US Army Corps
of Engineers
Waterways Experiment
Station

Preliminary Data Summary for March 1994 CERC Field Research Facility

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Coastal Engineering Research Center

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March 1994
Preliminary Data Summary

by Field Research Facility

U.S. Army Corps of Engineers
Waterways Experiment Station
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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).

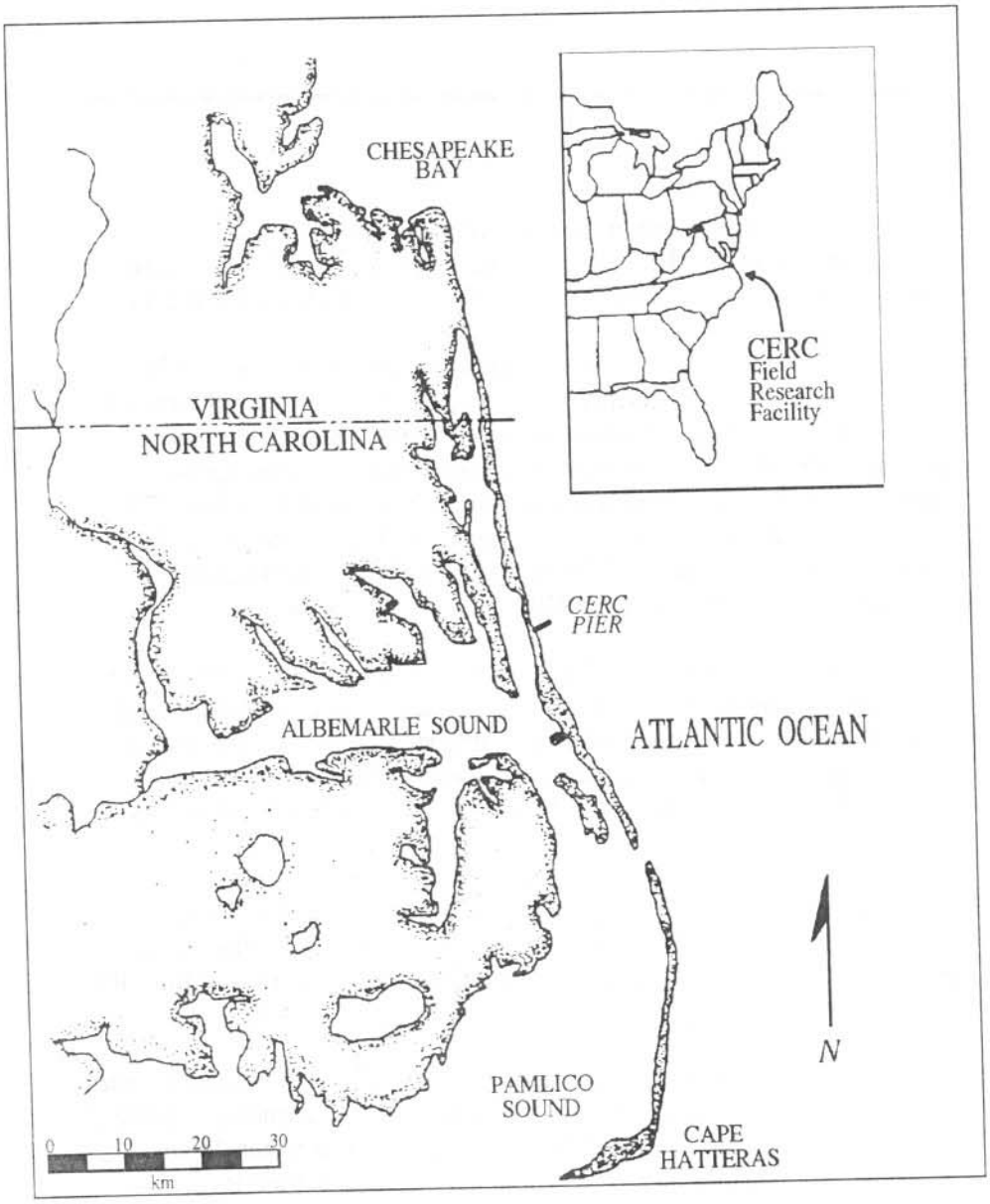

Figure 1. FRF Location Map

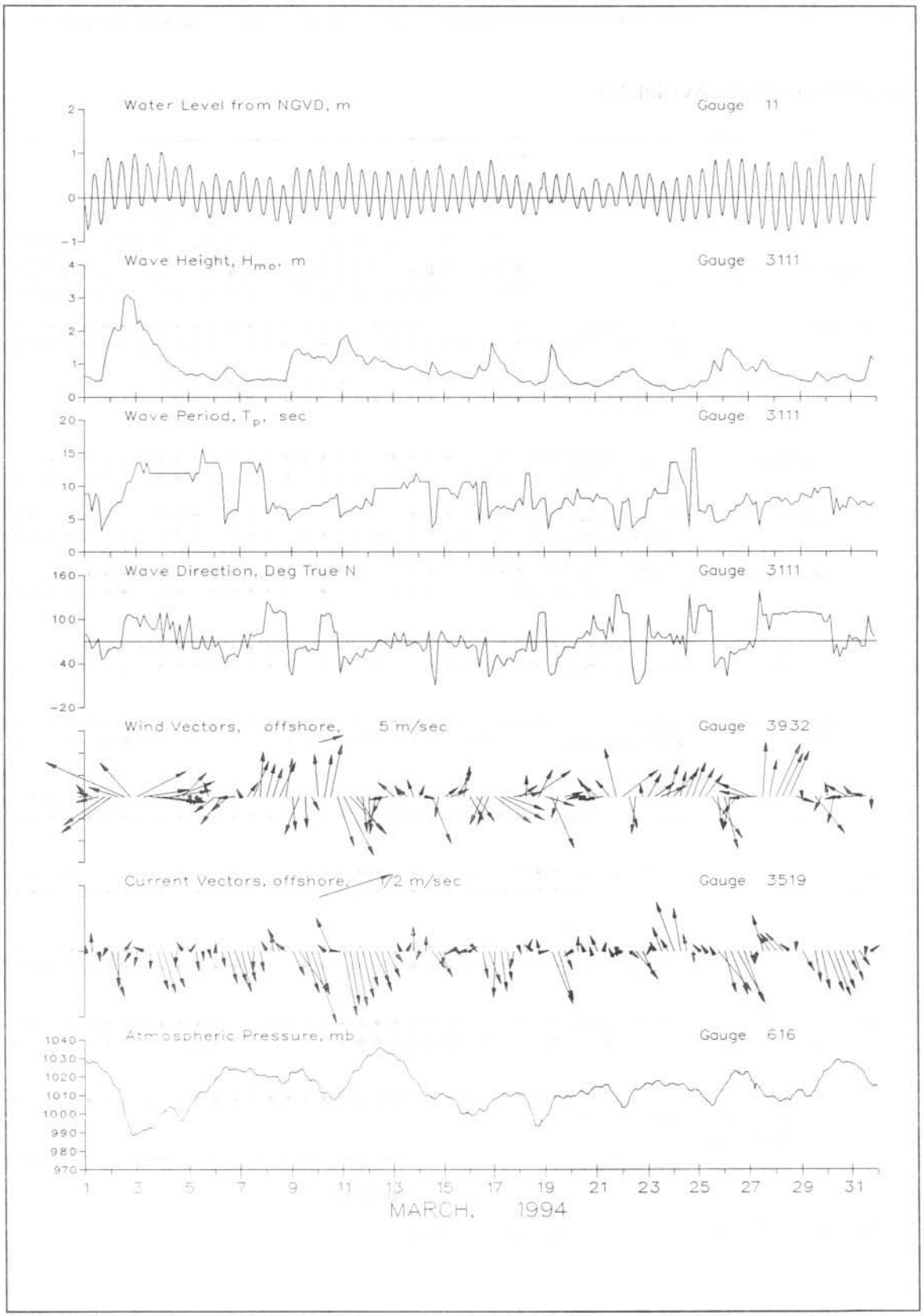

Figure 2. Month at a Glance

Table 1
Instrument Status/Data Availability

March 1994

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	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3519	Current meter 434 m north of FRF pier (0.9 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′ 45.48"	75 44′ 37.39"	11.60	569.00	-----	-----
3932	Anemometer	36 11′ 2.64"	75 44′ 46.50"	585.20	517.30	19.50	-----
641	Pressure Gauge	36 10′ 51.96"	75 44′ 42.21"	239.11	516.64	-1.64	-1.96
625	Baylor Staff	36 11′ 2.10"	75 44′ 46.31"	568.00	516.64	Surface	-8.36
