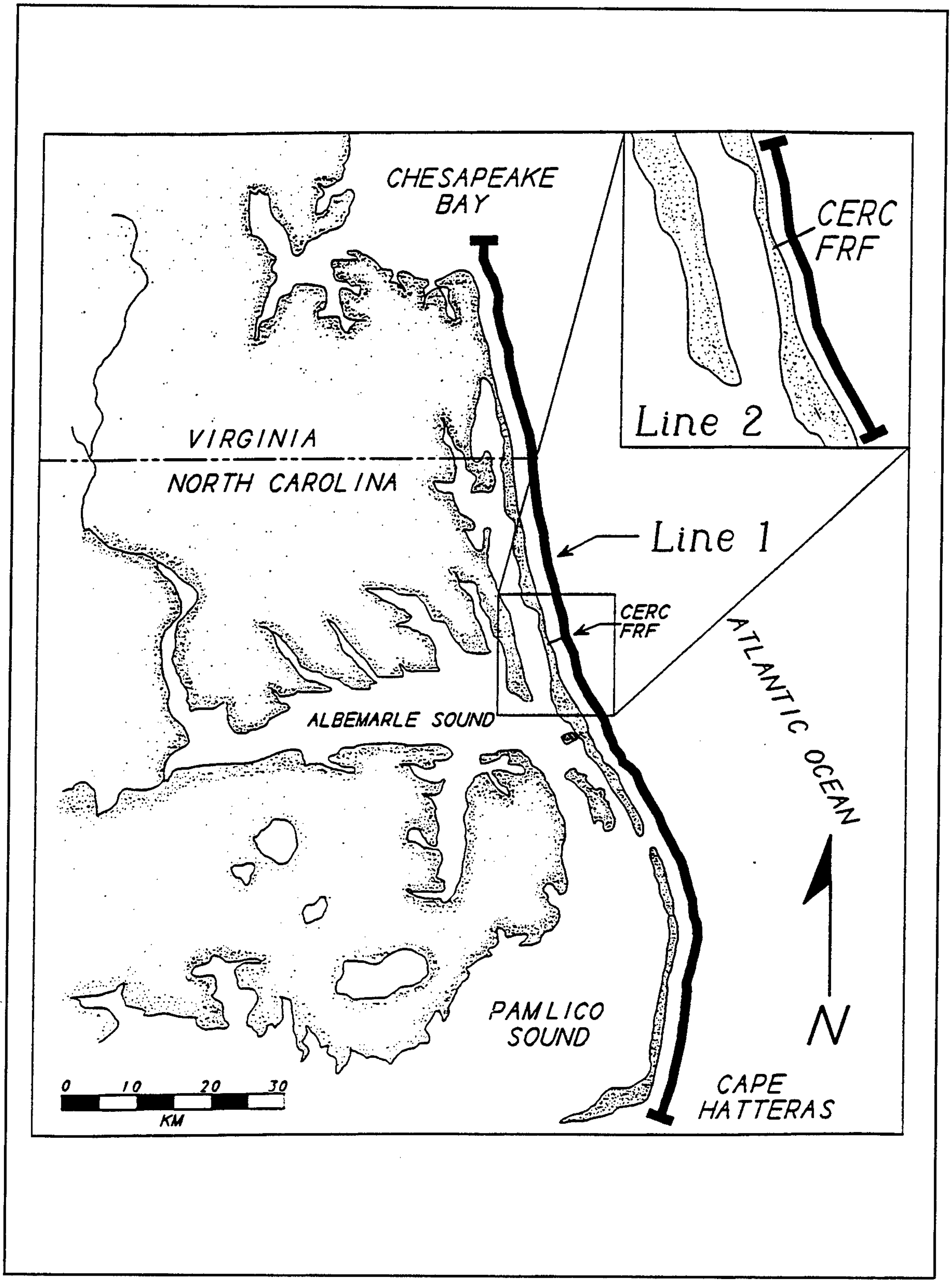

Figure 24. Aerial photography flight lines

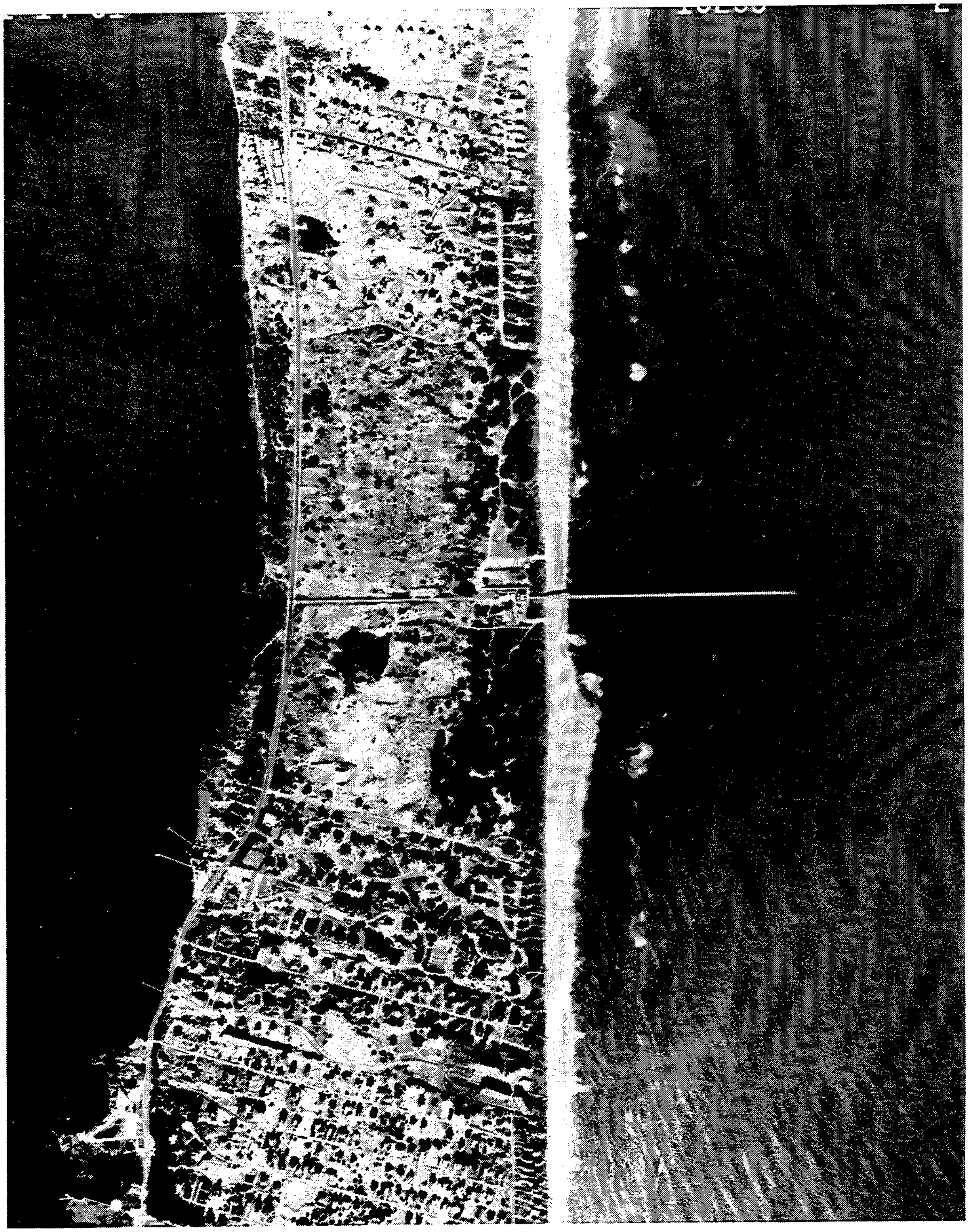

Figure 25. Sample aerial photograph, 14 January 1991 (Scale = 1:12,000)

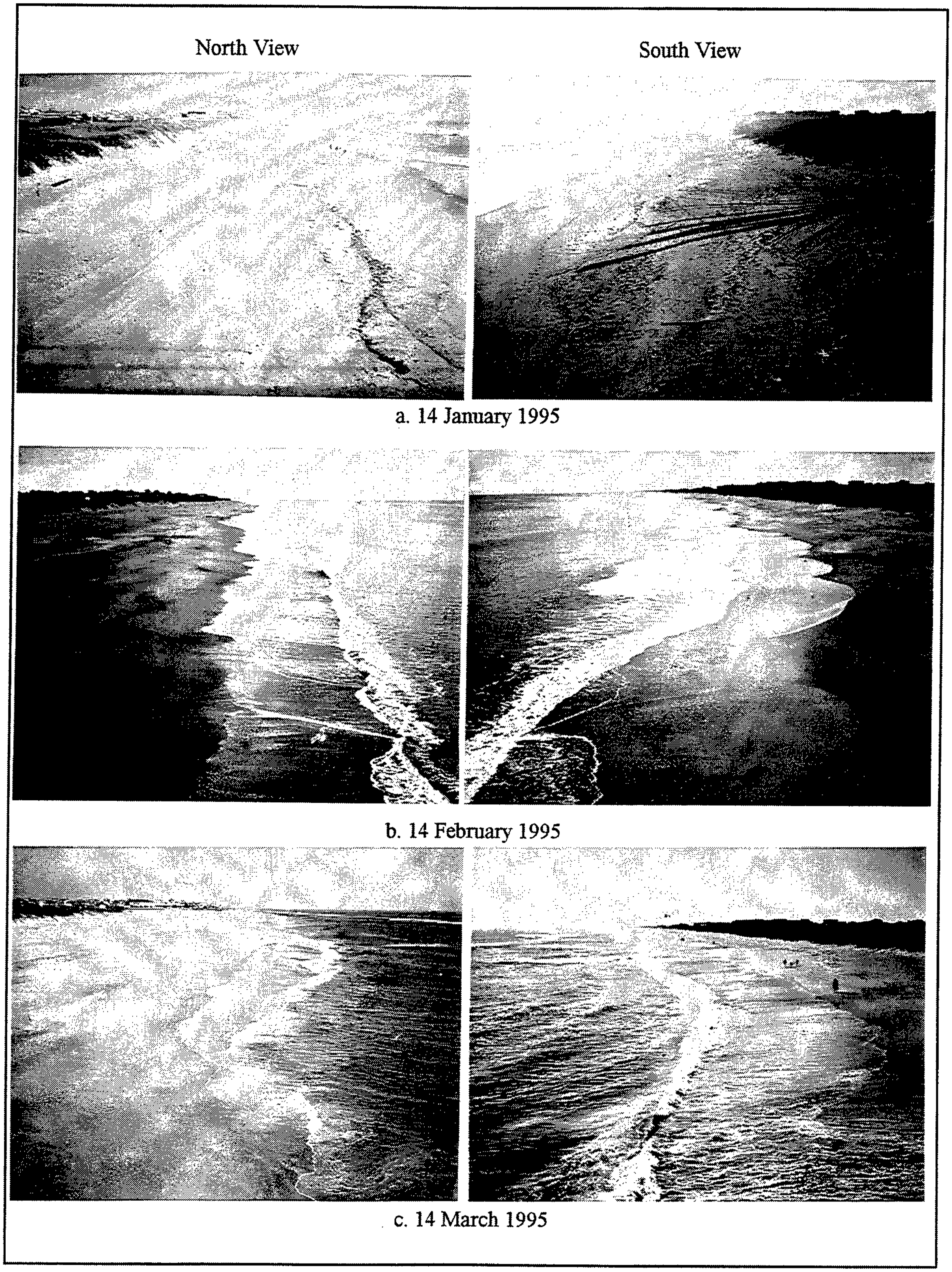

Figure 26. Beach photos looking north and south from the FRF pier (Sheet 1 of 4)

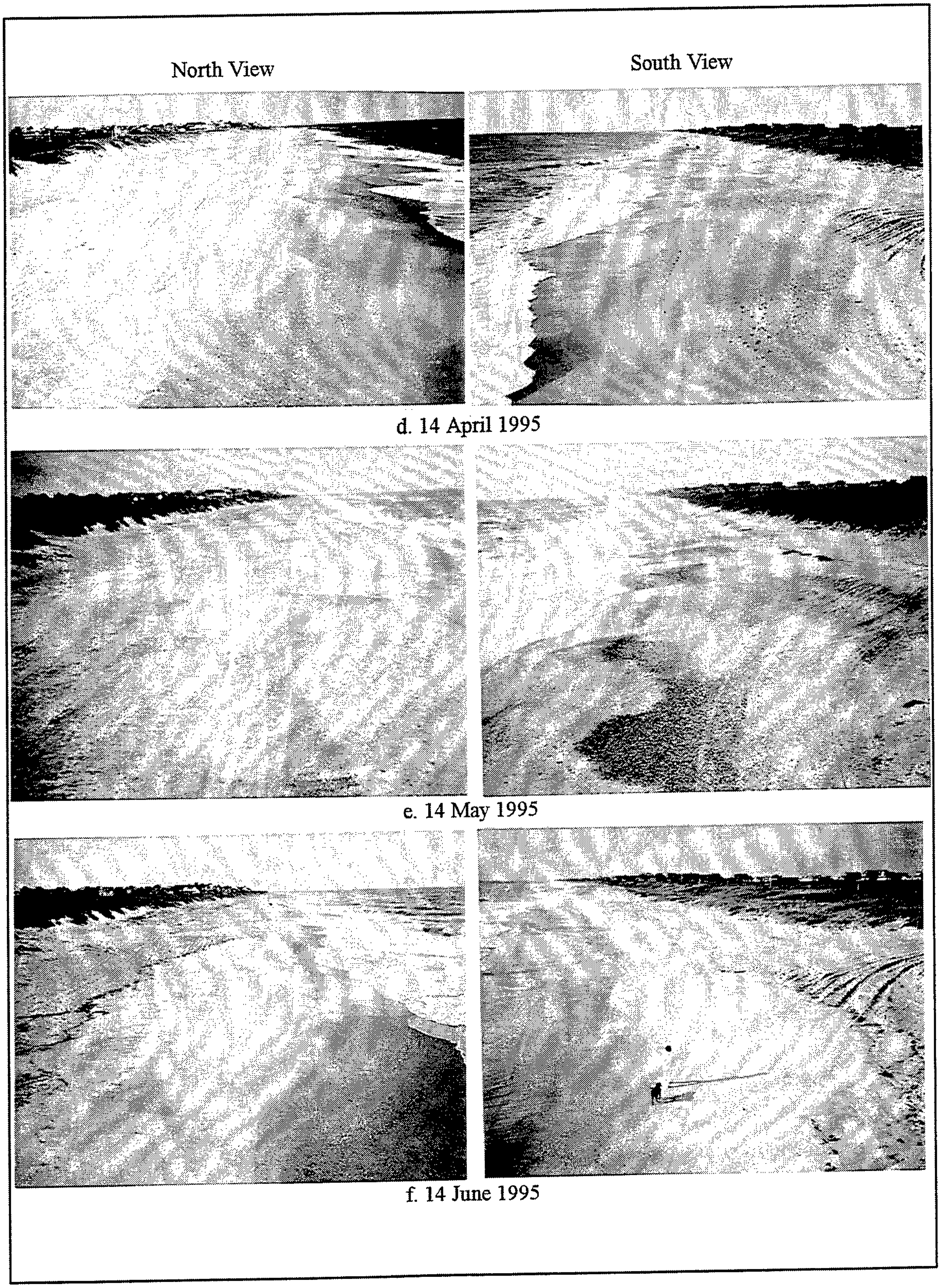

Figure 26. (Sheet 2 of 4)

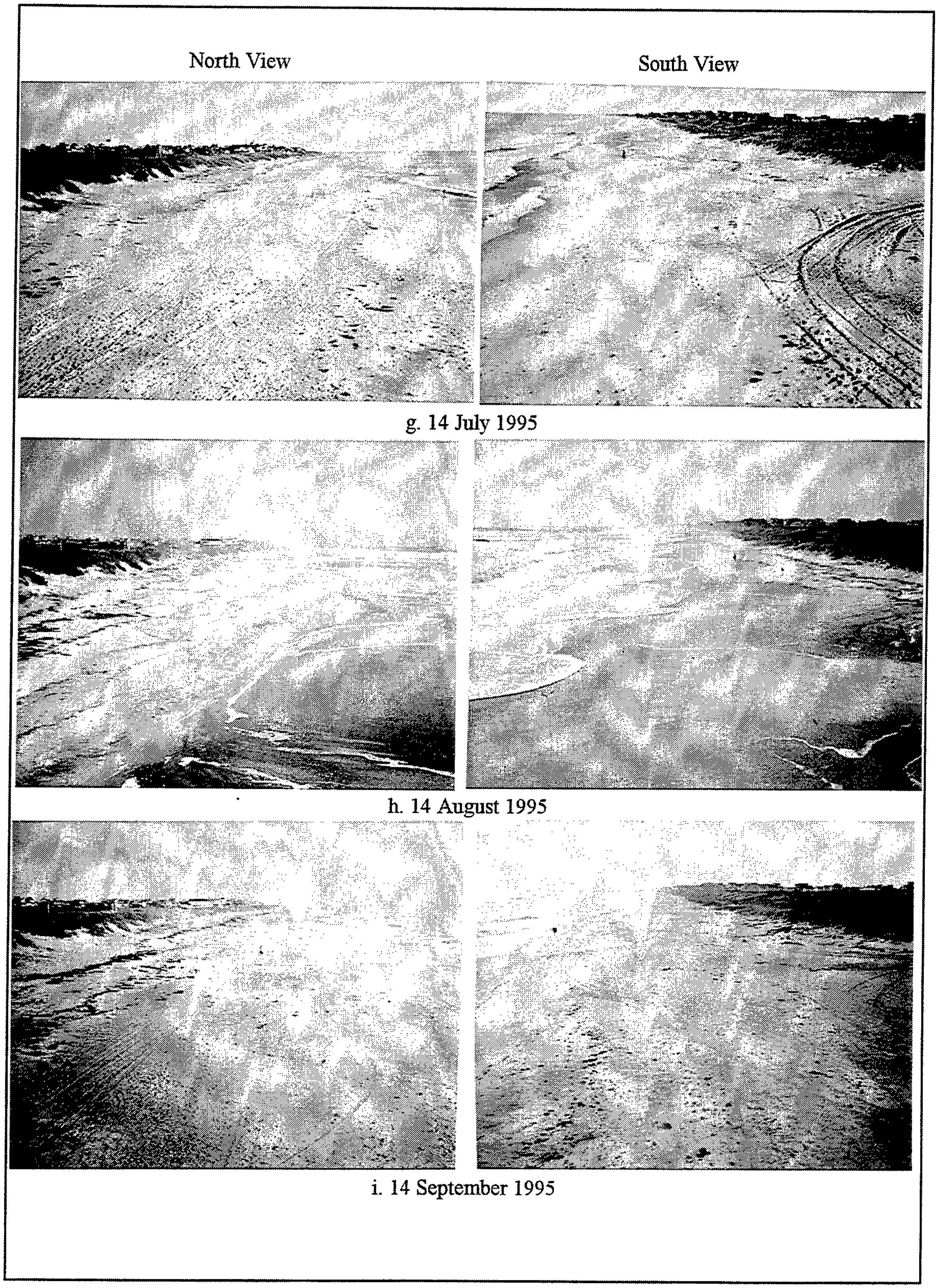

Figure 26. (Sheet 3 of 4)

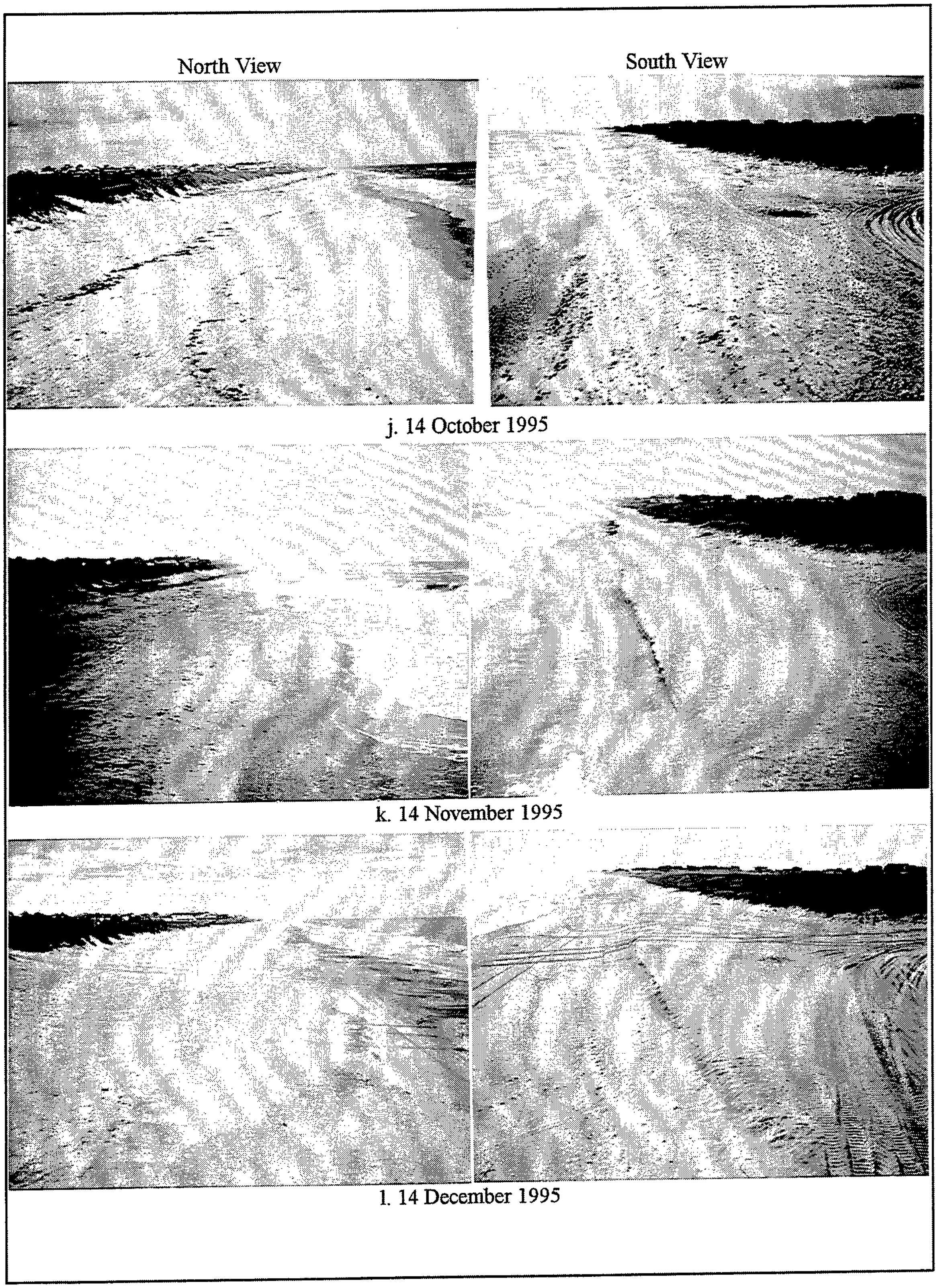

Figure 26. (Sheet 4 of 4)

9 Storms

This chapter discusses storms (defined here as times when the wave height parameter H_{mo} equaled or exceeded 2 m at the seaward end of the FRF pier). Sample spectra from Gauge 630 are given in Appendix B. Prestorm and/or poststorm bathymetry diagrams are given in Appendix A. Tracking information was provided by NOAA Daily Weather Maps (U.S. Department of Commerce 1995).

