US Army Corps
of Engineers
Waterways Experiment
Station

Preliminary Data Summary for December 1995 CERC Field Research Facility

by Clifford Baron, Michael Leffler, Kent Hathaway, Paul Hodges,
William Birkemeier, Brian Scarborough, Ray Townsend

Coastal Engineering Research Center

WES

Approved for Public Release; Distribution is Unlimited

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

December 1995
Preliminary Data Summary

by Field Research Facility

U.S. Army Corps of Engineers
Waterways Experiment Station
Coastal Engineering Research Center
1261 Duck Road
Duck, NC 27949-4472

Contents

Preface iv
1 — Introduction 1
2 — Meteorological Data 7
3 — Wave Data 12
4 — Current Data 17
5 — Visual Observations 20
6 — Water Levels 22
7 — Bathymetry 24

List of Figures

No.
1 FRF Location Map 2
2 Month at a Glance 3
3 Instrument Locations at FRF 6
4 Meteorological Monthly Summary 8
5 Wave Heights and Periods 16
6 Water Levels 22
7 CRAB Profiles 24
8 CRAB Profile Envelope 25
9 FRF Bathymetry (12 December 95) 26

List of Tables

No.
1 Instrument Status/Data Availability 4
2 Gauge Locations 5
3 Meteorological Data 9
4 Wave Data 13
5 Current Meter Data 18
6 Visually Observed Current Data 19
7 Visual Observations 21
8 Water Levels 23

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.

These reports are now available via the World Wide Web at http://frf.wes.army.mil/frf.html

These web pages contain general information about the Field Research Facility and data from 1980 to the present.

Your comments and criticisms are welcome.

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 *(baron@duck.wes.army.mil)*.

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).