3111	8 Meter Array North	36 11′ 17.59	75 44′ 32.62"	915.23	990.16	-7.50	-7.90
	8 Meter Array South	36 11′ 14.98	75 44′ 42.30"	914.20	735.37	-7.42	-7.90
	8 Meter Array East	36 11′ 16.88	75 44′ 40.32"	954.51	800.58	-7.62	-8.13
	8 Meter Array West	36 11′ 13.18"	75 44′ 38.84"	834.66	800.37	-6.98	-7.44
111	Pressure Gauge in center of 8 M Array	36 11′ 15.90"	75 44′ 38.88"	914.43	825.52	-7.76	-8.08
630	Waverider Buoy	36 12′ 16.44"	75 47′ 19.23"	3934.96	-2400.81	Surface	-17.00
3519	Current Meter	36 11′ 17.17"	75 44′ 34.15"	914.76	950.00	-5.30	-7.90
11	NOAA Tide Gauge	36 11′ 2.95"	75 44′ 46.76	596.49	514.20	Surface	-7.62

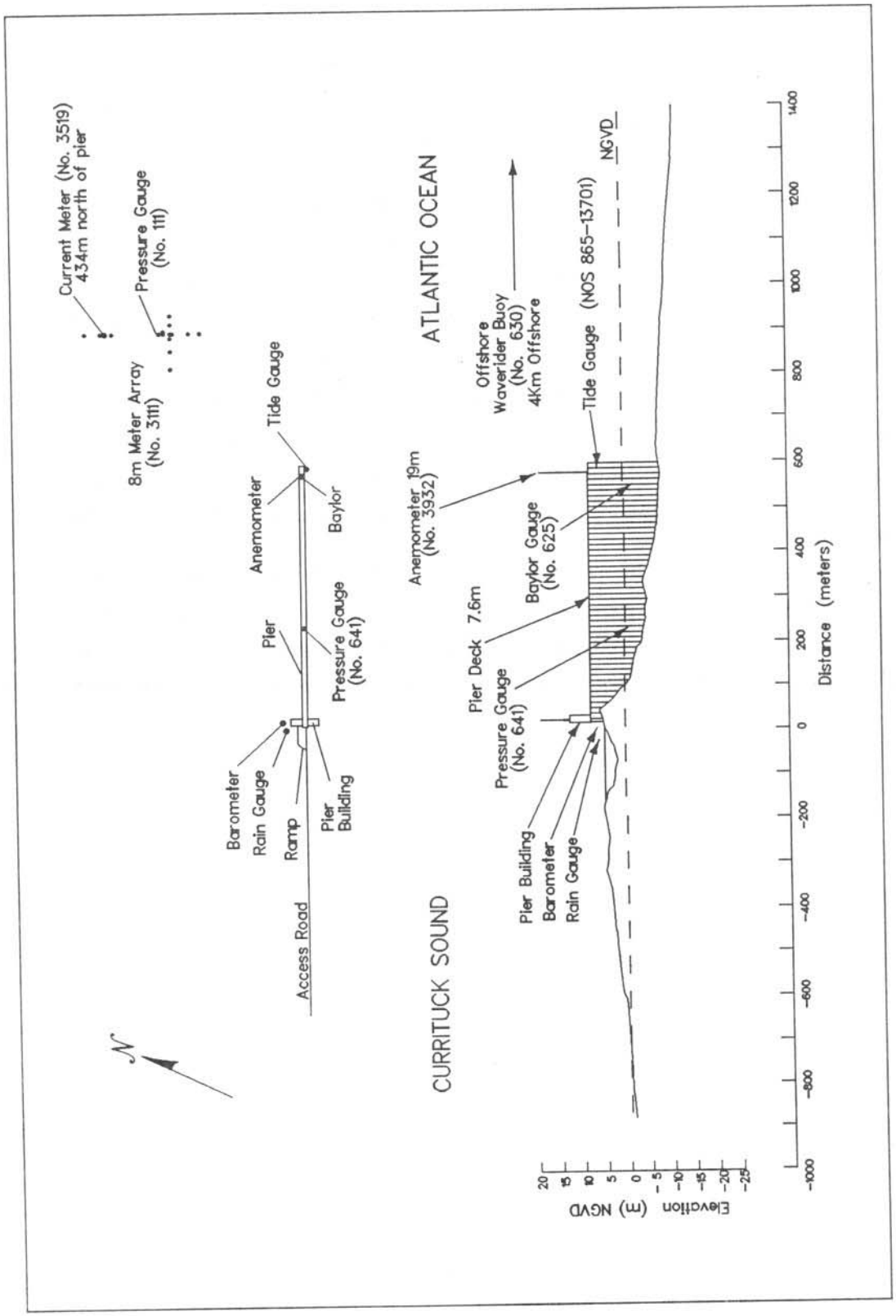

Figure 3. Instrument Locations, Elevations From NGVD

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 VAX 11/750. 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 (Figure 4) using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions are determined by vector averaging the data. Wind directions indicate where the wind is coming from. Temperature and atmospheric pressure means 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