15-16 January 1995 (Figure 27)

Following the passage of a cold front, onshore winds (from northeast) generated by a high pressure system reached 15 m/sec at 1216 EST on 15 January. The maximum H_{mo} (at Gauge 630) reached 3.2 m (T_p = 11.10 sec) at 1634 EST also on 15 January. There was 41 mm of precipitation.

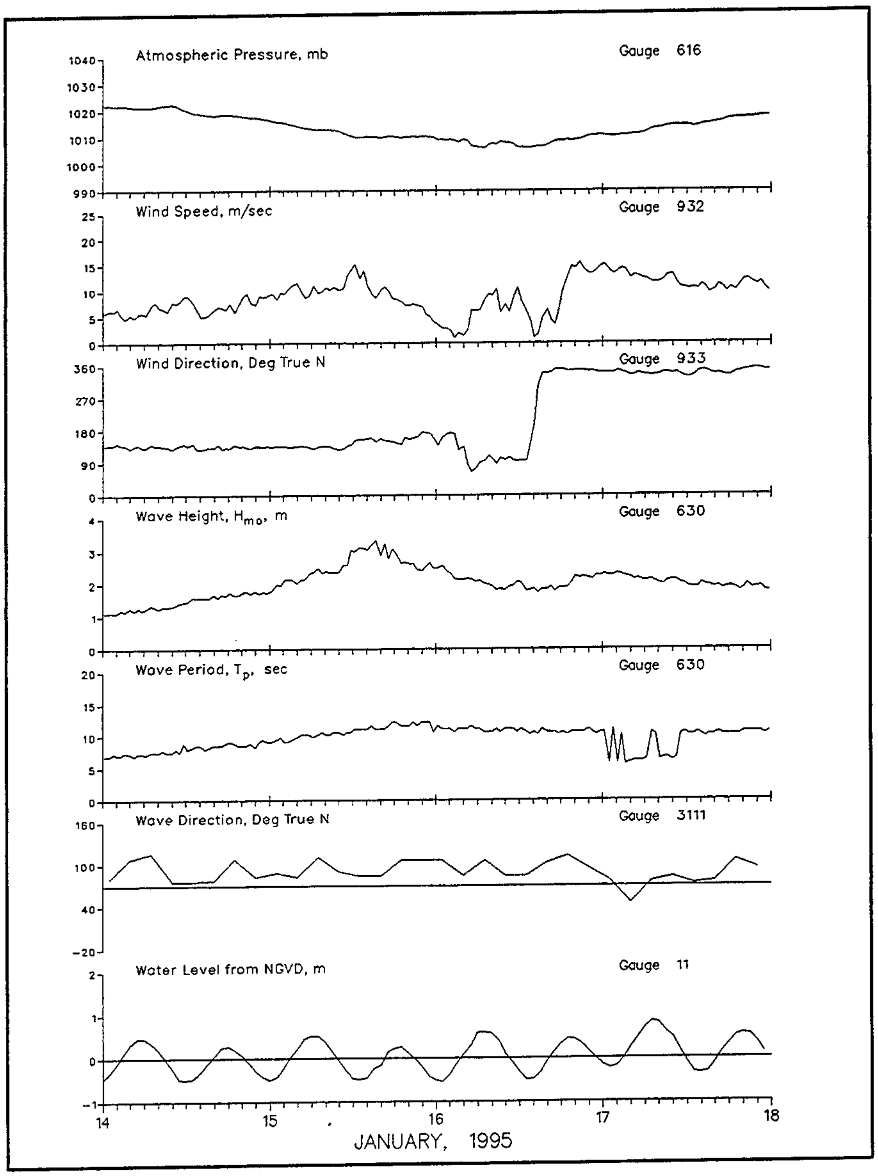

Figure 27. Data for 15-16 January 1995 storm

28-29 January 1995 (Figure 28)

A strong Canadian high pressure system in conjunction with an approaching storm produced onshore winds at the FRF beginning on 28 January. As the storm moved off the North Carolina coast it quickly intensified generating winds (from northeast) of 13 m/sec at 0208 EST on 29 January. Waves at Gauge 625 reached a maximum H_{mo} of 2.10 m (T_p = 7.3 sec) at 0208 EST also on 29 January. There was 5 mm of precipitation.

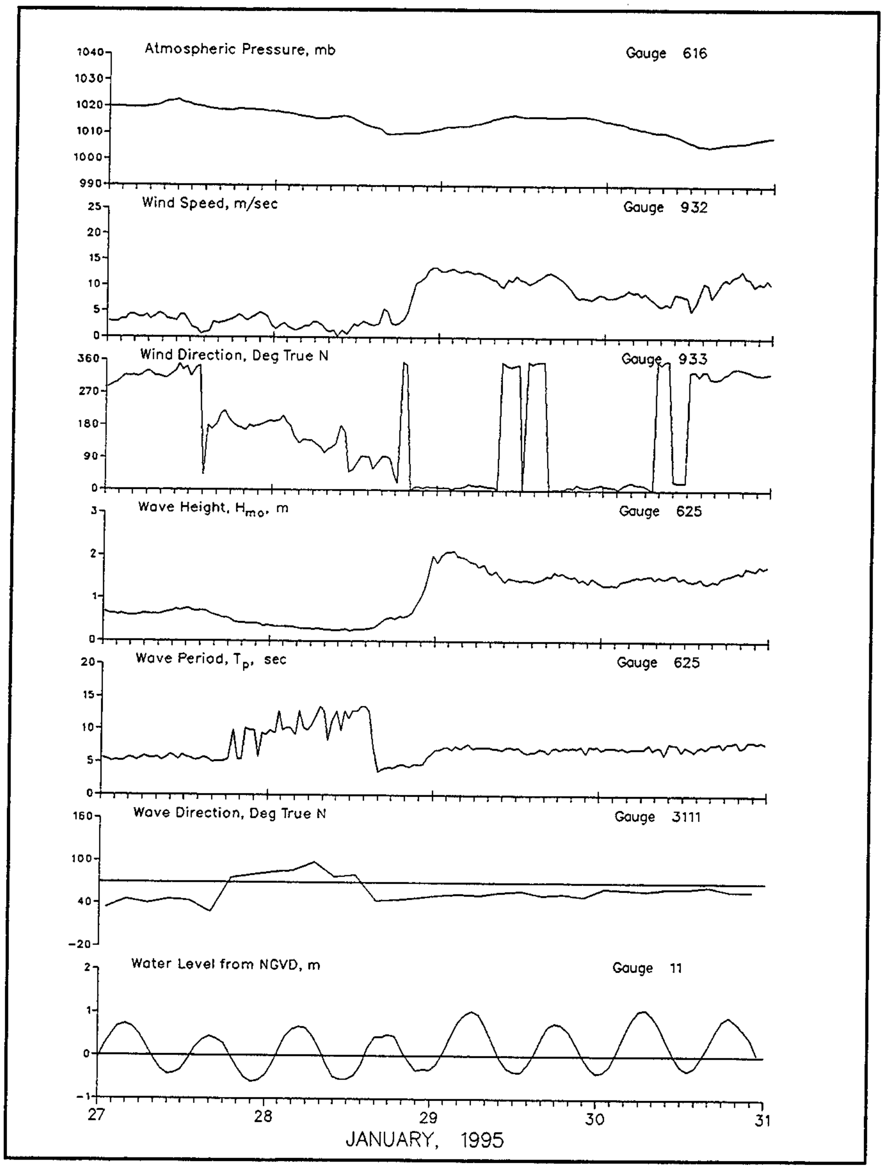

Figure 28. Data for 28-29 January 1995 storm

2 March 1995 (Figure 29)

Northerly winds funneled between a Canadian high pressure system and a small low pressure system located offshore of Cape Hatteras, NC, briefly generated storm waves at the FRF. Waves at Gauge 625 reached a maximum H_{mo} of 2.3 m (T_p = 9.8 sec) at 1142 EST on 2 March. Onshore winds (from the north) peaked at 16 m/sec at 0842 EST also on 2 March. The FRF received 13 mm of precipitation from this storm.

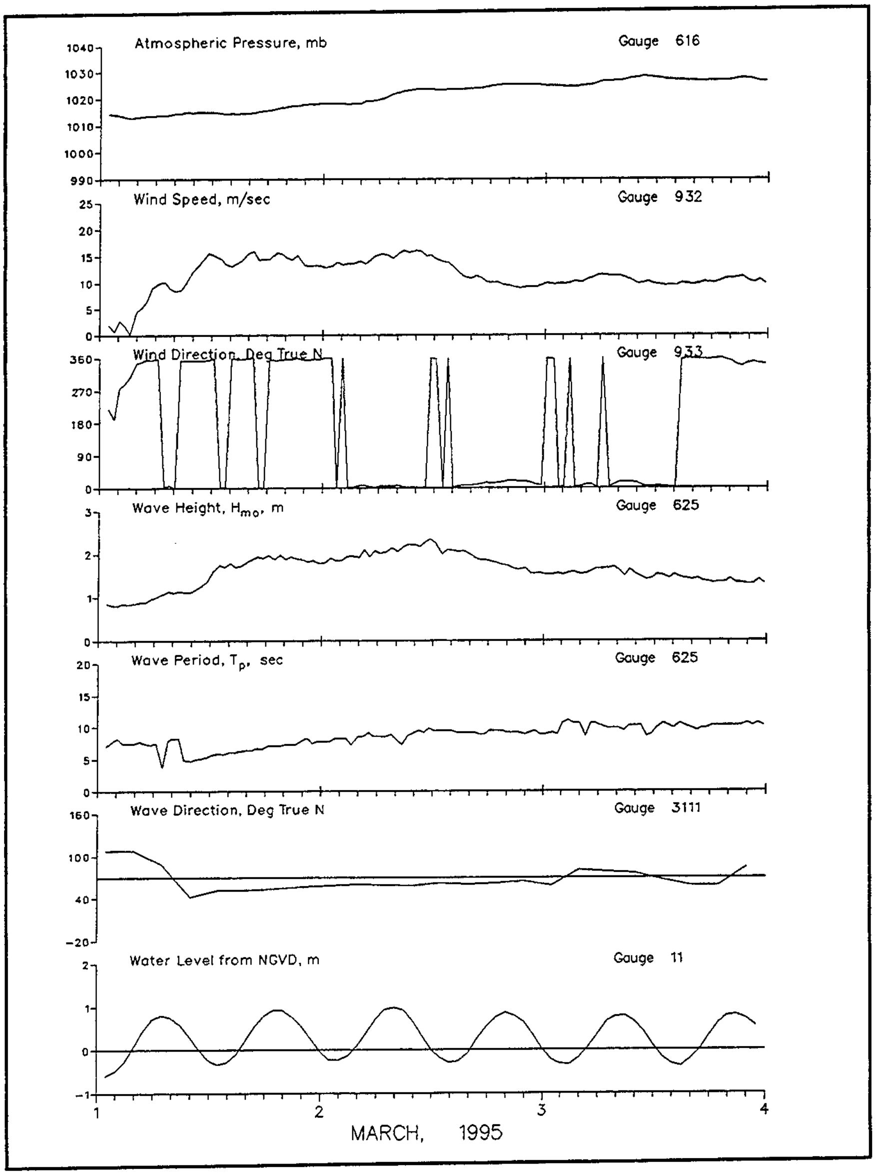

Figure 29. Data for 2 March 1995 storm

7-8 August 1995 (Figure 30)

A strong pressure gradient created by a Canadian high pressure system and a weak storm off Cape Hatteras, NC produced northeasterly winds of 10 m/sec, which peaked at 0400 EST on 8 August. The maximum H_{mo} (at Gauge 625) of 2.3 m (T_p = 10.2 sec) was recorded at 2116 EST on 7 August. There was 25 mm of precipitation at the FRF.

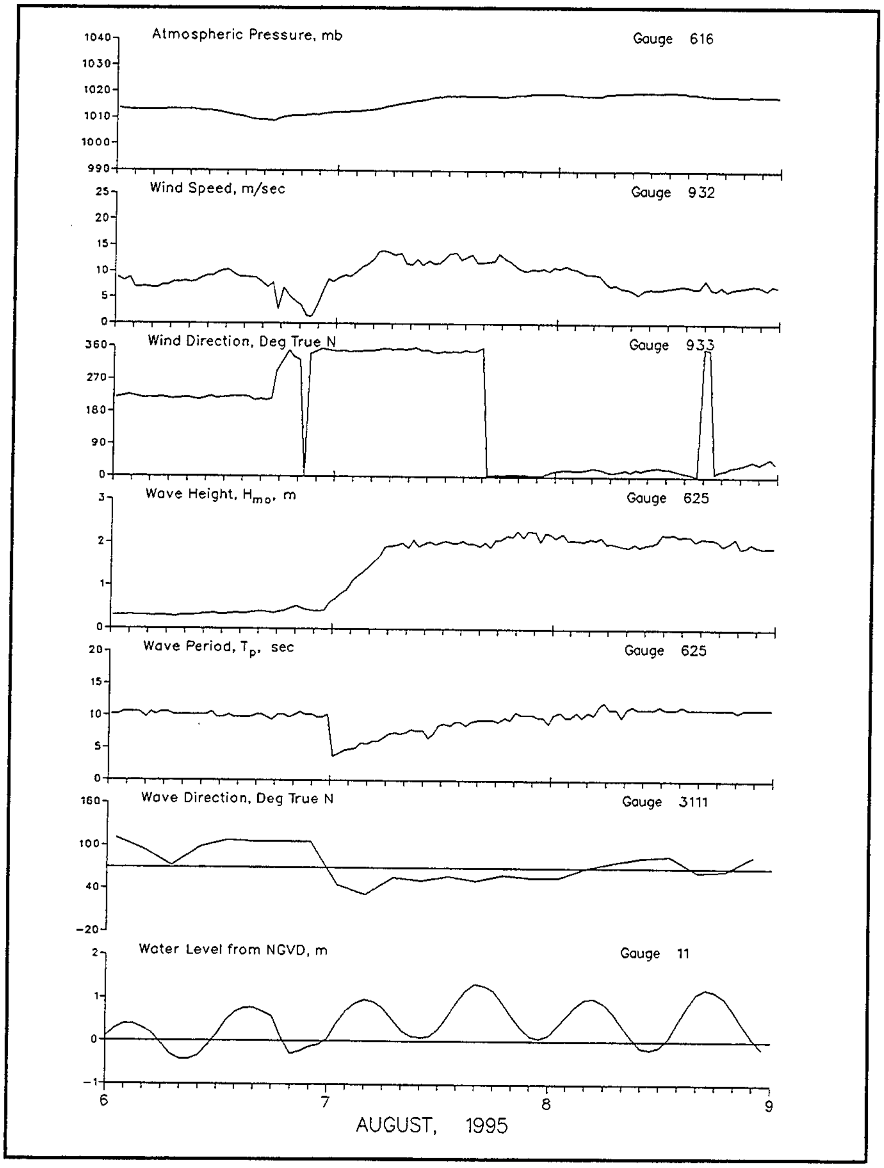

Figure 30. Data for 7-8 August 1995 storm

15-18 August 1995-Hurricane Felix (Figure 31)

Developing in the mid-Atlantic, Felix moved northwest then turned to the west on 15 August steering directly for the North Carolina coast. Downgraded from a category 3 to a 1 (on the Saffir/Simpson Scale) Felix stalled when he collided with a trough of low pressure entrenched along the East coast, then moved offshore, never making landfall. Maximum onshore winds (from northeast) at the FRF reached 17 m/sec at 1816 EST on 16 August. The maximum H_{mo} (at Gauge 630) of 4.6 m (T_p = 15.1 sec) was measured earlier that morning at 0208 EST. There was 6 mm of precipitation.

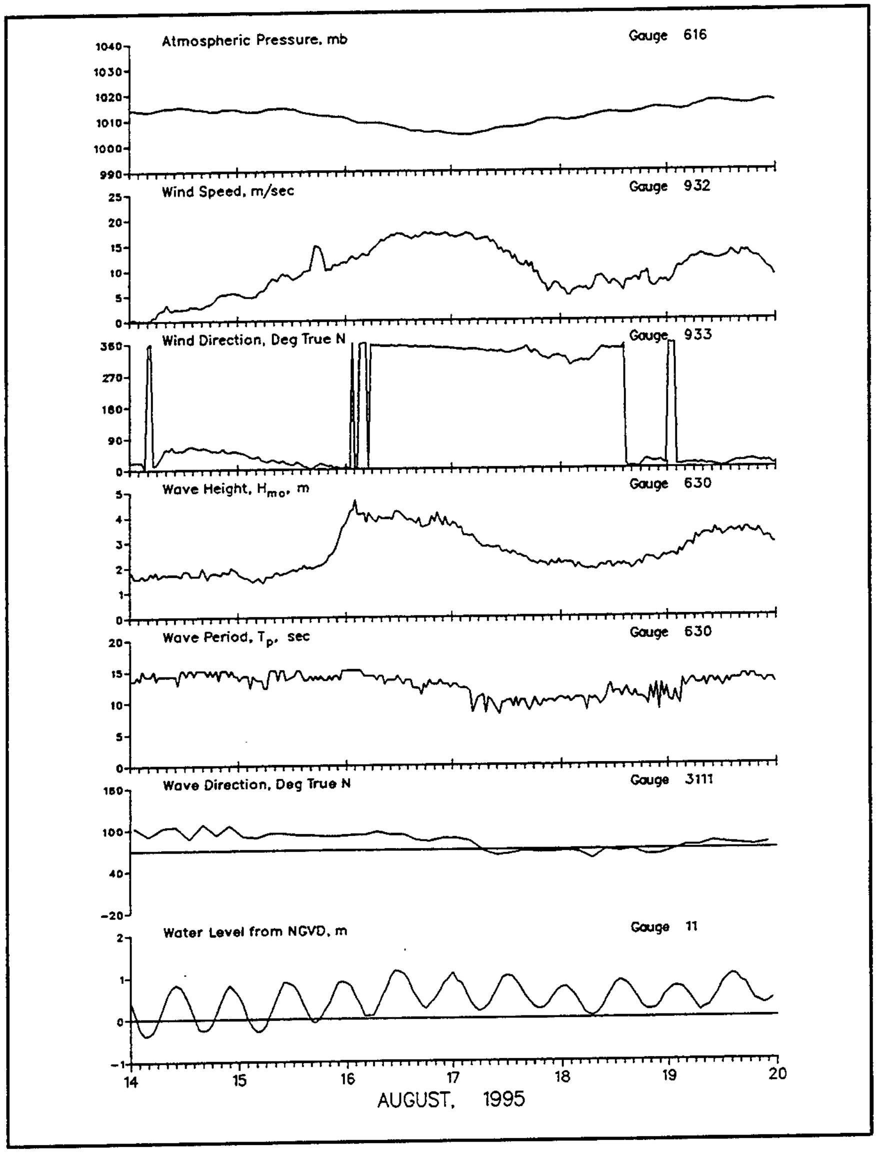

Figure 31. Data for Hurricane Felix, 15-18 August 1995

18-20 August 1995 (Figure 32)

Strong winds associated with the interaction of a Canadian high pressure system with the remnants of Hurricane Felix reached 14 m/sec (from northeast) at 1742 EST on 19 August. The maximum H_{mo} (at Gauge 630) reached 3.5 m (T_p = 14.2 sec) at 1708 EST on 19 August. There was no precipitation.

