US Army Corps
of Engineers
Waterways Experiment
Station

Preliminary Data Summary for March 1995 CERC Field Research Facility

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Coastal Engineering Research Center

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March 1995
Preliminary Data Summary

by Field Research Facility

U.S. Army Corps of Engineers
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Preface

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

1 Introduction

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. 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 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 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511.

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to eastern standard time (EST).

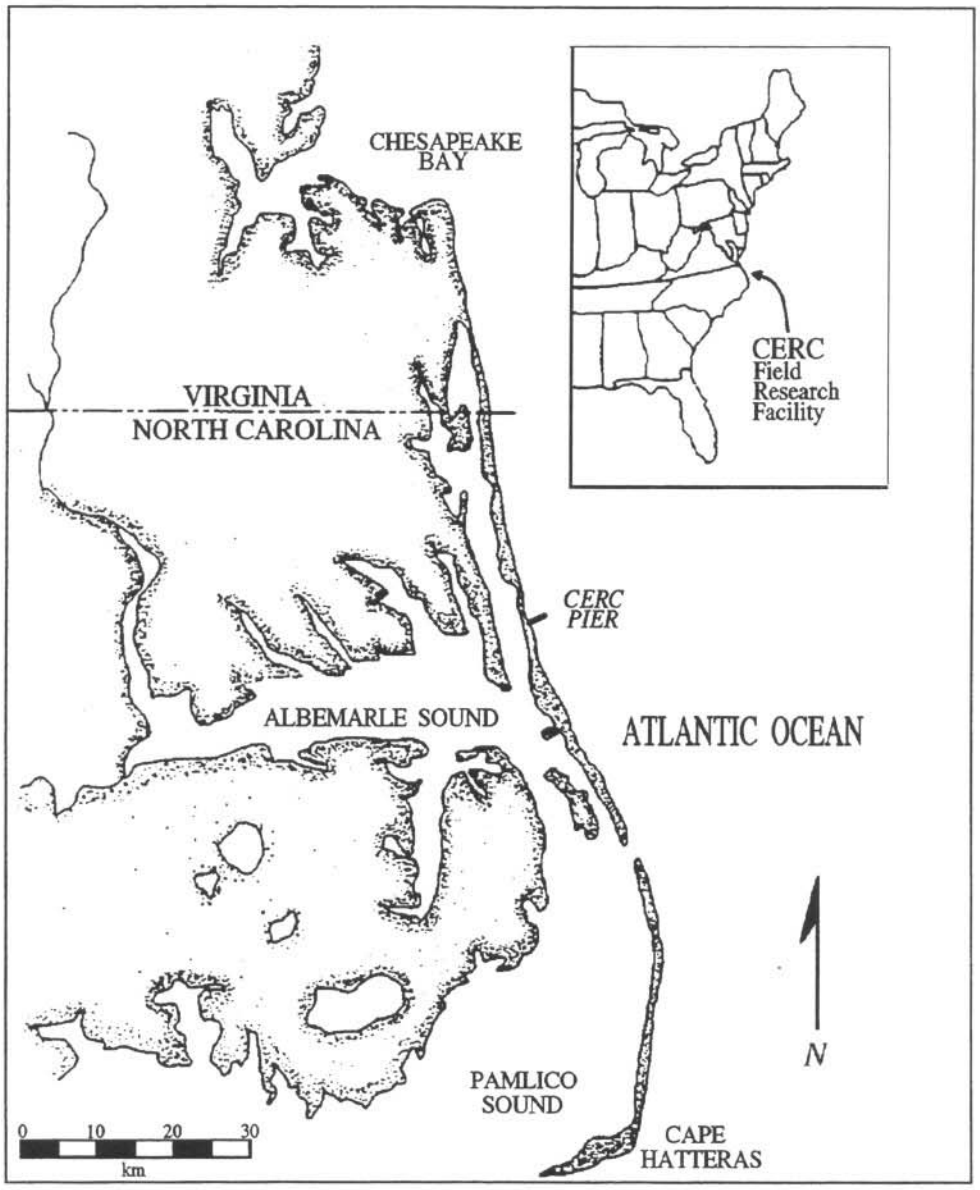

Figure 1. FRF Location Map

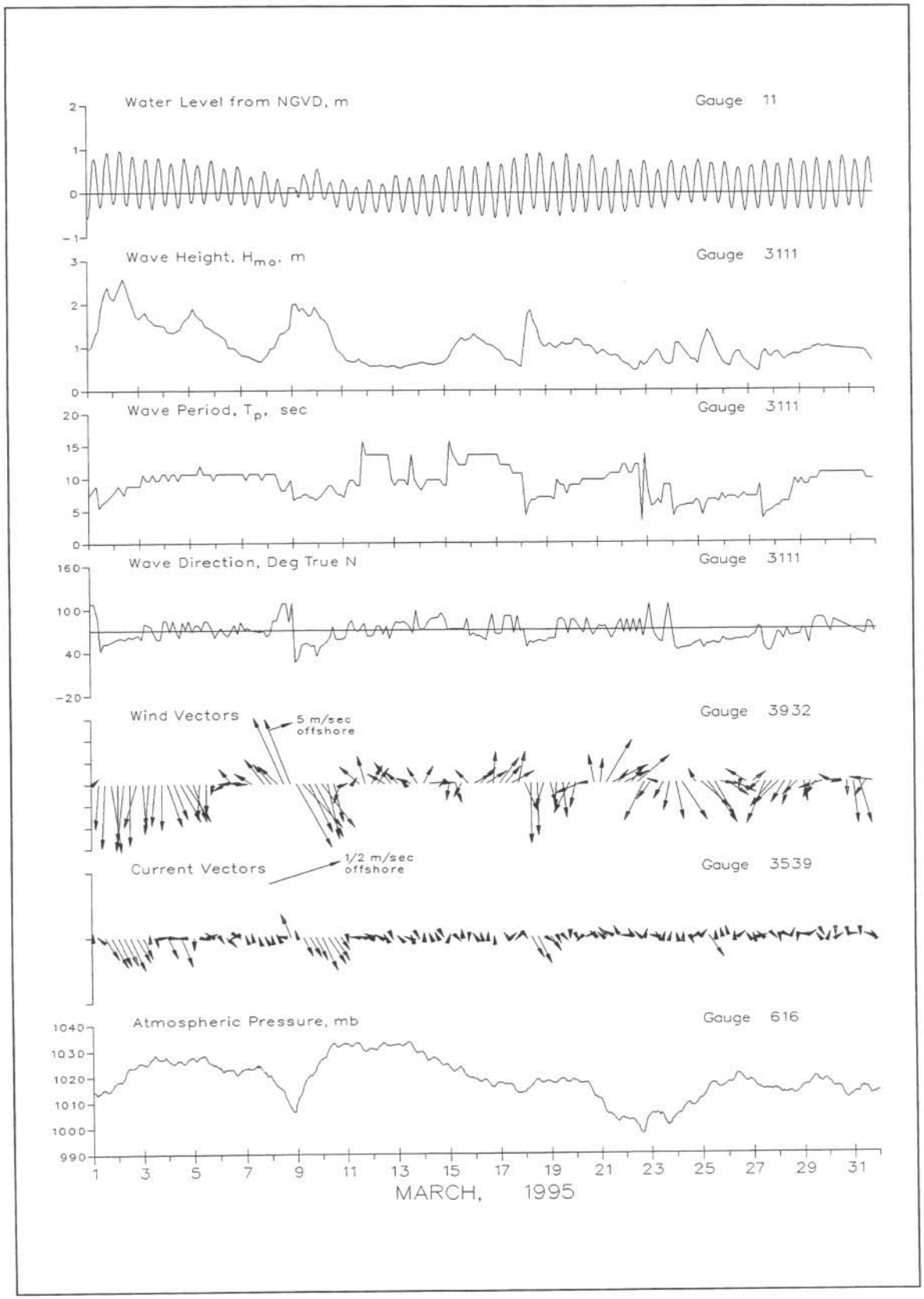

Figure 2. Month at a Glance

Table 1
Instrument Status/Data Availability

March 1995

Day of the month

Gauge ID	Description/Remarks		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
624	Air Temperature	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3932	Anemometer	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
641	Pressure Gauge on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
625	Baylor staff on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3111	8 Meter Array 309 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	/	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	/	
111	Pressure Gauge center of 8 Meter Array	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
630	Waverider buoy 4.0 km offshore	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3539	Current meter 343 m north of FRF pier (1.6 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11	NOAA tide gauge at end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	/	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Visual Observations (daily oceanographic and meteorological observations)	Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Gauge Status * = Operational / = Partial - = Non-Operational
Data Collected * = All / = Partial - = None
Visual Observations * = Complete / = Partial - = None