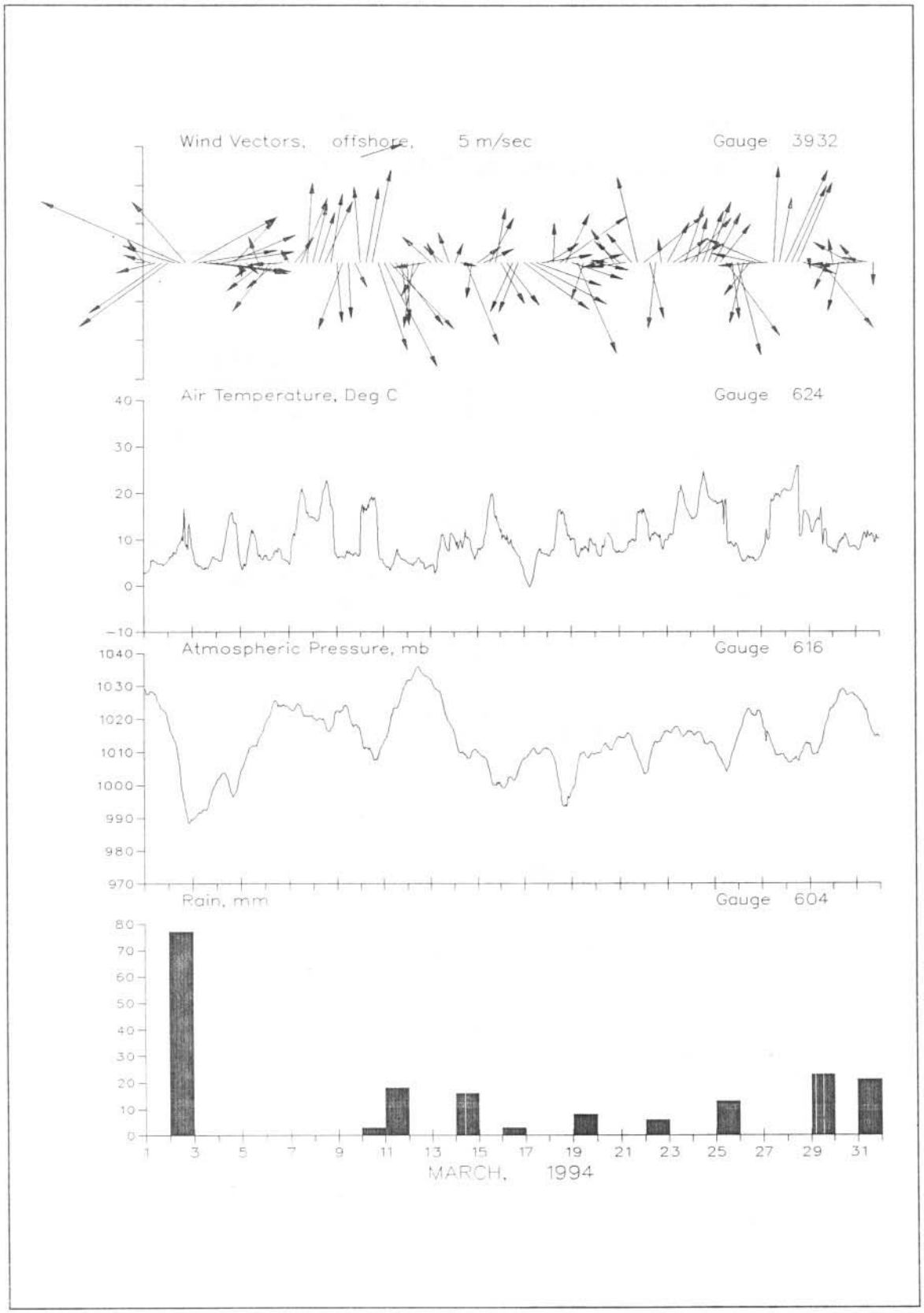

Figure 4. Meteorological Monthly Summary

Table 3
Meteorological Data

Mar 1994

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	3	147	2.8	1029.2	0
	700	3	109	4.4	1028.4	0
	1300	5	73	5.1	1025.9	0
	1900	10	51	4.7	1022.8	0
2	100	13	49	5.6	1018.2	10
	700	6	111	7.0	1013.2	21
	1300	17	117	9.7	999.2	28
	1900	10	142	8.9	990.0	18
3	100	11	237	7.3	989.9	0
	700	9	259	4.2	991.9	0
	1300	9	277	4.0	992.6	0
	1900	9	279	5.3	997.8	0
4	100	8	278	5.8	1001.8	0
	700	8	259	6.9	1003.9	0
	1300	8	244	14.4	999.8	0
	1900	7	219	13.6	997.7	0
5	100	2	353	4.6	1004.8	0
	700	2	317	6.1	1009.5	0
	1300	3	45	11.9	1011.9	0
	1900	3	162	6.3	1014.6	0
6	100	5	48	6.5	1019.0	0
	700	8	32	5.8	1023.0	0
	1300	5	44	7.1	1024.2	0
	1900	4	85	5.7	1024.3	0
7	100	2	153	4.6	1023.2	0
	700	4	212	11.9	1024.0	0
	1300	9	199	20.8	1022.4	0
	1900	10	183	16.0	1020.9	0
8	100	8	192	14.7	1020.4	0
	700	7	195	15.0	1020.3	0
	1300	8	201	21.5	1017.7	0
	1900	9	188	17.4	1017.6	0
9	100	8	355	6.2	1022.5	0
	700	9	17	6.2	1023.8	0
	1300	7	357	7.2	1020.8	0
	1900	3	336	7.2	1018.4	0
10	100	10	175	15.4	1015.1	0
	700	10	188	16.2	1011.4	0
	1300	12	190	18.5	1008.5	0
	1900	12	343	6.8	1009.5	3

Table 3
Meteorological Data (continued)

Mar 1994

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	15	336	4.6	1013.9	6
	700	11	320	3.4	1019.7	12
	1300	10	326	7.2	1023.3	0
	1900	8	353	5.8	1028.3	0
12	100	8	358	5.0	1031.9	0
	700	9	7	4.8	1034.1	0
	1300	5	25	5.7	1035.0	0
	1900	4	79	3.7	1033.0	0
13	100	5	136	4.5	1031.4	0
	700	3	156	4.8	1028.7	0
	1300	3	134	10.8	1023.4	0
	1900	4	162	7.7	1018.8	0
14	100	3	200	9.6	1014.3	0
	700	2	284	9.8	1009.9	5
	1300	11	340	10.6	1008.4	11
	1900	5	8	7.3	1010.4	0
15	100	3	230	8.1	1010.2	0
	700	4	242	10.0	1008.6	0
	1300	6	205	18.3	1003.8	0
	1900	7	189	14.8	999.9	0
16	100	6	333	12.2	999.8	0
	700	7	326	11.1	1000.9	3
	1300	7	21	8.1	1001.6	0
	1900	7	19	6.5	1005.1	0
17	100	9	310	2.2	1008.2	0
	700	10	302	0.2	1010.5	0
	1300	8	292	6.1	1009.9	0
	1900	6	259	7.0	1010.9	0
18	100	4	233	6.5	1011.1	0
	700	5	180	8.1	1007.7	0
	1300	10	231	16.6	998.8	0
	1900	7	202	13.4	993.5	0
19	100	6	290	10.3	998.9	0
	700	13	339	6.3	1007.2	8
	1300	5	15	8.2	1009.8	0
	1900	4	253	10.4	1009.3	0
20	100	4	284	8.8	1009.5	0
	700	2	72	8.2	1011.2	0
	1300	2	100	11.5	1011.4	0
	1900	5	150	7.7	1012.9	0

Table 3
Meteorological Data (concluded)

Mar 1994

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	4	135	7.3	1014.6	0
	700	4	80	7.9	1015.5	0
	1300	5	144	9.9	1012.8	0
	1900	11	168	16.2	1008.0	0
22	100	9	228	16.5	1003.4	0
	700	7	347	9.5	1009.2	6
	1300	9	5	11.4	1013.0	0
	1900	3	173	8.5	1014.9	0
23	100	6	205	9.8	1016.3	0
	700	5	231	12.7	1017.6	0
	1300	6	1	20.3	1016.1	0
	1900	8	196	17.1	1015.7	0
24	100	7	218	14.7	1016.2	0
	700	6	191	15.5	1016.1	0
	1300	7	199	24.0	1013.8	0
	1900	8	198	19.1	1012.9	0
25	100	7	205	18.2	1011.4	0
	700	6	214	17.9	1007.7	3
	1300	11	327	13.3	1004.6	0
	1900	7	353	8.8	1010.4	10
26	100	12	348	8.0	1015.6	0
	700	8	11	5.3	1021.2	0
	1300	5	33	6.2	1022.3	0
	1900	5	103	5.5	1021.3	0
27	100	7	116	7.5	1018.9	0
	700	5	85	9.9	1015.2	0
	1300	12	182	18.7	1009.9	0
	1900	8	189	18.9	1009.4	0
28	100	13	201	20.7	1007.8	0
	700	11	201	21.2	1007.7	0
	1300	11	200	25.9	1007.1	0
	1900	4	291	16.2	1012.1	0
29	100	1	353	13.2	1011.7	6
	700	2	278	14.1	1009.5	17
	1300	10	325	12.6	1013.7	0
	1900	4	21	8.5	1020.2	0
30	100	3	170	7.1	1024.0	0
	700	6	10	9.3	1028.0	0
	1300	3	77	11.1	1028.2	0
	1900	5	122	8.2	1027.8	0
31	100	3	141	8.2	1026.8	0
	700	6	87	9.8	1024.4	0
	1300	3	102	11.5	1019.3	8
	1900	3	359	9.5	1014.8	13
		Resultant		Mean	Mean	Total
		1	248	10.2	1013.8	188

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 VAX 4100 programmed to sample the gauges for two hour and forty-eight minute time frames. The sampling rate is two times per second which equals five contiguous 34 minute records per collection period. 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. When this analysis is complete, the data are written to optical disc.

