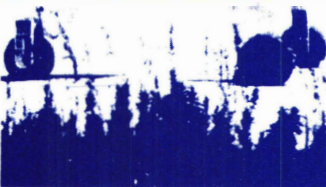




US Army Corps  
of Engineers



# PRELIMINARY DATA SUMMARY

OCTOBER 1989

by

Field Research Facility  
Coastal Engineering Research Center  
U. S. Army Engineer Waterways Experiment Station  
S. R. Box 271  
Kitty Hawk, N. C. 27949



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Prepared for Office, Chief of Engineers, U. S. Army  
Washington, D. C. 20314

**PRELIMINARY DATA SUMMARY**

**October 1989**

**U.S. Army Engineer Waterways Experiment Station  
Coastal Engineering Research Center  
Field Research Facility  
Duck, North Carolina**

## PRELIMINARY DATA SUMMARY

CERC Field Research Facility  
Duck, North Carolina

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.

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## PART I: INTRODUCTION

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC's) 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 7.6 m above the National Geodetic Vertical Datum (NGVD). In addition, a main building contains offices, an instrument repair shop, and a data acquisition room.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local oceanographic and meteorological conditions. Bottom profiles along both sides of the pier and periodic bathymetric surveys are also performed.

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. Michael W. Leffler at (919) 261-3511.

Part II presents the meteorological data; Parts III through VI present oceanographic data; Part VII presents nearshore profiles and bathymetry; and Part VIII, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used, their operational status during the month, and the data collection status. Figure 2 identifies the location of the instruments. The water depths at the wave gages and current meters vary and may be determined from information contained in Figure 7. Other installation information is contained in Table 1.

Times given in the report, unless otherwise specified, are referenced to eastern standard time (EST).

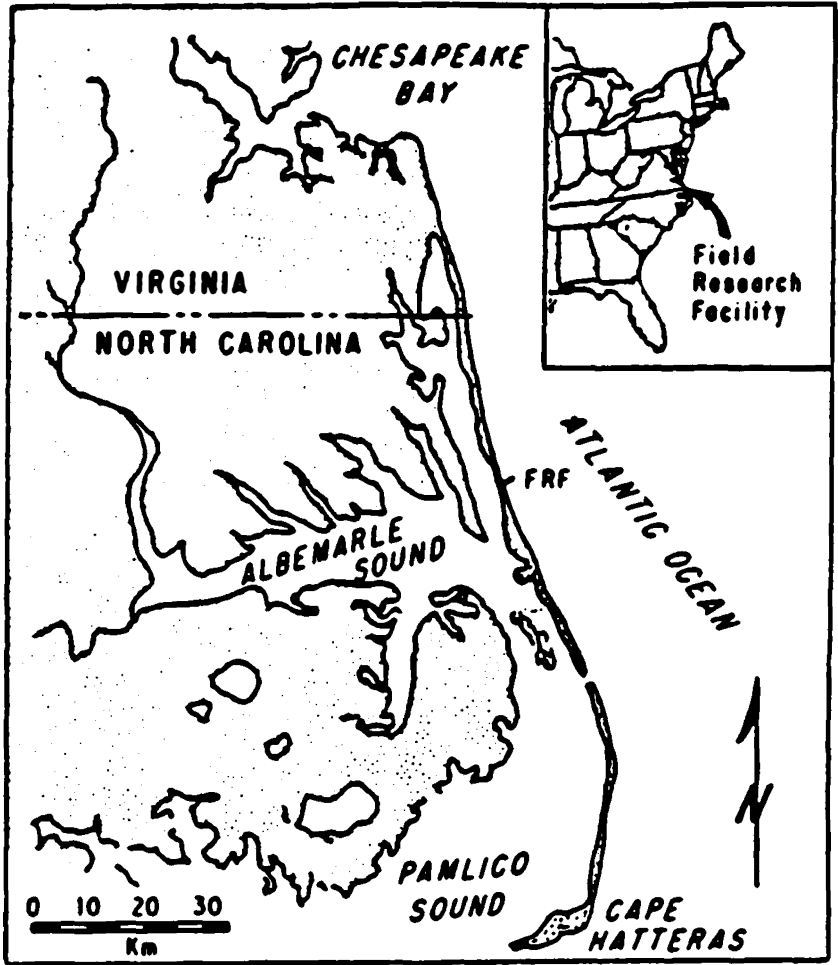


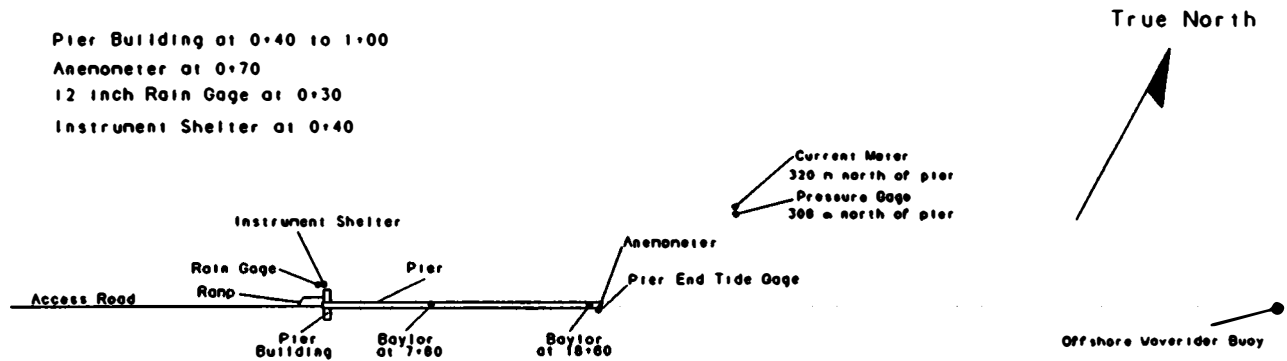
Figure 1. FRF location map

Table 1: Instrument Status/Data Availability

OCT 1989

Gage ID	Description/Remarks	Depth at Sensor		Day of the month																														
				1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	2	2	2	2	2	2	3	3	
616	Barometric Pressure		Gage Status	*																														
			Data Collected	*																														
			Analog Record	*																														
604	Precipitation		Gage Status	- / *																														
			Data Collected	- / *																														
624	Air Temperature		Gage Status	- / *																														
			Data Collected	- / *																														
932	Anemometer at Seaward End of Pier Elevation 19 m (NGVD)		Gage Status	*																														
			Data Collected	*																														
			Analog Record	*																														
645	Baylor staff at station 7+80 on FRF pier	see Figure 7	Gage Status	*																														
			Data Collected	* * * * / * / / * / / - - - - / * * * * / / / / / *																														
6 25	Baylor staff at station 18+6 0 on FRF pier	see Figure 7	Gage Status	*																														
			Data Collected	* * * * * * * * * * * * * * * * / * * * * * * * * * * * *																														
111	Pressure gage 309 m north of FRF pier (0.9 km offshore)	Approx. 7.8 m NGVD	Gage Status	*																														
			Data Collected	* * * * * * * * * * * * * * * * / * * * * * * * * * * * *																														
630	Waverider buoy 6 .0km offshore	Approx. 23 m NGVD	Gage Status	*																														
			Data Collected	/ / / / / / / / / / - - / / * * * * * * * * * * / / * * * *																														
519	Current meter 320 m north of FRF pier (0.9km offshore)	see Figure 7	Gage Status	* * * * * * * * * * / - - - - / * * * * * * * * * * * *																														
			Data Collected	* * * * * * * * * * / - - - - / * * * * * * * * * * * *																														
86 5 1370	NOAA tide station at seaward end of FRF pier		Gage Status	* / * * * * / * / / / * * * * * * * * * * * * * * * * / * * * * *																														
			Data Collected	* / * * * * / * / / / * * * * * * * * * * * * * * * * / * * * * *																														
Supplemental Observations (daily oceanographic and meteorological observations)			Daily observation	* *																														

Gage Status                      Daily Observation                      Analog Record                      Data Collected  
     Operational = \*                      Complete = \*                      Complete = \*                      All = \*  
     Partial = /                      Partial = /                      Partial = /                      Partial = /  
     Non-Operational = -                      None = -                      None = -                      None = -