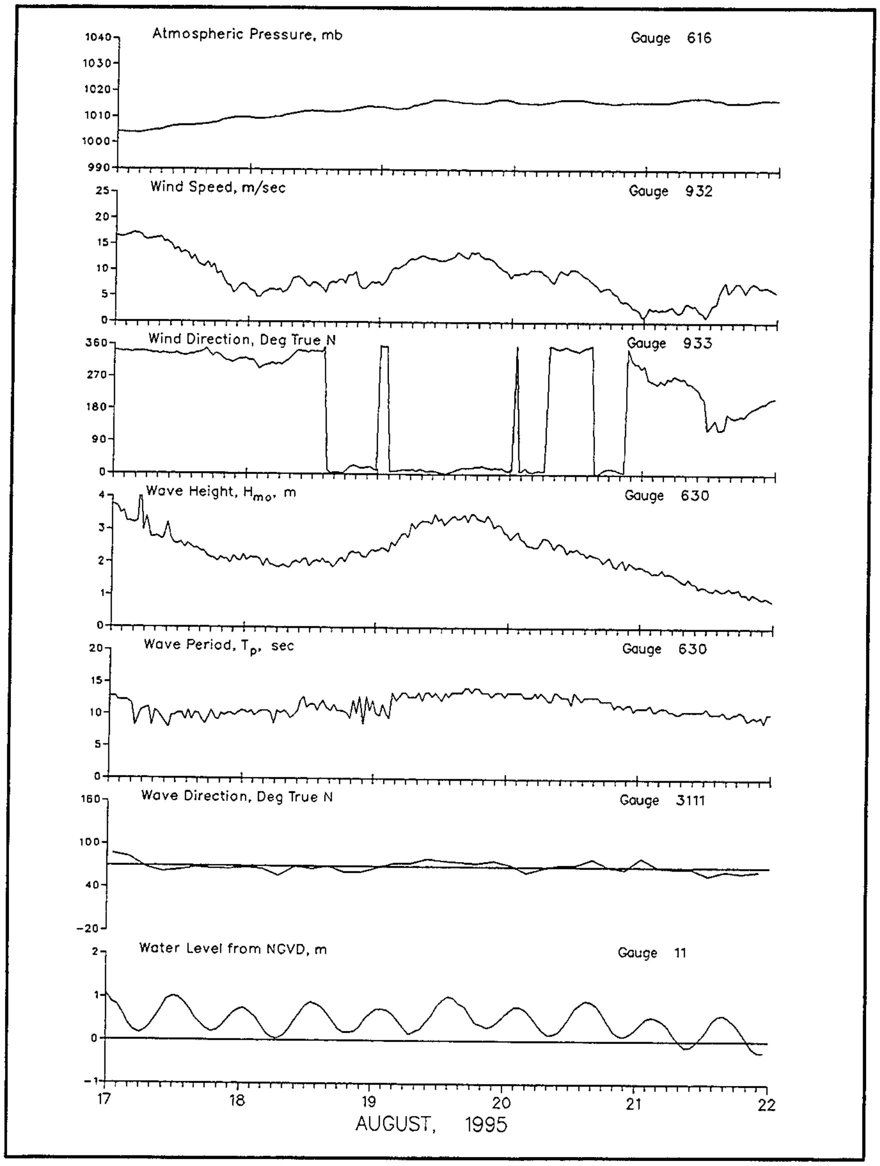

Figure 32. Data for 18-20 August 1995 storm

28 August 1995 (Figure 33)

A combination of a Canadian high pressure system and a low off the North Carolina coast produced onshore winds (from northeast) of 15 m/sec at 1934 EST on 28 August. The maximum H_{mo} (at Gauge 625) reached 2.2 m (T_p = 6.6 sec) at 1900 EST also on 28 August. There was 22 mm of precipitation.

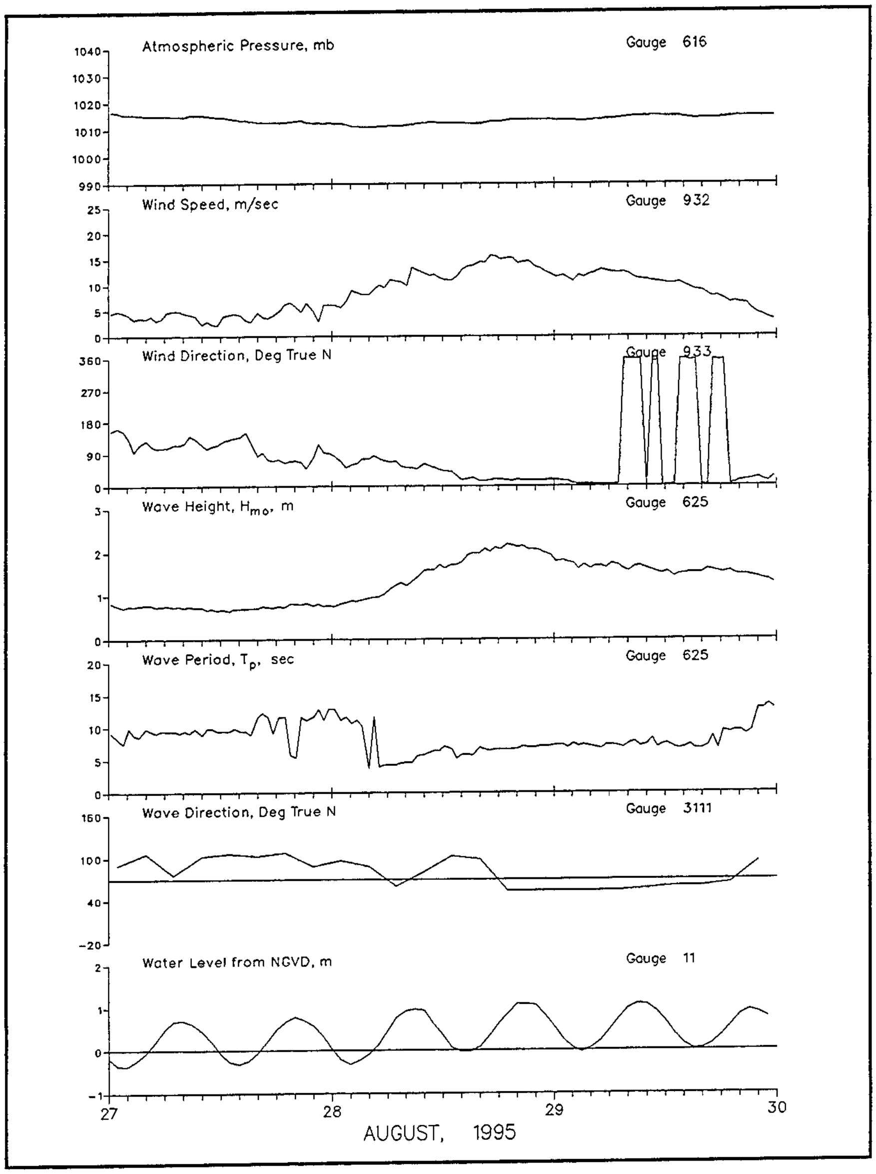

Figure 33. Data for 28 August 1995 storm

19 September 1995 (Figure 34)

Northeasterly winds associated with a Canadian high pressure system reached 13 m/sec at 1034 EST on 19 September. The maximum H_{mo} (at Gauge 625) of 2.1 m (T_p = 8.26 sec) followed at 1108 EST. There was no precipitation during this event.

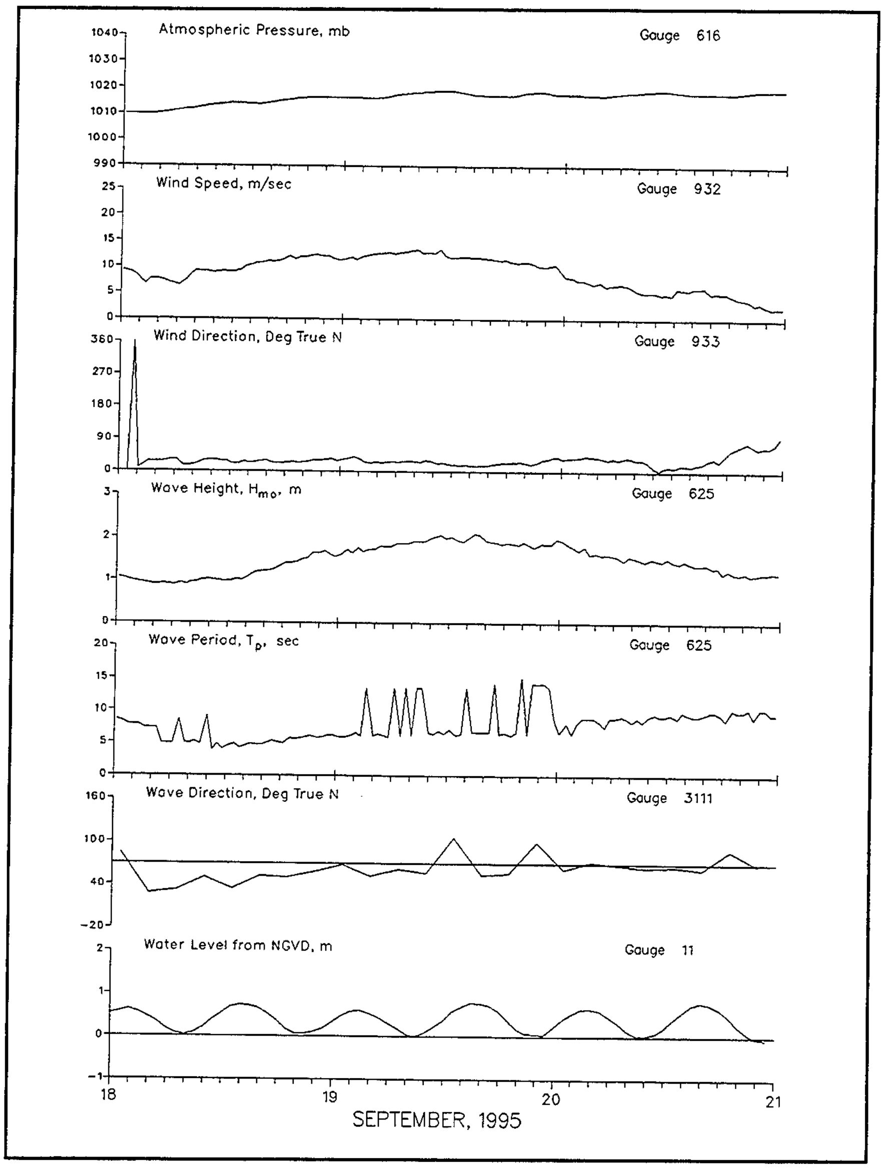

Figure 34. Data for 19 September 1995 storm

23 September 1995 (Figure 35)

Strong onshore winds were generated at the FRF preceding an advancing warm front. The maximum H_{mo} (at Gauge 625) of 2.1 m (T_p = 6.9 sec) was attained at 1000 EST on 23 September. Maximum winds (from the northeast) reached 15 m/sec earlier at 0916 EST. There was no precipitation.

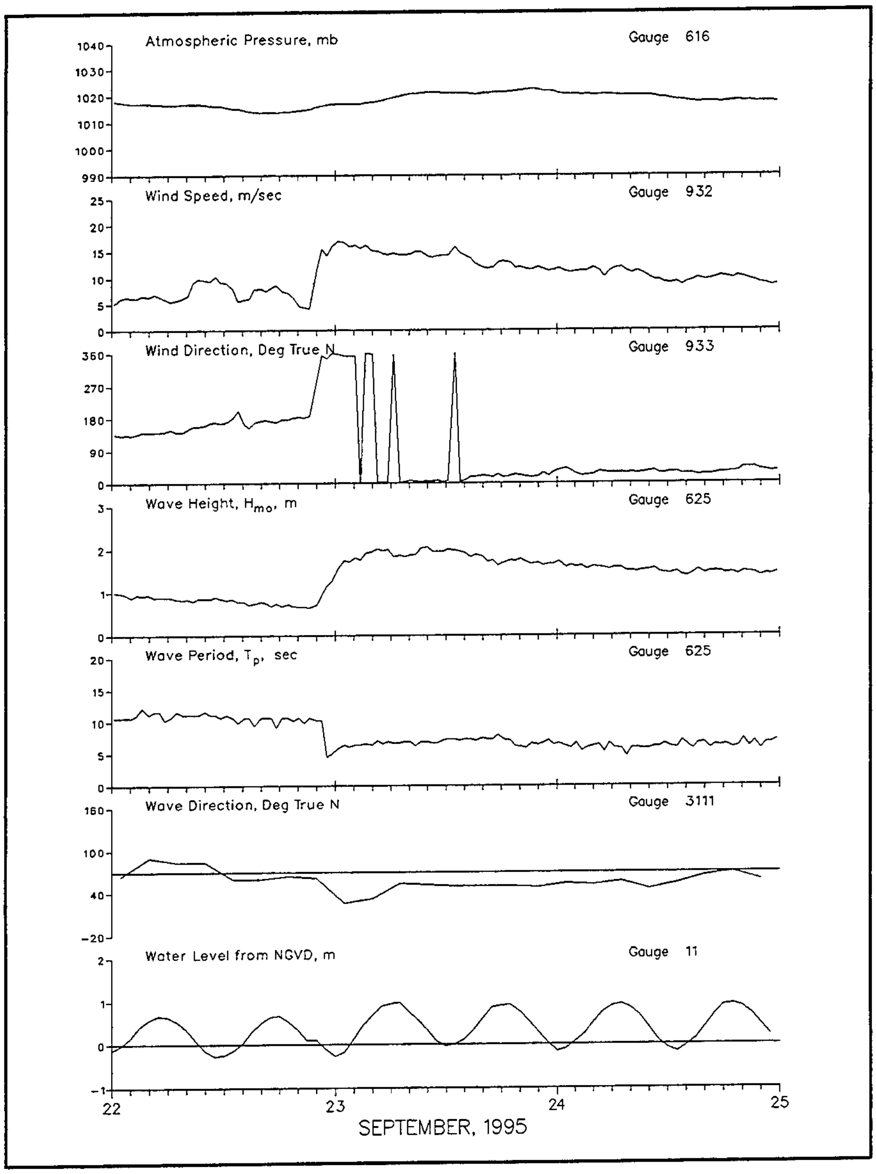

Figure 35. Data for 23 September 1995 storm

29-30 September 1995 (Figure 36)

Northeasterly winds associated with a Canadian high pressure system reached 13 m/sec at 0434 EST on 30 September. The maximum H_{mo} (at Gauge 625) was 2.1 m (T_p = 9.5 sec) at 0542 also on 30 September. There was 3 mm of precipitation.

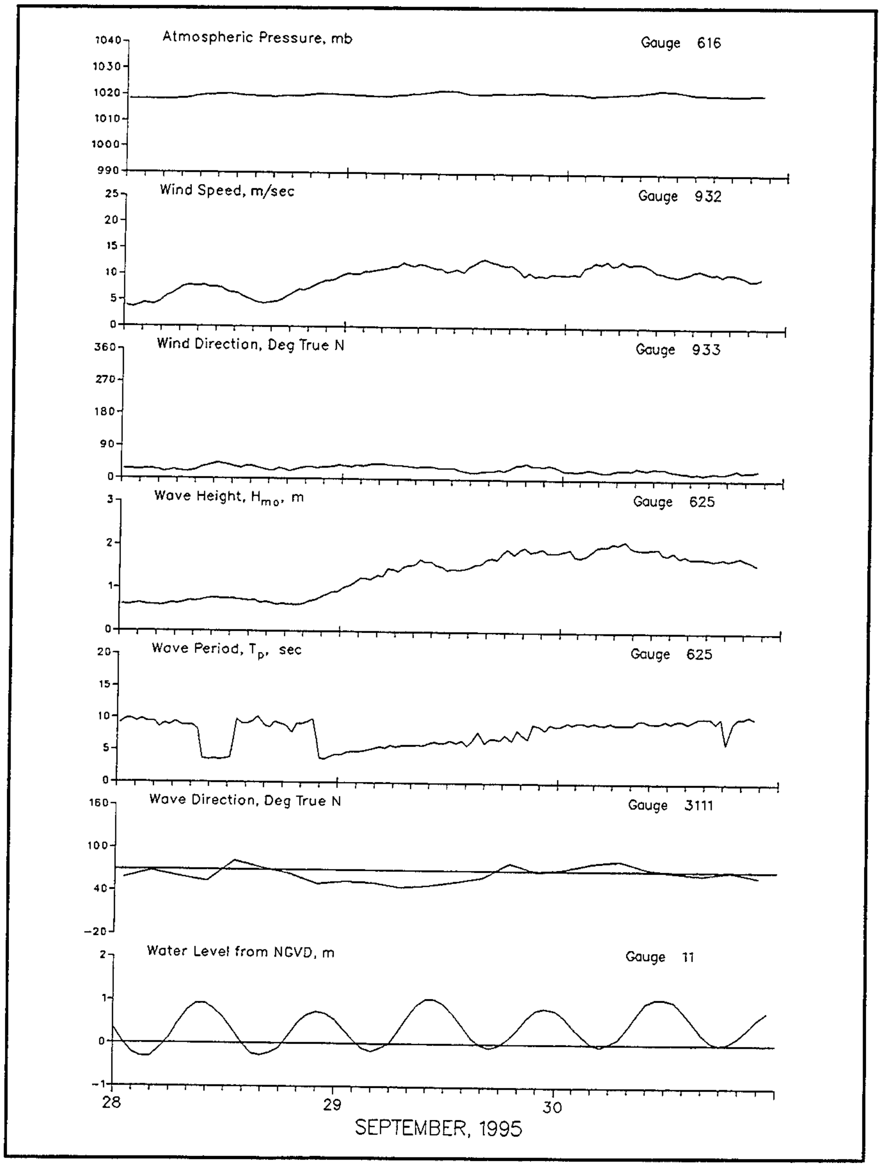

Figure 36. Data for 29-30 September 1995 storm

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Appendix A
Survey Data

Contour diagrams constructed from the bathymetric survey data are presented in this appendix. The profile lines surveyed are identified on each diagram. Contours are in half-meter increments referenced to NGVD. The distance offshore is referenced to the FRF monumentation baseline behind the dune.

Changes in FRF bathymetry diagrams constructed by contouring the difference between two contour diagrams are also presented with contour intervals of 0.25 m. Wide contour lines show areas of erosion. Other areas correspond to areas of accretion. Although these change diagrams are based on considerable interpolation of the original survey data, they do facilitate comparison of the contour diagrams.