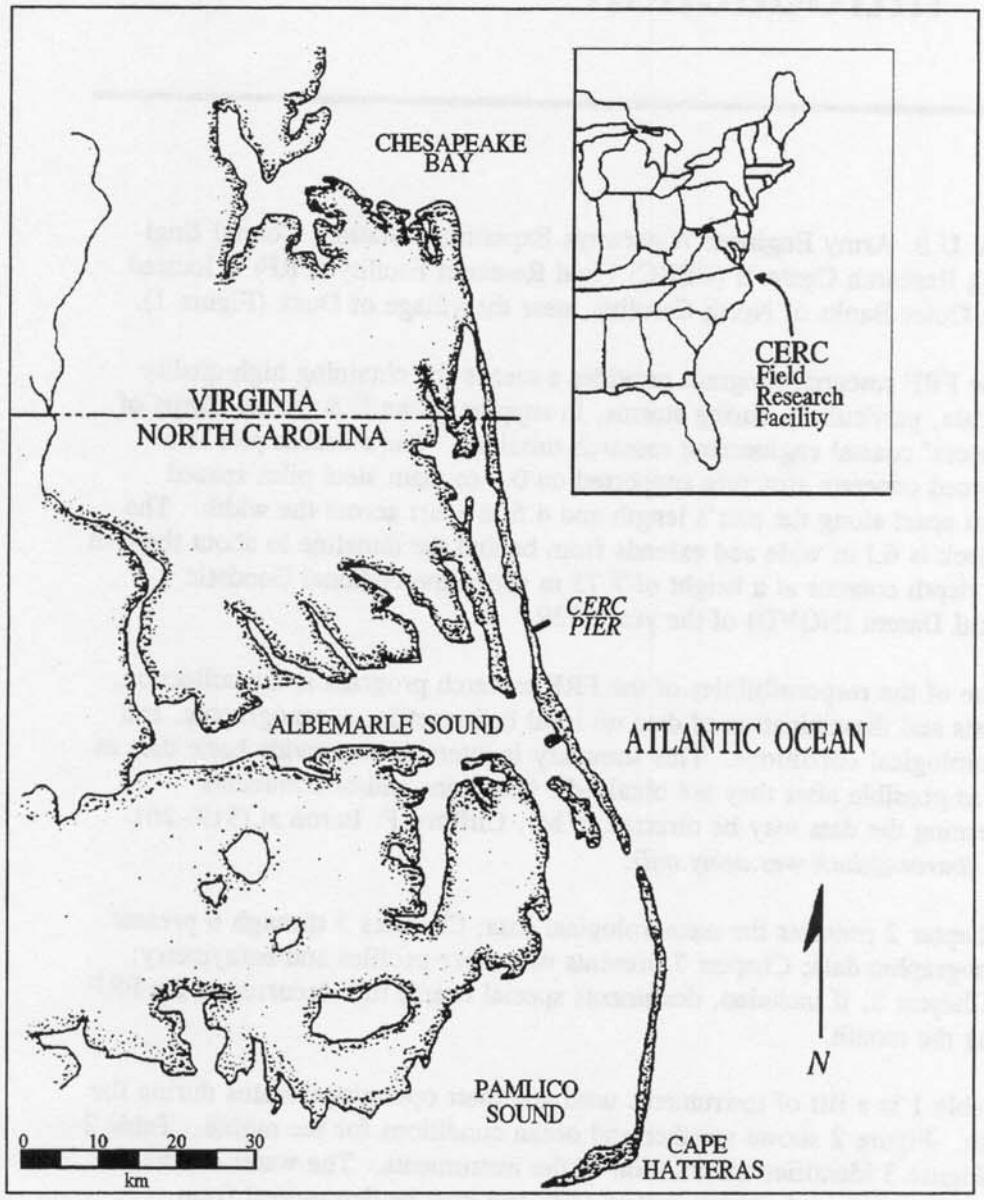

Figure 1. FRF Location Map

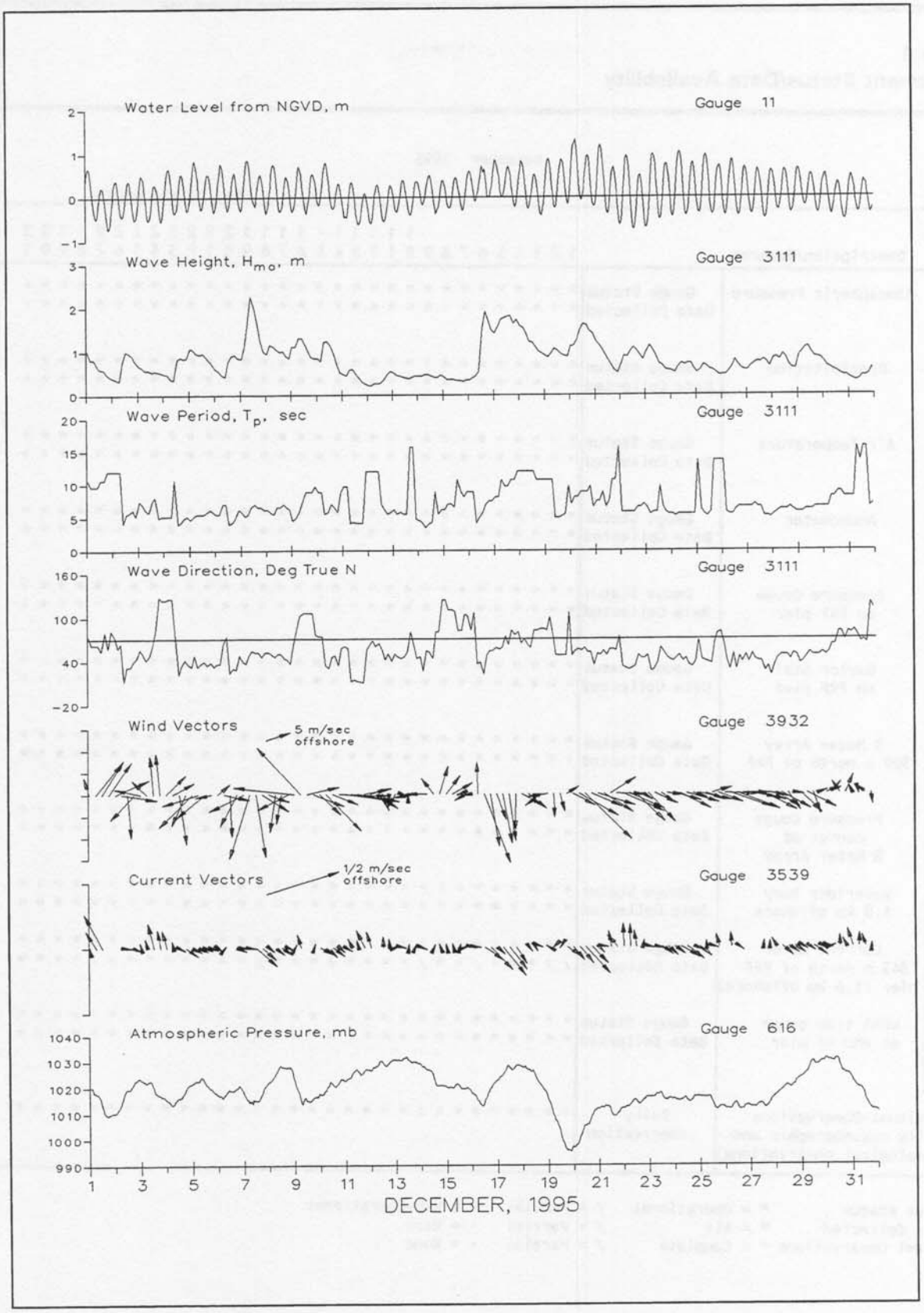

Figure 2. Month at a Glance

Table 1
Instrument Status/Data Availability

December 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

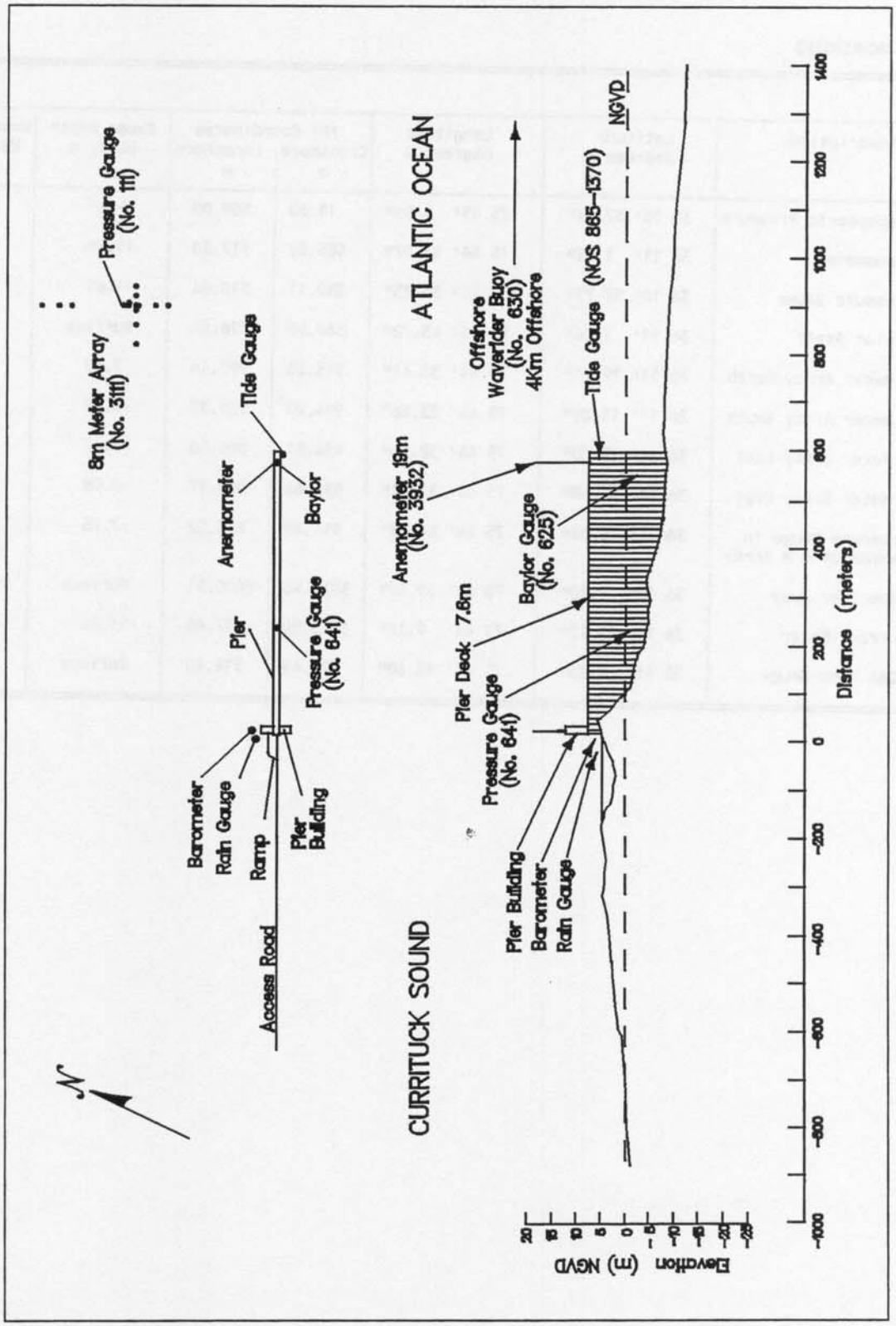

Figure 3. Instrument Locations, Elevations From NGVD

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

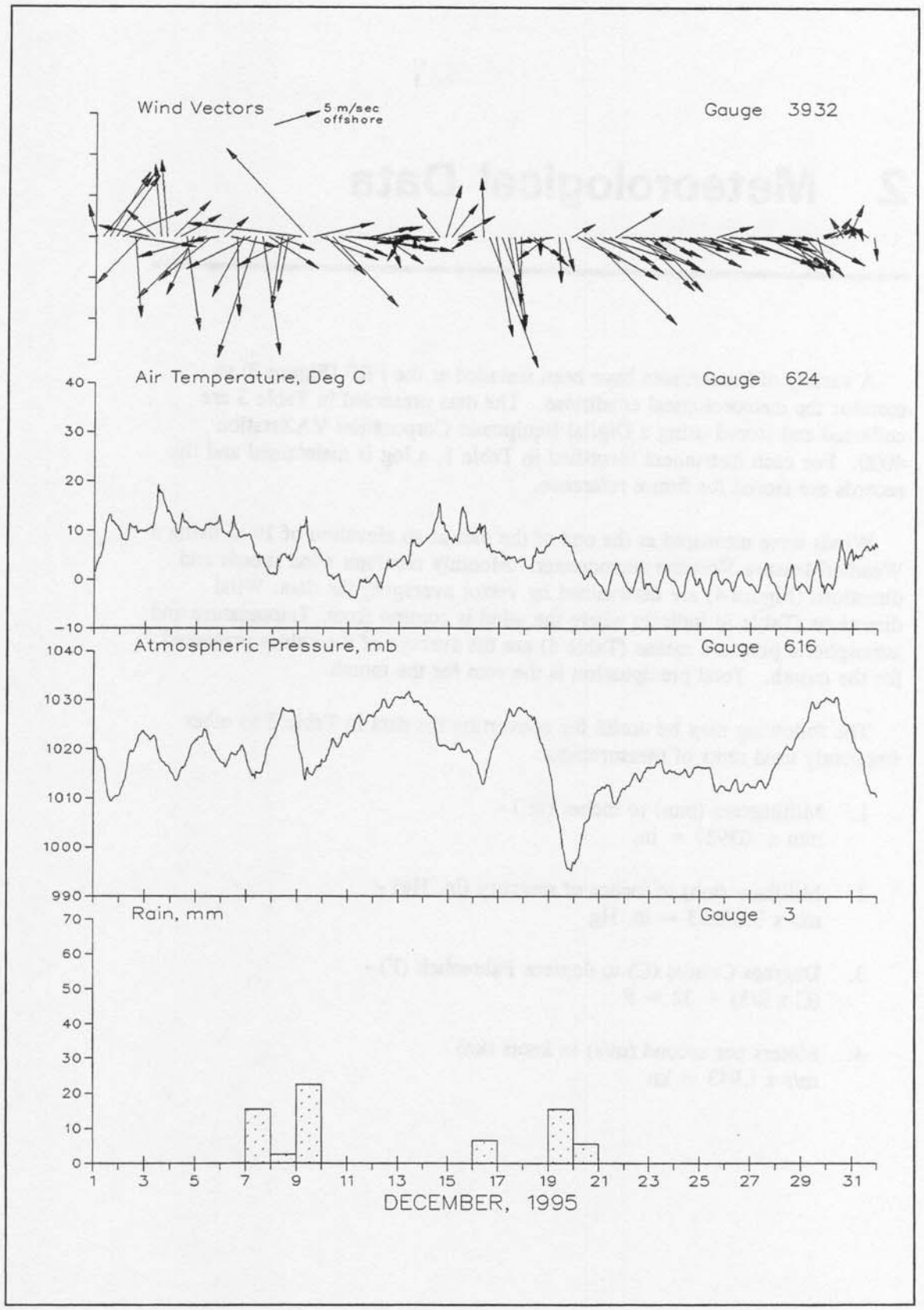

Figure 4. Meteorological Monthly Summary

Table 3
Meteorological Data

Dec 1995

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	4	166	1.6	1020.3	0
	700	9	214	5.4	1017.8	0
	1300	9	207	12.5	1011.7	0
	1900	9	210	11.2	1010.1	0
2	100	7	243	9.4	1011.0	0
	700	7	280	8.2	1015.9	0
	1300	10	356	10.6	1019.5	0
	1900	7	38	10.0	1022.9	0
3	100	5	1	10.0	1023.0	0
	700	4	137	10.8	1022.6	0
	1300	9	175	18.2	1018.9	0
	1900	9	175	15.0	1016.9	0
4	100	6	221	11.9	1015.2	0
	700	5	237	9.5	1013.9	0
	1300	12	353	11.9	1016.3	0
	1900	8	21	10.5	1020.3	0
5	100	10	40	10.4	1021.8	0
	700	7	70	10.2	1023.1	0
	1300	8	46	11.4	1021.0	0
	1900	3	77	11.5	1018.9	0
6	100	3	225	9.7	1017.1	0
	700	5	284	8.9	1017.7	0
	1300	10	358	10.6	1018.9	0
	1900	8	24	8.8	1020.7	0
7	100	8	59	9.1	1017.1	0
	700	15	15	5.8	1014.9	15
	1300	15	352	4.6	1015.0	0
	1900	6	307	2.1	1019.7	0
8	100	4	293	1.4	1022.6	0
	700	9	6	4.0	1026.1	3
	1300	7	9	4.5	1027.9	0
	1900	7	58	4.5	1027.5	0
9	100	12	97	8.9	1021.1	0
	700	14	141	11.7	1013.7	23
	1300	6	255	6.2	1014.9	0
	1900	7	294	5.8	1016.5	0
10	100	6	318	3.9	1017.3	0
	700	11	320	0.8	1020.4	0
	1300	6	294	0.7	1020.6	0
	1900	10	272	-1.7	1022.9	0

Table 3
Meteorological Data (continued)

Dec 1995

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	11	279	-3.2	1023.2	0
	700	8	281	-3.7	1025.9	0
	1300	7	281	-0.5	1025.7	0
	1900	6	257	-0.6	1026.9	0
12	100	4	252	0.8	1026.8	0
	700	5	308	-1.8	1028.5	0
	1300	4	342	3.5	1028.8	0
	1900	2	5	3.0	1030.0	0
13	100	3	27	3.9	1030.3	0
	700	1	296	3.7	1031.2	0
	1300	0		7.6	1030.3	0
	1900	3	78	6.7	1029.9	0