Table 2
Gauge Locations

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates Crosshore m	FRF Coordinates Longshore m	Gauge Depth NGVD, m	Water Depth NGVD, m
616	Atmospheric Pressure	36 10′ 57.03"	75 45′ 5.50"	11.60	569.00	-----	-----
3932	Anemometer	36 11′ 1.23"	75 44′ 43.07"	585.20	517.30	19.50	-----
641	Pressure Gauge	36 10′ 57.71"	75 44′ 56.23"	239.11	516.64	-1.64	-1.96
625	Baylor Staff	36 11′ 1.04"	75 44′ 43.72"	568.00	516.64	Surface	-8.36
3111	8 Meter Array North	36 11′ 19.14"	75 44′ 36.41"	915.23	990.16	-7.50	-7.90
	8 Meter Array South	36 11′ 11.28"	75 44′ 33.28"	914.20	735.37	-7.42	-7.90
	8 Meter Array East	36 11′ 13.70"	75 44′ 32.56"	954.51	800.58	-7.62	-8.13
	8 Meter Array West	36 11′ 12.48"	75 44′ 37.11"	834.66	800.37	-6.98	-7.44
111	Pressure Gauge in center of 8 M Array	36 11′ 14.06"	75 44′ 34.39"	914.43	825.52	-7.76	-8.08
630	Waverider Buoy	36 10′ 5.10"	75 41′ 59.30"	3934.96	-2400.81	Surface	-17.00
3539	Current Meter	36 11′ 23.57"	75 44′ 9.12"	1605.80	907.60	-11.60	-11.70
11	NOAA Tide Gauge	36 11′ 1.25"	75 44′ 42.60"	596.49	514.20	Surface	-7.62

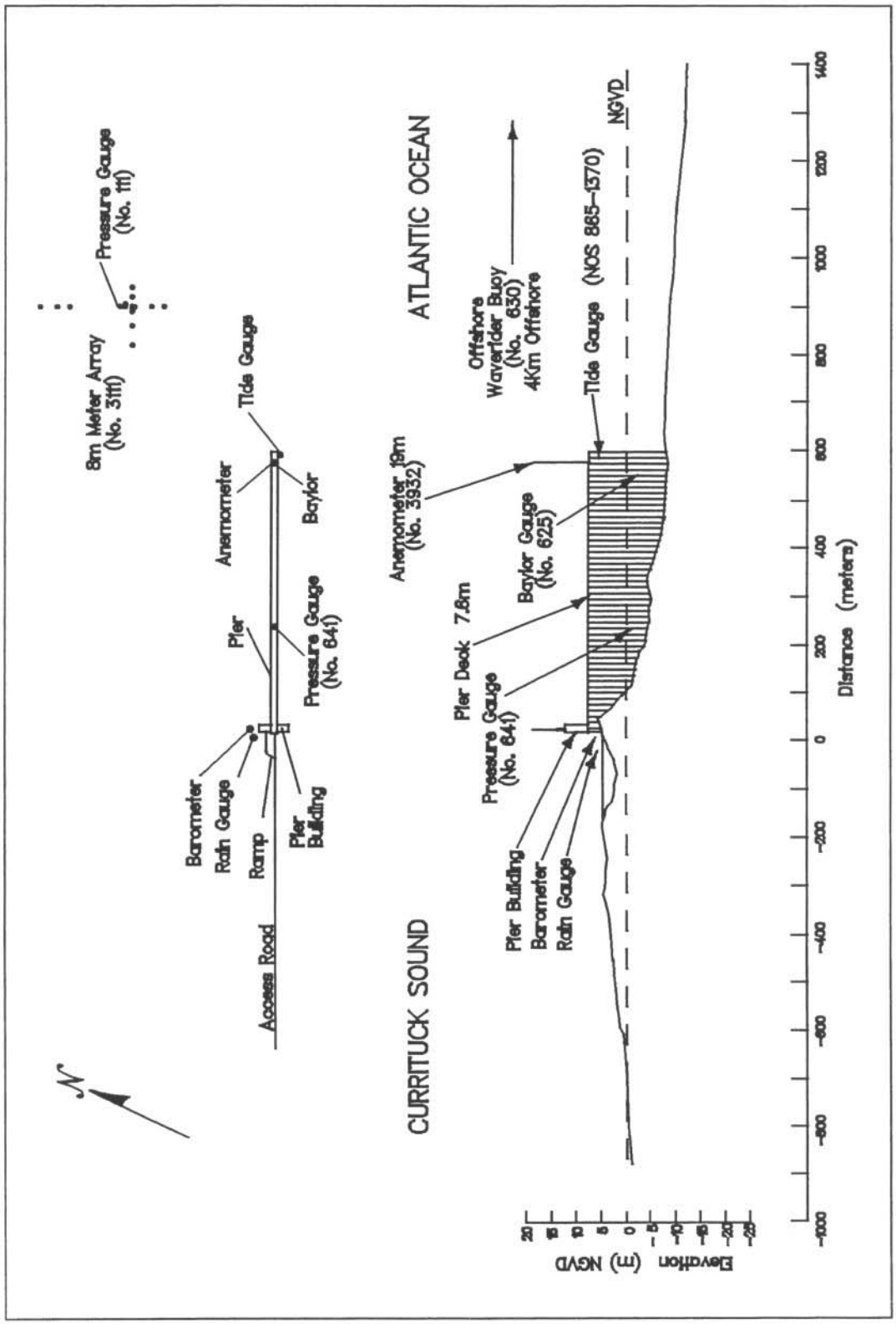

Figure 3. Instrument Locations, Elevations From NGVD

2 Meteorological Data

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
   mm x .03937 = in.