5

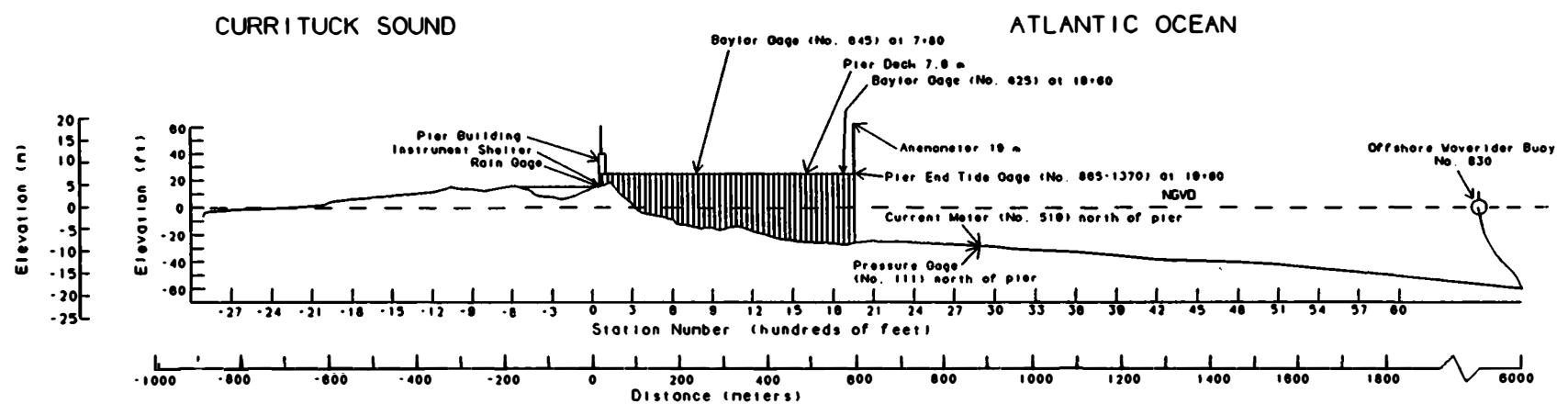


Figure 2. Instrument locations at FRF (all elevations from NGVD, all distances from FRF baseline).



## PART II: METEOROLOGICAL DATA

A variety of instruments have been installed at the FRF (Figure 2) to monitor the meteorological conditions. The data presented in Table 2 are collected and stored on magnetic tape using a Digital Equipment Corporation VAX 11/750. For each instrument identified in Table 1 as having analog outputs, chart records are obtained, 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 2) using a Weather Measure Skyvane anemometer.

Monthly resultant wind speeds and directions are determined by vector averaging the data. 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 2 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -  
 $\text{mm} \times .03937 = \text{in.}$
2. Millibars (mb) to inches of mercury (in. Hg) -  
 $\text{mb} \times 0.02953 = \text{in. Hg}$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -  
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -  
 $\text{m/s} \times 1.943 = \text{kn}$

Table 2: Meteorological Data

Oct 1989

Day	Hour	* Wind	* Wind	Temperature	Atm	Precipitation **
		Speed	Direction	deg C	Pressure	mm
		m/sec	deg TN		mb	
1	100	4	80		1019.6	0
	700	4	81		1018.6	25
	1300	6	98	Gage	1017.5	0
	1900	8	180	Inoperative	1015.9	0
2	100	7	180		1013.5	17
	700	7	173		1011.4	0
	1300	5	119	10.4	1008.7	6
	1900	3	60	20.5	1008.1	3
3	100	6	180	20.3	1007.4	0
	700	6	180	20.7	1010.1	0
	1300	8	147	24.3	1010.1	0
	1900	2	324	21.5	1010.4	0
4	100	13	351	19.3	1012.5	0
	700	9	3	15.9	1015.5	0
	1300	6	25	18.5	1013.5	0
	1900	4	304	17.0	1013.8	0
5	100	5	307	14.9	1014.2	0
	700	8	1	15.8	1016.2	0
	1300	2	275	18.9	1015.5	0
	1900	4	232	17.4	1014.8	0
6	100	5	214	17.2	1013.5	0
	700	10	233	18.3	1012.8	0
	1300	8	259	24.5	1010.4	0
	1900	5	213	22.2	1009.8	0
7	100	7	236	21.7	1008.4	0
	700	6	287	21.3	1009.4	0
	1300	8	360	19.2	1012.1	0
	1900	6	34	17.8	1013.5	0
8	100	7	41	16.8	1013.1	0
	700	8	42	15.1	1012.1	0
	1300	7	37	14.6	1008.7	0
	1900	7	321	12.9	1010.8	0
9	100	8	317	10.7	1013.5	0
	700	8	314	9.5	1017.5	0
	1300	6	356	14.3	1019.2	0
	1900	4	21	12.8	1020.9	0
10	100	2	263	11.1	1021.6	0
	700	5	76	14.3	1021.6	0
	1300	6	93	18.0	1019.2	0
	1900	3	153	18.1	1016.2	0
11	100	4	316	14.1	1015.9	0
	700	5	318	14.3	1018.2	0
	1300	6	10	20.0	1018.6	0
	1900	4	90	17.6	1020.3	0
12	100	2	94	13.2	1020.9	0
	700	3	117	16.2	1021.6	0
	1300	3	114	21.3	1020.3	0
	1900	5	358	17.7	1019.2	0
13	100	4	227	17.1	1018.9	0
	700	4	246	17.9	1019.2	0
	1300	5	251	22.8	1017.9	0
	1900	2	275	19.4	1017.9	0
14	100	2	219	18.5	1017.5	0
	700	1	214	18.3	1018.2	0
	1300	1	100	21.5	1017.2	0
	1900	2	137	19.4	1016.9	0
15	100	1	216	18.7	1016.2	0
	700	3	239	18.9	1016.9	0
	1300	4	116	24.2	1016.5	0
	1900	4	153	20.4	1016.9	0
16	100	3	160	19.6	1017.5	0
	700	3	218	20.3	1018.9	0
	1300	5	347	26.8	1017.5	0
	1900	7	55	22.0	1016.9	0

(Continued)

Table 2: Meteorological Data

Oct 1989

Day	Hour	* Wind Speed	* Wind Direction	Temperature	Atm Pressure	Precipitation **
		m/sec	deg TN	deg C	mb	mm
17	100	5	219	20.4	1016.5	0
	700	5	20	21.2	1016.2	0
	1300	7	259	26.2	1013.5	0
	1900	8	75	23.1	1013.1	0
18	100	6	224	22.8	1013.1	0
	700	4	227	21.8	1012.8	7
	1300	3	156	21.5	1011.4	0
	1900	8	49	19.4	1011.8	0
19	100	5	110	19.9	1008.7	0
	700	8	143	21.0	1008.4	0
	1300	5	220	26.4	1008.4	0
	1900	4	351	20.7	1010.1	0
20	100	5	99	20.9	1008.7	0
	700	12	259	14.4	1008.4	0
	1300	7	262	11.5	1009.4	0
	1900	7	275	12.7	1010.8	0
21	100	9	276	9.3	1014.2	0
	700	8	270	7.9	1016.2	0
	1300	9	220	13.8	1014.2	0
	1900	9	219	13.7	1014.2	0
22	100	10	251	14.0	1015.5	0
	700	8	308	12.2	1018.6	0
	1300	8	360	15.4	1021.3	0
	1900	5	328	13.7	1023.6	0
23	100	4	317	11.4	1025.3	0
	700	10	20	16.5	1026.3	0
	1300	6	21	16.8	1026.7	0
	1900	6	41	15.3	1027.0	0
24	100	6	54	15.8	1026.3	0
	700	10	32	16.1	1026.0	0
	1300	10	25	17.6	1025.0	0
	1900	11	23	16.5	1024.3	0
25	100	12	25	16.3	1023.0	0
	700	11	28	16.1	1023.3	0
	1300	9	12	17.6	1023.3	0
	1900	8	13	16.7	1023.0	0
26	100	9	25	16.8	1022.3	0
	700	8	38	16.9	1023.3	0
	1300	7	17	18.7	1024.0	0
	1900	5	23	16.8	1023.6	0
27	100	5	21	16.8	1023.6	0
	700	6	341	14.3	1024.3	0
	1300	7	1	19.2	1023.3	0
	1900	6	35	17.0	1023.0	0
28	100	5	15	16.3	1022.3	0
	700	5	14	16.7	1022.3	0
	1300	6	19	18.8	1021.3	0
	1900	6	42	17.6	1021.6	0
29	100	6	44	17.4	1020.9	0
	700	7	37	17.8	1021.6	0
	1300	7	50	19.5	1020.6	0
	1900	8	56	18.2	1020.3	0
30	100	8	52	17.9	1019.2	0
	700	6	42	18.0	1019.2	0
	1300	6	37	19.0	1017.5	0
	1900	7	72	19.0	1015.9	0
31	100	5	71	18.4	1013.1	6
	700	6	54	18.4	1009.1	0
	1300	5	255	20.9	1007.4	0
	1900	6	255	19.4	1009.8	0
		Resultant		Mean	Mean	Total
		2	10	17.7	1016.7	64

(Sheet 2 of 2)

\* Anemometer at end of pier used (gage No. 932)

\*\* Precipitation amounts for 1 & 2 October obtained from Supplementary Observations

### PART III: WAVE DATA

Wave data are collected from two Baylor staff gages (Gages 625 and 645), a pressure wave gage (Gage 111) and a Waverider buoy (Gage 630) as shown in Table 1 and Figure 2. The data are collected, analyzed, and stored on magnetic tape using a Digital Equipment Corporation VAX 11/750 programmed to sample the wave gages every 6 hr (more frequently during storms) beginning at 0100, 0700, 1300, and 1900 EST. The sampling rate is two times per second for four contiguous 34-min records.

