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ANNUAL DATA SUMMARY FOR 1980, CERC FIELD RESEARCH FACILITY

by

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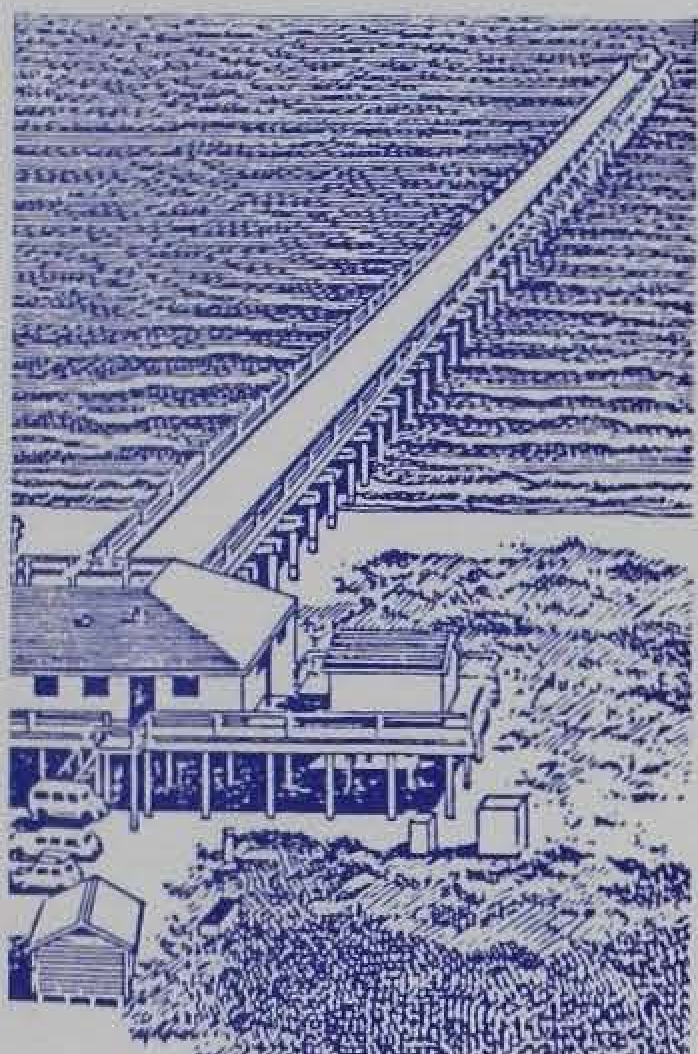

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20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

This report provides basic data and summaries of the measurements made during 1980 at the U. S. Army Engineer Waterways Experiment Station (WES) Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, N. C. The report is the second in a series of annual summaries of data collected at the FRF; the first, which summarizes data collected during 1977-79, was published as Coastal Engineering Research Center Miscellaneous Report 82-16 and is available from the WES Technical Report Distribution Section, Vicksburg, Miss.

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PREFACE

Data and data summaries presented herein were collected during 1980 and compiled at the U. S. Army Engineer Waterways Experiment Station (WES) Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) in Duck, N. C. This report, the second of a series of annual FRF data collection summaries, was carried out under CERC's Waves and Coastal Flooding Program.

The report was prepared by H. Carl Miller, Oceanographer, under the supervision of Curt Mason, Chief, FRF Group, Research Division. The author acknowledges the entire FRF Group for their efforts related to instrumentation, data collection, and analysis. Drs. Robert W. Whalin and Lewis E. Link, Chief and Assistant Chief, respectively, of CERC, and Dr. James R. Houston, Chief, Research Division, provided general guidance.

In addition, a special thank you is extended to the National Oceanic and Atmospheric Administration (NOAA) National Weather Service, who helped with the anemometer, NOAA/National Ocean Service, who maintained the tide gage and provided analysis results, and to S. Jeffress Williams, formerly of CERC, who provided the October sediment survey data.

Commander and Director of WES during the publication of this report was COL Tilford C. Creel, CE. Mr. F. R. Brown was Technical Director.

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CONVERSION FACTORS, INCH-POUND TO METRIC (SI) UNITS OF MEASUREMENTS

Inch-pound units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
acres	0.4046873	hectares
feet	0.3048	meters
millibars	100.0	pascals

ANNUAL DATA SUMMARY FOR 1980, CERC FIELD RESEARCH FACILITY

PART I: INTRODUCTION

1. The U. S. Army Engineer Waterways Experiment Station Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) located on 176 acres* at Duck, North Carolina (Figure 1), consists of a 561-m-long research pier and an accompanying office building. The FRF is located near the middle of Currituck Spit along a 100-km unbroken stretch of shoreline extending south from Rudee Inlet in Virginia to Oregon Inlet, North Carolina. It is bordered by the Atlantic Ocean to the east and Currituck Sound to the west. The Facility is designed to (a) provide a rigid platform from which waves, currents, water levels, and bottom elevations can be measured, especially during severe storms; (b) provide CERC with field experience and data to complement laboratory and analytical studies and numerical models; (c) provide a manned field facility for testing new instrumentation; and (d) serve as a permanent field base of operations for physical and biological studies of the site and adjacent region.

2. The research pier is a reinforced concrete structure supported on 0.9-m-diameter steel piles spaced 12.2 m apart along the pier length and 4.6 m apart across the width. The piles are embedded approximately 20 m below the ocean bottom. The pier deck is 6.1 m wide and extends from behind the dune line to about the 6-m water depth contour at a height of 7.8 m above mean sea level. The pilings are protected against sand abrasion by concrete erosion collars and against corrosion by a cathodic system.

3. A FRF Measurements and Analysis (FRFMA) program has been established to collect basic oceanographic and meteorological data at the site, reduce and analyze these data, and publish the results.

4. This report is the second in a series of annual reports and summarizes the data collected during 1980. It is organized such that descriptions of the instrumentation, including sensor calibration and maintenance (Part III) and data collection and analysis procedures (Part IV) precede reporting of the

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* A table of factors for converting inch-pound units of measurement to metric (SI) units is presented on page 5.

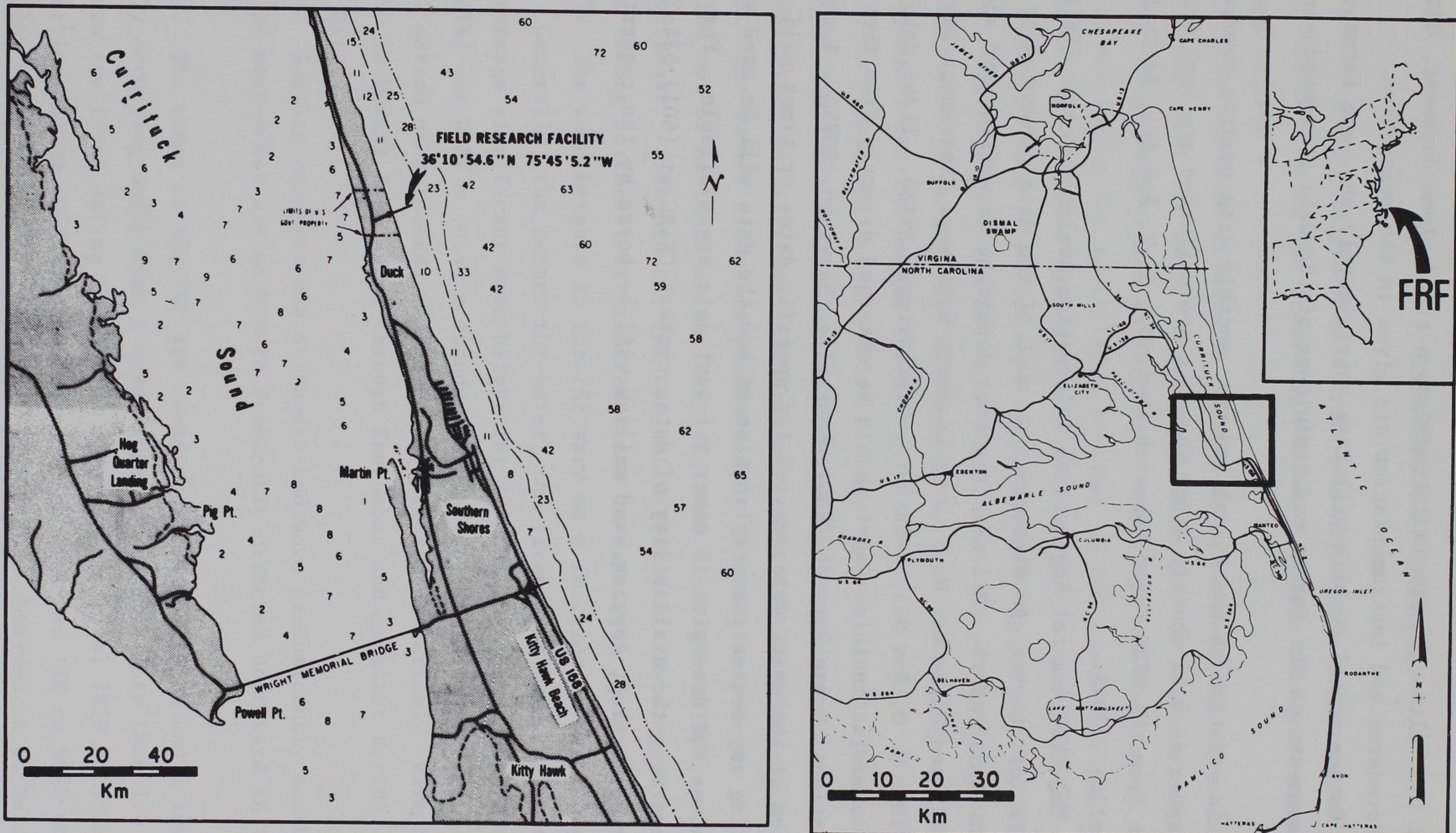


Figure 1. FRF location map

data (Part V). Although this is intended as a stand-alone document, details of some procedures and instrumentation are given in the references.

5. Future annual reports will have approximately the same format; readers' comments on the format and usefulness of the data presented are encouraged.

6. In addition to the annual reports, monthly data reports summarizing the same types of data shortly after the data are collected are available to requestors from the CERC Field Research Facility, S. R. Box 271, Kitty Hawk, North Carolina 27949.

7. The CERC Coastal Engineering Information Analysis Center (CEIAC) is responsible for storing and disseminating most of the data presented or alluded to in this report. All data requests should be in writing and addressed to Commander and Director, U. S. Army Engineer Waterways Experiment Station, ATTN: CEIAC, P. O. Box 631, Vicksburg, Mississippi 39180. Tidal data other than the summaries in this report should be obtained directly from the Tides Branch, National Ocean Service (NOS), Rockville, Maryland 20850. A complete explanation of the exact data desired for specific dates or times will expedite filling any request; an explanation of how the data will be used will help CEIAC or NOS determine if other relevant data are available. For information regarding the availability of data, contact CEIAC at (601) 634-2017. Costs for collecting, copying, and mailing will be borne by the requester.

PART II: CLIMATOLOGICAL SUMMARY

8. This section provides a brief summary of the environmental conditions at the FRF during the reporting period; complete tabulated summaries are contained in Part V.

9. The maritime climate at the FRF tends to moderate the seasons, producing winters that are warmer and summers that tend to be cooler than on the mainland. Large temperature differences between day and night occur during late fall and spring due to the slow response of the ocean to changing temperature trends and frequent land and sea breeze effects. Air and water temperatures at the FRF tend to be lowest in February and highest in July and August.

10. The precipitation was fairly well distributed throughout the year; the monthly average during 1980 was 68 mm. May was the wettest month (112 mm), while September was the driest (30 mm).

11. A persistent breeze, warm in summer and chilly in winter, blows at the FRF; seldom is it dead calm. On occasion, severe winds blow as a result of either extratropical cyclones (northeasters) or tropical cyclones (hurricanes).

12. The summer winds are predominantly from the southwest, while winter winds blow out of northern directions. Extreme winds generally came from the north-northeast. Although the FRF was not directly hit by a major hurricane in 1980, strong northeasters produced winds in excess of 15 m/second.

13. The wave heights at the FRF vary as a function of water depth and season. Generally, the deeper the water, the larger the wave conditions. The annual average significant wave height for 1980 at the seaward end of the pier (8-m depth) was 0.87 m (0.44 m standard deviation), with an average peak spectral period of 9 seconds (2.8 seconds standard deviation). Wave heights tended to be lowest from April through September and greatest during January through March.

14. Surface currents are strongest and move predominantly southward during the winter and are much more frequently directed northward in the summer.

15. The tides at the FRF are semidiurnal, with 2 high and 2 low tides generally occurring daily with a tide range of slightly more than 1.0 m. Local mean sea level during 1980 was 8 cm above the local 1929 National Geodetic Vertical Datum (NGVD). The extreme high tide was 118 cm NGVD observed on 2 March, while the lowest tide was -119 cm NGVD observed on 16 March.

16. The depth contours are relatively straight and parallel to the coast in the vicinity of the FRF with the exception of the area immediately adjacent to the pier. Here the contours bend drastically toward shore (a) as much as 250 m at the 7-m depth contour (i.e., normally seaward of the end of the pier) and (b) 20 m at the 3-m depth contour (i.e., near the beach). Frequently a bar is present nearshore, while occasionally a two-bar system is evident.

17. The sand size varies both temporally and spatially at the FRF. In 1980, foreshore sizes during the low-wave condition of summer tended to be finer than at the high-energy periods during winter. The surface sediments on the beach tend to be fine-to-medium-fine-grained, with relatively coarse, poorly sorted sands at the beach step; a shell fraction is also evident. Sands offshore tend to become increasingly fine, with moderately well-sorted very-fine-to-fine quartz sand out to the -17 m contour.

PART III: INSTRUMENTATION

18. This part identifies the instruments used for long-term monitoring of oceanographic and meteorological conditions and briefly describes their design and operation. More detailed explanations can be found in Miller (1980). Equipment (i.e. the surveying system) used for collecting other types of data is discussed in Part IV.

Wave Gages

19. Five wave gages were operated in 1980 as part of the FRFMA for monitoring wave conditions in the vicinity of the FRF (Figure 2). These included a wave staff gage on Jennette's Fishing Pier in Nags Head, N. C., approximately 40 km south of the FRF; two wave staff gages on the FRF pier (one at station 6+20 (hundreds of feet), the other at station 19+00); and two Waverider buoy gages located 0.6 and 3 km offshore.

Staff gages

20. The wave staffs were parallel cable types manufactured by the Baylor Company, Houston, Texas, and were designed for an accuracy and resolution of 1 and 0.1 percent full scale, respectively. The Baylor gages required little maintenance except to keep the cables taut and free of anything which could cause an electrical short across them, i.e. fishermen's nets, ropes, biological fouling, etc. Defective parts required replacement; this type of gage (specifically the transducer elements) is susceptible to lightning damage.

21. The transducer elements were connected to test cables in the laboratory and calibrated prior to installation by placing an electrical short between the cables at known distances and noting the voltage output from the transducer. In the field, electronic signal conditioning amplifiers were used to ensure the output signal from the gage was within a 0- to 5-V range. The transducer elements and signal conditioning electronics held their calibrations very well; differences greater than 1 percent full scale were unusual. Table 1 shows the dates when calibration/maintenance was performed for the Baylor staff gages.

22. Since the Baylor staff gages actually sense the water level on the gage, a 20-minute average of the levels measured four times per second can be

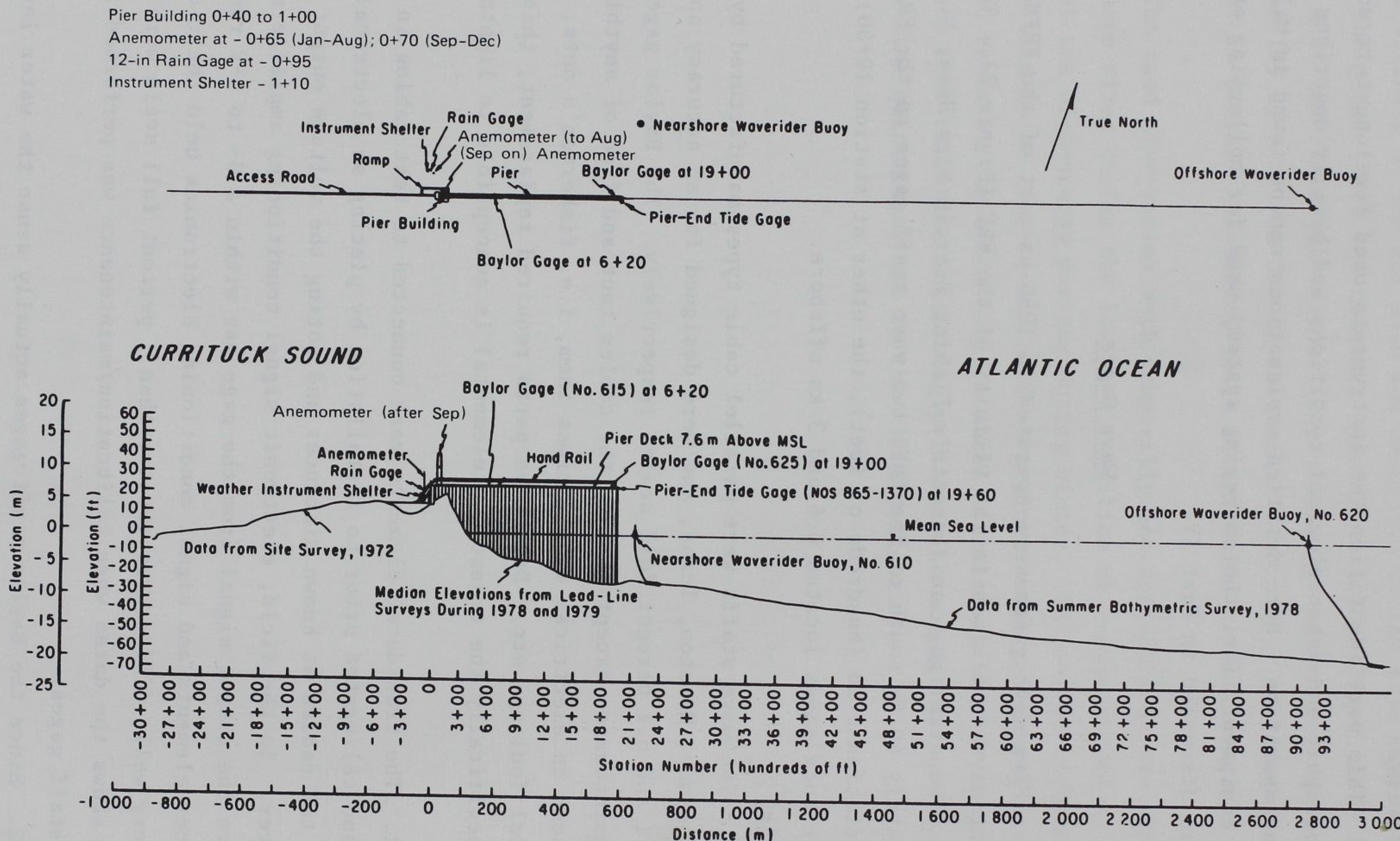


Figure 2. FRF instrument locations

Table 1

1980 Calibration/Maintenance Schedule for Baylor Staff Gages

Gage	Date	Calibration/Maintenance Performed
112 (Nags Head)	11 Apr	Amplifiers calibrated
	22 Apr	Replacement calibrated transducer was installed
	10 Jul	Replacement calibrated transducer and amplifiers were installed
625 (Baylor gage at 19+00)	8 Jan	Cleaned and tightened cables
	9 Jan	Replacement calibrated transducer was installed and amplifiers were calibrated
	22 Jan	Calibrated amplifier
	31 Jan	Replacement calibrated transducer installed and amplifiers calibrated
	11 Feb	Calibrated amplifiers
	27 Feb	Replacement calibrated transducer with lightning protection circuit installed
	27 Mar	Calibrated amplifiers; -3 percent error full scale noted
	16 Apr	Calibrated amplifiers
	13 Jun	Calibrated amplifiers
	28 Jun	Calibrated amplifier
	8 Jul	Replaced IC's in amplifier and calibrated
	24 Jul	Cleaned cables
	28 Jul	Calibrated amplifiers
	11 Aug	Changed data cables and calibrated amplifiers
	22 Aug	Calibrated amplifiers
	28 Aug	Calibrated amplifiers
	23 Sep	Calibrated amplifiers
	27 Sep	Calibrated amplifiers
	3 Oct	Calibrated amplifiers
	4 Oct	Calibrated amplifiers
	14 Oct	Calibrated amplifiers
	21 Oct	Calibrated amplifiers
	31 Oct	Calibrated amplifiers
	4 Nov	Replacement calibrated transducer installed
	13 Nov	Calibrated amplifiers
	20 Nov	Calibrated amplifiers
	1 Dec	Calibrated amplifiers
	10 Dec	Calibrated amplifiers
	15 Dec	Replacement calibrated transducer installed
615 (Baylor gage at 6+20)	22 Jan	Calibrated amplifiers
	14 Feb	Calibrated amplifiers
	17 Mar	Calibrated amplifiers
	16 Apr	Calibrated amplifiers; 2 percent error full scale noted
	22 Apr	Calibrated amplifiers
	28 May	Calibrated amplifiers
	13 Jun	Calibrated amplifiers
	5 Jul	Amplifiers repaired
	7 Jul	Replacement calibrated transducer installed and amplifiers calibrated
	24 Jul	Cleaned cables
	22 Aug	Calibrated amplifiers
	22 Sep	Calibrated amplifiers
	27 Sep	Calibrated amplifiers
	3 Oct	Calibrated amplifiers
	14 Oct	Calibrated amplifiers
	21 Oct	Calibrated amplifiers
	31 Oct	Calibrated amplifiers
	13 Nov	Calibrated amplifiers
	20 Nov	Calibrated amplifiers
	1 Dec	Calibrated amplifiers
	10 Dec	Calibrated amplifiers

used to provide a mean sea (or tide) level. (It was suggested that the Baylor staff gages along the FRF pier be used to measure water levels across the surf zone to investigate the water's slope. This was not pursued because the gage zero value showed both a random variation due to the difficulty in measuring the zero offset and a time-dependent change due to amplifier drift.)

23. The procedure used to monitor the gage zero level was to measure the water level on the gage and gage output, then compare that to the corresponding gage output for the measured water level based on the gage calibration curve. Differences implied a drift of the gage zero. In practice, this was accomplished as follows:

- a. The distance from the pier deck to the still-water level was measured by lowering a weighted surveyor's tape (i.e. lead line) from the FRF pier deck (on a calm day) to the visually determined still-water level next to the gage.
- b. The distance from the bottom of the gage to the still-water level was determined by accounting for the distance from the top of the gage to the pier deck in the above measurement and taking the difference between that value and the gage length.
- c. The gage output value was determined as the average of the few-minute sample of gage measurement output while the weighted tape measurement was made.
- d. The lead-line-determined level and the measured gage output were then compared to determine the zero offset of the gage.

24. This procedure is believed to be accurate to no better than ±10 cm; errors arise from estimating the still-water level and from movement, bending, and expansion of the surveyor's tape used in the lead-line measurement. This accuracy is not sufficient for the detection of water slopes across the surf zone, which may only amount to a few centimeters difference at the measurement locations. The gage zero drift or uncertainty is random (see Figure 3).

25. Although this variability seems artificial, precautions were taken in the analysis of the 20-minute data records when computing wave statistics (see Part IV).

Waverider buoy gages

26. The Waverider buoys were manufactured by the Datawell Laboratory for Instrumentation, Haarlem, Netherlands. Each 0.7-m-diameter buoy floats on the water's surface and (a) measures the vertical acceleration produced by the passage of a wave, (b) doubly integrates this signal to produce a displacement signal, and (c) telemeters this signal to an onshore receiver and associated electronics which extract the displacement signal for data logging

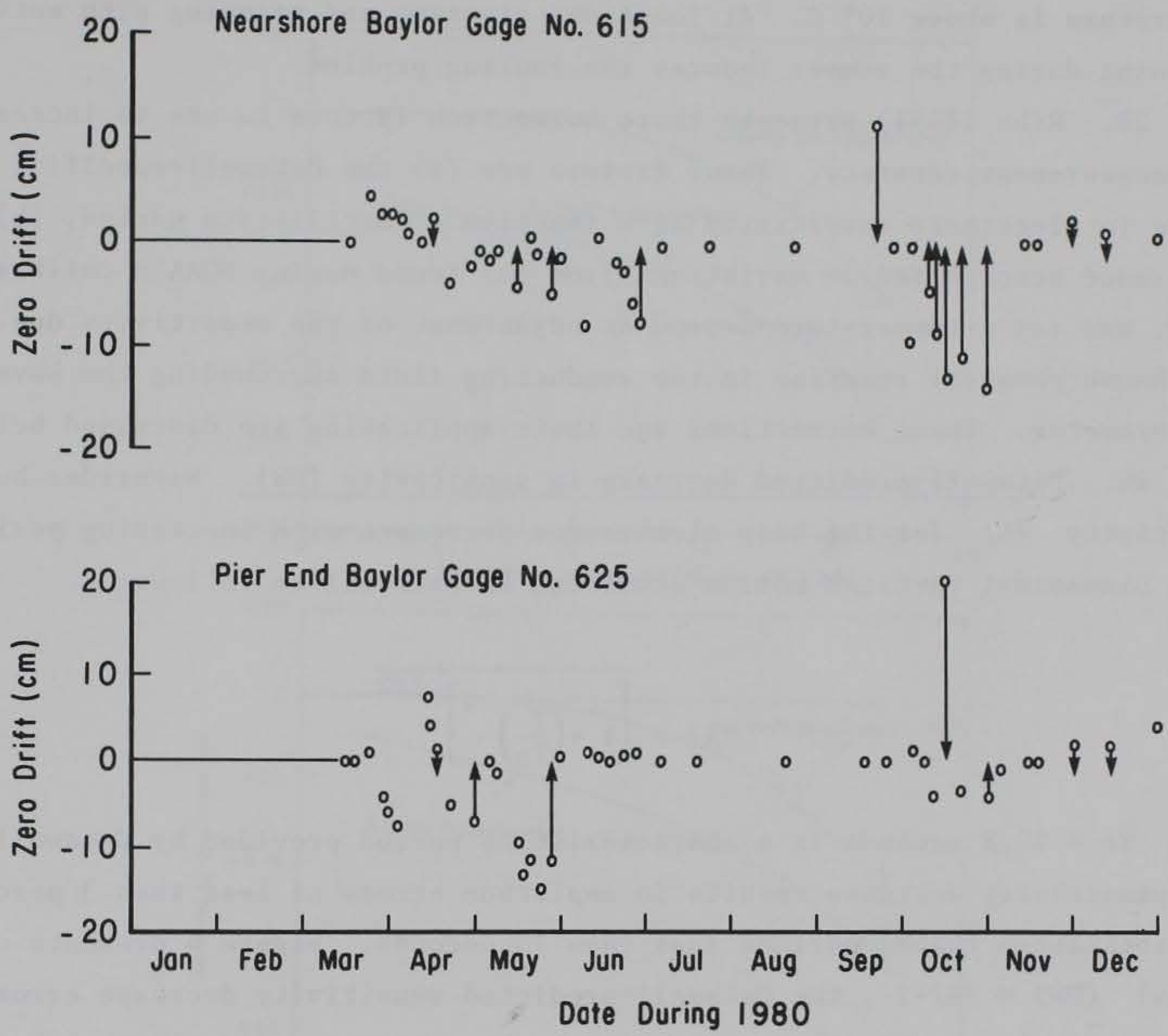


Figure 3. Amplifier zero drift during 1980 (arrows indicate when amplifiers were reset to 0.0 cm)

and analysis. The manufacturer states that wave amplitudes are correct within 3 percent of their true value for frequencies between 0.065 and 0.5 Hz (i.e., wave periods between 15 and 2 second). For frequencies as low as 0.03 Hz (i.e., for a 33-second period), the manufacturer provides a frequency response curve which must be used to maintain the 3 percent accuracy. The frequency response curve was not used for the data in this report since wave periods greater than 17 seconds were never observed.

27. Datawell recommends that Waverider buoys be cleaned and new batteries installed at least every 9 months. The buoys were replaced with cleaned, repainted, and calibrated buoys in October 1979 and August 1980. The buoys were calibrated at the Engineering Support Offices, Ocean Wave Instrument Facility, National Oceanic and Atmospheric Administration (NOAA) (Ribe 1981). Considerable biological growth occurs during the summer months when the water

temperature is above 10° C. At least one cleaning and painting with antifoulant paint during the summer reduces the fouling problem.

28. Ribe (1981) presents three correction factors to use to increase wave measurement accuracy. These factors are (a) the Datawell-specified decrease in electronic sensitivity as a function of oscillation period, (b) a difference error based on deviations from (a) found during NOAA's calibrations, and (c) a temperature-dependent adjustment of the sensitivity due to an unknown chemical reaction in the conducting fluid surrounding the Waverider accelerometer. These corrections and their application are discussed below.

29. Datawell-predicted decrease in sensitivity (DW). Waverider buoy sensitivity /A/ for the buoy electronics decreases with increasing period T of sinusoidal vertical motion according to Datawell as follows:

$$/A/ = \overline{\left[1 + \left(\frac{T}{To}\right)^4\right]}^{\,1/2} \quad (1)$$

where To = 30.8 seconds is a characteristics period provided by Datawell. This sensitivity decrease results in amplitude errors of less than 3 percent for oscillation (wave) periods less than 15 seconds. Figure 4 presents curves for (a) (DW) = /A/-1 , the Datawell-predicted sensitivity decrease error, and (b) the actual sensitivity decrease error obtained from predeployment buoy calibrations. Note the actual sensitivity does not follow the Datawell relationship (Equation 1) given above.

30. Difference error (d). Ribe (1981) presents a least-mean-squares second-order polynomial of the form shown below in period T for a "best-estimate" difference error d between the Datawell-predicted decrease in sensitivity and that found from the actual buoy calibrations:

$$d = a_o + (a_1 \times T) + (a_2 \times T^2) \quad (2)$$

In Table 2, DW and d are tabulated as functions of T for each of the FRF buoys.

31. Temperature-related error. It was determined that for some unknown number of Waveriders the sensitivity was drifting downward, possibly since manufacture, and averaging about 1 percent per year. Sensitivity loss from some unknown chemical reaction was related to increases in electrical

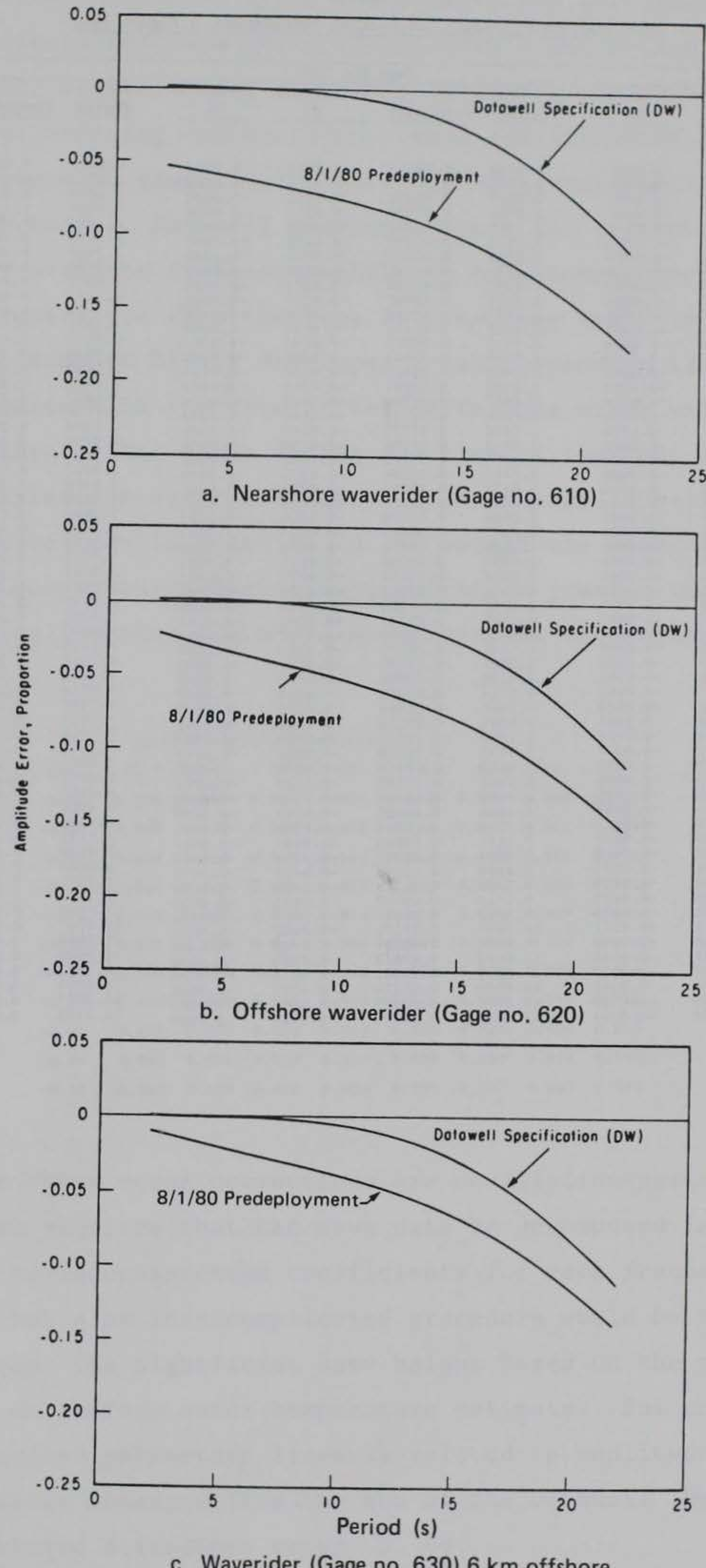


Figure 4. Predeployment Waverider gage calibrations (after Ribe 1981)

Table 2

Waverider Predeployment Calibration Information, 1 August 1980

Gage No. 610				Gage No. 620				Gage No. 630			
Period	Frequency	Difference d	Datawell DW	Period	Frequency	Difference d	Datawell DW	Period	Frequency	Difference d	Datawell DW
2.0000	0.50000	-0.0484	-0.0000	2.0000	0.50000	-0.0212	-0.0000	2.0000	0.50000	-0.0104	-0.0000
2.0317	0.49219	-0.0485	-0.0000	2.0317	0.49219	-0.0214	-0.0000	2.0317	0.49219	-0.0106	-0.0000
2.0645	0.48438	-0.0487	-0.0000	2.0645	0.48438	-0.0215	-0.0000	2.0645	0.48438	-0.0107	-0.0000
2.0984	0.47656	-0.0488	-0.0000	2.0984	0.47656	-0.0217	-0.0000	2.0984	0.47656	-0.0108	-0.0000
2.1333	0.46875	-0.0489	-0.0000	2.1333	0.46875	-0.0218	-0.0000	2.1333	0.46875	-0.0110	-0.0000
2.1695	0.46094	-0.0491	-0.0000	2.1695	0.46094	-0.0220	-0.0000	2.1695	0.46094	-0.0111	-0.0000
2.2069	0.45313	-0.0492	-0.0000	2.2069	0.45313	-0.0221	-0.0000	2.2069	0.45313	-0.0113	-0.0000
2.2456	0.44531	-0.0494	-0.0000	2.2456	0.44531	-0.0223	-0.0000	2.2456	0.44531	-0.0114	-0.0000
2.2857	0.43750	-0.0495	-0.0000	2.2857	0.43750	-0.0225	-0.0000	2.2857	0.43750	-0.0116	-0.0000
2.3273	0.42969	-0.0497	-0.0000	2.3273	0.42969	-0.0227	-0.0000	2.3273	0.42969	-0.0118	-0.0000
2.3704	0.42188	-0.0499	-0.0000	2.3704	0.42188	-0.0229	-0.0000	2.3704	0.42188	-0.0119	-0.0000
2.4151	0.41406	-0.0500	-0.0000	2.4151	0.41406	-0.0231	-0.0000	2.4151	0.41406	-0.0121	-0.0000
2.4615	0.40625	-0.0502	-0.0000	2.4615	0.40625	-0.0233	-0.0000	2.4615	0.40625	-0.0123	-0.0000
2.5098	0.39844	-0.0504	-0.0000	2.5098	0.39844	-0.0235	-0.0000	2.5098	0.39844	-0.0125	-0.0000
2.5600	0.39063	-0.0506	-0.0000	2.5600	0.39063	-0.0237	-0.0000	2.5600	0.39063	-0.0127	-0.0000
2.6122	0.38281	-0.0508	-0.0000	2.6122	0.38281	-0.0240	-0.0000	2.6122	0.38281	-0.0129	-0.0000
2.6667	0.37500	-0.0510	-0.0000	2.6667	0.37500	-0.0242	-0.0000	2.6667	0.37500	-0.0131	-0.0000
2.7234	0.36719	-0.0512	-0.0000	2.7234	0.36719	-0.0244	-0.0000	2.7234	0.36719	-0.0133	-0.0000
2.7826	0.35938	-0.0514	-0.0000	2.7826	0.35938	-0.0247	-0.0000	2.7826	0.35938	-0.0136	-0.0000
2.8444	0.35156	-0.0517	-0.0000	2.8444	0.35156	-0.0250	-0.0000	2.8444	0.35156	-0.0138	-0.0000
2.9091	0.34375	-0.0519	-0.0000	2.9091	0.34375	-0.0252	-0.0000	2.9091	0.34375	-0.0141	-0.0000
2.9767	0.33594	-0.0522	-0.0000	2.9767	0.33594	-0.0255	-0.0000	2.9767	0.33594	-0.0143	-0.0000
3.0476	0.32813	-0.0524	-0.0000	3.0476	0.32813	-0.0258	-0.0000	3.0476	0.32813	-0.0146	-0.0000
3.1220	0.32031	-0.0527	-0.0001	3.1220	0.32031	-0.0262	-0.0001	3.1220	0.32031	-0.0149	-0.0001
3.2000	0.31250	-0.0530	-0.0001	3.2000	0.31250	-0.0265	-0.0001	3.2000	0.31250	-0.0152	-0.0001
3.2821	0.30469	-0.0533	-0.0001	3.2821	0.30469	-0.0268	-0.0001	3.2821	0.30469	-0.0155	-0.0001
3.3684	0.29688	-0.0536	-0.0001	3.3684	0.29688	-0.0272	-0.0001	3.3684	0.29688	-0.0158	-0.0001
3.4595	0.28906	-0.0539	-0.0001	3.4595	0.28906	-0.0276	-0.0001	3.4595	0.28906	-0.0161	-0.0001
3.5556	0.28125	-0.0543	-0.0001	3.5556	0.28125	-0.0279	-0.0001	3.5556	0.28125	-0.0165	-0.0001
3.6571	0.27344	-0.0546	-0.0001	3.6571	0.27344	-0.0284	-0.0001	3.6571	0.27344	-0.0169	-0.0001
3.7647	0.26563	-0.0550	-0.0001	3.7647	0.26563	-0.0288	-0.0001	3.7647	0.26563	-0.0173	-0.0001
3.8788	0.25781	-0.0554	-0.0001	3.8788	0.25781	-0.0292	-0.0001	3.8788	0.25781	-0.0177	-0.0001
4.0000	0.25000	-0.0558	-0.0001	4.0000	0.25000	-0.0297	-0.0001	4.0000	0.25000	-0.0181	-0.0001
4.1290	0.24219	-0.0562	-0.0002	4.1290	0.24219	-0.0302	-0.0002	4.1290	0.24219	-0.0185	-0.0002
4.2667	0.23438	-0.0567	-0.0002	4.2667	0.23438	-0.0308	-0.0002	4.2667	0.23438	-0.0190	-0.0002
4.4138	0.22656	-0.0572	-0.0002	4.4138	0.22656	-0.0313	-0.0002	4.4138	0.22656	-0.0195	-0.0002
4.5714	0.21875	-0.0577	-0.0002	4.5714	0.21875	-0.0319	-0.0002	4.5714	0.21875	-0.0200	-0.0002
4.7407	0.21094	-0.0582	-0.0003	4.7407	0.21094	-0.0325	-0.0003	4.7407	0.21094	-0.0206	-0.0003
4.9231	0.20313	-0.0588	-0.0003	4.9231	0.20313	-0.0332	-0.0003	4.9231	0.20313	-0.0212	-0.0003
5.1200	0.19531	-0.0594	-0.0004	5.1200	0.19531	-0.0339	-0.0004	5.1200	0.19531	-0.0218	-0.0004
5.3333	0.18750	-0.0601	-0.0004	5.3333	0.18750	-0.0346	-0.0004	5.3333	0.18750	-0.0225	-0.0004
5.5652	0.17969	-0.0607	-0.0005	5.5652	0.17969	-0.0354	-0.0005	5.5652	0.17969	-0.0232	-0.0005
5.8182	0.17188	-0.0615	-0.0006	5.8182	0.17188	-0.0363	-0.0006	5.8182	0.17188	-0.0239	-0.0006
6.0952	0.16406	-0.0623	-0.0008	6.0952	0.16406	-0.0372	-0.0008	6.0952	0.16406	-0.0247	-0.0008
6.4000	0.15625	-0.0631	-0.0009	6.4000	0.15625	-0.0381	-0.0009	6.4000	0.15625	-0.0256	-0.0009
6.7368	0.14844	-0.0640	-0.0011	6.7368	0.14844	-0.0391	-0.0011	6.7368	0.14844	-0.0265	-0.0011
7.1111	0.14063	-0.0649	-0.0014	7.1111	0.14063	-0.0402	-0.0014	7.1111	0.14063	-0.0275	-0.0014
7.5294	0.13281	-0.0659	-0.0018	7.5294	0.13281	-0.0414	-0.0018	7.5294	0.13281	-0.0285	-0.0018
8.0000	0.12500	-0.0670	-0.0023	8.0000	0.12500	-0.0426	-0.0023	8.0000	0.12500	-0.0296	-0.0023
8.5333	0.11719	-0.0681	-0.0029	8.5333	0.11719	-0.0439	-0.0029	8.5333	0.11719	-0.0307	-0.0029
9.1429	0.10938	-0.0693	-0.0039	9.1429	0.10938	-0.0453	-0.0039	9.1429	0.10938	-0.0319	-0.0039
9.8462	0.10156	-0.0705	-0.0052	9.8462	0.10156	-0.0467	-0.0052	9.8462	0.10156	-0.0331	-0.0052
10.6667	0.09375	-0.0718	-0.0071	10.6667	0.09375	-0.0482	-0.0071	10.6667	0.09375	-0.0344	-0.0071
11.6364	0.08594	-0.0730	-0.0100	11.6364	0.08594	-0.0496	-0.0100	11.6364	0.08594	-0.0355	-0.0100
12.8000	0.07813	-0.0741	-0.0146	12.8000	0.07813	-0.0509	-0.0146	12.8000	0.07813	-0.0366	-0.0146
14.2222	0.07031	-0.0749	-0.0220	14.2222	0.07031	-0.0518	-0.0220	14.2222	0.07031	-0.0372	-0.0220
16.0000	0.06250	-0.0751	-0.0345	16.0000	0.06250	-0.0519	-0.0345	16.0000	0.06250	-0.0371	-0.0345
18.2857	0.05469	-0.0739	-0.0569	18.2857	0.05469	-0.0506	-0.0569	18.2857	0.05469	-0.0355	-0.0569
21.3333	0.04688	-0.0698	-0.0984	21.3333	0.04688	-0.0459	-0.0984	21.3333	0.04688	-0.0307	-0.0984

conductivity of the conductive fluid surrounding the accelerometer. This drift could be identified from calibrations over a succession of time.

32. In 1982 Datawell made available an improved modulator printed-circuit board for bringing calibrations within specification and for preventing further decrease in sensitivity; however, this modification was not made for the 1980 FRF buoys. Datawell provided curves for correction of calibration sensitivity based on differences between buoy temperature during calibration and buoy temperature when the buoy is measuring waves in the ocean. The NOAA Engineering Support Office developed a table based on the Datawell curve which can be entered with the uncorrected difference error value d (Table 2) and the temperature of the water during the time of the buoy operation to determine the difference error correction (see tabulation below). The difference error correction is added to d to obtain the corrected difference error D. For temperatures during buoy operation greater than the buoy temperature during calibration (22.4°C), no correction is necessary.

	Water Temperature (degree C)							
Diff.	22:4	20	18	16	14	12	10	8
0.00	0.000	0.001	0.001	0.001	0.001	0.000	-0.000	-0.002
-0.01	0.000	0.007	0.008	0.009	0.010	0.011	0.011	0.011
-0.02	0.000	0.009	0.012	0.014	0.016	0.018	0.019	0.020
-0.03	0.000	0.009	0.013	0.016	0.019	0.021	0.024	0.026
-0.04	0.000	0.008	0.012	0.016	0.020	0.023	0.027	0.029
-0.05	0.000	0.006	0.011	0.016	0.020	0.024	0.028	0.032
-0.06	0.000	0.004	0.010	0.015	0.020	0.025	0.030	0.034
-0.07	0.000	0.003	0.009	0.015	0.021	0.026	0.031	0.036
-0.08	0.000	0.003	0.010	0.017	0.023	0.029	0.034	0.039
-0.09	0.000	0.006	0.013	0.019	0.026	0.032	0.038	0.043
-0.10	0.000	0.010	0.017	0.024	0.031	0.037	0.043	0.049

33. Since these error corrections are oscillation-period dependent, their application requires that the wave data be decomposed into amplitude coefficients or variance-spectrum coefficients for each frequency or period. A less accurate but also less complicated procedure would be to apply a single correction to, say, the significant wave height based on the peak spectral wave period and an average water temperature estimate. For correction of amplitudes or derived parameters linearly related to amplitude, a correction factor $F(T)$ can be obtained from the sum of the Datawell DW and temperature-corrected difference error D by:

$$F(T) = \frac{1}{1 + (DW + D)} \tag{3}$$

which can be applied by multiplying the uncorrected amplitude by $F(T)$ for T equal to the peak spectral wave period. For correction of parameters related to the square of the amplitude (i.e., total energy or variance spectrum coefficients), the following should be used:

$$\left[F(T)\right]^2 = \left[\frac{1}{1 + (DW + D)}\right]^2 \tag{4}$$

34. The following example demonstrates use of the calibration results. The nearshore Waverider buoy on 25 October recorded the annual extreme significant wave height of 3.80 m with an associated peak spectral period of 10.9 seconds. From Table 2, the Datawell-predicted sensitivity error DW is -0.0071, with a corresponding uncorrected difference error d of -0.0718.

35. To determine the correction for the difference error, the water temperature is also required; the ocean water temperature at that time was approximately 16° C (see Part V). The correction (see tabulation) is 0.015, thus:

$$D = d + 0.015 = -0.0718 + 0.015 \text{ or } D = -0.0568$$

$F(T)$ can be determined from Equation 3 as

$$F(T) = \frac{1}{1 + (DW + D)}$$

$$= \frac{1}{1 + (-0.0071 - 0.0568)}$$

$$= \frac{1}{0.9361}$$

$$F(T) = 1.0683$$

Finally, the corrected significant height is $3.80 \text{ m} \times F(T) = 3.80 \text{ m} \times 1.0683 = 4.06 \text{ m}$, which is a 7 percent increase.

36. In general, the wave statistics errors are near 5 percent for wave

periods less than 12 seconds (12 seconds is equal to the annual mean plus one standard deviation wave period). Errors of this magnitude are generally tolerable for most engineering applications, although it is worthwhile to know the error bounds for some design considerations. When investigating coastal phenomena involving very long period swells of 15 seconds or greater these corrections will produce significant increases in the magnitudes of the wave parameters and it is recommended that the corrections be used.

Tide Gages

37. Water level data from the FRF pier are presented in this report. A NOAA/NOS control station, located at the seaward end of the research pier, consisted of a Leupold-Stevens gage manufactured by Leupold and Stevens, Inc., Beaverton, Oregon. The Leupold-Stevens analog-to-digital recorder was a float-activated, negator-spring, counterpoised instrument that mechanically converts the vertical motion of a float into a coded, punched paper tape record. The below-deck installation at pier station 19+60 (see Figure 2) consisted of a 30.5-cm-diameter stilling well with a 2.5-cm orifice and a 21.6-cm-diameter float.

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

39. Quarterly, a NOAA/NOS tide "party," which consisted of NOS personnel familiar with the installation and equipment, performed a tide station inspection and review. The tide gage was surveyed in from existing NOS control positions and the equipment checked and adjusted as needed; and NOS and FRF personnel reviewed procedures for tending the gage and handling the data. Any specific comments on the previous months of data were discussed to ensure data accuracy.

Meterological Instruments

Anemometer

40. Winds were measured using a Weather Service Model F420C anemometer consisting of a cup rotor and spread-tail wind vane. Through mid-September, the anemometer was located 58 m behind the dune, with the cups 6.4 m above NGVD. In late September, the instrument was relocated to the top of the laboratory building at an elevation of 19.1 m (Figure 2). The accuracy of the speed transmitter and indicator assemblies was (a) 1 percent up to 100 m/sec and (b) 2 percent over 100 m/sec. The wind direction transmitter and indicator assemblies were accurate to ±5 deg at an air speed of 0.26 m/s or greater.

41. In September, after installation on the laboratory roof, NOAA/ National Weather Service (NWS) personnel calibrated the speed cups and set the direction reference to true north. The speeds were found to be approximately 5 percent faster than actual, and the instrument was reset. The anemometer had been last calibrated in the spring of 1979 at which time, it is believed, the zero offset was incorrectly set; consequently, the data before September should be corrected by reducing the value indicated by 5 percent.

42. The wind speed and direction were recorded on a battery-powered Esterline-Angus recorder. Problems with the recorder's clock and tape advance mechanism and the pen actuator (for indicating direction) were frequently found, and the unit required day-to-day maintenance.

43. Maintenance of the anemometers consisted of troubleshooting the records and resetting the instrument based on the calibration results.

Microbarograph

44. This recording instrument, an aneroid sensor used to measure atmospheric pressure, responded to pressure changes on the order of 0.169 mb. The microbarograph was manufactured by the Belfort Instrument Company, Baltimore, Maryland, and was located inside the office trailer, 6 m above NGVD, until June when it was moved inside the laboratory building, 9 m above NGVD (Figure 2).

45. Daily, the microbarograph was compared to an NWS aneroid barometer; adjustments, although infrequent, were made as necessary. The microbarograph required very little maintenance except that required to ink the pen and wind the clock every 3 days when the chart paper was changed.

Maximum/minimum thermometers

46. NWS maximum and minimum thermometers were used to determine the

daily extreme temperatures. The thermometers were housed in an NWS instrument shelter located 91 m behind the dune (Figure 2). The shelter was designed with louvered sides, a double roof, and a slatted bottom for housing instruments requiring protection from direct sun.

47. The actual temperature readings at the time the thermometers were read (i.e., the present temperature) were compared to ensure accuracy of maximum and minimum values. Maintenance consisted of periodic removal and cleaning of the thermometers with soap and clean water and lubricating the support used to hold and reset the instruments.

Rain gage

48. A 30-cm weighing rain gage manufactured by the Belfort Instrument Company, Baltimore, Maryland, used to measure the daily amount of precipitation, was located near the instrument shelter 87 m behind the dune (Figure 2). The manufacturer's specifications indicated that the instrument accuracy was ±0.5 percent for precipitation amounts less than 15 cm and ±1.0 percent for amounts above 15 cm.

49. A 15-cm-capacity "true check" clear plastic rain gage with a 0.025-cm resolution, manufactured by the Edwards Manufacturing Company, Albert Lea, Minnesota, was used to monitor the performance of the weighing rain gage. This gage, located near the weighing gage, was checked daily, and very few discrepancies were identified throughout the year. The weighing rain gage required little maintenance except to wind the clock and ink the pen. The pen mark on the chart records did "bleed" or drip down when a driving rain was directed at the access door.

Sling psychrometer

50. A sling psychrometer was used to measure wet and dry bulb temperatures for determining relative humidity and dew point. The psychrometer had two thermometers mounted in a frame which was rotated rapidly. A moistened muslin wick was attached to the bulb (i.e. wet bulb) of one of the thermometers, and the device was whirled to ventilate both thermometers. The wet and dry bulb temperatures were read, and a set of NWS tables were used to determine the dew point.

51. These thermometers required little maintenance except to change the muslin wick every month or two and to clean the sling and thermometers with soap and water. The instruments were not calibrated, but the thermometers were compared daily to detect any bias or malfunction.