2. Millibars (mb) to inches of mercury (in. Hg) -
   mb x 0.02953 = in. Hg

3. Degrees Celsius (C) to degrees Fahrenheit (F) -
   (C x 9/5) + 32 = F

4. Meters per second (m/s) to knots (kn) -
   m/s x 1.943 = kn

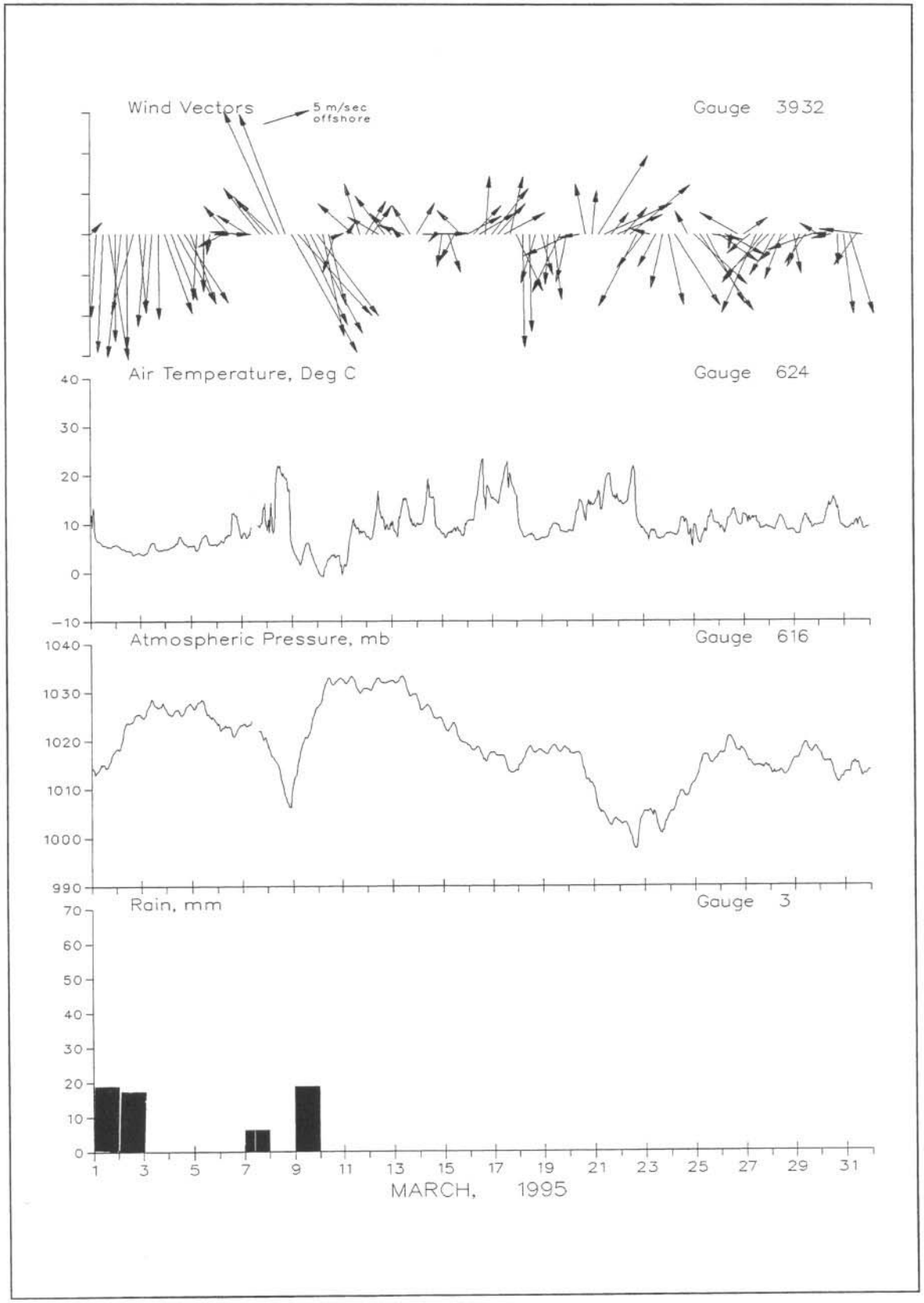

Figure 4. Meteorological Monthly Summary

Table 3
Meteorological Data

Mar 1995

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	2	220	12.1	1014.5	0
	700	10	3	6.5	1013.9	18
	1300	15	2	5.6	1014.7	0
	1900	16	352	5.3	1016.4	0
2	100	13	359	5.8	1018.4	0
	700	15	5	4.8	1021.1	13
	1300	14	1	4.6	1023.6	0
	1900	10	13	3.8	1025.3	0
3	100	10	355	4.0	1025.1	0
	700	11	4	4.2	1026.7	0
	1300	10	4	6.3	1027.5	0
	1900	10	359	4.7	1027.0	0
4	100	10	343	4.8	1026.2	0
	700	8	341	5.3	1025.7	0
	1300	9	335	7.0	1025.7	0
	1900	10	331	5.9	1027.2	0
5	100	9	343	5.5	1027.0	0
	700	8	3	5.0	1028.0	0
	1300	7	1	7.7	1026.1	0
	1900	2	7	5.8	1025.0	0
6	100	0		5.9	1023.5	0
	700	3	59	6.4	1023.0	0
	1300	4	143	7.9	1022.2	0
	1900	2	269	11.6	1022.4	0
7	100	3	95	7.9	1023.6	0
	700	4	126	7.9	1023.4	6
	1300		Hardware Error			0
	1900	7	145	10.3	1021.0	0
8	100	6	143	8.8	1018.8	0
	700	6	138	8.9	1015.9	0
	1300	16	158	22.0	1012.0	0
	1900	16	161	19.4	1007.1	0
9	100	16	334	4.8	1011.9	0
	700	13	321	2.2	1017.6	18
	1300	12	337	5.7	1020.7	0
	1900	13	335	3.8	1024.7	0
10	100	12	326	0.5	1027.3	0
	700	13	349	0.8	1031.4	0
	1300	9	348	3.1	1032.2	0
	1900	5	15	3.3	1032.3	0

Table 3
Meteorological Data (continued)

Mar 1995

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	0		-0.3	1032.7	0
	700	2	209	5.1	1032.7	0
	1300	5	135	9.6	1031.9	0
	1900	6	165	8.6	1030.2	0
12	100	5	206	7.3	1030.7	0
	700	4	209	8.5	1031.9	0
	1300	4	124	12.4	1032.3	0
	1900	6	146	9.5	1032.0	0
13	100	3	140	10.7	1032.5	0
	700	1	146	10.4	1032.7	0
	1300	3	113	15.4	1031.7	0
	1900	4	152	11.3	1029.6	0
14	100	4	205	10.3	1027.9	0
	700	5	268	11.5	1027.0	0
	1300	7	9	15.6	1026.5	0
	1900	1	38	9.5	1024.6	0
15	100	4	7	8.1	1023.1	0
	700	5	344	8.2	1022.7	0
	1300	4	25	8.5	1021.9	0
	1900	4	140	7.7	1019.6	0
16	100	4	237	10.8	1019.0	0
	700	5	219	12.1	1018.4	0
	1300	5	235	21.5	1017.2	0
	1900	7	183	17.6	1016.8	0
17	100	7	214	15.5	1017.6	0
	700	5	217	14.7	1016.9	0
	1300	5	237	21.8	1015.0	0
	1900	7	190	18.6	1013.4	0
18	100	7	338	13.1	1015.0	0
	700	14	359	7.3	1017.2	0
	1300	12	358	7.7	1018.2	0
	1900	6	14	6.7	1017.9	0
19	100	5	347	7.2	1017.5	0
	700	6	2	8.2	1018.3	0
	1300	8	354	10.2	1018.6	0
	1900	8	22	8.6	1018.2	0
20	100	6	10	8.4	1018.1	0
	700	6	63	9.7	1017.4	0
	1300	2	78	15.0	1016.2	0
	1900	6	170	13.6	1012.0	0

Table 3
Meteorological Data (concluded)

Mar 1995

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	5	185	13.9	1010.1	0
	700	11	207	16.3	1005.2	0
	1300	8	240	19.4	1003.9	0
	1900	3	213	16.2	1003.6	0
22	100	5	242	14.9	1003.3	0
	700	4	215	14.4	1003.0	0
	1300	9	225	20.2	999.0	0
	1900	10	23	10.5	1002.4	0
23	100	5	33	8.8	1005.4	0
	700	2	109	8.4	1005.0	0
	1300	4	25	7.2	1002.3	0
	1900	7	10	7.2	1002.8	0
24	100	9	349	8.2	1005.4	0
	700	10	331	7.8	1008.0	0
	1300	5	15	11.4	1008.5	0
	1900	3	155	7.6	1009.7	0
25	100	8	317	9.8	1012.2	0
	700	11	329	6.7	1016.6	0
	1300	9	334	10.7	1016.2	0
	1900	3	281	10.6	1016.0	0
26	100	5	308	9.1	1017.4	0
	700	5	300	9.2	1020.2	0
	1300	2	8	12.9	1019.7	0
	1900	5	124	9.9	1017.7	0
27	100	3	230	11.9	1017.0	0
	700	3	46	11.1	1015.0	0
	1300	10	20	10.3	1014.7	0
	1900	7	35	9.2	1014.8	0
28	100	7	41	9.3	1013.8	0
	700	6	27	9.6	1013.3	0
	1300	6	17	11.3	1013.1	0
	1900	4	42	8.7	1014.1	0
29	100	5	350	8.5	1016.3	0
	700	4	18	9.2	1018.1	0
	1300	4	32	11.3	1018.5	0
	1900	5	68	9.3	1018.3	0
30	100	2	124	9.7	1017.3	0
	700	1	94	11.7	1015.7	0
	1300	2	74	14.6	1013.8	0
	1900	4	358	12.3	1011.5	0
31	100	10	354	9.4	1013.4	0
	700	10	346	9.6	1015.3	0
	1300	4	31	9.6	1014.9	0
	1900	5	98	8.9	1013.0	0
		Resultant		Mean	Mean	Total
		3	357	9.5	1018.7	43

3 Wave Data

Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using a iterative maximum liklihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all H_{mo} and T_p values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