Wave height  $H_{w0}$  is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gage has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 deg 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 magnetic tape.

Table 3 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 3 are average values computed from this data. Figure 3 is a time history of all  $H_{w0}$  and  $T_p$  values obtained for all gages.

Differences in wave periods between wave gages (Table 3 and Figure 3) may be the result of wave breaking, wave reformation, or the presence of multiple wave trains containing nearly equal energy.

Table 3: Wave Data

Oct 1989

Day	Hour	645		625		111		630	
		Baylor at 7+80 Hmo,m	T,sec	Baylor at 18+60 Hmo,m	T,sec	Pressure Gage Hmo,m	T,sec	Offshsr Hmo,m	Wvrdr T,sec
1	0100	0.34	4.57	0.53	10.67	0.58	8.00		*
	0700	0.53	5.33	0.65	10.67	0.70	5.45	1.02	5.22
	1300	0.52	4.83	0.70	9.85	0.68	6.74	1.08	6.40
	1900	0.64	3.82	0.95	6.24	0.94	6.24		*
2	0100	0.56	5.45	0.88	7.31	0.93	9.48		*
	0700	0.68	5.33	1.01	8.83	1.02	5.69	1.49	5.69
	1300	0.53	6.09	0.86	6.92	0.96	6.24	1.31	5.95
	1900	0.53	6.92	0.86	7.76	1.05	8.26		*
3	0100	0.46	8.00	0.82	8.00	0.99	8.00		*
	0700	0.52	7.11	0.96	7.76	0.99	7.76	1.20	7.53
	1300	0.58	3.56	0.91	8.26	0.97	8.26	1.27	7.76
	1900	0.37	8.26	0.68	8.26	0.76	8.26		*
4	0100	1.04	4.57	1.21	4.57	1.28	4.41		*
	0700	1.31	6.92	1.62	6.92	1.74	6.92	2.37	6.92
	1300	0.97	6.56	1.17	5.33	1.18	7.53	1.75	7.11
	1900	0.85	6.09	0.95	5.69	1.05	7.31		*
5	0100	0.56	6.56	0.66	6.74	0.73	6.56		*
	0700	1.01	5.82	1.08	6.56	1.06	5.95	1.77	5.95
	1300	0.61	6.24	0.71	6.24	0.75	6.24	1.14	6.24
	1900	0.27	5.33	0.41	6.56	0.44	6.24		*
6	0100	0.18	14.22	0.30	9.48	0.30	9.14		*
	0700	*		0.23	12.80	0.24	14.22	0.63	2.46
	1300	0.10	12.80	0.19	14.22	0.22	14.22	0.56	2.41
	1900	*		0.24	12.19	0.24	12.19		*
7	0100	0.25	12.80	0.23	14.22	0.24	13.47		*
	0700	0.20	13.47	0.21	13.47	0.23	11.64	0.48	2.13
	1300	1.00	5.69	0.98	5.69	1.02	5.22	1.46	5.33
	1900	0.70	5.33	0.74	5.69	0.79	5.57		*
8	0100	0.76	5.33	0.84	4.92	0.79	4.92		*
	0700	*		0.93	5.45	0.94	5.22	1.40	5.02
	1300	0.66	5.22	0.65	5.57	0.64	4.74	0.99	5.45
	1900	0.89	4.66	0.78	4.66	0.81	4.57		*
9	0100	*		0.81	5.12	0.85	5.12		*
	0700	0.95	5.33	0.86	5.69	0.91	5.33	1.62	5.69
	1300	0.91	6.09	0.91	5.95	0.91	5.95	1.37	5.82
	1900	0.66	5.45	0.78	5.82	0.85	6.24		*
10	0100	0.50	5.95	0.64	5.95	0.64	6.09		*
	0700	0.35	4.74	0.45	5.12	0.44	6.24	0.75	6.40
	1300	0.38	3.12	0.58	6.24	0.52	6.09	0.93	3.28
	1900	*		0.77	4.92	0.79	4.92		*
11	0100	0.43	4.66	0.65	5.12	0.65	4.74		*
	0700	0.43	5.45	0.61	7.11	0.63	8.00	0.91	5.82
	1300	0.35	4.74	0.60	6.56	0.61	6.24	0.86	5.82
	1900	0.30	4.83	0.44	9.48	0.49	10.67		*
12	0100	0.31	6.74	0.50	7.31	0.52	6.56		*
	0700	*		0.54	7.11	0.62	6.92	0.85	6.92
	1300	0.30	6.40	0.53	6.74	0.57	6.24	0.79	6.56
	1900	*		0.50	11.13	0.52	8.53		*
13	0100	0.25	10.67	0.53	10.24	0.60	10.24		*
	0700	0.26	8.83	0.49	8.26	0.57	8.83	0.63	8.53
	1300	*		0.42	8.26	0.48	8.00		*
	1900	*		0.37	7.76	0.47	7.76		*
14	0100	*		0.38	7.76	0.42	7.31		*
	0700	*		0.36	8.00	0.42	7.76		*
	1300	*		0.35	9.48	0.40	10.24		*
	1900	*		0.38	10.67	0.47	10.67		*
15	0100	*		0.37	9.48	0.44	9.48		*
	0700	*		0.42	9.14	0.46	9.48		*
	1300	*		0.38	9.48	0.42	9.14		*
	1900	*		0.40	8.53	0.43	8.53		*
16	0100	*		0.32	8.00	0.38	9.85	0.48	8.00
	0700	*		0.35	8.83	0.41	8.83	0.53	6.92
	1300	*		0.32	9.14	0.35	7.11	0.46	7.76
	1900	*		0.32	9.85	0.36	8.83		*

\* Electronic problems

(Continued)

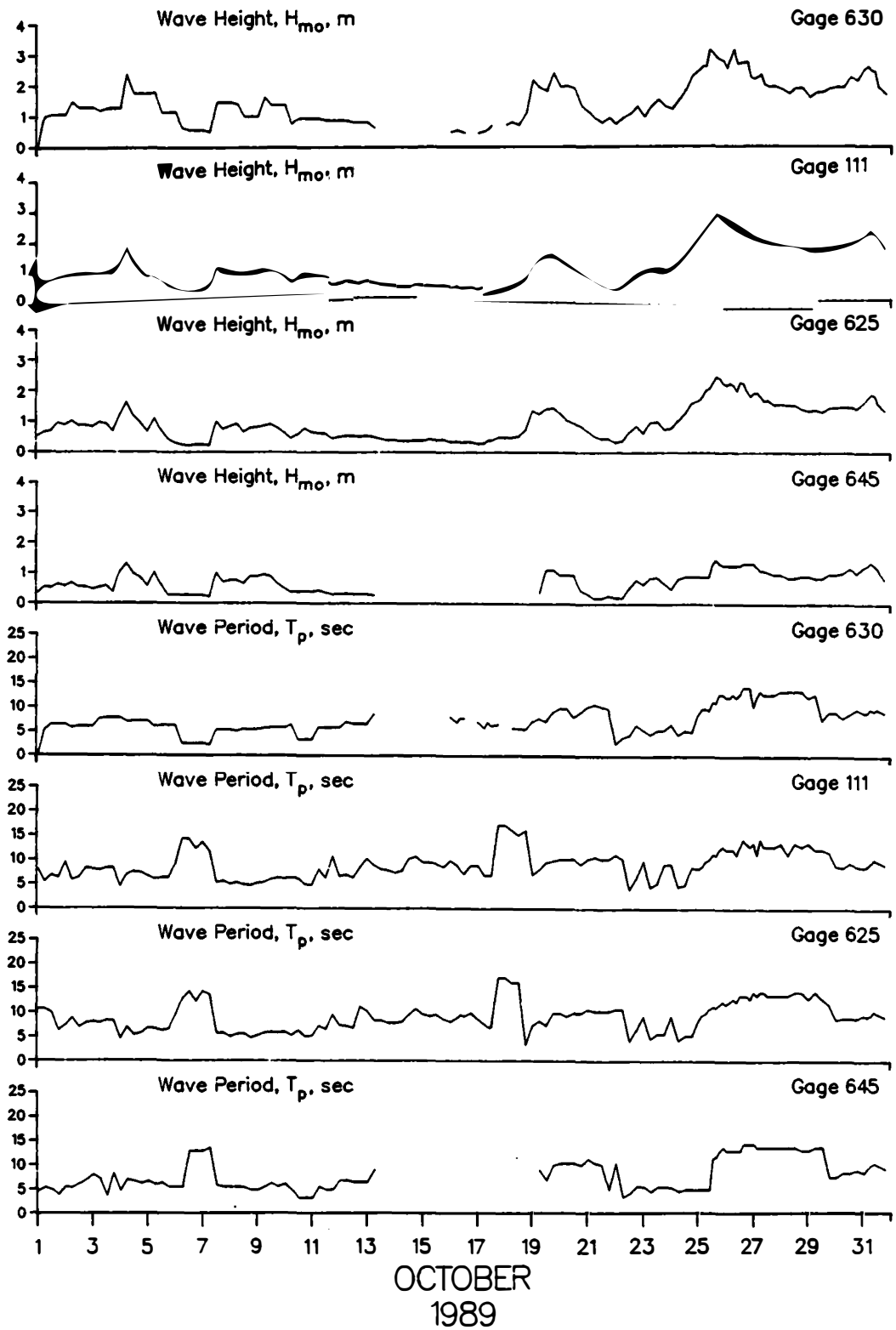
(Sheet 1 of 2)