14	100	5	81	8.0	1027.9	0
	700	4	1	9.3	1026.9	0
	1300	4	145	13.3	1022.1	0
	1900	6	194	11.4	1020.8	0
15	100	5	213	8.4	1019.9	0
	700	5	236	7.9	1020.3	0
	1300	0		14.8	1019.9	0
	1900	3	53	9.7	1019.9	0
16	100	2	79	9.5	1017.7	0
	700	7	178	10.9	1013.9	6
	1300	17	341	6.8	1016.1	0
	1900	12	351	5.9	1020.6	0
17	100	6	342	5.4	1022.9	0
	700	12	350	4.1	1026.0	0
	1300	11	353	4.6	1026.9	0
	1900	8	1	4.0	1028.5	0
18	100	4	303	2.6	1027.6	0
	700	5	313	2.5	1026.7	0
	1300	2	359	5.6	1023.5	0
	1900	4	47	6.1	1019.9	0
19	100	4	79	8.2	1014.7	0
	700	6	357	8.6	1007.3	15
	1300	4	347	8.6	999.9	0
	1900	3	237	6.9	995.7	0
20	100	5	302	3.5	996.7	0
	700	9	303	1.3	1001.5	5
	1300	14	319	1.4	1005.7	0
	1900	7	297	0.3	1010.2	0

Table 3
Meteorological Data (concluded)

Dec 1995

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	8	290	-1.3	1011.9	0
	700	7	307	-3.2	1012.7	0
	1300	6	234	2.2	1009.6	0
	1900	6	273	1.6	1010.3	0
22	100	9	297	-1.3	1012.0	0
	700	8	298	-2.7	1013.7	0
	1300	9	318	2.3	1014.1	0
	1900	2	305	-1.9	1015.5	0
23	100	8	321	-1.4	1016.3	0
	700	5	298	-2.9	1017.5	0
	1300	4	310	2.0	1016.0	0
	1900	3	278	0.2	1015.7	0
24	100	6	287	-1.2	1015.1	0
	700	7	301	-3.2	1015.2	0
	1300	7	288	2.0	1014.5	0
	1900	3	291	-0.5	1016.3	0
25	100	7	283	-0.9	1016.3	0
	700	4	292	-3.2	1016.2	0
	1300	4	251	1.5	1012.9	0
	1900	5	293	-0.6	1012.5	0
26	100	7	273	0.1	1011.8	0
	700	9	292	-2.3	1012.8	0
	1300	9	294	1.2	1011.8	0
	1900	5	270	-0.4	1012.7	0
27	100	6	282	-1.0	1012.3	0
	700	6	286	-2.6	1013.2	0
	1300	8	301	2.8	1012.5	0
	1900	4	284	-0.2	1014.6	0
28	100	6	304	-2.5	1017.1	0
	700	7	303	-4.0	1019.5	0
	1300	5	329	1.7	1020.0	0
	1900	2	280	-2.1	1022.4	0
29	100	6	319	-0.9	1024.1	0
	700	7	301	-2.7	1027.1	0
	1300	5	344	3.1	1028.5	0
	1900	2	245	-1.1	1029.8	0
30	100	3	248	-0.9	1030.3	0
	700	3	212	-0.5	1029.7	0
	1300	3	150	7.8	1027.2	0
	1900	4	200	3.7	1025.1	0
31	100	2	156	3.9	1021.7	0
	700	0		5.0	1019.5	0
	1300	2	126	6.7	1014.8	0
	1900	3	353	6.9	1011.3	0
		Resultant		Mean	Mean	Total
		3	312	4.3	1018.7	67