Table 4
Wave Data

Mar 1995

Day	Hour	641 Pressure Gauge Hmo,m	641 Pressure Gauge Tp,sec	625 Baylor Gauge Hmo,m	625 Baylor Gauge Tp,sec	3111 8 Meter Array Hmo,m	3111 8 Meter Array Tp,sec	3111 8 Meter Array Dir,TN	630 Waverider Hmo,m	630 Waverider Tp,sec
1	0100	0.80	7.0	0.85	7.2	0.96	7.6	108	1.21	8.3
	0700	0.89	7.6	1.09	3.8	1.26	8.9	88	1.39	9.2
	1300	0.88	6.1	1.74	6.0	1.94	6.2	52	2.18	5.9
	1900	1.41	7.4	1.87	7.2	2.39	7.1	54	2.39	6.6
2	0100	0.97	8.1	1.91	7.8	2.10	8.2	58	2.46	7.8
	0700	1.42	6.5	2.06	8.6	2.27	8.9	0	2.51	8.1
	1300	1.03	8.6	2.00	9.5	2.40	8.9	62	2.78	9.9
	1900	1.16	9.5	1.78	9.5	1.94	8.9	62	2.17	9.2
3	0100	0.81	8.9	1.52	9.2	1.65	8.9	58	1.73	8.9
	0700	0.95	10.7	1.67	9.9	1.80	9.8	78	1.90	10.3
	1300	0.79	10.3	1.49	10.7	1.60	10.8	66	1.73	10.3
	1900	0.80	9.9	1.35	10.3	1.51	9.8	58	1.59	9.5
4	0100	0.74	5.9	1.35	10.7	1.49	10.8	84	1.58	9.9
	0700	0.66	10.3	1.29	10.3	1.34	10.8	84	1.51	9.9
	1300	0.57	11.7	1.24	10.7	1.38	9.8	60	1.50	9.5
	1900	0.73	12.2	1.40	9.9	1.58	10.8	72	1.72	10.7
5	0100	0.85	11.7	1.54	9.5	1.73	10.8	68	1.93	9.9
	0700	0.96	10.7	1.62	10.7	1.75	10.8	78	1.94	9.5
	1300	0.86	12.2	1.54	11.2	1.62	10.8	84	1.71	11.7
	1900	0.69	11.7	1.32	11.2	1.44	10.8	72	1.56	10.7
6	0100	0.65	11.2	1.25	11.2	1.32	10.8	68	1.55	11.2
	0700	0.58	10.7	1.12	10.3	1.23	10.8	66	1.47	10.3
	1300	0.45	10.3	0.96	9.9	0.99	10.8	68	1.19	10.3
	1900	0.48	10.3	0.95	10.3	0.97	10.8	66	1.01	10.3
7	0100	0.35	9.5	0.78	9.5	0.80	10.8	72	0.88	10.3
	0700	0.29	11.2	0.82	8.9	0.78	10.8	70	0.82	9.5
	1300	0.25	9.5	0.76	9.1	0.68	10.7	0	0.73	9.5
	1900	0.26	11.2	0.77	10.3	0.65	9.8	70	0.72	9.9
8	0100	0.44	5.7	0.80	9.9	0.82	10.8	66	0.87	10.3
	0700	0.63	7.2	1.09	7.4	0.98	10.8	84	1.20	7.6
	1300	0.95	8.1	1.19	8.1	1.30	8.2	108	1.49	7.8
	1900	0.90	8.9	1.30	8.9	1.38	8.9	82	1.53	8.3
9	0100	1.16	6.0	1.56	9.9	1.98	6.6	26	2.05	5.9
	0700	0.98	7.0	1.42	7.4	1.83	7.1	50	2.11	7.0
	1300	1.17	7.4	1.59	7.4	1.82	7.6	52	2.19	7.6
	1900	0.87	7.0	1.42	6.8	1.75	7.1	50	1.96	7.4
10	0100	1.14	7.0	1.48	6.8	1.80	7.1	48	2.19	7.2
	0700	0.78	6.3	1.38	7.4	1.63	8.2	54	1.89	7.6
	1300	0.76	6.0	1.24	8.6	1.33	8.9	76	1.44	6.5
	1900	0.42	6.6	0.88	8.1	0.93	7.6	58	1.06	8.3

Table 4
Wave Data (continued)

Mar 1995

		641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
Day	Hour	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
11	0100	0.35	6.0	0.78	7.4	0.81	7.1	60	0.83	7.2
	0700	0.22	10.2	0.76	8.1	0.66	9.8	84	0.75	6.5
	1300	0.23	15.1	0.79	9.2	0.66	8.9	68	0.67	8.6
	1900	0.26	15.1	0.79	8.6	0.64	15.7	80	0.76	8.3
12	0100	0.23	14.3	0.60	15.1	0.57	13.6	62	0.64	7.8
	0700	0.20	14.3	0.58	14.3	0.56	13.6	76	0.54	14.3
	1300	0.21	13.5	0.54	12.9	0.57	13.6	64	0.60	13.5
	1900	0.19	14.3	0.60	9.9	0.54	13.6	58	0.59	9.5
13	0100	0.19	9.9	0.67	8.9	0.57	8.9	82	0.58	9.2
	0700	0.18	10.3	0.65	9.2	0.51	9.8	82	0.55	9.5
	1300	0.18	9.5	0.64	8.6	0.57	8.9	76	0.56	9.5
	1900	0.23	14.3	0.64	9.9	0.60	9.8	98	0.61	9.5
14	0100	0.23	14.3	0.72	8.6	0.63	8.2	70	0.64	8.6
	0700	0.24	9.2	0.74	8.9	0.61	9.8	82	0.61	7.8
	1300	0.24	9.8	0.75	9.1	0.60	9.7	0	0.61	9.5
	1900	0.24	9.9	0.60	9.2	0.61	9.8	94	0.64	8.9
15	0100	0.23	17.1	0.64	8.6	0.68	8.9	70	0.67	8.9
	0700	0.38	14.3	0.77	14.3	0.92	13.6	72	0.90	15.1
	1300	0.49	14.3	0.92	12.9	1.12	12.0	72	1.06	12.9
	1900	0.53	12.2	1.03	12.2	1.15	12.0	86	1.12	12.2
16	0100	0.64	13.5	1.18	13.5	1.21	13.6	66	1.15	10.7
	0700	0.57	13.5	1.18	13.5	1.21	13.6	62	1.15	12.9
	1300	0.65	13.5	1.21	13.5	1.12	13.6	56	1.12	13.5
	1900	0.49	13.5	1.08	13.5	1.05	13.6	92	1.01	12.9
17	0100	0.37	13.5	0.99	12.9	0.95	13.6	64	0.89	12.9
	0700	0.31	12.9	0.83	12.2	0.81	12.0	90	0.81	12.2
	1300	0.19	12.2	0.72	11.7	0.69	12.0	90	0.67	12.2
	1900	0.29	11.7	0.64	11.2	0.64	10.8	90	0.73	11.2
18	0100	0.17	11.2	0.54	11.2	0.53	10.8	72	0.56	9.9
	0700	1.11	5.0	1.46	5.7	1.76	5.9	54	1.79	5.1
	1300	0.67	5.9	1.50	7.0	1.55	6.6	54	1.98	7.2
	1900	0.66	6.8	1.11	7.2	1.14	7.1	54	1.29	7.6
19	0100	0.39	3.8	0.98	7.6	1.01	7.1	58	1.06	7.2
	0700	0.41	6.3	1.02	6.0	1.01	6.6	58	1.15	5.9
	1300	0.41	3.3	1.03	9.2	1.02	8.9	86	1.13	9.2
	1900	0.44	8.3	1.08	8.9	1.05	7.6	64	1.13	8.3
20	0100	0.36	17.1	0.99	9.2	1.06	8.9	84	1.12	8.9
	0700	0.45	7.4	1.07	9.2	1.15	8.9	70	1.17	9.2
	1300	0.38	7.4	0.96	10.3	1.01	9.8	86	1.13	7.4
	1900	0.46	4.6	1.04	9.9	1.01	9.8	62	1.12	8.9

Table 4
Wave Data (concluded)