Table 3: Wave Data

Oct 1989									
Day	Hour	645		625		111		630	
		Baylor at 7+80		Baylor at 18+60		Pressure Gage		Offshr Wvdr	
		Hmo,m	T,sec	Hmo,m	T,sec	Hmo,m	T,sec	Hmo,m	T,sec
17	0100	*		0.27	8.53	0.31	8.83	0.45	6.92
	0700	*		0.29	7.53	0.38	6.74	0.51	5.82
	1300	*		*		*		0.69	6.24
	1900	*		0.48	17.07	0.47	17.07	*	
18	0100	*		0.47	17.07	0.52	17.07	*	
	0700	*		0.48	16.00	0.58	16.00	0.78	5.69
	1300	*		0.52	16.00	0.57	15.06	0.69	5.57
	1900	*		0.72	3.28	0.58	16.00	1.10	5.45
19	0100	*		1.35	7.31	1.49	6.92	2.15	7.11
	0700	*		1.25	8.26	1.38	8.00	1.91	7.76
	1300	1.12	6.74	1.41	7.31	1.57	9.48	1.79	7.11
	1900	1.13	9.85	1.45	9.85	1.58	9.85	2.37	9.14
20	0100	0.95	10.24	1.28	9.85	1.51	10.24	1.93	9.85
	0700	*		1.05	9.14	1.19	10.24	1.95	9.85
	1300	0.53	10.24	0.94	9.85	1.12	10.24	1.87	8.00
	1900	0.44	9.85	0.86	9.85	0.93	9.14	1.30	9.14
21	0100	0.33	11.13	0.68	10.67	0.69	10.24	1.11	10.24
	0700	0.18	10.24	0.52	10.24	0.55	10.67	0.89	10.67
	1300	0.19	9.85	0.43	10.24	0.43	10.24	0.76	10.24
	1900	0.27	4.83	0.43	10.24	0.45	10.24	0.93	9.85
22	0100	0.21	10.24	0.31	10.67	0.33	11.13	0.72	2.61
	0700	0.20	3.33	0.38	10.67	0.37	10.24	0.93	3.82
	1300	0.54	4.13	0.67	4.13	0.69	3.94	1.06	4.34
	1900	0.80	5.57	0.86	6.40	0.90	6.24	1.28	6.40
23	0100	0.65	5.45	0.63	9.14	0.70	9.85	0.95	5.45
	0700	0.86	4.41	0.98	4.57	1.09	4.41	1.29	4.49
	1300	0.89	5.45	1.01	5.57	1.09	5.22	1.51	5.33
	1900	0.69	5.45	0.75	5.57	0.79	9.14	1.28	5.45
24	0100	0.49	5.22	0.79	9.14	0.84	9.14	1.20	6.56
	0700	0.83	4.41	1.05	4.20	1.07	4.49	1.51	4.41
	1300	0.91	4.83	1.28	5.12	1.28	4.92	1.82	5.33
	1900	*		1.61	5.22	1.79	8.53	2.29	5.02
25	0100	*		1.71	8.53	1.94	8.26	2.47	8.83
	0700	1.50	11.13	2.04	9.85	2.15	9.85	2.60	9.85
	1300	1.33	11.13	2.29	11.13	2.40	11.13	3.01	11.13
	1900	1.35	12.80	2.43	11.64	2.66	12.19	2.80	12.80
26	0100	1.28	12.80	2.20	11.64	2.36	12.19	2.53	12.19
	0700	*		2.18	12.80	2.58	12.19	3.14	12.80
	1300	1.28	11.64	2.31	13.47	2.30	12.80	2.70	12.80
	1900	*		2.01	13.47	2.04	13.47	*	
27	0100	1.14	14.22	1.94	14.22	1.99	13.47	2.18	10.24
	0700	1.11	13.47	1.81	14.22	1.91	14.22	2.31	13.47
	1300	*		1.71	13.47	1.70	12.80	1.93	12.80
	1900	0.98	13.47	1.56	13.47	1.70	12.80	*	
28	0100	*		1.58	13.47	1.54	13.47	1.85	13.47
	0700	0.88	13.47	1.55	13.47	1.59	11.13	1.71	13.47
	1300	*		1.55	14.22	1.68	13.47	1.88	13.47
	1900	0.93	12.80	1.43	14.22	1.61	12.80	*	
29	0100	*		1.36	12.80	1.37	13.47	1.58	12.19
	0700	0.86	13.47	1.39	14.22	1.44	12.19	1.74	12.80
	1300	*		1.32	12.80	1.36	12.19	1.76	7.53
	1900	1.00	7.31	1.47	11.64	1.47	11.64	1.88	9.14
30	0100	*		1.48	8.53	1.52	8.83	1.92	9.14
	0700	1.05	8.26	1.50	8.83	1.59	8.53	1.91	8.00
	1300	1.20	8.26	1.50	8.83	1.55	9.48	2.24	8.83
	1900	1.04	8.83	1.45	8.83	1.51	8.83	2.14	9.85
31	0100	1.23	8.26	1.63	9.48	1.79	8.53	2.51	9.14
	0700	1.38	9.85	1.91	9.48	2.02	9.48	2.46	9.85
	1300	1.19	9.85	1.62	9.85	1.88	9.85	1.91	9.85
	1900	0.84	9.14	1.38	9.14	1.42	9.14	1.69	9.14
	Mean	0.70	7.70	0.93	9.04	0.99	9.01	1.49	7.73
	Std dev	0.36	3.12	0.54	3.08	0.58	3.00	0.67	2.86

\* Electronic problems

(Sheet 2 of 2)



#### PART IV: CURRENT DATA

Current data (Table 4) are collected from a Marsh-McBirney electromagnetic biaxial current meter (Table 1 and Figure 2) and by visually observing the movement of dye on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier 12 m offshore.

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 data.