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

Dec 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
1	0100	0.50	7.4	0.62	7.4	1.02	10.8	74	0.79	7.6
	0700	0.36	10.3	0.82	10.3	0.82	9.8	62	0.92	10.3
	1300	0.29	9.9	0.55	10.7	0.60	10.8	54	0.75	10.3
	1900	0.25	11.7	0.53	11.2	0.50	12.0	58	0.52	10.7
2	0100	0.23	7.8	0.35	10.3	0.39	12.0	74	0.49	7.2
	0700	0.19	7.8	0.31	11.2	0.33	12.0	64	0.44	8.1
	1300	0.67	4.7	0.92	4.6	1.01	5.6	32	1.12	4.5
	1900	0.60	5.7	0.92	6.1	0.91	6.2	40	1.12	5.9
3	0100	0.48	5.1	0.71	4.5	0.68	7.6	56	0.87	8.3
	0700	0.38	6.5	0.61	6.8	0.58	6.2	42	0.69	7.2
	1300	0.27	8.6	0.60	8.6	0.54	7.6	62	0.65	6.6
	1900	0.35	4.3	0.56	9.2	0.54	5.0	128	0.65	4.8
4	0100	0.31	5.0	0.46	5.4	0.50	5.3	124	0.60	5.2
	0700	0.29	5.7	0.36	5.6	0.38	5.3	126	0.49	5.3
	1300	0.52	3.8	0.77	3.7	0.84	4.1	22	0.83	3.6
	1900	0.70	5.0	0.80	4.6	0.84	5.0	42	1.02	5.0
5	0100	0.66	5.2	1.04	4.6	1.08	4.8	32	1.21	5.1
	0700	0.74	5.3	0.97	5.2	0.97	5.6	32	1.15	5.4
	1300	0.57	4.9	0.97	4.5	0.96	5.6	40	1.05	6.1
	1900	0.56	5.7	0.77	6.6	0.79	6.2	38	0.84	6.1
6	0100	0.39	5.5	0.62	5.9	0.60	5.6	36	0.68	5.6
	0700	0.33	4.5	0.44	6.6	0.47	7.1	64	0.55	5.5
	1300	0.52	4.1	0.78	3.7	0.77	4.1	24	0.85	3.9
	1900	0.76	5.3	0.93	5.2	0.93	5.0	28	1.05	5.1
7	0100	0.52	4.9	0.86	5.3	0.84	5.9	40	0.97	6.1
	0700	0.99	5.7	1.39	5.5	1.67	5.6	48	1.57	5.4
	1300	0.72	7.0	1.88	7.0	1.99	7.1	52	2.40	7.0
	1900	0.92	6.3	1.23	6.5	1.25	6.6	46	1.63	7.0
8	0100	0.56	5.9	0.90	6.0	0.95	6.2	52	1.14	6.1
	0700	0.79	5.3	0.98	5.6	1.12	5.6	46	1.29	5.9
	1300	0.64	6.3	0.96	5.9	1.00	6.6	50	1.17	6.1
	1900	0.69	6.5	0.87	6.5	0.91	6.6	42	1.07	6.8
9	0100	0.57	4.5	1.06	4.1	1.11	4.6	62	1.19	4.5
	0700	0.84	5.9	1.31	5.6	1.30	5.9	102	1.54	5.9
	1300	0.61	8.3	1.23	8.3	1.16	8.9	106	1.45	8.3
	1900	0.63	8.9	0.79	8.9	0.87	8.9	106	1.00	8.3
10	0100	0.57	4.4	0.77	8.6	0.85	8.9	74	1.02	8.6
	0700	0.73	4.6	0.94	4.9	1.23	5.6	34	1.26	5.0
	1300	0.71	7.2	1.06	6.8	1.13	7.1	46	1.36	7.0
	1900	0.50	5.7	0.69	7.4	0.71	5.9	34	0.95	6.1

Table 4
Wave Data (continued)

Dec 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	0.28	4.7	0.52	10.3	0.49	9.8	60	0.77	3.4
	0700	0.41	5.2	0.56	5.4	0.58	4.2	12	0.87	5.4
	1300	0.39	4.5	0.57	4.1	0.48	4.2	12	0.69	4.5
	1900	0.21	4.1	0.38	3.8	0.32	4.2	10	0.45	3.9
12	0100	0.10	14.3	0.22	12.9	0.22	12.0	62	0.25	7.6
	0700	0.16	3.6	0.32	3.1	0.26	12.0	60	0.38	2.6
	1300	0.15	3.2	0.29	11.7	0.28	7.1	56	0.35	3.4
	1900	0.25	4.5	0.46	5.4	0.47	5.6	50	0.53	5.2
13	0100	0.31	5.3	0.51	5.7	0.52	6.2	50	0.60	6.0
	0700	0.23	18.3	0.44	5.9	0.44	5.9	44	0.52	5.6
	1300	0.21	17.1	0.39	5.5	0.39	5.6	52	0.47	5.5
	1900	0.19	15.1	0.46	16.0	0.41	15.7	62	0.47	5.3
14	0100	0.27	4.5	0.49	4.2	0.44	4.6	46	0.53	4.5
	0700	0.23	3.1	0.50	4.1	0.48	3.5	54	0.56	3.7
	1300	0.23	4.2	0.46	4.2	0.44	4.4	44	0.50	4.1
	1900	0.16	12.2	0.40	9.5	0.40	5.6	80	0.44	4.6
15	0100	0.27	6.8	0.38	7.2	0.42	6.2	124	0.58	5.7
	0700	0.18	7.2	0.34	6.8	0.36	7.1	110	0.46	6.6
	1300	0.23	6.5	0.31	9.5	0.33	10.8	82	0.39	6.6
	1900	0.16	6.8	0.29	6.8	0.32	8.2	104	0.34	8.9
16	0100	0.22	8.9	0.31	6.8	0.35	8.9	82	0.36	7.6
	0700	0.26	4.5	0.46	4.2	0.44	4.2	36	0.55	4.2
	1300	0.84	5.1	1.03	4.8	1.53	5.9	22	1.31	5.1
	1900	0.72	6.8	1.60	7.8	1.72	7.6	54	1.97	7.8
17	0100	0.83	8.6	1.32	8.9	1.42	8.2	58	1.58	7.6
	0700	0.71	5.7	1.48	6.0	1.72	10.8	58	1.80	7.4
	1300	0.89	6.5	1.65	9.9	1.80	9.8	62	1.98	10.7
	1900	0.67	12.2	1.54	11.2	1.63	10.8	76	1.80	11.7
18	0100	0.91	12.2	1.53	11.7	1.59	12.0	64	1.60	12.2
	0700	0.77	11.7	1.35	11.7	1.40	12.0	62	1.37	11.7
	1300	0.71	12.2	1.09	10.7	1.21	12.0	82	1.18	10.3
	1900	0.62	12.2	0.93	11.7	1.00	10.8	84	1.00	11.2
19	0100	0.56	10.3	0.89	9.5	0.90	10.8	82	1.00	9.9
	0700	0.57	4.2	0.91	11.2	0.96	10.8	76	1.03	9.9
	1300	0.65	5.4	1.00	5.3	1.01	5.0	48	1.10	5.1
	1900	0.67	5.3	0.86	5.5	0.90	5.6	48	0.93	5.3
20	0100	0.78	7.0	1.01	7.4	1.12	7.1	48	1.26	6.6
	0700	0.87	7.8	1.04	8.3	1.27	8.2	56	1.34	8.3
	1300	0.72	7.0	1.40	6.8	1.63	8.9	58	1.91	7.6
	1900	0.98	7.2	1.32	7.2	1.47	9.8	52	1.52	8.9