Pyranograph

52. A mechanical pyranograph, manufactured by the Weather Measure Corporation, Sacramento, California, was located on the top of the weather instrument shelter and provided a record of the duration and intensity of solar radiation. The pyranograph was not calibrated, but was observed to operate in a reasonable manner. This equipment required that the glass cover be cleaned, the chart paper changed every week, the timer wound, and the pen inked.

PART IV: DATA COLLECTION AND ANALYSIS

53. In this section, the FRF data acquisition system, data collection techniques, and data analysis procedures are discussed.

Digital Wave Data

Recorders/signal conditioning

54. The data acquisition system consisted of a primary and backup recorder and associated electronics for signal conditioning prior to recording. Two different primary recorders were used to collect the wave data. Prior to October 1980, the primary system transmitted analog data signals via telephone lines from the FRF to Ft. Belvoir, Virginia, where the data were recorded in digital form on a Modcomp II/25 minicomputer. After October, a Data General NOVA-4 minicomputer located in the FRF laboratory building was used to collect the data. In addition, a backup system consisting of a Lockheed Store 7 (FM) recorder located at the FRF was used to record data when the primary system was known to be inoperative. Frequently during storm conditions the backup system was run simultaneously with the primary system to ensure that wave data were obtained. A second FM recorder located at CERC (Ft. Belvoir) was used to play these tapes into the Modcomp so that the data recorded could be digitized.

55. Regardless of the system used, the voltage signal from the sensors required certain conditioning. For the phoneline/Modcomp system, the signal was first amplified and biased to ensure a 0- to 5-V range, then converted to a frequency-modulated (FM) signal by exciting a voltage-controlled oscillator (VCO). That signal was then transmitted to Ft. Belvoir via telephone line where a discriminator was used to convert it back to a voltage signal. This signal was fed into a demultiplexer and converted to a serial data stream which was then sampled by the Modcomp. For the NOVA-4 and FM recording systems, the 0- to 5-V signal was fed directly into the recorders. However, since the FM recorder operated on a maximum output of 3 V, it linearly scaled the 0- to 5-V signal by a factor of 3/5.

Collection

56. The signal from the wave sensors was routinely sampled four times per second for 20 minutes every 6 hours beginning as near as possible to 0100,

0700, 1300, and 1900 hours Eastern Standard Time (EST); these hours correspond to the times that the NWS creates daily synoptic weather maps. During storms, hourly data recordings were made. Since the Modcomp/phoneline and NOVA-4 systems were automated, recording data during nonduty hours and on weekends and holidays created only a minimum of problems. Prior to October, the FM recorder was run manually, and for most dates only two observations, one in the morning and one in the afternoon during duty hours, were obtained. In general, the FM recorder was not run on the weekends and holidays unless there was a particularly interesting event in progress, such as a storm or experiment. After October, a controller was used to turn the recorder on and off at specified times; this automation permitted FM data collection in the evening and on weekends.

Data tapes

57. The wave data were recorded in digital form with the following basic tape format: two records of header information which include (a) the station identification number, (b) the date and time, and (c) a variable number of records necessary to obtain 20 minutes of data from all sensors at a sample rate of four values per second. Each record contained 384 20-bit integer words (i.e., binary format); each integer word represented the computer units corresponding to the instantaneous voltage output of the sensor. The above sequence of records was repeated for each recording interval until the data tape was filled. Seven-track tapes were used for data recorded via the Modcomp computer, while nine-track tapes were used with the NOVA-4. (The 20-bit word size is unusual but necessary because CERC processed the data on a CDC 6600 machine with a 60-bit word size; when necessary, CERC converted the data tapes to an ASCII format).

Analysis/summarization procedures

58. The CERC procedure for analyzing and summarizing digital wave data was based on a Fast Fourier Transform (FFT) spectral analysis procedure. The final results were also subjected to human editing and quality control before public distribution (Thompson 1977; Harris 1974). The computer analysis routine used 4096 data points (1024 seconds of data sampled four times per second) for each data record processed. The program first edited the digital data record, checking for nonnumeric characters, jumps, and spikes (i.e., deviations greater than 2.5 and 5 standard deviations from the mean, respectively). If more than five bad data points were found in a row or more than

2.5 percent of the digital values in a record were determined to be bad, the record was rejected as unsuitable for analysis; for a few bad data points, the routine linearly interpolated between the erroneous values. If the record was determined suitable for analysis, the distribution function of the sea surface elevations and first five moments were computed. The variance (second moment) and skewness (third moment) were checked to determine if full analysis of the data record was warranted. Records with very low variance values and excessively skewed distribution functions were not fully analyzed.

59. After it had been determined that the record justified full analysis, a cosine bell data window was applied to increase the resolution for the energy spectrum of the record (use of the data window is discussed by Harris (1974)). After application of the data window, the program computed the variance spectrum (energy spectrum) using an FFT procedure.

60. Significant wave height and peak spectral (or significant) period provided a convenient way to characterize the wave conditions contained in the data record and were more conducive to statistical summarization than the more complete, but complex, description provided by the spectrum.

61. Although significant wave height is defined as the average height of the highest one-third of the waves in a record, experimental results and calculations based on the Rayleigh distribution function show that the significant height is approximately equal to four times the standard deviation of the wave record (U. S. Army Corps of Engineers, Coastal Engineering Research Center (CERC) 1977). The peak spectral wave period (also referred to as the significant or peak period) for each digital record is defined as that period associated with the maximum energy density in the spectrum (Thompson 1977).

62. After 1 month of data had been analyzed, the significant wave height and peak period values were segregated by gage and tabulated for visual editing. The editor checked for such things as unreasonable distribution of the sea surface elevations; clipping of the crest or troughs; inconsistencies between successive observations; large trends in the 17-minute, 4-second data record; and discontinuities in the data. After the data had been edited, monthly summaries of significant height and peak period were generated for inclusion in summary reports.

Water Level Data

Collection

63. The water level information was obtained from an NOS tide gage, which produced a digital paper tape of instantaneous water levels sampled continuously at 6-minute intervals. At the end of each month, the paper tape was removed from the recorder and mailed to NOS in Rockville, Maryland, for analysis.

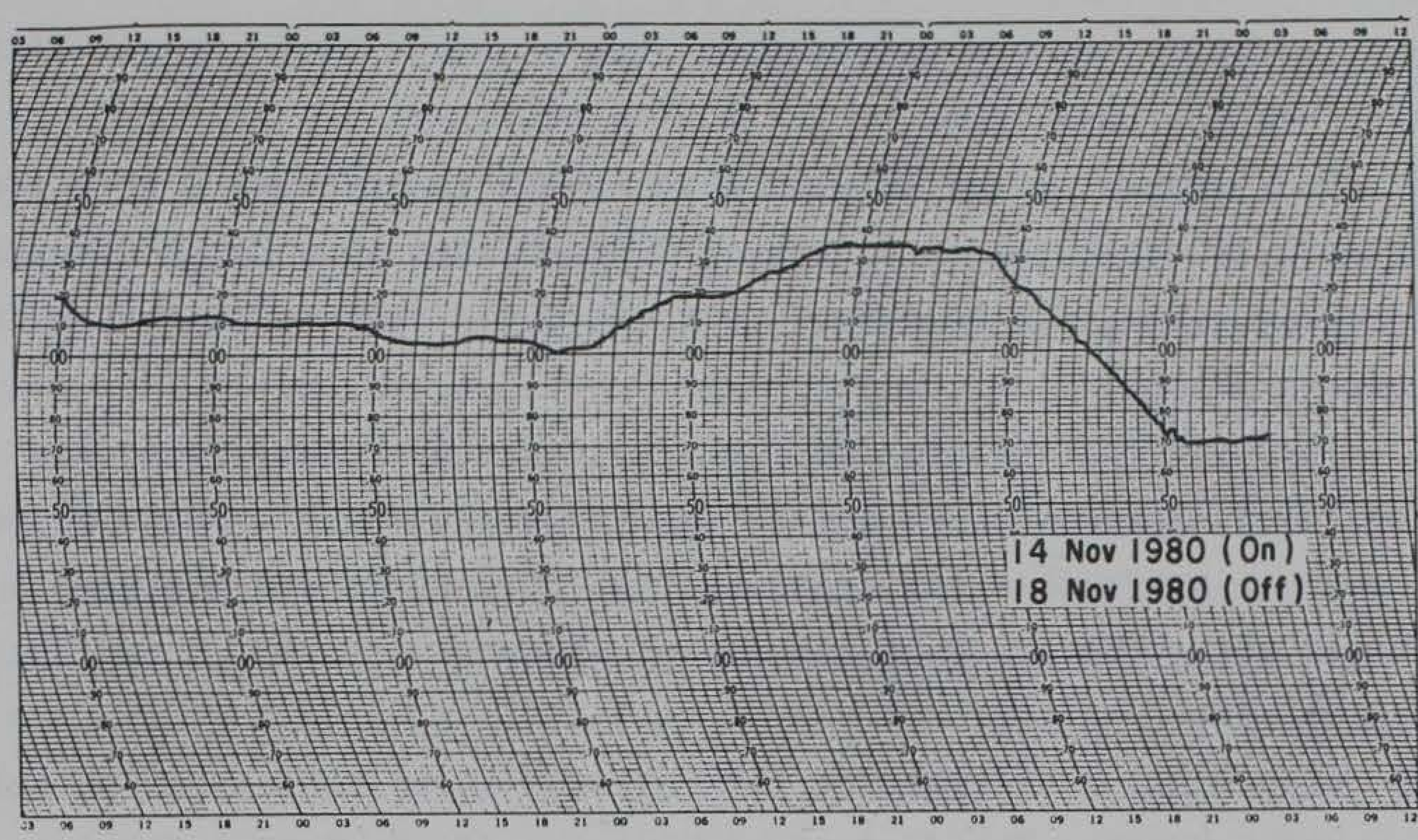
Analysis

64. The digital paper tape records of tide heights taken every 6 minutes were analyzed by the Tides Analysis Branch of NOS. A Mitron interpreter created a digital magnetic computer tape from the punch paper tape. This tape was then processed on a Univac 732 computer. First a listing of the instantaneous tidal height values was obtained for manual checking. If errors were encountered, a computer program was used to fill in or recreate bad or missing data, using correct values from the nearest tide station and accounting for known time lags and elevation anomalies. The data were plotted and a new listing was generated and rechecked. When the validity of the data had been confirmed, monthly tabulations of daily highs and lows, hourly heights (instantaneous height selected on the hour), and various extreme and/or mean water level statistics were generated. The mean sea level (msl) reported is the average of the hourly heights throughout the month, while the mean tide level (mtl) is midway between mean high water (mhw) and mean low water (mlw).

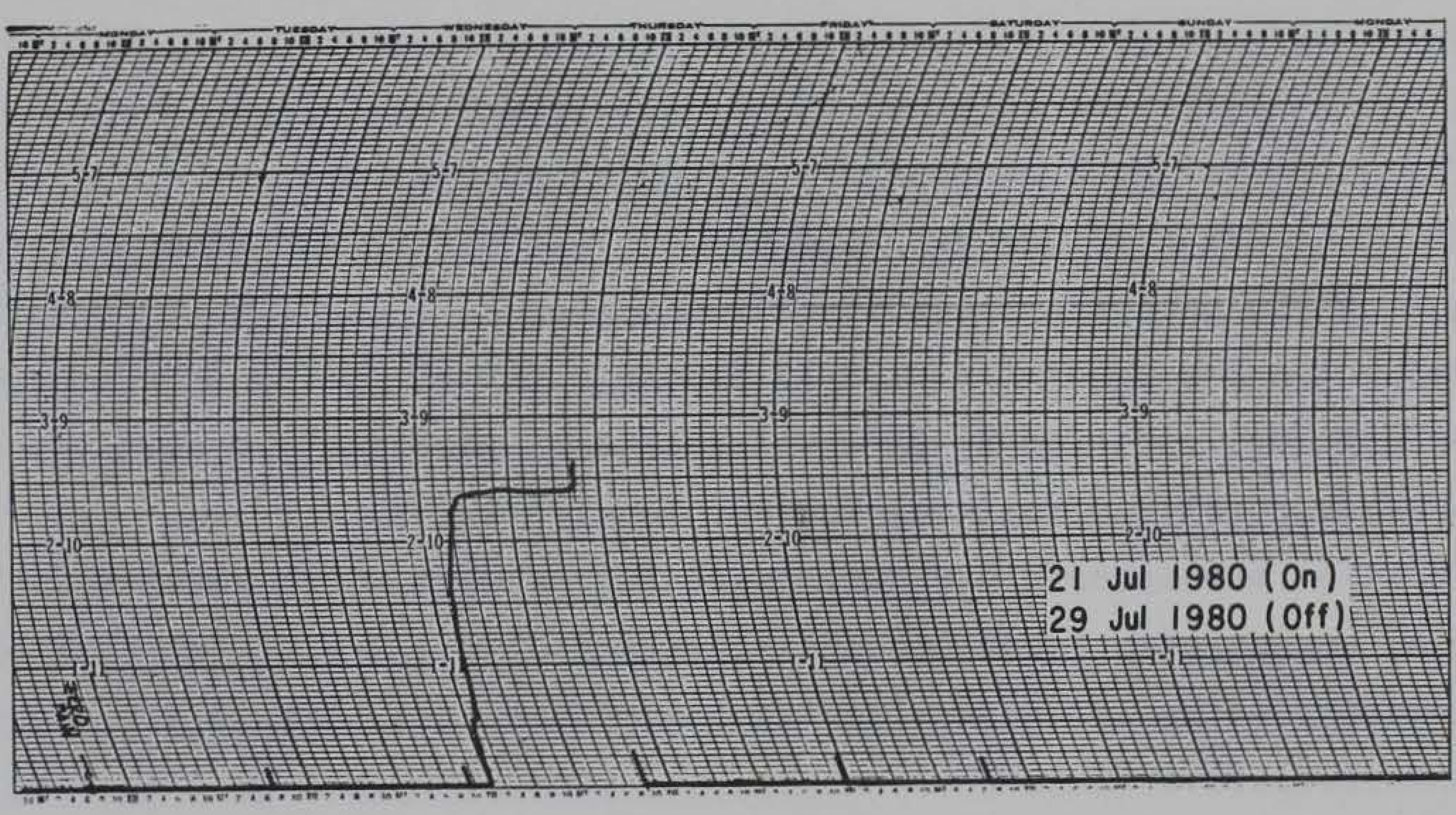
Weather and Visual Observations

Meteorological data collection

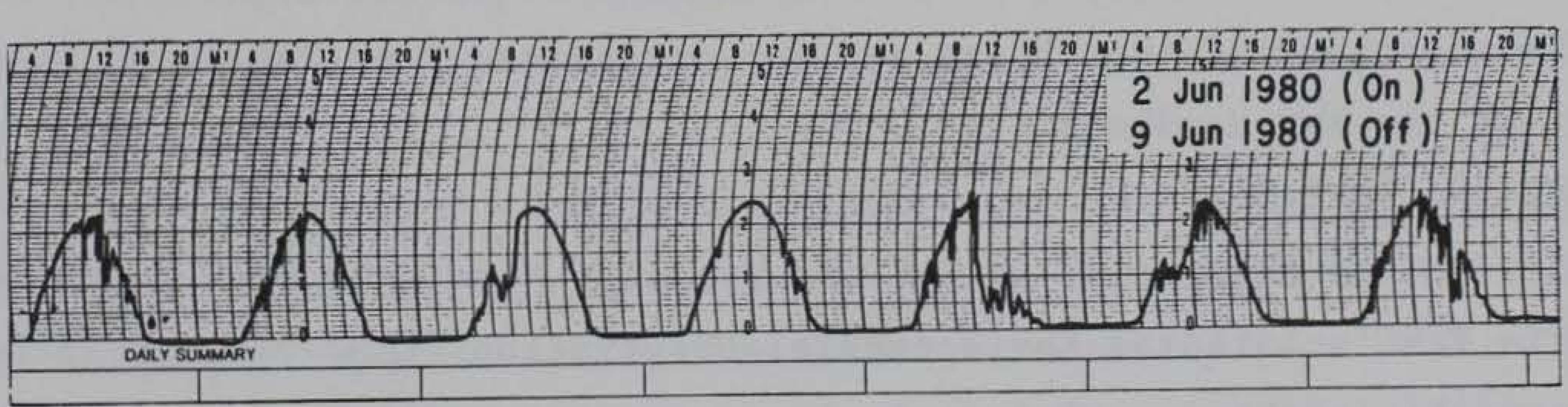
65. Each instrument used for monitoring the meteorological conditions at the FRF was read and inspected daily. For those instruments with analog chart recording capabilities, (a) the pen was zeroed (where applicable), (b) the chart time checked and corrected, if necessary, (c) a daily reading marked on the chart for reference, (d) the starting and ending chart times recorded, as necessary, and (e) new charts installed when needed. Sample chart records for the microbarograph (atmospheric pressure), rain gage, and pyranograph (solar radiation) are presented in Figure 5. The daily reading was recorded for all instruments except the pyranograph. Concurrent with the



a. Microbarograph



b. Rain gage



c. Pyranograph

Figure 5. Sample chart records for the microbarograph, rain gage, and pyranograph

instrument readings, weather information such as cloud cover, visibility, and predominant weather conditions were visually obtained.

66. The monthly meteorological data tables in Appendix A were prepared from single daily observations made near 0700 EST and thus do not represent daily or hourly averages; therefore, caution should be exercised when interpreting the results.

67. The wind information provided in this report, excluding that found in the tables of Appendix A, was based on wind speed and direction values determined every 6 hours from the instrument chart records and represents estimated average values based on 10 minutes of record.

Meteorological data analysis

68. Wind roses were computed for the wind speed and direction values obtained every 6 hours. The directions were specified at 22.5-deg intervals; i.e., a 16-compass-point-direction specification. Frequency distributions of wind speed for each direction were computed for the entire year, each 3-month season, and monthly. In addition to the wind roses, resultant directions and speeds were determined by vectorally adding each observation.

69. Dew point values reported herein were determined from psychrometer readings by computing the wet bulb temperature depression (dry bulb minus wet bulb) and using Table 19 in Appendix III of "Weather Service Observing Handbook No. 1--Marine Surface Observations" (National Oceanic and Atmospheric Administration, National Weather Service 1974).

70. The atmospheric pressure trend is a number which specifies the manner and amount of pressure change occurring over a 3-hour interval before the pressure reading is made. The first number of the three-digit code represents the characteristics of the change and was determined by comparing the barograph record to Table 17, Appendix III, of the Weather Service Observing Handbook. The last two digits of the pressure trends are a code which indicates the magnitude of the change and was determined from Table 18, Appendix III, of the NWS Handbook.

Visual data collection

71. At the FRF, daily visual observations made near 0700 hours and conforming to CERC's Littoral Environmental Observation (LEO) Program (Schneider 1981) were obtained to supplement instrumented data collection. These included observations of surface current speed and direction and wave-approach angle at the seaward end of the FRF pier.

Bathymetric and Pier Surveys

Collection

72. In October of 1980, an FRF bathymetric survey was performed by Langley and McDonald, Inc. of Virginia Beach, Virginia, which covered the beach, nearshore, and offshore area. Each survey range extended seaward from the baseline behind the dune sometimes as far as 3200 m offshore, and ranges were located up to 4 km north and south of the pier. Control consisted of a series of monuments installed by CERC and the U. S. Army Engineer District, Wilmington (SAW), which were resurveyed by Langley and McDonald, Inc. The survey techniques used were as follows.

73. Beach surveying. Conventional level and tape techniques (Czerniak 1972) were used for the beach portion of the survey, with accurate results conforming to these specifications:

a. Horizontal accuracy ± 15 cm.

b. Vertical accuracy ± 0.3 cm.

The beach portion of the survey extended from the monument baseline behind the dune to the maximum wading depth, approximately -0.5 m msl.

74. Nearshore surveys. The contractor used a sea sled with a stadia rod mounted on it to conduct surveys through the surf zone. The sled was pulled offshore by a boat and then winched to shore by means of a cable marked every 6.1 m. Each time a mark came to the winch (as the sled was winched in), the rod elevation was read from the beach by means of a level.

75. Offshore surveying. The contractor surveyed offshore by means of an analog fathometer mounted on a boat and two people on shore who triangulated the boat's position. The fathometer was calibrated on each range line by comparing its measurement to the sea sled value at the sea sled's most seaward position. The angle and depth information was correlated and manually reduced to produce position and depth data. No correction for wave effects was made by the contractor.

76. Pier soundings. Weekly soundings along both sides of the FRF pier were performed. The lead-line surveying technique consisted of lowering a weighted measuring tape and noting the distance below the pier deck. Positions between the pier bents (i.e., every 12.2 m) were used to minimize inaccuracies due to scour near the pilings.

77. Analysis. The pier, beach, nearshore, and offshore data were

reduced to position (X,Y) and depth (Z) triplets relative to the local NGVD. The data were listed, and a display of the profiles (i.e., distance along the range versus elevation) using line printer graphics was generated for visual inspection. After the data had been edited and determined to be acceptable, another set of routines was used to compute various statistics (i.e., maximum and minimum sand elevations) and displays (i.e., graphic profile representations, envelopes of elevations, and time sequences of elevations), as in Appendix C.

78. The offshore portion of the October bathymetric survey showed an "artificial" rhythmical bending of the bottom contours. Errors in the offshore portion are believed to have been the result of (a) using a floating surveying platform, (b) not performing a bar check calibration of the fathometer (i.e., calibrating at various depths and positions along the range), and (c) not accounting for wave motion in the fathometer data. At greater depths, stratification of the water temperature, water density, and thermoclines would have affected the accuracy of the measurements. Because of the low slope in the offshore region, small errors in elevation resulted in significant excursions of the contours. Although the fathometer depth data seaward of the pier end are believed accurate to ±0.2 m, caution should be exercised when the data are used.

Photography

Aerial

79. Quarterly aerial photographic missions were performed by a contractor as part of the measurement program using a 9-in. negative format mapping aerial camera capable of black and white and color photography. All coverage was at least 55 percent overlap, with all flights flown as close as possible to periods of low tide and between 1000 and 1400 hours with less than 10 percent cloud cover.

80. The flight lines were concentrated near the FRF although one flight line extended from Cape Henry, Virginia, to Cape Hatteras, North Carolina. The flight lines and scale specifications are shown in Figure 6.

Beach

81. As part of the visual observations, daily color slides of the beach were taken using a 35-mm camera from the pier looking north and south. The

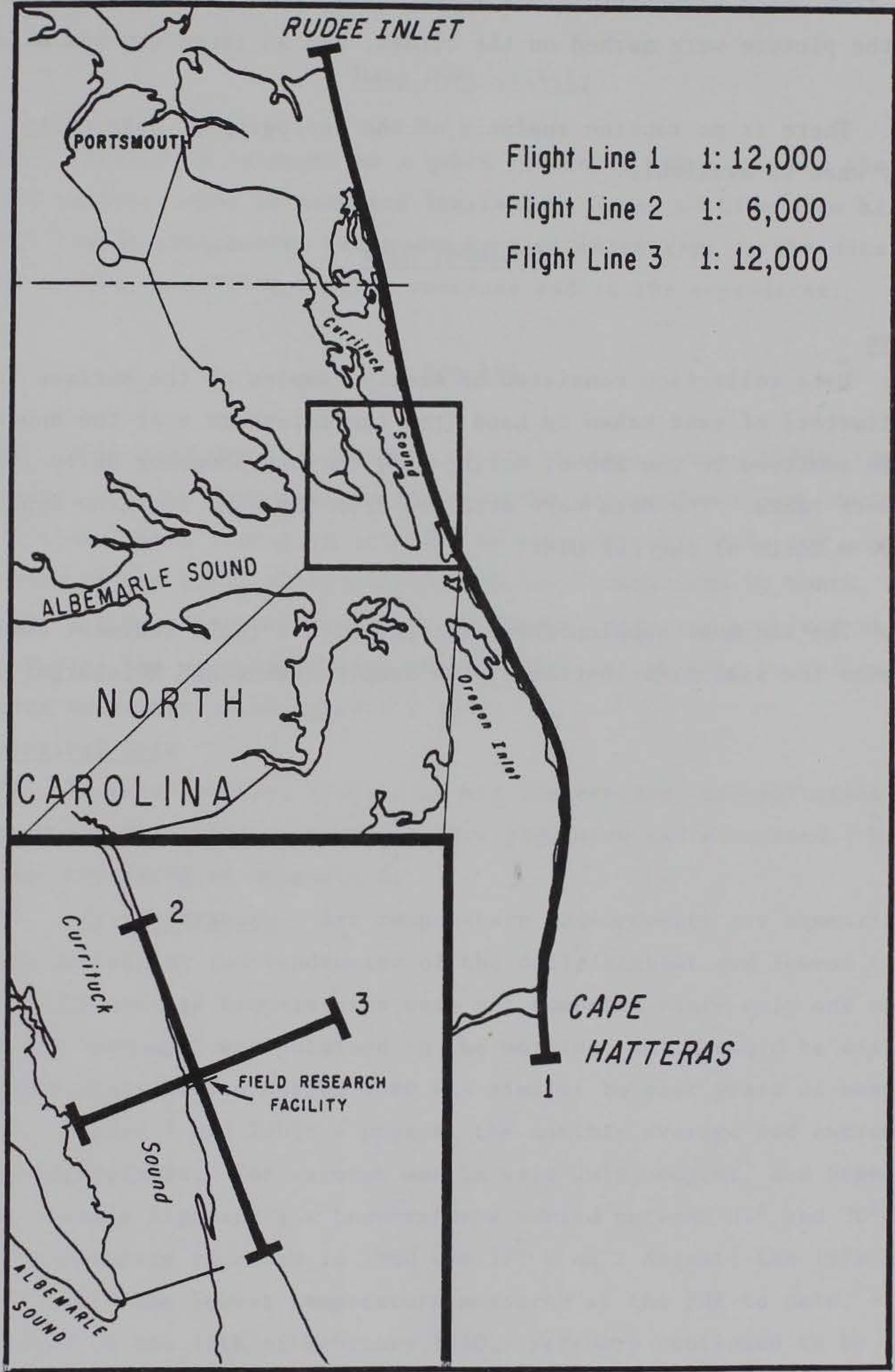


Figure 6. Quarterly aerial photography flight lines, 1980

location from which each picture was taken, date, time, and a brief description of the picture were marked on the slides, and an inventory was maintained.

Analysis

82. There is no routine analysis of the photographic data except to inventory what is available.

Sediment Data

Collection

83. Data collection consisted of weekly samples of the surface layer (top centimeter) of sand taken by hand from the foreshore near the upper swash limit. In addition to the above, during July through November daily foreshore samples were taken. The data were obtained from the same location approximately 500 m north of the FRF pier.

Analysis

84. The sediment samples were analyzed with a rapid sediment analyzer to determine the size distribution of the sample (Duane and Meisburger 1969).

PART V: DATA AVAILABILITY/RESULTS

Data Availability

85. Table 3 is intended as a quick reference guide to show the dates for which various types of data are available. Wave and tide gage histories and other status information which may explain major gaps in the data are provided in the respective results sections and in the appendices.

Results

86. This part provides results of the weather, wave, tidal, water characteristics, survey, photography, and sediment measurements made during the year. Although this report is intended to provide basic data for analysis by users, many of the daily observations have been summarized by month, season, or year to aid in interpretation. If individual data are required where summaries appear, the user can obtain the detailed information by following the procedures described in paragraphs 6 and 7.

Meteorological data

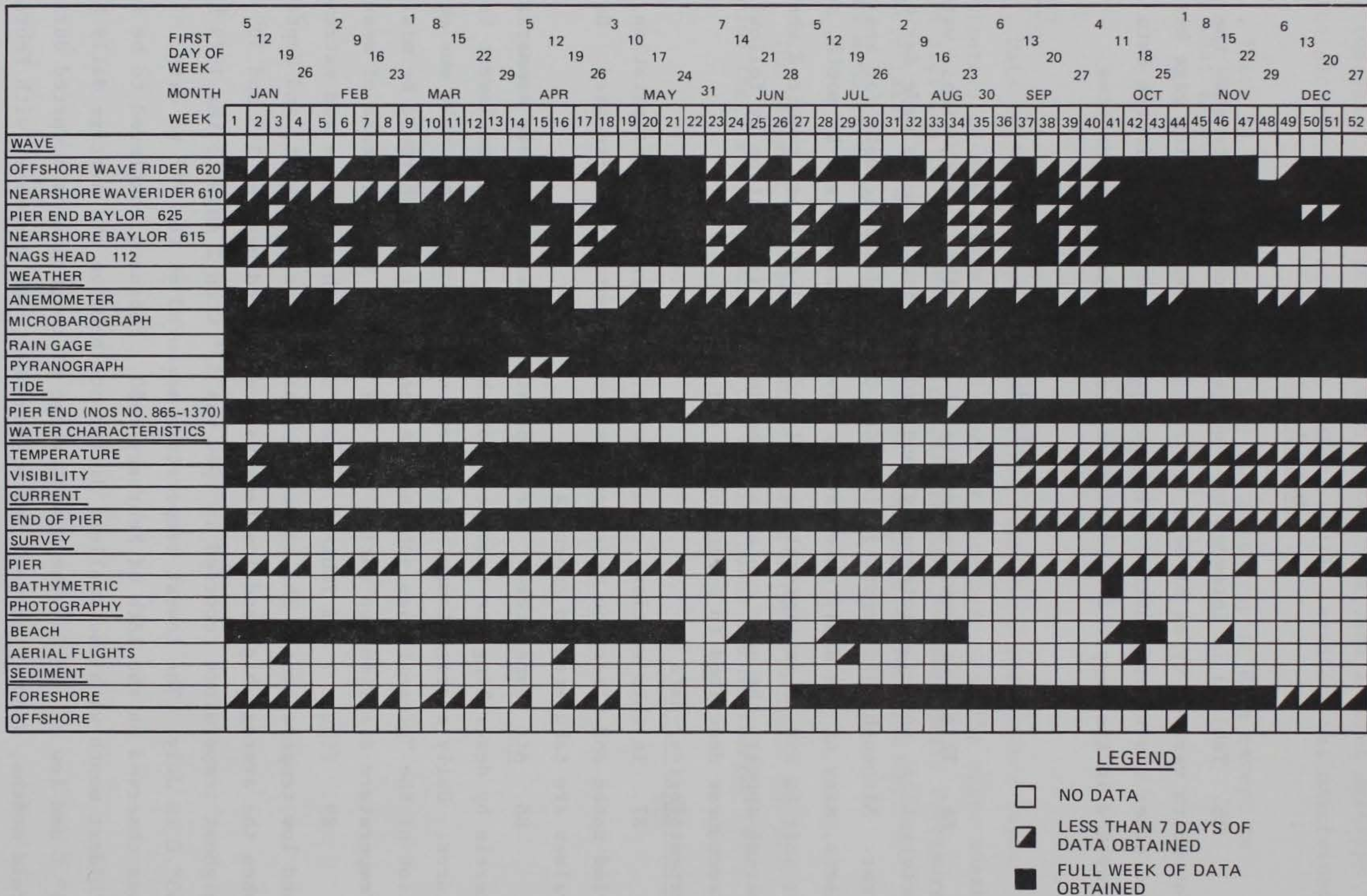
87. In this section, results of air temperature, precipitation, and wind speed and direction measurements are presented and discussed. Daily values are tabulated in Appendix A.

88. Air temperature. Air temperature measurements are summarized herein by describing the tendencies of the daily highest and lowest temperatures. Daily average temperatures were not computed since only one observation of the "present" was obtained in the morning, which could be misleading. Temperature distribution during 1980 was similar to past years of measurements.

89. Figure 7 and Table 4 present the monthly average and extreme high and low temperatures. The warmest months were July, August, and September, when the average high and low temperatures varied between 21° and 30° C. The highest temperature recorded in 1980 was 37° C on 2 August; the 1979 high was 43° C in July. The lowest temperature measured at the FRF to date, -11° C, was observed on the 18th of February 1980. February continued to be the coldest month with the smallest difference between the average daily high of 3° C and low of -2° C. The widest range of temperatures occurred during the cold months, January through March, November, and December, with February

Table 3

1980 Data Availability



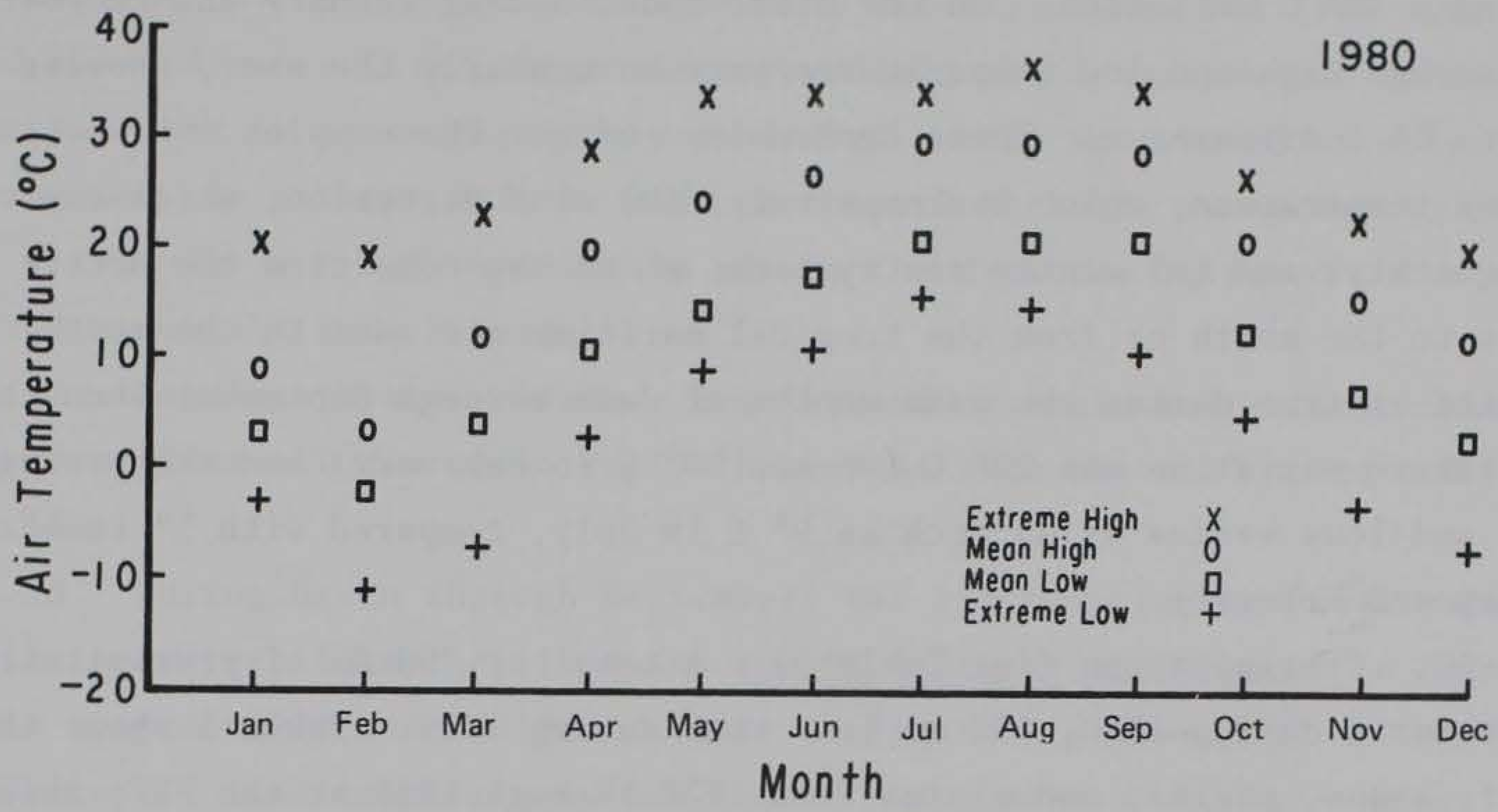


Figure 7. Monthly high and low air temperatures, 1980

Table 4

Meteorological Data Summary for 1980

	Temperature, °C						Precip-itation	Wind						
	High			Low				Average	Number of	Resultant		Extreme		
Month	Average	Extreme	Date	Average	Extreme	Date	mm	Speed m/sec	Obser-vations	Speed m/sec	Direction (deg from true N)	Speed m/sec	Direction (deg from true N)	Date
Jan	9	20	12	3	-3	31	89	5.8	111	3.1	356	10.8	203 23	11th 13th
Feb	3	19	23	-2	-11	18	66	5.6	103	2.4	337	11.3	338	10th 29th
Mar	12	23	22	4	-7	3	89	6.1	121	1.4	334	20.6	23	2nd
Apr	20	29	26	11	3	2	112	4.9	82	1.0	241	11.3	203 248	10th 15th
May	24	34	25	15	9	3	39	4.4	77	0.8	219	8.2	23 45	8th 26th
Jun	27	34	30	18	11	21	60	5.5	93	0.8	210	12.4	248	7th
Jul	30	34	21	21	16	25	64	4.0	113	1.4	217	8.2	248	3rd
Aug	30	37	2	21	15	25	48	4.5	96	0.7	284	8.2	23	22nd
Sep	29	34	3	21	11	12	30	4.0	95	0.8	183	7.2	248	3rd 23rd
Oct	21	27	11 14	13	5	27	73	5.4	113	0.7	323	14.9	248	25th
Nov	16	23	5 10	7	-3	20	96	5.8	114	1.9	317	12.9	23	16th
Dec	12	20	9	3	-7	29	47	6.2	111	3.3	358	14.9	0	25th
Annual	19	37	Aug	11	-11	Feb	793	5.2	1229	1.0	323	20.6	23	Mar

showing a 30° C variation. On the other hand, during January and February, the average high and low temperatures were most nearly the same, showing only a 5° to 6° C difference. These tendencies reflect the complex interaction of (a) sea temperature, which varies slowly; (b) wind direction, which can change very quickly; and (c) winter air systems, which can come from the Arctic air masses to the north or from the tropical maritime air mass to the south. The opposite is true during the warm months of June through September when the temperature variation was 23° C (versus 30° C in February) and the average highs and lows varied by as much as 9° C in July, compared with 5° to 6° C in January and February.

90. Precipitation (See Table 4). A total of 793 mm of precipitation was measured during 1980, 400 mm less than during 1979. Table 5 shows the monthly means, maxima, and minima from 1978 through 1980 at the FRF; absent during 1980 were monthly rainfalls in excess of 125 mm, as occurred in 1979 during January (180), May (239), and September (160), and in 1978 during March (137), May (145), June (130), and November (130). April was the wettest month of 1980, with 112 mm of rain measured; September was the driest month, with 30 mm of rainfall. 1980 totals were the lowest in 7 of the months and the highest in 3 others.

Table 5

Monthly Precipitation Means, Maxima, and Minima at the FRF from 1978 Through 1980

Month	Maxima mm	Year	Minima mm	Year	Monthly Mean 1978-80
Jan	180	1979	89	1980	135
Feb	94	1979	66	1980	80
Mar	137	1978	64	1979	97
Apr	112	1980	71	1979	86
May	239	1979	39	1980	141
Jun	130	1978	60	1980	87
Jul	104	1978	64	1980	79
Aug	48	1979 and 1980	36	1978	44
Sep	160	1979	13	1978	68
Oct	73	1980	25	1978	51
Nov	130	1978	96	1980	108
Dec	84	1978	47	1980	60

91. Winds. Since the wind speed and direction data for 1980 were obtained every 6 hours (i.e., four times per day), the summaries are believed to be far superior to those previously published, which were based on only one daily value. No attempt will be made to compare the data summaries to prior years except for a brief explanation of why the data are believed to be more representative and less biased.

92. Land-sea breeze, weather fronts, and cyclonic and anticyclonic pressure systems all can cause rapid changes in both the wind speed and direction.

93. During March through September, the air temperatures were warmer than the seawater; likewise, from January to February and October to December, the air temperatures were colder. These temperature differences, along with differences in land temperature, can create daily coastal breezes which vary direction from morning to evening. Passage of weather systems can also cause the wind direction to change. Figure 8 shows all occasions during 1980 when the measured wind direction changed from offshore to onshore or vice-versa between 0700-1300, 1300-1900, and 1900-0100 hours. Onshore implies an easterly component of direction, while offshore is westerly; half arrows indicate the shift was either from or toward a direction without an easterly/westerly component; i.e., north or south.

94. Figure 8 shows the following tendencies in wind direction changes for 1980: (a) during the morning hours 0700-1300, when, typically, heating occurs after sunrise, the wind directions change from offshore/westerly to onshore/easterly; (b) conversely, in the evening from 1900-0100, during cooling times after sunset, wind directions shift from onshore to offshore; (c) wind direction changes during the afternoon hours from 1300 to 1900 appear mixed but show some correlation with the temperature differences between the ocean and the air/land (see Figure 24 and paragraph 124).

95. Measurements made once a day would be incomplete and would produce significantly biased information. As noted in the data analysis section, all wind information summaries except for the meteorological tables in Appendix A were created from observations made every 6 hours.

96. Measurements made every 6 hours, however, have the following shortcomings: peak conditions can be missed; precise times when fronts pass can only be bracketed; correlation to other physical phenomena, such as the rise and fall of the tides, can be difficult; etc. Hourly meteorological

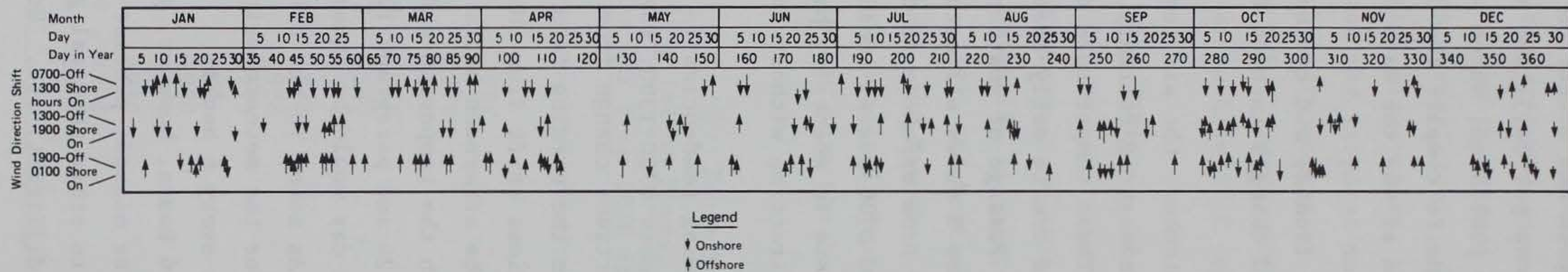


Figure 8. Times of wind direction change, 1980 (observations made every 6 hours)

measurements provide a very detailed description of the conditions; NWS collects wind data every hour and averages three successive observations to create data summaries every 3 hours, which appears to be the optimum meteorological sampling plan. However, the author's review of the continuous analog chart records confirmed that for all but a very few exceptions the 6-hour data sampling interval represents an unbiased assessment of wind conditions.

97. The annual average wind speed is in excess of 5 m/sec, with a strong western tendency (see Table 5). The highest speed (not gusts) was 20.6 m/sec from the northeast recorded late on 2 March as the result of a very intense low-pressure system (shown in Figure 9) off the Virginia-Carolina coast on the morning of 3 March.

98. The annual wind rose for 1980 (Figure 10) indicates the winds blew onshore from the north side of the FRF pier (i.e., from north-northeast, northeast, and east-northeast directions) in excess of 26 percent of the time and from the south side 15 percent of the time. The strongest winds occurred during the cold months (Figure 11) and blew out of the north-northeast. Winds blowing from the north through east-northeast directions produce onshore moving waves and southerly moving surface currents, while winds from the east through south directions generally produce onshore waves and northerly moving surface currents. Over 51 percent of the time in 1980, the winds were offshore not producing onshore waves.

99. Wind roses (see Figure 12) for the spring and summer seasons April-September show the strong influence of the tropical maritime air mass which produces winds that blow from the southwesterly direction. A more northerly tendency for the winds during January through March is the result of the dominance of the arctic and polar continental air mass. The high speeds and frequent north-northeasterly directions observed for winds during the winter result from the continental high-pressure systems as well as extratropical and tropical cyclones (low-pressure systems). Extratropical winds originating as arctic and polar "Canadian high" air masses with clockwise circulations move east across the United States producing initially eastern and finally northern or northeasterly winds along this coast; extratropical "northeaster" storms associated with low-pressure (counterclockwise circulation) systems tend to move north along the Atlantic coast producing strong northeasterly winds followed by winds from north and northwest. October through December is a transition time when both the tropical and arctic air masses cause a great variety in the wind conditions.