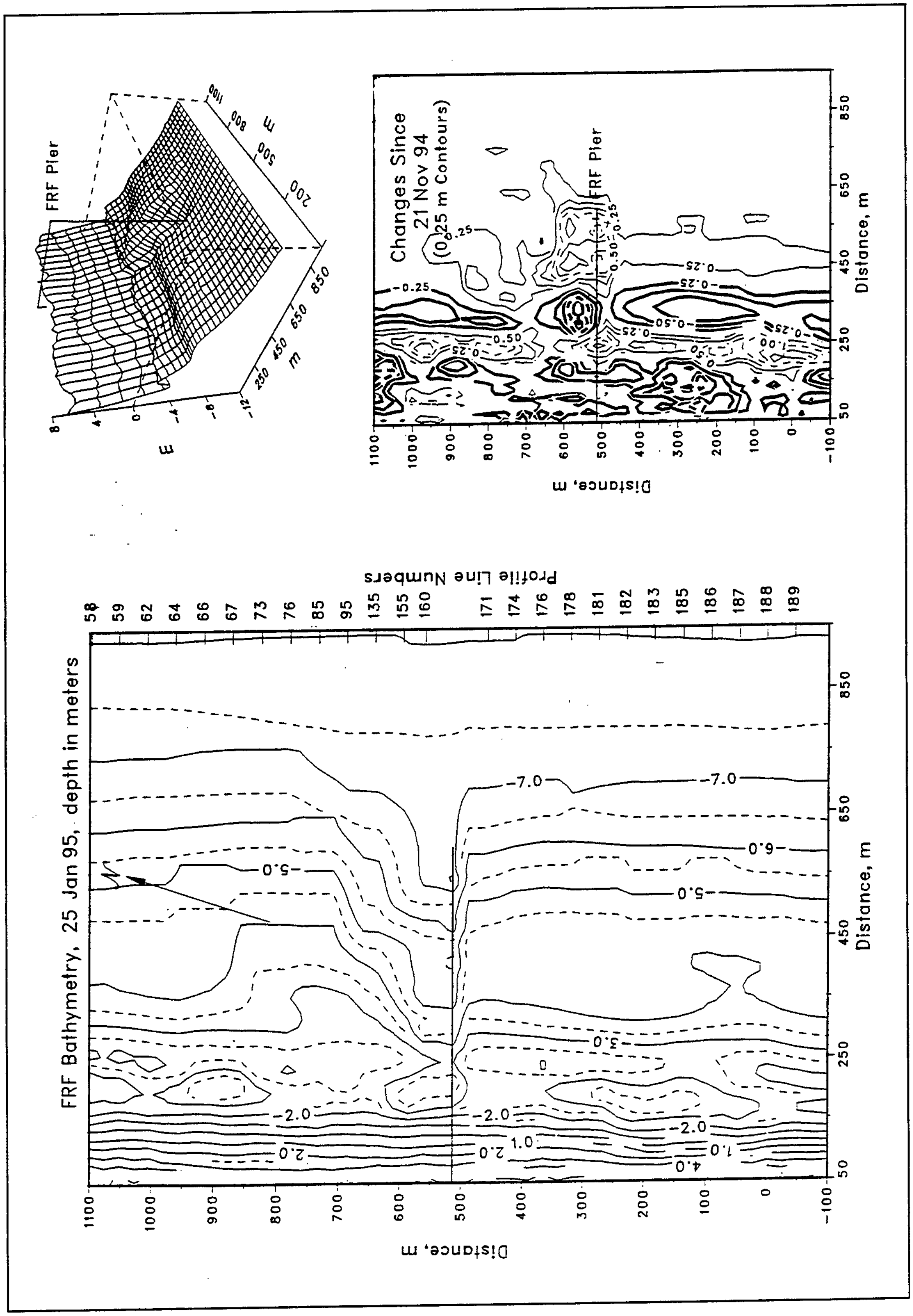

Figure A1. FRF bathymetry, 25 January 1995 (depths relative to NGVD)

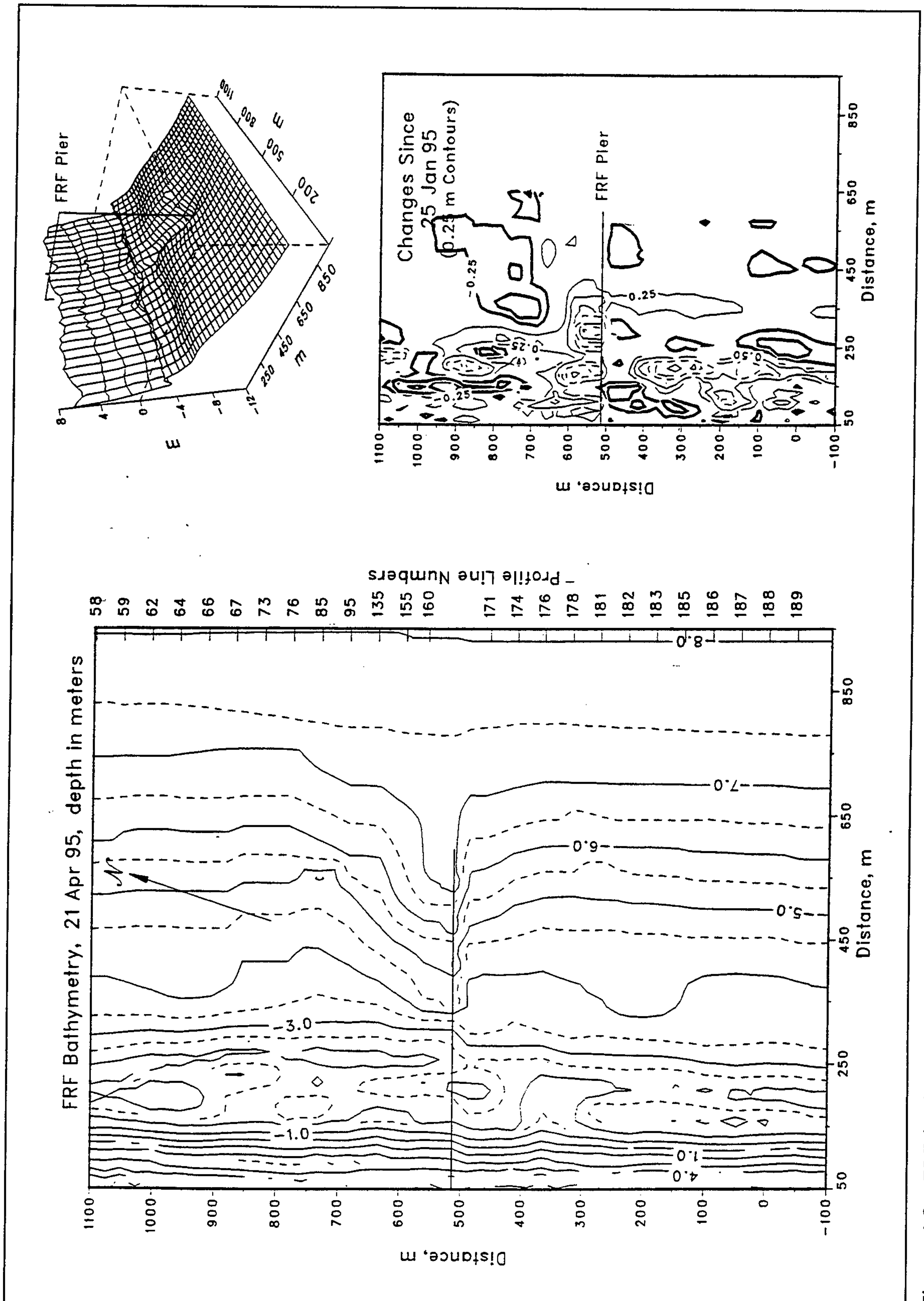

Figure A2. FRF bathymetry, 21 April 1995 (depths relative to NGVD)

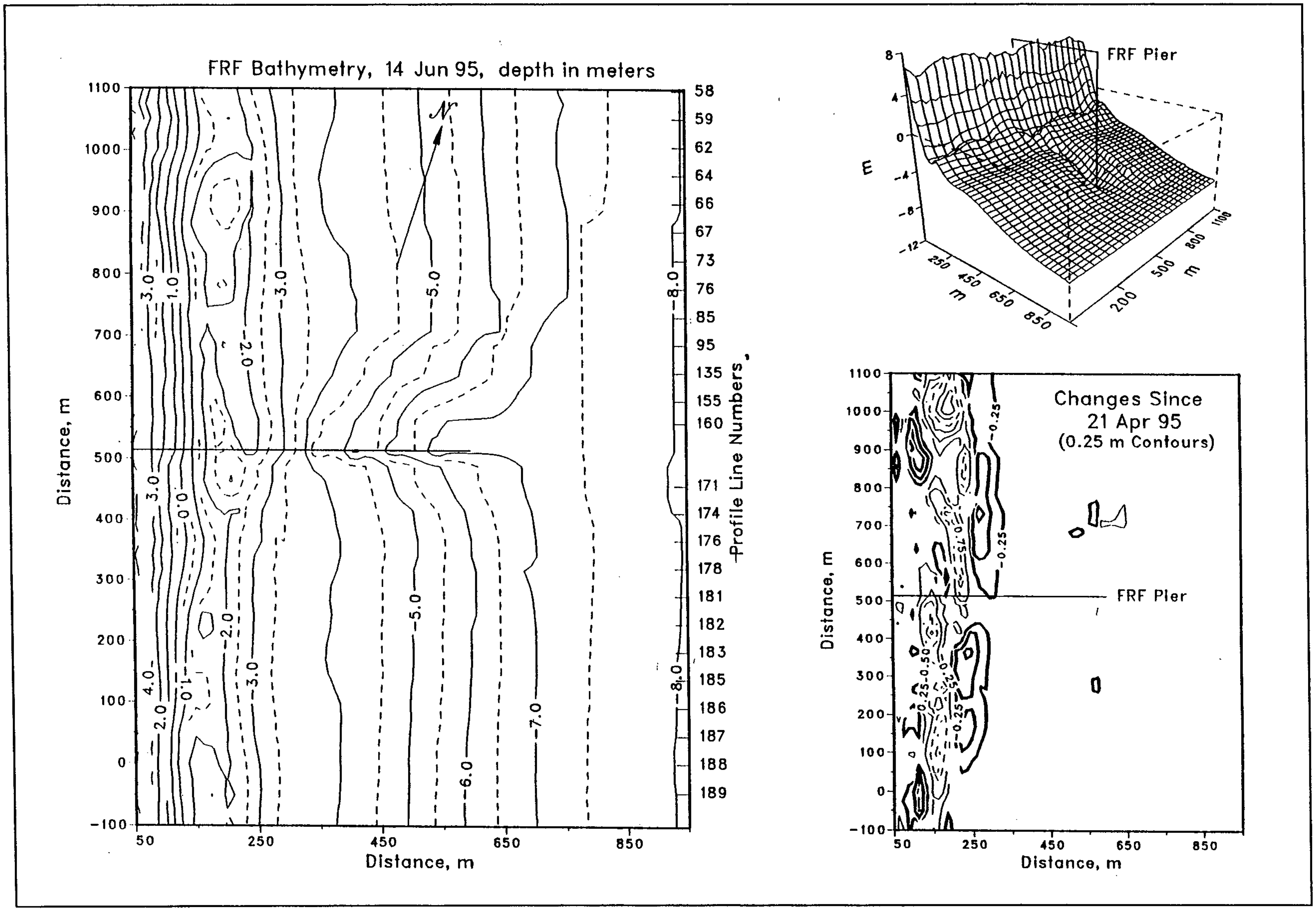

Figure A3. FRF bathymetry, 14 June 1995 (depths relative to NGVD)

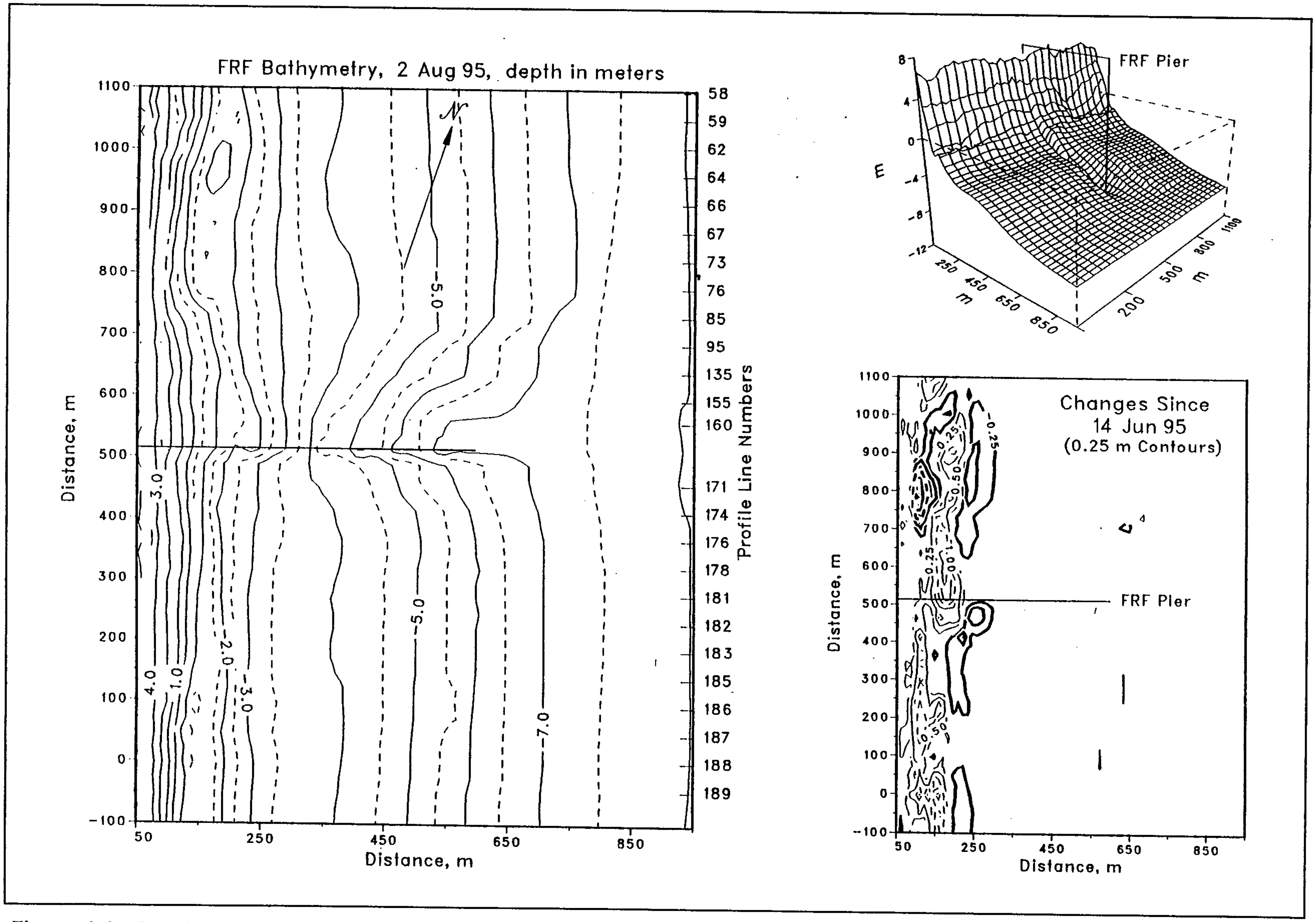

Figure A4. FRF bathymetry, 2 August 1995 (depths relative to NGVD)

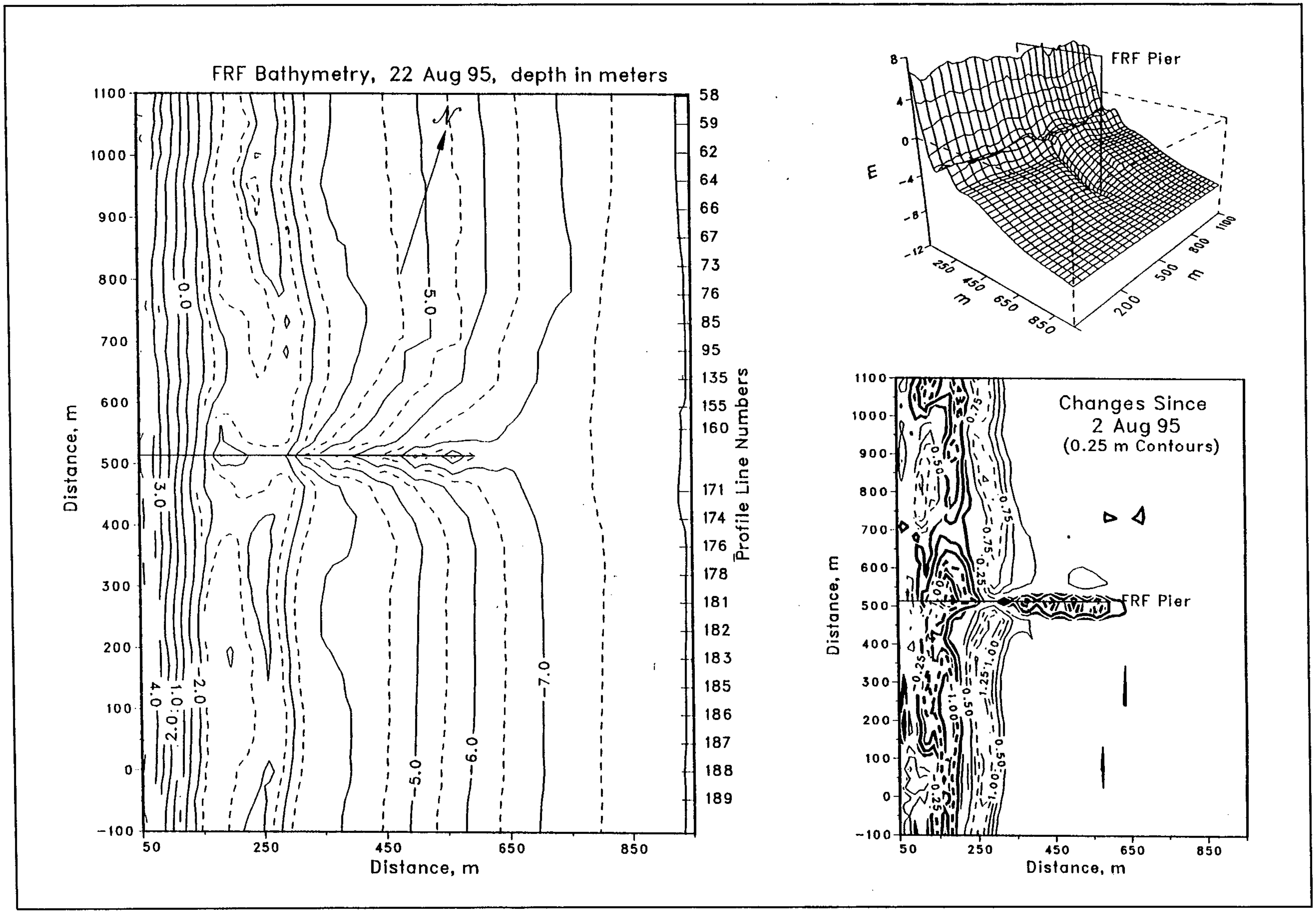

Figure A5. FRF bathymetry, 22 August 1995 (depths relative to NGVD)

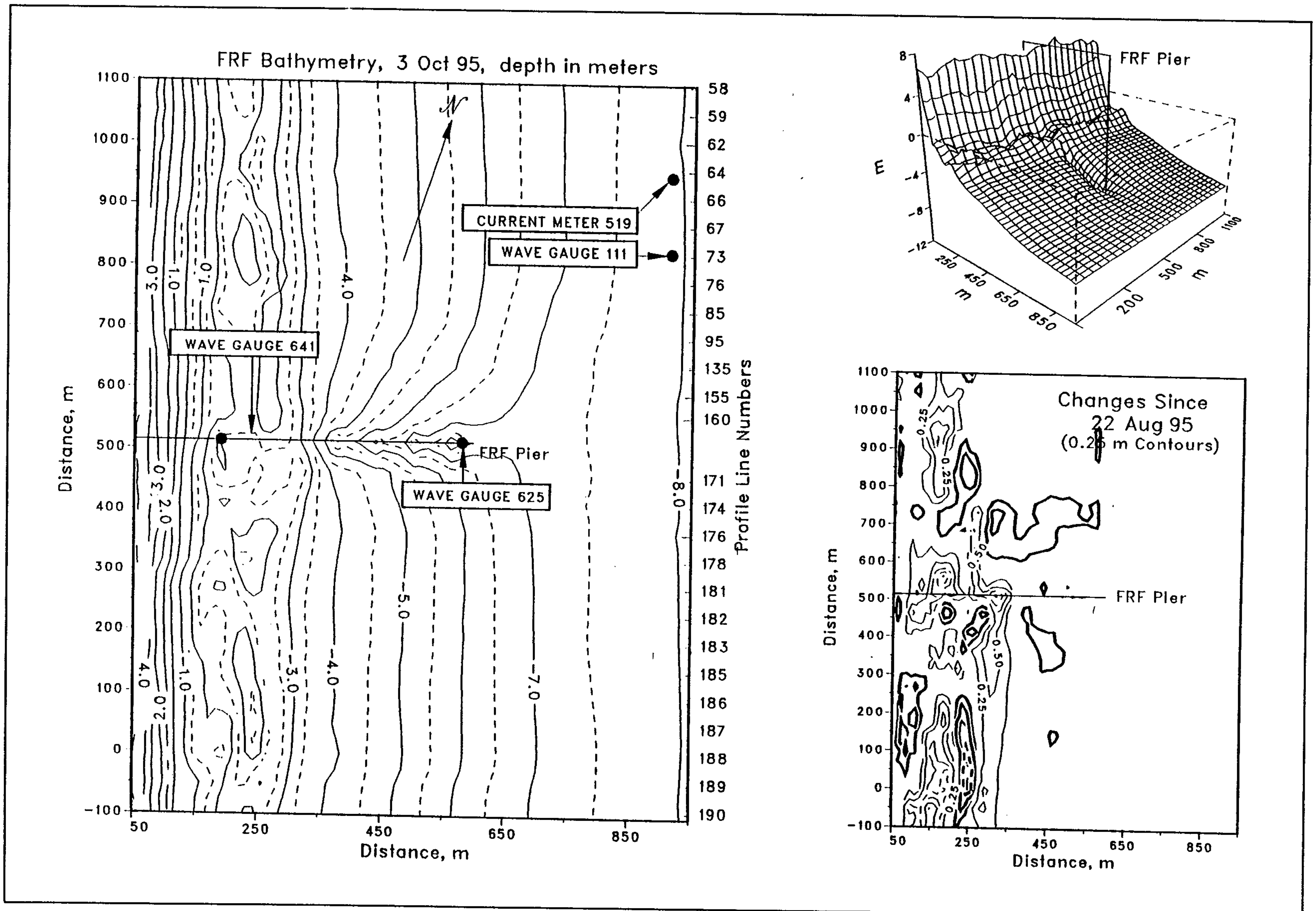

Figure A6. FRF bathymetry, 3 October 1995 (depths relative to NGVD)