Table 4
Wave Data (concluded)

Dec 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	0.65	7.0	1.13	7.0	1.23	7.6	50	1.43	7.4
	0700	0.85	7.0	1.01	7.0	1.06	8.9	54	1.25	8.3
	1300	0.46	10.3	0.84	8.5	0.80	7.6	56	0.96	8.3
	1900	0.45	5.2	inoperative		0.56	10.8	54	0.77	7.2
22	0100	0.35	5.1			0.69	5.9	32	0.81	3.5
	0700	0.81	6.0	0.89	8.5	0.88	5.9	28	0.99	7.0
	1300	0.41	6.1	1.09	6.0	1.09	5.9	32	1.23	7.4
	1900	0.73	6.0	0.90	6.3	0.90	6.6	44	1.01	6.6
23	0100	0.43	6.1	0.89	4.2	0.99	6.6	48	1.08	7.4
	0700	0.82	6.1	0.93	5.9	1.05	5.9	28	1.21	6.0
	1300	0.44	5.4	0.73	9.5	0.71	9.8	58	0.87	5.1
	1900	0.44	6.0	0.56	6.0	0.59	5.9	46	0.73	4.7
24	0100	0.35	5.2	0.54	5.6	0.55	5.6	40	0.60	4.9
	0700	0.41	5.2	0.49	5.3	0.63	5.6	48	0.79	5.3
	1300	0.55	5.6	0.72	5.6	0.69	5.6	44	0.84	5.5
	1900	0.58	5.4	0.61	5.6	0.73	5.6	32	0.87	5.7
25	0100	0.36	6.1	0.46	6.0	0.50	13.6	68	0.64	5.7
	0700	0.50	5.5	0.63	5.6	0.69	5.6	40	0.74	5.7
	1300	0.46	5.6	0.56	5.4	0.59	5.9	36	0.68	5.5
	1900	0.34	5.4	0.51	13.5	0.51	13.6	78	0.59	6.0
26	0100	0.29	6.0	0.39	13.5	0.47	13.6	64	0.47	7.0
	0700	0.36	5.5	0.50	5.2	0.53	5.6	28	0.67	5.5
	1300	0.69	6.3	0.75	6.1	0.81	6.2	28	1.06	6.5
	1900	0.49	5.7	0.62	6.8	0.61	6.6	38	1.10	6.3
27	0100	0.45	5.5	0.56	6.5	0.57	6.6	38	0.82	5.6
	0700	0.51	5.6	0.68	6.8	0.71	7.1	42	0.95	6.8
	1300	0.62	6.5	0.76	6.6	0.75	6.6	40	0.96	6.6
	1900	0.49	5.3	0.72	5.3	0.74	5.3	32	0.85	7.6
28	0100	0.65	5.3	0.72	5.4	0.84	5.6	36	0.85	6.1
	0700	0.52	6.0	0.83	6.1	0.80	6.2	48	0.94	6.8
	1300	0.70	6.5	0.80	6.3	0.85	6.2	48	1.11	6.3
	1900	0.44	5.2	0.61	5.9	0.61	6.2	50	0.87	6.5
29	0100	0.67	5.0	0.80	5.7	0.88	5.9	36	0.86	5.6
	0700	0.60	6.1	1.02	6.0	1.08	6.2	46	1.14	6.0
	1300	0.76	6.3	0.95	6.3	0.97	6.2	48	1.20	6.3
	1900	0.51	6.6	0.82	6.8	0.86	6.6	48	0.95	6.8
30	0100	0.54	6.5	0.68	6.8	0.75	6.6	48	0.77	6.8
	0700	0.34	6.3	0.59	8.9	0.61	8.2	62	0.63	6.6
	1300	0.32	11.7	0.50	8.3	0.53	8.9	80	0.57	9.2
	1900	0.22	9.2	0.46	8.6	0.44	8.2	68	0.45	8.9
31	0100	0.26	12.9	0.37	7.8	0.38	8.2	78	0.39	8.3
	0700	0.17	12.2	0.29	7.8	0.32	15.7	76	0.32	7.8
	1300	0.28	12.2	0.38	14.3	0.43	15.7	68	0.46	4.8
	1900	0.31	14.3	0.42	15.1	0.47	6.6	120	0.58	6.1
Mean		0.50	6.9	0.76	7.2	0.80	7.5	55	0.92	6.6
Std dev		0.22	2.9	0.34	2.6	0.38	2.7	23	0.40	1.9