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 1994

Day	Hour	641 Pressure Gage Hmo,m	Tp,sec	625 Baylor Gauge Hmo,m	Tp,sec	3111 8 Meter Array Hmo,m	Tp,sec	Dir,N	630 Waverider Hmo,m	Tp,sec
1	0100	0.33	5.5	0.61	9.5	0.64	8.9	80	0.63	7.4
	0700	0.25	5.0	0.59	6.1	0.55	6.2	60	0.60	6.1
	1300	0.29	3.6	0.59	3.1	0.50	8.2	74	0.58	8.3
	1900	0.53	4.1	1.01	4.2	1.10	4.6	48	1.02	3.9
2	0100	0.78	6.5	1.77	6.1	1.89	6.6	60	1.66	6.3
	0700	0.83	7.8	1.97	7.4	2.02	7.6	60	2.36	7.6
	1300	0.82	9.2	2.40	8.9	3.01	8.9	96	2.84	8.1
	1900	0.91	13.5	2.72	11.7	3.00	10.8	106	3.30	11.2
3	0100	1.29	13.5	2.15	12.2	2.22	13.6	102	2.78	12.2
	0700	0.92	13.5	2.07	13.5	2.04	12.0	106	2.17	12.9
	1300	1.11	12.9	1.64	12.9	1.83	12.0	90	1.96	12.2
	1900	0.83	12.2	1.42	11.7	1.60	12.0	90	1.72	11.7
4	0100	0.79	13.5	1.09	12.9	1.28	12.0	70	1.46	11.7
	0700	0.52	12.2	0.89	12.2	1.03	12.0	86	1.07	12.2
	1300	0.45	10.7	0.84	13.5	0.91	12.0	66	1.04	11.7
	1900	0.39	12.2	0.66	12.9	0.77	12.0	58	0.82	11.7
5	0100	0.43	12.9	0.67	12.9	0.70	12.0	106	0.72	11.7
	0700	0.27	10.3	0.63	12.9	0.65	12.0	60	0.74	11.2
	1300	0.29	16.0	0.66	12.2	0.73	15.7	78	0.69	11.2
	1900	0.23	10.3	0.57	14.3	0.60	13.6	58	0.64	12.9
6	0100	0.24	10.3	0.50	14.3	0.51	13.6	62	0.54	12.9
	0700	0.31	3.2	0.67	3.7	0.69	12.0	56	0.75	3.9
	1300	0.41	4.3	0.87	4.8	0.89	5.9	50	1.05	6.0
	1900	0.30	6.1	0.79	7.0	0.79	6.6	54	0.86	7.2
7	0100	0.24	13.5	0.57	5.9	0.60	13.6	64	0.73	5.6
	0700	0.17	9.2	0.46	11.7	0.48	13.6	60	0.53	12.9
	1300	0.28	5.5	0.45	12.9	0.51	13.6	76	0.59	12.9
	1900	0.36	6.3	0.49	12.9	0.53	13.6	80	0.78	5.9
8	0100	0.39	5.9	0.49	11.7	0.53	5.9	124	0.72	5.6
	0700	0.43	6.1	0.49	7.0	0.54	7.6	110	0.65	6.3
	1300	0.39	6.6	0.47	6.6	0.51	7.1	112	0.65	6.1
	1900	0.37	6.6	0.46	7.0	0.47	6.6	108	0.56	6.8
9	0100	0.59	5.3	1.20	5.3	1.29	5.6	24	1.36	5.7
	0700	0.75	5.6	1.27	6.5	1.44	6.2	60	1.57	6.5
	1300	0.55	5.0	1.23	6.6	1.27	6.6	64	1.43	6.8
	1900	0.64	6.6	1.15	7.2	1.21	7.1	60	1.46	7.2
10	0100	0.67	6.6	1.17	7.0	1.24	7.1	58	1.57	7.2
	0700	0.93	7.4	1.05	7.2	1.22	7.6	104	1.47	7.0
	1300	0.58	7.4	0.93	7.4	1.02	8.2	106	1.22	8.3
	1900	0.84	8.9	1.07	8.9	1.33	8.9	82	1.34	8.6

Table 4
Wave Data (continued)

Mar 1994

		641 Pressure Gage		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
Day	Hour	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,N	Hmo,m	Tp,sec
11	0100	0.65	5.4	1.55	5.4	1.79	5.9	50	1.98	6.0
	0700	0.96	6.1	1.45	6.3	1.62	6.2	38	1.94	6.1
	1300	0.52	6.5	1.18	6.8	1.24	7.1	54	1.55	7.2
	1900	0.71	5.7	1.14	6.6	1.22	6.6	48	1.28	7.6
12	0100	0.41	3.9	0.96	8.1	1.00	7.6	56	1.24	7.8
	0700	0.63	5.6	1.12	6.1	1.22	9.8	62	1.14	6.8
	1300	0.47	9.9	0.96	9.9	1.06	9.8	72	1.18	10.3
	1900	0.45	9.5	0.93	9.9	1.01	9.8	66	1.04	9.9
13	0100	0.40	4.9	0.82	9.5	0.89	9.8	82	0.93	9.9
	0700	0.31	9.5	0.74	9.5	0.86	9.8	70	0.86	9.9
	1300	0.36	9.5	0.75	10.7	0.84	9.8	64	0.84	9.9
	1900	0.36	9.5	0.77	9.5	0.93	10.8	68	0.89	10.7
14	0100	0.27	11.7	0.75	11.2	0.80	10.8	66	0.77	10.7
	0700	0.39	8.6	0.72	11.2	0.75	10.8	60	0.82	11.2
	1300	0.45	3.6	0.75	10.7	1.07	3.8	34	1.00	3.6
	1900	0.41	4.5	0.66	9.9	0.68	9.8	74	0.78	10.3
15	0100	0.22	8.6	0.62	10.3	0.71	9.8	74	0.79	9.9
	0700	0.30	8.9	0.70	9.9	0.78	8.9	70	0.86	10.3
	1300	0.25	9.2	0.65	8.9	0.69	8.2	64	0.74	8.9
	1900	0.25	10.7	0.57	9.2	0.60	10.8	72	0.72	10.3
16	0100	0.19	11.7	0.51	10.7	0.57	10.8	62	0.56	10.3
	0700	0.27	8.6	0.52	12.2	0.72	10.8	62	0.66	10.3
	1300	0.54	4.4	0.79	9.9	0.80	10.8	60	0.97	4.6
	1900	0.50	5.2	0.84	10.3	0.96	5.0	22	0.88	5.2
17	0100	0.74	6.1	1.27	6.8	1.37	6.6	44	1.72	6.6
	0700	0.57	6.5	1.00	6.5	1.05	6.6	42	1.14	6.3
	1300	0.46	6.1	0.78	6.6	0.76	6.6	46	0.93	6.5
	1900	0.26	6.3	0.62	6.6	0.64	6.2	42	0.75	8.1
18	0100	0.16	12.9	0.47	8.1	0.48	8.2	58	0.56	8.3
	0700	0.15	12.2	0.44	6.8	0.47	12.0	56	0.53	7.2
	1300	0.20	4.5	0.43	7.4	0.43	6.6	56	0.69	7.4
	1900	0.23	7.4	0.38	7.6	0.42	7.6	108	0.46	6.3
19	0100	0.35	6.6	0.47	9.5	0.47	8.2	108	0.52	8.1
	0700	0.71	4.7	1.00	4.3	1.58	5.9	24	1.43	5.0
	1300	0.67	6.5	0.92	6.0	0.93	6.6	48	1.02	6.8
	1900	0.32	9.9	0.64	5.6	0.67	8.2	62	0.75	7.6
20	0100	0.25	9.9	0.46	7.0	0.46	7.6	62	0.54	6.8
	0700	0.15	9.5	0.38	9.9	0.39	9.8	74	0.40	9.2
	1300	0.17	8.3	0.35	8.6	0.41	8.2	76	0.44	8.9
	1900	0.14	8.3	0.41	8.6	0.39	8.2	78	0.46	8.3

Table 4
Wave Data (concluded)