Mar 1995

		641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
Day	Hour	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
21	0100	0.35	9.9	0.82	9.5	0.82	9.8	76	0.93	8.9
	0700	0.54	6.6	1.02	6.5	0.91	9.8	76	1.16	6.1
	1300	0.43	6.8	0.91	10.7	0.79	10.8	58	0.92	10.3
	1900	0.40	7.8	0.87	10.7	0.80	10.8	76	0.80	10.3
22	0100	0.38	14.3	0.68	12.2	0.67	12.0	66	0.69	11.7
	0700	0.23	13.5	0.61	11.7	0.59	10.8	66	0.55	9.9
	1300	0.22	12.2	0.56	13.5	0.45	12.0	66	0.51	11.2
	1900	0.39	3.2	0.82	3.2	0.64	3.4	60	0.73	3.2
23	0100	0.38	8.1	0.61	3.6	0.61	8.2	106	0.69	8.3
	0700	0.29	4.1	0.82	5.2	0.82	5.9	60	0.88	5.7
	1300	0.46	4.6	0.91	8.9	0.84	5.9	52	0.97	5.7
	1900	0.29	2.9	0.71	8.9	0.60	8.9	106	0.75	9.5
24	0100	0.36	4.0	0.56	3.9	0.61	4.1	46	0.94	4.2
	0700	0.66	5.2	0.98	5.6	1.08	5.6	44	1.62	5.4
	1300	0.72	5.6	1.05	5.8	0.80	5.8	0	1.55	6.4
	1900	0.26	5.9	0.67	5.5	0.69	5.9	50	0.82	6.6
25	0100	0.31	5.6	0.52	6.3	0.60	6.2	54	0.60	6.1
	0700	0.64	5.5	1.01	6.0	1.16	5.9	50	1.47	5.6
	1300	0.77	6.6	1.13	7.0	1.23	6.6	52	1.33	6.6
	1900	0.40	5.7	0.90	6.6	0.87	6.2	50	0.94	7.2
26	0100	0.25	6.6	0.71	7.2	0.60	6.6	54	0.69	7.6
	0700	0.23	5.9	0.57	7.0	0.54	7.1	54	0.62	7.4
	1300	0.31	3.8	0.86	6.8	0.87	6.6	56	0.91	6.8
	1900	0.26	8.3	0.81	7.4	0.71	7.6	58	0.82	7.6
27	0100	0.19	5.0	0.60	7.0	0.57	7.1	60	0.65	7.2
	0700	0.17	9.5	0.54	6.8	0.45	7.1	74	0.51	6.8
	1300	0.38	3.0	0.72	3.0	0.79	3.6	46	0.72	2.7
	1900	0.47	4.8	0.84	4.8	0.78	4.8	40	0.89	5.0
28	0100	0.33	4.7	0.94	5.4	0.84	5.6	66	0.89	5.5
	0700	0.36	5.4	0.87	5.7	0.76	6.2	56	0.86	5.7
	1300	0.26	4.0	0.72	5.9	0.74	6.2	60	0.78	5.7
	1900	0.39	4.3	0.80	5.9	0.82	9.8	62	0.87	6.0
29	0100	0.26	9.8	0.84	8.9	0.81	9.8	72	0.85	8.6
	0700	0.32	8.9	0.80	8.3	0.90	8.9	50	0.86	9.2
	1300	0.26	10.7	0.91	10.3	0.96	9.8	84	0.97	9.5
	1900	0.40	10.7	1.01	9.2	1.01	10.8	86	0.94	11.2
30	0100	0.29	10.7	0.98	10.3	0.99	10.8	72	1.07	10.7
	0700	0.38	11.2	0.90	11.2	0.96	10.8	82	0.97	10.3
	1300	0.29	10.7	1.08	10.7				0.95	10.7
	1900	0.59	11.2	1.04	10.3				1.19	11.2
31	0100	0.55	3.3	1.15	11.2	Inoperative			1.17	7.0
	0700	0.49	4.5	0.95	11.2				1.09	10.7
	1300	0.26	10.7	0.84	9.9	0.90	10.8	62	0.98	8.1
	1900	0.37	7.6	0.80	9.5	0.76	9.8	78	0.81	9.2
Mean		0.51	8.9	1.01	9.0	1.04	9.2	65	1.14	8.8
Std dev		0.29	3.4	0.35	2.5	0.45	2.4	19	0.51	2.3