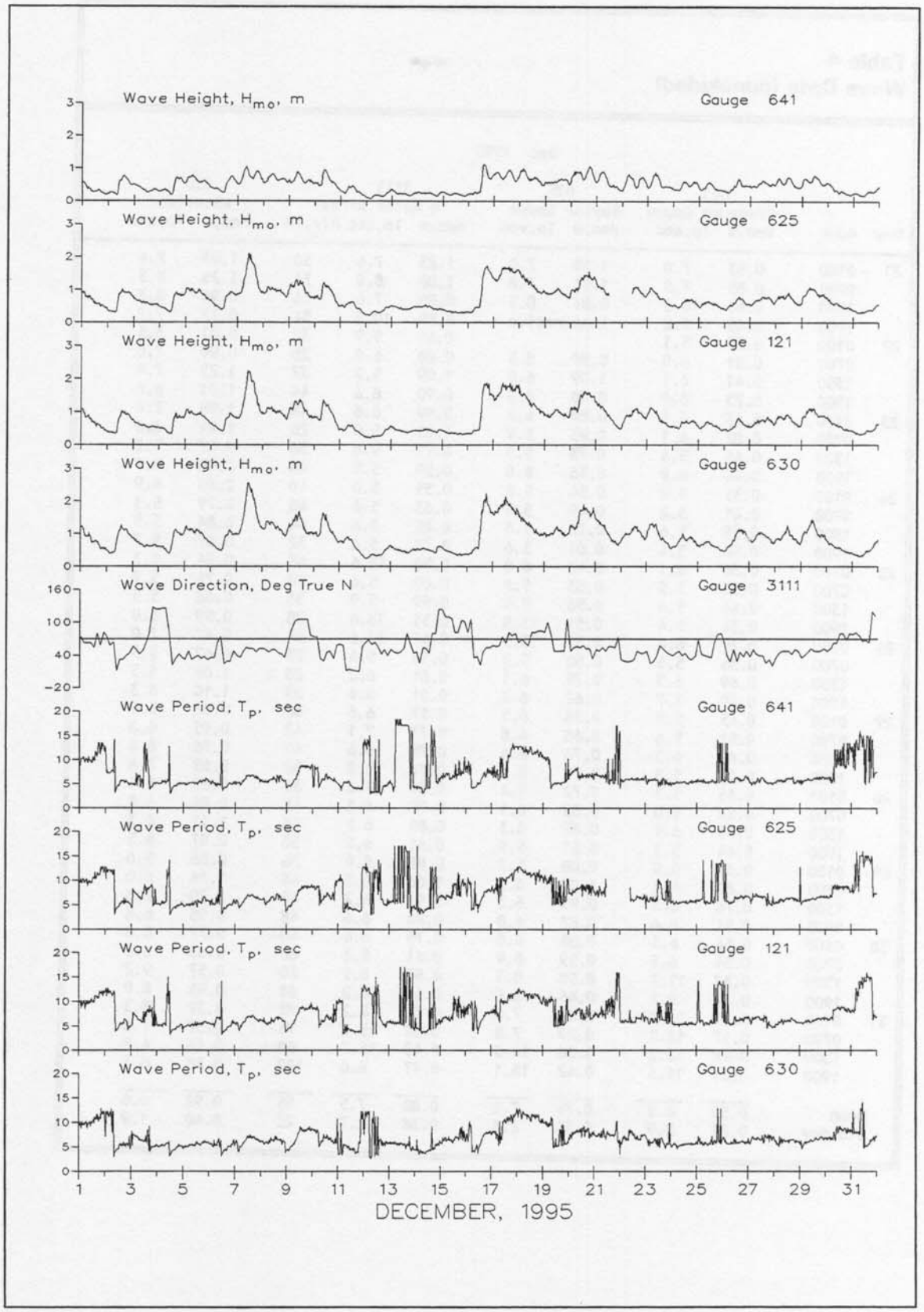

Figure 5. Wave Heights and Periods

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

DECEMBER 1995

Day	Time	Cross Shore	Long Shore	Speed	Dir
1	100	4	0	1	348
	700	5	-8	15	332
	1300	4	-21	28	335
	1900				
2	100		inoperative		
	700				
	1300	2	6	2	102
	1900	1	8	6	116
3	100	3	0	4	345
	700	2	-1	7	345
	1300	1	-13	20	348
	1900	1	-7	14	352
4	100	3	-7	14	347
	700	3	0	5	350
	1300	3	8	4	121
	1900	2	14	10	130
5	100	2	11	7	119
	700	1	10	7	116
	1300	2	9	5	115
	1900	2	8	4	111
6	100	3	7	4	131
	700	3	3	2	33
	1300				
	1900	1	10	7	115
7	100	2	7	4	99
	700	1	9	4	100
	1300	0	29	19	137
	1900	1	20	12	138
8	100	2	9	5	134
	700	1	13	8	134
	1300	1	14	9	130
	1900	2	9	4	120
9	100	1	4	3	26
	700	2	-4	10	345
	1300				
	1900	0	0	0	
10	100	0	16	10	122
	700	2	16	10	138
	1300	0	17	10	131
	1900	2	10	5	136
11	100	1	9	5	124
	700	4	-3	7	335
	1300	1	0	6	348
	1900	4	-9	14	337
12	100	3	-8	12	344
	700				
	1300	2	-3	8	357
	1900	2	-1	7	352
13	100	1	5	3	67
	700	2	6	3	108
	1300	1	2	3	7
	1900	1	2	3	22
14	100	1	7	4	115
	700				
	1300	2	3	2	22
	1900	2	1	3	344
15	100	2	1	3	349
	700	2	0	3	348
	1300	1	2	3	13
	1900	1	3	2	70
16	100	1	5	3	107
	700	2	4	2	98
	1300	0	22	16	129
	1900	0	33	22	141
17	100	0	13	7	139
	700	2	35	26	147
	1300	2	28	21	148
	1900	3	21	14	152
18	100				
	700	-1	7	4	145
	1300	0	9	4	156
	1900	0	4	1	115
19	100	2	2	2	305
	700	3	3	2	221
	1300	4	3	1	209
	1900	0	14	12	129
20	100	3	16	13	146
	700	3	21	16	144
	1300	1	34	26	143
	1900	1	22	16	142
21	100	1	11	6	140
	700	1	6	2	100
	1300	0	-7	12	350
	1900	6	-5	11	321
22	100	-1	-11	18	358
	700	-2	-9	17	359
	1300	1	-7	13	352
	1900	2	-2	5	9
23	100	-1	3	3	107
	700	0	10	7	106
	1300	0	13	10	130
	1900	2	13	9	139
24	100	1	12	9	132
	700	-1	20	15	125
	1300	0	20	15	133
	1900	0	10	7	116
25	100	1	15	11	137
	700	0	-1	5	357
	1300	0	6	4	110
	1900	1	-3	9	348
26	100				
	700	0	-3	11	355
	1300	2	6	5	131
	1900				
27	100		inoperative		
	700				
	1300	0	1	4	7
	1900	0	0	0	
28	100	2	-1	6	332
	700	1	12	10	138
	1300	1	12	9	130
	1900	1	12	8	130
29	100	1	7	5	123
	700	1	10	6	129
	1300	0	15	11	132
	1900	0	8	5	123
30	100	0	6	4	109
	700	0	2	2	65
	1300	0	-3	8	359
	1900	2	-1	6	336
31	100	1	-6	13	344
	700	0	0	0	
	1300	2	-2	9	344
	1900	1	1	2	6

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

Dec 1995

	Pier End				Mid-Surf Zone				Beach		
Day	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir
1	38	-51	63	17	33	-20	38	38	South	19	N
2	-5	32	32	169	0	61	61	160	South	50	S
3	5	-47	47	346	0	-34	34	340	South	14	S
4	3	10	10	141	4	20	21	70	South	23	N
5	-11	18	22	191	0	22	22	160	South	66	S
6	8	18	20	136	6	16	17	138	South	28	S
7	13	87	88	151	-30	76	82	182	North	100	S
8	0	47	47	160	8	55	56	151	North	57	S
9	17	-8	19	43	6	-61	61	346	South	126	N
10	15	51	53	143	34	61	70	131	North	40	S
11	15	14	21	70	13	16	21	120	North	77	S
12	20	20	29	70	11	36	37	143	North	43	S
13	6	10	12	129	1	6	7	149	North	50	S
14	0	0	0		8	11	14	70	South	4	N
15	8	5	9	70	4	-11	11	359	South	5	N
16	12	61	62	149	16	36	39	136	North	71	S
17	0	87	87	160	0	87	87	160	North	71	S
18	0	61	61	160	32	12	35	91	North	23	N
19	2	19	19	154	-2	22	22	166	South	11	N
20	0	61	61	160	0	76	76	160	North	53	S
21	10	34	35	143	5	30	31	151	North	40	S
22	15	24	28	70	0	68	68	160	North	30	S
23	0	47	47	160	4	41	41	154	North	18	S
24	8	55	56	151	0	68	68	160	North	34	S
25	5	16	17	143	0	51	51	160	North	22	S
26	4	28	28	151	8	51	51	151	North	32	S
27	3	17	17	151	-15	51	53	177	North	18	S
28	-8	41	41	171	11	76	77	151	North	27	S
29	6	38	39	151	46	76	89	70	North	43	S
30	8	20	22	70	0	-29	29	340	South	3	N
31	0	-44	44	340	0	-27	27	340	South	4	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 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

Dec 1995

Day	Time	Wave Approach Angle at Pier End deg from True N Primary	Secondary		Width of Surf Zone,m	Water Characteristics at Pier End Temp.,C	Density g/cc	Secchi Vis.,m
1	0753	75	130		94	11.1	1.0242	0.3
2	1022	25			137	12.2	1.0254	0.6
3	1105	75			119	12.2	1.0252	0.3
4	0836	100			41	12.8	1.0251	1.2
5	0822	30	70		160	11.9	1.0254	0.6
6	0838	90			45	11.9	1.0253	0.9
7	0844	40			232	10.8	1.0251	0.3
8	0906	30			162	9.4	1.0245	0.6
9	1112	105			216	10.0	1.0244	0.9
10	1028	25			197	9.4	1.0251	1.2
11	0924	10			53	6.7	1.0251	1.8
13	0923	40			52	8.6	1.0253	2.1
14	0853	35	65		50	9.7	1.0251	2.4
15	0837	100			40	10.0	1.0250	1.8
16	1121	160	45		38	10.6	1.0250	2.1
17	1118	60	25		67	8.9	1.0242	0.6
18	0807	65			185	7.8	1.0245	0.3
19	0820	65	40		140	8.9	1.0242	0.3
20	0715	50			151	7.2	1.0248	0.3
21	0735	50			152	6.7	1.0244	0.3
22	0805	35			53	6.7	1.0250	0.3
23	1025	35			51	7.2	1.0252	0.6
24	1030	20			55	6.1	1.0246	0.6
25	1010	40			43	6.1	1.0242	1.8
26	0824	35			17	5.6	1.0240	1.2
27	0940	45			52	6.1	1.0246	1.2
28	1009	50	30		52	5.6	1.0246	0.9
29	1110	50			125	5.0	1.0248	0.3
30	0945	70	45		110	5.0	1.0240	0.6
31	1020	100			27	5.0	1.0242	1.8

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.