Table 4: Current Data  
Oct 1989

Day	Time	Pier Measurements					Beach Measurements			Current Meter	
		Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface)		(500m UpDrift)			0.9 km Offshore		
		Speed	Dir	Distance from Baseline (m)	Speed	Dir	Location	Speed	Dir	Depth -5.6m (NGVD) ID #519	Dir
1	0100-Along									17	S
	Cross									10	off
	Result									20	130
1	0700-Along	11	S		15	N		11	N	17	S
	Cross	4	off	128	0		South			5	off
	Result	12	138		15	340				18	144
1	1300-Along									14	S
	Cross									14	off
	Result									20	115
1	1900-Along									9	S
	Cross									8	off
	Result									12	118
2	0100-Along									14	S
	Cross									4	off
	Result									15	144
2	0700-Along	36	N		68	N		22	N	4	S
	Cross	4	off	128	10	on	South			0	
	Result	36	346		68	331				4	160
2	1300-Along									3	S
	Cross									4	off
	Result									5	107
2	1900-Along									1	N
	Cross									1	on
	Result									1	295
3	0100-Along									4	S
	Cross									8	off
	Result									9	97
3	0700-Along	12	S		14	N		55	N	6	N
	Cross	1	off	207	2	on	North			7	off
	Result	12	154		14	331				9	29
3	1300-Along									0	
	Cross									8	off
	Result									8	70
3	1900-Along									1	N
	Cross									1	off
	Result									1	25
4	0100-Along									20	S
	Cross									12	off
	Result									23	129
4	0700-Along	29	S		38	S		114	S	21	S
	Cross	4	on	213	4	on	North			13	off
	Result	29	169		38	166				25	128
4	1300-Along									17	S
	Cross									12	off
	Result									21	125
4	1900-Along									8	S
	Cross									8	off
	Result									11	115
5	0100-Along									16	S
	Cross									11	off
	Result									19	125
5	0700-Along	38	S		25	S		94	S	11	S
	Cross	0		226	5	on	North			7	off
	Result	38	160		26	171				13	128
5	1300-Along									4	S
	Cross									1	on
	Result									4	174
5	1900-Along									6	N
	Cross									4	off
	Result									7	14

KEY = All speeds in cm/sec  
 N = Northward, Shore parallel  
 S = Southward, Shore parallel  
 on = onshore off = offshore

Table 4: Current Data (Continued)  
Oct 1989

Time	Alongshore Cross-shore Resultant	Pier Measurements					Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519	
		Dye at (579 m) (surface)		Dye at Mid-Surr Zone (surface) Distance from Baseline			Dye 12m offshore (surface)			Speed	Dir
Day		Speed	Dir	(m)	Speed	Dir	Location	Speed	Dir	Speed	Dir
6 0100	Along Cross Result									8 2 8	N on 326
6 0700	Along Cross Result	23 21 32	N off 22	152	11 12 16	N off 28	South	0		14 13 19	N on 297
6 1300	Along Cross Result									14 6 15	N on 317
6 1900	Along Cross Result									9 5 10	N on 311
7 0100	Along Cross Result									2 1 2	S off 133
7 0700	Along Cross Result	47 2 47	S on 163	165	34 3 34	S on 166	North	84 S		1 1 1	S on 205
7 1300	Along Cross Result									17 15 23	S off 119
7 1900	Along Cross Result									6 2 6	N off 358
8 0100	Along Cross Result									0 5 5	off 70
8 0700	Along Cross Result	17 5 18	S on 177	250	27 3 27	S on 166	North	40 S		16 12 20	S off 123
8 1300	Along Cross Result									10 10 14	S off 115
8 1900	Along Cross Result									16 9 18	S off 131
9 0100	Along Cross Result									21 14 25	S off 126
9 0700	Along Cross Result	38 0 38	S off 160	240	38 6 39	S off 151	North	89 S		25 12 28	S off 134
9 1300	Along Cross Result									14 14 20	S off 115
9 1900	Along Cross Result									17 10 20	S off 130
10 0100	Along Cross Result									9 10 13	S off 112
10 0700	Along Cross Result	8 5 9	S off 129	207	6 0 6	S off 160	North	25 S		6 8 10	S off 107
10 1300	Along Cross Result									12 4 13	N on 322
10 1900	Along Cross Result									0 3 3	off 70

KEY - All speeds in cm/sec  
N = Northward, Shore parallel  
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Table 4: Current Data (Continued)  
Oct 1989

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements					Beach Measurements			Current Meter		
			Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface)		(500m updrift)			0.9 km Offshore			
			Speed	Dir	Distance from Baseline (m)	Speed	Dir	Location	Speed	Dir	Depth -5.6m (NGVD) ID #519	Speed	Dir
11	0100	Along Cross Result										2 0 2	N  340
11	0700	Along Cross Result	20 2 20	S on 166	226	14 6 15	S off 138		5 S	North		1 5 5	S off 81
11	1300	Along Cross Result										9 12 15	S off 107
11	1900	Along Cross Result										9 7 11	S off 122
12	0100	Along Cross Result										3 3 4	N on 295
12	0700	Along Cross Result	0 0 0		226	7 1 7	N on 334		51 S	South		16 9 18	S off 131
12	1300	Along Cross Result											
12	1900	Along Cross Result											
13	0100	Along Cross Result											
13	0700	Along Cross Result	15 3 16	N off 351	226	6 7 10	N off 30		30 S	North			
13	1300	Along Cross Result											
13	1900	Along Cross Result											
14	0100	Along Cross Result											
14	0700	Along Cross Result	20 3 21	N off 349	152	4 5 7	N off 30		47 S	South			Cage Inoperative
14	1300	Along Cross Result											
14	1900	Along Cross Result											
15	0100	Along Cross Result											
15	0700	Along Cross Result	27 0 27	N  340	165	6 3 7	N off 11		0	South			
15	1300	Along Cross Result											
15	1900	Along Cross Result											

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Table 4: Current Data (Continued)  
Oct 1989

Day	Time	Alongshore Cross-shore Result	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519		
			Dye at (579 m) (surface) Speed	Dir	Dye at Mid-Surr Zone (surface) Distance from Baseline (m)	Speed	Dir	Location	Speed	Dir	Speed	Dir
16	0100	Along Cross Result										
16	0700	Along Cross Result	12 5 13	N off 4	165	8 2 8	N off 357	South	12	N		
16	1300	Along Cross Result										
16	1900	Along Cross Result										
17	0100	Along Cross Result										
17	0700	Along Cross Result	30 8 31	N off 354	152	11 3 11	N off 357	South	21	N		
17	1300	Along Cross Result										
17	1900	Along Cross Result									13 8 15	N on 308
18	0100	Along Cross Result									9 7 11	N on 302
18	0700	Along Cross Result	11 16 20	N off 36	165	0 0 0	0 0	South	28	N	10 8 13	N on 301
18	1300	Along Cross Result									7 9 11	S off 108
18	1900	Along Cross Result									8 16 18	S off 97
19	0100	Along Cross Result									34 19 39	S off 131
19	0700	Along Cross Result	13 1 13	N off 346	347	11 2 11	N on 329	North	126	S	20 14 24	S off 125
19	1300	Along Cross Result									30 9 31	S off 143
19	1900	Along Cross Result									30 21 37	S off 125
20	0100	Along Cross Result									30 22 37	S off 124
20	0700	Along Cross Result	11 26 28	S off 92	268	0 49 49	off 93	South	98	S	20 1 20	S off 157
20	1300	Along Cross Result									0 6 6	on 250
20	1900	Along Cross Result									2 14 14	N off 62

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Table 4: Current Data (Continued)  
Oct 1989

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519	
			Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface)		Dye 12m offshore (surface)			Speed	Dir
			Speed	Dir	Distance from Baseline (m)	Speed	Dir	Location	Speed		
21	0100	-Along Cross Result								12 9 15	N on 303
21	0700	-Along Cross Result	15 14 21	N off 22	201	0 18 18		South	3 N	6 0 6	N  340
21	1300	-Along Cross Result								16 11 19	N on 305
21	1900	-Along Cross Result								23 12 26	N on 312
22	0100	-Along Cross Result								14 11 18	N on 302
22	0700	-Along Cross Result	32 3 32	S off 154	207	23 2 23	off	North	30 S	7 2 7	S off 144
22	1300	-Along Cross Result								13 5 14	S off 139
22	1900	-Along Cross Result								10 5 11	S off 133
23	0100	-Along Cross Result								5 2 5	S off 138
23	0700	-Along Cross Result	32 13 35	S on 182	238	51 20 55	off	North	88 S	18 9 20	S off 133
23	1300	-Along Cross Result								17 9 19	S off 132
23	1900	-Along Cross Result								48 18 51	S off 139
24	0100	-Along Cross Result								26 10 28	S off 139
24	0700	-Along Cross Result	61 9 62	S on 169	213	30 6 31	off	North	60 S	31 14 34	S off 136
24	1300	-Along Cross Result								25 11 27	S off 136
24	1900	-Along Cross Result								32 17 36	S off 132
25	0100	-Along Cross Result								34 17 38	S off 133
25	0700	-Along Cross Result	38 10 39	S on 174	226	44 4 44	off	no observation		34 17 38	S off 133
25	1300	-Along Cross Result								23 14 27	S off 129
25	1900	-Along Cross Result								25 20 32	S off 121

KEY = All speeds in cm/sec  
 N = Northward, Shore parallel  
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Table 4: Current Data (Continued)  
Oct 1989