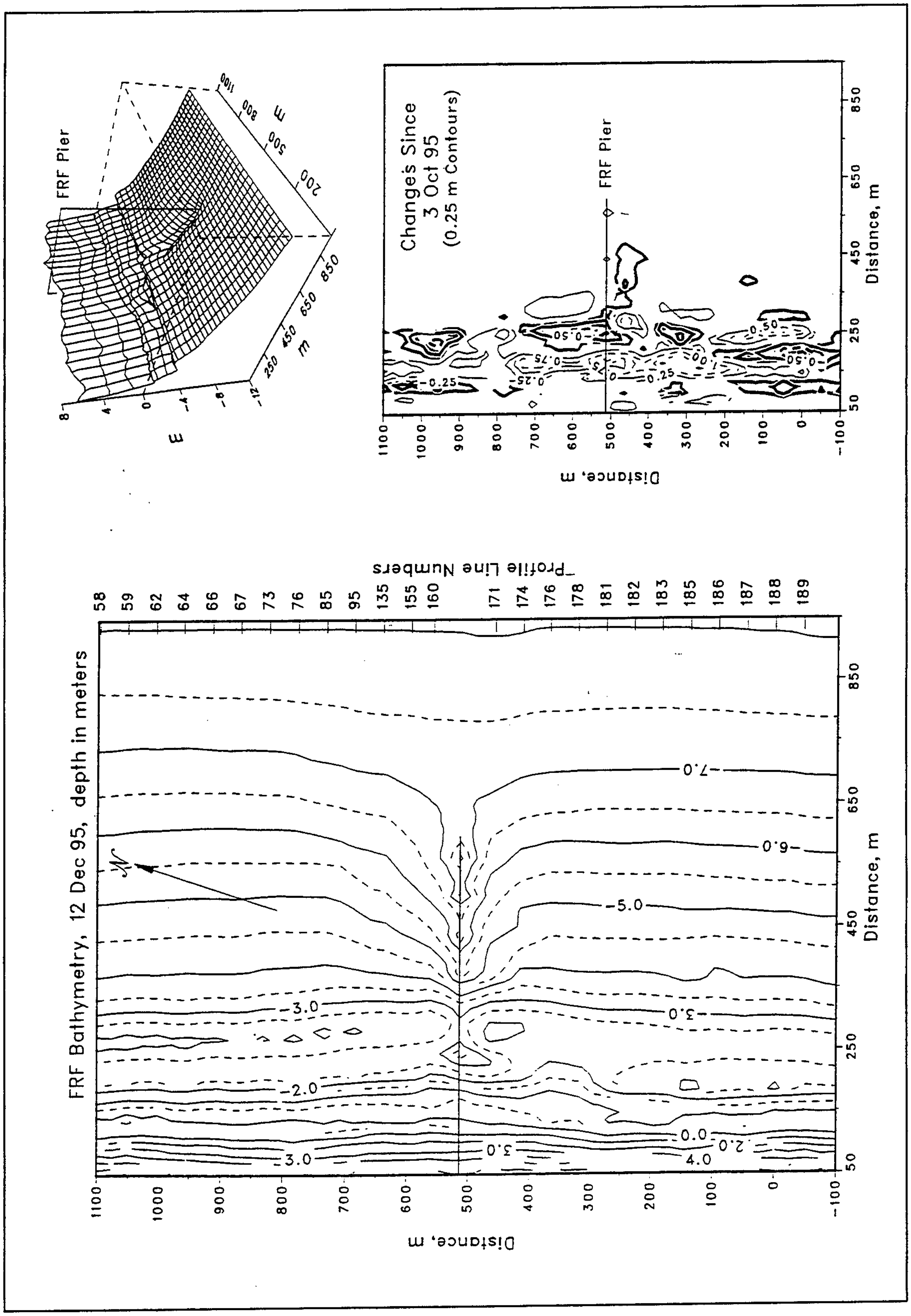

Figure A7. FRF bathymetry, 12 December 1995 (depths relative to NGVD)

Appendix B
Wave Data for Gauge 630

Wave data summaries for Gauge 630 for 1995 and for 1980 through 1995 are presented in the following pages:

Daily H_{mo} and T_p

Figure B1 displays the individual wave height H_{mo} and peak spectral wave period T_p values, along with the monthly mean values.

Joint Distributions of H_{mo} and T_p

Annual and monthly joint distribution tables are presented in Tables B1 and B2, and data for 1980 through 1995 are in Tables B3 and B4. Each table gives the frequency (in parts per 10,000) for which the wave height and peak period were within the specified intervals; these values can be converted to percentages by dividing by 100. Marginal totals are also included. The row total gives the number of observations out of 10,000 that fell within each specified peak period interval. The column total gives the number of observations out of 10,000 that fell within each specified wave height interval.

Cumulative Distributions of Wave Height

Annual and monthly wave height distributions for 1995 are plotted in cumulative form in Figures B2 and B3. Data for 1980 through 1995 are plotted in Figure B4.

Peak Spectral Wave Period Distributions

Annual and monthly peak wave period T_p distribution histograms for 1995 are presented in Figures B5 and B6. Data for 1980 through 1995 are presented in Figure B7.

Persistence of Wave Heights

Table B5 shows the number of times in 1995 when the specified wave height was equaled or exceeded at least once during each day for the duration (consecutive days). Data for 1980 through 1995 are averaged and given in Table B6. An example is shown below:

Height	Consecutive Day(s) or Longer																		
m	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.5	18	15		14	13	12		11	10	9				8		7			
1.0	50	34	24	21	18	14	12	8	7	3			2						
1.5	41	19	8	6	2	1													
2.0	22	9	5	1															
2.5	10	5	2																
3.0	6	1																	
3.5		1																	
4.0	1																		

This example indicates that wave heights equaled or exceeded 1.0 m 50 times for at least 1 day; 34 times for at least 2 days; 24 times for at least 3 days, etc. Therefore, on 16 occasions the height equaled or exceeded 1.0 m for 1 day exactly (50 - 34 = 16); on 10 occasions for 2 days; on 3 occasions for 3 days, etc. Note that the height exceeded 1 m 50 times for 1 day or longer, while heights exceeded 0.5 m only 18 times for this same duration. This change in durations occurred because the longer durations of lower waves may be interspersed with shorter, but more frequent, intervals of higher waves. For example, one of the times that the wave heights exceeded 0.5 m for 16 days may have represented three times the height exceeded 1 m for shorter durations.

Spectra

Monthly spectra for the offshore Waverider buoy (Gauge 630) are presented in Figure B8. The plots show "relative" energy density as a function of wave frequency. These figures summarize the large number of spectra for each month. The figures emphasize the higher energy density associated with storms, as well as the general shifts in energy density to different frequencies. As used here, "relative" indicates the spectra have been smoothed by the three-dimensional surface drawing routine. Consequently, extremely high- and low-energy density values are modified to produce a smooth surface. The figures are not intended for quantitative measurements; however, they do provide the energy density as a function of frequency relative to the other spectra for the month.

Monthly and annual wave statistics for Gauge 630 for 1995 and for 1980 through 1995 are presented in Table B7.

Figure B9 plots monthly time-histories of wave height and period.

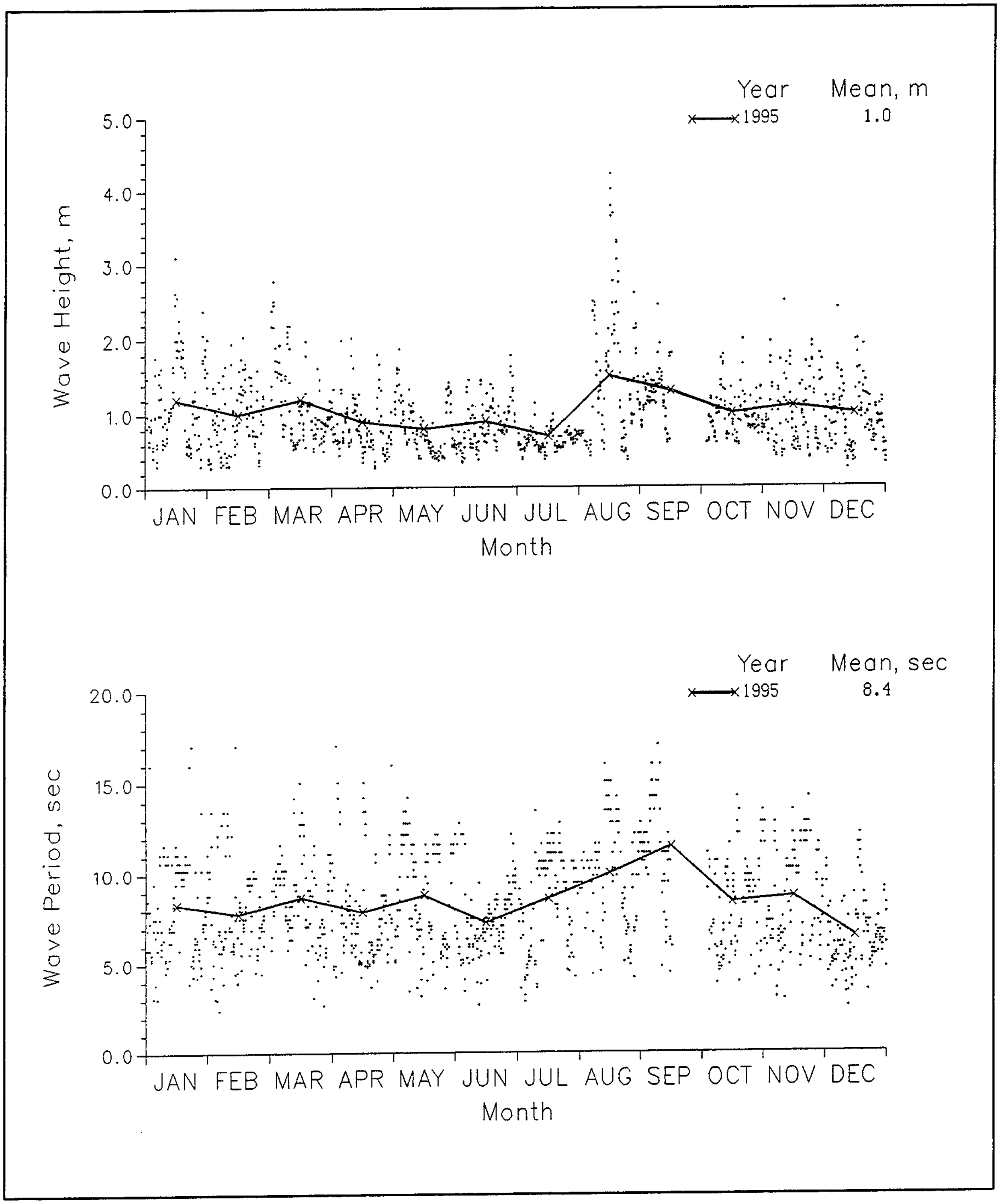

Figure B1. 1995 daily wave height and period values with monthly means for Gauge 630

Table B1
Annual Joint Distribution of H_{mo} versus T_p

Annual 1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec)												Total
	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	
0.00 - 0.49	15	15	44	95	146	117	95	66	219	36	131	22	1001
0.50 - 0.99	29	204	343	714	634	503	503	671	904	138	350	22	5015
1.00 - 1.49	.	22	168	430	517	328	233	219	408	109	146	.	2580
1.50 - 1.99	.	.	7	124	160	175	117	87	211	22	80	.	983
2.00 - 2.49	.	.	.	22	51	51	22	44	87	7	7	7	298
2.50 - 2.99	.	.	.	.	7	.	7	7	22	7	7	.	57
3.00 - 3.49	.	.	.	.	.	.	.	.	7	15	7	.	29
3.50 - 3.99	.	.	.	.	.	.	.	.	.	15	7	.	22
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	15	.	15
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	44	241	562	1385	1515	1174	977	1094	1858	349	750	51	

Table B2
Monthly Joint Distribution of H_{mo} versus T_p

January 1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	81	81	.	81	81	81	163	81	81	163	893
0.50 - 0.99	.	325	325	976	488	244	325	.	894	.	163	81	3821
1.00 - 1.49	.	.	163	569	732	163	.	.	569	.	.	.	2196
1.50 - 1.99	.	.	.	.	407	325	325	244	813	.	.	.	2114
2.00 - 2.49	.	.	.	81	81	81	81	163	244	.	.	.	731
2.50 - 2.99	.	.	.	.	.	.	.	.	163	.	.	.	163
3.00 - 3.49	.	.	.	.	.	.	.	.	81	.	.	.	81
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	325	569	1707	1708	894	812	488	2927	81	244	244	

February 1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	89	89	179	179	268	89	357	268	446	89	2053
0.50 - 0.99	89	268	536	179	536	446	179	804	446	.	179	.	3662
1.00 - 1.49	.	179	89	536	1250	446	268	357	.	.	.	.	3125
1.50 - 1.99	.	.	.	536	89	268	179	.	.	.	.	.	1072
2.00 - 2.49	.	.	.	.	.	89	.	.	.	.	.	.	89
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	89	447	714	1340	2054	1428	894	1250	803	268	625	89	

March 1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	.	.	.	.	.	.	.	.	.	0
0.50 - 0.99	83	83	167	500	417	667	750	1083	833	167	333	.	5083
1.00 - 1.49	.	.	.	167	333	417	417	250	583	83	333	.	2583
1.50 - 1.99	.	.	.	167	.	250	167	417	500	.	.	.	1501
2.00 - 2.49	.	.	.	167	167	250	.	83	.	.	.	.	667
2.50 - 2.99	.	.	.	.	.	.	83	83	.	.	.	.	166
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	
Total	83	83	167	1001	917	1584	1417	1916	1916	250	666	0	

(Continued)

(Sheet 1 of 4)

Table B2 (Continued)

April 1995, Gauge 630
Percent Occurrence (X100) of Height and Period

Height (m)	Period (sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	167	83	83	333	83	333	83	167	.	1332
0.50 - 0.99	.	83	750	1417	750	833	833	167	83	583	500	167	6166
1.00 - 1.49	.	.	250	333	500	417	333	167	.	.	.	.	2000
1.50 - 1.99	.	.	.	167	83	167	.	.	.	.	.	.	417
2.00 - 2.49	.	.	.	.	83	.	.	.	.	.	.	.	83
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	83	1000	2084	1499	1500	1499	417	416	666	667	167	

May 1995, Gauge 630
Percent Occurrence (X100) of Height and Period

Height (m)	Period (sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	323	726	161	.	.	645	.	323	.	2178
0.50 - 0.99	.	323	323	403	323	565	242	565	1048	242	726	.	4760
1.00 - 1.49	.	.	81	565	242	242	242	242	887	81	81	.	2663
1.50 - 1.99	.	.	.	.	81	81	161	81	.	.	.	.	404
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	323	404	1291	1372	1049	645	888	2580	323	1130	0	

June 1995, Gauge 630
Percent Occurrence (X100) of Height and Period

Height (m)	Period (sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	167	167	.	.	83	167	.	167	.	751
0.50 - 0.99	83	250	167	1333	1917	1083	917	250	83	.	167	.	6250
1.00 - 1.49	.	.	83	333	417	833	500	417	83	.	.	.	2666
1.50 - 1.99	.	.	.	.	.	83	83	.	83	.	83	.	332
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	83	250	250	1833	2501	1999	1500	750	416	0	417	0	

(Continued)

(Sheet 2 of 4)

Table B2 (Continued)

July 1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	81	.	.	244	.	244	407	.	81	.	1057
0.50 - 0.99	81	325	732	813	569	407	1057	1545	2927	81	325	.	8862
1.00 - 1.49	.	.	.	81	.	.	.	.	.	.	.	.	81
1.50 - 1.99	.	.	.	.	.	.	.	.	.	.	.	.	0
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	81	325	813	894	569	651	1057	1789	3334	81	406	0	

August 1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	.	177	177	88	.	177	.	.	.	619
0.50 - 0.99	.	.	.	177	177	442	442	796	619	.	265	.	2918
1.00 - 1.49	.	.	354	354	177	.	.	177	796	88	265	.	2211
1.50 - 1.99	.	.	.	.	88	88	.	177	442	265	442	.	1502
2.00 - 2.49	.	.	.	.	177	177	88	265	796	88	88	.	1679
2.50 - 2.99	.	.	.	.	88	.	.	.	88	88	88	.	352
3.00 - 3.49	.	.	.	.	.	.	.	.	.	177	88	.	265
3.50 - 3.99	.	.	.	.	.	.	.	.	.	177	88	.	265
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	177	.	177
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	0	354	531	884	884	618	1415	2918	883	1501	0	

September 1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	.	.	.	.	.	.	.	.	.	0
0.50 - 0.99	.	.	.	.	328	.	.	164	1311	.	164	.	1967
1.00 - 1.49	.	.	328	.	.	328	164	656	1639	1967	1311	.	6393
1.50 - 1.99	.	.	.	164	328	.	.	.	492	.	492	.	1476
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	164	164
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	0	328	164	656	328	164	820	3442	1967	1967	164	

(Continued)

(Sheet 3 of 4)

Table B2 (Concluded)

October 1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height (m)	Period (sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	.	.	.	.	.	.	.	.	.	0
0.50 - 0.99	.	88	351	439	351	351	789	1754	1053	351	439	.	5966
1.00 - 1.49	.	88	263	702	877	526	175	263	439	.	88	.	3421
1.50 - 1.99	.	.	.	263	.	88	263	.	.	.	.	.	614
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	176	614	1404	1228	965	1227	2017	1492	351	527	0	

November 1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height (m)	Period (sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	85	.	85	.	85	85	.	169	254	.	254	.	1017
0.50 - 0.99	.	169	.	254	424	508	85	678	1441	169	847	.	4575
1.00 - 1.49	.	.	169	593	593	339	254	85	254	.	254	.	2541
1.50 - 1.99	.	.	85	85	847	339	85	85	169	.	85	.	1780
2.00 - 2.49	.	.	.	.	.	.	85	.	.	.	.	.	85
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	85	169	339	932	1949	1271	509	1017	2118	169	1440	0	

December 1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height (m)	Period (sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	81	161	161	242	242	323	323	.	.	.	.	.	1533
0.50 - 0.99	.	403	565	1613	1129	242	161	81	242	.	.	.	4436
1.00 - 1.49	.	.	323	726	887	242	403	242	242	.	.	.	3065
1.50 - 1.99	.	.	.	161	81	323	81	.	161	.	81	.	888
2.00 - 2.49	.	.	.	.	81	.	.	.	.	.	.	.	81
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	81	564	1049	2742	2420	1130	968	323	645	0	81	0	

(Sheet 4 of 4)

Table B3
Annual Joint Distribution of H_{mo} versus T_p (All Years)

Annual 1980-1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec)												Total
	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	
0.00 - 0.49	24	15	29	65	85	123	338	278	196	66	120	5	1344
0.50 - 0.99	32	140	276	505	574	534	887	766	774	126	234	15	4863
1.00 - 1.49	.	11	149	407	412	243	272	217	324	44	115	2	2196
1.50 - 1.99	.	.	11	163	238	111	84	77	142	31	67	3	927
2.00 - 2.49	.	.	1	24	90	67	50	34	63	25	33	1	388
2.50 - 2.99	.	.	.	1	14	32	20	14	34	9	23	1	148
3.00 - 3.49	.	.	.	.	1	10	12	12	20	7	8	.	70
3.50 - 3.99	.	.	.	.	.	.	5	9	12	5	5	.	36
4.00 - 4.49	.	.	.	.	.	.	2	4	7	3	5	.	21
4.50 - 4.99	.	.	.	.	.	.	.	1	1	.	1	.	3
5.00 - Greater	.	.	.	.	.	.	.	.	.	1	1	.	2
Total	56	166	466	1165	1414	1120	1670	1412	1573	317	612	27	

Table B4
Monthly Joint Distribution of H_{mo} versus T_p (All Years)

January 1980-1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	74	6	12	68	56	37	130	278	247	43	93	12	1056
0.50 - 0.99	56	191	210	432	377	315	401	692	815	80	185	12	3766
1.00 - 1.49	.	12	167	630	550	247	241	198	469	19	43	6	2582
1.50 - 1.99	.	.	25	303	432	173	105	117	259	31	43	.	1488
2.00 - 2.49	.	.	.	43	148	173	93	43	130	31	19	6	686
2.50 - 2.99	.	.	.	.	19	68	49	25	74	12	49	.	296
3.00 - 3.49	.	.	.	.	.	25	25	6	37	.	.	.	93
3.50 - 3.99	.	.	.	.	.	.	.	6	12	.	.	.	18
4.00 - 4.49	.	.	.	.	.	.	.	.	6	.	.	.	6
4.50 - 4.99	.	.	.	.	.	.	.	.	6	.	.	.	6
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	130	209	414	1476	1582	1038	1044	1365	2055	216	432	36	