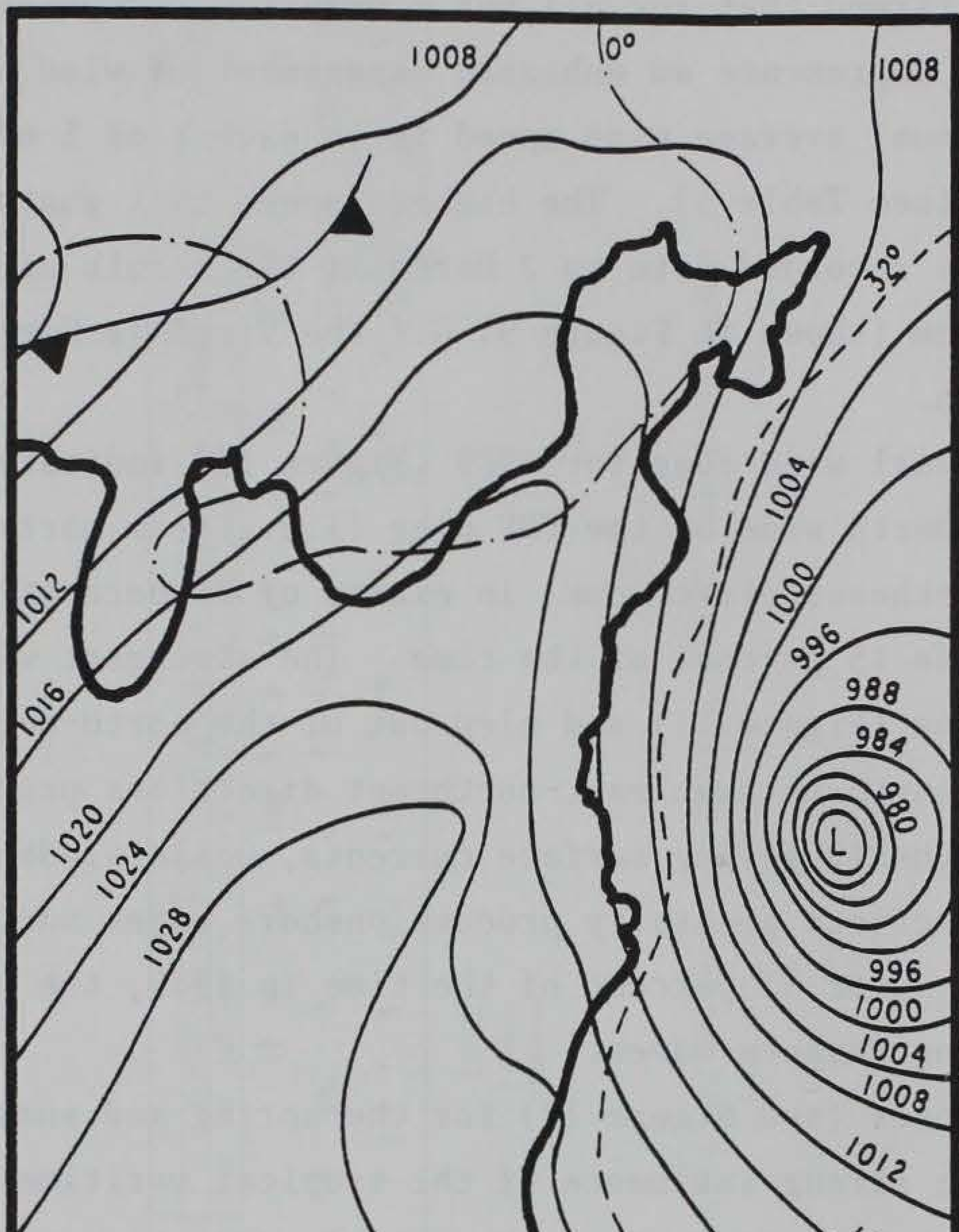


Figure 9. Weather map for 3 March 1980
(pressure in millibars)

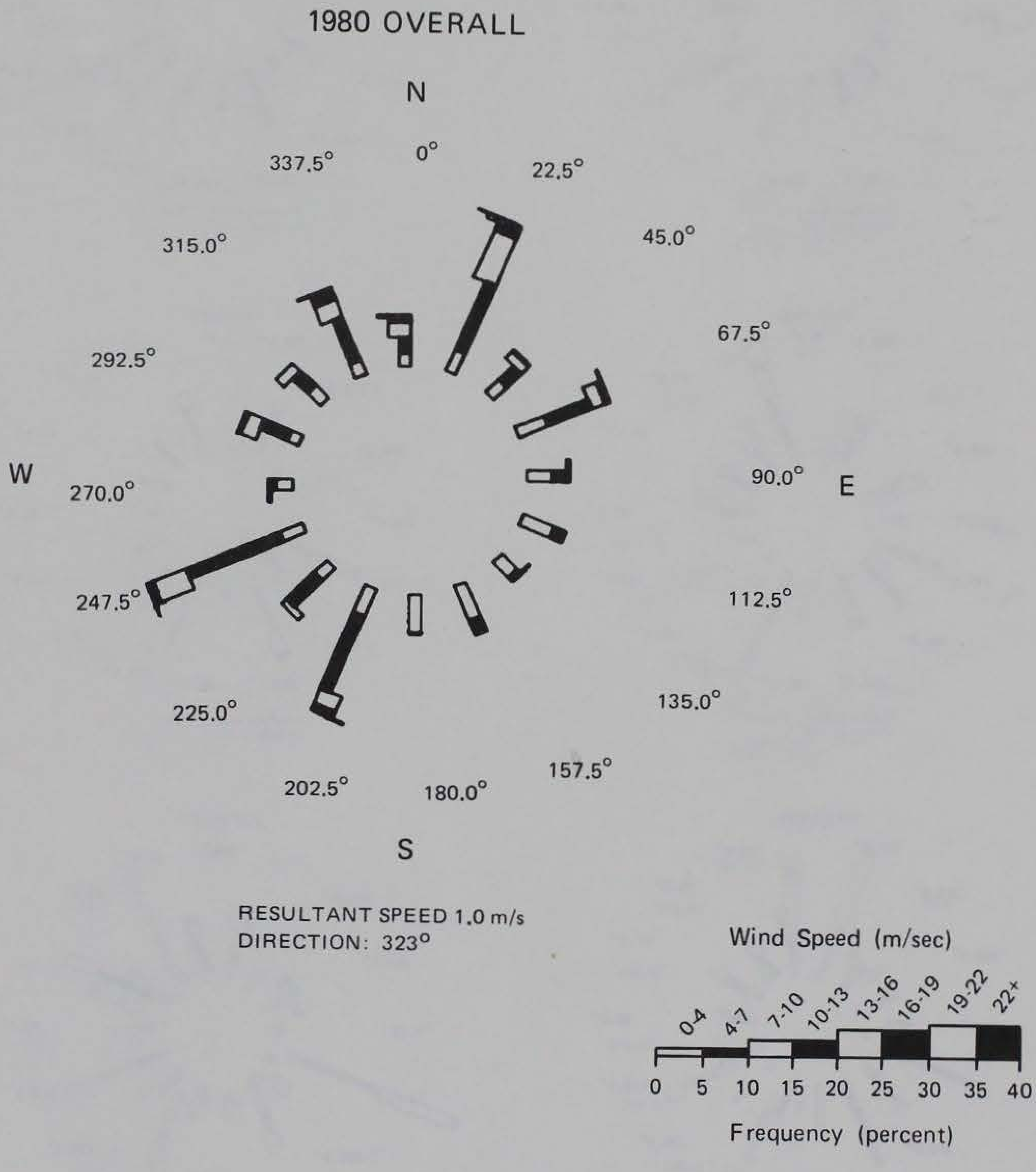


Figure 10. 1980 annual wind rose for the FRF, reference true north

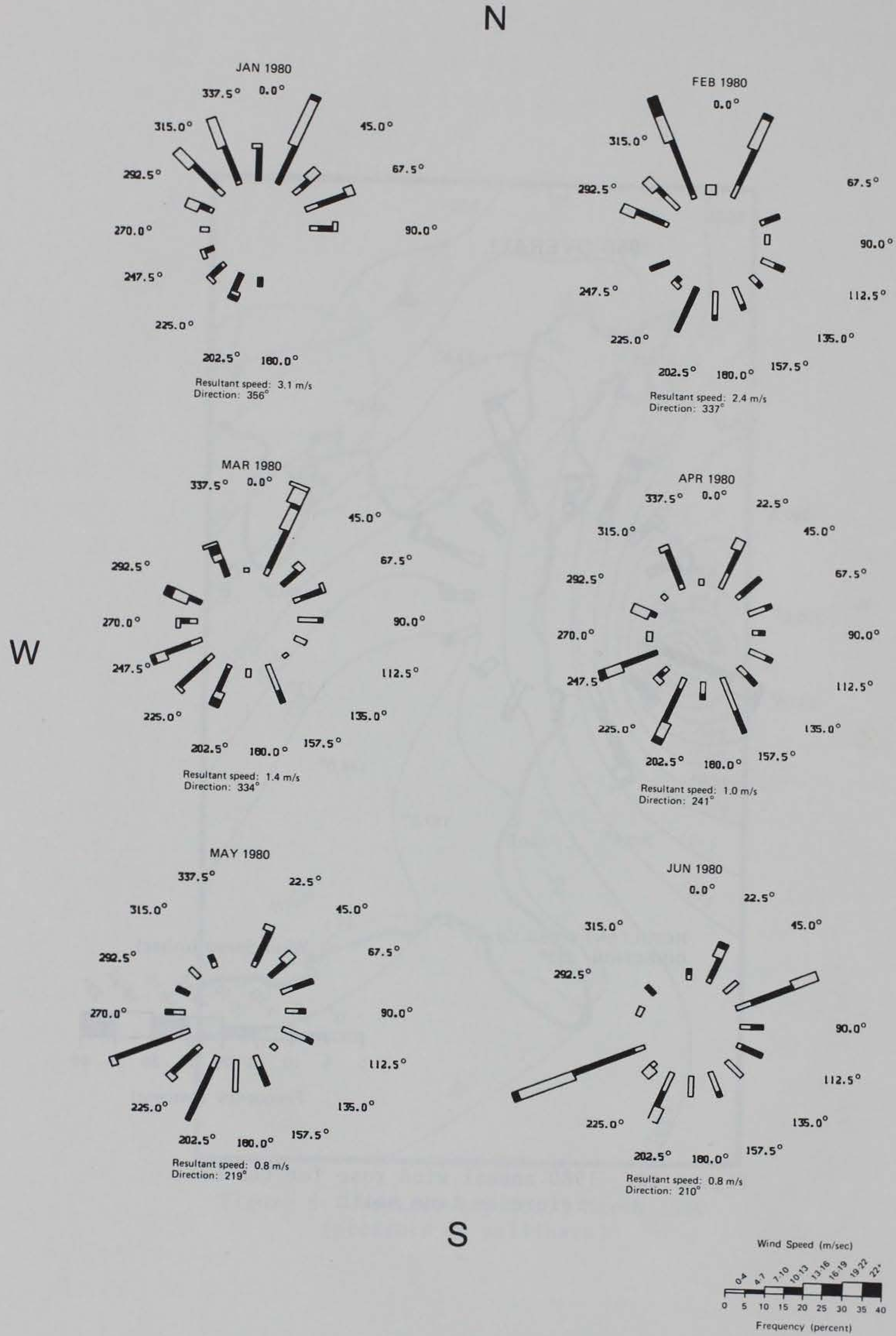


Figure 11. 1980 monthly wind roses for the FRF (Continued)

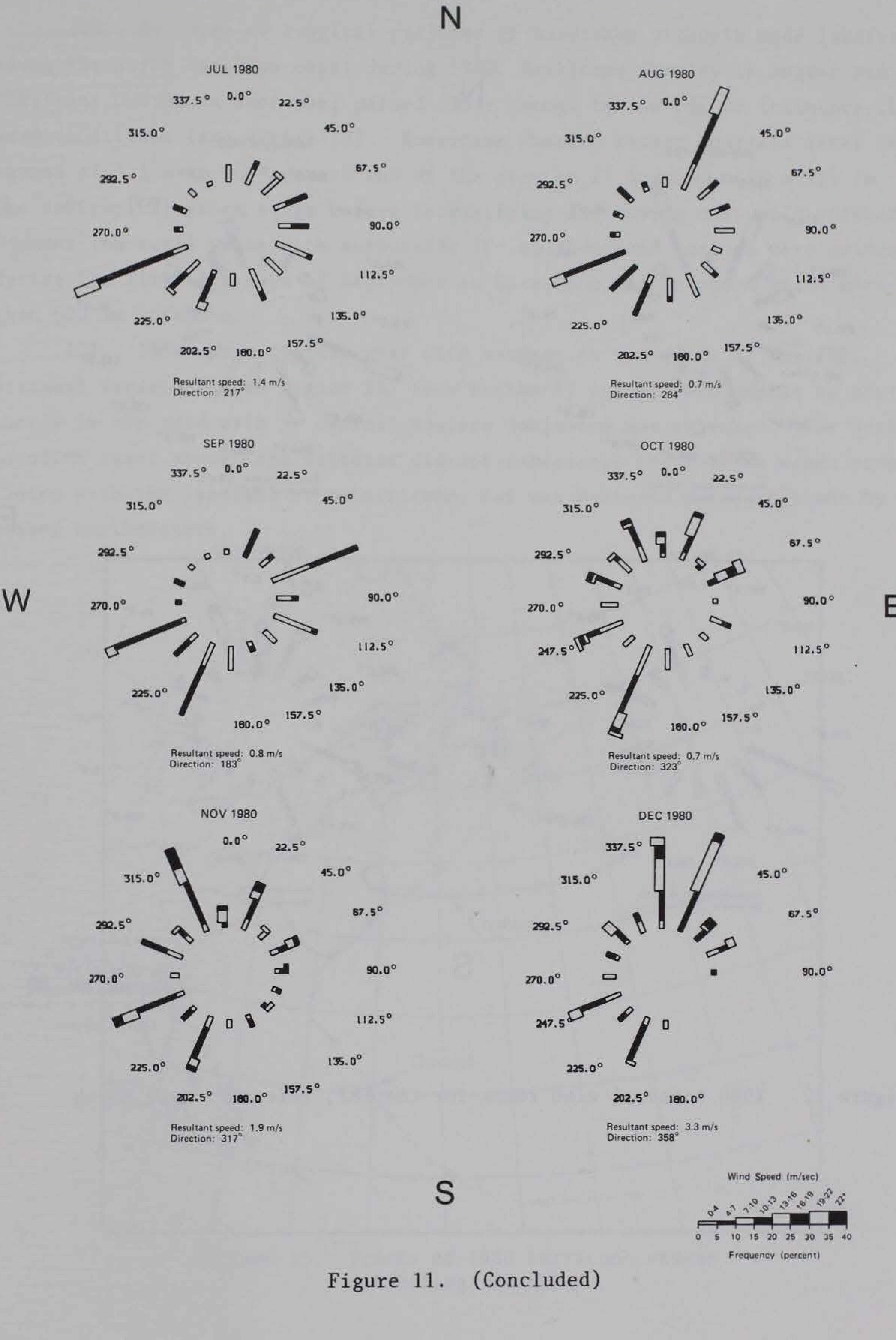


Figure 11. (Concluded)

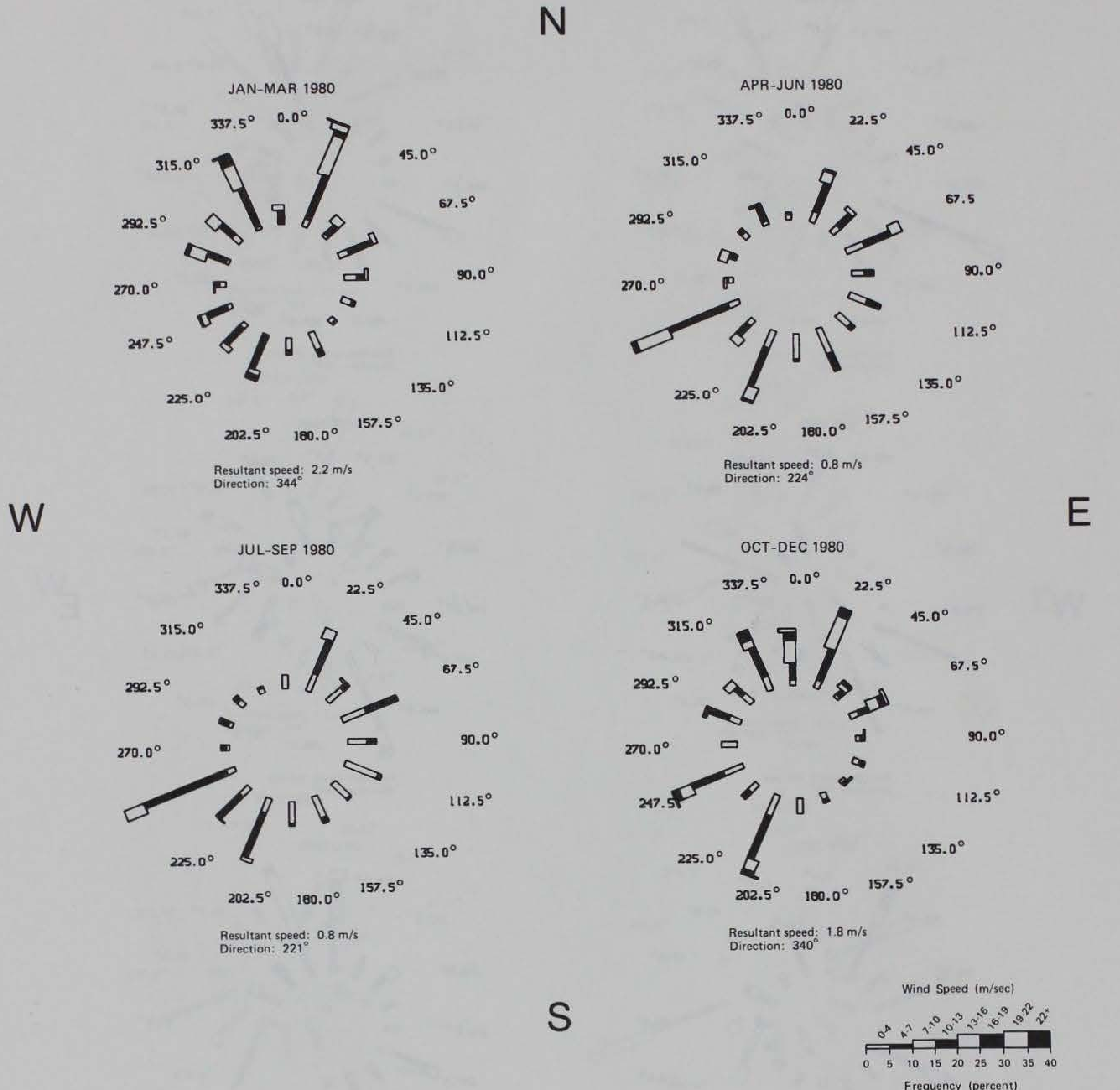


Figure 12. 1980 seasonal wind roses for the FRF, reference true north

100. Although no tropical cyclones of hurricane strength made landfall along the North Carolina coast during 1980, Hurricane Charley in August and Hurricane George in September passed close enough to the FRF to influence the wave conditions (see Figure 13). Hurricane Charley caused moderate waves in excess of 1.5 m at the seaward end of the pier on 21 August while still in the subtropical storm stage before intensifying and moving east well offshore. Remnant 1-m-swell waves with associated 12- to 15-second periods were evident during the first few days of September as Hurricane George moved north more than 600 km offshore.

101. 1980 was a typical year with respect to the winds at the FRF. Seasonal variation (see Figure 14) from southerly in the warm months to northerly in the cold with an overall western dominance was expected. The North Carolina coast above Cape Hatteras did not experience the extreme winds associated with the landfall of a hurricane, but was battered numerous times by strong northeasters.

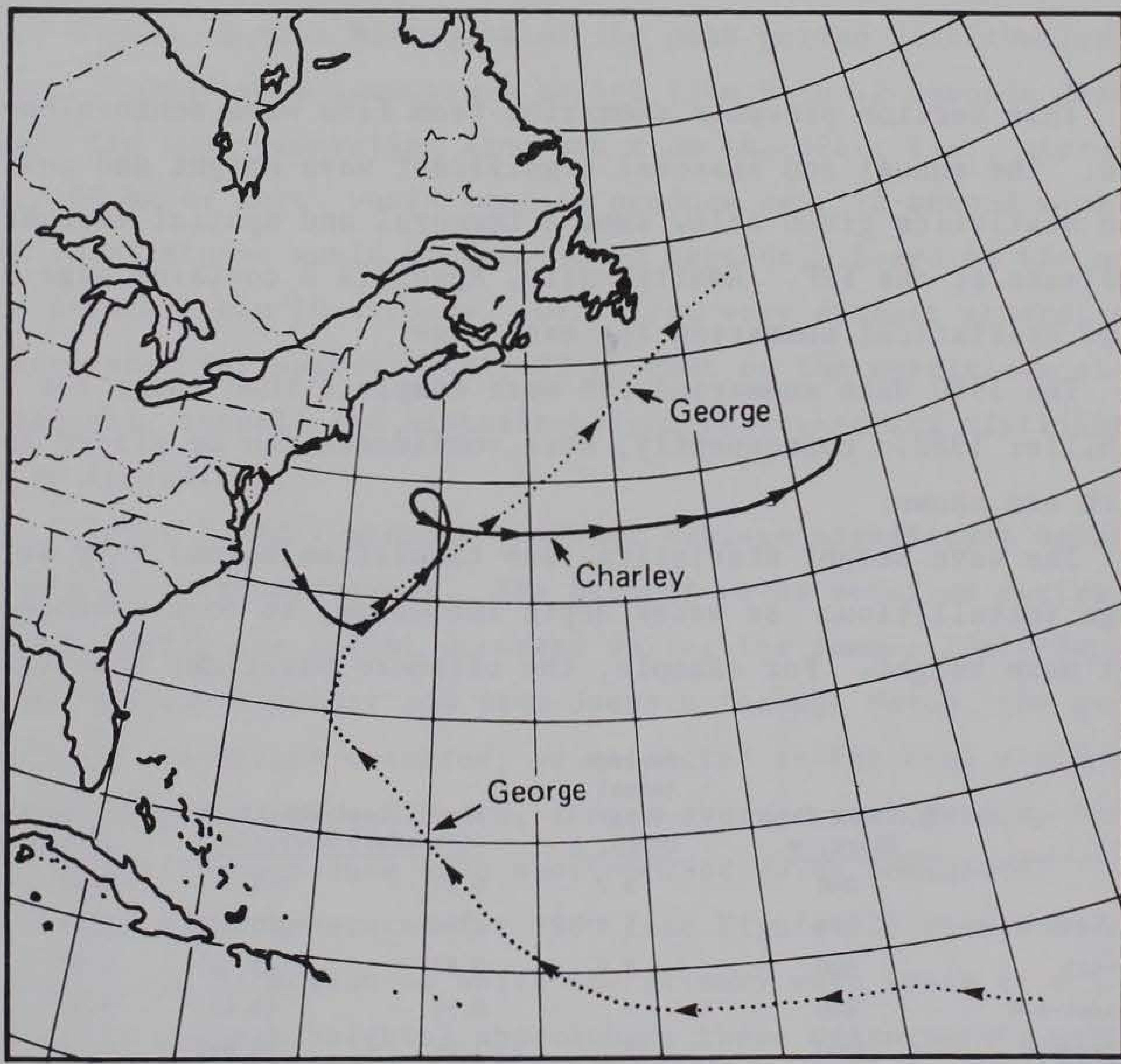


Figure 13. Tracks of 1980 hurricane storms affecting the FRF

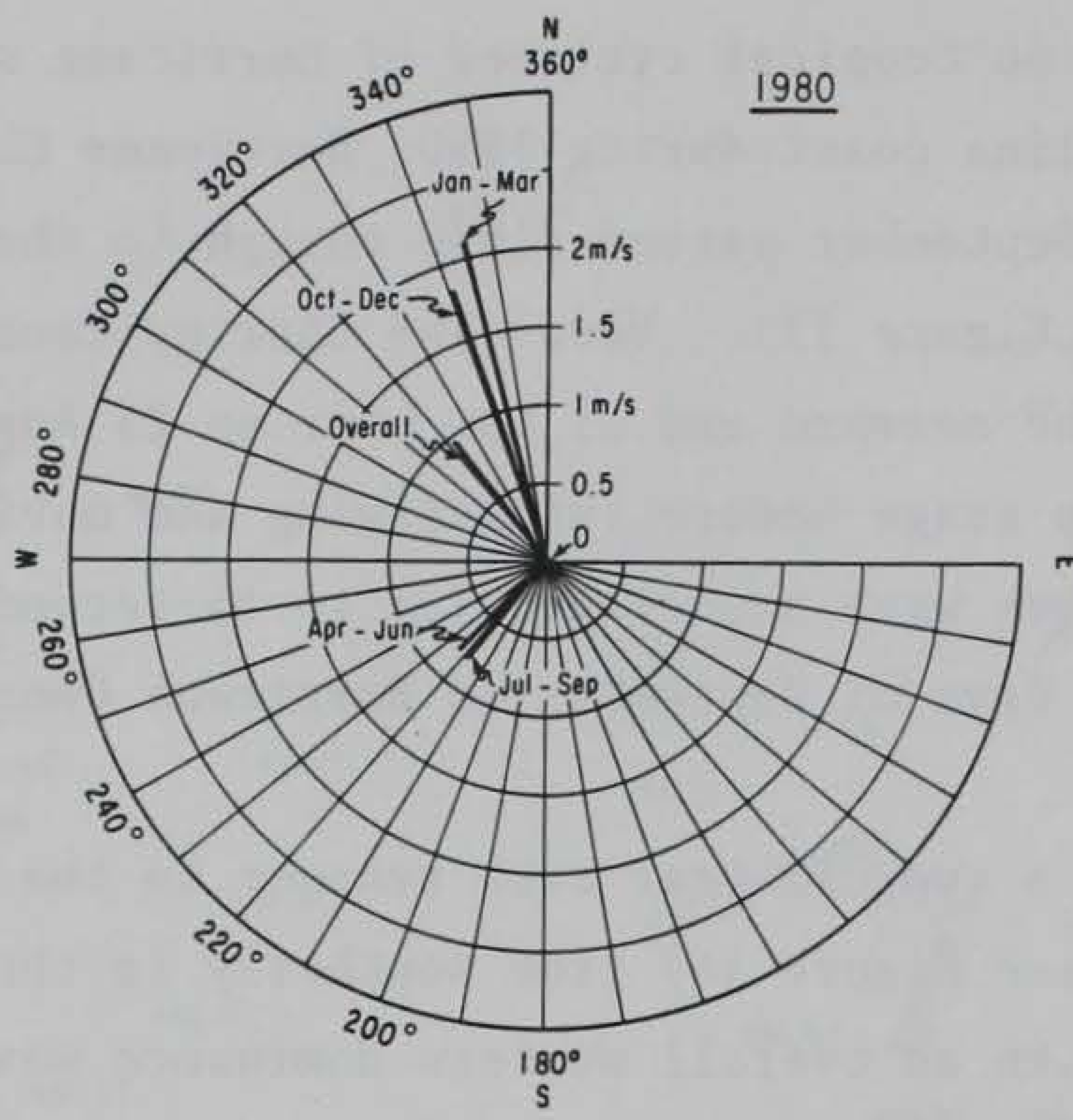


Figure 14. Annual and seasonal resultant wind speed and direction for the FRF, 1980

Wave data

102. This section presents summaries from five wave sensors operated during 1980. The annual and seasonal significant wave height and peak spectral period statistics given below show a temporal and spatial variability of the wave climate at the FRF. Additionally, Appendix B contains gage histories and selected statistical summaries for each gage.

103. The 1980 data summaries are more complete than those for 1978 and 1979 (see Miller 1982); consequently, more confidence can be placed in the trends which are shown.

104. The wave height statistics (see tabulation below) vary as a function of gage installation: as water depth increases, so does average annual significant wave height. For example, the offshore Waverider buoy (gage

Gage	Distance from Shore, m	Average Annual Water Depth, m	Significant Height, m (Standard Deviation)		Peak Period, sec (Standard Deviation)	
Nags Head-112	200	5.2	0.87	(0.44)	9.00	(2.81)
Nearshore Baylor-615	100	1.5	0.66	(0.32)	8.79	(3.45)
Pier End Baylor-625	500	8.4	0.87	(0.44)	9.00	(2.81)
Nearshore Waverider-610	600	7	0.99	(0.63)	9.17	(2.81)
Offshore Waverider-620	3000	18	1.06	(0.64)	8.56	(2.83)

No. 620) is moored 3 km from shore where the water depth is 18 m; the annual mean significant wave height was 1.06 m, with a 0.64-m standard deviation. The nearshore Baylor gage (gage No. 615), located approximately 100 m from shore in 1.5 m of water, had an annual average significant wave height of 0.66 m, with a 0.32-m standard deviation.

105. Individual data observations show a similar correlation between wave heights and depth; this correlation agrees with the trends of Vincent (1981) whose method for obtaining the maximum energy one could expect in a wind wave sea as a function of the water depth predicts the variation with depth.

106. Figure 15 presents the annual cumulative distribution of significant wave heights for the FRF gages for 1980. In general, the probability of high waves increases with water depth at the gage installation. The nearshore Baylor was in very shallow water inside the breaker zone, even during moderate to low wave conditions; consequently, these statistics represent a lower energy wave climate frequently due to waves breaking seaward of the gage.

107. Figure 16 is a histogram of the peak period distributions. Periods during highest wave conditions varied from 5 to 12 seconds depending on the distance the wave-generating area was from the pier; i.e., storms far offshore, say 500 km or more, would tend to produce near 12-second wave periods, while more local storms would produce lower periods. Based on the occurrence of periods greater than 10 seconds, swell from very distant generating areas may have accounted for approximately 20 percent of the conditions at the coast. Seasonal, annual, and historic-height-versus-period distributions are presented in Appendix B.

108. Tables 6 and 7 present seasonal average significant height and peak period values, respectively. The highest waves occurred during January through March, while the lowest occurred during the summer (July-September). From October through December and from January through March, the greatest variety of wave conditions occurred, as reflected in the high standard deviations. During January through March, longer average peak periods occurred as compared to April through June when short-period waves dominated.

109. Wave roses generated for 1980 (see Figure 17) were based on visual measurements of the direction at which the primary wave train (i.e., the wave train having the largest heights) approached; these measurements were made daily (near 0700) at the seaward end of the FRF pier. Wave height was determined from the pier end Baylor staff gage at a corresponding time. The

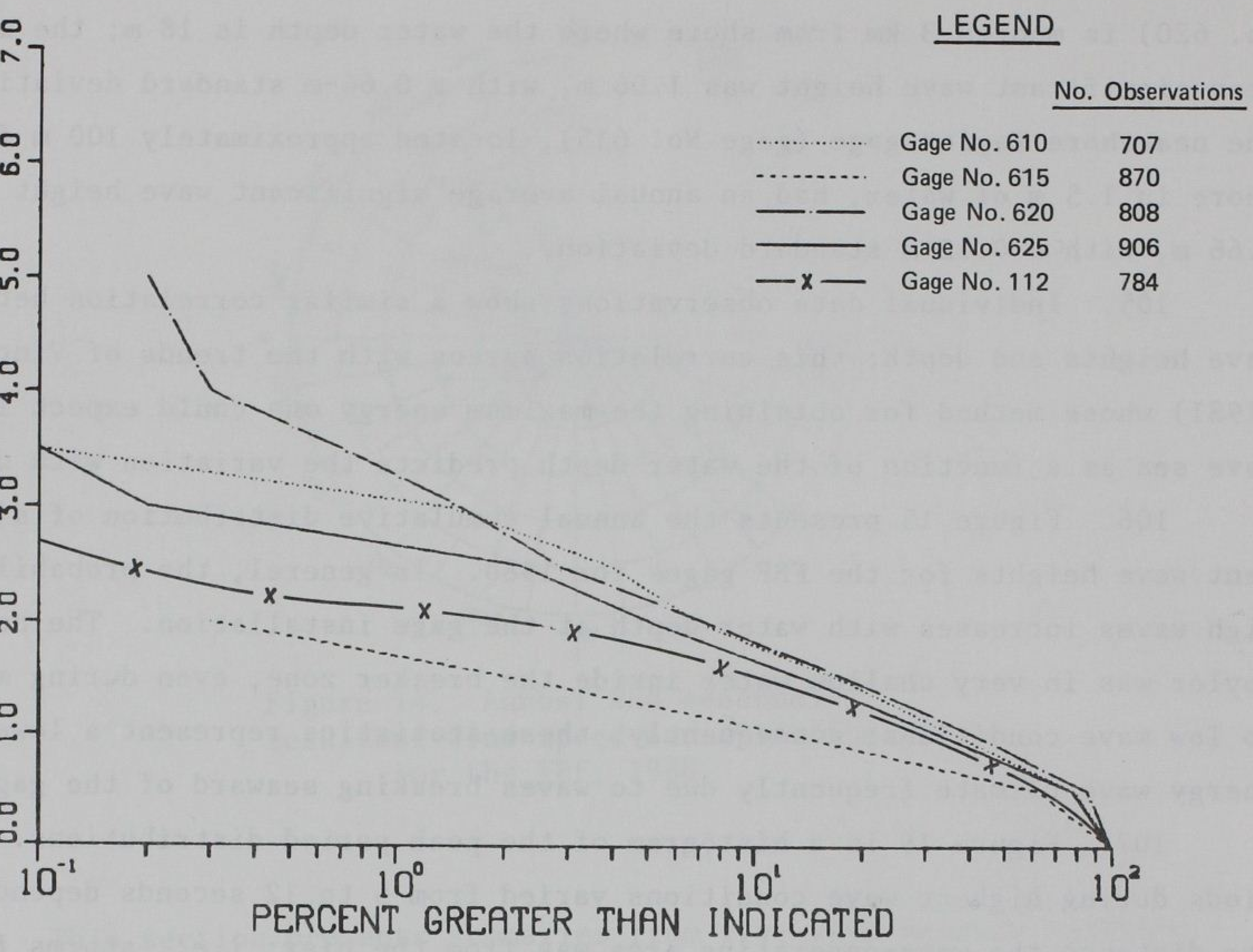


Figure 15. 1980 annual wave height distributions

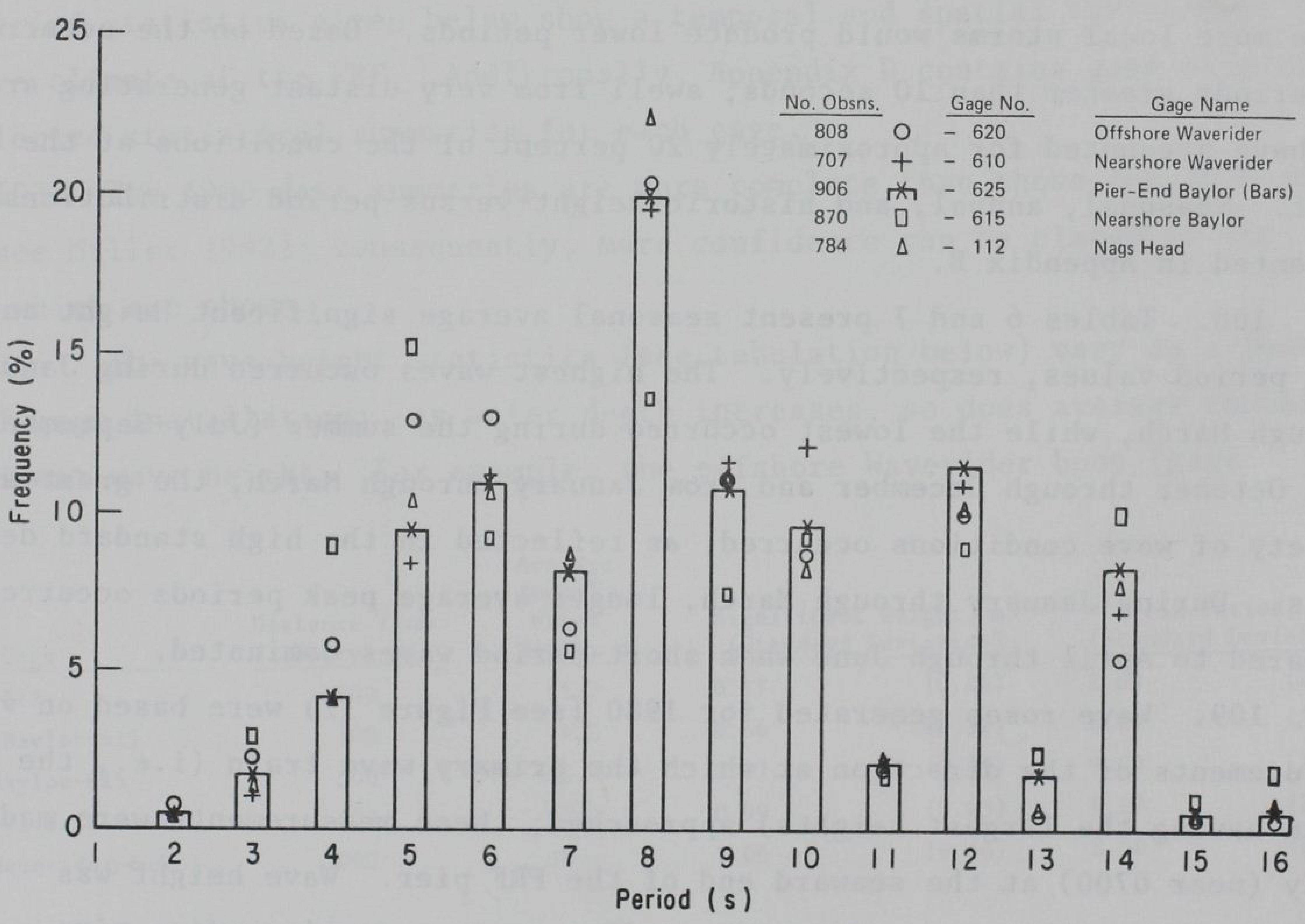


Figure 16. 1980 annual wave period distributions

Table 6

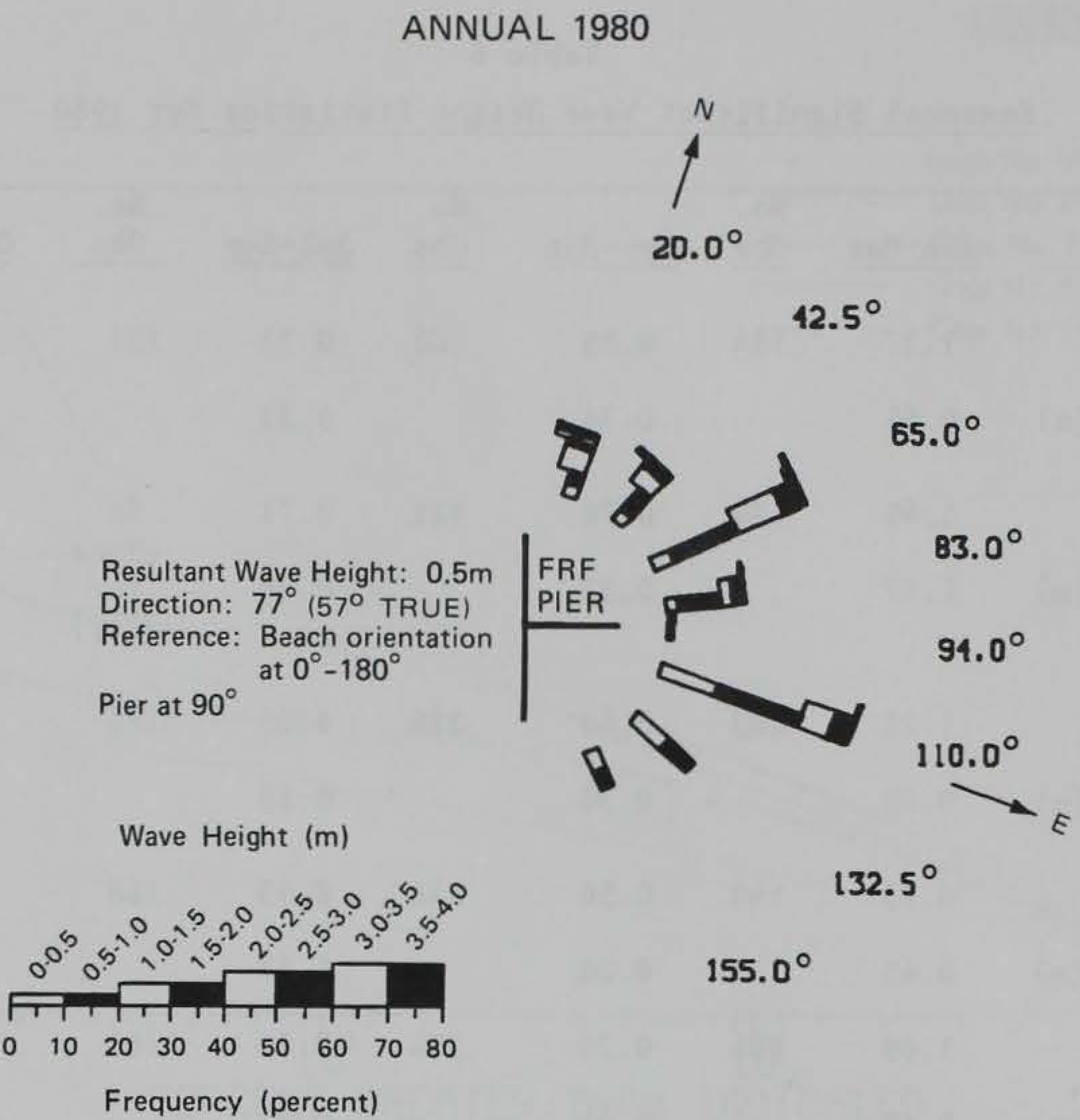
Seasonal Significant Wave Height Statistics for 1980

Gage No.	Jan-Mar	No. Obs	Apr-Jun	No. Obs	Jul-Sep	No. Obs	Oct-Dec	No. Obs
620								
Height (m)	1.37	184	0.85	162	0.72	151	1.14	311
Standard deviation (m)	0.65		0.34		0.33		0.75	
610								
Height (m)	1.45	129	0.72	172	0.71	76 (None for July)	1.02	330
Standard deviation (m)	0.77		0.33		0.30		0.64	
625								
Height (m)	1.21	203	0.69	218	0.63	170	1.07	315
Standard deviation (m)	0.62		0.30		0.28		0.58	
615								
Height (m)	0.93	149	0.56	216	0.53	168	0.67	337
Standard deviation (m)	0.45		0.20		0.17		0.30	
112								
Height	1.09	206	0.70	204	0.70	165	0.98	209 (None for Dec)
Standard deviation (m)	0.42		0.30		0.33		0.51	

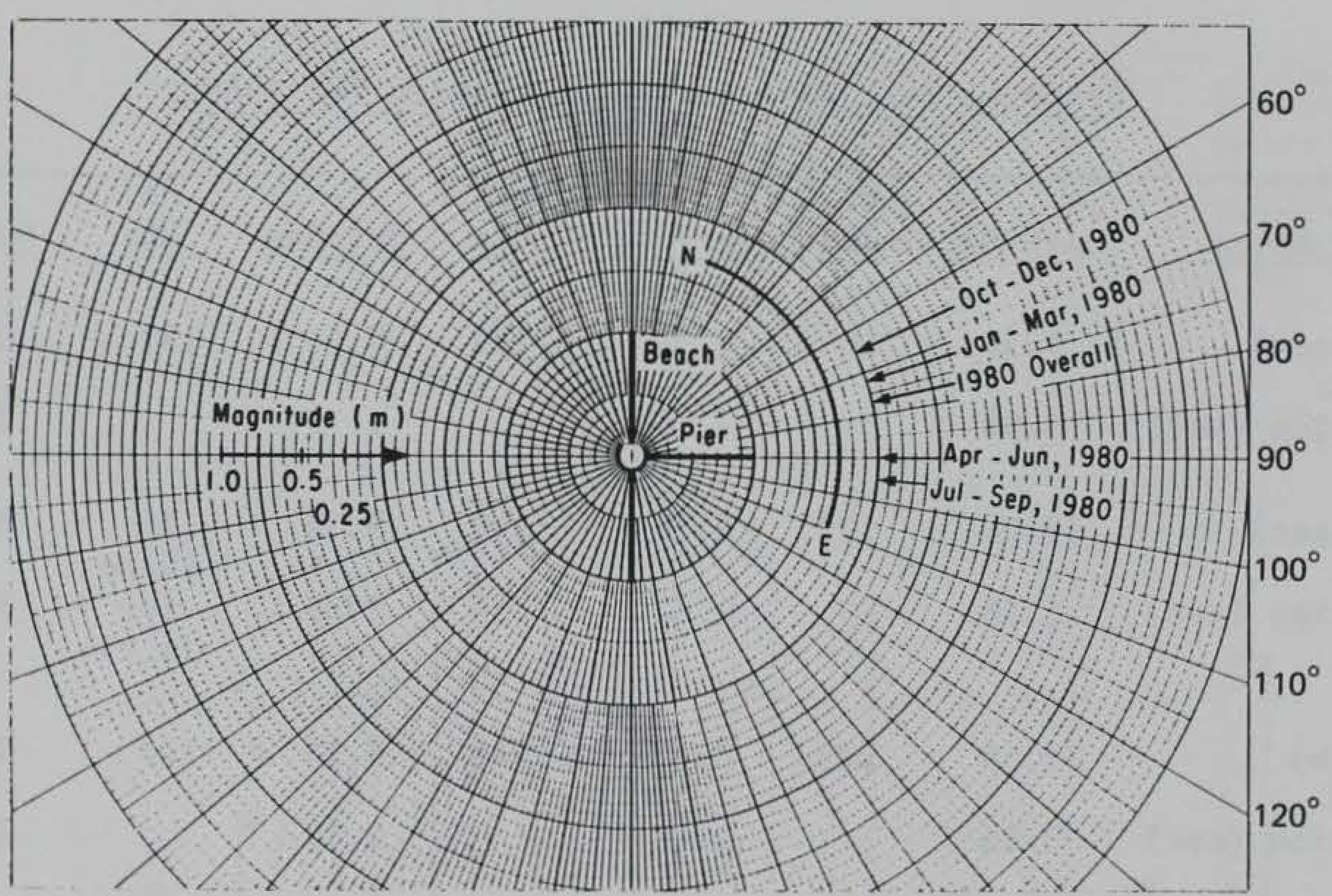
Table 7

Seasonal Peak Wave Period Statistics for 1980

Gage No.	Jan-Mar	No. Obs	Apr-Jun	No. Obs	Jul-Sep	No. Obs	Oct-Dec	No. Obs
620								
Period (sec)	9.30	184	8.12	162	8.71	151	0.27	311
Standard deviation (sec)	3.08		2.53		2.77		2.75	
610								
Period (sec)	10.08	129	8.79	172	9.32	76 (None for July)	8.99	330
Standard deviation (sec)	2.56		2.60		2.39		3.00	
625								
Period (m)	9.54	203	8.73	218	9.35	170	9.08	315
Standard deviation (sec)	3.05		2.49		2.97		2.95	
615								
Period (sec)	9.14	149	8.49	216	8.70	168	8.88	337
Standard deviation (sec)	3.35		3.22		3.56		3.56	
112								
Period	9.37	206	8.50	204	9.15	165	9.00	209 (None for Dec)
Standard deviation (sec)	2.96		2.82		2.65		2.71	



a. 1980 overall wave rose



b. Resultant wave magnitude and directions

Figure 17. Directional wave summaries for 1980

angles are relative to the pier at 90° and the beach oriented from 0° to 180°.

110. Wave heights approached the beach most frequently (50 percent) from the north side of the pier, 5 percent were shore normal, and 45 percent came from the south side of the pier (Figure 17a). Although accounting for less than 2 percent, waves in excess of 2 m approached from angles greater than 60 deg north of the pier axis. The angles shown represent the frequency of wave occurrence in 22.5-deg intervals, 11.25 deg on both sides of the angle displayed; except for the interval which includes the pier, which is split into angles greater than 76.25 deg and less than or equal to 90.0 deg; i.e., includes the shore-normal directions and angles greater than 90.0 deg but less than or equal to 98.75 deg.

111. The resultant magnitude and direction of wave approach for the year was 0.5 m from an angle 13 deg north of the pier axis, respectively, as shown in Figure 17b. Figure 17b also indicates the seasonality of the wave climate: waves during the cold months of January through March and October through December showed a northeastern tendency, while during April through September the waves approached more nearly shore-normal or from south of the pier.

112. The seasonal wave roses presented in Figure 18 indicate there was a strong northeastern tendency during January through March. During the period from April through June, somewhat of a transition period, waves approached slightly more often from south of the pier, while waves in July through September had a strong southerly tendency. Waves during October through December showed the greatest tendency for approaching from the northeastern directions.

113. The tendency for waves to approach from north or south of the pier was very well correlated to the variation in the tendency for northern or southern winds (see paragraphs 91-101).

114. Although no hurricane severely affected the FRF, high wave conditions associated with "northeaster" storms occurred regularly during the cold months. On 16 occasions, the significant wave height exceeded 2 m at the seaward end of the pier, 25 percent of which persisted for 3 or more days (see the persistence tables in Appendix B). Three storms were particularly severe and accounted for the extreme significant wave heights measured at each gage location. First, on 3 March, a low pressure system located off the Virginia-North Carolina coast produced persistent onshore winds and high waves (see Figure 9); the high water levels produced significant wave heights H_s in

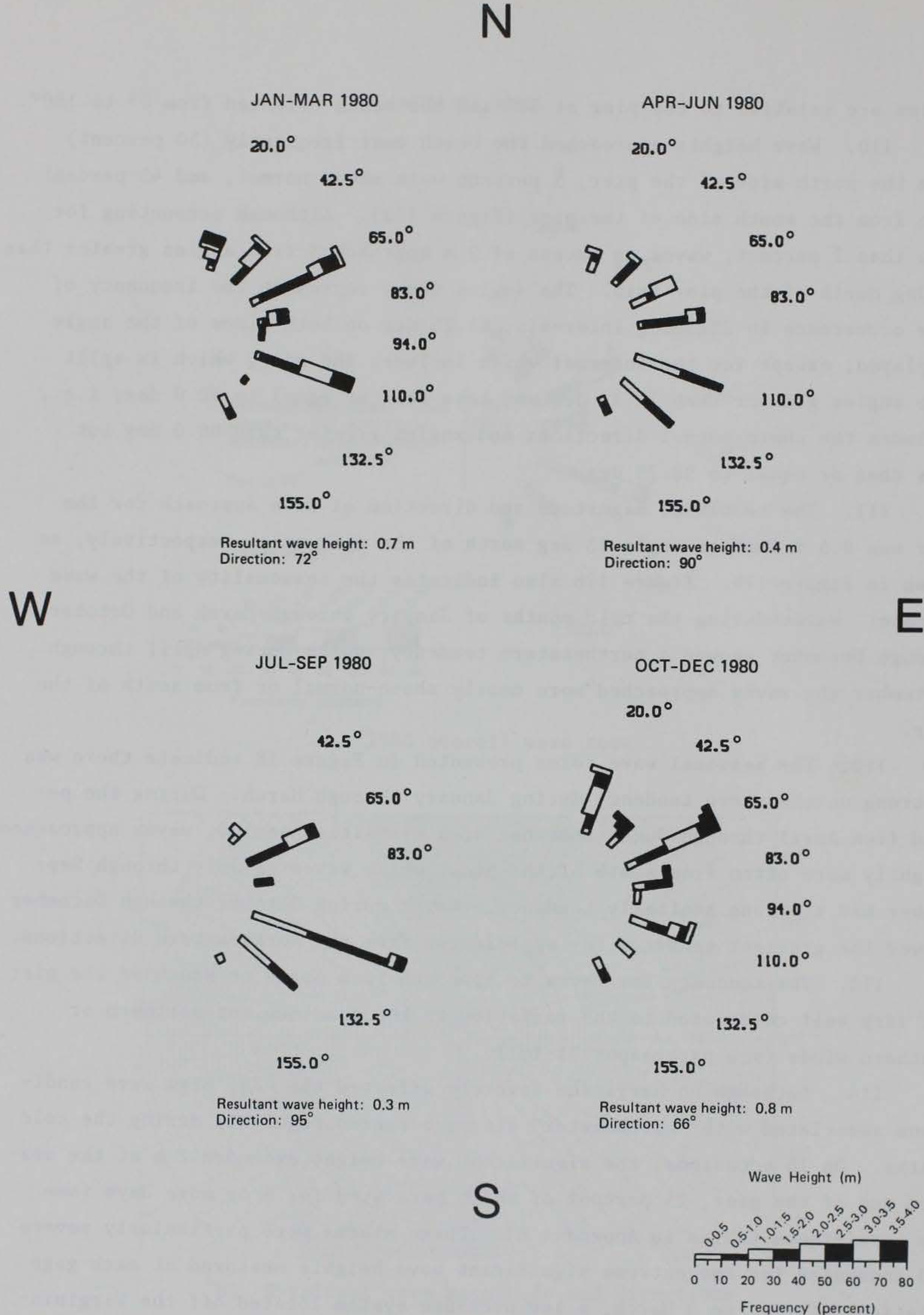


Figure 18. Seasonal wave roses for the seaward end of FRF pier, reference beach 0 to 180 deg

excess of 2.3 m at the nearshore Baylor location. On October 25th, peak conditions of H_s = 3.5 m were experienced at the pier end Baylor; this resulted from a northeaster coincident with a local perigean spring tide (see Miller et al. 1980). The last storm of 1980 on 29 December produced significant wave heights in excess of 2.9 m at the pier-end Baylor location (Miller et al. 1980).

Tidal data

115. This section presents the FRF tide and water level data. The various tide height values and water level datums due to predominantly astronomical forces of the sun and moon are discussed, followed by discussions of the extreme high- and low-water levels which were particularly influenced by meteorological conditions.

116. Monthly and annual tide statistics are shown in Table 8, with 1979 annual average and extremes included at the bottom for comparison. Tides at the FRF are semidiurnal, and the average tide range for the year was 102 cm. The average of all tide hights (msl) during the year, was 8 cm above NGVD. Mean higher high water (mhhw), the highest of the two daily high tide tide levels, was 68 cm and exceeded the mhw value by 9 cm; mlw was -43 cm, and mean lower low water (mllw) was -47 cm for the year. (All tide values unless otherwise specified are referenced NGVD). The annual tide statistics for 1980 were very nearly the same as those for 1979.

117. Mean and extreme tide levels are presented as a function of month in Figure 19. The 5- to 6-month periodicity in the rise and fall of the mean values presented are due in part to the inclination of the sun, a long-period astronomical tide constituent commonly referred to as Ssa , which has a periodicity of approximately 6 months. An additional explanation for the periodicity observed may be (a) astronomical forces with annual periodicity and (b) seasonal oscillation of the specific volume of the seawater as a function of temperature, called the steric effect (see Pattullo et al. 1955). The distribution of all hourly heights is presented relative to NGVD in Figure 20. Since the 1980 local MSL is 8 cm above NGVD, one can see that negative departures from the mean are larger than positive departures. Harris (1981) indicates it is not unusual for the magnitude of positive and negative departures from the mean to be unequal.

118. Figure 21 shows the distribution of the daily highest and lowest tide levels which occurred throughout the year. On 87 occasions, or 1 percent

Table 8

Tide Statistics for 1980 (cm)*

	mhhw	mhw	mtl	msl	mlw	mllw	mr	eh	Day/Hour	el	Day/Hour
Monthly for 1980											
Jan	74.1	63.1	12.5	12.5	-38.4	-42.7	101.5	116.4	5/9.3	-65.8	24/19.5
Feb	69.8	61.3	10.7	11.3	-39.9	-45.7	101.2	107.9	17/8.0	-83.8	19/3.3
Mar	59.1	52.1	0.9	0.9	-50.3	-54.3	102.4	117.7	2/19.5	-118.9	16/12.9
Apr	65.8	58.2	7.9	7.9	-42.4	-45.1	100.6	91.7	29/19.0	-78.9	15/0.4 16/1.9
May	74.1	64.6	13.7	14.0	-36.9	-39.9	101.2	112.2	1/20.2	-75.6	13/11.9
Jun	68.3	56.7	5.8	5.8	-45.4	-50.3	102.1	102.1	8/15.4	-73.8	10/10.7
Jul	64.6	55.2	3.7	4.3	-47.5	-51.8	102.7	89.6	29/20.5	-66.1	3/5.0
Aug	68.6	59.4	6.1	7.0	-47.2	-51.2	106.4	112.2	22/16.3	-72.5	28/2.5
Sep	70.4	61.9	11.0	11.3	-39.9	-43.3	101.8	109.7	25/7.6	-65.2	22/23.9
Oct	69.5	61.9	11.0	11.3	-39.9	-43.6	101.8	105.2	24/7.9	-89.3	27/3.4
Nov	66.4	57.9	7.6	7.6	-42.7	-47.5	100.6	103.6	24/8.7	-77.7	8/1.1
Dec	61.6	51.5	2.4	2.7	-46.6	-51.5	98.1	87.8	17/3.3	-83.2	22/0.9
Cumulative by Year									Month		Month
1980	67.7	58.7	7.8	8.1	-43.0	-47.2	101.7	117.7	Mar	-118.9	Mar
1979	68.9	60.0	8.5	9.1	-43.0	-43.6	100.0	120.7	Feb	-95.1	Sep

* Explanation of abbreviations: mhhw = mean high high water; mhw = mean high water; mtl = mean tide level; msl = mean sea level; mlw = mean low water; mllw = mean low low water; mr = mean range; eh = extreme high water; and el = extreme low water.