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519	
			Dye at (579 m) (surface) Speed Dir	Dye at Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface) Location Speed Dir	Speed	Dir		
26	0100	Along Cross Result							5 13 14	S off 91	
26	0700	Along Cross Result	8 1 8	S off 151	238	23 14 26	N off 11	North 55 S	24 18 30	S off 123	
26	1300	Along Cross Result							12 14 18	S off 111	
26	1900	Along Cross Result							19 10 21	S off 132	
27	0100	Along Cross Result							8 2 8	S on 174	
27	0700	Along Cross Result	10 3 10	N on 326	238	12 2 12	N off 351	South 23 N	23 6 24	S off 145	
27	1300	Along Cross Result							28 16 32	S off 130	
27	1900	Along Cross Result							29 12 31	S off 138	
28	0100	Along Cross Result							22 15 27	S off 126	
28	0700	Along Cross Result	0 0 0		213	12 7 14	N off 11	South 25 N	16 4 16	S off 146	
28	1300	Along Cross Result							14 16 21	S off 111	
28	1900	Along Cross Result							11 9 14	S off 121	
29	0100	Along Cross Result							12 13 18	S off 113	
29	0700	Along Cross Result	20 1 20	S on 163	226	30 9 32	S off 143	South 71 S	5 11 12	S off 94	
29	1300	Along Cross Result							12 10 16	S off 120	
29	1900	Along Cross Result							15 12 19	S off 121	
30	0100	Along Cross Result							22 16 27	S off 124	
30	0700	Along Cross Result	23 9 24	S on 182	262	10 3 11	N off 357	South 112 N	29 12 31	S off 138	
30	1300	Along Cross Result							28 20 34	S off 124	
30	1900	Along Cross Result							15 14 21	S off 117	

KEY = All speeds in cm/sec  
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S = Southward, Shore parallel  
on = onshore off = offshore

Table 4: Current Data (Concluded)  
Oct 1989

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519		
			Dye at (579 m) (surface) Speed	Dir	Dye at Mid-Surf Zone (surface) Distance from Baseline (m)	Speed	Dir	Location	Speed	Dir	Speed	Dir
31	0100	-Along Cross Result									15	S
											17	off
											23	111
31	0700	-Along Cross Result	13	S		38	N		117	N	9	S
			6	on	250	8	off	South			9	off
			14	184		39	351				13	115
31	1300	-Along Cross Result									17	S
											10	off
											20	130
31	1900	-Along Cross Result									12	S
											6	off
											13	133

KEY = All speeds in cm/sec  
 N = Northward, Shore parallel  
 S = Southward, Shore parallel  
 on = onshore    off = offshore

## PART V: SUPPLEMENTAL OBSERVATIONS

Visual wave direction measurements (Table 5) of both the primary wave train (i.e. that having the larger 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 orientated 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 jar along with a thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The jar is removed, the temperature read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the surface visibility.



Table 5: Supplemental Observations

Oct 1989

Day	Time	Wave Approach Angle at Pier End deg from True N		Radar Wave Angle deg from True N	Width of Surf Zone, m	Water Characteristics at Pier End		
		Primary	Secondary			Temp., C	Density g/cc	Secchi Vis., m
1	0830	80			12	22.2	1.0200	1.2
2	0920	85	130	60	41	22.2	1.0210	1.5
3	0730	90	50	80	69	22.5	1.0212	3.0
4	0700	50		60	115	72.0	1.0214	1.2
5	0730	40		60	31	21.7	1.0194	1.5
6	0800	none	visible		35	21.7	1.0208	1.5
7	0815	5			19	21.1	1.0225	1.8
8	1000	45			55	21.1	1.0224	1.5
9	0800	30			47	19.5	1.0204	1.5
10	0800	50			26	19.5	1.0194	2.4
11	0800	90	55		23	19.5	1.0210	3.7
12	0720	110			38	19.5	1.0202	4.0
13	0800	80			49	20.0	1.0219	3.4
14	0830	none	visible		16	20.6	1.0220	2.7
15	0800	45	95		13	20.8	1.0218	2.7
16	0800	105			5	21.2	1.0221	3.4
17	0800	110			6	20.6	1.0232	1.5
18	0800	110			9	20.7	1.0234	1.2
19	0800	100	40	90	59	19.9	1.0232	0.6
19	0720	110		50	73	20.6	1.0200	0.3
21	0940	95	50		26	18.9	1.0224	6.7
22	0930	10			21	18.9	1.0230	0.3
23	0750	20			24	18.9	1.0231	0.3
24	0645	50			76	17.8	1.0208	0.9
25	0800	90	35	90	380	18.1	1.0190	0.6
26	0745	95		90	342	17.8	1.0204	0.3
27	0800	90		90	308	17.9	1.0210	0.9
28	0830	90		90	266	18.3	1.0208	0.6
29	0830	50	90	90	247	18.4	1.0190	1.2
30	0830	100		85	271	18.8	1.0184	1.8
31	0745	90		90	306	18.9	1.0182	1.2

## PART VI: 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 gage 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 4 along with a list of mean and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level.

Table 6 contains the time at the center of each 12.42-hr tidal cycle and the range, high, low, and mean water levels during each tidal cycle.

# FRF Tide Heights

Oct 1989

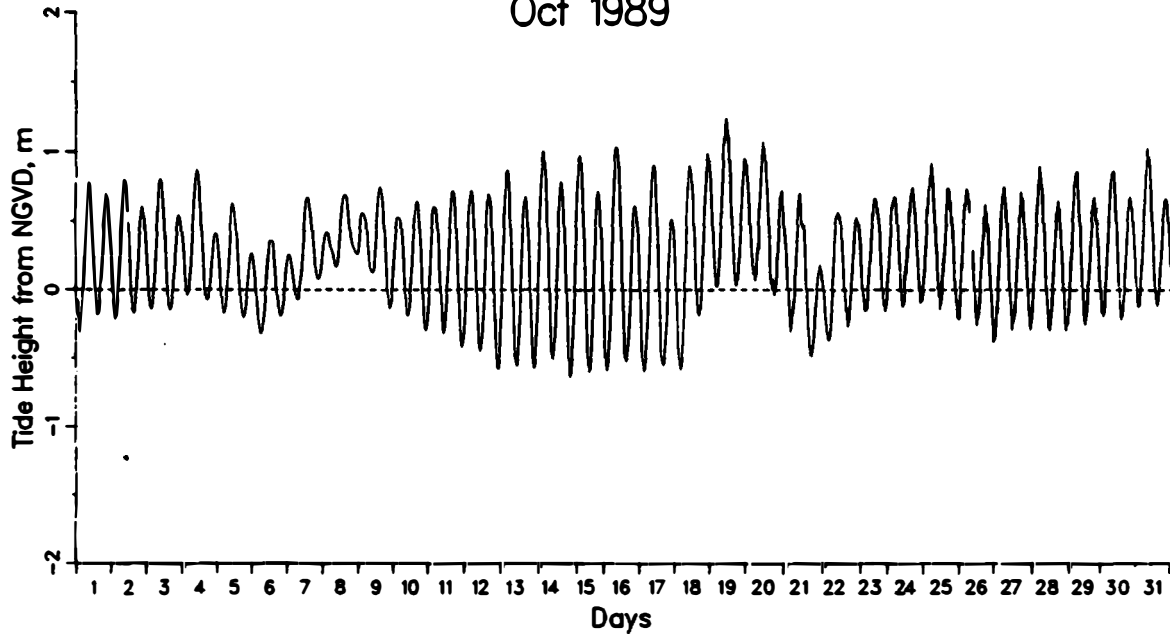


Figure 4. Water Level Time History

### Monthly Water Levels, m NGVD

Extreme Low = -0.64 on day 15 at 24 EST  
Extreme High = 1.24 on day 19 at 1036 EST  
Monthly Mean = 0.23  
Mean Low = -0.27  
Mean High = 0.73  
Mean Range = 0.99