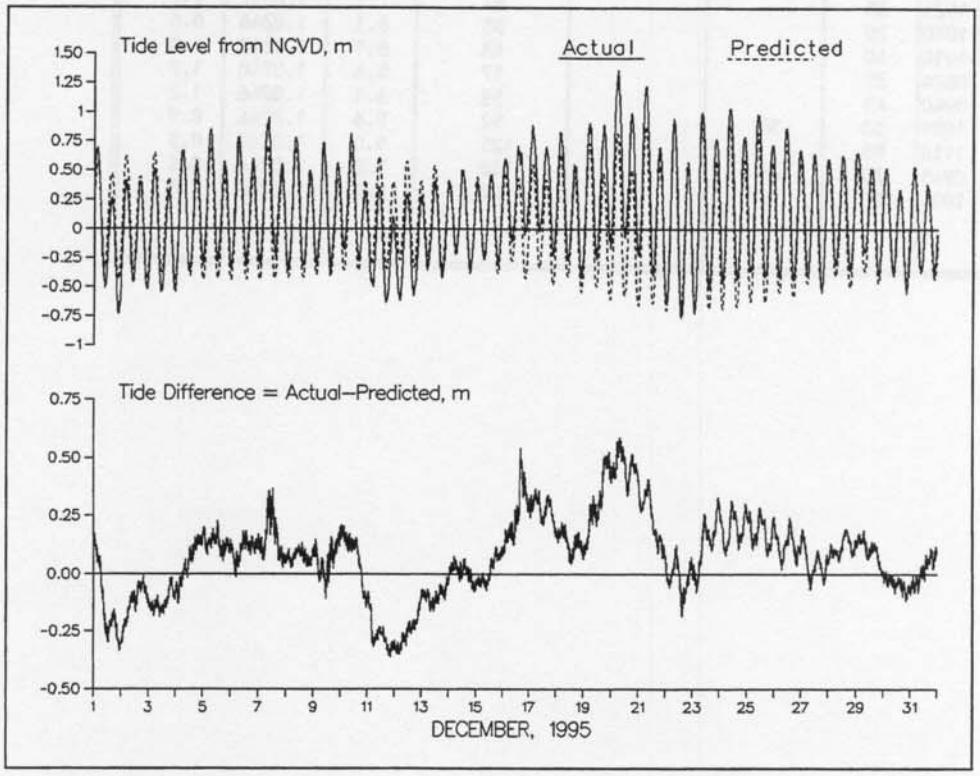

Figure 6. Water Level Variation

Table 8
Water Levels, m NGVD

DEC 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	0306	0.69	1	0924	-0.51	0.11	1.20	16	1300	0.71	16	1906	-0.05	0.35	0.76
1	1524	0.26	1	2112	-0.73	-0.22	0.99	17	0212	0.89	17	0836	-0.03	0.41	0.92
2	0330	0.41	2	0936	-0.46	-0.05	0.87	17	1454	0.71	17	2042	-0.23	0.25	0.93
2	1542	0.41	2	2218	-0.52	-0.07	0.93	18	0300	0.83	18	0936	-0.27	0.27	1.10
3	0436	0.51	3	1024	-0.55	-0.01	1.06	18	1524	0.55	18	2142	-0.43	0.07	0.98
3	1636	0.32	3	2306	-0.55	-0.08	0.87	19	0448	0.90	19	1106	-0.26	0.33	1.16
4	0600	0.66	4	1154	-0.37	0.14	1.03	19	1706	0.89	19	2300	-0.17	0.38	1.06
4	1742	0.58	4	2330	-0.32	0.13	0.90	20	0548	1.36	20	1142	-0.07	0.60	1.43
5	0600	0.85	5	1218	-0.29	0.27	1.14	20	1736	0.99	20	2348	-0.23	0.36	1.22
5	1812	0.57	6	0018	-0.35	0.11	0.93	21	0630	1.22	21	1230	-0.40	0.41	1.62
6	0648	0.78	6	1324	-0.33	0.23	1.11	21	1836	0.70	22	0054	-0.65	0.03	1.35
6	1848	0.59	7	0124	-0.32	0.13	0.91	22	0648	0.94	22	1324	-0.76	0.10	1.71
7	0824	0.95	7	1436	-0.27	0.33	1.22	22	1942	0.55	23	0142	-0.73	-0.08	1.28
7	1942	0.55	8	0106	-0.36	0.09	0.91	23	0806	1.00	23	1430	-0.52	0.24	1.52
8	0742	0.78	8	1424	-0.32	0.21	1.10	23	2030	0.77	24	0218	-0.47	0.17	1.24
8	1954	0.50	9	0200	-0.33	0.09	0.82	24	0848	1.04	24	1512	-0.44	0.30	1.47
9	0836	0.74	9	1412	-0.41	0.15	1.14	24	2148	0.79	25	0248	-0.37	0.20	1.15
9	2106	0.56	10	0300	-0.18	0.18	0.74	25	0930	0.98	25	1554	-0.41	0.27	1.39
10	0854	0.81	10	1548	-0.27	0.24	1.09	25	2236	0.72	26	0412	-0.41	0.16	1.13
10	2124	0.32	11	0430	-0.50	-0.08	0.81	26	1042	0.86	26	1654	-0.44	0.20	1.30
11	0954	0.36	11	1606	-0.64	-0.16	1.00	26	2254	0.67	27	0506	-0.40	0.14	1.07
11	2206	0.10	12	0418	-0.61	-0.26	0.71	27	1112	0.64	27	1742	-0.52	0.06	1.16
12	1054	0.29	12	1648	-0.58	-0.14	0.88	28	0000	0.60	28	0618	-0.31	0.14	0.91
12	2300	0.28	13	0436	-0.36	-0.03	0.63	28	1224	0.63	28	1854	-0.36	0.14	0.99
13	1030	0.41	13	1742	-0.43	-0.01	0.83	29	0106	0.65	29	0812	-0.20	0.22	0.86
13	2336	0.40	14	0548	-0.18	0.10	0.58	29	1254	0.52	29	2012	-0.40	0.07	0.91
14	1200	0.50	14	1800	-0.39	0.08	0.89	30	0248	0.52	30	0900	-0.40	0.07	0.93
15	0024	0.41	15	0706	-0.27	0.07	0.68	30	1436	0.33	30	2036	-0.56	-0.09	0.88
15	1306	0.46	15	1930	-0.32	0.08	0.78	31	0306	0.52	31	0918	-0.38	0.06	0.90
16	0130	0.60	16	0748	-0.12	0.25	0.71	31	1500	0.39	31	2130	-0.40	-0.01	0.79

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 November 1995 and the survey(s) in December 1995 on profile line 188, located 517 m south of the pier.