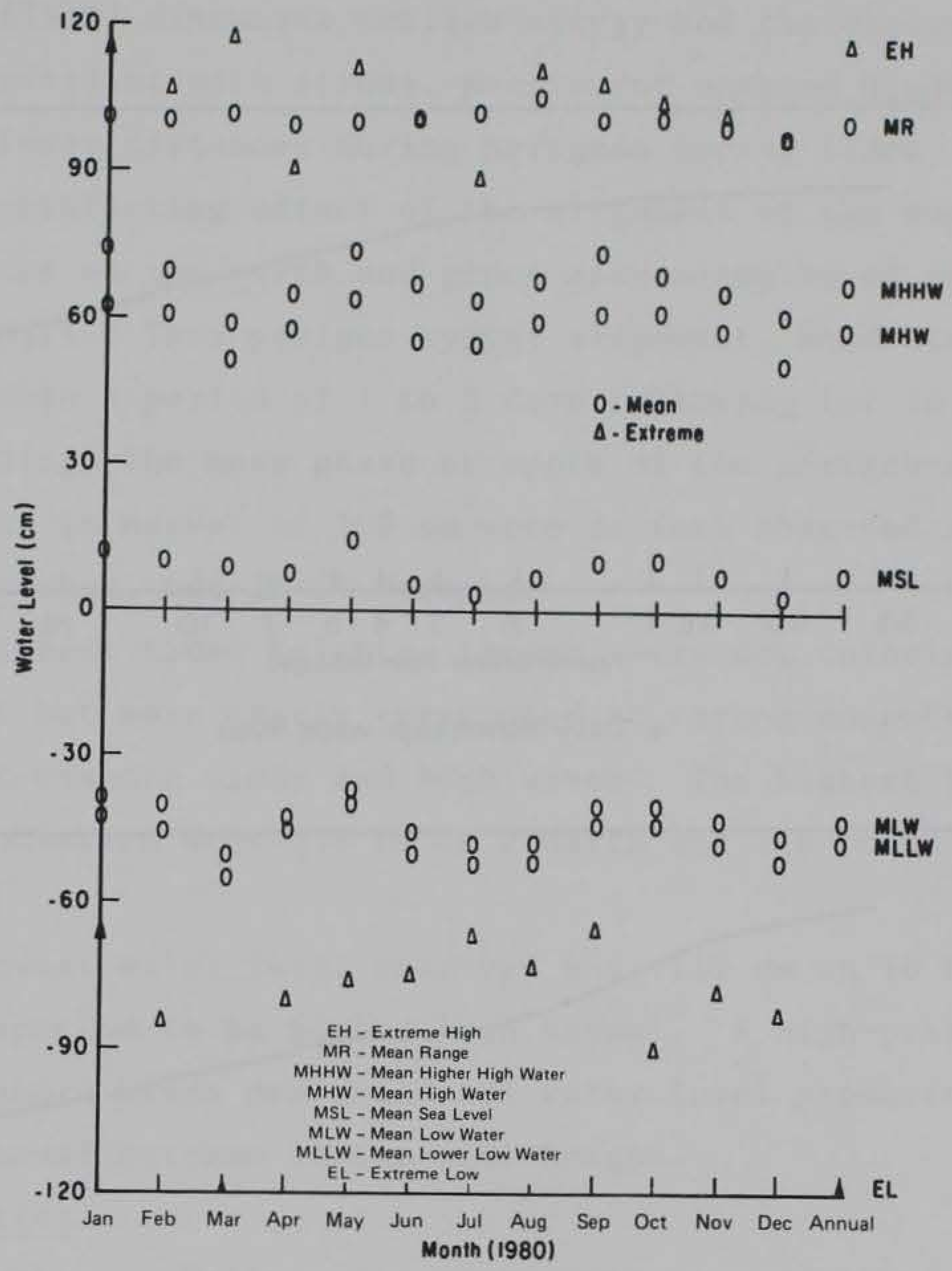


Figure 19. Monthly tidal means and extremes for the seaward end of the FRF pier, 1980

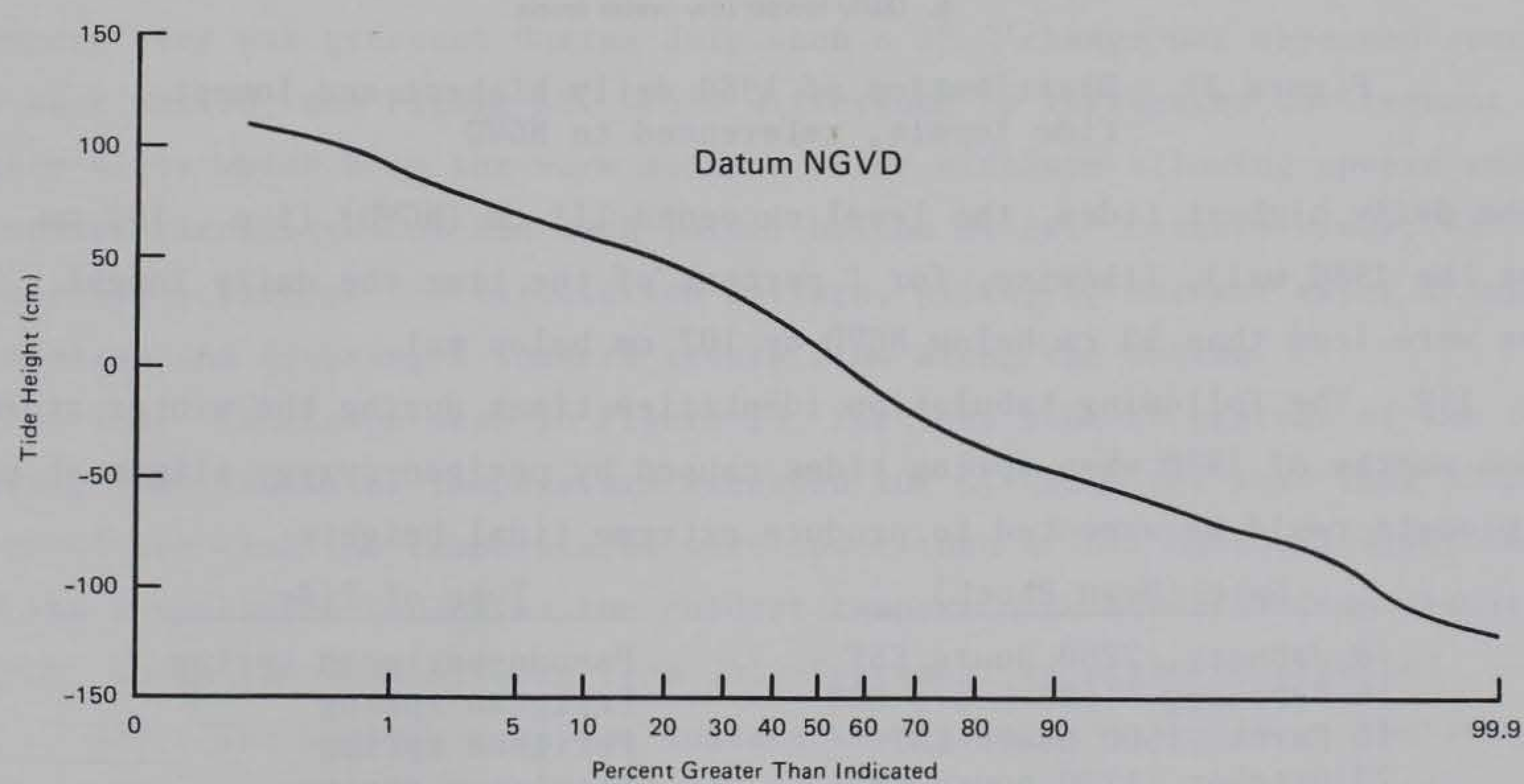
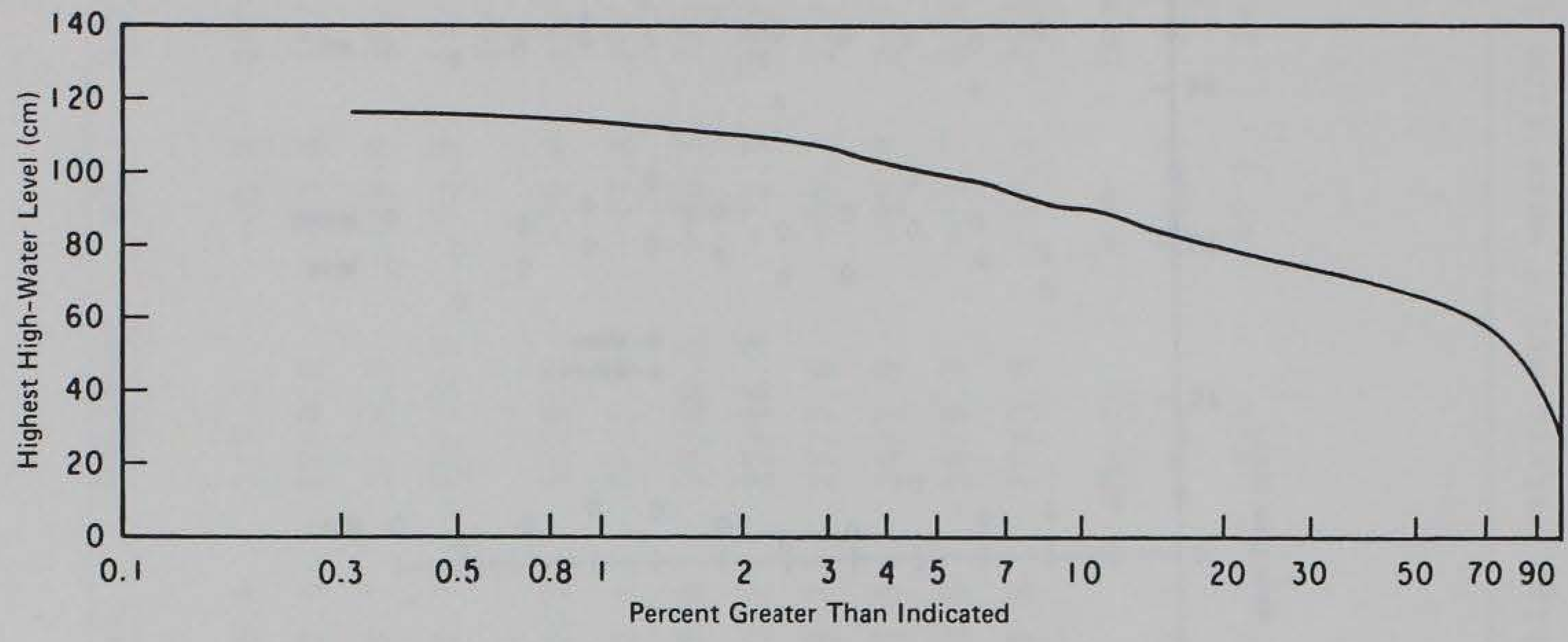
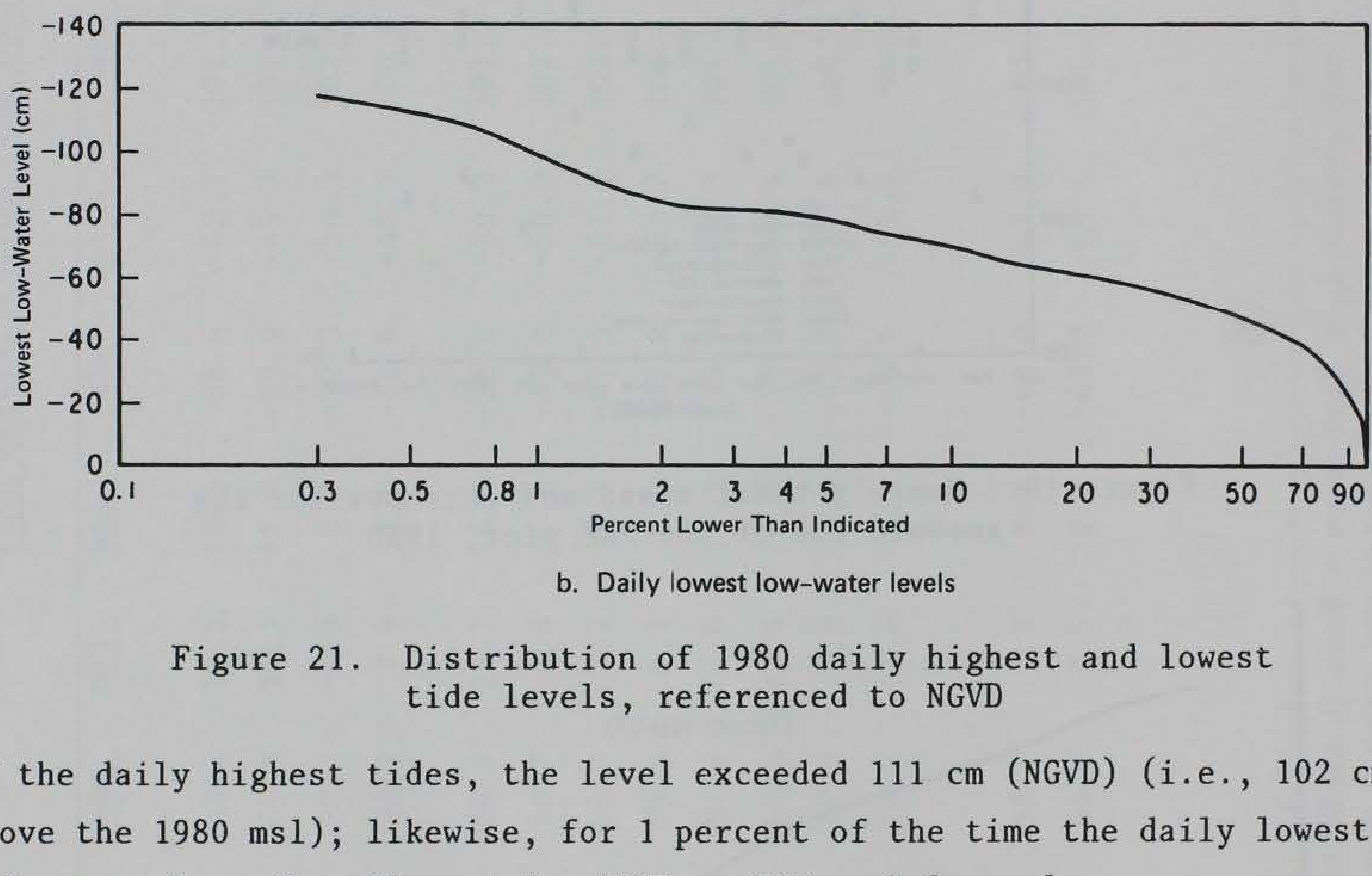


Figure 20. Hourly tide height distribution, 1980



a. Daily highest high-water levels



b. Daily lowest low-water levels

Figure 21. Distribution of 1980 daily highest and lowest tide levels, referenced to NGVD

of the daily highest tides, the level exceeded 111 cm (NGVD) (i.e., 102 cm above the 1980 msl); likewise, for 1 percent of the time the daily lowest tides were less than 98 cm below NGVD or 107 cm below msl.

119. The following tabulation identifies times during the winter storm season months of 1980 when spring tides caused by perigee-syzygy alignment of the planets could be expected to produce extreme tidal heights:

Date (Mean Epoch)	Type of Tide
18 January, 2200 hours EST	Pseudo-perigean spring
16 February, 1600 hours EST	Perigean spring
16 March, 1500 hours EST	Perigean spring
23 October, 1230 hours EST	Proxigean spring
21 November, 1100 hours EST	Perigean spring

120. Wood (1978) discusses perigee-syzygy and the occurrence of coastal flooding (when coincident with strong, persistent onshore winds) associated with the reduced lunar distances during perigean spring tides. Wood attributes this to the reinforcing effect of the alignment of the sun and moon's gravitational forces on the earth and gives many examples of the effects this may have on the coast. This perigee-syzygy alignment, Wood states, may cause tidal flooding within a period of 1 to 3 days following (or in some few cases, a day or so preceding) the mean phase or epoch of the perigee-syzygy alignment. Tide heights in excess of 100 cm were in fact observed on 16-19 January, 17 February, 24 October, and 22-24 November.

121. The highest tidal heights, though, were not coincident with the perigean alignment but more nearly correlated to strong nonastronomical forces such as persistent onshore winds and high waves. The highest and second highest water levels observed were 118 cm on 2 March and 116 cm on 5 January, respectively.

122. The lowest water level observed was -119 cm on 16 March, a time when tides were expected to be higher than normal. A high-pressure system and sustained offshore winds dominated the water level producing forces and resulted in the annual extreme lowest tide height.

Water characteristics

123. Temperature. Daily sea surface water temperatures at the seaward end of the FRF pier are presented as a function of time in Figure 22, and the distribution of temperatures is shown in Figure 23. The difference in daily temperatures was greatest during July when a 9° C change was observed over a 24-hour period, see Figure 22. This difference is attributed to frequent offshore winds which blow the warm surface water offshore allowing upward and landward circulation of the much colder bottom water. Onshore winds, on the other hand, reverse the circulation pattern, piling up surface water along the shoreline and creating a seaward return flow along the bottom.

124. As can be seen in Figure 23, for less than 20 percent of the time during 1980 the water temperature exceeded 20° C, while for less than 10 percent of the time the temperatures were lower than 4° C. Seasonal distribution of the temperature indicates the coldest temperatures occurred from January-March, while the warmest were from July-September as might be expected.

125. The monthly mean sea surface temperatures measured at the seaward end of the FRF pier (see tabulation below) varied in phase with the air

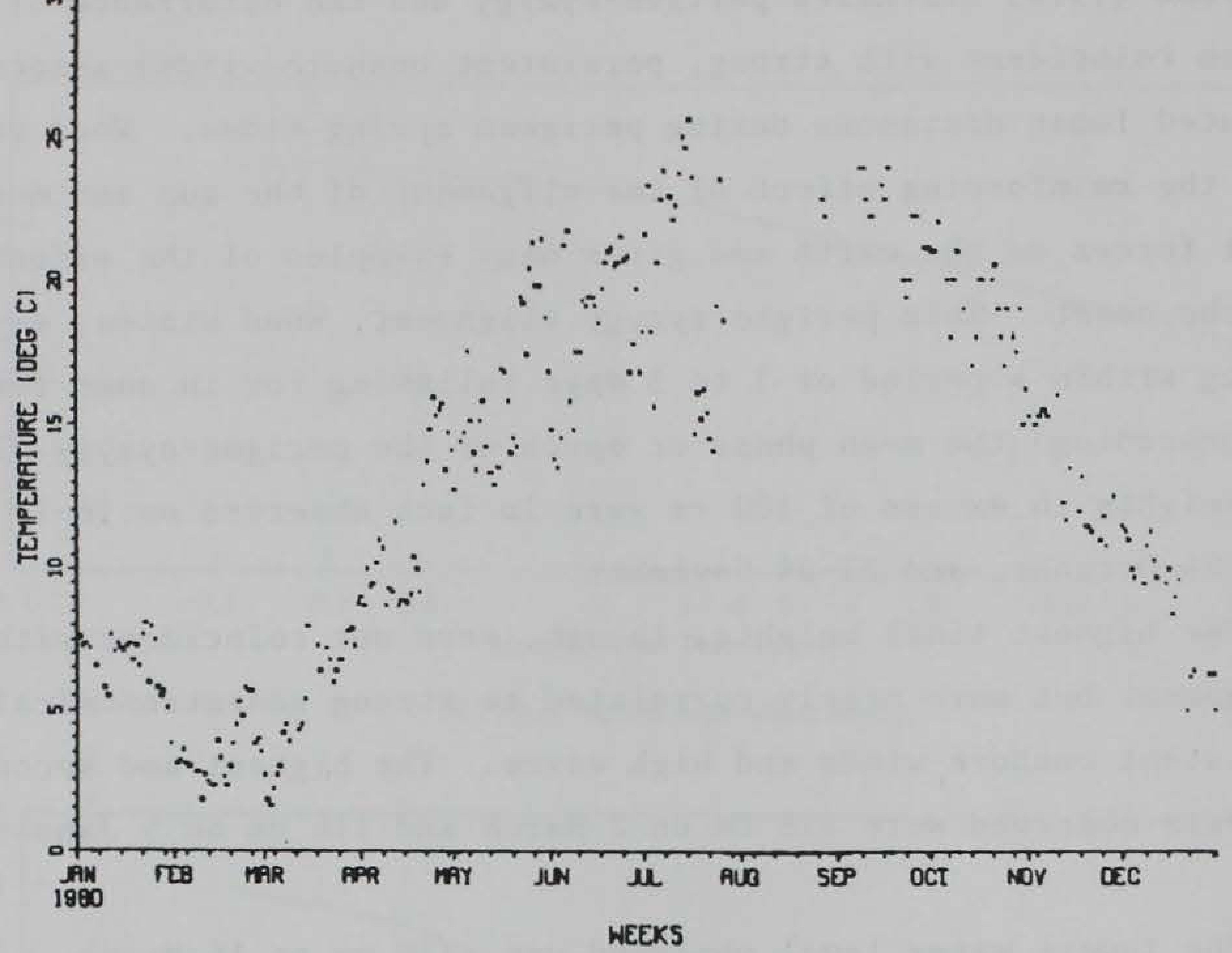


Figure 22. Sea surface temperatures, 1980, for the seaward end of the FRF pier

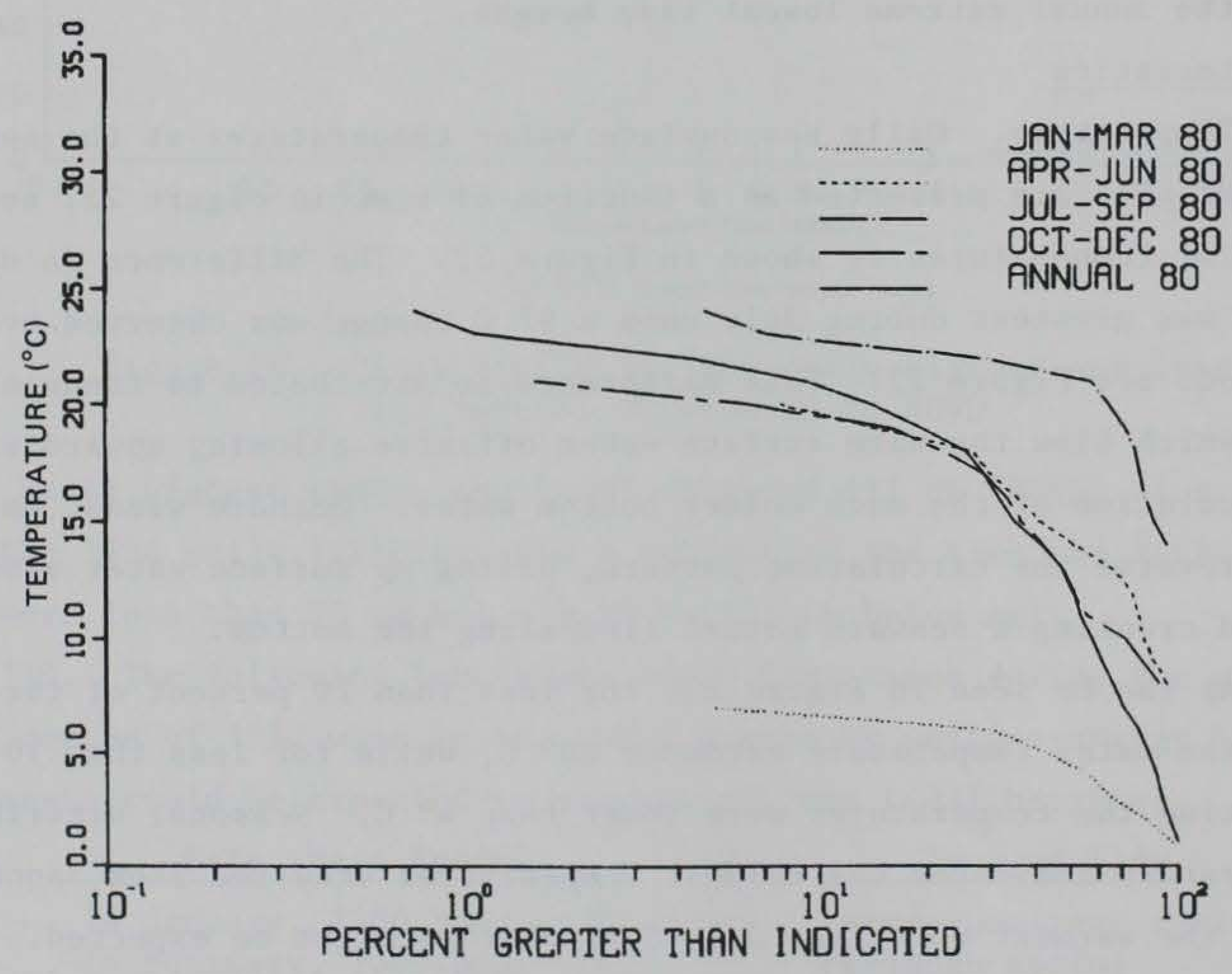


Figure 23. Annual and seasonal distributions of sea surface temperatures, 1980, at the FRF

temperatures presented previously, but the temperature ranges varied inversely from those of air temperature. July was a time of maximum range in water temperature and minimum range in air temperature, while February's ranges were at a minimum for water and a maximum for air.

Month 1980	Sea Surface Temperature, °C	Visibility m
Jan	6.8	1.3
Feb	3.5	1.4
Mar	5.5	1.0
Apr	11.2	2.5
May	16.2	2.7
Jun	18.5	3.9
Jul	20.1	4.6
Aug	*	3.4
Sep	22.1	2.9
Oct	19.0	1.4
Nov	13.2	1.0
Dec	8.9	0.9

* No measurement.

126. Figure 24 shows the daily difference between the surface water temperature and the air temperatures measured behind the dune 1.5 m above ground. This temperature difference can be important to coastal engineers when assessing storm surge and wave growth values because of the modification of wind stress and, consequently, the transfer of momentum from the wind to the sea surface. When the air is cooler than the water, increased turbulence causes increased momentum transfer for a given wind speed; conversely, when the air is warmer, a stable condition results and less momentum for a given wind speed is transferred. The largest difference was 16° C which occurred during August. During October through February, the water was warmer than the air occasionally by more than 10° C. March and September are periods of transition, with warming and cooling of the coastal waters occurring respectively.

127. Visibility. Visibility in coastal nearshore waters depends on the amount of salts, soluble organic material, detritus, living organisms, and inorganic particles in the water. These dissolved and suspended materials

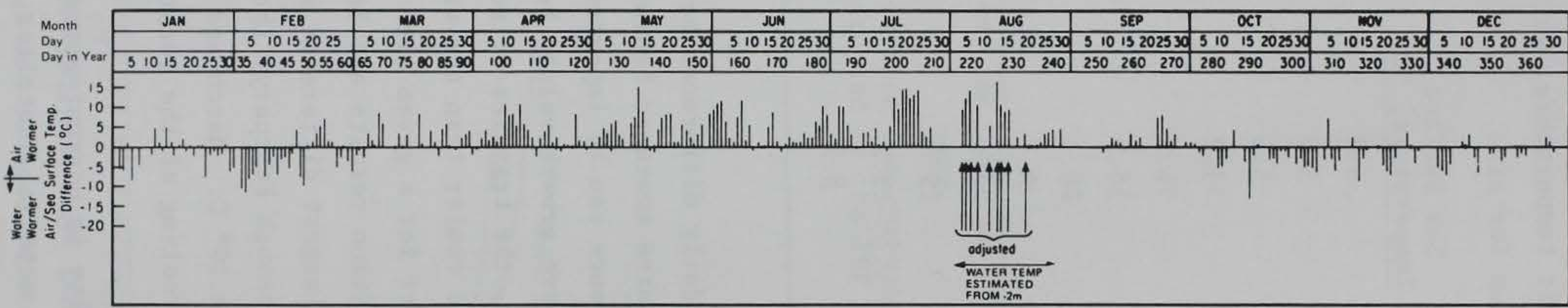


Figure 24. Air/water temperature differences, 1980, for the seaward end of the FRF pier

change the adsorption and attenuation characteristics of the water which vary daily and throughout the year. Daily water visibility measurements made at the seaward end of the pier are shown as a function of time in Figure 25.

128. The daily visibility is highly variable. Fifty percent of the time the surface visibility at the seaward end of the pier is less than 2 m (Figure 26). Visibility in excess of 6 m occurred about 10 percent of the time (or 30 days) during 1980, predominantly in July, August, and September. The greatest range of visibility occurred in August when greater than 5 m changes over 24 hours were not uncommon. Visibility varies much the same as surface water temperature (see tabulation, paragraph 125); onshore winds tend to bring clearer surface waters to the coast, and offshore winds produce upwelling of more turbid bottom water.

Current Data

129. Currents measured at the seaward end of the FRF pier and 500 m updrift of the pier on the beach are discussed in this section. Monthly and annual summaries as well as time histories of the daily values (Figures 27 and 28) are presented. The monthly average surface current speeds (see tabulation on page 67) were strongest toward the south at the pier end during the winter months. These currents were caused by predominantly northerly winds and persistently high wave conditions. From April through September, the winds blew predominantly from southerly directions and more frequently produced northwardly moving currents as was especially evident in the wave-induced beach currents.

130. Current speeds were generally higher and the seasonality of the current direction was more evident on the beach than at the seaward end of the pier.

131. Peak current speeds were generally higher and more frequent for southward flow than for northward-moving water except for the persistent northerly currents on the beach during the summer months (Figure 28).

Survey results

132. Weekly pier surveys from both sides of the pier and time histories of bottom elevations at selected locations along the pier are presented in Appendix C.

133. Bathymetry. Figure 29 is a contour diagram of the 1980 beach and nearshore bathymetry; the offshore data are not included due to the questionable accuracy of the depth information.

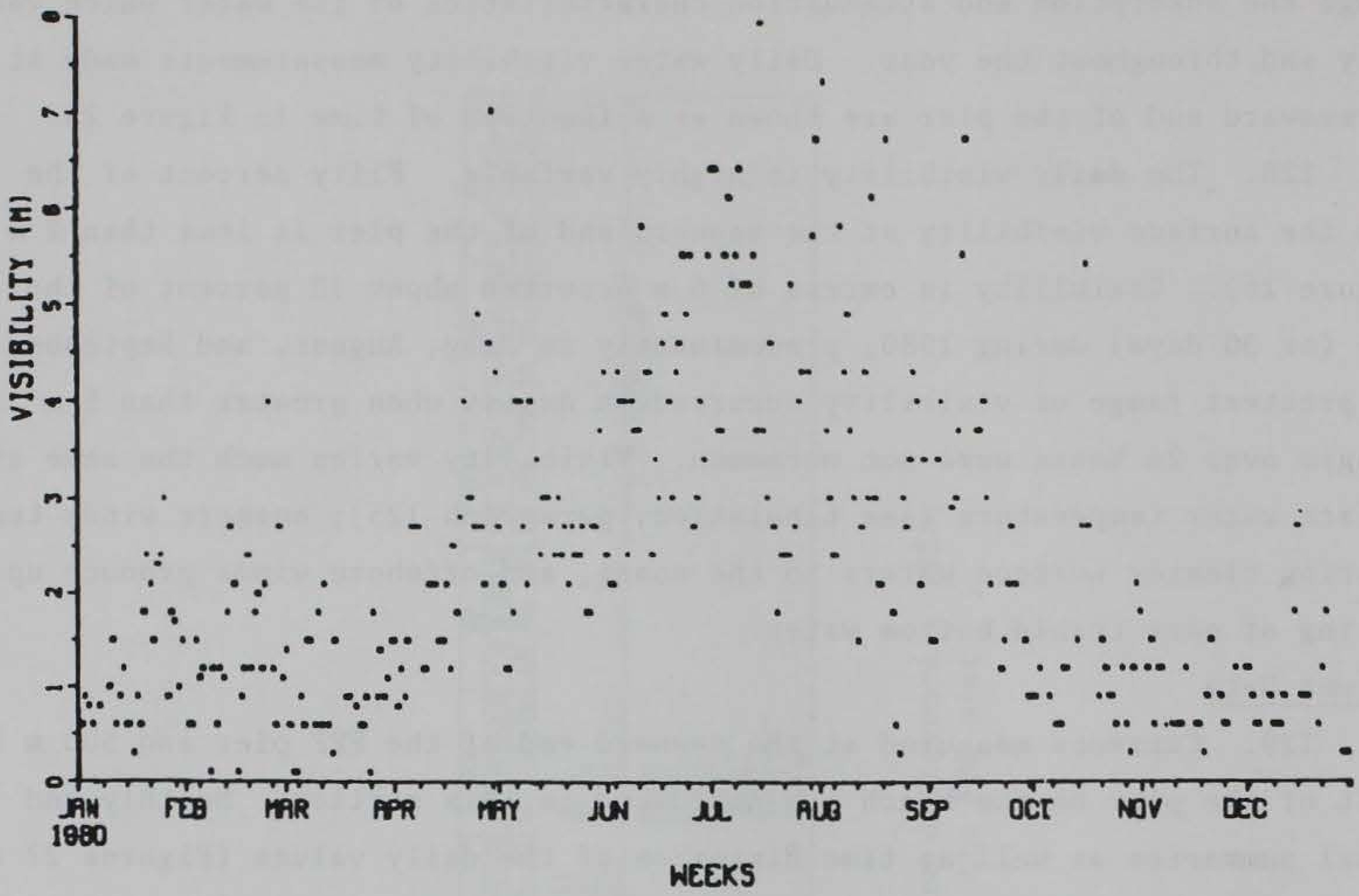


Figure 25. Water visibility, 1980, for the seaward end of the FRF pier

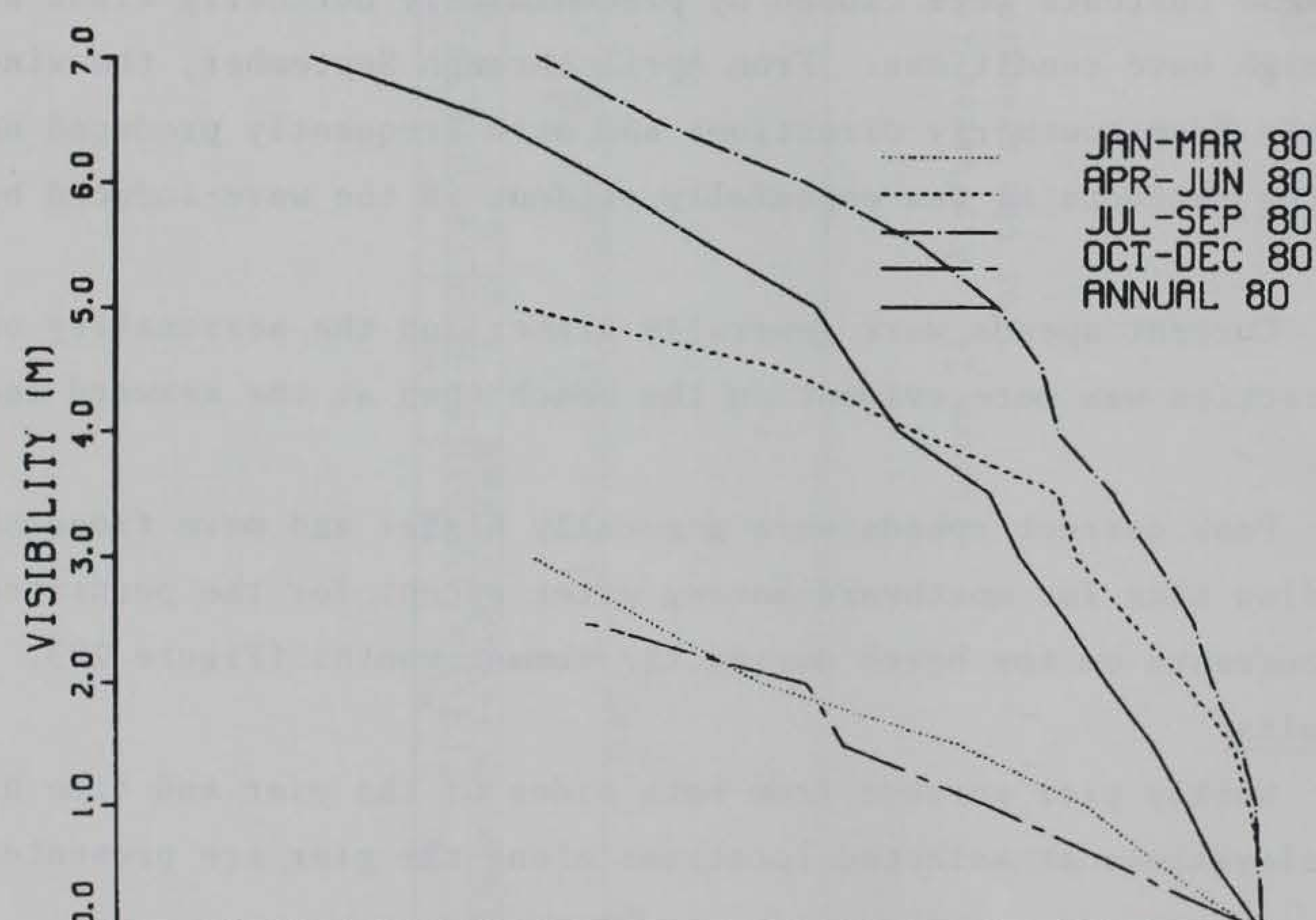


Figure 26. Distribution of visibility measurements, 1980, at the FRF

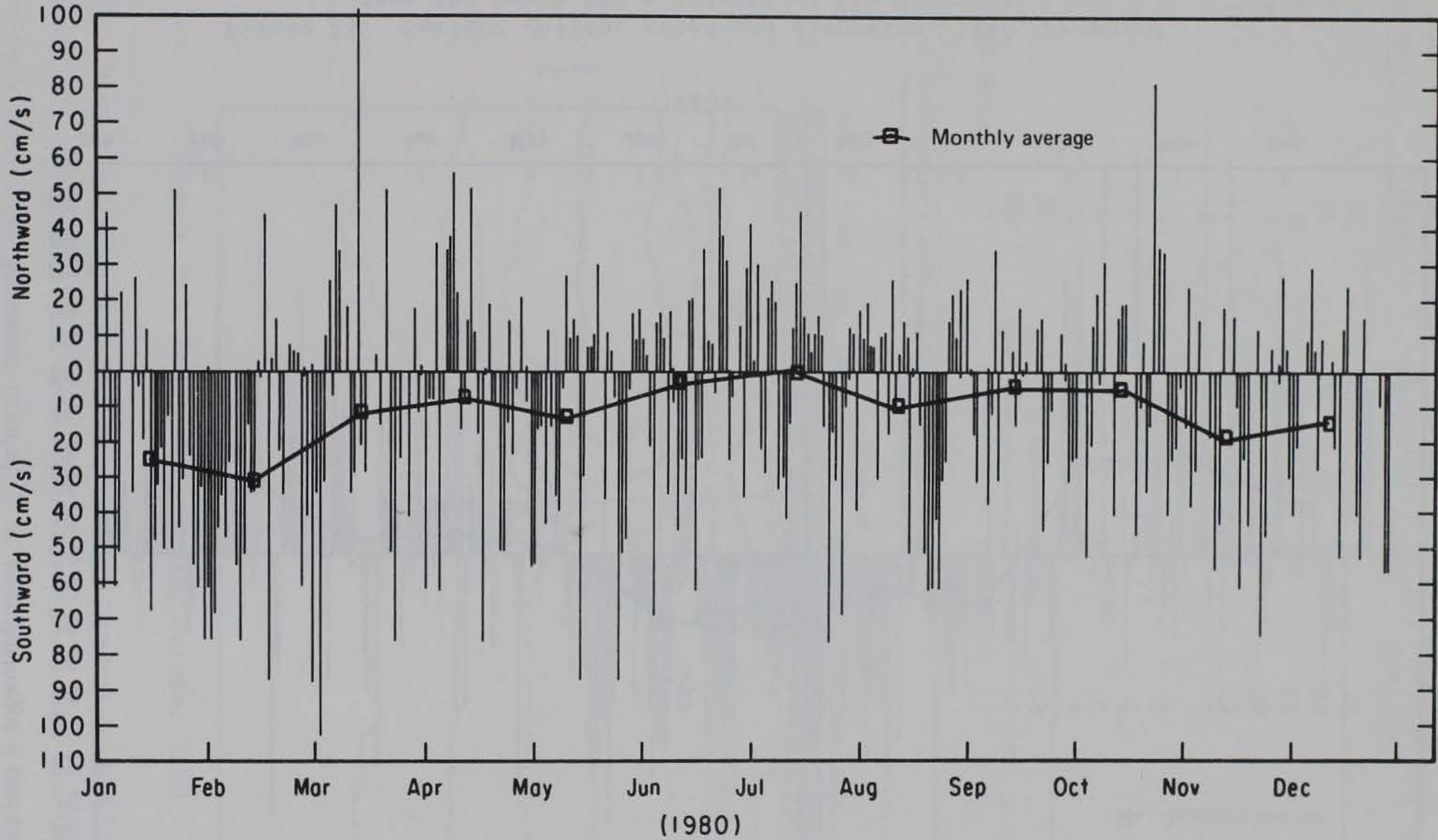


Figure 27. Surface current speed, 1980, at the seaward end of the FRF pier

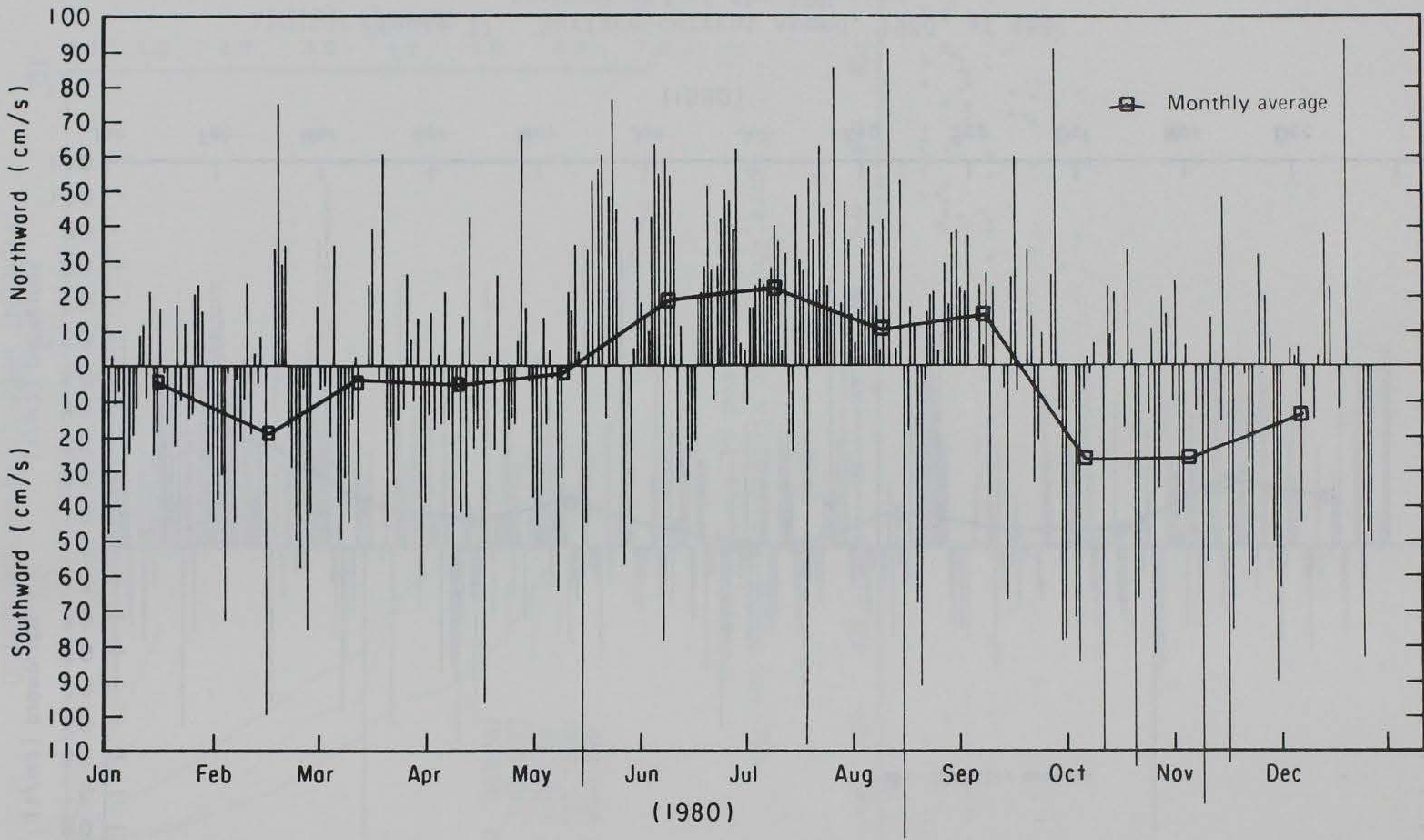


Figure 28. Surface current speed and direction, 1980, measured from the beach 500 m updrift of the FRF pier

	Mean Surface Currents, cm/sec*				
	Pier End				
Monthly	1980	1979	1978	Monthly Average	Beach 1980
Jan	26	15	15	19	6
Feb	31	22	37	30	19
Mar	8	20	37	22	4
Apr	4	10	15	10	6
May	15	13	10	13	3
Jun	2	21	-1	7	-19
Jul	-1	6	4	3	-22
Aug	8	7	4	6	-10
Sep	4	14	12	10	-14
Oct	4	8	10	7	27
Nov	19		9	14	27
Dec	13	7	9	10	14
Annual Mean	11	12	11	11	3

* + = southward; - = northward.

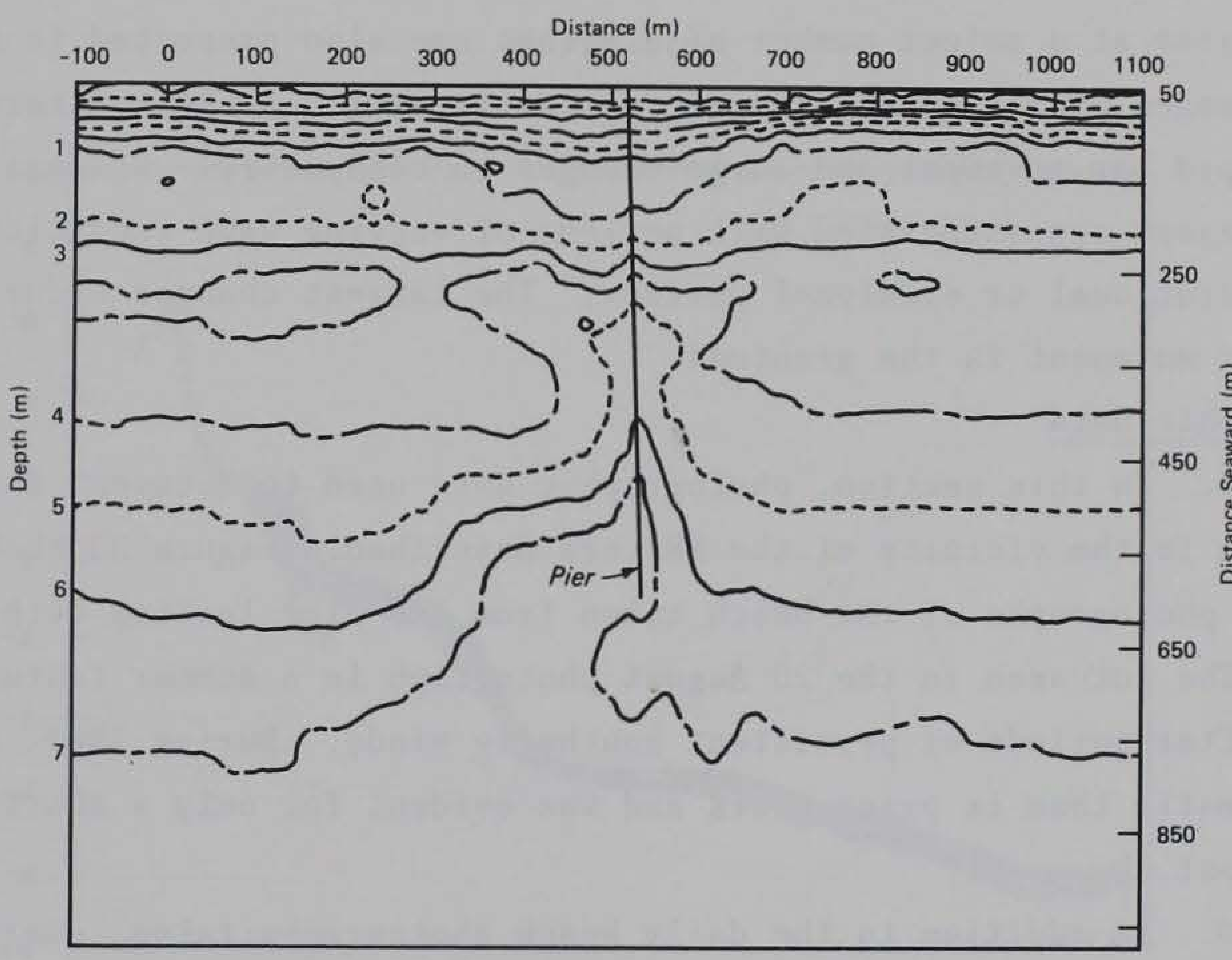


Figure 29. FRF bathymetry for October 1980

134. Near the pier, contours deeper than 3 m were significantly modified. The 7-m contour diverged some 250 m towards shore, but the 3-m contour was relatively unchanged showing only a 20-m change. This bending of the contours near the pier is persistent throughout the year, although the absolute depth of the trough under the pier changes as a function of changing wave and current conditions.

135. Pier profiles. Between April and September, the profiles under the pier had a consistent shape and only about a 1-m variation seaward of the local msl beach intercept (Figure 30). During the winter months January through March and October through December, the profiles exhibit a much more varied shape and large changes all along the profile (Figure 31).

136. Figure 32 shows the magnitude of the change in elevation as a function of the distance along the pier. The development and movement of bars account for the largest of the changes.

137. The weekly profiles from both sides of the FRF pier presented in Appendix C show when the bar system developed, how it moved, and when it was no longer present. As the bathymetry shows, the pier's influence causes these profiles to be considerably different from those farther than 150 m north or south of the pier.

138. The variations of bottom elevations as a function of time throughout the year at a select number of stations are also presented in Appendix C. Large changes over a short time are generally attributable to storms which cause rapid bar movement and large changes in bathymetry. Gradual changes over a season are associated with periods of varying wave conditions and reflect accretional or erosional periods. The largest changes occur nearshore where bar movement is the greatest.

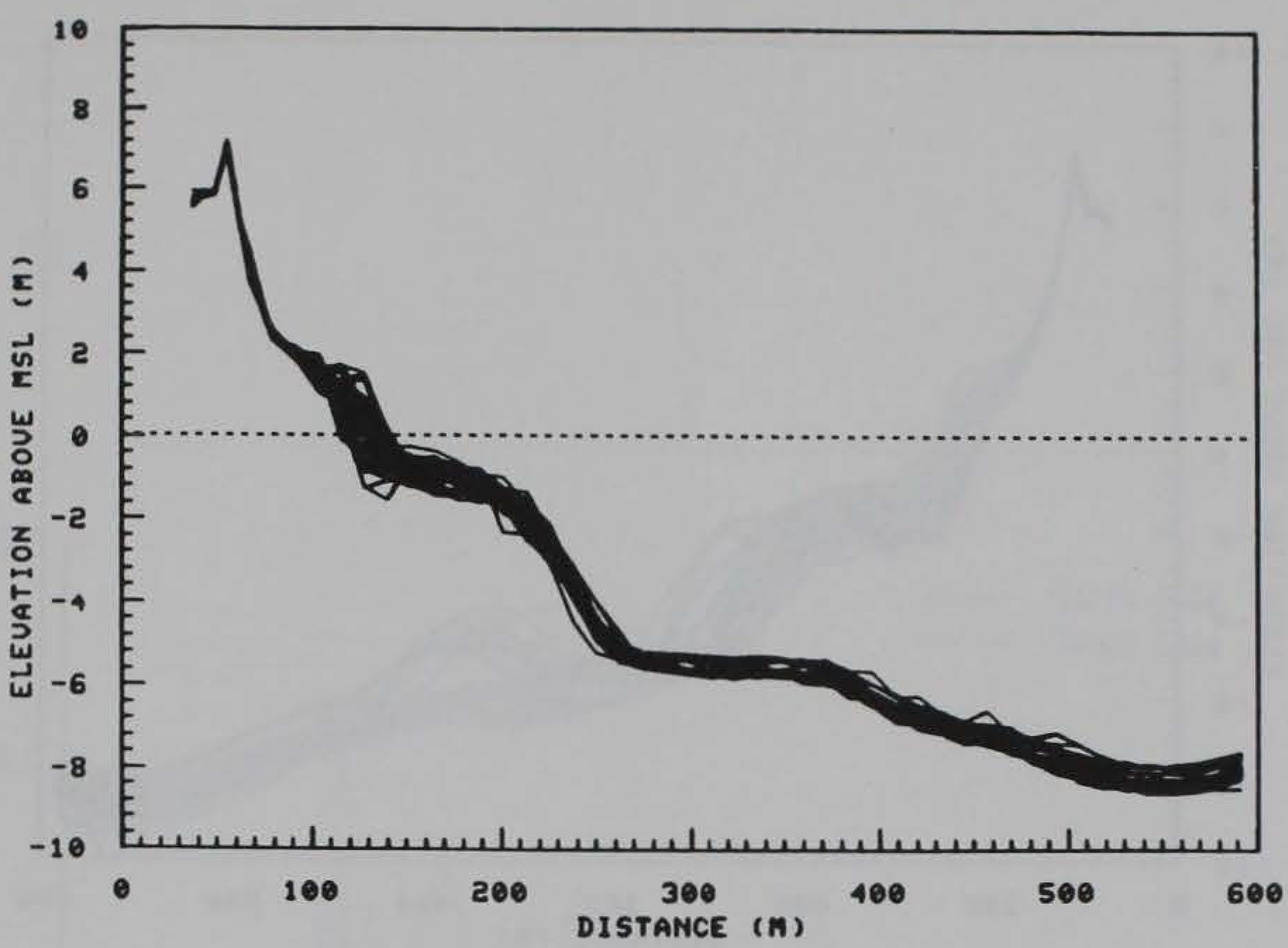
Photographic data

139. In this section, photographic data used to document the beach condition in the vicinity of the FRF are described. Figure 33 shows samples of daily photographs of the beach taken from the pier looking both north and south. The cut seen in the 20 August photograph is a summer feature and occurs after periods of persistent southerly winds. During 1980, the cut was less dramatic than in prior years and was evident for only a short time in late August.