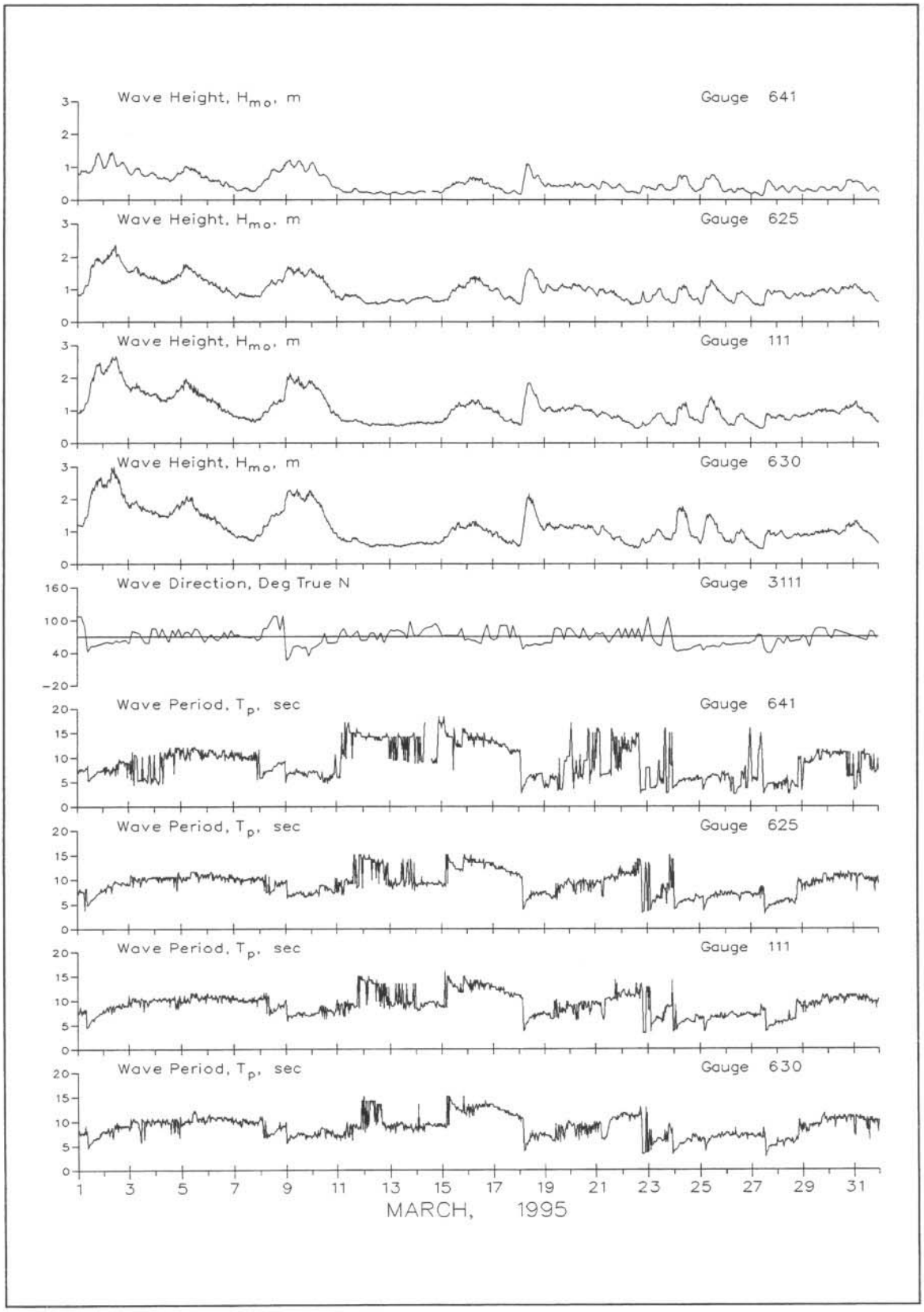

Figure 5. Wave Heights and Periods

4 Current Data

Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

Table 5
Current Meter Data - Gauge 3539

MARCH 1995

Day	Time	Cross Shore	Long Shore	Speed	Dir
1	100	0	-3	4	355
	700	1	0	2	313
	1300	-2	18	19	152
	1900	-1	25	25	155
2	100	0	23	23	158
	700	0	23	23	157
	1300	0	27	27	159
	1900	-1	21	21	154
3	100	0	17	17	159
	700	0	-2	3	355
	1300	1	7	7	167
	1900	-4	1	5	81
4	100	0	17	17	159
	700	-2	1	3	95
	1300	0	23	23	161
	1900	7	-1	7	267
5	100	3	9	10	179
	700	-5	4	7	103
	1300	-6	0	7	67
	1900	4	-4	7	305
6	100	0	5	5	151
	700	-3	9	10	139
	1300	2	0	2	241
	1900	0	1	1	127
7	100	0	-1	2	341
	700	0	-2	3	348
	1300	0	0	0	
	1900	0	0	0	
8	100	0	-1	2	350
	700	0	-1	2	332
	1300	5	-2	6	281
	1900	0	-18	19	340
9	100	0	-4	5	342
	700	0	16	16	157
	1300	-1	17	17	153
	1900	0	19	19	156
10	100	0	27	27	158
	700	-3	23	23	151
	1300	-2	20	20	151
	1900	-1	11	11	149
11	100	1	5	5	170
	700	2	0	3	278
	1300	2	0	2	281
	1900	1	0	1	294
12	100	4	-3	6	296
	700	2	-2	3	303
	1300	0	-1	2	332
	1900	0	2	2	159
13	100	0	0	0	
	700	0	0	0	
	1300	0	0	0	
	1900	0	2	2	153
14	100	0	-2	3	358
	700	0	-2	3	338
	1300	1	-3	4	333
	1900	0	1	1	149
15	100	0	0	0	
	700	-1	4	5	138
	1300	0	-5	6	351
	1900	2	4	4	185
16	100	1	-2	3	328
	700	0	-2	3	347
	1300	0	-2	3	360
	1900	0	0	0	
17	100				
	700	1	-2	3	326
	1300	-2	-1	3	43
	1900	4	2	4	220
18	100	0	3	3	148
	700	-1	18	18	154
	1300	0	23	23	157
	1900	-3	7	8	128
19	100	-1	13	13	150
	700	0	6	6	154
	1300	-1	5	5	141
	1900	1	2	2	182
20	100	0	5	5	154
	700	6	3	6	223
	1300	2	0	2	242
	1900	2	-4	5	318
21	100	2	-2	4	313
	700	3	-7	9	317
	1300	5	-5	7	299
	1900	1	-7	8	331
22	100	3	0	3	273
	700	1	-5	6	335
	1300	2	-2	4	316
	1900	-2	-3	5	15
23	100	1	0	1	286
	700	0	-2	3	332
	1300	0	-1	2	13
	1900	0	-1	2	13
24	100	0	-1	2	347
	700	0	-1	2	4
	1300	0	7	7	158
	1900	4	1	5	232
25	100	-3	-2	5	35
	700	-2	19	19	151
	1300	0	-2	3	353
	1900	0	-4	5	349
26	100	0	-6	7	344
	700	0	-2	3	359
	1300	-3	0	4	49
	1900	0	-1	2	325
27	100	0	0	0	
	700	1	-1	3	314
	1300	0	0	0	
	1900	-1	4	4	137
28	100	1	6	6	171
	700	-2	3	4	118
	1300	-2	-3	5	22
	1900	3	5	6	188
29	100	4	-1	5	275
	700	-4	0	5	54
	1300	0	0	0	
	1900	0	2	2	152
30	100	0	-1	2	19
	700	1	1	2	178
	1300	0	0	0	
	1900	0	2	2	168
31	100	-2	1	3	87
	700	0	2	2	174
	1300	2	0	2	289
	1900	0	-1	2	330

KEY:

+cross-shore = offshore, cm/sec
-cross-shore = onshore, cm/sec
+longshore = south, cm/sec
-longshore = north, cm/sec
Speed = Resultant speed, cm/sec
Dir = Resultant direction, degrees true north

Table 6
Visually Observed Current Data

Mar 1995

	Pier End				Mid-Surf Zone				Beach		
Day	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir
1	0	102	102	160	0	152	152	160	no observation		
2	0	47	47	160	-4	36	36	166	North	23	S
3	-6	55	56	166	-20	102	104	171	North	30	S
4	0	68	68	160	20	102	104	149	North	26	S
5	0	61	61	160	30	102	106	143	North	29	S
6	6	29	30	149	5	47	47	154	North	9	N
7	4	-21	21	351	0	-41	41	340	South	5	N
8	0	-24	24	340	0	-55	55	340	South	44	N
9	0	87	87	160	0	76	76	160	North	82	S
10	0	102	102	160	-15	76	78	171	North	47	S
11	0	0	0		19	21	28	118	North	0	
12	0	-24	24	340	24	-20	32	30	South	21	N
13	0	-23	23	340	5	-7	9	19	no observation		
14	4	10	11	70	35	-17	39	43	South	6	N
15	0	55	55	160	-7	44	44	169	North	22	S
16	0	0	0		45	-23	50	42	South	12	N
17	15	15	21	70	30	-16	34	42	South	0	
18	0	0	0		-6	-12	14	313	South	15	S
19	-4	44	44	166	0	51	51	160	North	20	S
20	0	76	76	160	-26	87	91	177	North	75	S
21	20	-34	39	11	15	-51	53	357	South	12	N
22	17	-17	25	25	24	-24	34	25	South	27	N
23	3	-5	6	7	26	17	31	104	North	9	S
24	0	51	51	160	10	68	68	151	North	40	S
25	0	68	68	160	26	87	91	143	North	62	S
26	0	23	23	160	-6	61	61	166	North	24	S
27	-2	3	4	184	0	12	12	160	North	2	S
28	0	27	27	160	-2	24	25	166	North	14	S
29	-8	51	51	169	3	22	22	151	North	11	S
30	0	3	3	160	21	-28	35	17	South	21	N
31	0	61	61	160	0	51	51	160	North	37	S

KEY:
+cross-shore = offshore, cm/sec
-cross-shore = onshore, cm/sec
+longshore = south, cm/sec
-longshore = north, cm/sec
Speed = Resultant speed, cm/sec

5 Visual Observations

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 7
Visual Observations

Mar 1995

Day	Time	Wave Approach Angle at Pier End deg from True N Primary	Secondary	Radar Wave Angle deg from True N	Width of Surf Zone,m	Water Characteristics at Pier End Temp.,C	Density g/cc	Secchi Vis.,m
1	0730	25	95	90	108	6.7	1.0238	3.4
2	0720	55	30	55	340	6.1	1.0240	0.6
3	0730	70	25	80	162	5.6	1.0237	0.9
4	0940	70	25	70	148	5.8	1.0229	0.9
5	1045	70	25	65	235	6.1	1.0230	0.6
6	0745	70	35		147	6.1	1.0224	1.5
7	0800	80			5	6.7	1.0224	1.8
8	0740	105		90	123	6.1	1.0257	2.7
9	0730	40	0	45	273	6.9	1.0258	0.6
10	0725	55	15	55	193	5.0	1.0254	0.6
11	1023	60			137	5.8	1.0228	2.7
12	1048	110			101	6.7	1.0230	3.0
13	1015	30	100		117	7.2	1.0232	3.0
14	0920	90			117	7.8	1.0245	3.7
15	0915	75	30		98	8.9	1.0232	2.1
16	0843	95			184	9.2	1.0226	4.0
17	0848	75			87	7.2	1.0251	4.6
20	0755	75		70	130	8.6	1.0227	4.3
19	1040	70	15	70	114	8.3	1.0241	3.7
18	1050	50	5	50	207	6.9	1.0254	1.5
21	0716	75	140	75	110	8.6	1.0236	2.1
22	0750	50	120		91	8.3	1.0246	3.4
23	0815	45			131	8.3	1.0247	4.6
24	0718	40	25	35	126	8.9	1.0222	2.4
25	1052	45	20	50	155	8.9	1.0214	0.9
26	1030	60	20	60	130	9.4	1.0212	2.4
27	0712	70			3	9.4	1.0216	2.7
28	0715	70	25	65	6	9.4	1.0222	3.0
29	0719	70		70	113	9.4	1.0224	3.7
30	0708	70			119	10.0	1.0230	3.4
31	0708	75	45	60	119	10.3	1.0222	2.1