**Table 6: Water Levels,m NGVD**

		Oct 1989			
Mid-Cycle Day	Time	Low	High	Mean	Range
1	612	-0.31	0.79	0.26	1.09
1	1837	-0.19	0.70	0.24	0.89
2	703	-0.21	0.80	0.31	1.02
2	1928	-0.17	0.61	0.20	0.78
3	753	-0.15	0.81	0.32	0.95
3	2018	-0.15	0.55	0.21	0.69
4	843	-0.04	0.87	0.42	0.91
4	2109	-0.12	0.41	0.14	0.53
5	934	-0.17	0.63	0.23	0.80
5	2159	-0.23	0.27	0.01	0.50
6	1024				
6	2249	-0.19	0.26	0.03	0.45
7	1115	-0.07	0.68	0.32	0.75
7	2340	0.08	0.42	0.26	0.34
8	1205				
9	30	0.24	0.56	0.39	0.32
9	1255				
10	121				
10	1346	-0.20	0.65	0.22	0.84
11	211	-0.30	0.61	0.17	0.91
11	1436	-0.32	0.72	0.21	1.05
12	301	-0.42	0.72	0.15	1.15
12	1527	-0.45	0.70	0.10	1.15
13	352	-0.58	0.87	0.17	1.44
13	1617	-0.55	0.68	0.06	1.23
14	442	-0.57	1.01	0.24	1.58
14	1707	-0.51	0.79	0.10	1.30
15	532	-0.64	0.98	0.21	1.62
15	1758	-0.59	0.72	0.05	1.31
16	623	-0.59	1.04	0.26	1.63
16	1848	-0.52	0.62	0.03	1.14
17	713	-0.59	0.91	0.19	1.50
17	1938	-0.55	0.52	-0.04	1.07
18	804	-0.58	0.91	0.21	1.49
18	2029	-0.19	0.99	0.40	1.18
19	854	0.02	1.24	0.63	1.22
19	2119	0.03	0.95	0.48	0.93
20	944	0.06	1.07	0.54	1.01
20	2210	-0.06	0.73	0.27	0.79
21	1035	-0.31	0.70	0.20	1.01
21	2300	-0.49	0.18	-0.15	0.67
22	1125	-0.37	0.56	0.14	0.94
22	2350	-0.27	0.52	0.15	0.79
23	1216	-0.16	0.66	0.27	0.82
24	41	-0.16	0.68	0.27	0.84
24	1306	-0.12	0.75	0.32	0.87
25	131	-0.10	0.91	0.38	1.01
25	1356	-0.15	0.74	0.31	0.88
26	222				
26	1447	-0.26	0.62	0.16	0.88
27	312	-0.38	0.75	0.20	1.13
27	1537	-0.29	0.71	0.20	1.01
28	402	-0.29	0.90	0.30	1.19
28	1628	-0.30	0.65	0.15	0.94
29	453	-0.30	0.86	0.29	1.16
29	1718	-0.25	0.68	0.21	0.94
30	543	-0.20	0.87	0.36	1.06
30	1808	-0.23	0.68	0.24	0.91
31	634	-0.12	1.03	0.44	1.16
31	1859	-0.12	0.66	0.29	0.78

PART VII: NEARSHORE PROFILES

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-Zeiss surveying system; a Zeiss Elta-2 first-order, self-recording 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 5 shows the last survey in September and the only survey in October on profile line 188, located 517 m south of the pier. On the foreshore (60 - 120 m) a prominent berm returned while just off shore (120 - 260 m) the nearshore bar migrated 10 m shoreward then moved 40 m seaward. Offshore there was a deepening of the trough (220 - 360 m) as well as a flattening of the offshore bar (360 - 560 m).

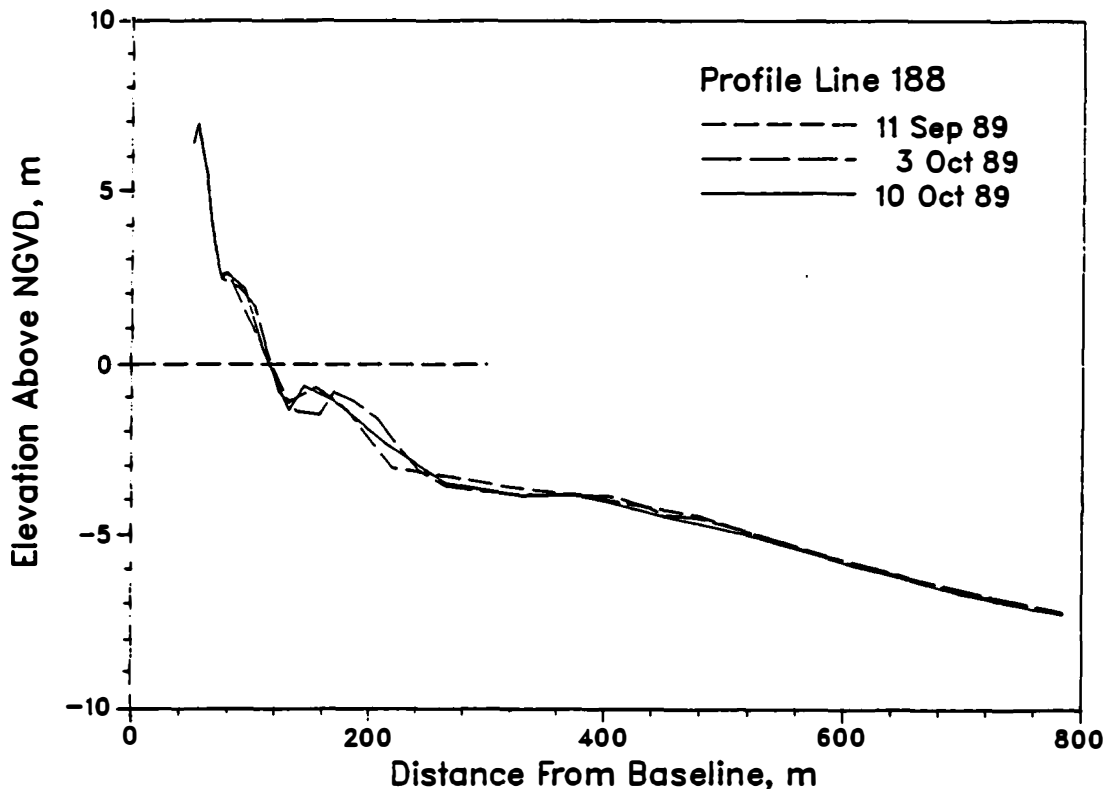


Figure 5. Monthly CRAB profiles on profile 188 - 517 m south of pier.

The profile envelope (Figure 6) reflects the maximum changes that occurred on the profile during 1989. The largest change is a result of the seaward movement of the nearshore bar.

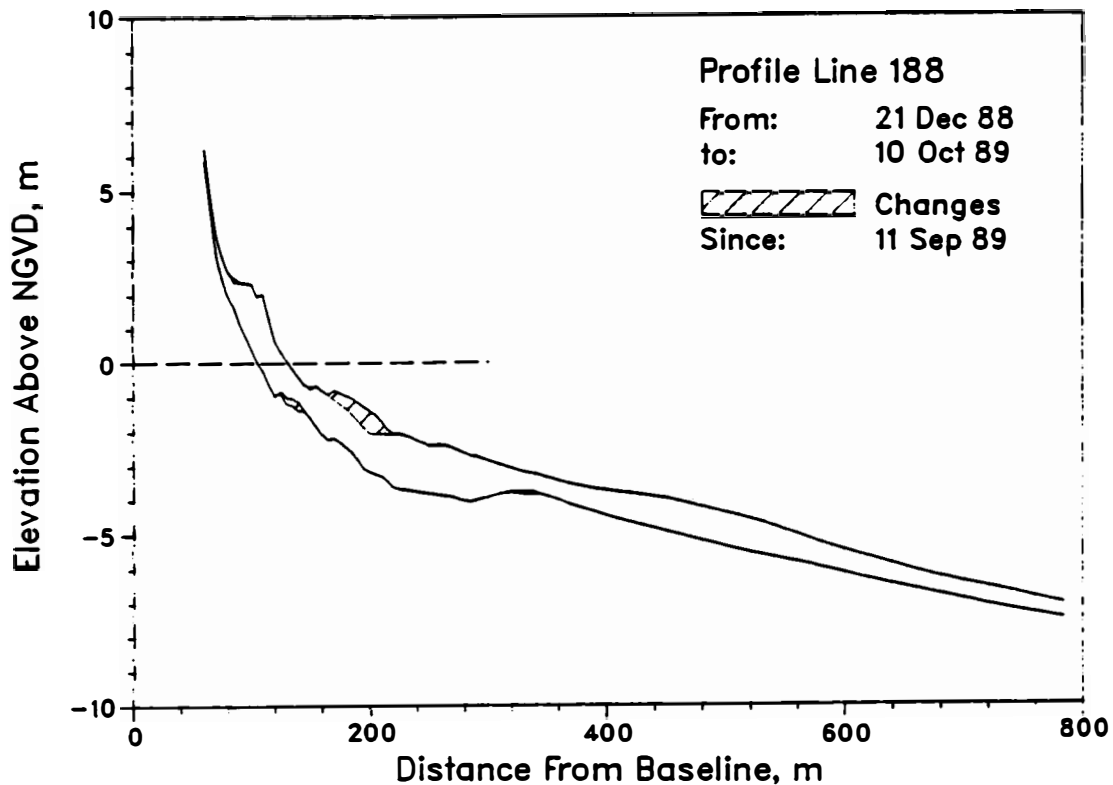


Figure 6. CRAB profile envelope - profile 188.