February 1980-1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	14	.	14	48	68	55	96	164	116	41	116	7	739
0.50 - 0.99	48	96	191	369	464	328	478	710	1004	14	150	7	3859
1.00 - 1.49	.	20	137	594	622	273	307	362	505	61	171	.	3052
1.50 - 1.99	.	.	7	239	342	184	123	130	157	61	82	.	1325
2.00 - 2.49	.	.	.	68	150	61	34	61	75	48	82	.	579
2.50 - 2.99	.	.	.	7	20	55	34	7	82	14	48	7	274
3.00 - 3.49	.	.	.	.	.	20	7	20	27	14	14	.	102
3.50 - 3.99	.	.	.	.	.	.	.	7	7	.	7	.	21
4.00 - 4.49	.	.	.	.	.	.	.	7	27	.	7	.	41
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	7	.	.	.	.	.	7
Total	62	116	349	1325	1666	976	1086	1468	2000	253	677	21	

March 1980-1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	6	11	6	17	39	44	127	50	160	55	94	.	609
0.50 - 0.99	17	72	193	409	491	491	613	657	883	99	237	.	4162
1.00 - 1.49	.	17	199	403	502	315	326	276	646	55	282	.	3021
1.50 - 1.99	.	.	11	215	243	121	99	149	282	55	105	.	1280
2.00 - 2.49	.	.	.	39	66	61	77	61	110	22	77	.	513
2.50 - 2.99	.	.	.	.	28	17	33	11	50	11	33	6	189
3.00 - 3.49	.	.	.	.	6	11	6	11	44	6	6	.	90
3.50 - 3.99	.	.	.	.	.	.	.	17	44	.	17	.	78
4.00 - 4.49	.	.	.	.	.	.	6	11	17	.	17	.	51
4.50 - 4.99	.	.	.	.	.	.	.	.	11	.	.	.	11
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	23	100	409	1083	1375	1060	1287	1243	2247	303	868	6	

(Continued)

(Sheet 1 of 4)

Table B4 (Continued)

April 1980-1995, Gauge 630
Percent Occurrence (X100) of Height and Period

Height (m)	Period (sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	6	11	17	45	34	28	263	156	140	95	140	.	935
0.50 - 0.99	67	168	263	542	609	531	899	771	944	257	391	11	5453
1.00 - 1.49	.	11	117	296	363	318	341	302	307	61	112	.	2228
1.50 - 1.99	.	.	6	168	128	78	78	78	173	17	61	.	787
2.00 - 2.49	.	.	.	28	67	22	39	45	78	22	6	.	307
2.50 - 2.99	.	.	.	6	17	17	28	17	39	22	11	.	157
3.00 - 3.49	.	.	.	.	.	22	11	22	22	6	.	.	83
3.50 - 3.99	.	.	.	.	.	6	22	.	6	.	.	.	34
4.00 - 4.49	.	.	.	.	.	.	6	.	6	.	.	.	12
4.50 - 4.99	.	.	.	.	.	.	.	6	.	.	.	.	6
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	73	190	403	1085	1218	1022	1687	1397	1715	480	721	11	

May 1980-1995, Gauge 630
Percent Occurrence (X100) of Height and Period

Height (m)	Period (sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	5	16	38	103	180	147	332	278	229	60	142	.	1530
0.50 - 0.99	16	196	359	550	517	773	1187	980	702	98	240	5	5623
1.00 - 1.49	.	5	163	272	289	174	348	261	310	16	76	.	1914
1.50 - 1.99	.	.	5	82	87	65	109	76	103	16	44	.	587
2.00 - 2.49	.	.	.	11	60	49	22	38	11	16	16	.	223
2.50 - 2.99	.	.	.	.	22	16	5	5	5	11	5	.	69
3.00 - 3.49	.	.	.	.	.	.	16	5	5	5	5	.	36
3.50 - 3.99	.	.	.	.	.	.	.	5	5	.	.	.	10
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	21	217	565	1018	1155	1224	2019	1648	1370	222	528	5	

June 1980-1995, Gauge 630
Percent Occurrence (X100) of Height and Period

Height (m)	Period (sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	17	23	35	105	163	280	594	454	268	29	35	.	2003
0.50 - 0.99	41	192	379	699	885	804	1602	978	530	116	134	.	6360
1.00 - 1.49	.	6	111	262	221	210	204	105	82	.	29	.	1230
1.50 - 1.99	.	.	12	41	76	47	29	12	76	.	41	.	334
2.00 - 2.49	.	.	.	.	17	12	35	6	.	.	.	.	70
2.50 - 2.99	.	.	.	.	.	6	.	.	.	.	.	.	6
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	58	221	537	1107	1362	1359	2464	1555	956	145	239	0	

(Continued)

(Sheet 2 of 4)

Table B4 (Continued)

July 1980-1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	11	17	74	137	183	411	1113	719	331	91	166	11	3264
0.50 - 0.99	34	194	400	708	782	713	1301	959	537	160	148	46	5982
1.00 - 1.49	.	11	46	160	188	68	97	29	29	.	.	.	628
1.50 - 1.99	.	.	.	34	6	11	17	11	29	.	.	.	108
2.00 - 2.49	.	.	.	6	.	.	6	.	.	.	.	.	12
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	45	222	520	1045	1159	1203	2534	1718	926	251	314	57	

August 1980-1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	17	23	57	107	141	192	583	436	277	57	74	.	1964
0.50 - 0.99	28	113	266	526	781	775	1391	837	713	136	255	28	5849
1.00 - 1.49	.	6	141	305	255	181	221	141	136	17	45	.	1448
1.50 - 1.99	.	.	.	62	113	51	23	23	68	17	57	.	414
2.00 - 2.49	.	.	.	11	34	23	17	17	74	11	11	.	198
2.50 - 2.99	.	.	.	.	11	.	11	.	17	6	11	.	56
3.00 - 3.49	.	.	.	.	6	6	6	.	6	11	6	.	41
3.50 - 3.99	.	.	.	.	.	.	.	6	.	11	6	.	23
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	11	.	11
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	45	142	464	1011	1341	1228	2252	1460	1291	266	476	28	

September 1980-1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	6	12	17	29	29	64	222	239	175	152	99	6	1050
0.50 - 0.99	.	117	233	373	478	548	921	764	991	117	286	.	4828
1.00 - 1.49	.	12	87	443	437	286	426	239	350	146	187	6	2619
1.50 - 1.99	.	.	12	152	257	111	76	93	76	17	105	6	905
2.00 - 2.49	.	.	.	29	82	47	58	23	52	47	52	6	396
2.50 - 2.99	.	.	.	.	.	52	35	12	6	6	6	.	117
3.00 - 3.49	.	.	.	.	.	6	12	6	6	6	6	.	42
3.50 - 3.99	.	.	.	.	.	.	6	6	6	6	6	.	30
4.00 - 4.49	.	.	.	.	.	.	6	.	6	.	.	.	12
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	6	.	.	6
Total	6	141	349	1026	1283	1114	1762	1382	1668	503	747	24	

(Continued)

(Sheet 3 of 4)

Table B4 (Concluded)

October 1980-1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	27	.	5	5	33	60	174	130	179	22	114	.	749
0.50 - 0.99	22	71	228	347	391	342	749	602	841	184	336	5	4118
1.00 - 1.49	.	22	179	613	391	190	206	255	396	81	184	.	2517
1.50 - 1.99	.	.	22	239	369	125	109	81	190	81	163	22	1401
2.00 - 2.49	.	.	.	27	130	147	81	60	130	33	49	5	662
2.50 - 2.99	.	.	.	.	33	81	33	49	49	16	49	.	310
3.00 - 3.49	.	.	.	.	.	22	5	11	27	11	27	5	108
3.50 - 3.99	.	.	.	.	.	.	11	27	16	16	5	.	75
4.00 - 4.49	.	.	.	.	.	.	11	16	16	.	.	5	48
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	5	5
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	5	5
Total	49	93	434	1231	1347	967	1379	1231	1844	444	927	52	

November 1980-1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	50	25	25	31	44	82	252	227	94	57	183	19	1089
0.50 - 0.99	31	101	302	542	504	466	542	617	611	107	176	38	4037
1.00 - 1.49	.	13	252	485	630	390	302	277	309	38	126	19	2841
1.50 - 1.99	.	.	19	214	397	208	139	94	139	38	13	6	1267
2.00 - 2.49	.	.	.	31	139	101	101	25	31	13	6	.	447
2.50 - 2.99	.	.	.	.	6	38	6	13	31	.	13	.	107
3.00 - 3.49	.	.	.	.	.	6	13	44	38	6	6	.	113
3.50 - 3.99	.	.	.	.	.	.	6	13	25	13	6	.	63
4.00 - 4.49	.	.	.	.	.	.	.	6	6	6	.	.	18
4.50 - 4.99	.	.	.	.	.	.	.	6	.	.	6	.	12
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	6	.	6
Total	81	139	598	1303	1720	1291	1361	1322	1284	278	541	82	

December 1980-1995, Gauge 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	63	31	44	81	38	56	113	188	106	94	194	6	1014
0.50 - 0.99	31	169	269	557	588	244	394	588	725	119	231	25	3940
1.00 - 1.49	.	.	194	475	575	288	244	169	375	31	119	.	2470
1.50 - 1.99	.	.	19	238	475	188	119	63	156	44	88	.	1390
2.00 - 2.49	.	.	13	6	213	119	38	31	69	63	81	.	633
2.50 - 2.99	.	.	.	.	6	38	.	31	63	6	63	.	207
3.00 - 3.49	.	.	.	.	.	6	50	19	31	19	25	.	150
3.50 - 3.99	.	.	.	.	.	.	19	19	25	19	19	.	101
4.00 - 4.49	.	.	.	.	.	.	.	13	6	31	25	.	75
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	6	.	6
5.00 - Greater	.	.	.	.	.	.	.	.	6	6	6	.	18
Total	94	200	539	1357	1895	939	977	1121	1562	432	857	31	

(Sheet 4 of 4)