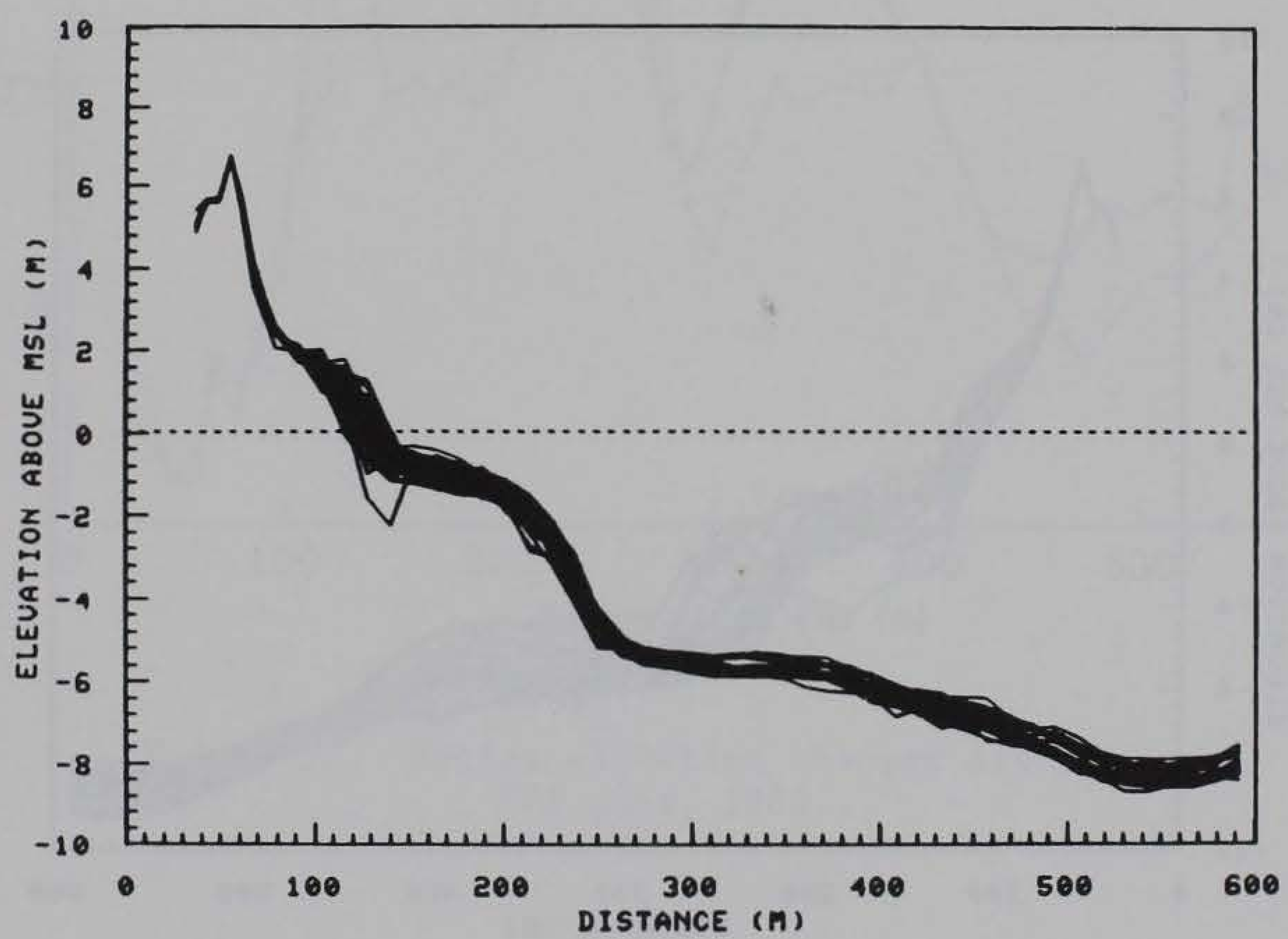
140. In addition to the daily beach photographs taken, quarterly aerial photographic missions were flown. Table 9 is an inventory of the photography obtained during 1980, and Figure 34 is a sample photographic negative showing the FRF pier on the 16th of July.

Sediment Data

141. In this section, results of sediment analyses of sand samples taken from the foreshore throughout the year are presented. In addition, results are presented from one survey in October along a 30-km-long transect

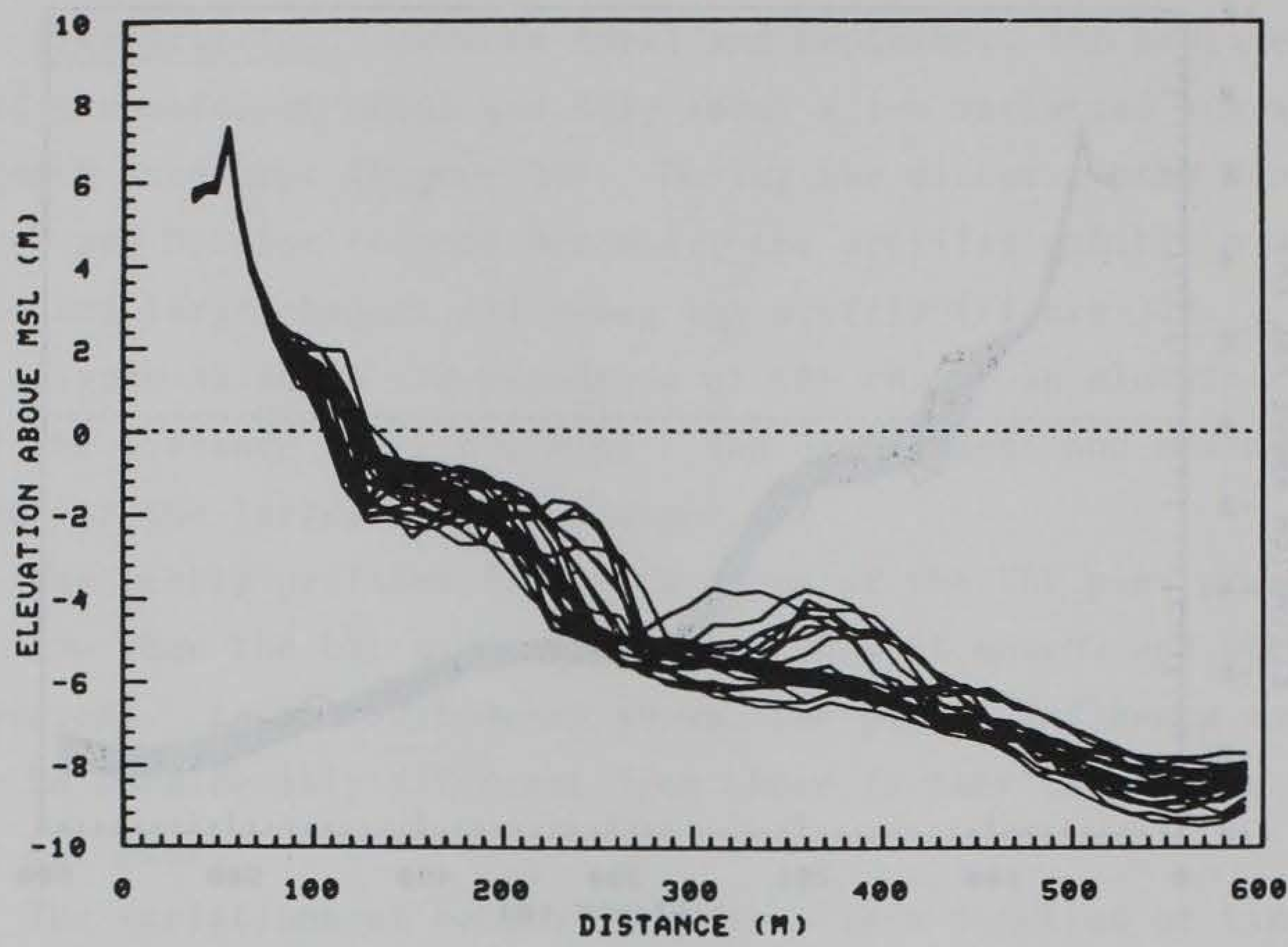


a. North side

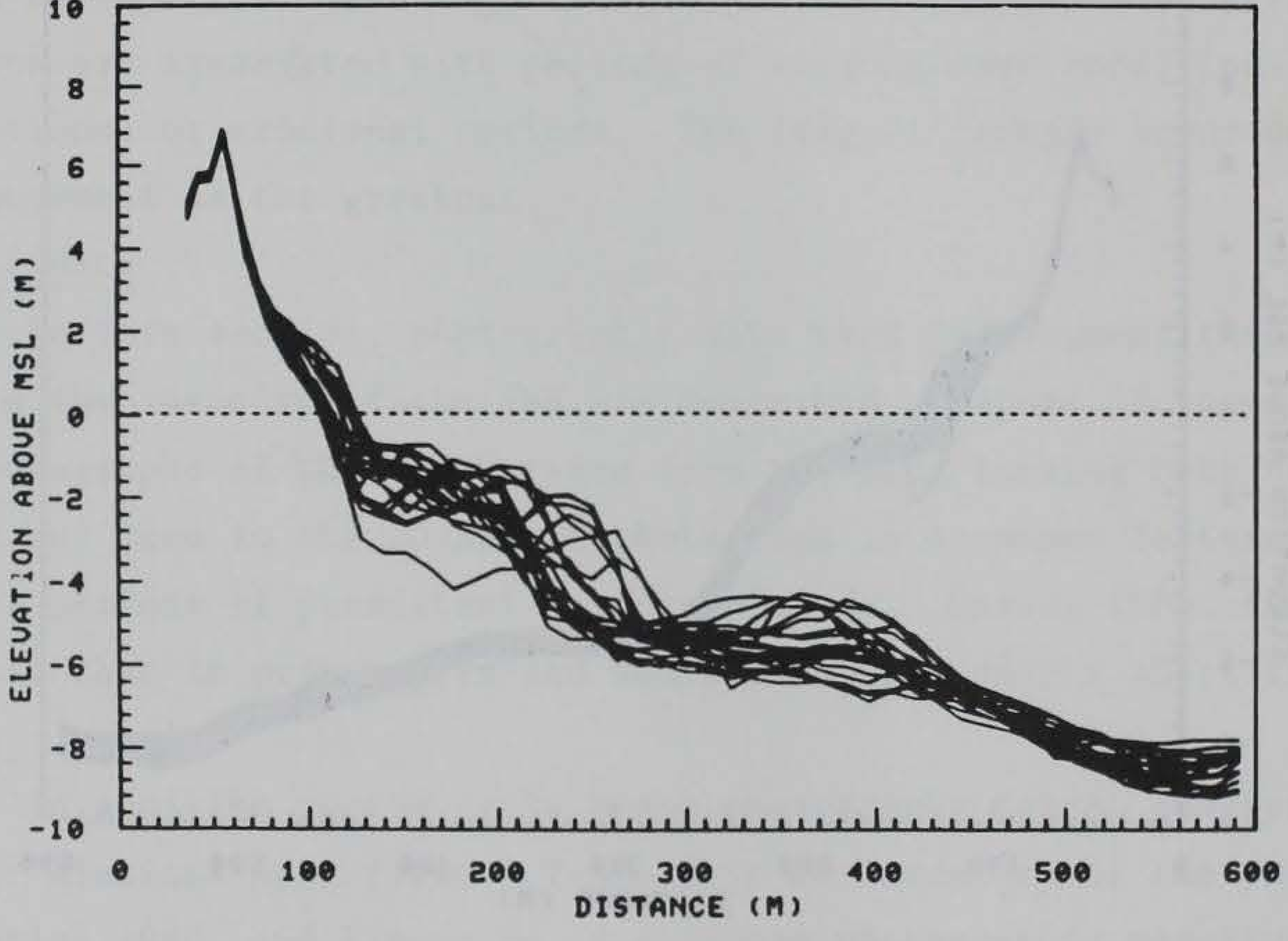


b. South side

Figure 30. Pier profile envelopes, April-September 1980



a. North side



b. South side

Figure 31. Pier profile envelopes, January-March and October-December 1980

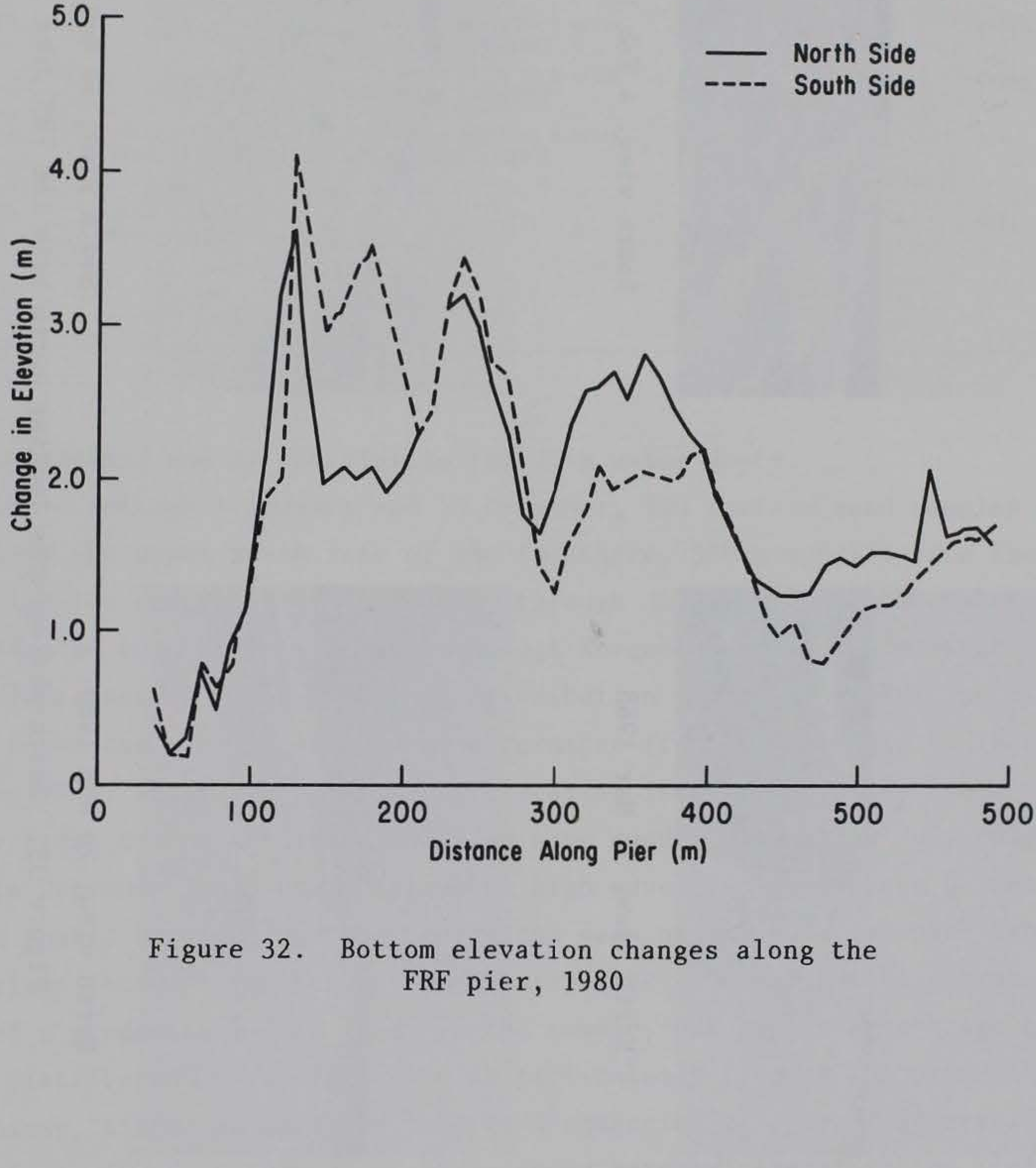


Figure 32. Bottom elevation changes along the FRF pier, 1980

North view, 15 Mar 1980

South view, 4 Feb 1980

North view, 20 Aug 1980

South view, 10 May 1980

Figure 33. Beach photographs looking north from the FRF pier

Table 9

1980 Aerial Photography Inventory

Date	Flight Line No. 1	Flight Line No. 2	Flight Line No. 3	(Negatives) Film Format
16 Jan		2 miles north to 2 miles south (1:6,000)		Color
		2 miles north to 2 miles south (1:2,400)		Color
16 Jan	Cape Henry to Cape Hatteras (1:12,000)	+2 miles north to the pier (1:6,000)	Currituck Sound to Atlantic Ocean (1:12,000)	B/W
15 Apr		2 miles north to 2 miles south (1:6,000)		Color
		2 miles north to 2 miles south (1:2,400)		Color
15 Jul	Corolla to Oregon Inlet (1:12,000)	2 miles north to 2 miles south (1:6,000)	Currituck Sound to Atlantic Ocean (1:12,000)	B/W
15 Oct	Corolla to Kitty Hawk (1:6,000)			B/W

from the seaward end of the pier to the 33-m water depth.

142. Between 4 January and 30 December, 130 surface sand samples were taken from the upper swash zone of the foreshore, 500 m updrift from the pier. Weekly samples were taken from January through June and during December, while daily samples were taken from July through November. Table 10 presents statistical parameters of the sediment distribution for each sample, and Figure 35 shows the mean grain size as determined from CERC's Rapid Sediment Analyzer (RSA) analysis. Considerable scatter is evident, but a trend for smaller sizes during the relatively low wave conditions during July and larger sizes in December and January (times of high wave conditions) can be seen. Caution should be exercised when using the mean of a sample to infer typical grain sizes found on the beach. Frequently, the mean may not be a true indicator of a predominant size found in the sample, but simply an average based on the distribution of sizes. This is particularly true as the sizes become more coarse, since the analysis reports frequencies at 1/2-phi intervals and increasingly larger intervals of sizes occur between classification limits as shown in the tabulation on page 77.

143. As an example, a sample taken on 20 November 1980 is described on page 78. The frequency distribution, given in the tabulation, shows a

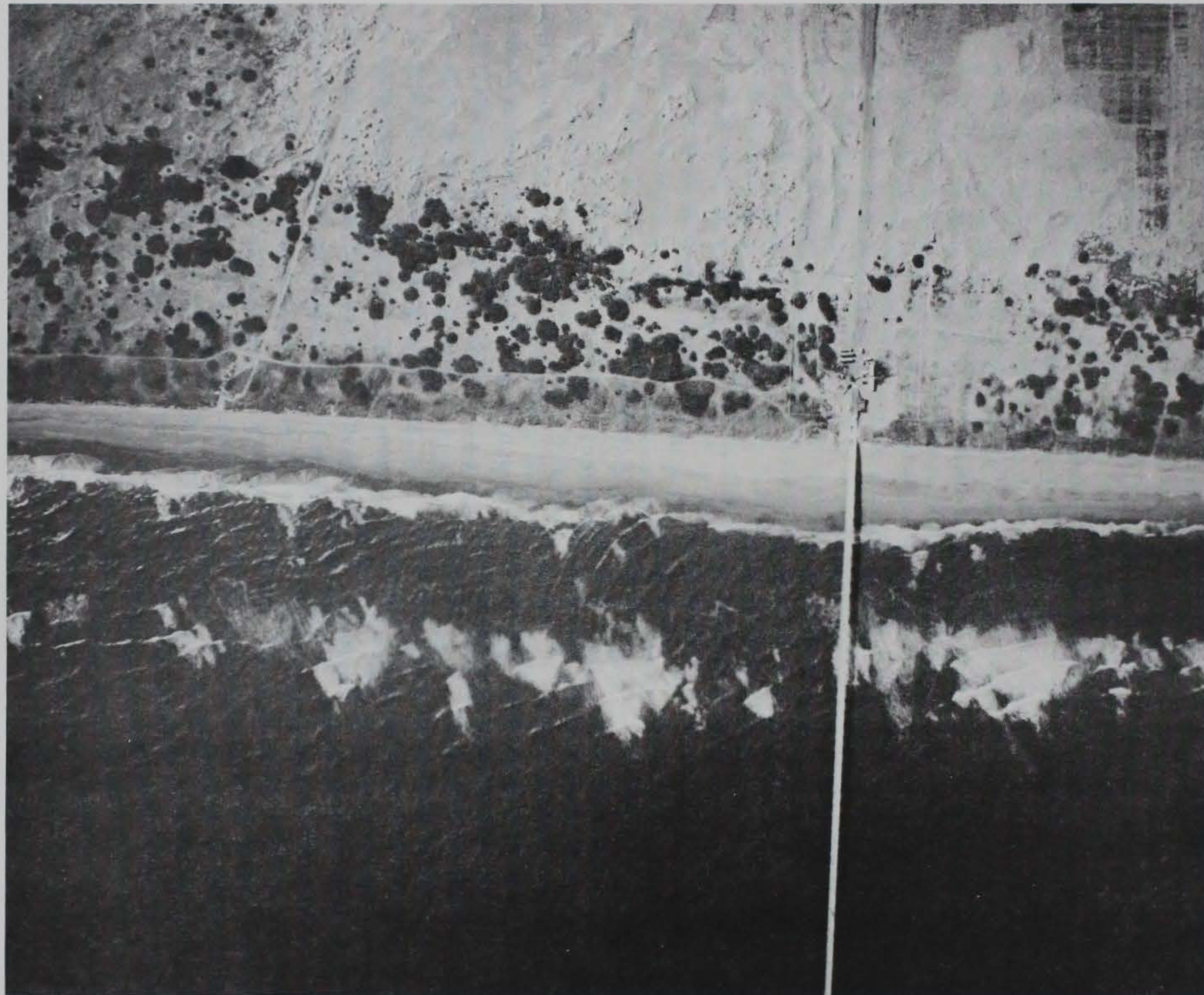


Figure 34. Sample aerial photograph of FRF taken 16 July 1980

Table 10

Statistical Parameters of the 1980 Foreshore Sediment Samples

Date	Median Phi	Median mm	Mean Phi	Mean mm	Standard Deviation phi	Skewness phi	Kurtosis phi
0104	0.84	0.560	1.21	0.431	0.91	1.23	3.21
0109	1.71	0.306	1.79	0.289	0.54	0.74	2.87
0119	0.76	0.589	1.10	0.467	0.81	1.34	3.53
0123	0.98	0.508	1.06	0.480	0.80	0.41	2.99
0201	1.42	0.373	1.40	0.380	0.86	-0.17	2.49
0402	0.90	0.537	1.01	0.498	0.72	0.31	3.51
0413	1.33	0.399	1.31	0.405	0.76	-0.03	2.34
0503	1.12	0.462	1.24	0.423	0.63	0.37	3.49
0606	1.83	0.282	1.81	0.284	0.64	-0.90	4.58
0613	1.40	0.380	1.32	0.400	0.80	-0.69	3.29
0701	1.46	0.364	1.58	0.333	0.53	0.45	2.59
0702	1.69	0.311	1.75	0.297	0.65	-0.54	4.97
0703	1.68	0.312	1.65	0.319	0.95	-0.44	3.05
0704	1.68	0.311	1.74	0.300	0.65	-0.21	3.46
0705	1.89	0.270	2.04	0.243	0.82	0.53	3.34
0706	1.45	0.366	1.55	0.342	0.67	0.41	2.66
0707	1.80	0.288	1.88	0.272	0.49	0.58	2.64
0708	0.41	0.752	0.62	0.649	0.87	0.57	2.13
0709	2.10	0.233	2.18	0.220	0.57	0.66	2.84
0710	2.20	0.218	2.23	0.213	0.41	0.06	2.95
0711	1.97	0.256	1.95	0.258	0.52	-0.72	4.49
0712	1.93	0.263	1.93	0.263	0.49	-0.11	2.91
0713	0.98	0.505	1.21	0.431	0.66	1.27	4.06
0714	1.37	0.386	1.48	0.359	0.49	0.53	2.70
0715	1.86	0.275	1.93	0.263	0.47	0.67	2.86
0716	1.96	0.258	2.02	0.247	0.59	0.06	3.72
0718	2.06	0.240	2.03	0.245	0.73	-1.26	6.51
0719	1.74	0.299	1.88	0.271	0.58	0.53	3.67
0720	1.87	0.274	1.96	0.257	0.47	0.57	2.96
0721	2.11	0.232	2.17	0.222	0.49	0.54	2.89
0722	1.99	0.52	2.00	0.251	0.42	0.24	2.17
0723	2.01	0.248	1.99	0.252	0.54	-1.92	10.20
0724	1.80	0.287	1.87	0.273	0.46	0.19	3.27
0726	1.79	0.289	1.90	0.268	0.52	0.78	2.87
0727	0.78	0.584	0.98	0.506	0.54	1.19	3.41
0729	1.41	0.375	1.54	0.343	0.46	0.83	2.83
0730	1.25	0.420	1.41	0.376	0.74	0.39	3.15
0731	1.32	0.400	1.45	0.366	0.63	0.40	2.83
0801	1.82	0.283	1.91	0.266	0.54	0.25	4.08
0802	1.77	0.293	1.88	0.272	0.61	0.05	3.32
0803	1.69	0.310	1.76	0.295	0.51	0.37	2.27
0804	1.53	0.347	1.52	0.348	0.74	-0.51	3.17
0805	1.97	0.256	1.99	0.252	0.49	0.04	3.23
0806	1.81	0.286	1.82	0.283	0.58	0.18	2.55
0807	1.39	0.381	1.55	0.341	0.74	0.77	3.04
0808	1.44	0.368	1.56	0.339	0.64	0.50	3.93
0809	1.57	0.337	1.65	0.318	0.69	0.11	3.29
0810	1.12	0.459	1.18	0.443	0.68	0.15	2.90
0813	1.58	0.334	1.68	0.313	0.51	0.57	2.57
0814	2.10	0.233	2.08	0.236	0.47	0.07	2.35
0815	1.67	0.314	1.66	0.315	0.62	-0.45	3.92
0817	1.31	0.403	1.38	0.384	0.55	0.08	4.14
0818	1.12	0.459	1.30	0.406	0.62	0.91	3.16
0819	1.10	0.465	1.12	0.460	0.75	0.05	2.48
0822	1.05	0.483	1.13	0.458	0.53	0.33	3.34
0823	0.81	0.571	0.99	0.504	0.73	0.61	2.66
0824	0.83	0.562	0.99	0.505	0.73	0.62	2.50
0825	0.83	0.563	1.01	0.495	0.67	0.75	3.56
0826	0.14	0.908	0.47	0.720	0.95	1.07	2.90
0828	0.39	0.762	0.49	0.714	0.43	1.49	5.47
0829	1.23	0.428	1.34	0.396	0.75	0.26	2.41
0830	1.78	0.292	1.78	0.292	0.62	-0.88	5.25
0831	1.29	0.409	1.33	0.399	0.69	0.15	1.96

(Continued)

Table 10 (Concluded)

Date	Median Phi	Median mm	Mean Phi	Mean mm	Standard Deviation phi	Skewness phi	Kurtosis phi
0902	1.87	0.274	1.91	0.267	0.62	-0.68	5.73
0903	1.69	0.310	1.79	0.289	0.56	0.57	2.37
0904	1.69	0.310	1.79	0.290	0.60	0.49	2.76
0905	0.77	0.588	0.92	0.530	0.79	0.47	2.69
0908	0.15	0.899	0.46	0.728	0.85	1.86	5.10
0910	1.41	0.377	1.46	0.364	0.67	0.24	2.51
0911	1.26	0.416	1.34	0.394	0.56	0.47	2.94
0912	1.47	0.360	1.50	0.354	0.68	-0.46	3.87
0915	1.49	0.356	1.58	0.334	0.52	0.10	2.49
0916	1.43	0.372	1.56	0.339	0.64	0.59	2.99
0917	1.51	0.352	1.59	0.333	0.56	0.36	3.00
0918	1.43	0.371	1.57	0.337	0.54	0.79	2.85
0919	1.01	0.497	1.15	0.451	0.78	0.38	2.88
0922	1.04	0.486	1.11	0.464	0.93	0.17	2.51
0923	1.37	0.387	1.51	0.351	0.67	0.49	3.24
0924	1.04	0.486	1.07	0.477	0.79	0.20	2.28
0925	1.38	0.383	1.49	0.355	0.60	0.55	2.62
0926	1.43	0.370	1.57	0.337	0.52	0.91	3.11
0929	1.76	0.296	1.77	0.292	0.43	0.12	2.30
0930	1.25	0.420	1.32	0.400	0.58	0.43	2.58
1001	1.39	0.380	1.45	0.366	0.71	-0.06	3.01
1002	1.16	0.448	1.19	0.437	0.90	-0.04	2.16
1003	0.67	0.627	0.90	0.535	0.82	0.54	2.25
1006	0.99	0.505	1.06	0.478	0.49	0.37	2.94
1008	0.43	0.741	0.53	0.691	0.43	0.63	3.86
1009	0.96	0.515	1.08	0.473	0.68	0.43	2.93
1010	0.97	0.510	1.13	0.456	0.76	0.18	2.31
1011	2.41	0.189	2.45	0.182	0.29	0.68	2.61
1014	1.19	0.437	1.27	0.414	0.70	0.23	2.29
1015	1.59	0.333	1.62	0.324	0.55	-0.27	3.27
1016	1.69	0.309	1.73	0.302	0.48	-0.29	3.59
1017	1.62	0.324	1.68	0.311	0.51	-0.09	3.06
1020	1.56	0.340	1.62	0.324	0.59	0.10	2.92
1023	2.38	0.192	2.39	0.191	0.06	3.71	14.76
1024	1.49	0.357	1.56	0.340	0.37	0.48	2.34
1027	0.93	0.525	0.92	0.528	0.79	-0.01	2.23
1028	1.14	0.453	1.25	0.421	0.65	0.41	2.51
1030	1.08	0.473	1.22	0.428	0.72	0.49	2.90
1031	1.10	0.466	1.18	0.440	0.68	0.09	3.24
1101	1.45	0.366	1.58	0.333	0.53	0.74	2.90
1103	1.05	0.486	1.13	0.457	0.50	0.63	3.04
1104	0.81	0.568	0.95	0.518	0.54	0.86	4.03
1105	0.93	0.526	0.98	0.507	0.62	-0.09	3.65
1106	1.23	0.427	1.37	0.387	0.58	0.53	2.73
1107	-0.04	1.030	-0.01	1.005	0.23	0.74	4.66
1110	1.53	0.347	1.59	0.333	0.57	-0.38	3.94
1112	1.45	0.366	1.57	0.336	0.58	0.54	3.00
1113	1.44	0.368	1.50	0.354	0.52	0.26	2.96
1114	1.33	0.397	1.41	0.376	0.56	0.29	3.18
1117	1.21	0.433	1.33	0.399	0.64	0.23	3.02
1118	0.96	0.513	1.11	0.464	0.77	0.35	3.29
1119	0.94	0.522	1.19	0.439	0.71	1.15	3.21
1120	0.18	0.883	0.28	0.821	0.47	1.86	6.74
1121	0.40	0.760	0.61	0.655	0.75	0.88	2.88
1124	0.58	0.670	0.63	0.561	0.73	1.01	3.40
1125	0.84	0.560	0.98	0.507	0.70	0.69	2.95
1126	0.48	0.717	0.71	0.611	0.59	1.31	4.10
1128	1.16	0.446	1.25	0.419	0.78	0.40	2.37
1201	1.44	0.368	1.51	0.350	0.65	-0.12	3.90
1208	0.57	0.674	0.82	0.565	0.80	0.76	2.50
1215	1.34	0.395	1.48	0.359	0.65	0.42	2.60
1224	1.07	0.475	1.21	0.433	0.58	0.63	3.25
1230	0.98	0.509	1.14	0.452	0.60	0.97	3.21

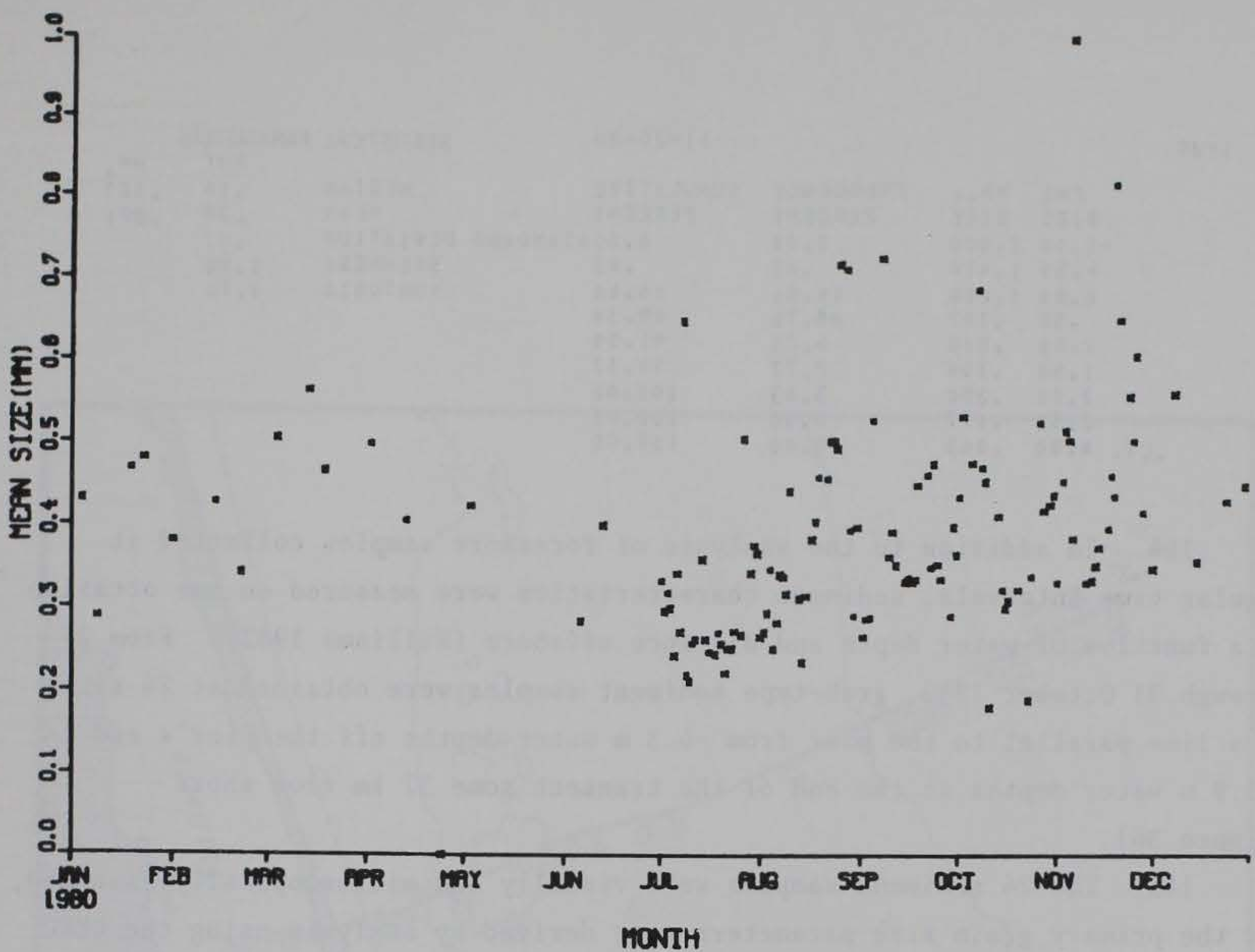


Figure 35. RSA-determined mean grain size of the foreshore samples taken in 1980, 500 m north of the FRF pier

Phi Size	mm Size	mm Interval
-1.00	2.000	
		0.586
-0.50	1.414	
		0.414
0.00	1.000	
		0.293
0.50	0.707	
		0.207
1.00	0.500	
		0.146
1.50	0.354	
		0.104
2.00	0.250	
		0.073
2.50	0.177	
		0.052
3.00	0.125	
		0.037
3.50	0.088	
		0.025
4.00	0.063	

dominance of the 0.707-mm size (0.5∅) with some 1.000-mm (0.0∅) sizes present. The mean, reported at 0.821, is not similar to either size present. The mean is useful for generally classifying the material sizes on the beach; i.e., for distinguishing between coarse, medium, fine, or very fine sand sizes in a sample. The standard deviation is useful for determining the sorting characteristics of the sample; i.e., the similarity of the sand sizes.

1+20			11-20-80	STATISTICAL PARAMETERS		
					PHI	MM.
PHI SIZE	MM. SIZE	FREQUENCY PERCENT	CUMULATIVE PERCENT	MEDIAN	.18	.881
				MEAN	.28	.821
-1.00	2.000	0.00	0.00	STANDARD DEVIATION	.47	
-.50	1.414	.63	.63	SKEWNESS	1.86	
0.00	1.000	16.01	16.64	KURTOSIS	6.74	
.50	.707	68.70	85.34			
1.00	.500	6.25	91.59			
1.50	.354	2.77	94.37			
2.00	.250	5.63	100.00			
2.50	.177	0.00	100.00			
.LT. 4.00	.063	0.00	100.00			

144. In addition to the analysis of foreshore samples collected at regular time intervals, sediment characteristics were measured on one occasion as a function of water depth and distance offshore (Williams 1982). From 27 through 31 October 1980, grab-type sediment samples were obtained at 24 sites in a line parallel to the pier from -6.3 m water depths off the pier's end to -32.9 m water depths at the end of the transect some 37 km from shore (Figure 36).

145. The 24 sediment samples were visually and microscopically examined, and the primary grain size parameters were derived by analysis using the CERC RSA. The sediments were all fairly similar in color and composition and ranged from very fine to very coarse gray sand. In general, the samples from the -6.3 m contour seaward to about the -17 m contour (Figure 37) were gray, moderately well sorted, very fine to fine quartz sand, findings which are in agreement with the 1979 survey (Miller, 1982) of 13 short core samples taken from the shore seaward to a depth of -15.8 m. Sediments at sample site number 14, taken near the crest of the second shoal, contrast the most with the other samples in the transect. The sediment in this sample was medium to very coarse quartz sand with rock fragments and broken shell fragments very similar to typical samples from the beach at the FRF.

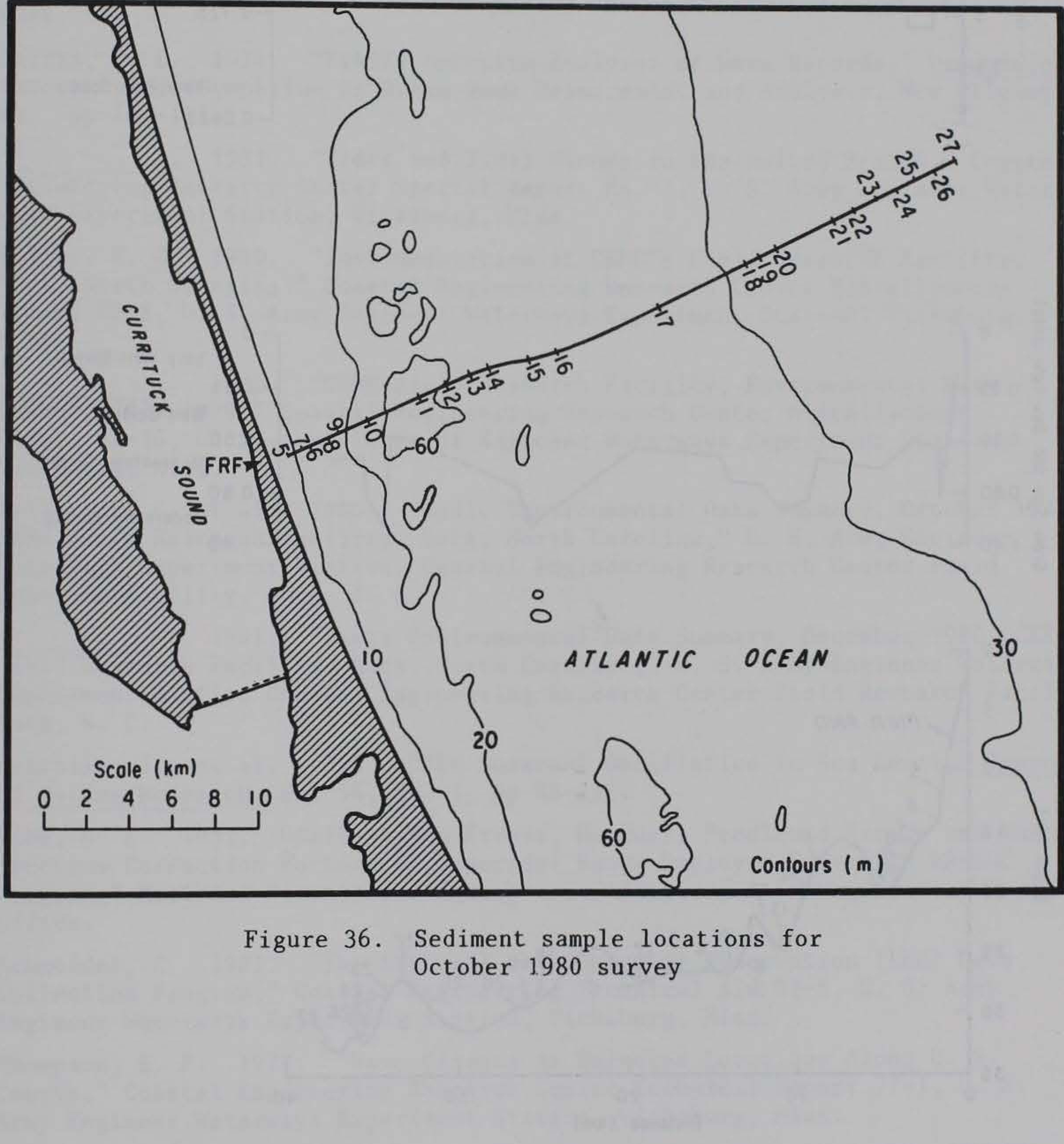


Figure 36. Sediment sample locations for October 1980 survey

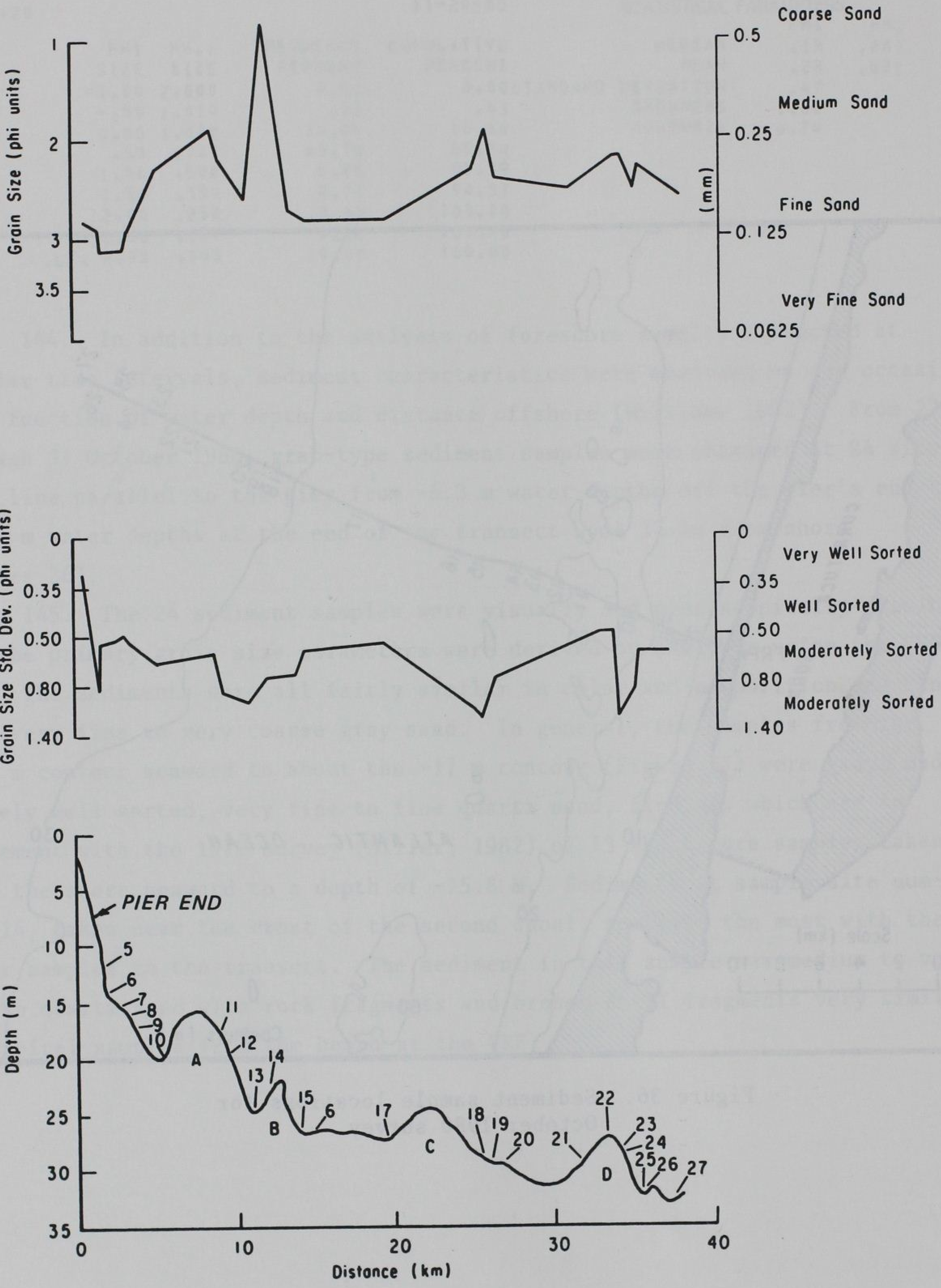


Figure 37. Mean sediment grain size and position along the October 1980 survey line

REFERENCES

Czerniak, M. T. 1972. "Specifications for the Optimum Survey of BEP Profiles," Memorandum for Record, U. S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va.

Duane, D. B., and Meisburger, E. P. 1969. "Geomorphology and Sediments of the Nearshore Continental Shelf, Miami to Palm Beach, Florida," Technical Memorandum No. 29, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Harris, D. L. 1974. "Finite Spectrum Analyses of Wave Records," Proceedings, International Symposium on Ocean Wave Measurement and Analysis, New Orleans, La. pp 107-124.

___________. 1981. "Tides and Tidal Datums in the United States," Coastal Engineering Research Center Special Report No. 7, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Miller, H. C. 1980. "Instrumentation at CERC's Field Research Facility, Duck, North Carolina," Coastal Engineering Research Center Miscellaneous Report 80-8, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

___________. 1982. "CERC Field Research Facility, Environmental Data Summary 1977-1979," Coastal Engineering Research Center Miscellaneous Report 82-16, U. S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, Miss.

Miller, H. C. et al. 1980. "Basic Environmental Data Summary, October 1980, CERC Field Research Facility, Duck, North Carolina," U. S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center Field Research Facility, Duck, N. C.

___________. 1981. "Basic Environmental Data Summary, December 1980, CERC Field Research Facility, Duck, North Carolina," U. S. Army Engineer Waterways Experiment Station Coastal Engineering Research Center Field Research Facility, Duck, N. C.

Pattullo, J., et al. 1955. "The Seasonal Oscillation in Sea Level," Journal of Marine Research, Vol 14, No. 1, pp 88-155.

Ribe, R. L. 1981. "Calibration Errors, Datawell Predicted Errors and Energy Spectrum Correction Factors of Waverider Buoys Deployed Under the ARSLOE Program," National Oceanic and Atmospheric Administration Engineering Support Office.

Schneider, C. 1981. "The Littoral Environmental Observation (LEO) Data Collection Program," Coastal Engineering Technical Aid 81-5, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Thompson, E. F. 1977. "Wave Climate at Selected Locations Along U. S. Coasts," Coastal Engineering Research Center Technical Report 77-1, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

U. S. Army Corps of Engineers, Coastal Engineering Research Center (CERC). 1977. Shore Protection Manual, 3d ed., Vols I, II, and III, Stock No. 008-022-00113-1, U. S. Government Printing Office, Washington, D. C.

Vincent, C. L. 1981. "A Method for Estimating Depth-Limited Wave Energy," Coastal Engineering Technical Aid 81-16, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Williams, S. J. 1982. "Geological Characteristics of the Shoreface to Mid-Continental Shelf off Duck, North Carolina," Coastal Engineering Research Center unpublished report, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

National Oceanic and Atmospheric Administration, National Weather Service; "Weather Service Observing Handbook No. 1--Marine Surface Observations," 1974. Reprinted Jun 1979.

Wood, F. J. 1978. "The Strategic Role of Perigean Spring Tides in Natural History and North American Coastal Flooding," National Oceanic and Atmospheric Administration, National Ocean Survey, Rockville, Md.

APPENDIX A: METEROLOGICAL DATA

1. Meterological data summaries are explained below:

   a. Keynotes on meteorological observations (Page A2). Presented for use in interpreting the monthly meteorological data tables is a list of observation symbols and their definitions.

   b. Monthly data tables (Pages A3-A14). The daily meteorological observations are tabulated by month. The "Amount of Precipitation" represents the total precipitation since the rain gage was last reset (i.e., the bucket was emptied); consequently, the values entered on a Monday represent the total rainfall since the previous reading, which frequently was made on the previous Friday. The same situation holds true for the maximum and minimum thermometers, which are manually reset: the values reported represent the temperature extremes since the last resetting.

2. Monthly average cloud cover, visibility, atmospheric pressure, temperature extremes, dew point temperatures, and wind speed values, as well as the total monthly precipitation, are entered at the bottom of each table.

Table A1

Keynotes on Meterological Observations

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1. Wind Field Gustiness (WFG): A plus symbol (+) is entered if the wind speed varies by more than 5 m/sec.

2. Variation (VAR): The peak value of the wind speed is entered under VAR when the peak value exceeds the value of the wind speed by at least 5 m/sec.

3. Weather conditions:

WS Water spout
TH Thunderstorm
FD Freezing drizzle
F Fog
SS Snow shower
RS Rain shower
H Hail
S Snow
R Rain
D Drizzle
K Haze or smoke

4. Intensity of weather conditions:

(+) Unusually intense
(-) Mild conditions

5. Pressure Trend:

First number indicates characteristic of change

0 = Increasing then decreasing
1 = Increasing then steady, or increasing more slowly
2 = Increasing either steady or unsteady
3 = Decreasing or steady, then increasing; or increasing, then increasing more rapidly
4 = Steady
5 = Decreasing then increasing
6 = Decreasing then steady or decreasing more slowly
7 = Decreasing steady or unsteady
8 = Steady or increasing then decreasing or decreasing then decreasing more slowly

Next two columns indicate code of the amount of change in last 3 hours; higher numbers indicate more change, i.e.