6 Water Levels

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

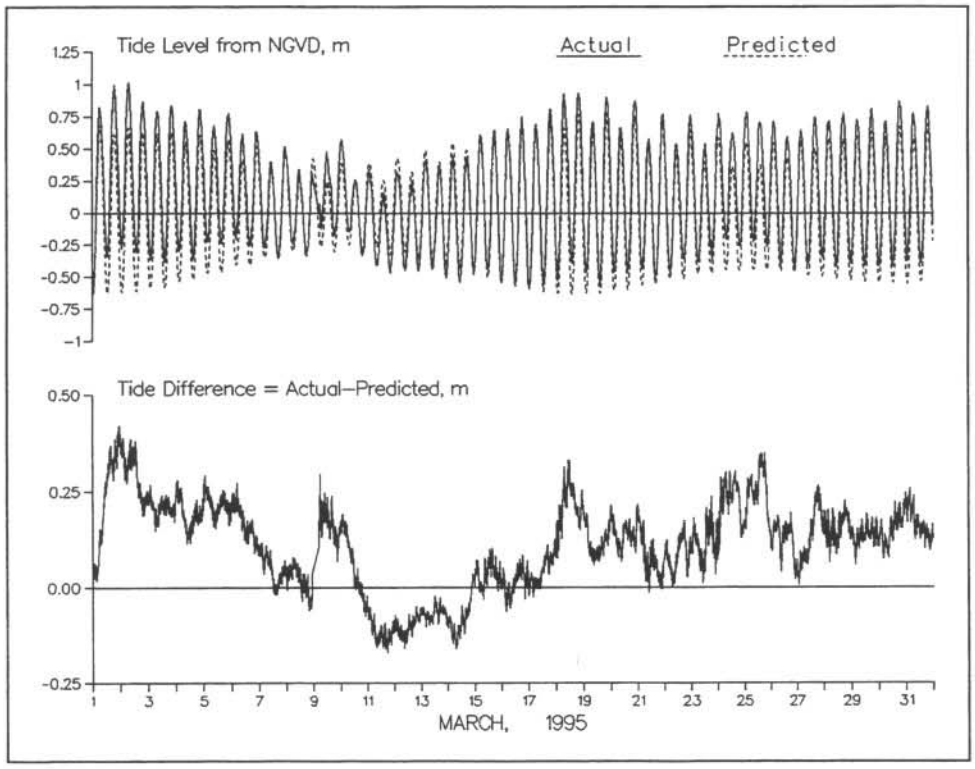

Figure 6. Water Level Variation

Table 8
Water Levels, m NGVD

MAR 1995 Tide Levels

	High			Low		Mean	Range		High			Low		Mean	Range
Day	Time	m	Day	Time	m	m	m	Day	Time	m	Day	Time	m	m	m
1	0642	0.82	1	0030	-0.60	0.19	1.43	16	1854	0.75	16	1230	-0.55	0.08	1.30
1	1942	0.99	1	1306	-0.34	0.32	1.34	17	0712	0.69	17	0054	-0.59	0.05	1.28
2	0748	1.02	2	0142	-0.28	0.36	1.30	17	1930	0.81	17	1312	-0.56	0.13	1.37
2	2006	0.87	2	1406	-0.31	0.28	1.18	18	0712	0.93	18	0148	-0.53	0.22	1.46
3	0836	0.79	3	0218	-0.37	0.22	1.16	18	1954	0.93	18	1418	-0.40	0.29	1.33
3	2048	0.83	3	1430	-0.38	0.24	1.22	19	0900	0.71	19	0230	-0.47	0.12	1.17
4	0906	0.71	4	0318	-0.31	0.21	1.02	19	2048	0.90	19	1454	-0.54	0.20	1.44
4	2100	0.81	4	1448	-0.37	0.23	1.18	20	0900	0.66	20	0318	-0.47	0.12	1.13
5	0948	0.68	5	0336	-0.23	0.22	0.91	20	2224	0.87	20	1530	-0.47	0.22	1.34
5	2230	0.77	5	1524	-0.24	0.26	1.01	21	1106	0.58	21	0412	-0.44	0.07	1.02
6	1024	0.61	6	0430	-0.21	0.19	0.82	21	2312	0.77	21	1612	-0.50	0.12	1.27
6	2236	0.63	6	1612	-0.26	0.18	0.90	22	1130	0.54	22	0542	-0.48	0.04	1.02
7	1030	0.40	7	0518	-0.28	0.05	0.67	22	2336	0.76	22	1712	-0.36	0.18	1.12
7	2312	0.51	7	1654	-0.36	0.08	0.87	23	1306	0.54	23	0642	-0.39	0.07	0.92
8	1154	0.34	8	0630	-0.24	0.03	0.58	24	0106	0.77	23	1900	-0.37	0.21	1.14
9	0006		8	1754	No data this cycle			24	1342	0.62	24	0748	-0.21	0.22	0.83
9	1218	0.47	9	0712	-0.13	0.18	0.60	25	0248	0.79	24	2030	-0.26	0.26	1.04
10	0106	0.57	9	1818	-0.18	0.20	0.75	25	1442	0.70	25	0842	-0.23	0.26	0.93
10	1348	0.25	10	0818	-0.15	0.06	0.41	26	0336	0.71	25	2106	-0.27	0.23	0.98
11	0212	0.33	10	1948	-0.34	-0.01	0.67	26	1554	0.59	26	0924	-0.41	0.13	1.00
11	1524	0.16	11	0918	-0.41	-0.13	0.57	27	0442	0.64	26	2218	-0.44	0.11	1.08
12	0254	0.32	11	2106	-0.47	-0.06	0.79	27	1706	0.74	27	1018	-0.40	0.17	1.14
12	1606	0.24	12	0942	-0.45	-0.10	0.69	28	0536	0.71	27	2306	-0.35	0.20	1.06
13	0418	0.41	12	2154	-0.46	-0.02	0.87	28	1806	0.77	28	1112	-0.43	0.19	1.20
13	1630	0.37	13	1012	-0.44	-0.05	0.81	29	0542	0.72	28	2336	-0.39	0.17	1.12
14	0524	0.44	13	2242	-0.51	-0.05	0.96	29	1818	0.81	29	1206	-0.42	0.19	1.23
14	1724	0.43	14	1100	-0.54	-0.05	0.97	30	0624	0.71	30	0042	-0.42	0.15	1.13
15	0530	0.61	14	2342	-0.48	0.08	1.09	30	1836	0.87	30	1236	-0.42	0.24	1.29
15	1842	0.65	15	1154	-0.45	0.08	1.10	31	0636	0.77	31	0112	-0.38	0.21	1.15
16	0624	0.65	16	0024	-0.55	0.05	1.20	31	2006	0.83	31	1318	-0.39	0.22	1.22

7 Bathymetry

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in February 1995 and the survey(s) in March 1995 on profile line 188, located 517 m south of the pier.

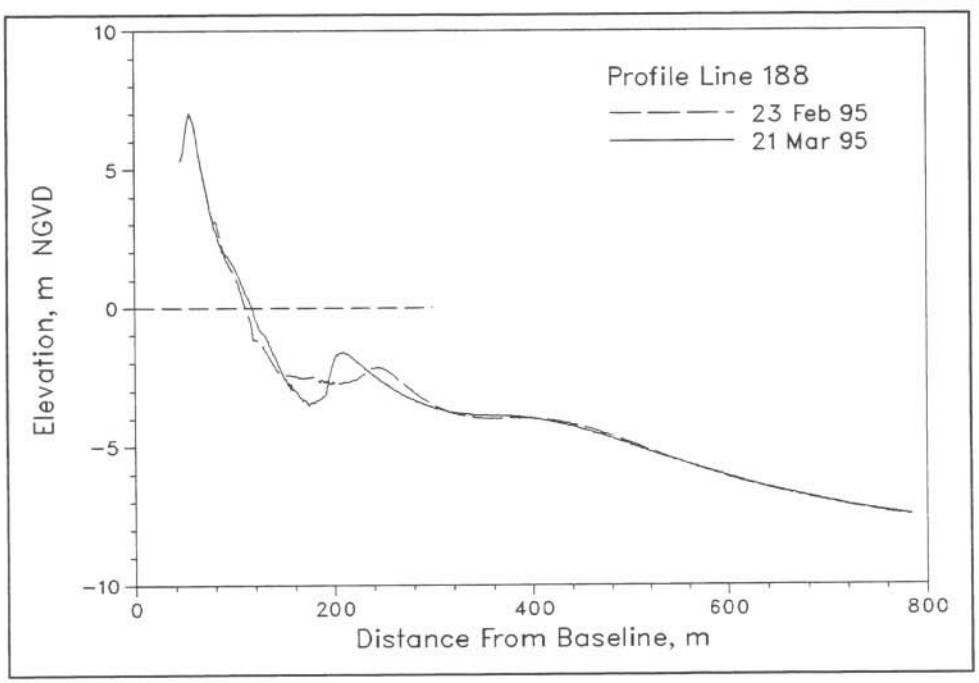

Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1995. Cross-hatched areas indicate changes to the annual envelope which occurred in March.