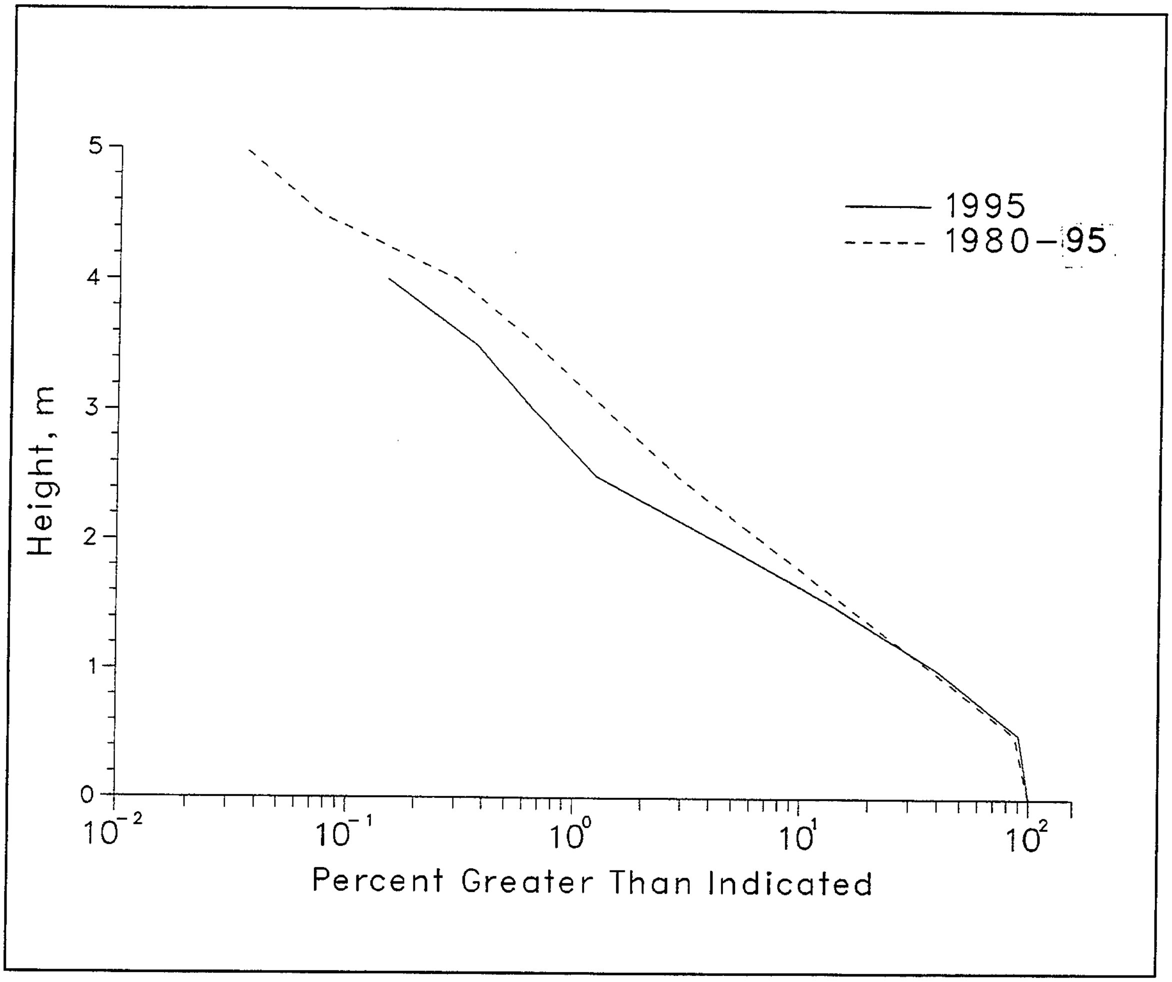

Figure B2. Annual cumulative wave height distributions for Gauge 630

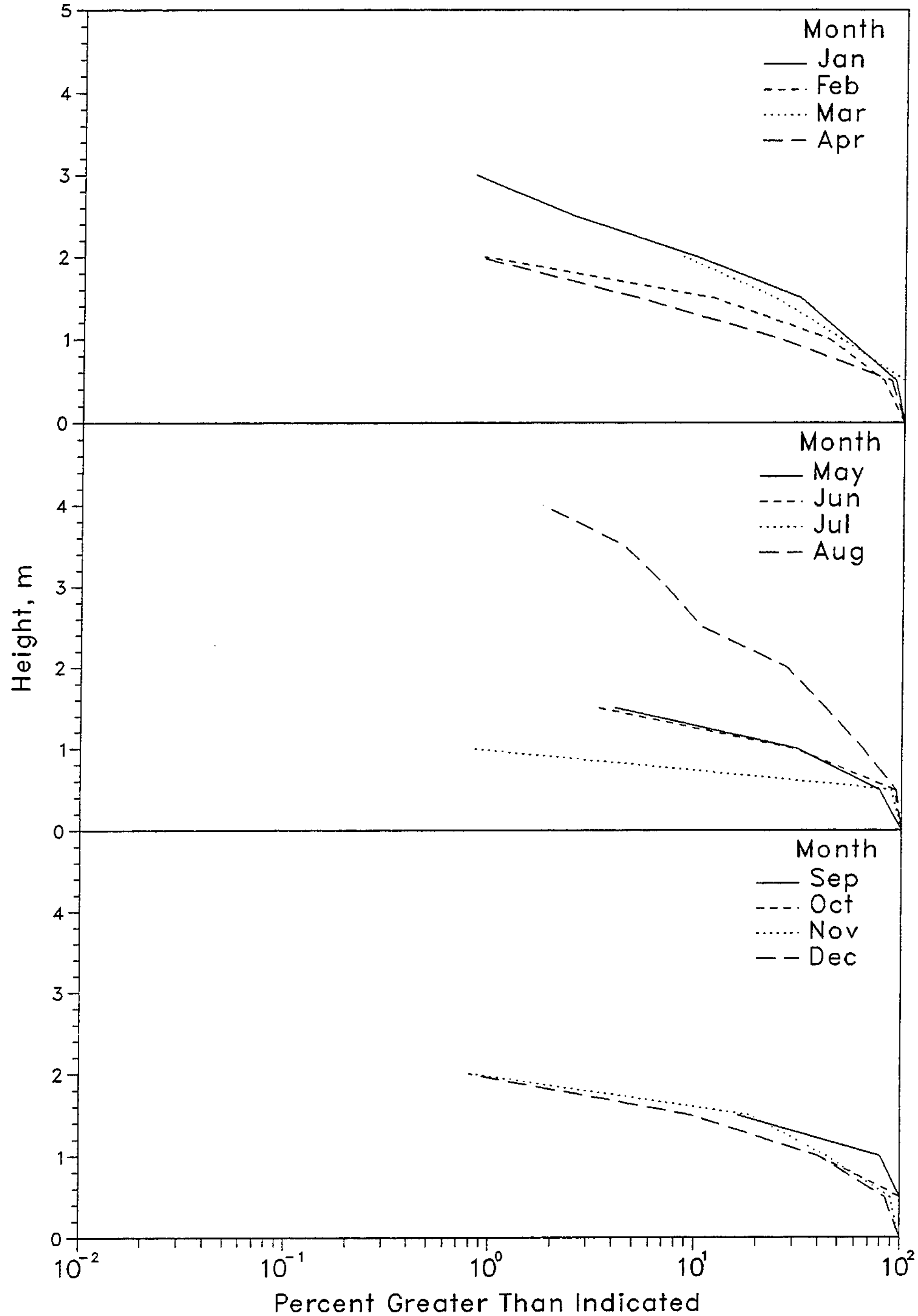

Figure B3. 1995 monthly wave height distributions for Gauge 630

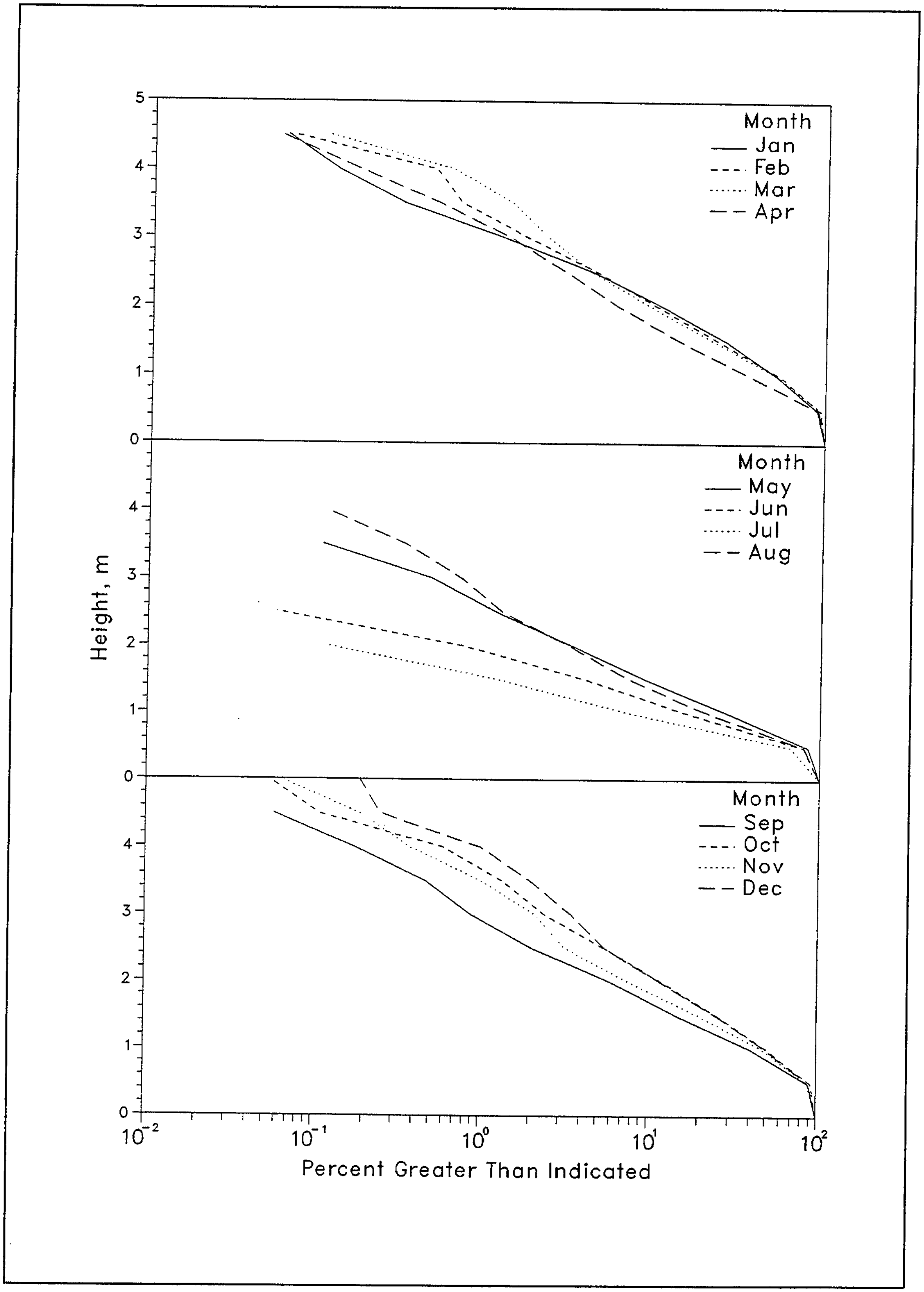

Figure B4. 1980-1995 monthly wave height distributions for Gauge 630

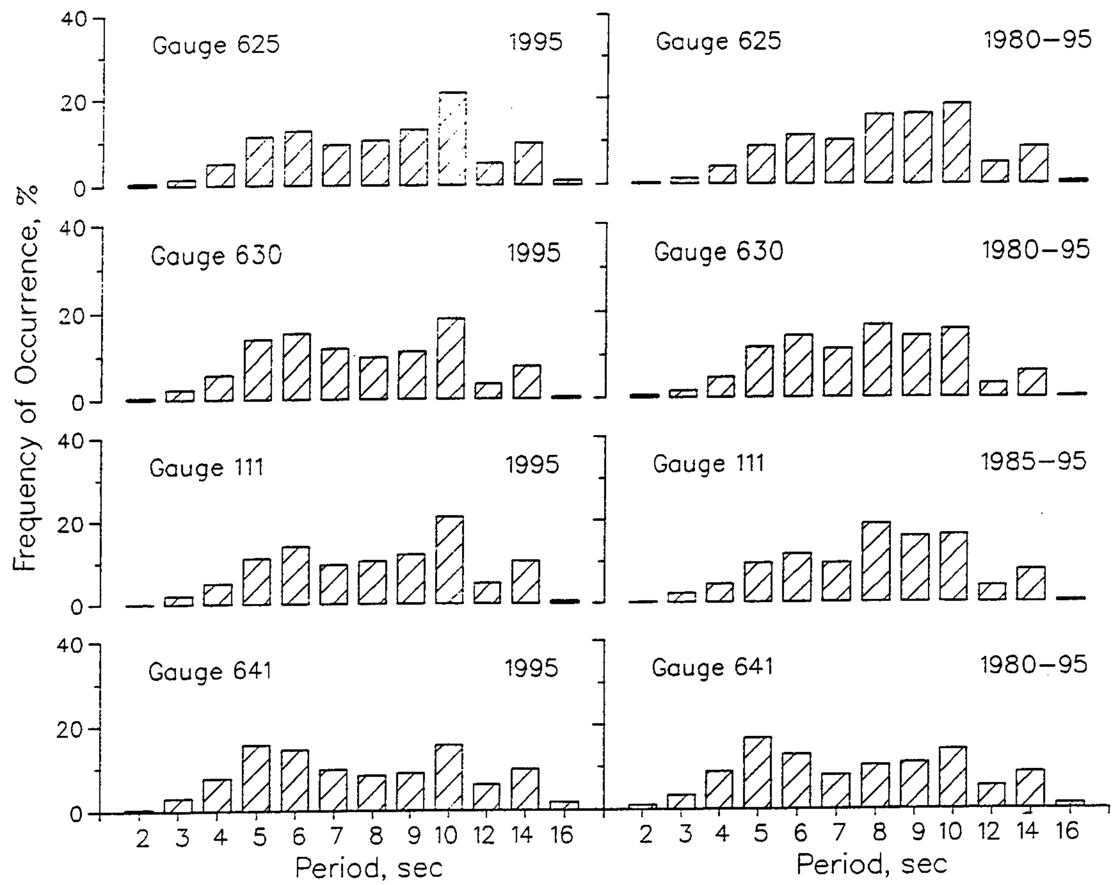

Figure B5. Annual wave period distributions for all gauges

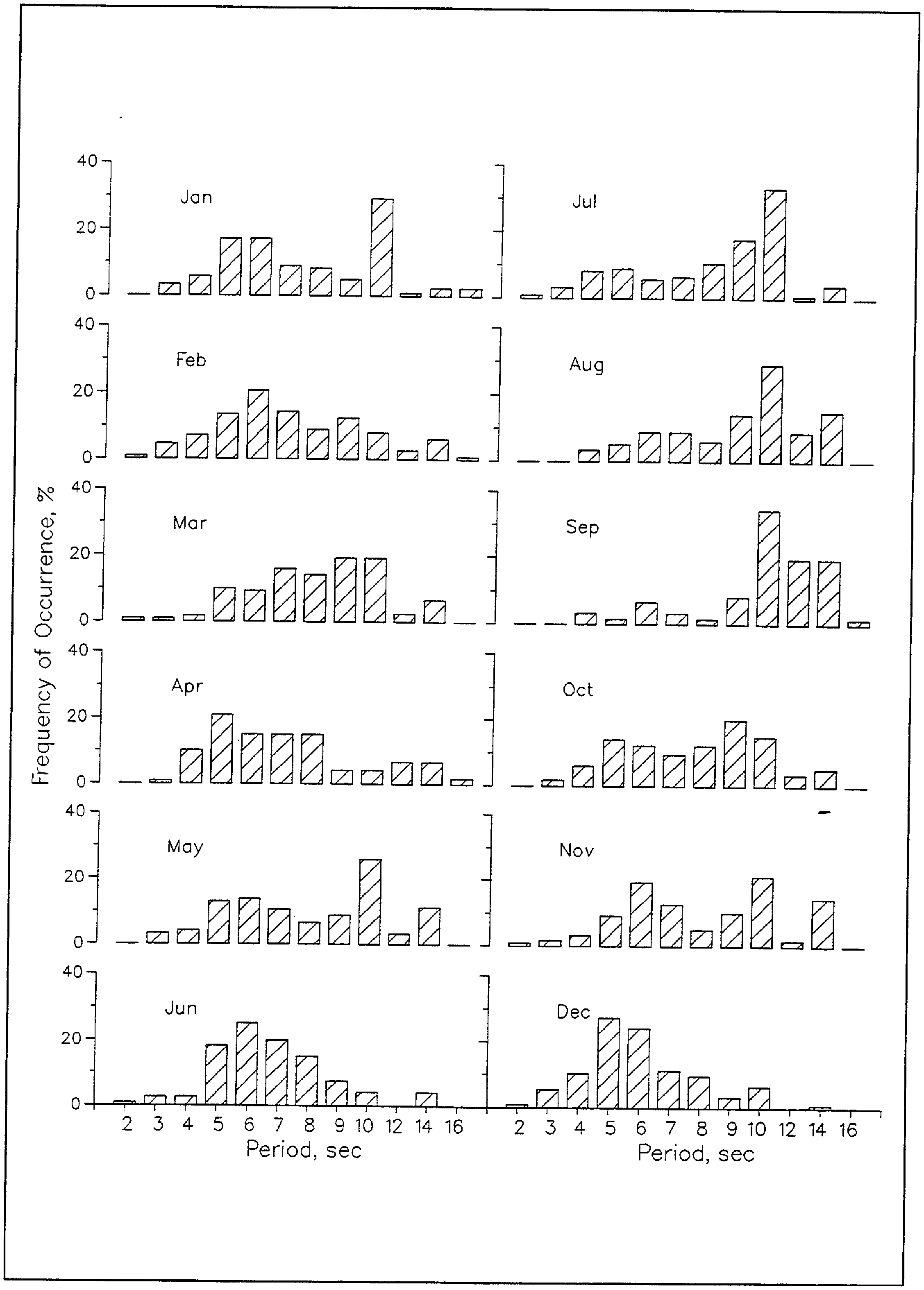

Figure B6. 1995 monthly wave period distributions for Gauge 630

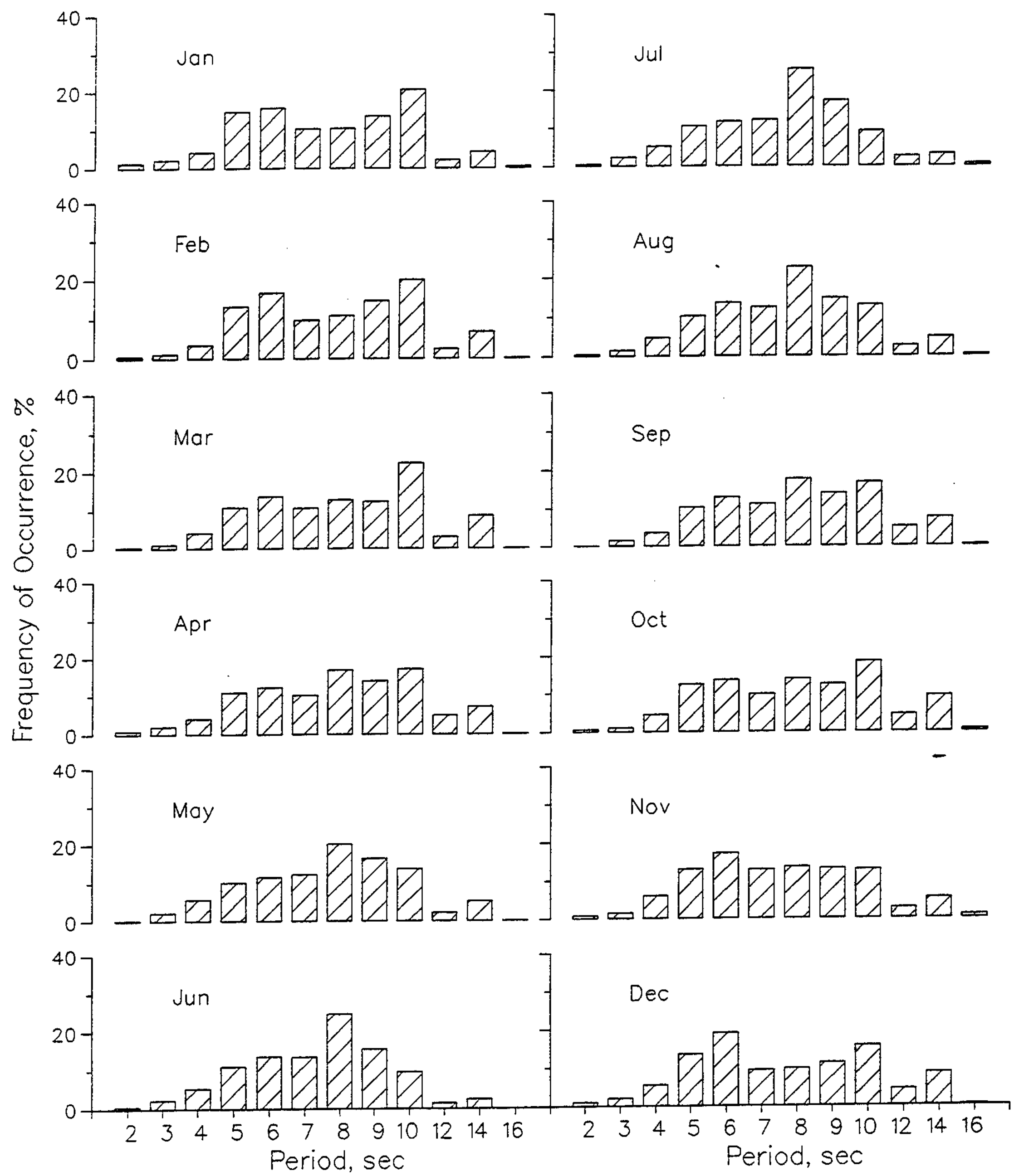

Figure B7. 1980-1995 monthly wave period distributions for Gauge 630

Table B5
1995 persistence of H_{mo} for Gauge 630

Height (m)	Consecutive Day(s) or Longer																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.5		11		9			8		7						6		5		4
1.0	58	44	28	21	13	9	6	5	3			1							
1.5	38	22	9	4		3	2	1											
2.0	13	6	3	2		1													
2.5	5	3																	
3.0	3	1																	
3.5		1																	
4.0	1																		

Table B6
1980 through 1995 persistence of H_{mo} for Gauge 630

Height (m)	Consecutive Day(s) or Longer																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.5	19	17	15	14		13	11		10		9		8	7		6			5
1.0	51	35	24	17	13	10	7	6	5		3		2				1		
1.5	39	22	11	6	4		2		1										
2.0	21	11	5	2		1													
2.5	11	5	2																
3.0	6	3	1																
3.5	3	1																	
4.0	2	1																	

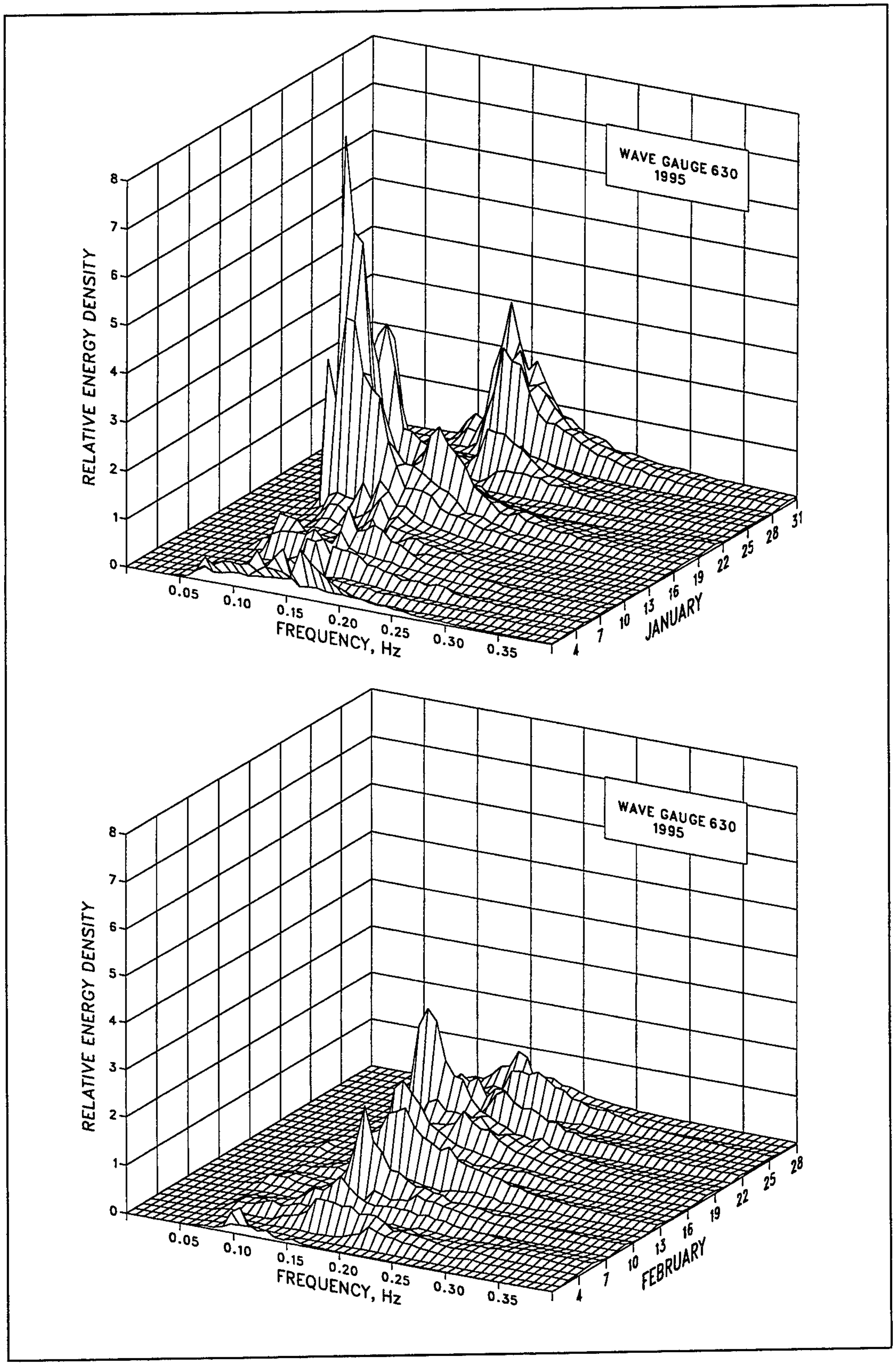

Figure B8. 1995 monthly spectra for Gauge 630 (Sheet 1 of 6)

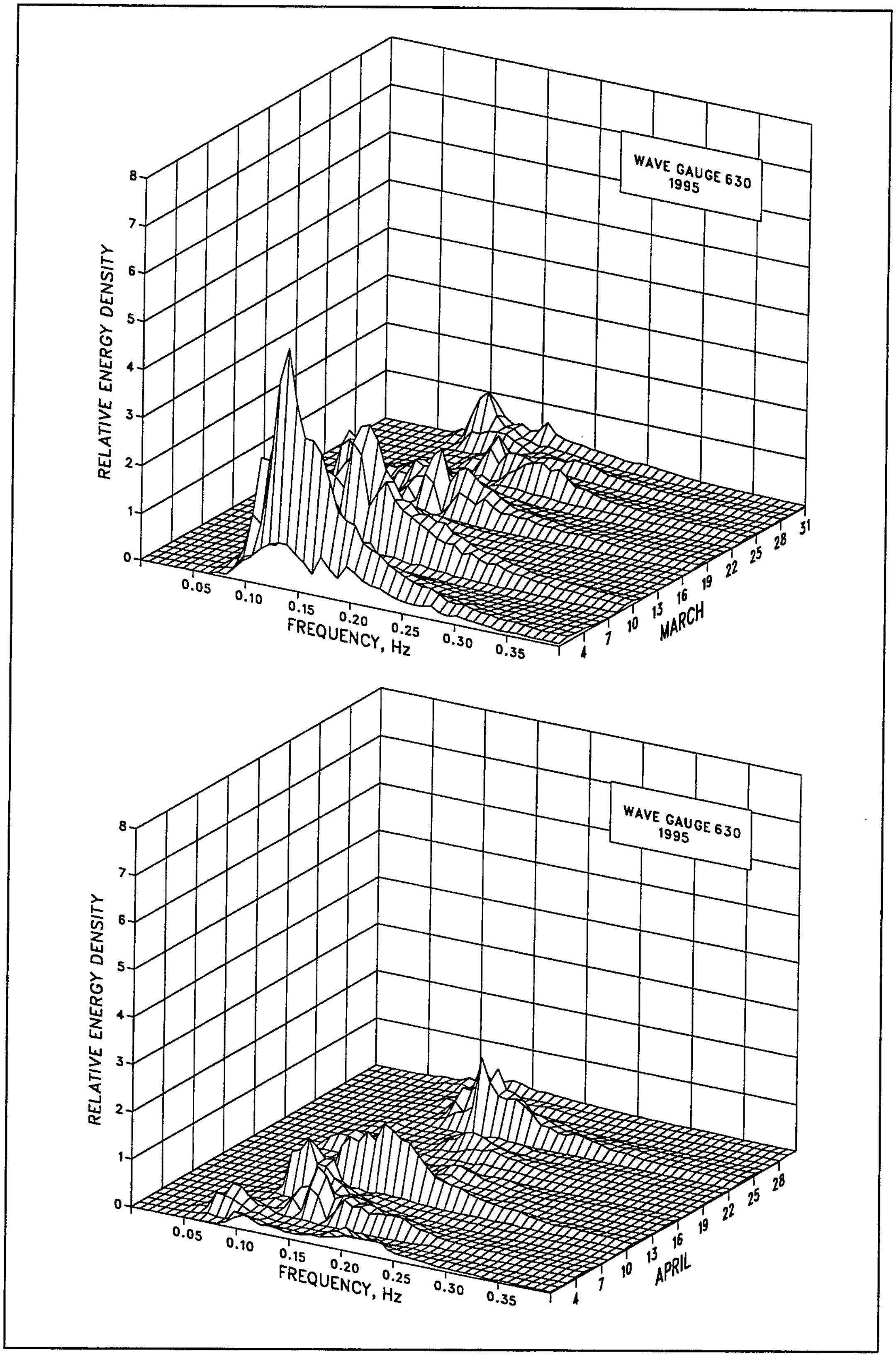

Figure B8. (Sheet 2 of 6)