B. Bathymetry. Figure 7 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 12 September (there was no survey in October). Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

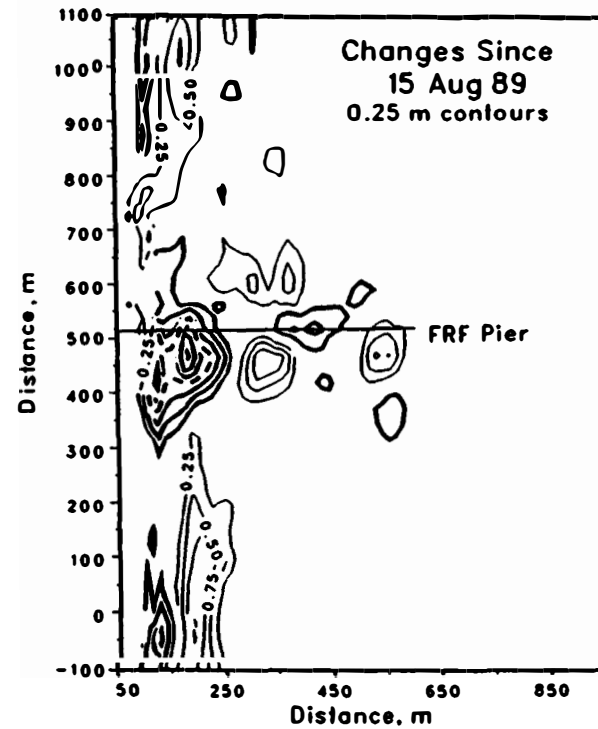
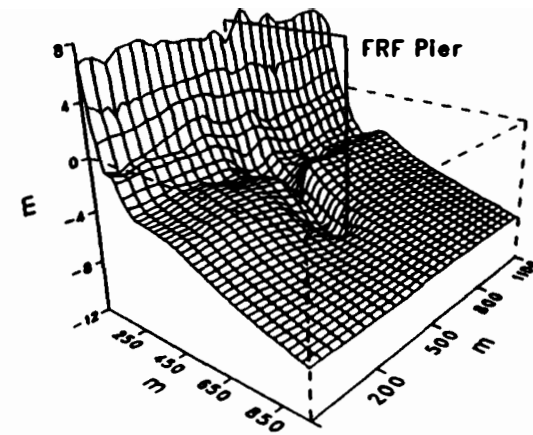
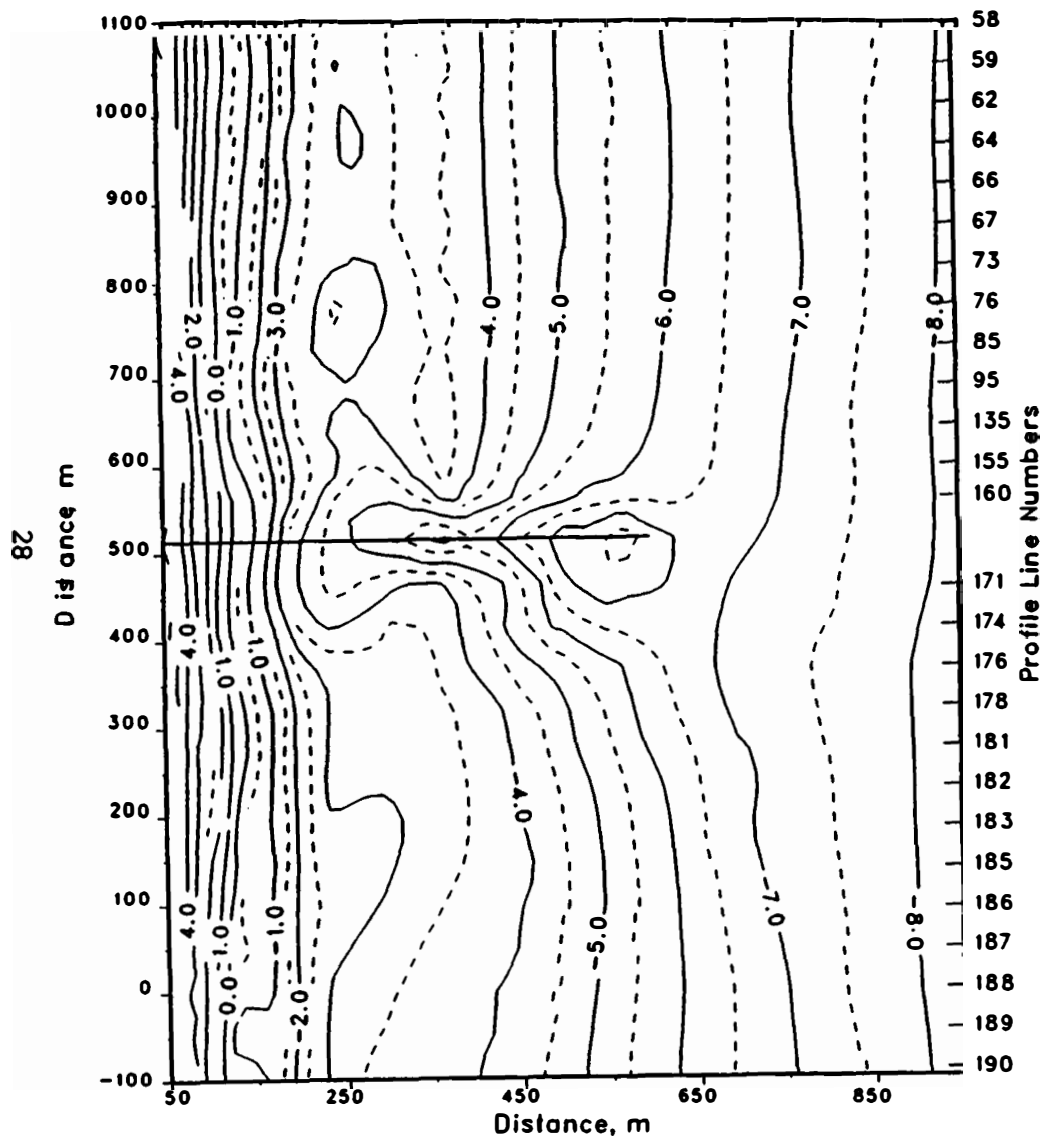


Figure 7. FRF bathymetry 12 Sep 89 depths relative to NGVD

## PART VIII. SPECIAL EVENTS

A. Storm Data Collection. The following list identifies times when the significant wave height at the seaward end of the pier (i.e. as measured at the end of the pier) exceeded 2 m and four contiguous 34 minute wave records were obtained every three hours:

<u>Start</u>	<u>End</u>
25 Oct (0700)	26 Oct (1934)

### B. Storm Synopsis.

25-26 October - A strong high pressure system stalled over West Virginia generated winds (from north-northeast) which produced storm waves for two days at the FRF. Peak winds of 13 m/s were recorded early on 24 October with the maximum  $H_{m0}$  (at gage 625) of 2.60 m ( $T_p = 12.19$  sec) occurring at 2008 EST on 25 October.



## Distribution List

### Government Agencies:

OCE	U.S. Geological Survey
BERH	U.S. National Park Service
NAO	U.S. Naval Academy
NASA/Wallops Flight Center	U.S. Naval Civil Eng. Lab
NOAA (NOS, NWS)	U.S. Naval Fac. Eng. Com.
SAD	U.S. Naval Oceanographic Off.
SAW	U.S. Naval Research Lab

### Colleges/Universities:

Allegheny University	Southern Illinois University
California Inst. of Tech.	Stockton State College
East Carolina University	University of Akron
Florida Inst. of Tech.	University of Delaware
Harvard University	University of Florida
Naval Post Graduate School	University of Maryland
NC State University	University of Miami
Old Dominion University	University of North Carolina
Oregon State University	University of N. Colorado
Prince George's College	University of Rhode Island
Rutgers University	University of Virginia
Scripps Inst. of Oceanography	Va. Inst. of Marine Science

### Others:

City of Va. Beach, VA	MEC Systems Corporation
Coastal Barge Corporation	Moffatt & Nichol, Eng.
Coastal and Est. Res., Inc.	Offshore Coastal Technologies
Coastal Science & Eng., Inc.	Mr. Rowland
Dr. Galvin	Mr. Savage
GEOMET Tech., Inc.	Sea Port Supply Corp.
Greenhorne & O'Mara, Inc.	Shell Development
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Mary Marr, Inc.	Mr. & Mrs. Valpey
Mr. Mason	WCTI-TV
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W. F. Baird & Asso. Coastal Engineers, Ltd (Canada)  
Queen's University, Ontario (Canada)  
Ministry of Construction, Coastal Division (Japan)  
Norwegian Hydrodynamic Laboratories (Norway)  
University of New South Wales (Australia)  
University of Sydney (Australia)