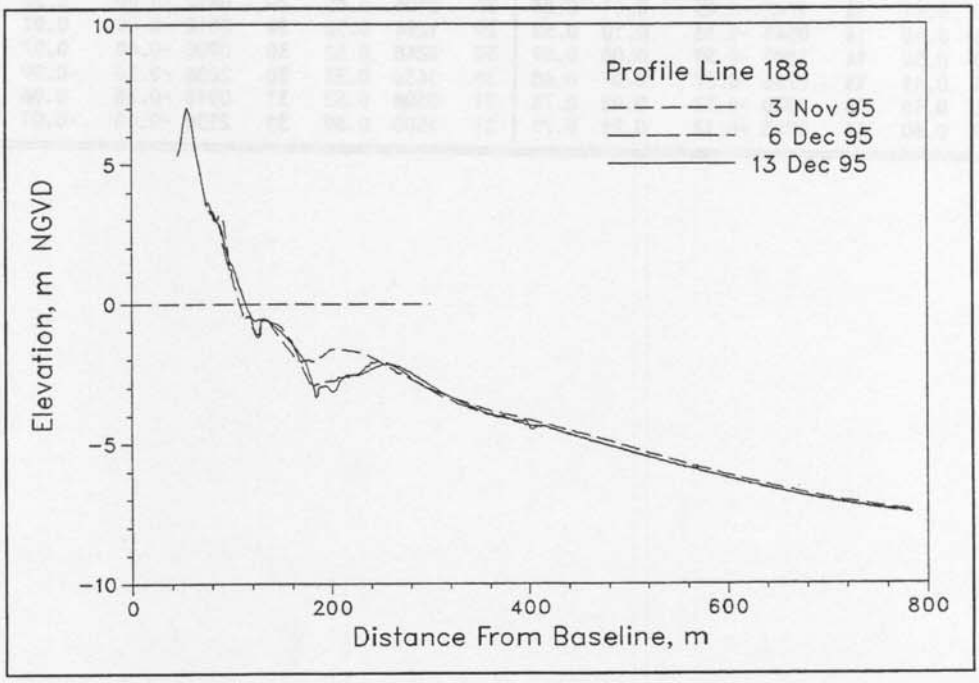

Figure 7. Monthly CRAB Profiles on Profile Line 188.

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 December.

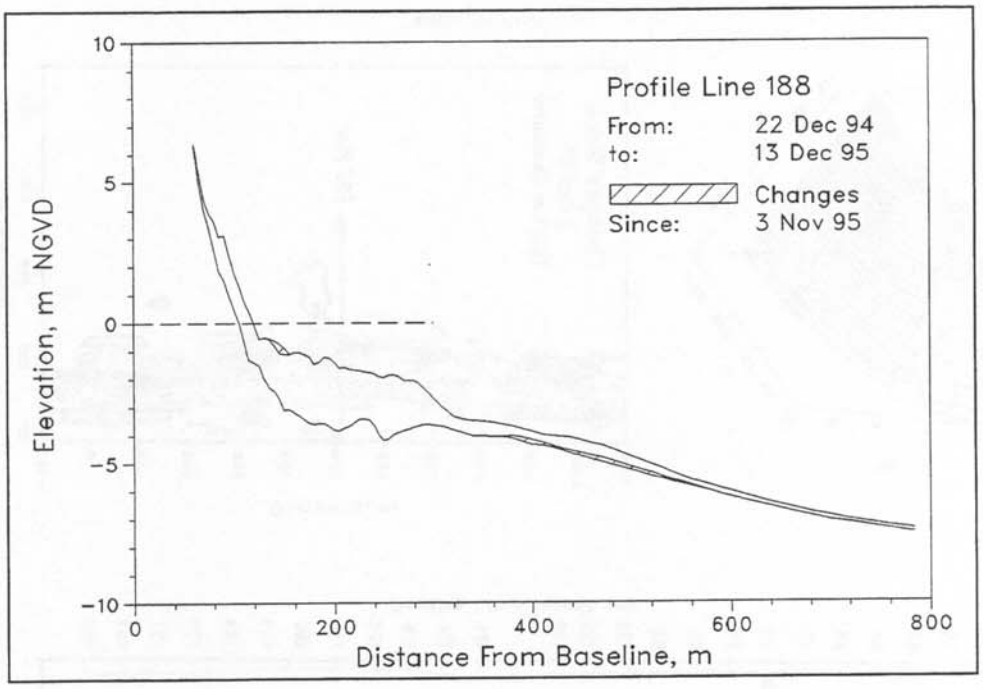

Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 12 December. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

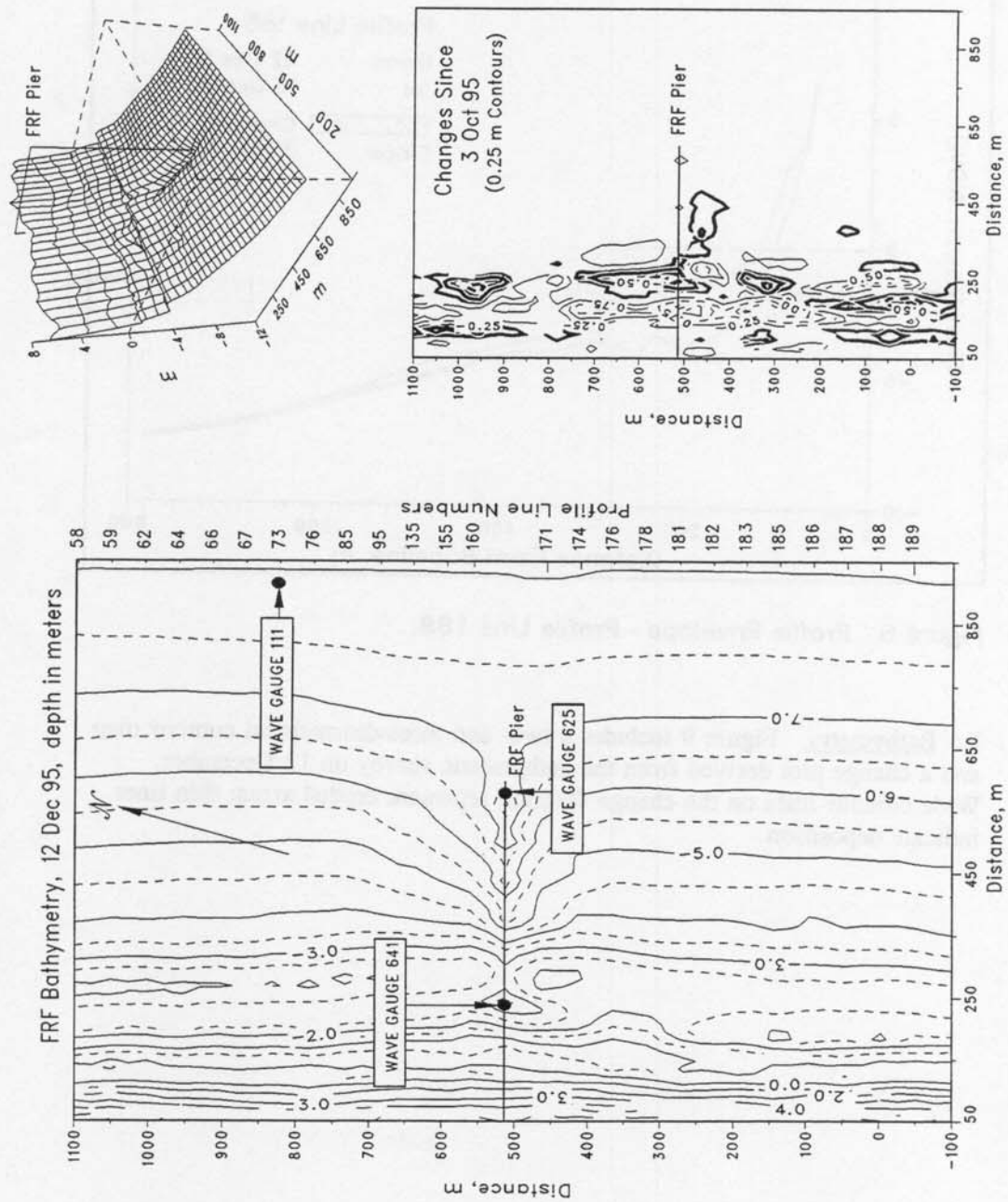

Figure 9. FRF Bathymetry, Depths Relative to NGVD

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)