Mar 1994

Day	Hour	641 Pressure Gage Hmo,m	641 Pressure Gage 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,N	630 Waverider Hmo,m	630 Waverider Tp,sec
21	0100	0.17	7.8	0.30	8.3	0.32	8.9	88	0.37	6.6
	0700	0.14	8.9	0.35	8.6	0.37	8.2	86	0.41	7.8
	1300	0.24	7.6	0.51	7.6	0.48	7.6	104	0.62	7.8
	1900	0.32	3.4	0.62	3.2	0.63	3.9	134	0.68	7.8
22	0100	0.53	7.0	0.65	6.8	0.78	7.6	108	1.05	6.6
	0700	0.50	3.5	0.69	8.3	0.79	8.2	106	0.90	8.1
	1300	0.58	4.1	0.73	4.0	0.80	4.2	12	0.83	4.1
	1900	0.31	4.7	0.55	4.7	0.57	5.3	20	0.63	5.4
23	0100	0.25	8.1	0.42	8.3	0.45	8.2	106	0.53	6.8
	0700	0.14	8.3	0.33	8.3	0.34	9.8	74	0.40	8.9
	1300	0.13	6.5	0.32	9.2	0.34	8.9	76	0.37	8.6
	1900	0.14	4.6	0.27	8.6	0.25	8.9	76	0.38	9.2
24	0100	0.10	11.2	0.19	13.5	0.20	13.6	66	0.23	13.5
	0700	0.13	5.9	0.21	11.7	0.23	12.0	66	0.25	11.2
	1300	0.14	5.4	0.25	10.3	0.27	9.8	50	0.34	10.7
	1900	0.19	6.1	0.31	16.0	0.30	15.7	84	0.45	3.6
25	0100	0.21	5.9	0.32	5.9	0.39	6.2	118	0.44	6.0
	0700	0.36	7.2	0.43	5.9	0.47	5.9	120	0.59	6.3
	1300	0.45	6.6	Inoperative		0.75	7.1	112	0.79	7.2
	1900	0.73	4.5	0.89	4.6	0.92	4.4	40	0.98	4.6
26	0100	0.59	4.4	1.01	4.6	1.25	4.8	46	1.25	4.5
	0700	0.89	5.3	1.25	5.4	1.42	6.2	56	1.46	5.5
	1300	0.52	5.7	1.18	6.8	1.17	7.1	54	1.43	6.5
	1900	0.52	7.2	0.83	9.2	0.87	7.6	58	1.04	9.2
27	0100	0.38	7.4	0.86	7.0	0.83	8.2	68	0.93	7.6
	0700	0.42	7.4	0.77	8.3	0.75	7.6	76	0.90	7.6
	1300	0.44	6.5	0.88	6.6	1.12	6.6	104	1.36	6.8
	1900	0.67	7.6	0.77	7.6	0.85	7.6	84	1.00	7.8
28	0100	0.35	8.9	0.70	8.1	0.77	8.2	106	0.98	8.3
	0700	0.52	7.8	0.63	7.8	0.69	7.6	108	0.87	7.6
	1300	0.35	4.8	0.58	7.4	0.64	7.6	108	0.81	7.4
	1900	0.49	7.6	0.52	7.6	0.59	7.6	110	0.68	7.2
29	0100	0.32	7.4	0.39	8.9	0.50	8.9	110	0.57	8.6
	0700	0.36	7.8	0.41	8.3	Inoperative			0.54	7.1
	1300	0.23	8.0	0.47	10.3	0.56	9.8	108	0.55	10.3
	1900	0.50	8.9	0.62	9.2	0.64	9.8	106	0.97	5.1
30	0100	0.22	9.5	0.42	9.9	0.48	9.8	96	0.52	9.5
	0700	0.28	9.2	0.53	9.2	0.60	5.6	52	0.69	5.4
	1300	0.24	8.3	0.58	6.1	0.63	6.2	48	0.68	6.6
	1900	0.28	8.1	0.66	7.0	0.66	6.6	58	0.73	6.6
31	0100	0.22	8.1	0.53	7.8	0.51	8.2	72	0.62	7.8
	0700	0.17	7.4	0.43	7.0	0.47	7.1	72	0.50	7.0
	1300	0.25	4.5	0.46	7.8	0.52	7.6	62	0.61	7.4
	1900	0.67	7.0	1.12	6.8	1.23	7.1	82	1.34	7.0
Mean		0.43	7.7	0.78	8.5	0.86	8.7	73	0.95	8.1
Std dev		0.23	2.7	0.44	2.7	0.49	2.6	24	0.53	2.3