00 = 0.0 millibars
51 = 5.1 millibars
100 = 10.0 millibars
200 = 20.0 millibars

Table A2

January 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visibility km	Amount of Precipitation, mm	Atmospheric Pressure mb	Pressure Trends	High Temperature °C	Low Temperature °C	Dry Bulb Temperature °C	Wet Bulb Temperature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direction (True N)	WFC	VAR
1	0730	D		100	8	0	1010.7	000									
2	0730			25	16	9	1010.7	230	11	2	3.0	2.0	1	1.0	320		
3	0730			0		0	1021.6	227	8	1	1.0	1.0	1		320		
4	0730			90	16	0	1022.6	500	8	1	8.0	7.0	6	6.7	050		
5	0730			100	16	9	1003.9	303	4	3	5.0	5.0	5	7.2	320		
6	0730			0	24	4	1020.5	237	5	-2	-2.0	-2.5	-3.5	6.1	320		
7	0730			10	24	0	1023.9	707	4	-2	03.0	2.0	1	5.1	230		
8	0730			100	5	5	1022.6	220	11	3	6.0	6.0	6	2.6	320		
9	0730					4	1024.6	603	8	6	7.0	7.0	7				
10	0730			50	24	0	1036.1	224	7	4	9.0	3.0	2	8.2	050		
11	0730	D		75	8	0	1027.7	810	11	4	9.0	8.5	8.5	5.1	190		
12	0730			50	24	13	1019.2	230	20	8	9.0	8.0	7	6.2	320		
13	0730			100	24	0	1031.7	00	11	5	06.0	5.0	4	8.2	050		
14	0730	F		100	1	4	1012.8	527	11	6	11.0	11.0	11	3.0	050		
15	0730	F		100	5	14	1017.8	124	14	8	08.5	8.5	8.5	8.2	320		
16	0730			10	24	0	1024.6	217	14	4	05.0	4.0	3	5.1	320		
17	0730			60	19	0	1024.9	400	9	4.1	7.0	6.5	6.5	5.1	050		
18	0730			100	3	0	1023.2	103	10	7	8.0	8.0	8	3.0	050		
19	0730			25	16	6	1021.6		11	5	5.5	5.0	4	6.2	310		
20	0930			40	24	0	1026.0	317	9	1	7.0	5.0	3	3.6	310		
21	0730			25	24	0	1020.5	207	9	4	4.5	4.0	3	5.7	360		
22	0730			75	24	0	1017.5	607	8	3	8.0	6.0	4	5.1	220		
23	0730	D		100	8	9	997.9	500	14	8	3.0	8.0	8	6.7	320		
24	0730			10	24	3	1011.7	227	8	-2	-1.0	-2.0	-4	7.2	310		
25	0730			50	24	0	1006.3	314	6.1	-2	6.0	5.0	4	5.7	250		
26	0730			50	16	0	1016.8	234	12	6	6.5	5.0	3	8.2	450		
27	0730	R	-	100	16	1	1018.2	303	7	4	4.0	4.0	4	8.2	040		
28	0730			90	24	3	1019.2	317	6	3	3.5	2.5	1.5	4.1	310		
29	0730			100	24	0	1020.6	103	7	3	6.0	4.5	2.5	8.2	040		
30	0730			75	24	0	1026.2	210	6	-3	-1.0	-2.0	-4	7.7	310		
31	0730	S	-	100	2	5	1016.1	524	2	-3	-1.0	-1.0	-1	6.2	310		
Monthly average:				64	17		1019.2		9	3			4	5.8			
Monthly total:						89											

Table A3

February 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visi-bility km	Amount of Precipita-tion, mm	Atmos-pheric Pressure mb	Pressure Trends	High Temper-ature °C	Low Temper-ature °C	Dry Bulb Temper-ature °C	Wet Bulb Temper-ature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direc-tion (True N)	WFC	VAR
1	0730			10	24	8	1017.8	107	-1	-7	-7.0	-7.0	-7	9.3	310		
2	0730			0	24	0	1024.3	220	-2	-8	-7.0	-8.0	-7	8.2	310		
3	0730			10	24	0	1027.0	214	-1	-8	-7.0	-7.0	-7	6.2	300		
4	0730			60	24	0	1023.9	400	0	-10	-4.0	-6.0	-2	6.2	310		
5	0730			10	24	0	1027.0	310	0	-5	-4.0	-5.0	-7	6.2	320		
6	0730			100	24	0	1024.3	500	2	-6	1.0	0.0	-2	3.1	40		
7	0730					13	1017.8	234									
8	0730			0	24	6	1029.7	217	5	-5.4	-3.0	-4.0	-7	6.2	320		
9	0730			100	8	0	1026.0	400	3	-6	0.0	-1.0	-3	3.1	330		
10	0730	SS	-	100	8	2	1009.4	124	3	-1	0.0	0.0	0	11.8	330		
11	0730			0	24	0	1020.2	317	2	-5	-4.0	-5.0	-8	4.6	310		
12	0730			40	24	0	1017.2	127	5	-4	0.0	-1.0	-3	5.1	320		
13	0730			0	27	0	1029.3	220	4	-4	0.0	-2.0	-6	6.2	20		
14	0730			0	24	0	1029.3		3	-6	-2.0	-3.0	-5	3.1	170		
15	0730			75	16	0	1022.6	400	9	-2	3.0	2.0	1	4.1	30		
16	0730	K	-	100	24	0	1003.6	730	10	2	7.5	6.0	4	6.2	170		
17	0730			90	24	4	1013.4	227	11	-3	-4.0	-2.5	-6	9.3	320		
18	0730			0	24	0	1026.3	227	1	-11	-8.0	-9.0	-12	2.6	310		
19	0730			90	24	0	1025.3	610	4	-8	3.0	2.0	1	4.1	40		
20	0730	F	+	50	1	0	1014.4	400	8	-3	5.0	4.0	3	4.6	40		
21	0730			0	16	0	1014.1	317	13	4	7.0	6.0	5	4.1	230		
22	0730	F		100	1	1	1015.8	107	15	6	10.0	10.0	10	3.6	220		
23	0730			0	24	0	1012.1	310	19	9	12.0	11.0	10	3.6	220		
24	0730	F	+	100	1	8	1016.8	327	16	7	7.0	7.0	7	5.1	320		
25	0730			100	16	0	1012.1	507	9	3	7.0	6.0	5	9.3	40		
26	0730	SS	-	100	16	6	1007.7	247	7	0	1.0	0.0	-2	8.2	310		
27	0730			0	24	0	1021.2	720	6	-5	1.0	-1.0	-5	6.7	210		
28	0730			100	24	0	1014.8	004	9	1	4.0	2.0	-1	5.1	50		
29	0730			50	24	0	1019.2	241	5	-1	0.0	-1.0	-3	10.8	330		
Monthly average:				49	19		1019.4		3	-2			-2	6.0			
Monthly total:						66											

Table A4

March 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visibility km	Amount of Precipitation, mm	Atmospheric Pressure mb	Pressure Trends	High Temperature °C	Low Temperature °C	Dry Bulb Temperature °C	Wet Bulb Temperature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direction (True N)	WFC	VAR
1	0730			100	24	0	1030.7	303	2	-4	-3.0	-4.0	-7	9.3	20		
2	0730			100	1	0	1013.8	003	1	-4.4	0.0	-1.0	-3	14.4	20	+	
3	0730			100	16	11	1020.2	107	1	-7.1	1.0	0.0	-2	6.2	330		
4	0730			40	24	0	1023.6	103	1	-7	-1.0	-2.0	-4	4.1	220		
5	0730			100	12	0	1020.9	107	8	-1	6.0	5.0	4	2.1	180		
6	0730	F	-	100	13	1	1022.6	247	9	3	5.0	4.0	3	6.2	20		
7	0730			25	8	0	1026.6	400	7	-6	4.0	3.0	2	3.1	180		
8	0730	F	-	100	16	0	1017.8	607	18	3	13.0	12.0	11	5.1	180		
9	0730	F	+	100	1	6	1009.4	317	15	9	10.0	10.0	10	5.1	270		
10	0730			25	24	0	1014.4	103	16	2	7.0	6.0	5	2.1	70		
11	0730			0	24	1	1007.3	237	13	7	10.0	8.0	6	6.7	300		
12	0730			100	24	0	1021.2	220	11	2	4.0	2.0	-1	7.7	40		
13	0730	D	-	100	8	4	1014.1	730	8	2	8.0	7.0	6	5.1	70		
14	0730			25	24	3	1009.7	230	18	3	5.0	4.0	3	9.3	290		
15	0730			00	24	0	1028.3	227	12	2	5.0	3.0	0	5.7	330		
16	0730			00	24	0	1032.7	170	14	4	8.0	7.0	6	1.5	180		
17	0730			100	24	0	1026.3	607	17	8	16.5	13.0	10	5.1	200		
18	0730			100	24	10	1011.1	314	21	15	15.0	15.0	15	7.2	240		
19	0730			00	24	1	1030.7	224	16	3	6.5	5.0	3	3.1	40		
20	0730	F	-	100	3	0	1025.3	807	11	6	11.0	10.0	9	4.1	150		
21	0730	R	-	100	8	12	1003.6	734	21	10	11.0	11.0	11	9.8	200		
22	0730			10	24	3	1005.3	210	22	6	8.0	5.0	1	12.9	300		
23	0730			00	24	0	1021.6	227	12	3	4.0	3.0	2	7.5	330		
24	0730			100	24	0	1020.9	317	9	2	10.0	8.0	6	5.1	240		
25	0730			00	24	11	1007.0	241	16	8	12.5	10.0	8	6.2	300		
26	0730			100	8	0	1020.9	224	17	6	6.5	5.0	3	6.2	30		
27	0730			25	24	0	1026.0	227	8	6	7.0	5.0	3	7.2	20		
28	0730			100	24	0	1028.3	110	10	6	8.0	7.0	6	4.6	60		
29	0730	F	+	100	15	13	1011.7	614	12	8	10.0	10.0	10	3.0	150		
30	0730	F	+	100	3	0	1012.8	107	17	9	10.5	10.0	10	2.6	150		
31	0730	F	+	100	3	13	1004.6	107	14	9	13.0	13.0	13	5.1	290		
Monthly average:				66	16		1018.4		12	4			5	5.9			
Monthly total:						89											

Table A5

April 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visibility km	Amount of Precipitation, mm	Atmospheric Pressure mb	Pressure Trends	High Temperature °C	Low Temperature °C	Dry Bulb Temperature °C	Wet Bulb Temperature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direction (True N)	WFC	VAR
1	0730			100	24	00	1019.2	244	27	6	07.0	05.0	03	7.2	020		
2	0730	F	-	0	5	00	1024.6	110	9	3	08.0	07.0	06	1.5	060		
3	0730	F	-	75	3	00	1020.2	317	20	8	11.5	11.0	11	2.0	020		
4	0730			100	24	00	1009.7	617	18	9	12.5	11.0	10	6.2	200		
5	0730			0	24	6	1011.0	230	23	9	10.5	09.0	08	10.3	330		
6	0730			0	24	00	1023.2	246	16	8	12.0	09.0	06	4.6	020		
7	0730			75	24	00	1026.6	120	14	9	12.0	10.0	08	4.6	110		
8	0730			90	8	00	1027.3	307	16	11	13.0	12.0	11	4.1	150		
9	0730			90	16	00	1015.8	603	19	14	19.0	16.0	14	8.2	200		
10	0730			25	24	100	1010.7	314	22	14	17.0	14.0	12	6.1	240		
11	0730			0	24	00	1017.2	224	24	14	17.0	15.0	14	4.1	240		
12	0730			40	24	00	1020.5	303	21	11	17.0	15.0	14	4.6	200		
13	0730			100	24	00	1015.8	314	26	17	20.0	18.0	17	5.1	290		
14	0730	F	-	100	8	15	1012.4	400	21	11	14.0	13.0	12	4.6	150		
15	0730			10	24	4	1008.3	124	22	12	13.0	11.0/	09	9.7	240		
16	0730			0	24	00	1013.8	214	18	9	11.0	08.0	05	9.3	290		
17	0730			10	24	00	1028.0	224	16	6	07.0	05.0	03	7.2	020		
18	0730			75	24	00	1024.6	400	12	9	12.0	09.0	06	4.1	200		
19	0730			0	24	00	1023.6	303	18	7	14.5	13.0	12	3.0	240		
20	0730			40	16	00	1022.6	400	19	9	13.5	12.0	11	2.0	120		
21	0730			50	16	00	1013.2	303	18	9	14.0	13.0	12	3.0	040		
22	0730			0	16	00	1012.8	310	18	10	16.0	12.0	09				
23	0730			10	24	00	1005.0	214	19	13	19.0	11.0	09				
24	0730			60	24	00	1006.3	117	16	13	16.0	15.0	14				
25	0730	F	+	50	7.5	00	1008.0	114	26	74	15.5	15.0	15				
26	0730			75	16	00	1009.7	117	29	13	15.0	12.0	10				
27	0730			50	16	00	1011.0	310	23	12	29.0	20.0	18				
28	0730			25	16	72	1004.6	503	27	13	15.0	14.5	14.5				
29	0730			0	24	14	1008.0	220	19	11	16.0	15.0	14				
30	0730			90	24	00	1005.3	107	23	14	14.5	12.5	11.5				
Monthly average:				45	22		1015.3		20	11			11	5.3			
Monthly total:						112											

Table A6

May 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visibility km	Amount of Precipitation, mm	Atmospheric Pressure mb	Pressure Trends	High Temperature °C	Low Temperature °C	Dry Bulb Temperature °C	Wet Bulb Temperature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direction (True N)	WFC	VAR
1	0730			100	16	1	1005.6	400	19	12	13.5	12.0	11				
2	0730			50	16	2	1012.8	114	14	11	15.0	13.5	12				
3	0730			60	24	0	1014.4	400	21	9	16.4	12.0	9				
4	0730	K	-	60	16	3	1011.1	303	23	9	19.0	15.0	12				
5	0730	K	-	60	16	0	1010.4	400	24	14	21.0	17.0	15				
6	0730	K	-	40	16	0	1006.0	400	29	18	21.0	17.0	15				
7	0730	K	-	40	16	0	1008.3	227	28	19	21.5	16.5	13.5				
8	0730	K	-	100	3	0	1007.3	310	24	16	16.0	14.0	13	5.1	20		
9	0730			75	24	1	1013.8	330	17	11	13.5	9.0	5	7.2	20		
10	0730			25	24	0	1020.2	224	17	9	16.0	12.0	9	1	120		
11	0730			75	24	0	1019.5	314	21	12	20.5	16.0	13	4.6	200		
12	0730			75	24	0	1018.2	310	26	19	22.0	19.0	17	5.1	240		
13	1200			50	24	0	1014.4	400	30	21	28.0	23.0	21	4.6	240		
14	0730			100	16	0	1012.1	307	31	22	22.5	20.0	19	4.0	240		
15	0730			100	24	1	1018.8	327	28	14	15.0	13.0	12	6.2	20		
16	0730			00	24	0	1026.0	224	18	12	16.0	13.0	11	5.7	60		
17	0730			25	24	0	1029.3	310	18	13	16.0	14.0	13	3.1	60		
18	0730			100	16	1	1021.6	710	21	15	21.0	19.0	18	3.1	200		
19	0730			50	16	0	1017.5	310	24	20	23.0	21.0	20	3.9	240		
20	0730			100	16	6	1013.8	303	31	16	22.5	21.5	21.5	1.5	240		
21	0730			90	24	24	1010.7	230	28	19	21.5	20.0	19				
22	0730	F	-	40	8	0	1020.2	214	26	14	20.5	18.0	17	2	40		
23	0730	F	-	100	16	0	1018.8	303	24	18	20.0	19.0	19	3.1	180		
24	0730				16	0	1012.8	103	22	10	22.0	21.5	21.5				
25	0730				11	0	1002.6		34	19	24.0	22.0	21				
26	1200			00	16	0	1010.4	214		17	19.5	17.0	16	8.1	40		
27	0730			00	24	0	1016.8	224	21	11	19.5	15.0	12	6.1	40		
28	0730			00	24	0	1019.9	114	23	15	23.0	18.0	15	4.1	290		
29	1045			00	16	0	1019.9	114	28	17	28.0	21.5	18	1.6	200		
30	0815			90	15	0	1022.2	151	29	20	22.0	19.5	18	5.1	130		
31	0830			10	15	0	1023.6	117	30	21	25.0	21.5	20	7.1	230		
Monthly average:				58			1015.5		24	15			15	4.4			
Monthly total:						39											

Table A7

June 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visibility km	Amount of Precipitation, mm	Atmospheric Pressure mb	Pressure Trends	High Temperature °C	Low Temperature °C	Dry Bulb Temperature °C	Wet Bulb Temperature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direction (True N)	WFC	VAR
1	0850			50	8	0	1017.5	103	30	22	24.0	21.0	20				
2	0830			0	15	0	1016.8	400	31	22	25.0	21.5	20	8.2	250		
3	0830			40	16	0	1014.4	107	31	22	25.0	21.0	19	3.2	250		
4	0815			75	8	0	1013.4	220	33	21	21.0	18.5	17.5	4.6	230		
5	0805			0	24	0	1020.5	220	23	18	23.0	17.0	13	6.7	230		
6	0745			60	24	0	1022.6	207	24	13	23.0	16.0	11	4.1	200		
7	0745			0	15	0	1016.8	007	27	22	23.0	20.5	19.5	8.2	250		
8	0745			75	11	0	1008.4	610	29	23	25.5	23.0	22	8.2	250		
9	0800			10	24	0	1015.8	210	32	15	18.5	12.0	06	7.2	040		
10	0815			0	24	0	1011.1	310	23	16	23.0	18.0	15	7.2	250		
11	0815			0	15	3	1018.8	217	29.1	17	19.5	17.5	16.5	6.2	070		
12	0720			0	15	0	1024.9	217	22	17	19.5	16.0	14	9.3	050		
13	0730			0	24	0	1024.6	114	21	16	19.0	14.0	10	9.3	070		
14	0845			90	15	0	1017.5	103	21	16	19.0	16.0	14	6.2	020		
15	0740			0	5	0	1013.4	103	23	19	23.5	21.0	20	7.7	250		
16	0835			0	0	0	1011.7	203	33	23	27.0	23.0	21	6.7	250		
17	0730			50	24	0	1017.8	114	34	18	20.5	17.0	15	11.3	020		
18	0710			90	24	0	1018.2	503	22	17	19.5	15.5	13	6.2	110		
19	0730			10	24	1	1016.1	114	21	17	21.0	18.5	17.5	6.2	070		
20	0730			25	24	00	1014.5	003	23	16	23.0	20.0	19	6.2	250		
21	0730			100	16	00	1020.9	110	31	11	21.0	17.0	15	2.1	020		
22	0730			0	24	0	1020.2	214	25	16	21.5	17.0	14	4.1	020		
23	0730			40	24	0	1022.9	214	26	13	23.0	19.0	17	3.1	250		
24	0730			90	24	0	1022.6	207	29	21	24.0	20.0	18	4.1	200		
25	0730			100	16	0	1019.5	500	28	20	23.0	20.0	19	3.1	110		
26	0800			100	1	29	1012.4	500	24	18	19.0	19.0	19	4.1	090		
27	0830			100	19	9	1015.5	217	24	18	23.5	22.5	22.5	3.1	290		
28	0700			50	8	0	1015.1	103	27	23	24.5	24.0	24	5.2	250		
29	0830			0	16	0	1013.4	603	33	24	27.0	25.0	24	6.2	250		
30	0815			50	24	23			34	19	25.5	24.0	23				
Monthly average:				40	17		1017.1		27	18			17	6.2			
Monthly total:						60											

Table A8

July 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visibility km	Amount of Precipitation, mm	Atmospheric Pressure mb	Pressure Trends	High Temperature °C	Low Temperature °C	Dry Bulb Temperature °C	Wet Bulb Temperature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direction (True N)	WFC	VAR
1	0815			00	6	1	1017.8	220	29	18	24.5	21.0	19	3.1	20		
2	0725			10	8	0	1021.9	214	27	20	25.0	23.5	22.5	3.1	160		
3	0845			75	8	0	1018.8	707	32	25	28.0	24.0	22	12.9	140		
4	0800			75	15	11	1018.5	110	33	22	26.0	24.0	23	5.1	270		
5	0830			10		1	1015.5	130	31	24	26.0	24.5	23.5	6.1	250		
6	0930			00		17	1011.7	207	33	18	26.0	25.0	25	3.6	340		
7	0745			00	32	1	1019.1	317	31	22	24.0	19.0	16	5.1	70		
8	0815			00	27	0	1019.9	114	26	18	23.5	20.0	18	5.6	250		
9	1000			75	15	0	1017.1	203	29	19	26.0	23.0	22	2.1	20		
10	1000			100		0	1014.1	403	28	23	25.0	24.0	24	3.1	290		
11	0730			50	8	1	1010.4	214	27	21	24.0	23.0	23	3.1	320		
12	0830			00	8	0	1011.4	203	29	23	28.0	25.0	24	3.6	250		
13	0745			40	16	25	1011.7	317	33	20	24.5	23.5	23.5	4.1	20		
14	0800			10	26	0	1018.5	110	27	22	25.5	21.0	19	4.1	90		
15	0945			10	32	0	1020.5	803	28	18	25.0	22.0	21	2.1	90		
16	0700			00		0	1016.1	510	29	23	29.0	24.0	22	7.2	270		
17	0700			00	15	0	1014.4	300	33	24	27.0	24.0	23	6.1	200		
18	1015			60		7			33	19	24.5	22.0	21	4.6	160		
19	0815			10	24	0	1021.9	207	32	22	29.0	26.0	25	5.1	250		
20	0900			10		0	1021.6	237	33	25	29.5	26.5	25.5	5.6	290		
21	0715			25	24	0	1022.6	214	34	25	26.5	25.0	24	8.1	250		
22	0730			25	24	0	1020.5	103	33	27	27.5	25.0	24	6.1	250		
23	0815			90	11	0	1017.8	807	33	25	28.0	25.0	24	5.1	200		
24	0845			90	15	0	1012.8	103	31	117	22.5	22.5	22.5	3.6	20		
25	1130			40	24	0			28	16	27.0	23.0	21	2.1	70		
26	0700			00	6	0	1018.5	400	29	119	24.0	22.0	21	1.1	130		
27	0900			60	16	0	1016.5	303	29	21	25.0	23.0	22	3.1	160		
28																	
29	0810			100	24	0			29	20	26.5	25.0	24	3.1	270		
30	0800			10	8	0	1014.4	214	31	23	27.0	23.0	21	2.6	320		
31	0930			40	8	0	1018.2	107	33	25	30.0	26.0	25	4.1	250		
Monthly average:				35	16		1017.1	--	30	21	--	--	22	4.5			
Monthly total:						64											

Table A9

August 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visi-bility km	Amount of Precipita-tion, mm	Atmos-pheric Pressure mb	Pressure Trends	High Temper-ature °C	Low Temper-ature °C	Dry Bulb Temper-ature °C	Wet Bulb Temper-ature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direc-tion (True N)	W F C	V A R
1	0815			0	8	0	1014.8	705	34	26	29.0	26.0	25	5.2	250		
2	0920			0	13	0	1015.1	306	37	23	33.0	25.0	23	3.1	290		
3	0800			0	8	0	1012.4	004	34	25	29.0	27.0	26	5.7	250		
4	0730			0	13	0	1014.8	214	36	26	29.0	26.0	25	6.2	250		
5	0915			40	13	0	1020.2	210	36	26	31.0	27.0	26	6.2	250		
6	0730			40	8	0	1021.9	310	36	26	29.0	26.0	25	6.2	320		
7	1135			10	8	23	1021.2	000	35	22	28.5	26.0	25	1.5	050		
8																	
9	0800			0	6	0	1013.8	303	31	26	28.0	26.0	25	4.1	320		
10	0730	F		100	2	0	1013.8	400	34	23	24.0	23.0	23	3.1	320		
11	0800			100	8	0	1017.2	114	31	23	28.0	25.0	24	7.2	250		
12	1130			50	24	0	1019.1	810	34	26	31.5	26.0	24	6.2	250		
13	0730	F		20	3	17	1014.8	207	34	18	25.5	24.0	23	3.6	320		
14	0730	F	+	10	2	5	1016.8	400	27	21	26.0	25.0	25	4.6	130		
15	0715			90	24	0	1015.8	307	32	25	27.0	25.0	24	6.2	250		
16	0815			100	8	0	1013.8	227	33	20	22.0	21.0	21	4.1	020		
17	1030			75	24	0	1023.3	314	27	19	23.0	20.0	19	7.2	050		
18	0800			90	24	0	1020.5	103	25	18	29.0	21.5	19	2.6	160		
19	0700			90	16	3	1018.8	500	26	21	25.0	23.5	22	4.1	230		
20	1600			25	3	0	1015.5	407	28	21	23.0	22.0	22	4.1	360		
21	0800			40	3	0	1014.1	407	25	22	23.0	20.0	19	5.2	050		
22	0730			75	16	0	1012.4	307	24	18	22.5	20.0	19	8.2	020		
23	0815			50	3	0	1018.2	220	24	18	22.0	21.0	21	6.2	020		
24	0710			0		0	1019.9	303	24	17	23.0	20.0	19	4.1	020		
25	1015			0		0	1021.9	207	26	15	25.0	22.0	21	3.1	020		
26	1415			0		0	1021.6	710	27	21	26.5	23.5	22.5	4.1	020		
27	0630			0		0	1021.9	307	27	16	23.0	22.0	22	2.6	050		
28	0930			0		0	1023.9	107	29	21	26.0	22.0	20	3.6	320		
29	0715			40		0	1025.3	110	30	21	24.5	23.5	23.5	1.0	320		
30	0730			10		0	1023.9	103	29	21	24.0	23.0	23	7.0	090		
31	0730			40		0	1022.2	107	29	21	25.5	23.9	22	2.0	130		
Monthly average:				37	11		1018.1		30	21			23	4.4			
Monthly total:						48											

Table A10

September 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visibility km	Amount of Precipitation, mm	Atmospheric Pressure mb	Pressure Trends	High Temperature °C	Low Temperature °C	Dry Bulb Temperature °C	Wet Bulb Temperature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direction (True N)	WFC	VAR
1																	
2	0730			25		0	1021.2	110	32	23	28.0	25.0	24	6.1	250		
3	0715			100		0	1020.5	310	34	25	26.0	24.0	23	4.6	290		
4	0715	F	+	100		0	1022.3	114	29	22	25.0	24.0	24	4.1	70		
5	0700	F	-	40		0	1022.6	400	29	19	25.5	25.0	25	1.1	90		
6																	
7																	
8	0700			40		0	1018.5	207	30	19	23.0	20.0	19	1.1	360		
9	0645			00		0	1021.2	314	28	22	24.0	19.0	16	2.1	50		
10	0645	F	-	75		0	1017.1	303	29	20	24.5	22.0	21	5.1	250		
11	0645			00		0	1017.5	314	30	21	22.5	18.0	16	7.1	50		
12	0700			00		0	1019.9	310	27	11	23.4	20.0	19	2.1	50		
13																	
14																	
15	0700			40		0	1009.7	400	30	21	26.0	23.0	22	4.1	250		
16	0800			50		0	1017.5	317	29	22	24.0	22.0	21	4.1	70		
17	0700			40		0	1015.8	107	26	23	26.0	24.0	23	3.6	200		
18	1034			25		0	1017.5	803	33	25	30.0	27.0	26	3.1	230		
19	0930			10		0	1024.3	117	29	23	26.0	23.0	22	5.1	70		
20																	
21																	
22	0715			00		0	1017.8	400	31	21	25.5	23.0	22	6.1	250		
23	0730			75	16	0	1013.3	100	33	24	26.0	24.0	23	6.1	250		
24	0830			100	16	0	1017.1	120	33	22	24.4	22.0	21	6.1	50		
25	0800			100	16	23	1017.5	303	24	22	22.5	21.5	21.5	5.1	250		
26	0730			75	16	3	1017.1	214	28	22	25.0	23.0	22	5.6	290		
27	0700			100	24	0	1024.6	217	29	18	18.5	14.0	11				
28																	
29	0900			90	24	0	1021.2	803	22	12	22.0	10.0	16				
30	0800			100	16	4	1013.8	607	23	21	22.0	21.0	21				
31																	
Monthly average:				54			1018.5		29	21			21	4.3			
Monthly total:						30											

Table A11

October 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visibility km	Amount of Precipitation, mm	Atmospheric Pressure mb	Pressure Trends	High Temperature °C	Low Temperature °C	Dry Bulb Temperature °C	Wet Bulb Temperature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direction (True N)	WFC	VAR
1	0830			100	16	14	1008.4	314	23	21	20.5	20.0	20				
2	0730	F	+	60	8	3	1009.7	307	22	19	20.0	19.0	19	2.1	250		
3	0800	F	+	90	13	0	1010.0	303	25	18	20.0	19.0	19	1.0	270		
4																	
5																	
6	0900			75	19	2	1022.2	314	26	13	19.0	16.0	14	11.3	50		
7	0645			10	24	0	1021.2	400	19	11	12.5	10.0	8	3.1	290		
8	0615	F	+	0	6	0	1017.5	400	21	12	15.0	13.5	11	3.1	250		
9	0625			0	16	0	1047.0	400	24	14	17.5	15.0	13	5.1	250		
10	0630			10	16	0	1015.5	310	26	17	19.0	18.0	18	1.0	20		
11	1030	K	+	40	8	0	1011.1	714	27	18	23.0	21.0	20	5.1	230		
12																	
13																	
14	0800			0	24	0	1024.9	317	27	7	14.0	9.0	4	5.1	340		
15	0700	K	-	25	16	0	1025.3	307	17	9	6.0	3.5	2	3.1	200		
16	0740			0	16	0	1026.0	303	23	12	18.0	16.5	15	3.1	200		
17	0715			0	16	0	1024.3	400	25	16	19.5	18.5	18	1.0	130		
18																	
19																	
20	0915			75	24	21	1014.1	234	26	14	17.0	13.0	10	10.3	20		
21	0800			0		0	1019.9	314	17	14	18.0	14.0	11	5.1	250		
22	0645			75	24	0	1019.2	303	21	15	15.5	14.0	13	2.1	230		
23	0730			75	24	0	1028.7	220	19	11	17.0	13.5	7	10.3	70		
24	0730			100	24	0	1027.0	703	17	14	16.5	14.0	12	12.9	70	+	
25	1000			100	24	23	1002.9	317	22	15	17.5	17.0	17	8.2	20		
26																	
27	0900			25	24	0	1025.3	120	18	5	13.5	10.0	7	3.6	70		
28	0715			100	24	0	1017.5	810	16	11	15.0	13.0	12	5.1	200		
29	0930			100	24	0	1021.9	234	21	13	14.0	12.0	11	10.3	20		
30	0730			100	16	4	1025.3	307	14	10	10.0	10.0	10	8.8	20		
31	1000			10	24	6	1021.6	803	12	7	11.0	9.0	7	3.6	290		
Monthly average:				45	16		1020.3		21	13			12	5.4			
Monthly total:						73											

Table A12

November 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visibility km	Amount of Precipitation, mm	Atmospheric Pressure mb	Pressure Trends	High Temperature °C	Low Temperature °C	Dry Bulb Temperature °C	Wet Bulb Temperature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direction (True N)	W F C	V A R
1	0730			0	16	0	1017.2	314	15	8	9.5	6.5	2	3.1	290		
2																	
3	0800			10	24	0	1030.0	207	18	7	12.0	8.5	4	3.6	70		
4	0900			50	24	0	1020.2	717	21	12				3.1	180		
5	0800			25	24	19	1011.1	217	23	12				5.1	340		
6	0815			0	24	0	1018.8	224	16	11				6.2	360		
7	0730			0	16	0	1017.5	303	14	11				6.2	200		
8																	
9																	
10	0900			0	16	0	1012.1	110	23	10				7.2	290		
11																	
12	0755			40	24	0	1020.9	314	22	3				9.3	340		
13	0845			0	24	0	1027.0	324	11	3				4.1	290		
14	1130			0	14	0	1022.6	814	14	7				6.2	250		
15																	
16																	
17	1000			25	16	4	1026.6	703	19	8				8.6	70		
18	0815			50	16	42	1006.0	303	19	8				4.6	290		
19	1100			90	16	0	1025.3	214	11	3				7.2	340		
20	0950			40	24	0	1029.3	214	6	-3				3.1	290		
21	0730	R	+	100	2	5	1022.2	807	11	9				5.1	340		
22																	
23																	
24	1200			100	8		1018.8	734	14	3				5.7	130		
25	1000			40	16	17	1021.2	120	17	11				9.3	360		
26	0800			75	24	0	1030.7	217	13	3				9.3	20		
27																	
28	0955			100	6	9	1007.7	403	18	6				5.1	250		
29																	
30																	
Monthly average:				39	17		1020.3		16	7				5.9			
Monthly total:						96											

Table A13

December 1980 Daily Meteorological Observations

Day	Time	Prevailing Weather Conditions	Intensity	0-100% Cloud Cover %	Visibility km	Amount of Precipitation, mm	Atmospheric Pressure mb	Pressure Trends	High Temperature °C	Low Temperature °C	Dry Bulb Temperature °C	Wet Bulb Temperature °C	Dew Point °C	Land Wind Speed m/sec	Land Wind Direction (True N)	WFC	VAR
1	1005			0	27	0	1023.6	110	12.8	3.9				6.2	250		
2	0800			60	16	0	1021.9	400	16.1	6.1				4.1	250		
3	0815			0	26	0			18.3	5.0				11.3	320		
4	0900			0	24	0	1030.7	214	10.6	1.7				4.1	320		
5	0830			60	24	0	1026.3	310	7.8	1.7				6.2	340		
6																	
7																	
8	0815	F	-	25	3	0	1022.2	400	15.0	2.2				4.1	250		
9	0830			50	8	0	1016.5	307	20.0	10.0				5.1	250		
10	0800	F/R	+/-	100	2	4	1013.1	303	18.3	13.3				3.6	250		
11	0815			40	16	19	1021.9	224	14.4	5.0				6.2	50		
12	0730	F	-	0	8	0	1022.9	307	8.3	-0.6				1.5	250		
13																	
14																	
15	0930			40	24	0	1022.2	303	15.0	2.8				4.1	70		
16	0815	F	+	100	3	8	1007.7	303	12.2	8.9				2.6	360		
17						4											
18	0940			0	24	0	1020.2	400	10.0	-3.9				6.2	200		
19	0825			0	16	0	1017.8	310	10.6	5.6				5.1	200		
20																	
21																	
22	0800			25	24	0	1036.8	400	12.8	-3.3				5.1	70		
23	0910	R	-	100	5	14	1024.3	203	10.0	2.2				3.6	360		
24	1130	F	+	100	0	0	1016.5	720	6.1	2.2				3.1	200		
25																	
26																	
27						4											
28						4											
29	1045	F	+	100	0	4	1010.7	403	13.3	-7.2				6.2	20		
30	1100	K		90	5	0	1013.1	120	7.2	5.0				8.2	360		
31	1200			100	19	0	1015.1	810	7.2	3.3				7.7	20		
Monthly average:				50	14		1020.2	--	12	3	--	--	--	5.2			
Monthly total:						61											

APPENDIX B: WAVE DATA

The wave data are summarized in the following forms:

a. Gage histories. Table B1 includes information about the gage, gage installation, and major interruptions in the data collection. Short interruptions in the operational status of the gage are not mentioned.

b. Time histories. All significant wave height and peak spectral wave period values are plotted as a function of the time throughout the year (see Figures B1, B4, B7, B10, and B13). So that the sequence of the data can be followed easily, solid lines connect consecutive data points for times when there is a gap smaller than 24 hours between observations.

c. Annual, seasonal, and monthly maxima, mean, and standard deviations of significant height and peak period. Mean significant wave height and standard deviation, mean peak wave period and standard deviation, and the extreme significant heights are listed in Tables B2, B6, B10, B14, and B18. Also included is the total number of observations obtained; at four observations per day, the maximum number of observations per month (based on a 30-day month) is 120. Frequently during 1980 the backup recorder was used and only two observations per day were recorded (except during storms and special events), or 60 observations during a 30-day month.

d. Maxium, mean, and standard deviations of significant height and peak period. The data presented in the tables described above are also graphed (see Figures B2, B5, B8, B11, and B14) for each month and for the year. The standard deviations are presented as "T" bars originating at the mean value and extending to the mean plus one standard deviation value. The extreme values are plotted above. No extreme period values are presented.

e. Joint distribution functions of significant height versus peak period. Joint distribution tables are presented for 1980 (Tables B3, B7, B11, B15, and B19) and for each season (Tables B4, B8, B12, B16, and B21). Each table gives the frequency (in parts per 1000) for which the significant height and peak period were within the specified intervals; these values can be converted to percent by dividing by 10.

   Marginal totals are also included. The row labeled "Total" gives the total numer of observations out of 1000 which fell within each specified peak period interval. The column "Total" gives the number of observations out of 1000 which fell within each specified significant height interval.

f. Annual and seasonal cumulative distributions of significant wave height. For each gage, annual and seasonal significant wave height distributions are plotted in cumulative form (see Figures B3, B6, B9, B12, and B15).

g. Persistence of significant wave heights. Tables B5, B9, B13, B17, and B22 show the number of times throughout the year that the specified wave height was equaled or exceeded at least once during each day of the duration (consecutive days) indicated. For example, for Gage 620, the Waverider located 3 km from shore, wave heights equaled or exceeded 0.5 m 45 times for at least 1 day; 39 times for at least 2 days; 30 times for at least 3 days; etc. Therefore, on 6 occasions one would expect the height to have equaled or exceeded 0.5 m for 1 day exactly; on 9 occasions for 2 days; on 3 occasions, 3 days; etc. Note that the height exceeded 1 m 48 times for 1 day or longer, while heights exceeded 0.5 m only 45 times for this same duration. This occurred because the longer durations of lower waves may be interspersed with shorter, but more frequent, intervals of higher waves. For example, the one time that wave heights exceeded 0.5 m for 29 days may represent 2 or 3 times that the height exceeded 1 m.

Table B1

Wave Gage Histories for 1980

Type of Gage	Coordinates	Beginning of Proper Operation	End of Proper Operation	Explanation	Gage Length m	Gage Range m, msl	Water Depth m, msl	Distance from Shore, km
		Offshore Waverider (Gage No. 620), FRF, Duck, N. C.						
Buoy - accelerometer	36°11.1'N × 75°44.4'W	Nov 1978	3 Jul 1980	Lightning damaged electronics	NA	Continuous	18*	3
		6 Jul 1980	22 Nov 1980	Trawler caught buoy in net - found near Oregon inlet				
		1 Dec 1980		Began monitoring Waverider 6 km from shore		Continuous	19	6
		Nearshore Waverider (Gage No. 610), FRF, Duck, N. C.						
Buoy - accelerometer	36°11.1'N × 75°44.7'W	Nov 1978	1 Feb 1980	Amplifier/noise problem	NA	Continuous	7	0.6*
		12 Feb 1980	22 Feb 1980	Amplifier/noise problem				
		2 Mar 1980	5 Mar 1980	Amplifier/noise problem				
		13 Mar 1980	12 Jun 1980	Mooring failure - buoy found on beach				
		12 Aug 1980		New installation				
		Pier End Baylor (Gage No. 625), Station 19+00 on FRF Pier (579 m ENE of Coordinates Given), Duck, N. C.						
Baylor - continuous wire	36°110'54"N × 75°45'50"W	Nov 1978	3 Jul 1980	Lightning damaged amplifiers	9.4	-2.1 to 7.0	8.4**	0.6
		7 Jul 1980						

(Continued)

Note: NA = not applicable.
* Depth determined from October 1980 bathymetric survey.
** Median depth from pier profiles taken during January through December 1980.

Table B1 (Concluded)

Type of Gage	Coordinates	Beginning of Proper Operation	End of of Proper Operation	Explanation	Gage Length m	Gage Range m, msl	Water Depth m, msl	Distance from Shore, km
		Nearshore Baylor (Gage No. 615), Station 6+20 on FRF Pier (189m ENE of Coordinates Given), Duck, N. C.						
Baylor - continuous wire	36°10'54"N × 75°45'50"W	Nov 1978	6 Jan 1980	Amplifier/noise problem	7.6	-0.6 to 7.0	1.5**	0.2
		18 Jan 1980	24 Feb 1980	Gage length changed	8.5	-1.6 to 7.0		
		24 Feb 1980	3 Jul 1980	Lightning damaged amplifiers				
		7 Jul 1980						
		Nags Head Baylor (Gage No. 112), Jennettes Fishing Pier,† Nags Head, N.C.						
Baylor - continuous wire	35°55'N × 75°36'W	Jul 1964	3 Jul 1980	Lightning damaged transducer	7.6	-2.4 to 5.2	5.2	0.1 (on north side of pier)
		11 Jul 1980	24 Nov 1980	Transducer failed (gage installation terminated)				

** Median depth from pier profiles taken from January to December 1980.
† Pier length, 229 m.

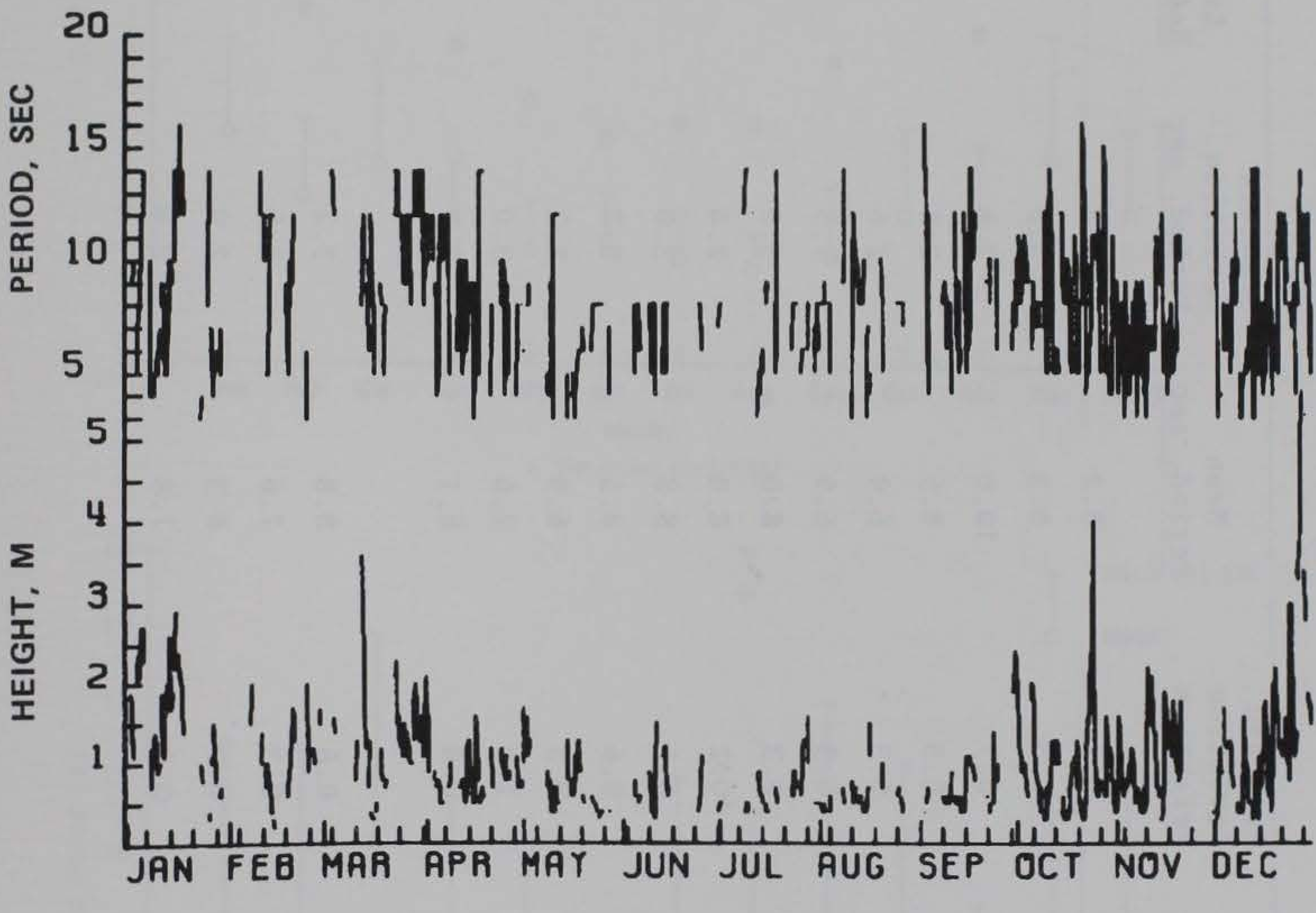
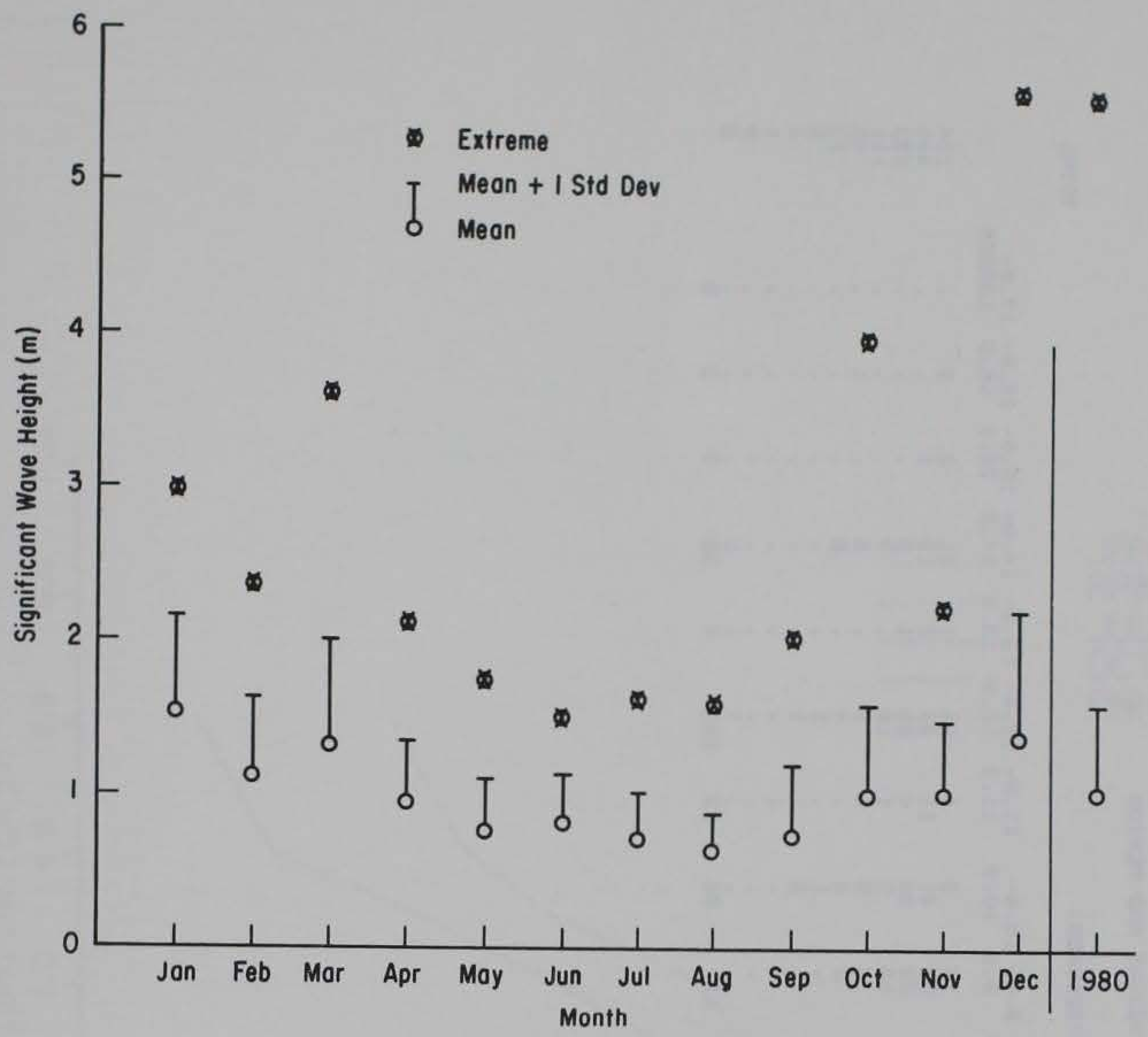


Figure B1. 1980 time history of significant wave height and period for the offshore Waverider (gage No. 620)

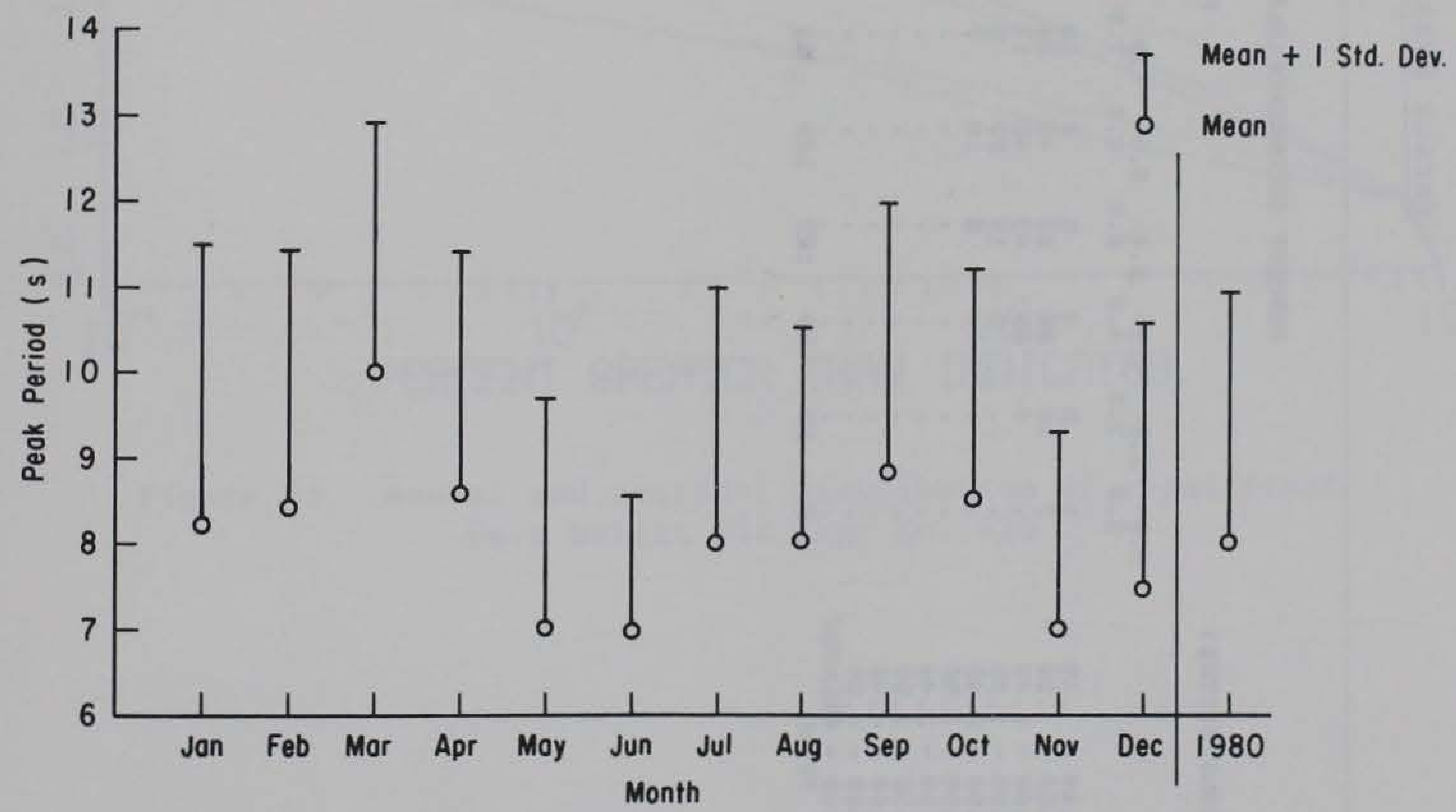
Table B2

1980 Wave Statistics for Gage No. 620

	Mean Height, m	Standard Deviation Height, m	Mean Period, sec	Standard Deviation Period, sec	Extreme Height, m	Date	Number Observations
Monthly							
Jan	1.5	0.7	8.2	3.8	2.9	16	72
Feb	1.1	0.5	8.3	3.0	2.3	10	48
Mar	1.3	0.7	10.0	2.8	3.6	13	64
Apr	0.9	0.3	8.5	2.8	2.1	1	65
May	0.7	0.3	6.9	2.6	1.7	1	59
Jun	0.7	0.3	6.9	1.5	1.5	11	38
Jul	0.6	0.3	8.0	3.0	1.6	28	53
Aug	0.6	0.2	8.0	2.4	1.5	17	50
Sep	0.8	0.4	8.8	3.0	2.0	30	48
Oct	1.0	0.6	8.5	8.7	4.0	25	117
Nov	1.0	0.5	6.9	2.2	2.2	11	82
Dec	1.3	1.0	7.6	3.0	5.6	28	111
Annual	1.0	0.6	8.1	2.9	5.6	Dec	807
Seasonal							
Jan-Mar	1.3	0.6	8.8	3.2	3.6	Mar	184
Apr-Jun	0.8	0.3	7.6	2.6	2.1	Apr	162
Jul-Sep	0.7	0.3	8.3	2.9	2.0	Sep	151
Oct-Dec	1.1	0.8	7.8	2.8	5.6	Dec	310



a. Significant wave height



b. Peak wave period

Figure B2. 1980 mean, extreme, and standard deviations of significant wave height and peak wave period for gage No. 620

Table B3

1980 Annual Joint Distribution of Significant Height

Versus Peak Period for Gage No. 620

PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	TOTAL
0.00 - .49	1	2	4	5	6	10	42	15	6	1	26	1	11	2	2	.	134
.50 - .99	7	16	26	63	42	20	113	52	41	11	27	2	19	1	.	.	440
1.00 - 1.49	.	4	26	43	42	17	19	22	20	4	26	1	9	.	.	.	233
1.50 - 1.99	.	.	2	15	29	9	15	16	7	1	10	.	7	.	.	.	111
2.00 - 2.49	.	.	.	2	10	7	5	4	5	1	5	.	6	.	1	.	46
2.50 - 2.99	.	.	.	.	.	.	1	2	4	.	4	.	2	.	.	.	13
3.00 - 3.49	.	.	.	.	.	.	6	.	1	.	1	.	.	.	.	.	8
3.50 - 3.99	.	.	.	.	.	.	1	.	2	.	1	.	.	.	.	.	4
4.00 - 4.49	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	2
TOTAL	8	22	58	128	129	63	202	111	86	19	101	4	55	3	3	0	