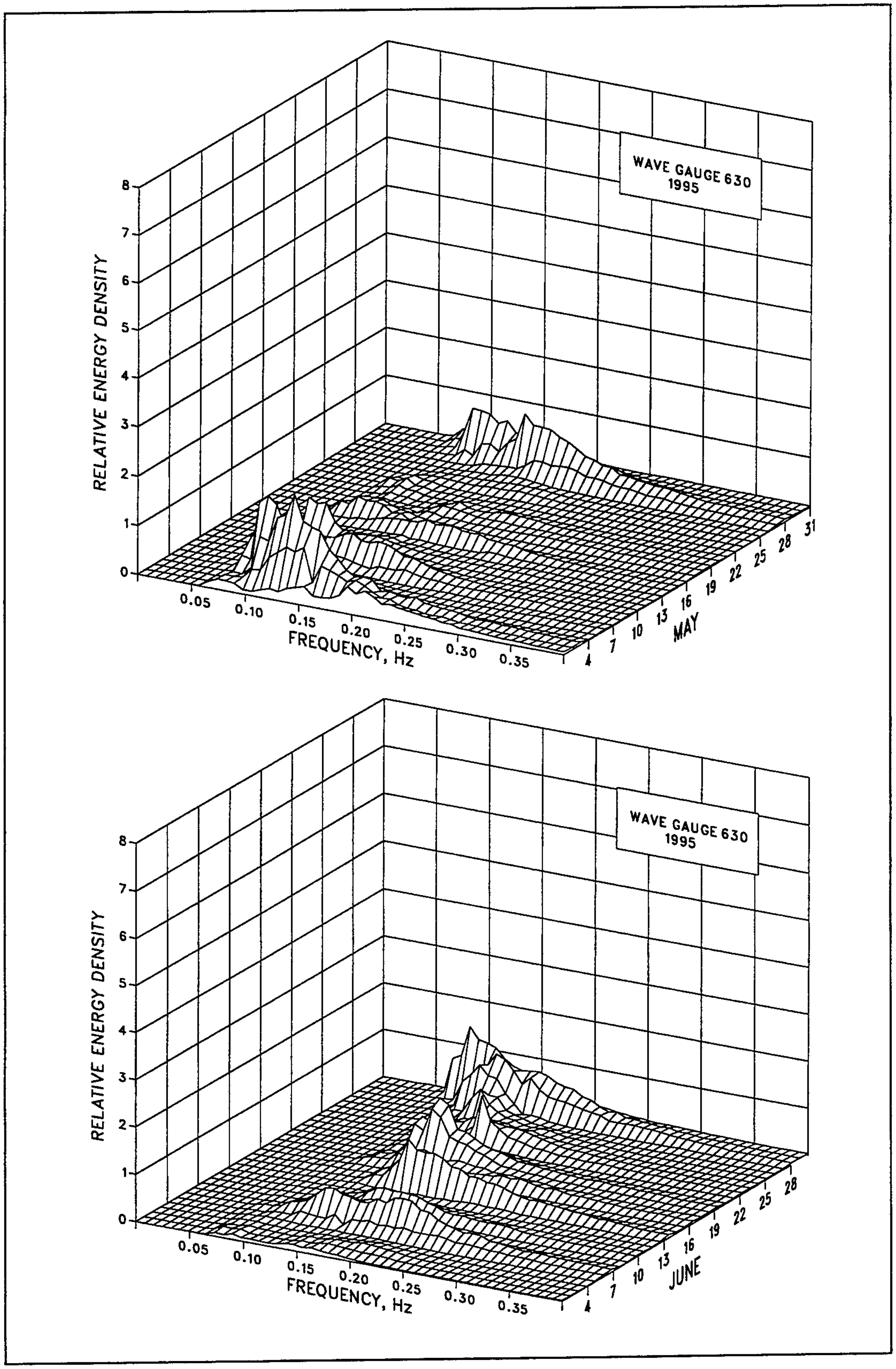

Figure B8. (Sheet 3 of 6)

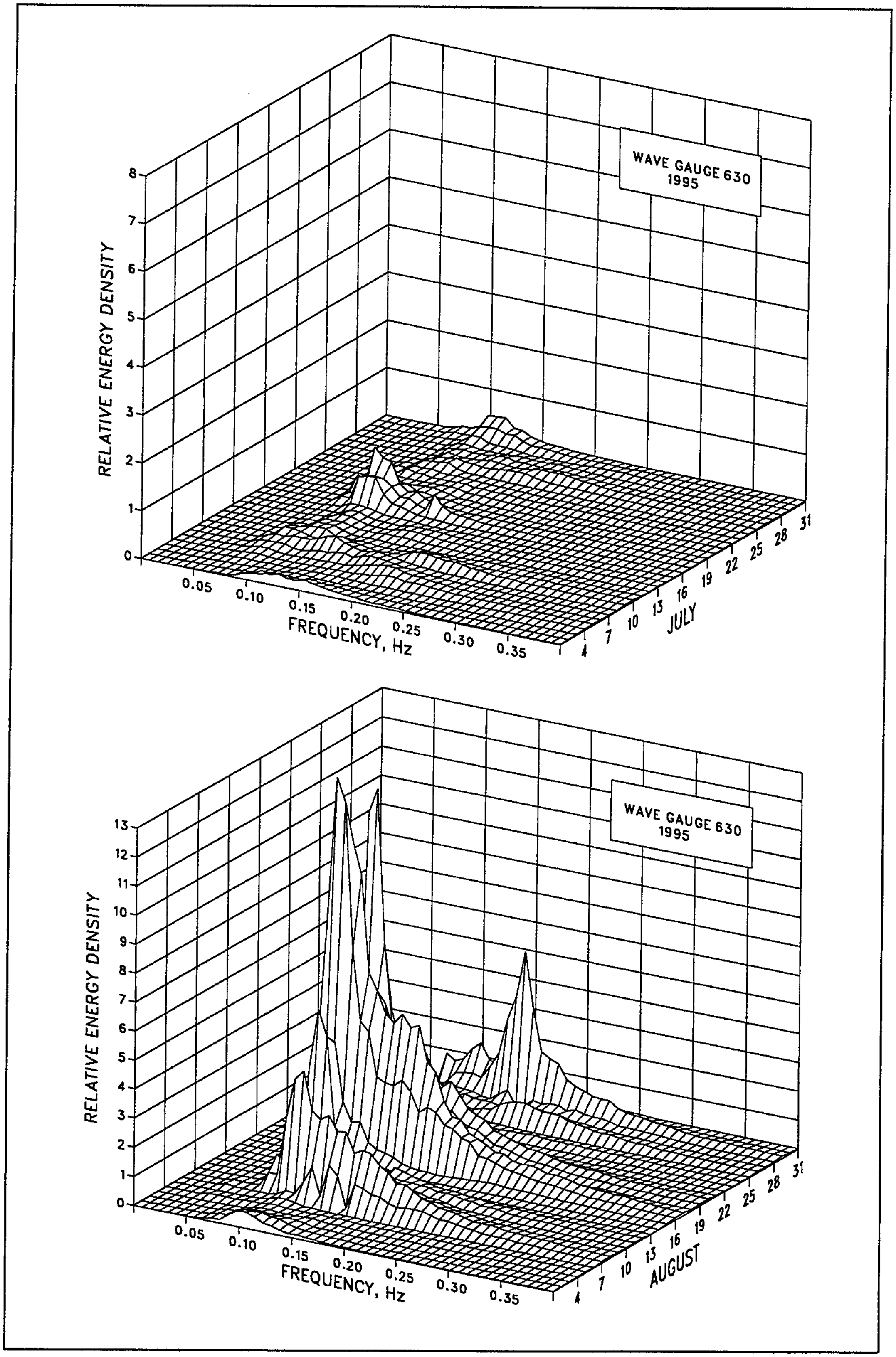

Figure B8. (Sheet 4 of 6)

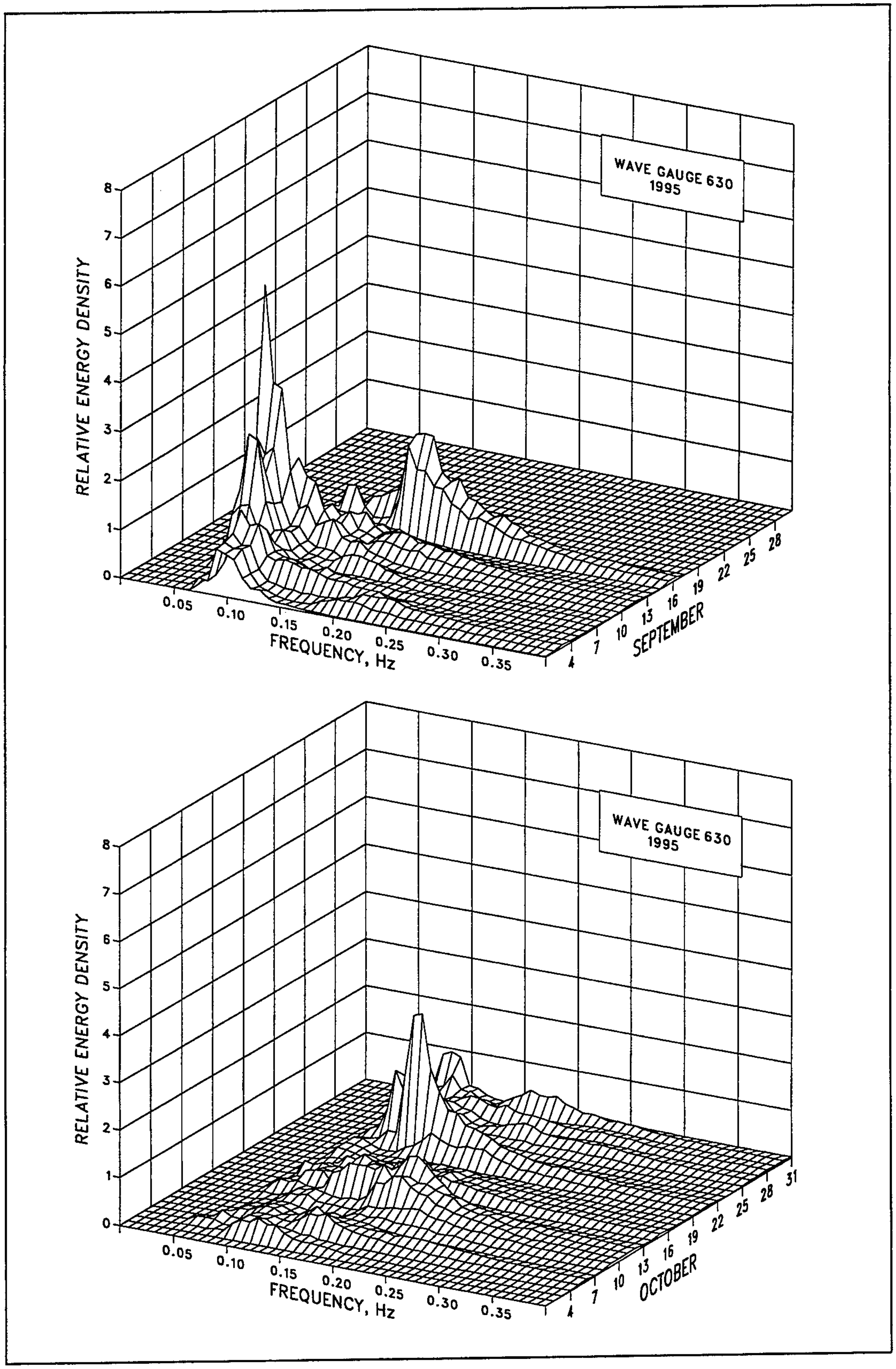

Figure B8. (Sheet 5 of 6)

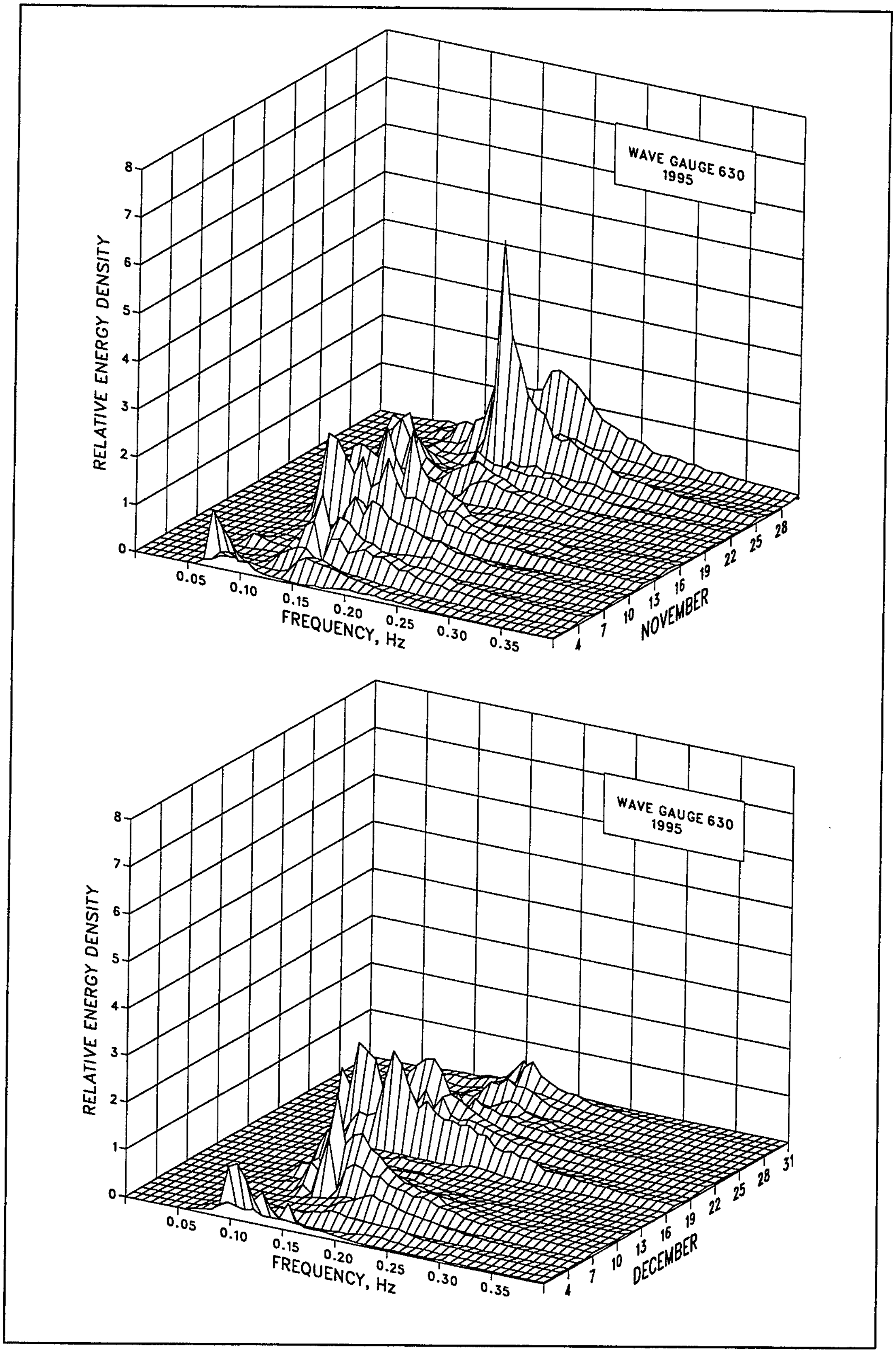

Figure B8. (Sheet 6 of 6)

Table B7
Wave statistics for Gauge 630

	1995							1980-1995						
	Height				Period			Height				Period		
Month	Mean m	Std. Dev. m	Extreme m	Date	Mean sec	Std. Dev. sec	Number Obs.	Mean m	Std. Dev. m	Extreme m	Date	Mean sec	Std. Dev. sec	Number Obs.
Jan	1.2	0.6	3.1	15	8.3	3.0	123	1.2	0.7	4.5	1983	8.1	2.7	1619
Feb	1.0	0.5	2.0	18	7.8	2.7	112	1.2	0.7	5.1	1987	8.4	2.5	1464
Mar	1.2	0.6	2.8	2	8.7	2.3	120	1.2	0.7	4.7	1983	8.6	2.6	1811
Apr	0.9	0.4	2.0	10	7.9	3.2	120	1.0	0.6	5.0	1988	8.6	2.7	1790
May	0.8	0.4	1.9	3	8.8	2.8	124	0.9	0.5	3.6	1994	8.2	2.5	1837
Jun	0.9	0.4	1.8	28	7.3	2.0	120	0.8	0.4	2.7	1991	7.9	2.2	1717
Jul	0.7	0.2	1.1	9	8.6	2.5	123	0.7	0.3	2.1	1985	8.1	2.4	1752
Aug	1.5	0.9	4.2	16	10.0	2.8	113	0.8	0.5	4.2	1995	8.3	2.5	1768
Sep	1.3	0.4	2.4	9	11.5	2.9	61	1.1	0.6	6.1	1985	8.7	2.7	1715
Oct	1.0	0.3	2.0	21	8.4	2.5	114	1.2	0.7	5.4	1991	8.6	2.8	1843
Nov	1.1	0.5	2.5	11	8.7	2.7	118	1.1	0.7	5.1	1994	8.1	2.7	1588
Dec	1.0	0.5	2.4	7	6.5	1.9	124	1.2	0.8	5.6	1980	8.3	2.9	1599
Annual	1.0	0.6	4.2	Aug	8.4	2.8	1372	1.0	0.6	6.1	Sep 1985	8.3	2.6	20503

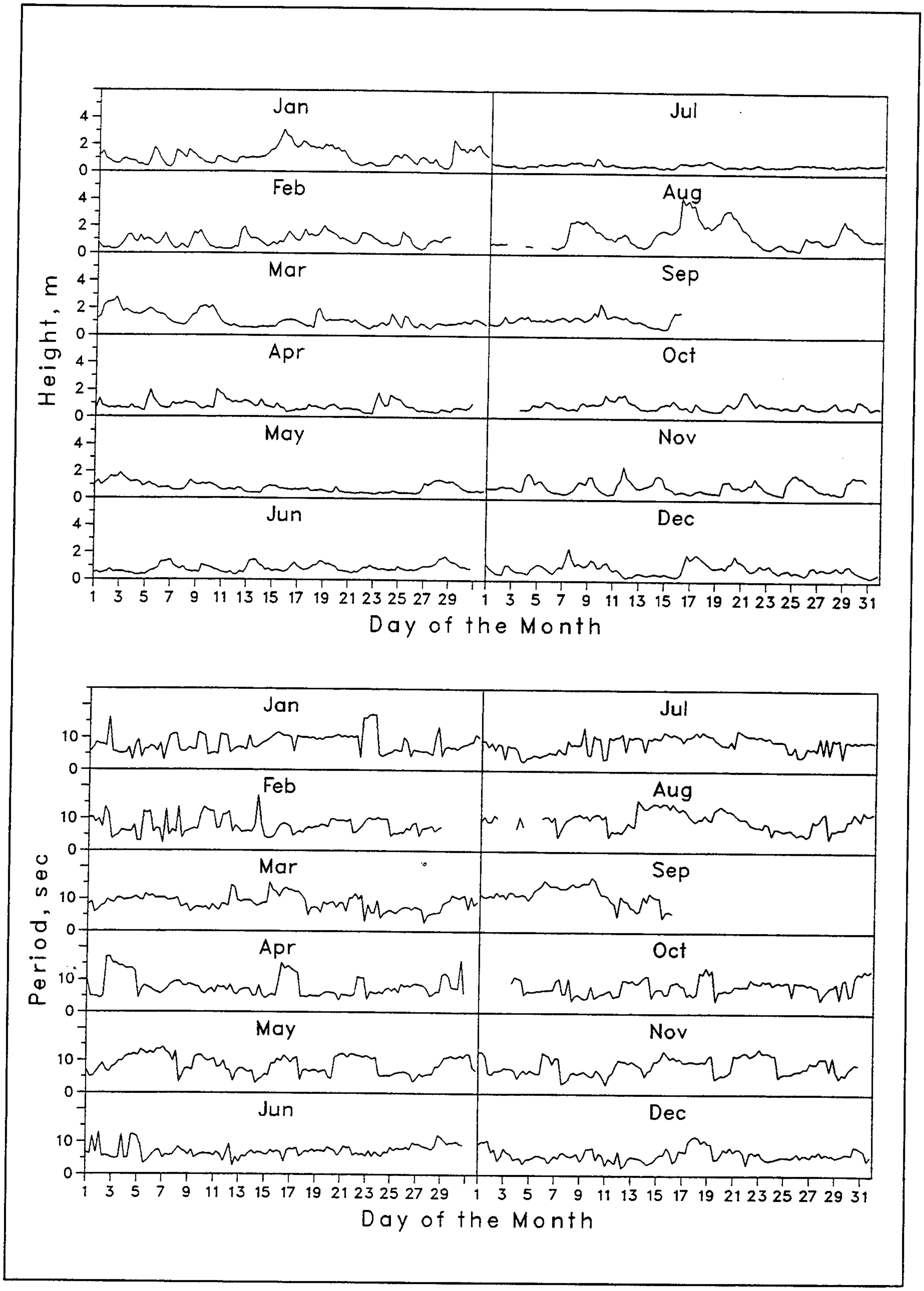

Figure B9. Time-histories of wave height and period for Gauge 630

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This report provides basic data and summaries for measurements made during 1995 at the U.S. Army Engineer Waterways Experiment Station (WES), Coastal and Hydraulics Laboratory's (CHL's) Field Research Facility (FRF) in Duck, NC. The report includes comparisons of the present year's data with cumulative statistics from 1980 to the present.

Summarizes in this report are meteorological and oceanographic data, monthly bathymetric survey results, samples of biannual aerial photography, and descriptions of 10 storms that occurred during the year. The year was highlighted by Hurricane Felix, which impacted the North Carolina coast on 15-18 August.

This report is the 17th in a series of annual summaries of data at the FRF that began with Miscellaneous report CERC-82-16, which summarizes data collected during 1977-1979. These reports are available from the WES Technical Report Distribution Section of the Information Technology Laboratory, Vicksburg, MS.

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