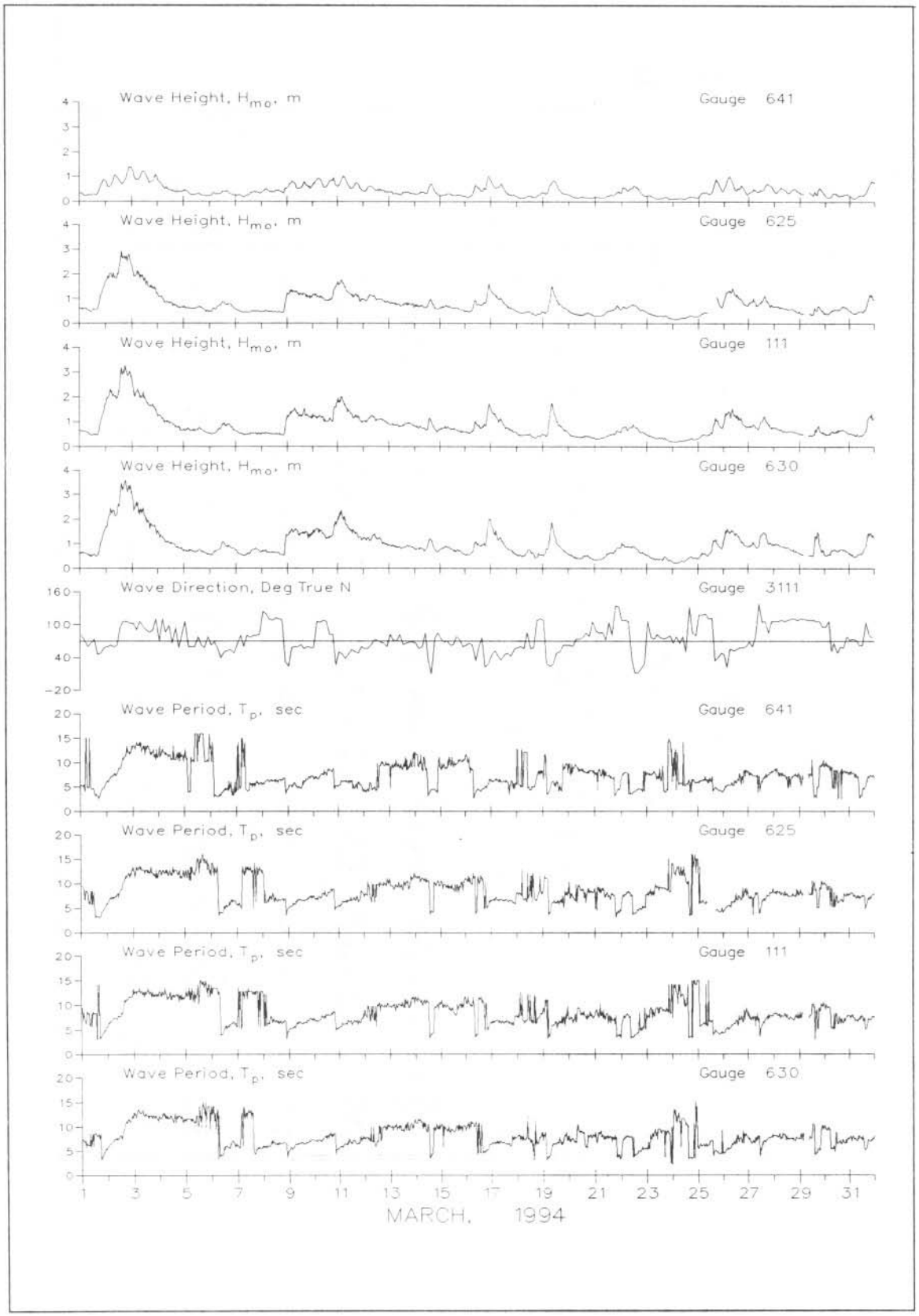

Figure 5. Time History of Wave Heights and Periods

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 519

MARCH 1994

Day	Time	Cross Shore	Long Shore	Speed	Dir
1	100	1	-5	6	351
	700	4	-13	14	356
	1300	-1	8	8	173
	1900	-2	3	4	205
2	100	-3	35	35	167
	700	-8	26	28	179
	1300	7	-5	9	31
	1900	-6	6	9	208
3	100	-5	10	12	189
	700	-4	-5	8	296
	1300	-4	13	14	180
	1900	-3	30	30	167
4	100	-3	33	33	167
	700	0	29	29	162
	1300	-4	11	12	185
	1900	-1	-7	8	328
5	100	6	-3	7	35
	700	-2	15	15	173
	1300	-1	7	7	176
	1900	0	6	6	164
6	100	2	-5	6	4
	700	-1	12	13	170
	1300	-2	25	25	167
	1900	0	26	26	162
7	100	-4	32	32	168
	700	-2	24	24	167
	1300	-5	14	15	183
	1900	-2	16	16	172
8	100	0	-7	8	335
	700	3	-13	14	354
	1300	-1	-18	19	335
	1900	-4	-7	10	311
9	100	1	20	20	158
	700	8	38	39	149
	1300	-2	33	33	165
	1900	-3	57	57	164
10	100	-3	32	33	168
	700	-2	-5	7	315
	1300	0	-26	27	339
	1900	2	1	2	98
11	100	-8	49	50	170
	700	-7	41	41	172
	1300	-7	42	43	171
	1900	-5	36	37	169
12	100	-3	27	28	168
	700	0	27	27	160
	1300	-4	31	32	169
	1900	0	22	22	159
13	100	2	10	10	148
	700	0	-6	7	337
	1300	5	-4	7	24
	1900	6	-17	19	359
14	100	-4	6	7	199
	700	4	-10	12	0
	1300	4	16	16	147
	1900	2	22	22	156
15	100	-5	11	12	190
	700	-4	1	5	239
	1300	1	4	4	149
	1900	-4	0	5	254
16	100	5	-1	6	48
	700	0	1	1	146
	1300	-3	21	21	171
	1900	0	26	26	162
17	100	-12	33	35	182
	700	-6	30	31	173
	1300	-4	23	23	173
	1900	-6	12	13	190
18	100	0	3	3	161
	700	7	-7	10	23
	1300	-3	-6	8	309
	1900	2	-9	10	350
19	100	2	0	2	75
	700	0	42	42	162
	1300	-3	38	38	166
	1900	0	15	15	161
20	100	-5	2	6	232
	700	4	-10	12	1
	1300	0	-6	7	338
	1900	0	-2	3	347
21	100	0	-12	13	340
	700	4	-5	7	15
	1300	0	-1	2	338
	1900	0	4	4	180
22	100	-7	0	8	250
	700	4	7	8	131
	1300	6	25	26	146
	1900	1	18	18	158
23	100	-2	3	4	208
	700	0	-7	8	333
	1300	1	-18	19	342
	1900	0	-9	10	332
24	100	1	-38	39	342
	700	7	-31	33	352
	1300	2	-12	13	349
	1900	-2	8	9	177
25	100	-2	-5	6	317
	700	0	-4	5	327
	1300	0	-3	4	333
	1900	10	36	37	145
26	100	-3	32	33	167
	700	0	35	35	162
	1300	3	43	43	156
	1900	-1	40	40	163
27	100	0	11	11	164
	700	-3	8	9	186
	1300	3	-27	28	345
	1900	-3	-13	15	326
28	100	-5	-15	17	321
	700	-5	-16	18	320
	1300	-3	-6	8	308
	1900	0	0	0	
29	100	2	17	17	154
	700	0	12	12	163
	1300	-4	24	24	171
	1900	-4	29	30	170
30	100	0	33	33	161
	700	-1	37	37	163
	1300	0	31	31	162
	1900	1	16	16	155
31	100	0	24	24	163
	700	3	13	14	149
	1300	-1	4	4	184
	1900	6	-1	6	53
	1900	6	-1	6	53

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 1994

	Pier End				Mid-Surf Zone				Beach		
Day	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir
1	0	-17	17	340	0	-8	8	340	South	0	
2	0	9	9	160	0	-23	23	340	North	51	S
3	0	-30	30	340	37	-61	71	11	South	46	N
4	10	20	23	133	18	-12	22	36	South	8	N
5	0	17	17	160	11	-36	37	357	South	3	N
6	-6	20	21	177	0	27	27	160	North	0	
7	5	16	17	70	0	-12	12	340	South	18	N
8	9	-30	32	357	9	-29	30	357	South	15	N
9	0	76	76	160	0	102	102	160	North	30	S
10	0	-51	51	340	0	-55	55	340	South	36	N
11	0	61	61	160	0	68	68	160	North	91	S
12	0	38	38	160	0	55	55	160	North	46	S
13	0	-8	8	340	0	8	8	160	North	10	S
14	0	-20	20	340	0	-9	9	340	South	8	N
15	13	-8	15	36	12	-14	18	22	South	11	N
16	0	41	41	160	0	29	29	160	North	46	S
17	0	47	47	160	0	55	55	160	North	52	S
18	0	-28	28	340	0	-20	20	340	South	10	N
19	0	61	61	160	0	87	87	160	North	153	N
20	0	0	0		0	0	0		North	3	S
21	0	-12	12	340	0	-8	8	340	South	8	N
22	0	61	61	160	0	0	0		North	46	N
23	17	-17	25	25	0	0	0		North	11	N
24	0	-20	20	340	0	-16	16	340	North	14	N
25	17	-17	25	25	24	-24	34	25	South	10	N
26	-15	61	63	174	-8	76	77	166	North	9	S
27	0	-76	76	340	0	-55	55	340	South	43	N
28	23	-47	52	7	4	-38	38	346	South	47	N
29	0	22	22	160	0	0	0		South	5	N
30	0	61	61	160	0	17	17	160	North	23	S
31	15	24	28	70	0	-7	7	340	South	8	N

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 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 1994

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	45			6	4.7	1.0200	1.2
2	0750	60	100		174	5.0	1.0100	1.2
3	0750	105			207	5.0	1.0254	0.6
4	0730	50			98	4.4	1.0248	0.3
5	0850	55	100		20	5.0	1.0230	1.8
6	0950	50	90		14	6.1	1.0222	2.4
7	0830	100			11	6.1	1.0170	1.8
8	0745	100			3	5.6	1.0238	0.9
9	0825	50	85		134	5.6	1.0244	1.8
10	0800	105	75		101	6.7	1.0206	1.2
11	0835	40			149	5.0	1.0252	0.6
12	0900	40		Radar	123	5.6	1.0222	0.6
13	0845	45	110		78	6.1	1.0206	2.7
14	0715	100			14	6.1	1.0212	0.9
15	0705	45	90		21	6.7	1.0222	1.8
16	0710	45			16	7.2	1.0202	1.2
17	0710	40		inoperative	122	7.0	1.0206	0.9
18	0730	40			12	7.0	1.0200	1.5
19	0900	40			154	6.9	1.0230	0.3
20	0900	40	100		14	7.2	1.0220	3.4
21	0730	95	50		8	7.2	1.0215	2.7
22	0730	100	40	all	14	6.7	1.0231	1.2
23	0725	45			12	7.8	1.0223	3.0
24	0715	100			6	8.3	1.0230	1.8
25	0725	110			9	7.2	1.0256	1.2
26	0745	65		month	128	7.8	1.0236	1.5
27	1015	100			122	9.4	1.0200	1.2
28	0750	100	140		30	8.6	1.0248	0.9
29	0800	95			12	8.9	1.0248	1.8
30	0805	40	95		18	8.6	1.0200	0.9
31	0820	95	60		18	8.9	1.0196	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 Leupold-Stevens digital recording float-type tide gauge is used to collect instantaneous 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.