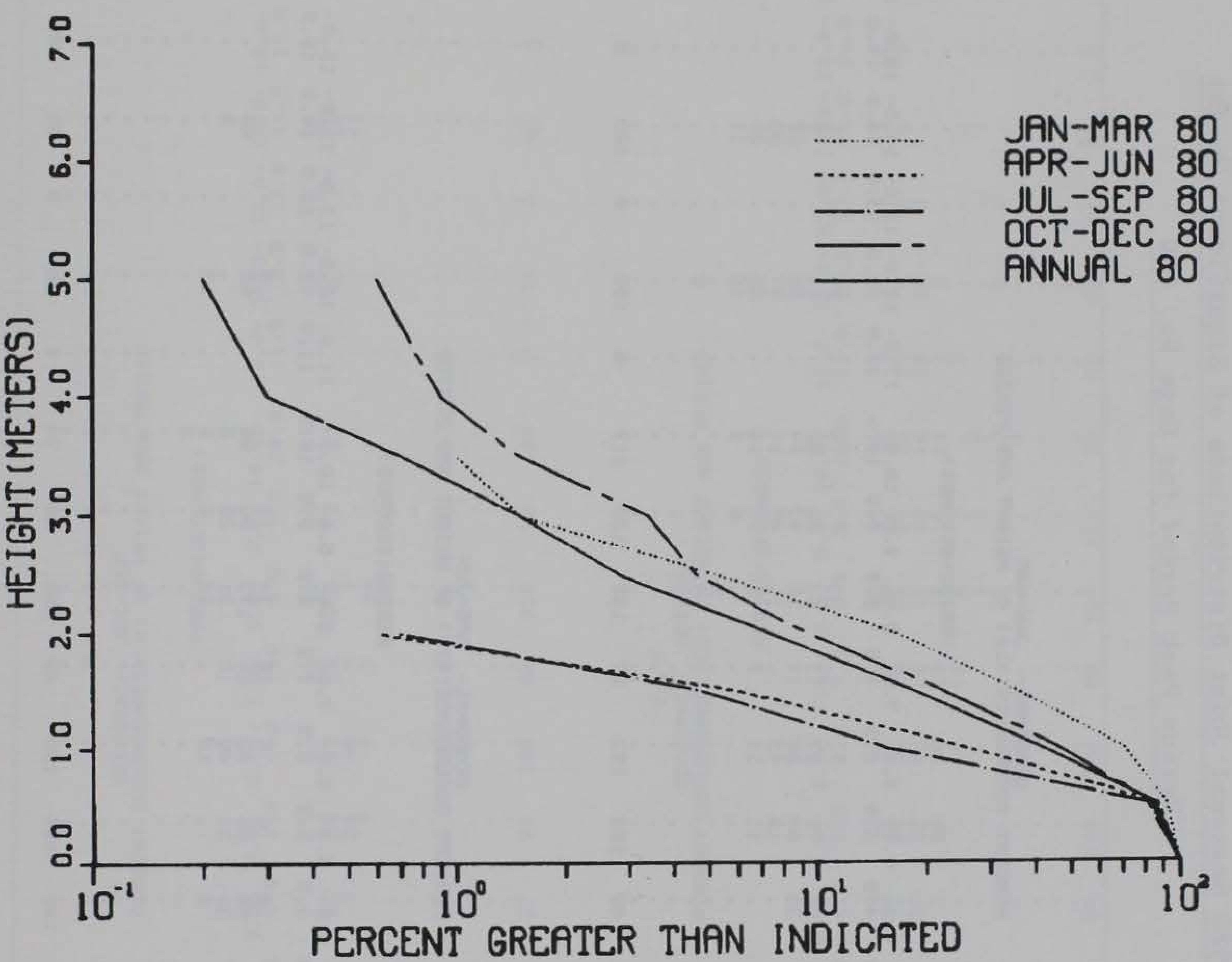


Figure B3. Annual and seasonal distribution of significant wave height for gage No. 620

Table B4

1980 Seasonal Joint Distributions of Significant Height

Versus Peak Period for Gage No. 620

SEASONAL- JAN-MAR
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	TOTAL
0.00 - .49	.	.	.	.	.	.	33	.	5	.	27	.	5	.	.	.	70
.50 - .99	.	5	16	71	27	11	33	22	22	.	11	.	5	.	.	.	223
1.00 - 1.49	.	5	33	60	22	11	16	43	54	.	82	.	22	.	.	.	348
1.50 - 1.99	.	.	.	16	43	.	11	49	11	.	27	.	33	.	.	.	190
2.00 - 2.49	.	.	.	11	11	5	5	11	16	.	22	.	27	.	5	.	113
2.50 - 2.99	.	.	.	.	.	.	.	5	5	.	16	.	11	.	.	.	37
3.00 - 3.49	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.	.	5
3.50 - 3.99	.	.	.	.	.	.	5	.	.	.	5	.	.	.	.	.	10
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	10	49	158	103	27	108	130	113	0	190	0	103	0	5	0	

SEASONAL- APR-JUN
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	TOTAL
0.00 - .49	.	.	12	6	6	12	74	12	.	.	6	.	.	.	.	.	128
.50 - .99	.	25	56	68	62	25	173	56	56	.	68	.	25	.	.	.	614
1.00 - 1.49	.	6	31	31	49	12	31	25	6	.	.	.	6	.	.	.	197
1.50 - 1.99	.	.	6	.	12	.	12	6	6	.	12	.	.	.	.	.	54
2.00 - 2.49	.	.	.	.	.	.	.	.	6	.	.	.	.	.	.	.	6
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	31	105	105	129	49	290	99	74	0	86	0	31	0	0	0	

(Continued)

Table B4 (Concluded)

SEASONAL- JUL-SEP
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	TOTAL
0.00 - .49	7	.	.	7	20	26	40	20	7	.	26	.	26	.	7	.	186
.50 - .99	7	20	20	60	53	26	245	79	53	.	46	.	53	.	.	.	662
1.00 - 1.49	.	.	7	20	46	7	7	.	.	.	7	.	13	.	.	.	107
1.50 - 1.99	.	.	.	7	7	7	20	.	.	.	.	.	.	.	.	.	41
2.00 - 2.49	.	.	.	.	.	.	7	.	.	.	.	.	.	.	.	.	7
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	14	20	27	94	126	66	319	99	60	0	79	0	92	0	7	0	

SEASONAL- OCT-DEC
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	TOTAL
0.00 - .49	.	6	3	6	3	6	32	23	10	3	35	3	13	6	3	.	152
.50 - .99	16	16	19	58	35	19	65	55	39	29	6	6	6	3	.	.	372
1.00 - 1.49	.	3	29	52	48	29	19	19	16	10	16	3	.	.	.	.	244
1.50 - 1.99	.	.	3	26	39	19	16	10	10	3	3	.	.	.	.	.	129
2.00 - 2.49	.	.	.	.	19	16	6	3	.	3	.	.	.	.	.	.	47
2.50 - 2.99	.	.	.	.	.	.	3	3	6	.	.	.	.	.	.	.	12
3.00 - 3.49	.	.	.	.	.	.	13	.	3	.	3	.	.	.	.	.	19
3.50 - 3.99	.	.	.	.	.	.	.	.	6	.	.	.	.	.	.	.	6
4.00 - 4.49	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	3
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	3	.	3	.	.	.	6
TOTAL	16	25	54	142	144	89	154	113	90	51	66	12	22	9	3	0	

Table B5

Persistence* of 1980 Significant Wave Heights for Gage No. 620

Height Exceeded	Consecutive Days																													
m	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
0.5	45	39	30	27	21	16	12		11	10	9		7	6	5	4	3						2						1	
1.0	48	32	22	12	6	4					3		2				1													
1.5	36	16	8		4		2	1																						
2.0	17	7	3	2		1																								
2.5	8	4	1	1																										
3.0	5	2	1																											
3.5	4																													
4.0	2																													

* Number of times during the year the given significant wave height was exceeded at least once a day for the specified number of consecutive days.

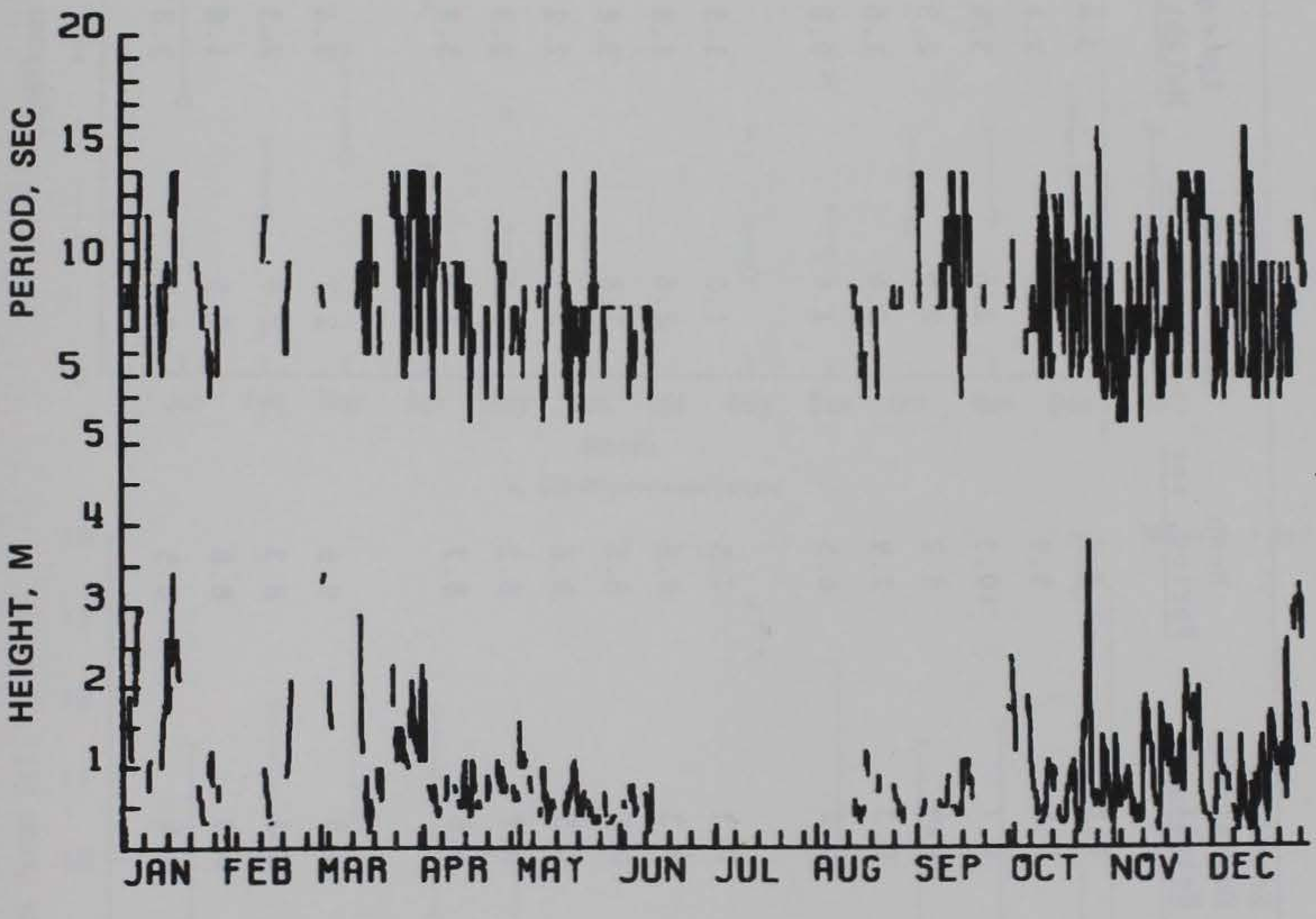


Figure B4. 1980 time history of significant wave height and period for the nearshore Waverider (gage No. 610)

Table B6

1980 Wave Statistics for Gage No. 610

	Mean Height, m	Standard Deviation Height, m	Mean Period, sec	Standard Deviation Period, sec	Extreme Height, m	Date	Number Observations
Monthly							
Jan	1.6	0.8	8.7	2.7	3.4	16	56
Feb	0.9	0.5	9.9	2.0	2.1	21	17
Mar	1.3	0.7	10.3	2.6	3.4	2	56
Apr	0.8	0.4	9.2	2.6	2.3	1	72
May	0.6	0.3	7.9	2.6	1.6	1	81
Jun	0.5	0.2	6.5	1.6	0.8	4	19
Jul	No data						
Aug	0.6	0.3	7.5	1.5	1.5	22	33
Sep	0.7	0.3	9.8	2.6	1.8	30	43
Oct	0.9	0.6	8.6	2.8	3.8	25	105
Nov	1.0	0.5	8.6	3.1	2.2	24	119
Dec	1.0	0.7	8.2	3.1	3.3	29	106
Annual	0.9	0.6	8.7	2.8	3.8	Oct	707
Seasonal							
Jan-Mar	1.4	0.8	9.6	2.7	3.4	Jan	129
Apr-Jun	0.7	0.3	8.3	2.6	2.3	Apr	172
Jul-Sep	0.7	0.3	8.8	2.5	1.8	Sep	76
Oct-Dec	1.0	0.6	8.5	3.0	3.8	Oct	330

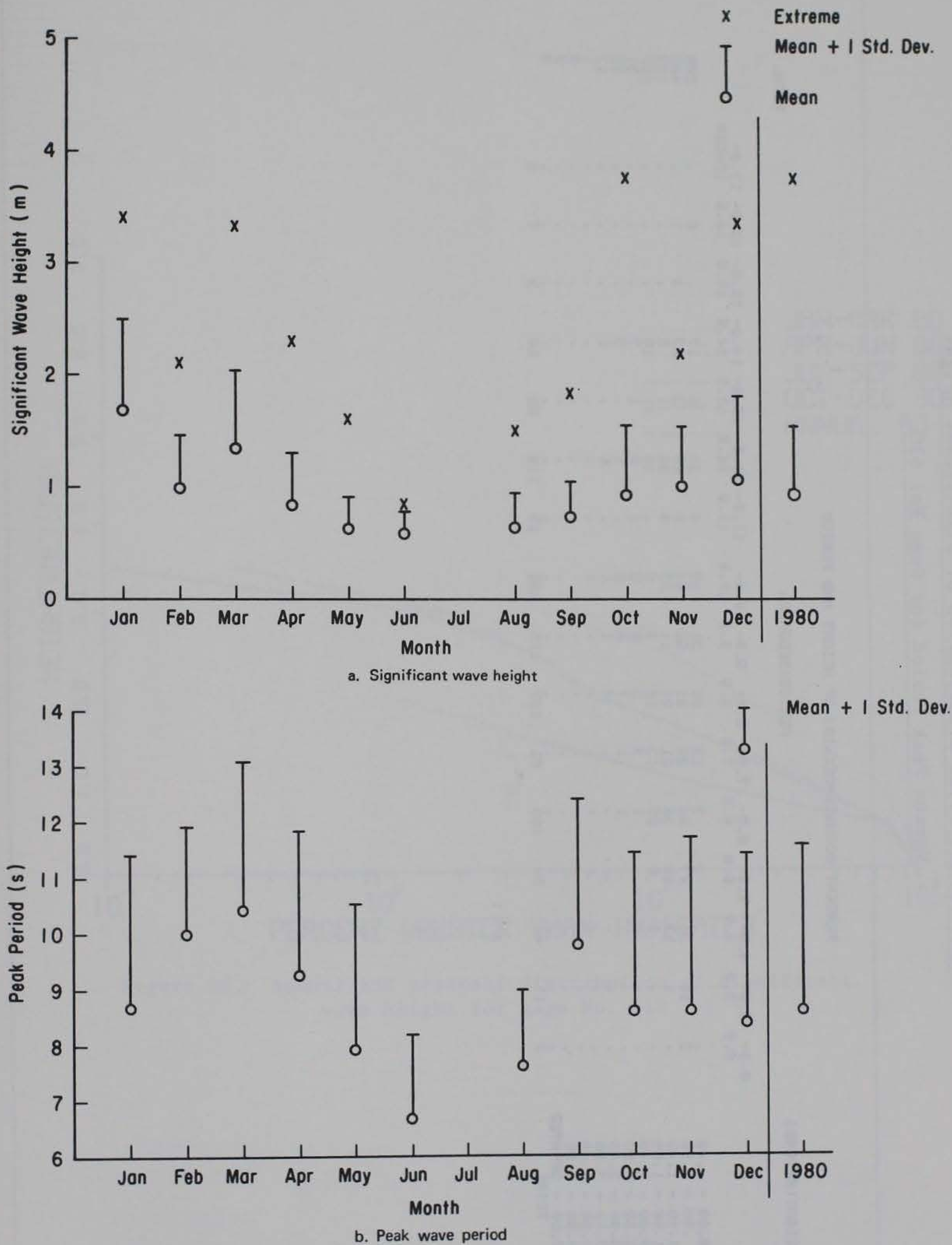


Figure B5. 1980 mean, extreme, and standard deviations of significant wave height and peak wave period for gage No. 610

Table B7

1980 Annual Joint Distribution of Significant Height

Versus Peak Period for Gage No. 610

PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS)																TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	
0.00 - .49	.	.	.	3	3	18	65	31	18	4	34	6	17	.	6	.	205
.50 - .99	3	10	30	47	44	25	81	52	64	8	28	3	23	3	1	.	422
1.00 - 1.49	.	1	13	28	35	21	21	11	23	6	25	1	8	.	.	.	193
1.50 - 1.99	.	.	1	6	25	13	16	8	6	.	10	11	10	.	.	.	106
2.00 - 2.49	.	.	.	.	1	3	3	6	3	1	6	1	7	.	.	.	31
2.50 - 2.99	.	.	.	.	1	1	7	6	6	.	1	.	3	.	.	.	25
3.00 - 3.49	.	.	.	.	.	.	4	1	1	.	6	.	1	.	.	.	13
3.50 - 3.99	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	3	11	44	84	109	81	197	115	122	19	110	22	69	3	7	0	

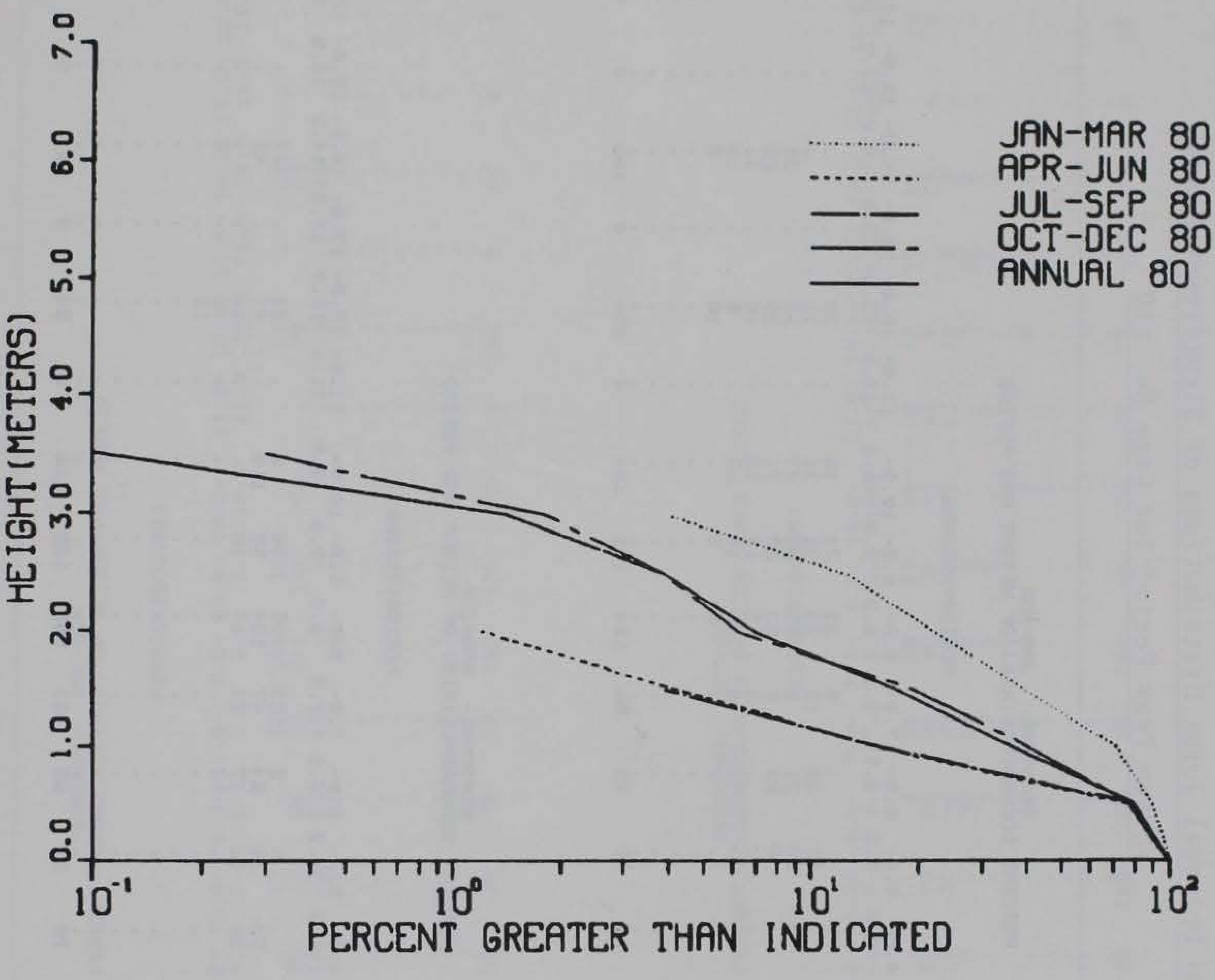


Figure B6. Annual and seasonal distribution of significant wave height for gage No. 610

Table B8

1980 Seasonal Joint Distributions of Significant Height

Versus Peak Period for Gage No. 610

SEASONAL- JAN-MAR
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS)																TOTAL
	0.0- 2.9	3.0- 3.9	4.0- 4.9	5.0- 5.9	6.0- 6.9	7.0- 7.9	8.0- 8.9	9.0- 9.9	10.0- 10.9	11.0- 11.9	12.0- 12.9	13.0- 13.9	14.0- 14.9	15.0- 15.9	16.0- 16.9	17.0- LONGER	
0.00 - .49	.	.	.	.	.	8	23	23	16	.	39	.	.	.	.	.	109
.50 - .99	.	.	.	16	39	16	23	31	31	.	31	.	.	.	.	.	187
1.00 - 1.49	.	.	16	39	31	8	23	31	47	.	85	.	31	.	.	.	311
1.50 - 1.99	.	.	.	8	23	8	23	23	31	.	39	.	23	.	.	.	178
2.00 - 2.49	.	.	.	.	.	8	8	16	16	.	16	.	31	.	.	.	95
2.50 - 2.99	.	.	.	.	.	8	16	16	23	.	8	.	16	.	.	.	87
3.00 - 3.49	.	.	.	.	.	.	8	8	.	.	16	.	8	.	.	.	40
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	0	16	63	93	56	124	148	164	0	234	0	109	0	0	0	

SEASONAL- APR-JUN
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS)																TOTAL
	0.0- 2.9	3.0- 3.9	4.0- 4.9	5.0- 5.9	6.0- 6.9	7.0- 7.9	8.0- 8.9	9.0- 9.9	10.0- 10.9	11.0- 11.9	12.0- 12.9	13.0- 13.9	14.0- 14.9	15.0- 15.9	16.0- 16.9	17.0- LONGER	
0.00 - .49	.	.	.	6	6	23	105	58	6	.	23	.	17	.	.	.	244
.50 - .99	.	17	58	35	64	47	134	58	110	.	41	.	41	.	.	.	605
1.00 - 1.49	.	6	12	12	17	23	17	12	.	.	12	.	.	.	.	.	111
1.50 - 1.99	.	.	.	.	12	.	6	.	.	.	6	.	6	.	.	.	30
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	12	.	.	.	.	.	12
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	23	70	53	99	93	262	128	116	0	94	0	64	0	0	0	

(Continued)

Table B8 (Concluded)

SEASONAL- JUL-SEP
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS)																TOTAL
	0.0- 2.9	3.0- 3.9	4.0- 4.9	5.0- 5.9	6.0- 6.9	7.0- 7.9	8.0- 8.9	9.0- 9.9	10.0- 10.9	11.0- 11.9	12.0- 12.9	13.0- 13.9	14.0- 14.9	15.0- 15.9	16.0- 16.9	17.0- LONGER	
0.00 - .49	.	.	.	13	.	13	105	39	.	.	13	.	26	.	.	.	209
.50 - .99	.	.	26	13	26	13	211	132	79	.	79	.	53	.	.	.	632
1.00 - 1.49	.	.	13	13	53	13	.	.	.	.	13	.	13	.	.	.	118
1.50 - 1.99	.	.	.	.	.	.	39	.	.	.	.	.	.	.	.	.	39
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	0	39	39	79	39	355	171	79	0	105	0	92	0	0	0	

SEASONAL- OCT-DEC
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS)																TOTAL
	0.0- 2.9	3.0- 3.9	4.0- 4.9	5.0- 5.9	6.0- 6.9	7.0- 7.9	8.0- 8.9	9.0- 9.9	10.0- 10.9	11.0- 11.9	12.0- 12.9	13.0- 13.9	14.0- 14.9	15.0- 15.9	16.0- 16.9	17.0- LONGER	
0.00 - .49	.	.	.	.	3	21	52	18	30	9	42	12	21	.	12	.	220
.50 - .99	6	12	27	73	39	21	45	39	48	18	9	6	15	6	3	.	367
1.00 - 1.49	.	.	12	36	42	27	27	6	30	12	12	3	3	.	.	.	210
1.50 - 1.99	.	.	3	9	39	24	12	9	.	.	3	24	9	.	.	.	132
2.00 - 2.49	.	.	.	.	3	3	3	6	.	3	.	3	3	.	.	.	24
2.50 - 2.99	.	.	.	.	3	.	9	6	3	.	.	.	.	.	.	.	21
3.00 - 3.49	.	.	.	.	.	.	6	.	3	.	6	.	.	.	.	.	15
3.50 - 3.99	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	3
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	6	12	42	118	129	96	154	84	117	42	72	48	51	6	15	0	

Table B9

Persistence* of 1980 Significant Wave Heights for Gage No. 610

Height Exceeded m	Consecutive Days 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
0.5	41	34	30	22	17	13	10		7				4	3				2												
1.0	37	25	12		6		5				2		1																	
1.5	18	13	9	7	5	3	1																							
2.0	15	5	3	2	1																									
2.5	8	4	2	1																										
3.0	5			1																										
3.5	1																													
4.0																														

* Number of times during the year the given significant wave height was exceeded at least once a day for the specified number of consecutive days.

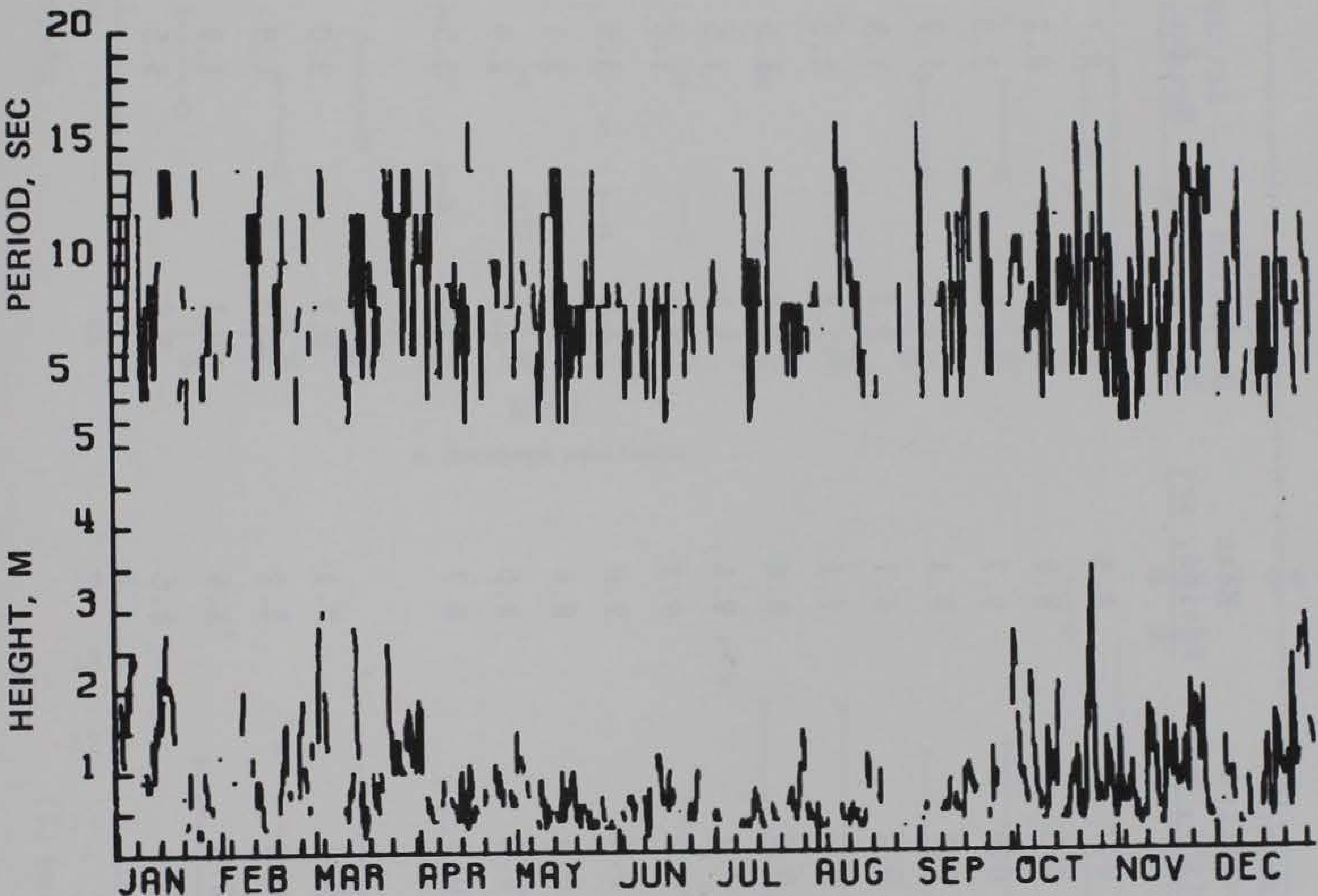
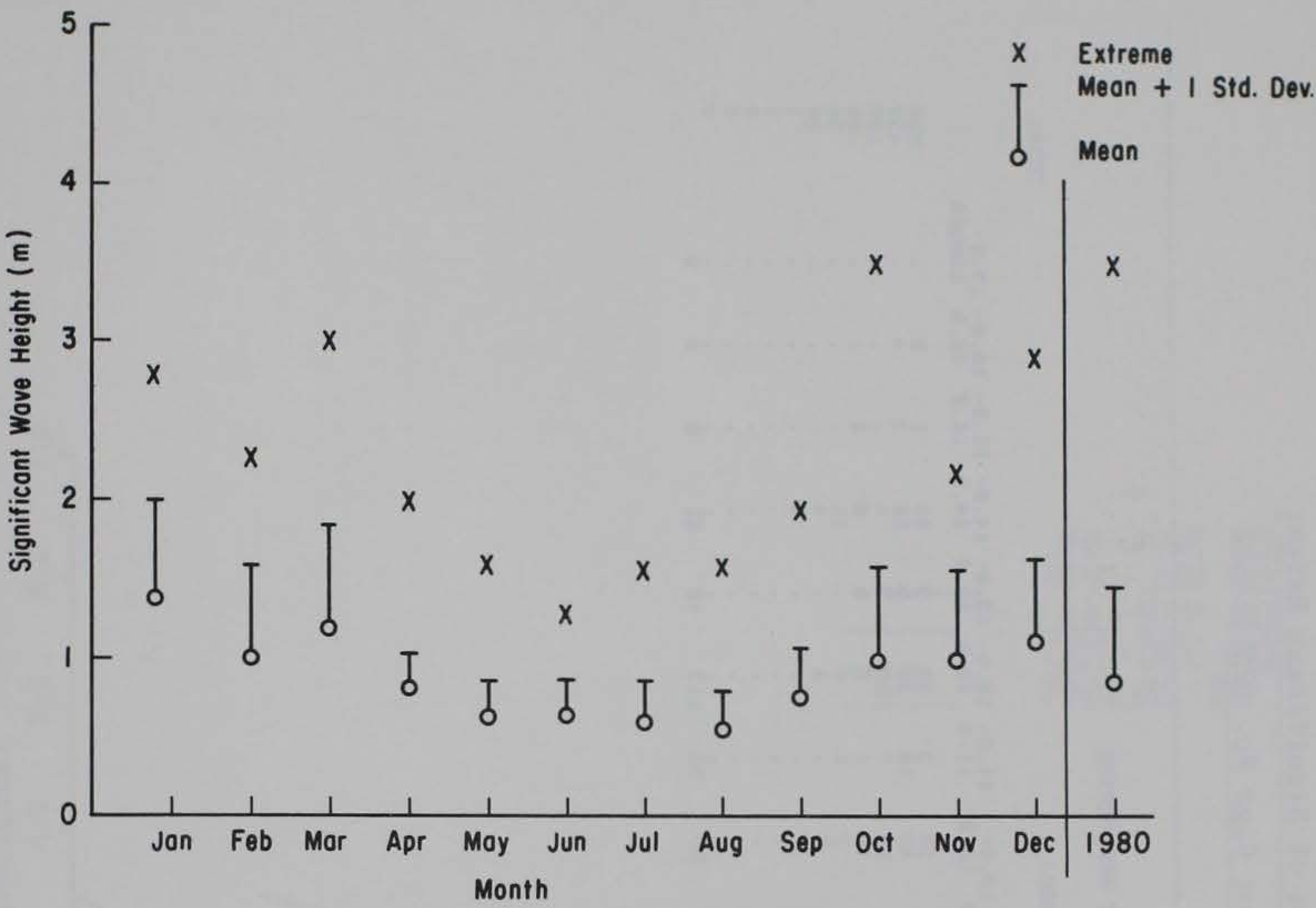


Figure B7. 1980 time history of significant wave height and period for the pier end Baylor (gage no. 625)

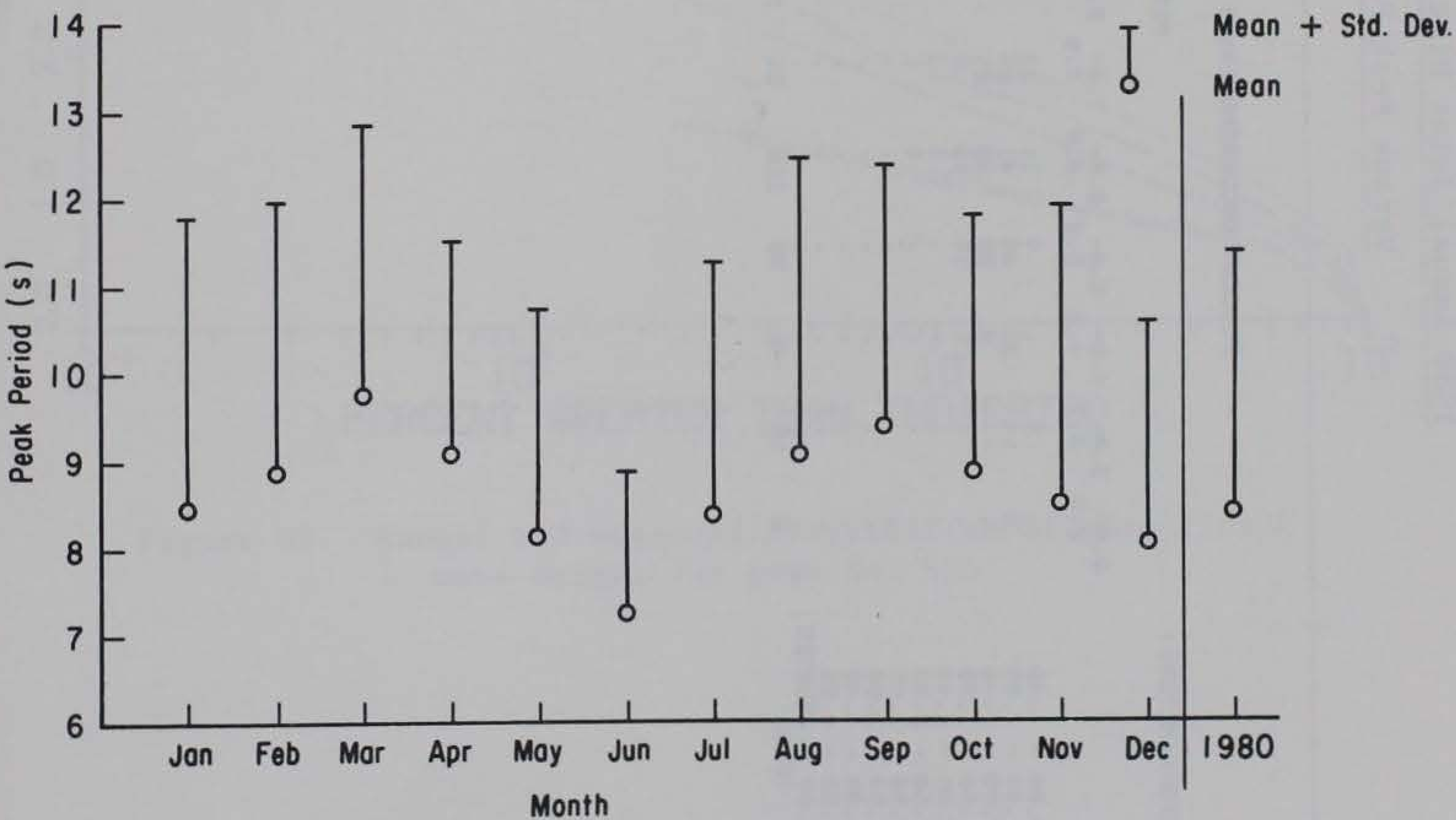
Table B10

1980 Wave Statistics for Gage No. 625

	Mean Height, m	Standard Deviation Height, m	Mean Period, sec	Standard Deviation Period, sec	Extreme Height, m	Date	Number Observations
Monthly							
Jan	1.3	0.7	8.5	3.3	2.7	16	72
Feb	1.0	0.5	8.9	3.0	2.2	7	54
Mar	1.2	0.6	9.7	3.1	3.0	3	77
Apr	0.7	0.3	9.1	2.4	1.9	1	74
May	0.6	0.2	8.1	2.7	1.5	1	87
Jun	0.6	0.2	7.1	1.8	1.2	12	57
Jul	0.6	0.2	8.4	2.9	1.5	28	66
Aug	0.5	0.2	9.1	3.3	1.5	22	55
Sep	0.7	0.3	9.3	3.0	1.9	30	49
Oct	1.0	0.6	9.0	2.8	3.5	25	112
Nov	1.0	0.5	8.6	3.3	2.1	24	117
Dec	1.1	0.6	8.0	2.7	2.9	29	86
Annual	0.9	0.5	8.7	3.0	3.5	Oct	906
Seasonal							
Jan-Mar	1.2	0.6	9.1	3.2	3.0	Mar	203
Apr-Jun	0.6	0.3	8.2	2.5	1.9	Apr	218
Jul-Sep	0.6	0.3	8.9	3.1	1.9	Sep	170
Oct-Dec	1.0	0.6	8.6	3.0	3.5	Oct	315



a. Significant wave height



b. Peak wave period mean and standard deviation

Figure B8. 1980 mean, extreme, and standard deviation of significant wave height and peak wave period for gage No. 625

Table B11

1980 Annual Joint Distribution of Significant Height

Versus Peak Period for Gage No. 625

PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	TOTAL
0.00 - .49	.	2	.	7	11	23	60	30	15	3	33	3	30	1	2	.	220
.50 - .99	2	14	32	49	41	25	95	55	47	10	35	3	22	3	4	.	437
1.00 - 1.49	.	.	9	29	38	21	24	15	13	7	29	7	4	.	.	.	196
1.50 - 1.99	.	.	1	10	19	8	9	4	12	1	9	6	9	2	.	.	90
2.00 - 2.49	.	.	.	.	2	3	4	2	3	1	4	.	11	.	.	.	30
2.50 - 2.99	.	.	.	.	1	1	7	1	3	.	3	.	4	.	.	.	20
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
3.50 - 3.99	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	2	16	42	95	112	81	199	108	93	22	113	19	81	6	6	0	

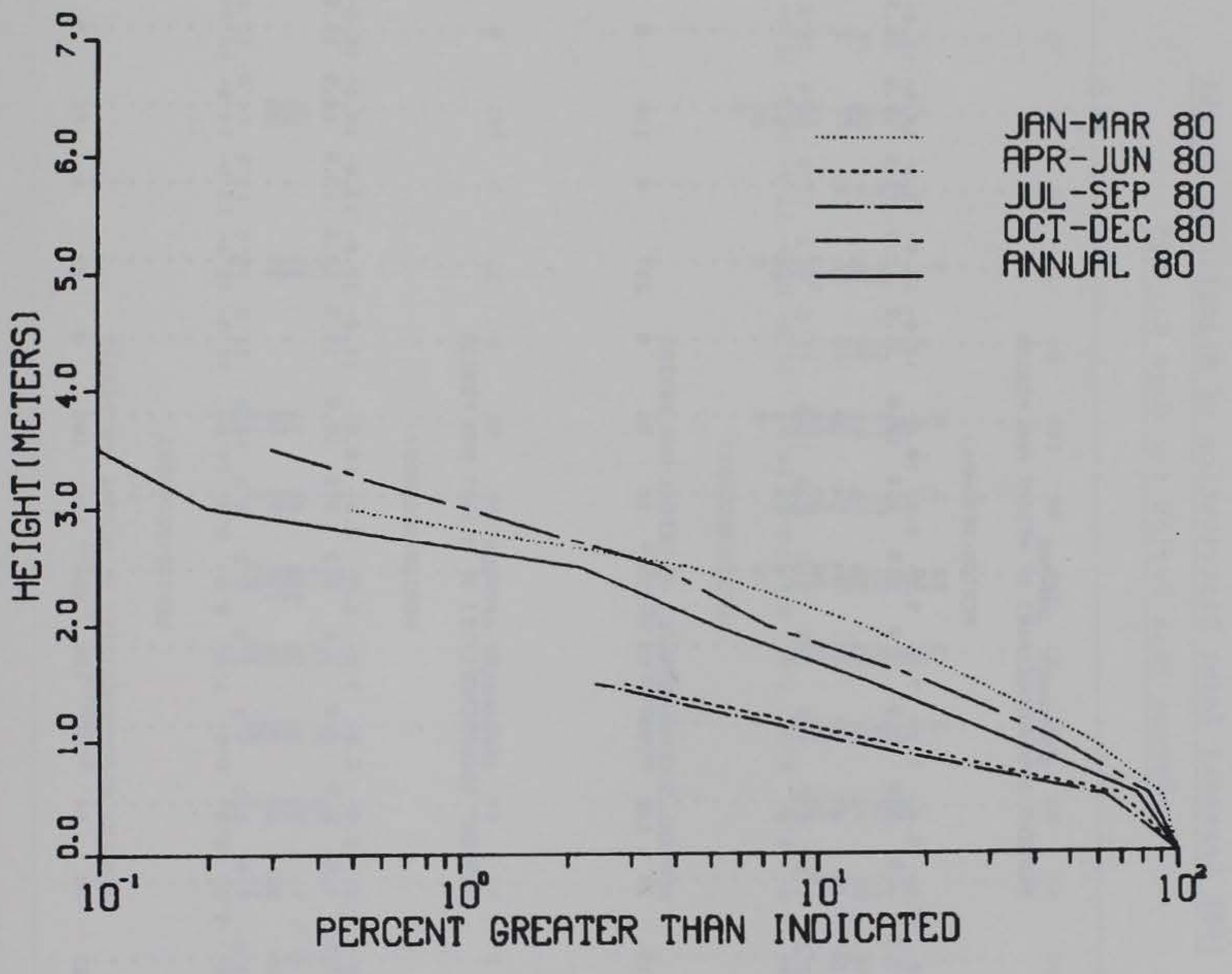


Figure B9. Annual and seasonal distribution of significant wave height for gage No. 625

Table B12

1980 Seasonal Joint Distribution of Significant Height

Versus Peak Period for Gage No. 625

SEASONAL- JAN-MAR
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	TOTAL
0.00 - .49	.	.	.	5	.	10	30	5	10	.	25	.	10	.	.	.	95
.50 - .99	5	15	30	69	59	15	34	34	30	.	54	.	.	.	.	.	345
1.00 - 1.49	.	.	5	39	25	15	25	39	20	.	103	.	15	.	.	.	286
1.50 - 1.99	.	.	.	15	15	10	15	10	25	.	30	.	25	.	.	.	145
2.00 - 2.49	.	.	.	.	5	.	5	10	5	.	20	.	44	.	.	.	89
2.50 - 2.99	.	.	.	.	.	.	10	.	5	.	5	.	20	.	.	.	40
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	5
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	5	15	35	128	104	50	119	98	95	0	237	0	119	0	0	0	

SEASONAL- APR-JUN
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	TOTAL
0.00 - .49	.	5	.	14	28	32	106	41	18	.	37	.	28	.	.	.	309
.50 - .99	.	18	32	60	32	50	165	78	55	.	37	.	23	.	5	.	555
1.00 - 1.49	.	.	14	5	28	18	23	5	18	.	.	.	.	.	.	.	111
1.50 - 1.99	.	.	.	5	.	.	.	.	14	.	9	.	.	.	.	.	28
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	23	46	84	88	100	294	124	105	0	83	0	51	0	5	0	

(Continued)

SEASONAL- JUL-SEP
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS)																TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	
0.00 - .49	.	.	.	6	12	47	106	65	18	.	24	.	88	.	6	.	372
.50 - .99	6	6	47	29	47	29	135	59	47	.	41	.	59	.	12	.	517
1.00 - 1.49	.	.	.	29	24	12	12	.	.	.	12	.	.	.	.	.	89
1.50 - 1.99	.	.	.	.	6	.	12	6	.	.	.	.	.	.	.	.	24
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	6	6	47	64	89	88	265	130	65	0	77	0	147	0	18	0	

SEASONAL- OCT-DEC
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS)																TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	
0.00 - .49	.	3	.	3	6	13	22	19	16	10	41	10	13	3	3	.	162
.50 - .99	.	16	25	38	32	13	63	51	54	29	19	10	16	10	3	.	379
1.00 - 1.49	.	.	13	38	60	32	32	16	13	19	10	19	3	.	.	.	255
1.50 - 1.99	.	.	3	16	41	16	10	3	10	3	.	16	10	6	.	.	134
2.00 - 2.49	.	.	.	.	3	10	10	.	6	3	.	.	3	.	.	.	35
2.50 - 2.99	.	.	.	.	3	3	13	3	6	.	6	.	.	.	.	.	34
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	3
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	19	41	95	145	87	150	95	105	64	76	55	45	19	6	0	

Table B13

Persistence* of 1980 Significant Wave Heights for Gage No. 625

Height Exceeded m	Consecutive Days 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
0.5	44	37	30	25	22	17	13	11		10	9	8	7		6		4		3		2									
1.0	43	29	19	10	6			4		3	2	1																		
1.5	28	15	7			3	1																							
2.0	15	6	4	2																										
2.5	8	3		1																										
3.0	2																													
3.5	1																													
4.0																														

* Number of times during the year the given significant wave height was exceeded at least once a day for the specified number of consecutive days.