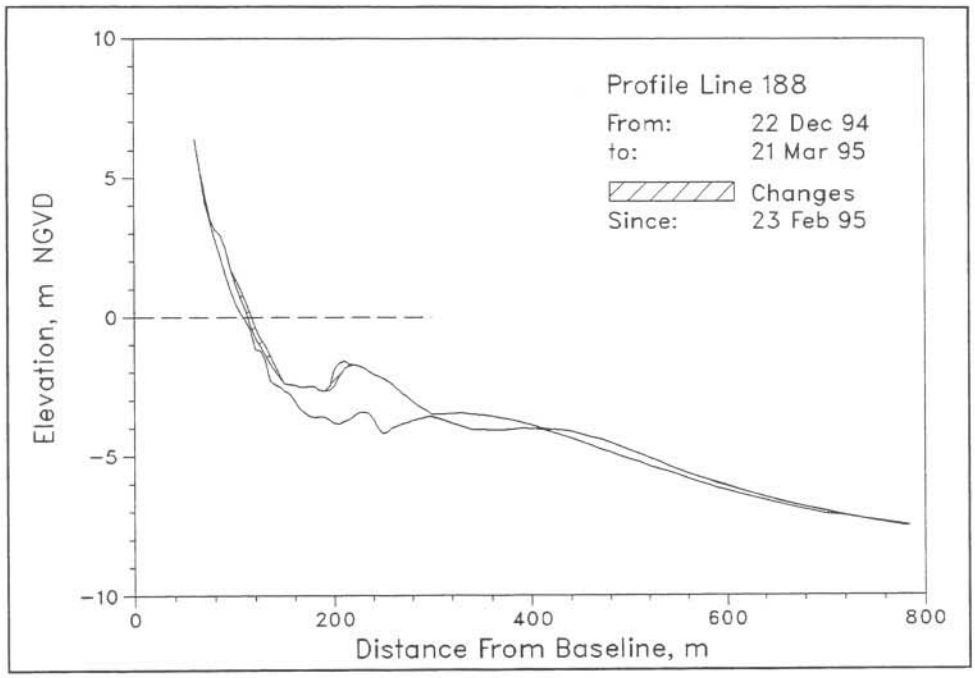

Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 25 January. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

There was no bathymetric survey in March. Figure 9 is for reference only.

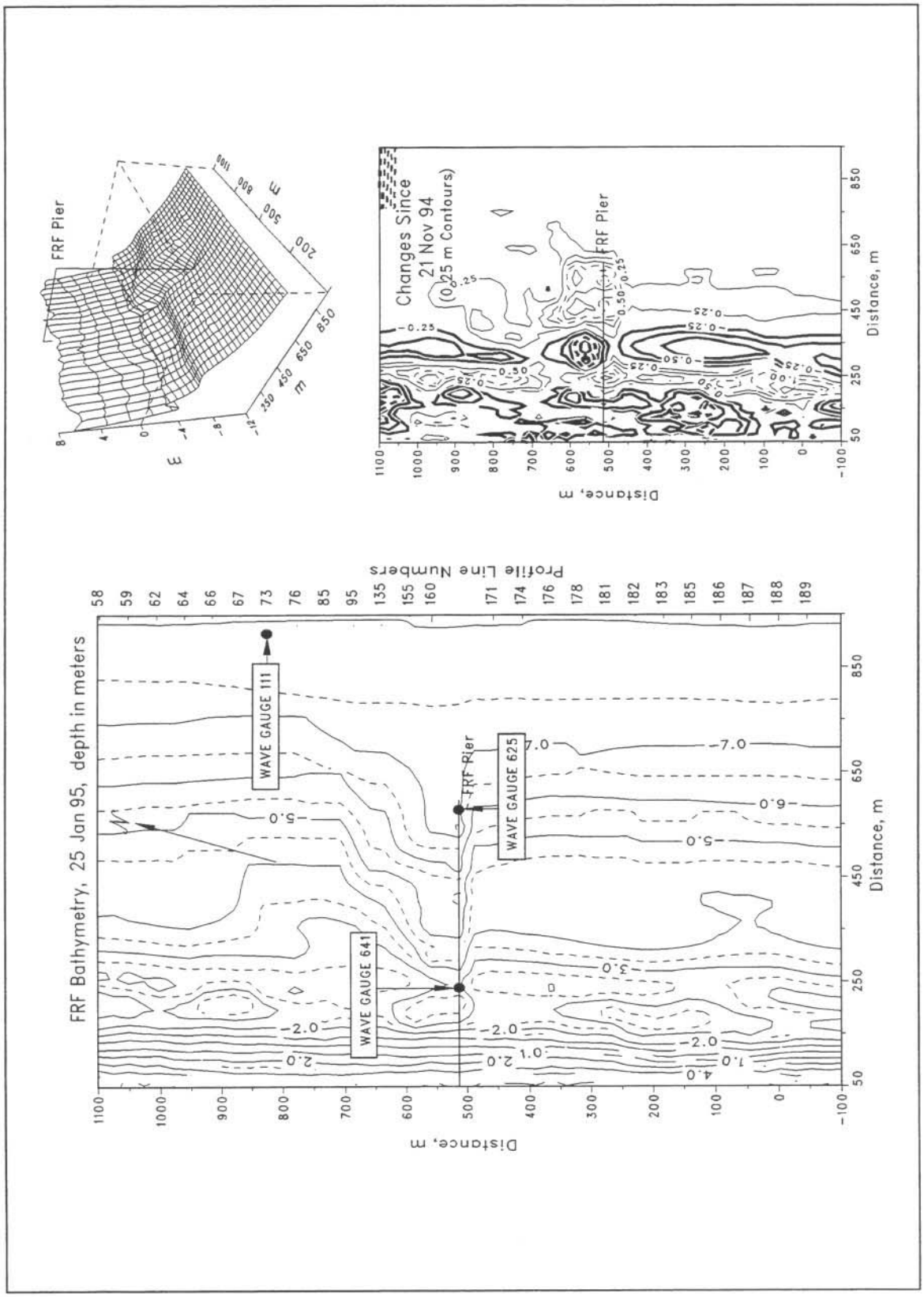

Figure 9. FRF Bathymetry, Depths Relative to NGVD

8 Special Events

A. Storm Data Collection. The following list identifies times when the wave height H_{mo} at the seaward end of the pier exceeded 2 m.

Start	End
02 Mar (0316)	02 Mar (1600)

B. Storm Synopsis.

Northerly winds were funneled between a high pressure system over Iowa and a low pressure system south of Cape Hatteras. Northerly winds reached 16 m/s at 0842 EST. The maximum H_{mo}, at gauge 625, reached 2.3 m (T_p=9.8 s) at 1142 EST. There was 13 mm of precipitation.

Distribution List

Government Agencies:

Back Bay National Wildlife Refuge
USACE-OCE
USACE-SAD
USACE-NAP
USACE-SAW
USACE-WES
NAVSAC
NOAA/NOS/OMS
National Marine Fisheries
U.S. Geological Survey
U.S. Library of Congress
U.S. National Park Service
U.S. National Weather Service
U.S. Naval Academy
U.S. Naval Civil Eng. Lab
U.S. Naval Oceanographic Off.
U.S. Naval Research Lab

Colleges/Universities:

Bucknell University
California Inst. of Tech.
Duke Marine Lab
East Carolina University
Florida Inst. of Tech.
M.I.T.
Naval Post Graduate School
NC State University
Old Dominion University
Oregon State University
Prince George's College
Scripps Institution of Oceanography
Stockton State College
University Calif-Berkeley
University of Florida
University of Maryland-College Park
University of Maryland-Baltimore
University of North Carolina
University of N C-Seagrant Program
University of Virginia
Va. Inst. of Marine Science
Rutgers University

Others:

Allied Signal Aerospace Co.
Applied Physics Lab
Cape Hatteras Nat. Seashore
Coastal and Est. Res., Inc.
Coastal Science & Eng., Inc.
Dr. Cy Galvin
GEOMET Tech., Inc.
Mr. Hodges
Dr. Hylton
Mr. Mason
Mr. Rodgers
WCTI-TV
MEC Systems Corporation
Moffatt & Nichol, Eng.
N.C. Div. Coastal Management
Oregon Inlet & Waterways Commis.
Raleigh-Durham Airport
Mr. Rowland
Mr. Savage
Science Application Int'l. Corp
Sherwood Industries
SEASUN Power Systems

Foreign:

Christchurch, Barbados
Ministry of Works, Bahamas
Dalhousie University, Halifax Nova Scotia
Queen's University, Ontario (Canada)
Ministry of Construction, Coastal Division (Japan)
Norwegian Hydrodynamic Laboratories (Norway)
University of Sydney (Australia)