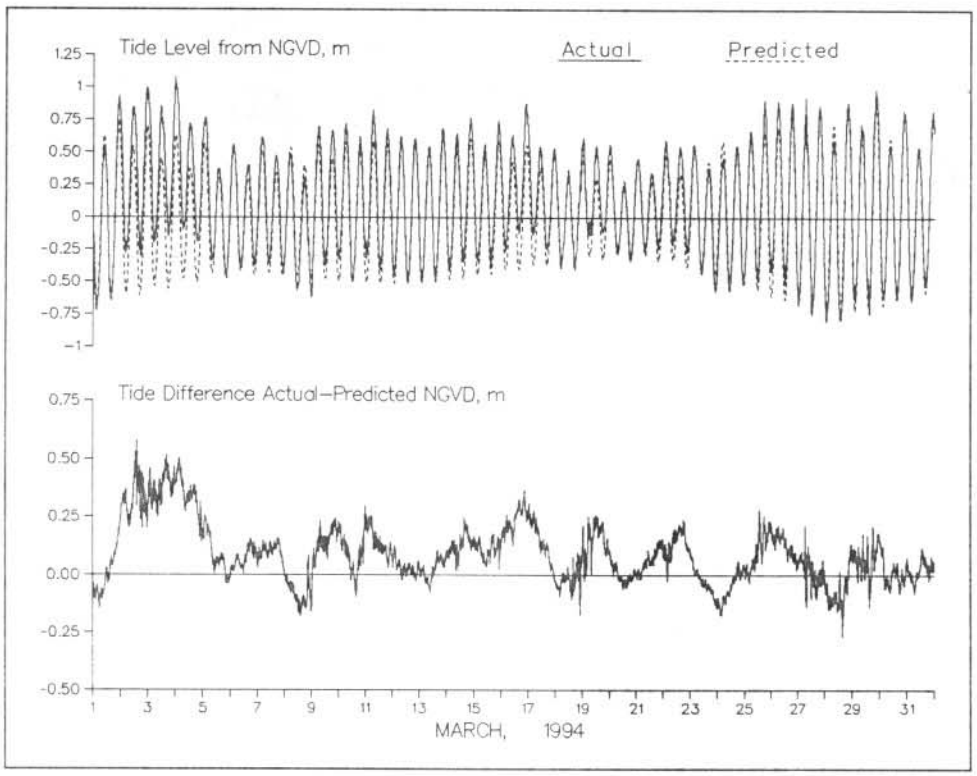

Figure 6. Water Level Time History

Table 8
Water Levels, m NGVD

MAR 1994 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	0918	0.55	1	0300	-0.73	-0.07	1.28	16	2136	0.88	16	1518	-0.13	0.36	1.00
1	2218	0.93	1	1524	-0.63	0.13	1.56	17	0954	0.54	17	0406	-0.13	0.20	0.68
2	1024	0.84	2	0412	-0.28	0.29	1.12	17	2242	0.53	17	1554	-0.25	0.12	0.78
2	2300	1.00	2	1718	-0.31	0.39	1.30	18	1054	0.36	18	0436	-0.40	-0.03	0.76
3	1054	0.85	3	0442	-0.20	0.32	1.06	19	0024	0.61	18	1712	-0.41	0.08	1.02
3	2324	1.07	3	1736	-0.15	0.45	1.23	19	1154	0.55	19	0418	-0.15	0.16	0.70
4	1206	0.71	4	0618	-0.10	0.33	0.82	20	0024	0.56	19	1806	-0.11	0.20	0.67
5	0142	0.76	4	1900	-0.20	0.28	0.96	20	1248	0.25	20	0730	-0.26	-0.01	0.51
5	0324	0.53	5	0824	-0.33	0.07	0.87	21	0136	0.45	20	1824	-0.34	0.06	0.79
6	0212	0.55	5	2030	-0.48	0.04	1.03	21	1330	0.34	21	0736	-0.26	0.05	0.61
6	1454	0.40	6	0842	-0.38	0.03	0.78	22	0154	0.59	21	1942	-0.24	0.17	0.83
7	0318	0.61	6	2118	-0.38	0.11	0.99	22	1448	0.55	22	0748	-0.22	0.17	0.76
7	0512	0.51	7	0942	-0.36	0.09	0.87	23	0242	0.56	22	2106	-0.27	0.17	0.83
8	0436	0.49	7	2224	-0.40	0.05	0.89	23	1548	0.38	23	0954	-0.44	-0.01	0.82
8	0554	0.34	8	1042	-0.57	-0.11	0.92	24	0442	0.46	23	2212	-0.57	-0.05	1.03
9	0524	0.70	8	2330	-0.62	0.02	1.32	24	1636	0.55	24	1036	-0.57	0.00	1.12
9	1812	0.67	9	1142	-0.38	0.15	1.05	25	0506	0.67	24	2236	-0.52	0.07	1.18
10	0600	0.72	9	2342	-0.32	0.20	1.04	25	1730	0.91	25	1148	-0.50	0.18	1.40
10	1842	0.62	10	1218	-0.50	0.05	1.12	26	0554	0.89	26	0000	-0.42	0.22	1.32
11	0636	0.82	11	0048	-0.32	0.22	1.14	26	1818	0.88	26	1218	-0.52	0.18	1.40
11	1848	0.68	11	1242	-0.41	0.15	1.09	27	0642	0.92	27	0042	-0.64	0.08	1.57
12	0654	0.62	12	0036	-0.45	0.10	1.08	27	1930	0.86	27	1218	-0.75	0.07	1.60
12	1942	0.60	12	1300	-0.50	0.06	1.11	28	0748	0.59	28	0124	-0.80	-0.07	1.39
13	0800	0.54	13	0148	-0.50	0.03	1.04	28	1942	0.86	28	1418	-0.79	0.01	1.65
13	2006	0.68	13	1342	-0.49	0.10	1.17	29	0754	0.72	29	0218	-0.64	0.06	1.36
14	0818	0.64	14	0236	-0.41	0.12	1.05	29	2048	0.99	29	1506	-0.74	0.15	1.73
14	2030	0.77	14	1430	-0.34	0.22	1.11	30	0918	0.55	30	0330	-0.60	0.01	1.14
15	0924	0.56	15	0324	-0.34	0.12	0.90	30	2148	0.80	30	1506	-0.63	0.08	1.43
15	2124	0.74	15	1436	-0.38	0.18	1.13	31	1006	0.54	31	0406	-0.65	-0.03	1.19
16	0936	0.63	16	0336	-0.26	0.20	0.90	31	2248	0.82	31	1612	-0.53	0.07	1.35

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 1994 and the survey(s) in March 1994 on profile line 188, located 517 m south of the pier.

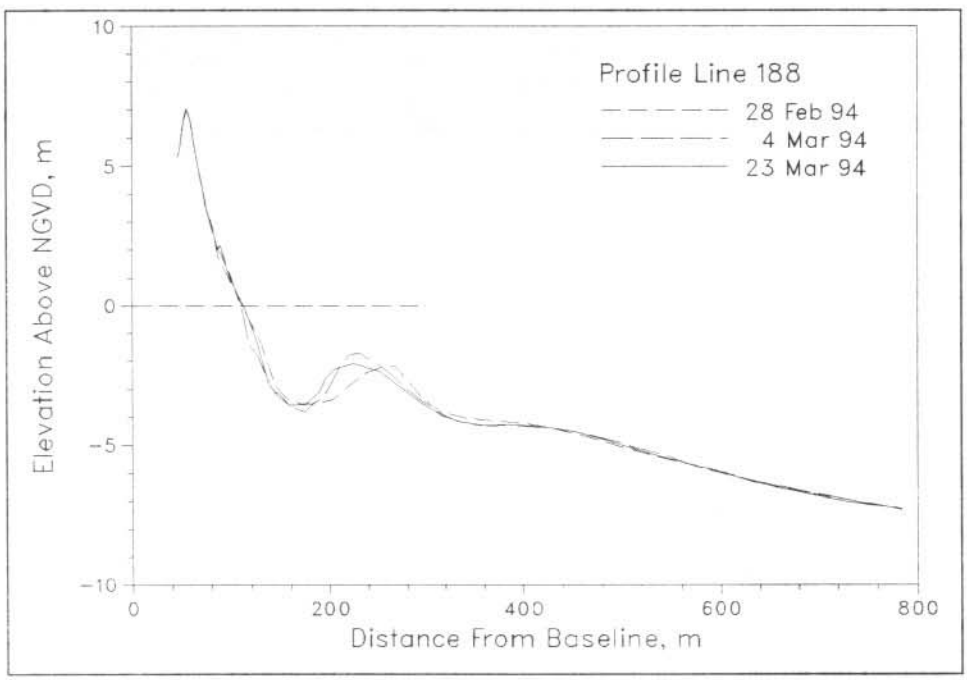

Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1994. Cross-hatched areas indicate changes to the annual envelope which occurred in March.

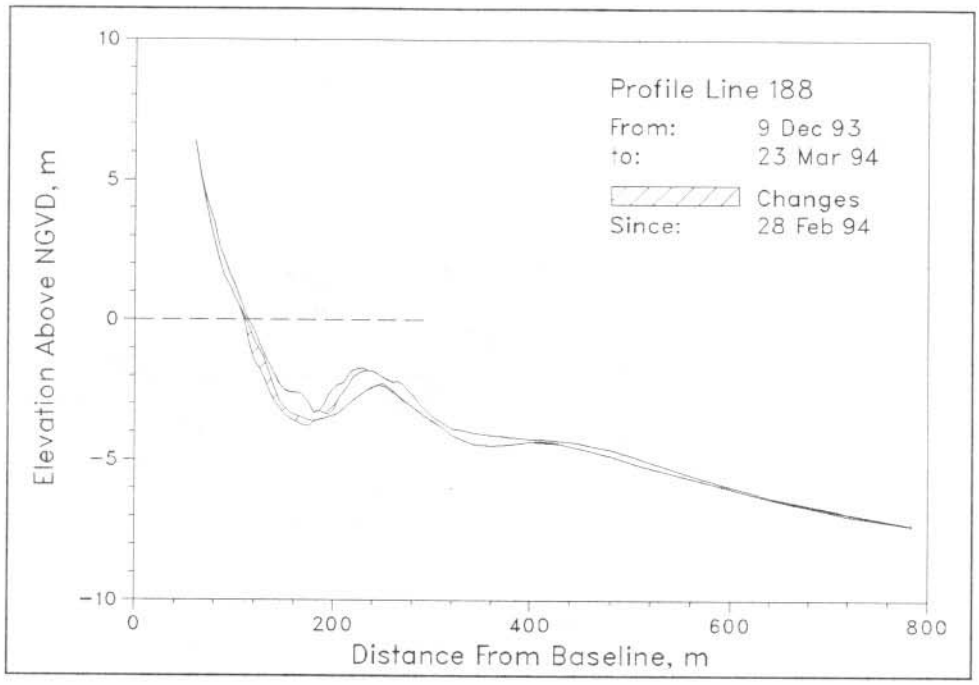

Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 24 January. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition. There was no bathymetry survey in March. Figure 9 is included for reference only.

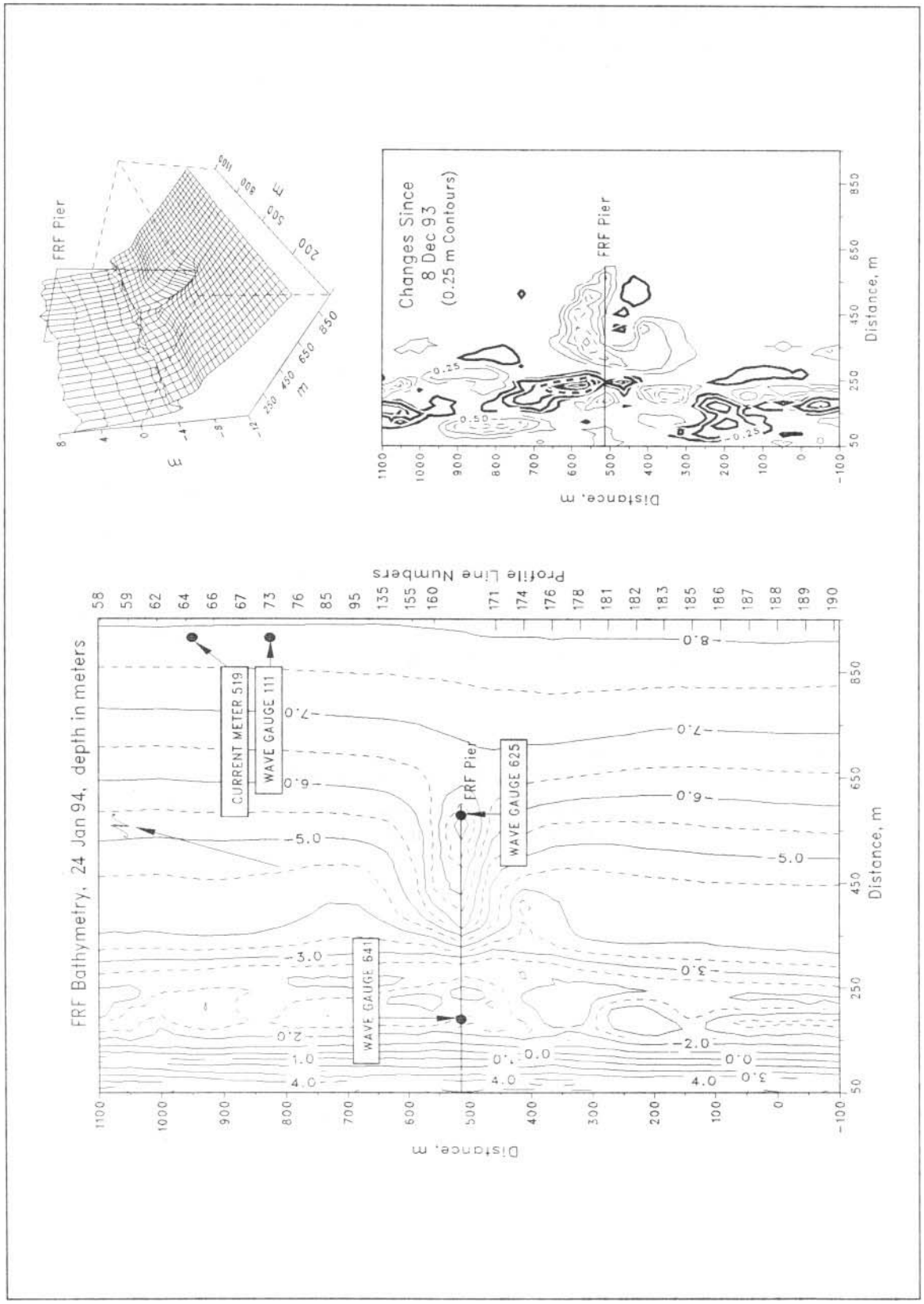

Figure 9. FRF Bathymetry, Depths Relative to NGVD

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
2 Mar (0434)	3 Mar (0700)

B. Storm Synopsis.

Forming over Georgia on the morning of 2 March, this storm moved to the northeast, remaining well inshore until 3 March when it moved offshore of New Jersey. The minimum atmospheric pressure was 989 mb. Maximum onshore winds (SE) reached 17 m/s at 1300 EST on 2 March. The maximum H_{mo}, at gauge 630, reached 3.40 m (T_p=11.6 s) at 2116 on 2 March. There was 77 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)