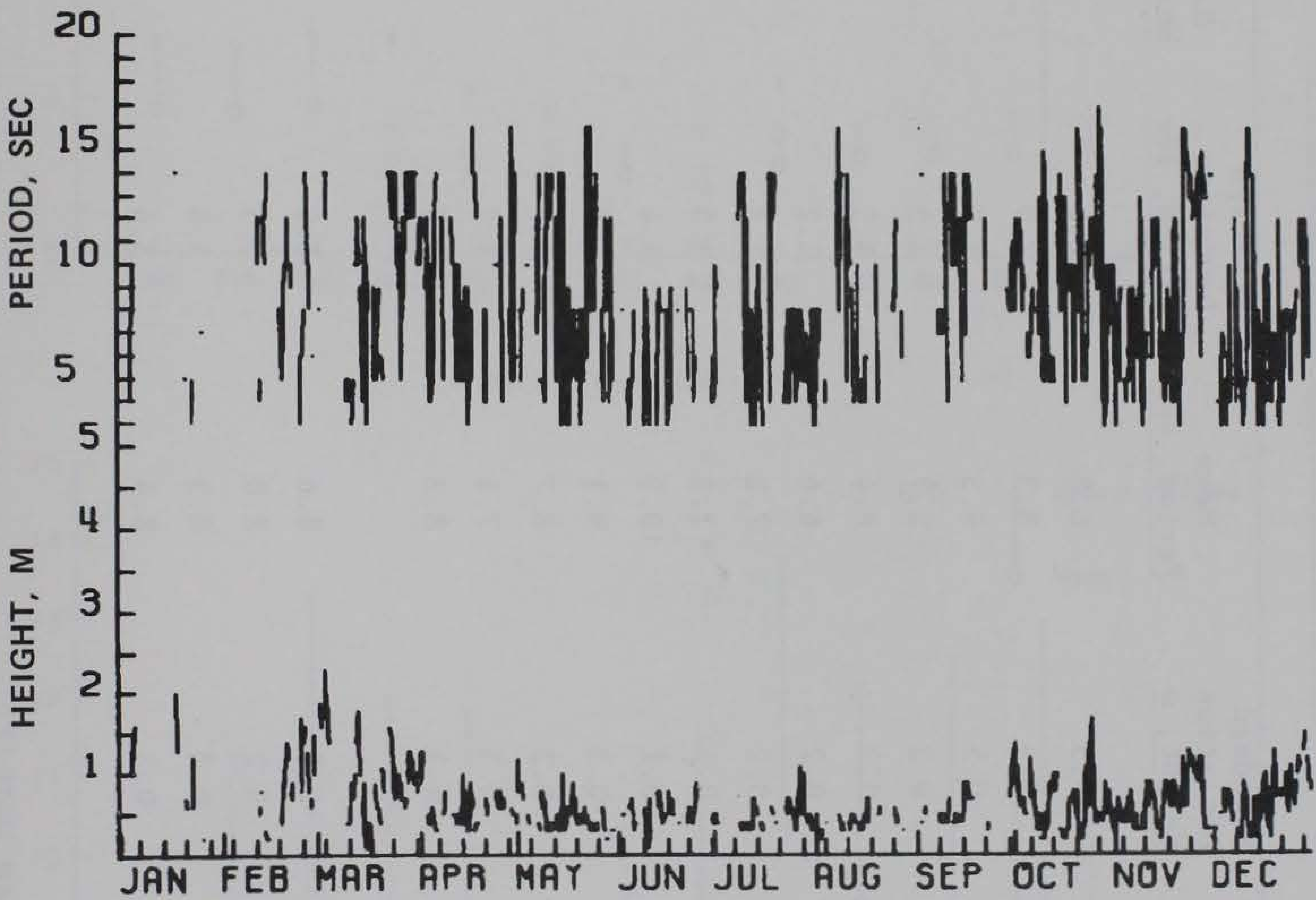
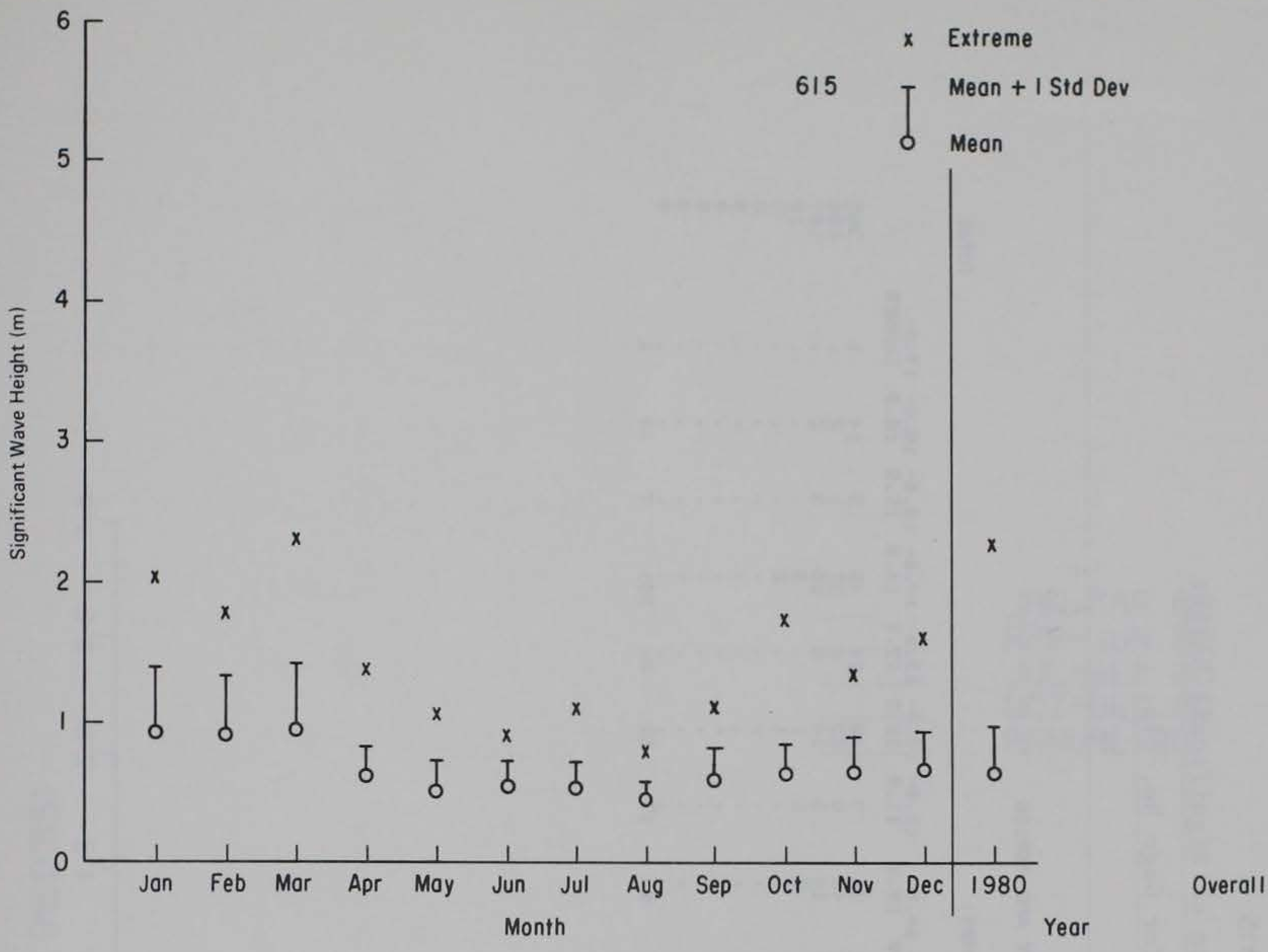


Figure B10. 1980 time history of significant wave height and period for the nearshore Baylor (gage No. 615)

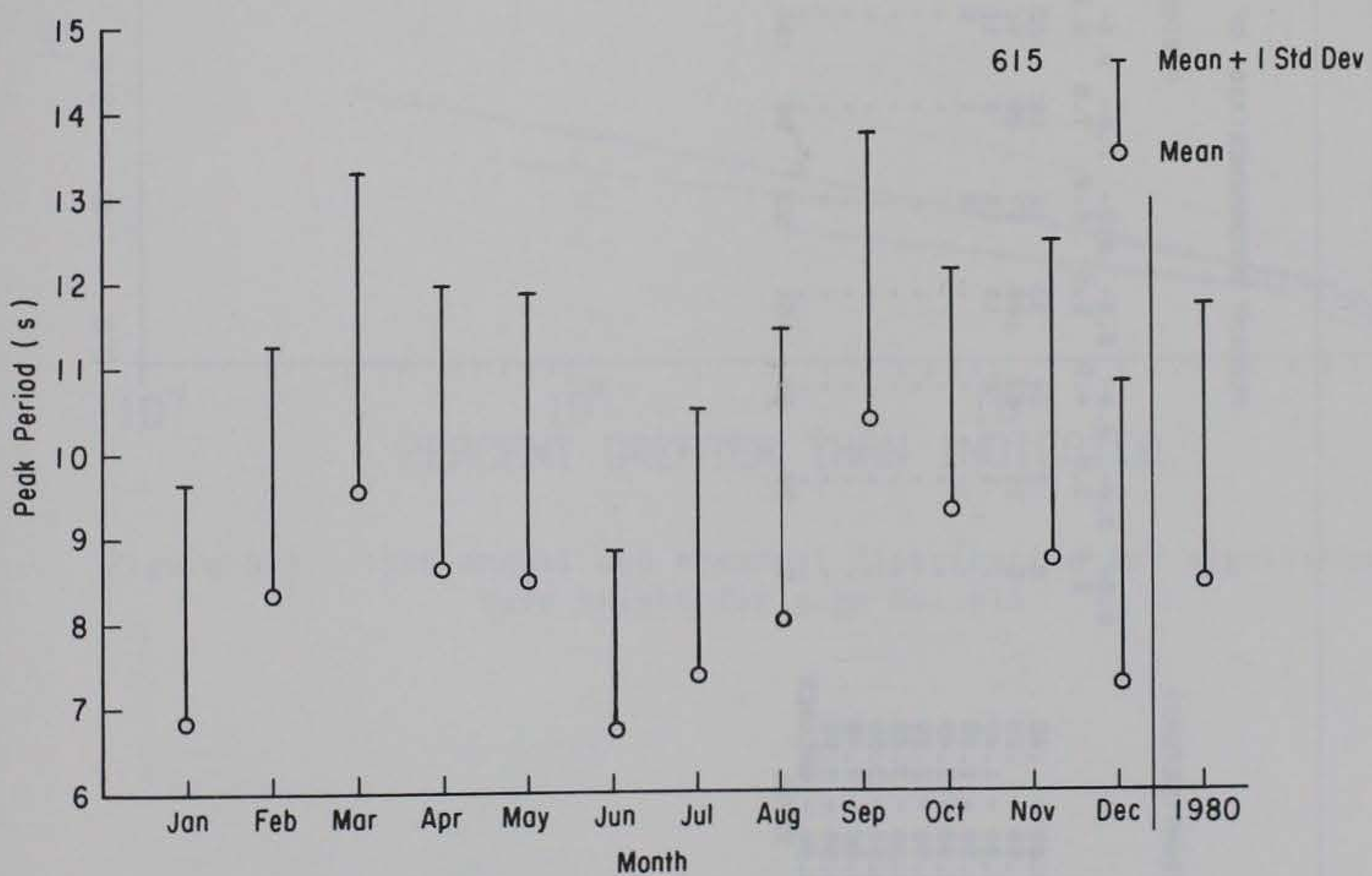
Table B14

1980 Wave Statistics for Gage No. 615

	Mean Height, m	Standard Deviation Height, m	Mean Period, sec	Standard Deviation Period, sec	Extreme Height, m	Date	Number Observations
Monthly							
Jan	0.9	0.5	6.8	2.8	2.0	18	29
Feb	0.9	0.4	8.3	2.9	1.7	17	43
Mar	0.9	0.5	9.5	3.7	2.3	3	77
Apr	0.6	0.2	8.7	3.3	1.3	1	72
May	0.5	0.2	8.4	3.5	1.2	1	87
Jun	0.5	0.2	6.6	2.2	0.9	25	57
Jul	0.5	0.2	7.2	3.3	1.1	27	68
Aug	0.4	0.1	7.9	3.5	0.8	22	58
Sep	0.6	0.2	10.3	3.4	1.1	30	44
Oct	0.6	0.3	9.1	3.0	1.7	25	117
Nov	0.6	0.3	8.7	3.7	1.3	24	118
Dec	0.6	0.3	7.1	3.7	1.5	30	102
Annual	0.6	0.3	8.3	3.5	2.3	Mar	870
Seasonal							
Jan-Mar	0.9	0.5	8.6	3.5	2.3	Mar	149
Apr-Jun	0.5	0.2	8.0	3.3	1.3	Apr	216
Jul-Sep	0.5	0.2	8.3	3.6	1.1	Jul	168
Oct-Dec	0.6	0.3	8.4	3.6	1.7	Oct	337



a. Significant wave height



b. Peak wave period mean and standard deviation

Figure B11. 1980 mean, extreme, and standard deviation of significant wave height and peak wave period for gage No. 615

Table B15

1980 Annual Joint Distribution of Significant Height

Versus Peak Period for Gage No. 615

PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	TOTAL
0.00 - .49	2	7	24	33	18	18	69	34	26	7	49	14	46	3	14	1	365
.50 - .99	5	31	63	108	57	29	51	36	49	6	23	2	37	1	2	.	500
1.00 - 1.49	.	1	2	10	16	8	11	5	14	3	14	8	10	3	2	.	107
1.50 - 1.99	.	.	.	.	2	1	5	.	3	1	1	.	6	.	.	.	19
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	.	3
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	7	39	89	151	93	56	136	75	92	17	88	24	101	7	18	1	

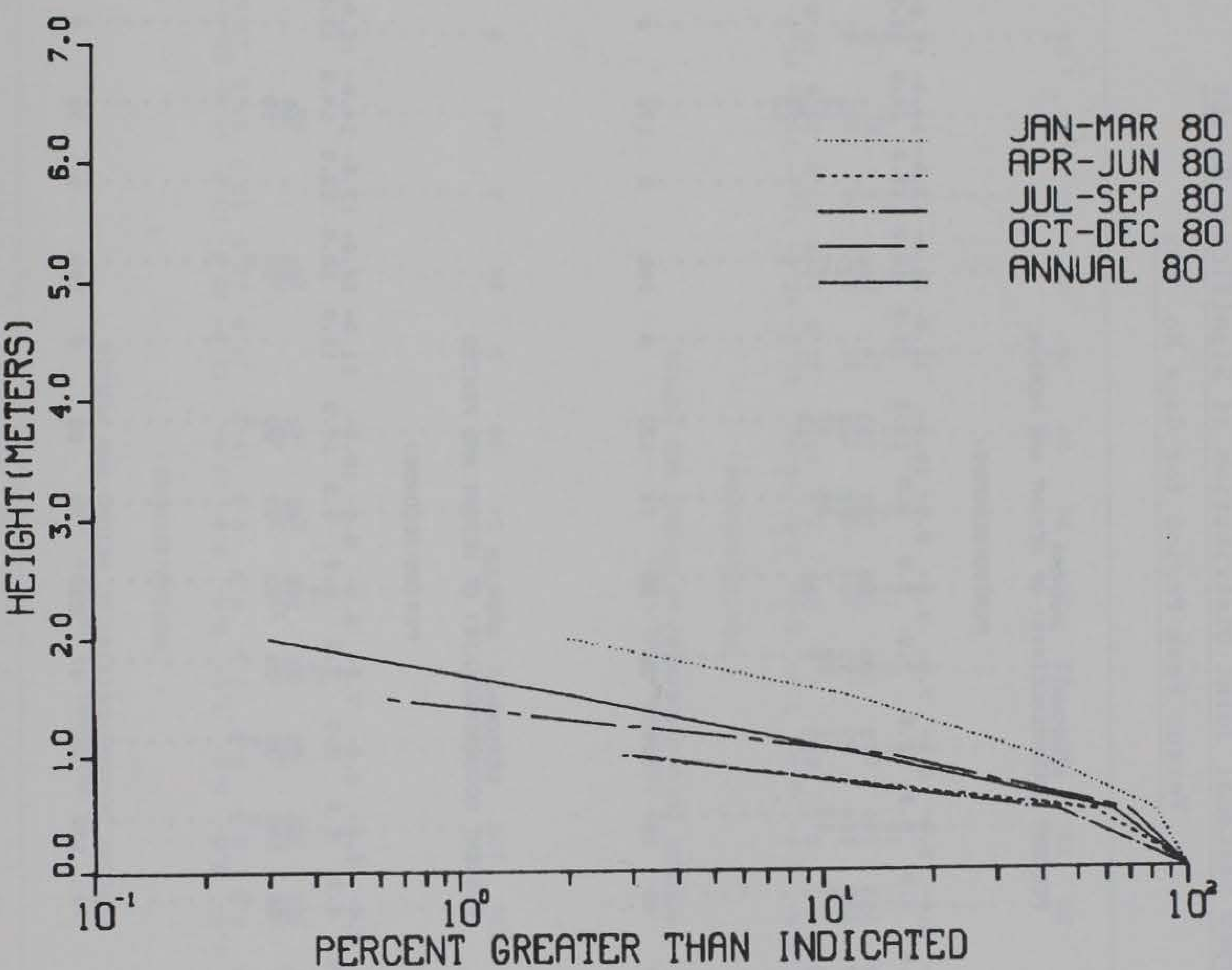


Figure B12. 1980 annual and seasonal distribution for significant wave height for gage No. 615

Table B16

1980 Seasonal Joint Distribution of Significant Height

Versus Peak Period for Gage No. 615

SEASONAL- JAN-MAR
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0- 2.9	3.0- 3.9	4.0- 4.9	5.0- 5.9	6.0- 6.9	7.0- 7.9	8.0- 8.9	9.0- 9.9	10.0- 10.9	11.0- 11.9	12.0- 12.9	13.0- 13.9	14.0- 14.9	15.0- 15.9	16.0- 16.9	17.0- LONGER	TOTAL
0.00 - .49	.	7	13	40	13	20	20	27	13	.	20	.	7	.	.	.	180
.50 - .99	.	27	40	114	27	13	34	27	60	.	27	.	74	.	.	.	443
1.00 - 1.49	.	.	7	13	47	20	7	20	47	.	47	.	47	.	.	.	255
1.50 - 1.99	.	.	.	.	13	7	27	.	13	.	7	.	34	.	.	.	101
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	7	.	13	.	.	.	20
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	34	60	167	100	60	88	74	133	0	108	0	175	0	0	0	

SEASONAL- APR-JUN
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0- 2.9	3.0- 3.9	4.0- 4.9	5.0- 5.9	6.0- 6.9	7.0- 7.9	8.0- 8.9	9.0- 9.9	10.0- 10.9	11.0- 11.9	12.0- 12.9	13.0- 13.9	14.0- 14.9	15.0- 15.9	16.0- 16.9	17.0- LONGER	TOTAL
0.00 - .49	.	9	23	28	23	28	116	42	14	.	83	.	60	.	14	.	440
.50 - .99	.	42	56	148	32	19	93	37	69	.	14	.	19	.	5	.	534
1.00 - 1.49	.	.	.	9	5	.	.	.	5	.	9	.	.	.	.	.	28
1.50 - 1.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	51	79	185	60	47	209	79	88	0	106	0	79	0	19	0	

(Continued)

SEASONAL- JUL-SEP
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	TOTAL
0.00 - .49	.	12	60	54	48	12	131	30	42	.	60	.	77	.	30	.	556
.50 - .99	.	24	71	83	42	30	36	24	18	.	24	.	65	.	.	.	417
1.00 - 1.49	.	.	.	.	.	12	18	.	.	.	.	.	.	.	.	.	30
1.50 - 1.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	36	131	137	90	54	185	54	60	0	84	0	142	0	30	0	

SEASONAL- OCT-DEC
PERCENT OCCURRENCE(X10) OF HEIGHT AND PERIOD

HEIGHT(METERS)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9	16.0-16.9	17.0-LONGER	TOTAL
0.00 - .49	6	3	12	24	3	15	30	36	33	18	36	36	39	9	12	3	315
.50 - .99	12	30	74	92	95	42	39	45	47	15	27	6	18	3	3	.	548
1.00 - 1.49	.	3	3	15	18	6	18	3	12	9	9	21	6	9	6	.	138
1.50 - 1.99	.	.	.	.	.	.	.	.	3	3	.	.	.	.	.	.	6
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	18	36	89	131	116	63	87	84	95	45	72	63	63	21	21	3	

Table B17

Persistence* of 1980 Significant Wave Heights for Gage No. 615

Height Exceeded	Consecutive Days																													
m	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
0.5	51	42	31	23	19	11	9		8				4					3	2		1									
1.0	26	15	11	7	4		1																							
1.5	10	4	1																											
2.0	2	1																												
2.5																														
3.0																														
3.5																														
4.0																														

* Number of times during the year the given significant wave height was exceeded at least once a day for the specified number of consecutive days.

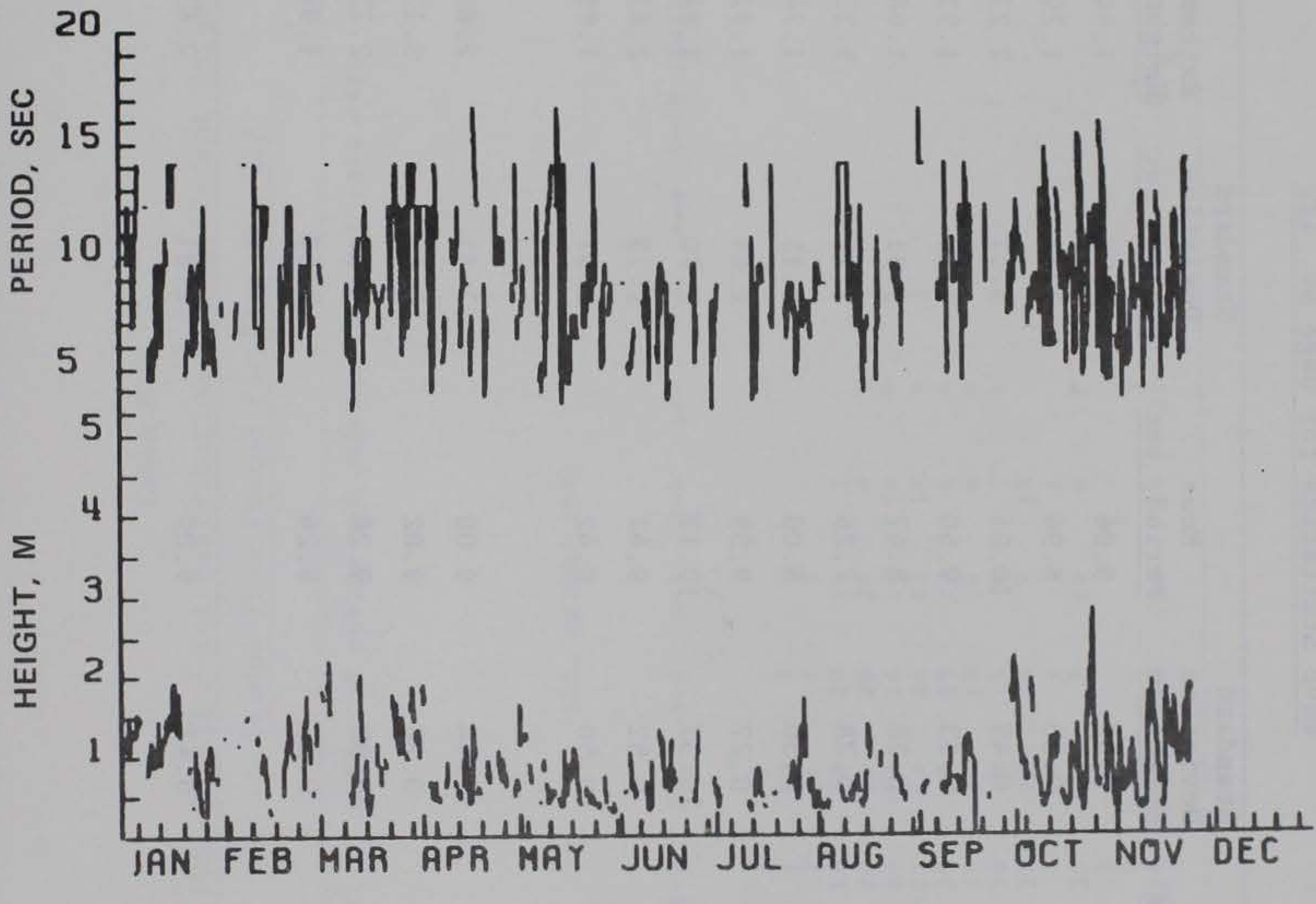


Figure B13. 1980 time history of significant wave height and period for the Nags Head Baylor (gage No. 112)

Table B18

Wave Statistics for Gage No. 112

Monthly	Mean Height, m	Standard Deviation Height, m	Mean Period, sec	Standard Deviation Period, sec	Extreme Height,m	Date	Number Observations
Jan	1.09	0.39	9.06	2.97	1.94	16/17	79
Feb	1.01	0.36	8.96	2.69	1.79	26	53
Mar	1.14	0.49	10.01	3.01	2.23	4	74
Apr	0.78	0.33	9.50	2.85	1.91	1	68
May	0.63	0.28	8.47	3.01	1.68	1	84
Jun	0.72	0.28	7.26	1.78	1.37	13	52
Jul	0.69	0.30	8.00	2.15	1.74	28	59
Aug	0.62	0.27	9.59	2.64	1.72	22	61
Sep	0.80	0.37	10.12	2.70	1.84	30	45
Oct	0.96	0.52	9.47	2.73	2.83	25	115
Nov	0.99	0.50	8.42	2.57	1.95	12	94
Annual							
1980	0.87	0.44	9.00	2.81	2.83	Oct	784
1977	0.65	0.28	9.02	2.86	2.13	Dec	850
1978	0.95	0.38	9.26	2.30	2.23	Apr	383
1979	0.76	0.35	9.24	2.50	1.90	Jan	368
Cumulative							
Jan 1977-Nov 1980	0.79	0.41	9.09	2.81	2.83	Oct 1980	2385

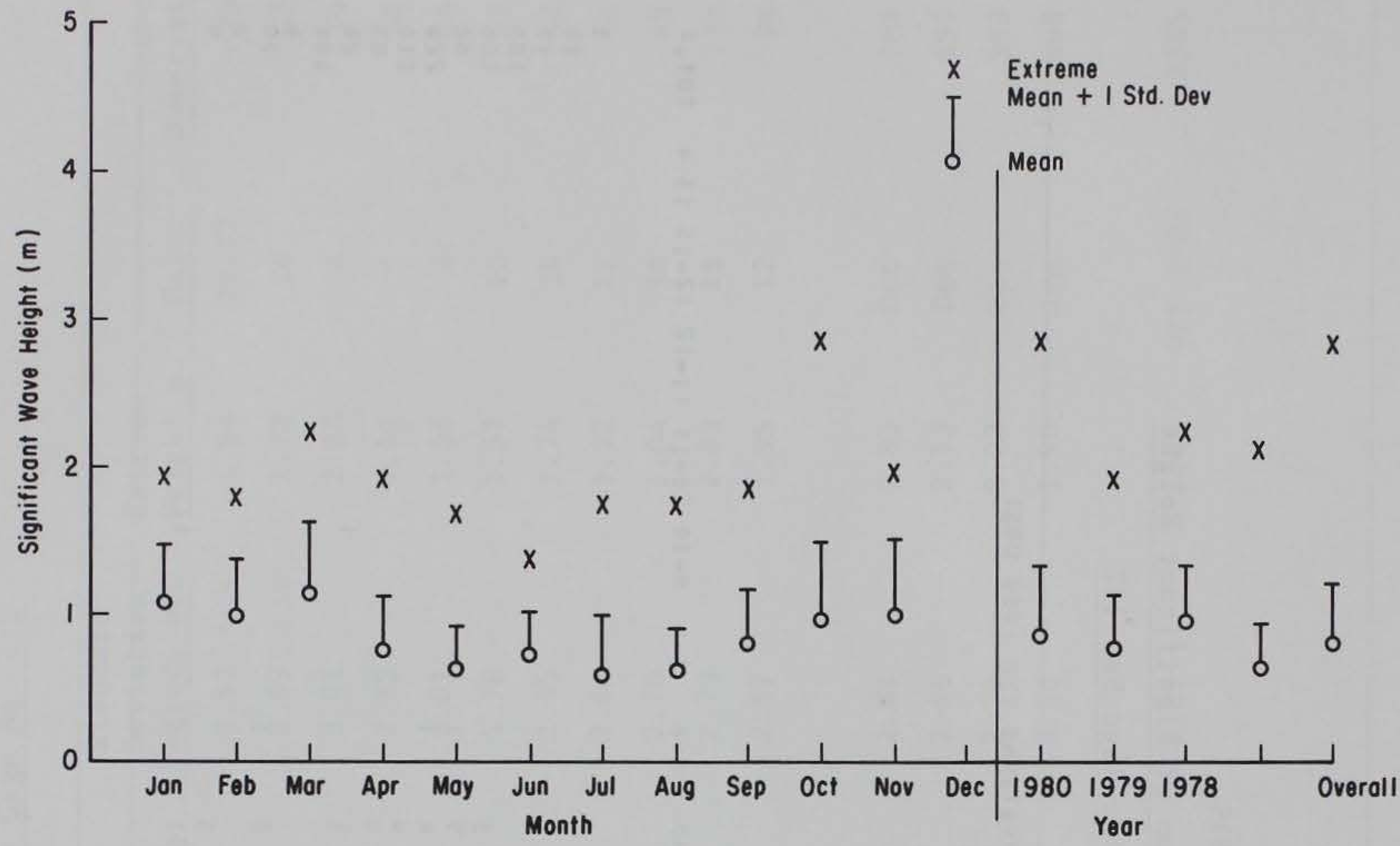
Table B19

1980 Annual Joint Distribution of Significant Height

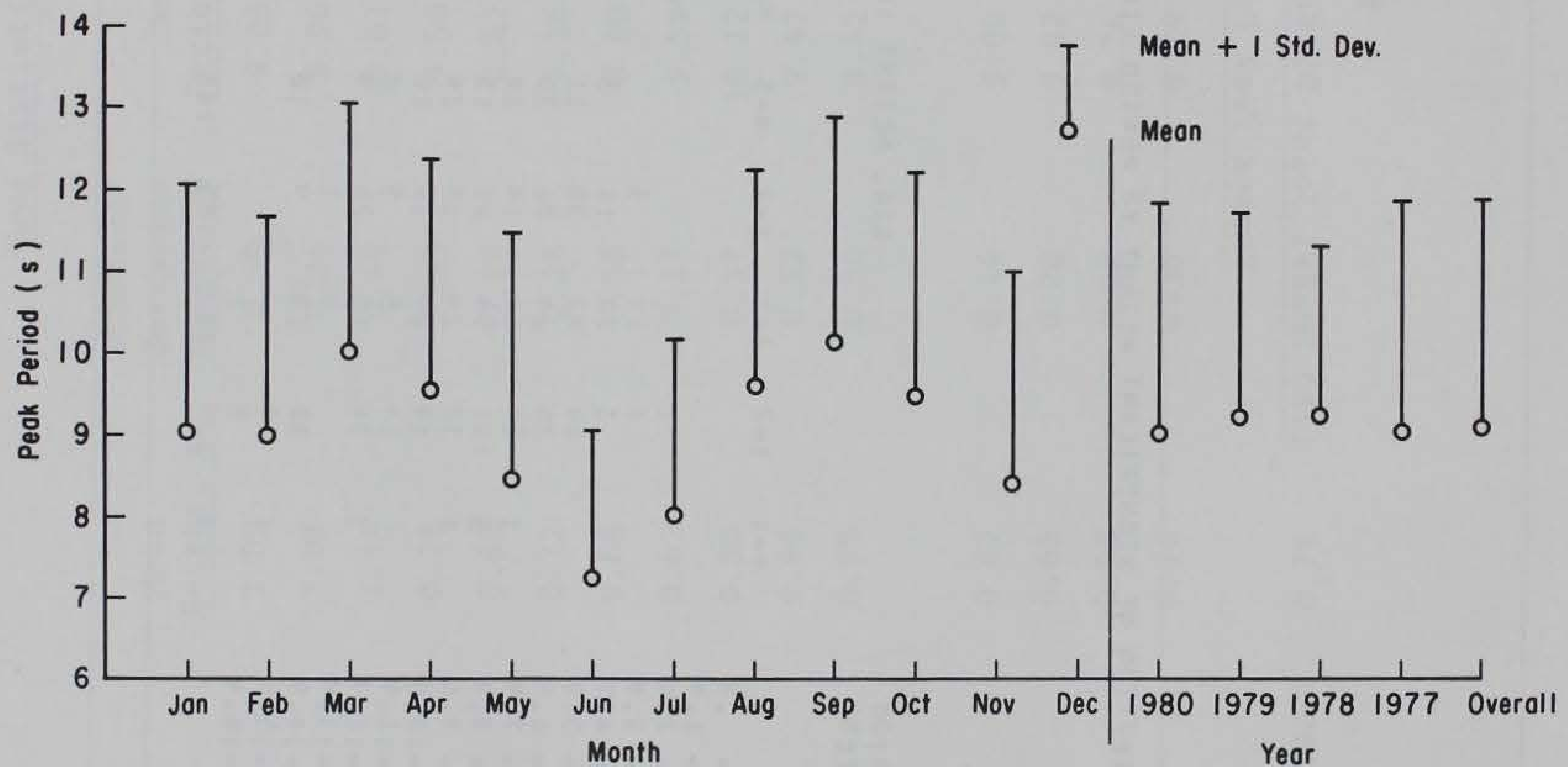
Versus Peak Period for Gage No. 112

DISTRIBUTION OF SIGNIFICANT HEIGHT VS PERIOD (IN OBSERVATIONS PER 1000 OBS)

PERIOD (SECS)	SIG. HEIGHT (FT)														
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13 +	TOT.*
0.0 - .9															
1.0 - 1.9															
2.0 - 2.9		1	1												3
3.0 - 3.9		1	10	3											14
4.0 - 4.9		3	24	11	3										41
5.0 - 5.9		10	42	38	11	1									103
6.0 - 6.9		26	24	26	20	8	3								106
7.0 - 7.9	1	24	14	14	14	14	5	1							88
8.0 - 8.9	3	121	54	20	13	10	4	1							226
9.0 - 9.9	1	38	29	15	14	8	4								110
10.0 -10.9		19	29	14	10	6	4								83
11.0 -11.9		10	5	5	4	1	1			1					28
12.0 -12.9	3	36	13	28	9	13									101
13.0 -13.9			4	1		1									6
14.0 -14.9		32	13	9	10	6	8	1							79
15.0 -15.9	1	3													4
16.0 -16.9		5	1				3								9
TOTAL	9	329	264	185	108	69	31	4		1					



a. Significant wave height



b. Peak wave period mean and standard deviation

Figure B14. 1980 mean, extreme, and standard deviation of significant wave height and peak wave period for gage No. 112

Table B20

Overall (1977-1980) Joint Distribution of Significant Height

Versus Peak Period for Gage No. 112

DISTRIBUTION OF SIGNIFICANT HEIGHT VS PERIOD (IN OBSERVATIONS PER 1000 OBS)

PERIOD (SECS)	SIG. HEIGHT (FT)														
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13 +	TOT.*
0.0 - .9															
1.0 - 1.9															
2.0 - 2.9		3													3
3.0 - 3.9		4	6	2	1										12
4.0 - 4.9		6	17	12	1										36
5.0 - 5.9		13	36	26	14	2									91
6.0 - 6.9	2	22	23	27	17	5	2								98
7.0 - 7.9	3	28	16	13	13	7	2								82
8.0 - 8.9	16	126	56	23	18	12	3								256
9.0 - 9.9	5	56	28	20	10	5	3								127
10.0 -10.9	3	30	32	13	7	5	2								93
11.0 -11.9		3	2	2	1										9
12.0 -12.9	6	36	18	18	8	7	2								94
13.0 -13.9			1												2
14.0 -14.9	4	42	10	6	5	4	3	1							75
15.0 -15.9		1													1
16.0 -16.9	1	9	6	1			3								20
17.0 -17.9															
18.0 -18.9															
19.0 -19.9															
20.0 -20.9		1													1
21.0 +															
TOTAL	41	380	250	163	95	49	19	3							

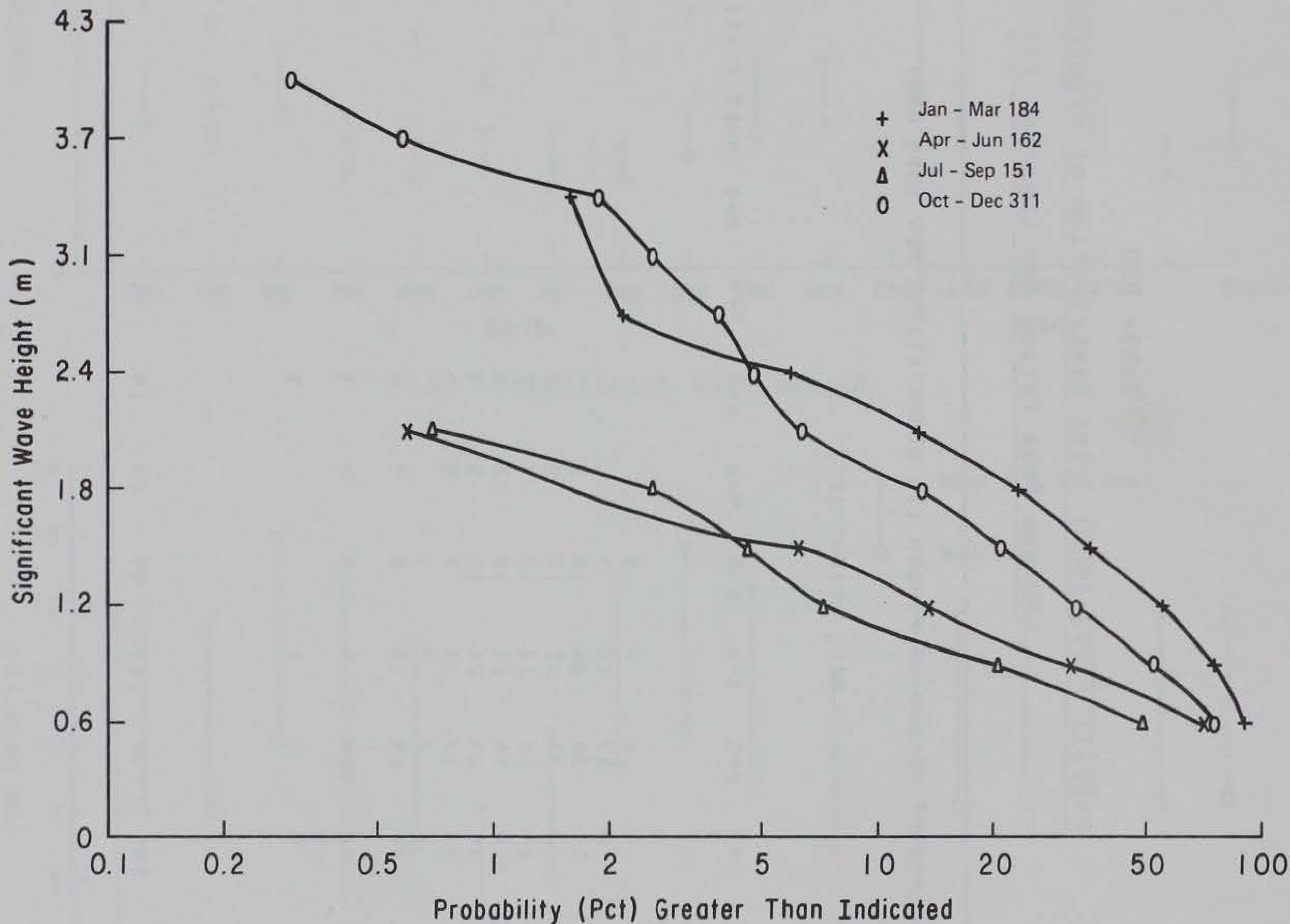


Figure B15. Seasonal distribution of significant wave height for gage No. 112

Table B21

Seasonal Joint Distribution of Significant Height

Versus Peak Period for Gage No. 112

DISTRIBUTION OF SIGNIFICANT HEIGHT VS PERIOD (IN OBSERVATIONS PER 1000 OBS)
SUMMARY FOR JAN 80 THROUGH MAR 80

PERIOD (SECS)	SIG. HEIGHT (FT) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13 +	TOT.*
0.0 - .9															
1.0 - 1.9															
2.0 - 2.9															
3.0 - 3.9			5												5
4.0 - 4.9			29	5											34
5.0 - 5.9		10	39	68	10										126
6.0 - 6.9		19	34	44	29	5									131
7.0 - 7.9		5	5	10	10	15	5								49
8.0 - 8.9	5	39	19	44	24	15									146
9.0 - 9.9	5	34	19	15	34	15	5								126
10.0 -10.9		15	5	10	34	24	5								92
11.0 -11.9															
12.0 -12.9	10	15	24	53	34	34									170
13.0 -13.9															
14.0 -14.9			5	24	39	24	15	5							112
15.0 -15.9															
16.0 -16.9							10								10
TOTAL	19	136	184	272	214	131	39	5							

(Continued)

Table B21 (Continued)

DISTRIBUTION OF SIGNIFICANT HEIGHT VS PERIOD (IN OBSERVATIONS PER 1000 OBS)
SUMMARY FOR APR 80 THROUGH JUN 80

PERIOD (SECS)	SIG. HEIGHT (FT) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13 +	TOT.*
0.0 - .9															
1.0 - 1.9															
2.0 - 2.9		5													5
3.0 - 3.9		5	15	10											29
4.0 - 4.9		10	34	15	5										64
5.0 - 5.9		20	74	25	10										127
6.0 - 6.9		44	20	5	5	5									78
7.0 - 7.9	5	20	34	34	10										103
8.0 - 8.9		191	49	15	15										270
9.0 - 9.9		29	34	10	10										83
10.0 -10.9		25	39	10			10								83
11.0 -11.9															
12.0 -12.9		54	10	15		10									88
13.0 -13.9															
14.0 -14.9		39	15												54
15.0 -15.9															
16.0 -16.9		15													15
TOTAL	5	456	324	137	54	15	10								

(Continued)

Table B21 (Continued)

DISTRIBUTION OF SIGNIFICANT HEIGHT VS PERIOD (IN OBSERVATIONS PER 1000 OBS)
SUMMARY FOR JUL 80 THROUGH SEP 80

PERIOD (SECS)	SIG. HEIGHT (FT) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13 +	TOT.*
0.0 - .9															
1.0 - 1.9															
2.0 - 2.9															
3.0 - 3.9			18												18
4.0 - 4.9			18	12											30
5.0 - 5.9		6	18	18											42
6.0 - 6.9		42	12	18	18										91
7.0 - 7.9		42	12	6	18	6	6								91
8.0 - 8.9	6	176	139	12	12	12									358
9.0 - 9.9		61	48	6		6									121
10.0 -10.9		18	24												42
11.0 -11.9															
12.0 -12.9		42	6	30											79
13.0 -13.9															
14.0 -14.9		91	24	6											121
15.0 -15.9															
16.0 -16.9			6												6
TOTAL	6	479	327	109	48	24	6								

(Continued)

Table B21 (Concluded)

DISTRIBUTION OF SIGNIFICANT HEIGHT VS PERIOD (IN OBSERVATIONS PER 1000 OBS)
SUMMARY FOR OCT 80 THROUGH NOV 80

PERIOD (SECS)	SIG. HEIGHT (FT)														
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13 +	TOT.*
0.0 - .9															
1.0 - 1.9															
2.0 - 2.9			5												5
3.0 - 3.9			5												5
4.0 - 4.9			14	14	5										33
5.0 - 5.9		5	33	38	24	5									105
6.0 - 6.9			29	33	29	19	10								120
7.0 - 7.9		33	5	5	19	33	10	5							110
8.0 - 8.9		91	24	10		14	14	5							158
9.0 - 9.9		33	19	29	10	10	10								110
10.0 -10.9		19	48	33	5										105
11.0 -11.9		38	19	19	14	5	5			5					105
12.0 -12.9		33	10	14		5									62
13.0 -13.9			14	5		5									24
14.0 -14.9		10	10	5			14								38
15.0 -15.9	5	10													14
16.0 -16.9		5													5
TOTAL	5	278	234	206	105	96	62	10		5					

Table B22

Persistence* of 1980 Significant Wave Heights for Gage No. 112

Height Exceeded m	Consecutive Days																													
	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
0.5	41	37	31	27	23	16			11	7	6	4		3							2							1		
1.0	45	25	18	6	5				3	2	1																			
1.5	25	12	6	1																										
2.0	4	1																												
2.5	1																													
3.0																														
3.5																														
4.0																														

* Number of times during the year the given significant wave height was exceeded at least once a day for the specified number of consecutive days.

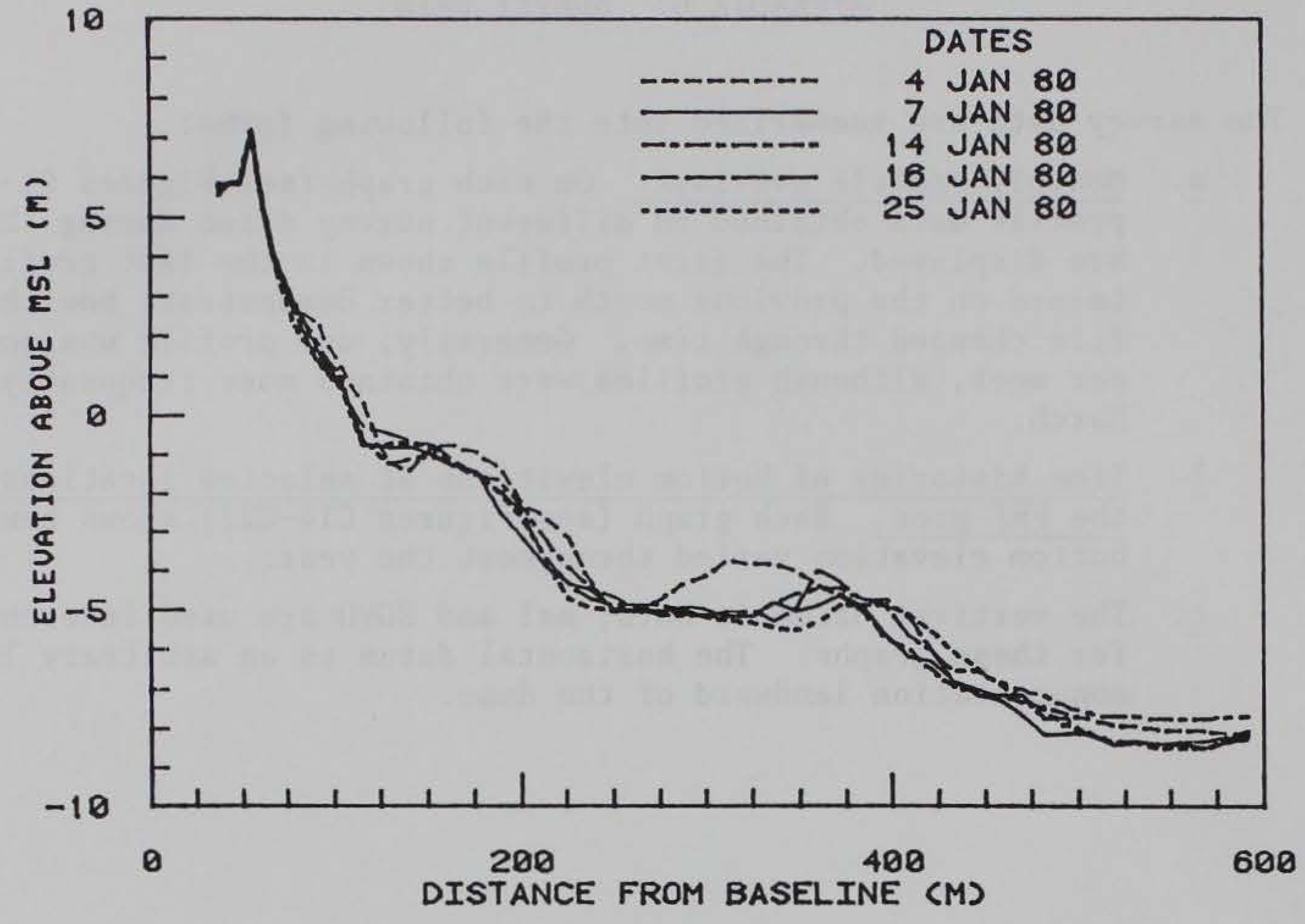
APPENDIX C: SURVEY DATA

The survey data are summarized into the following forms:

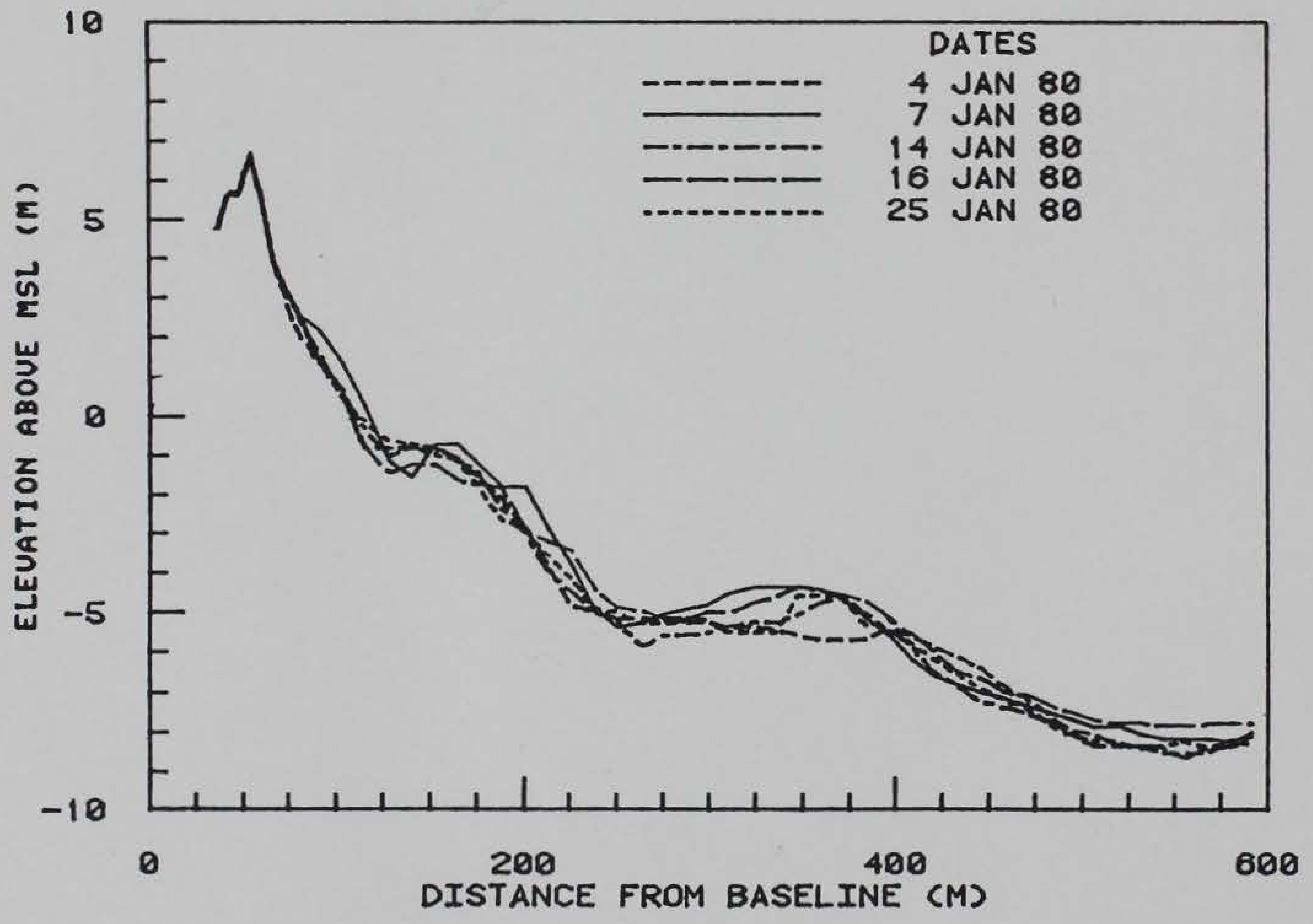
a. Monthly profile overlays. On each graph (see Figures C1-C13), profile data obtained on different survey dates during the month are displayed. The first profile shown is the last profile obtained on the previous month to better demonstrate how the profile changed through time. Generally, one profile was obtained per week, although profiles were obtained more frequently in March.

b. Time histories of bottom elevations at selected locations along the FRF pier. Each graph (see Figures C14-C22) shows how the bottom elevation varied throughout the year.

c. The vertical datum is NGVD; msl and NGVD are used interchangably for these graphs. The horizontal datum is an arbitrary line of monumentation landward of the dune.

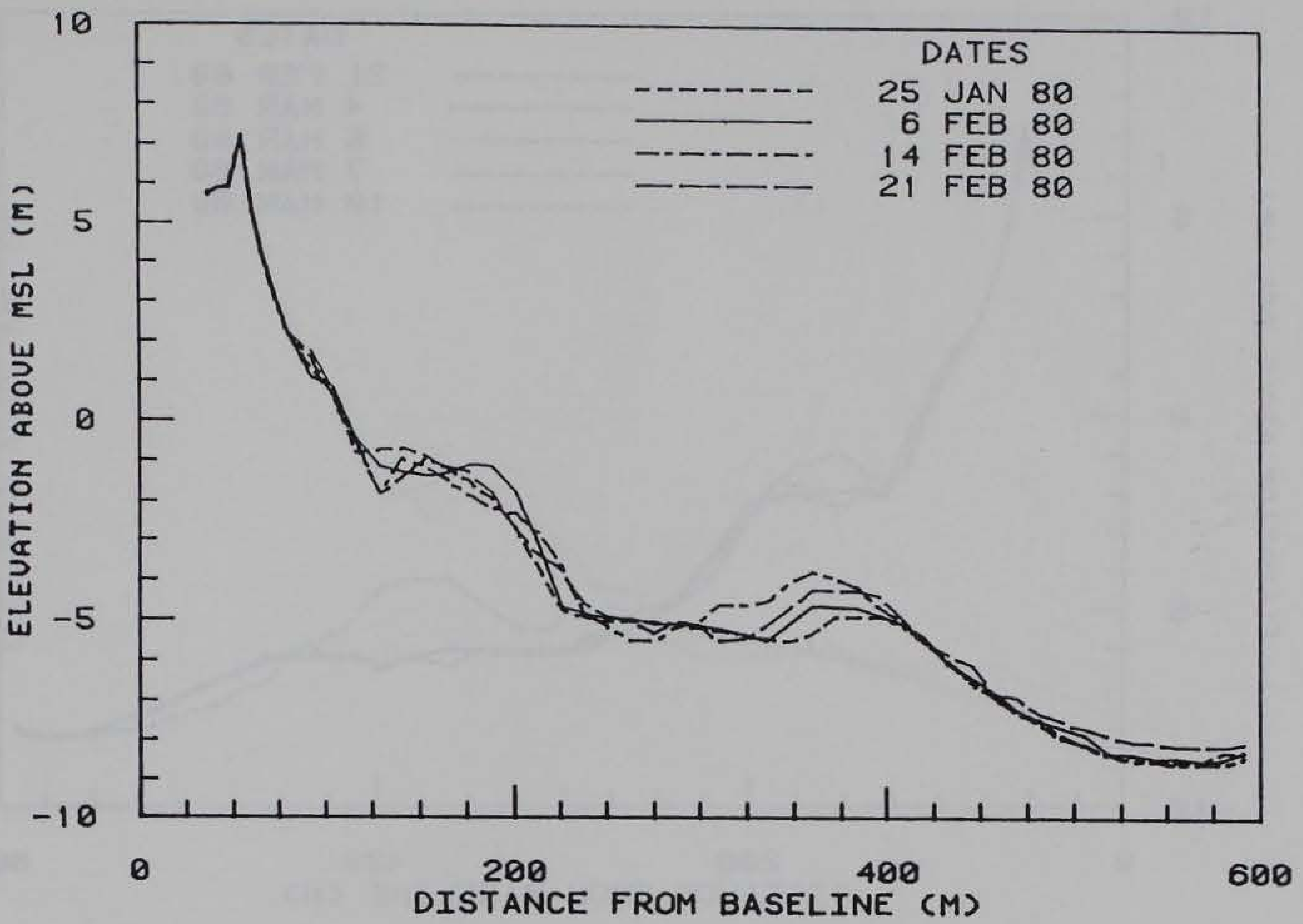


a. North side

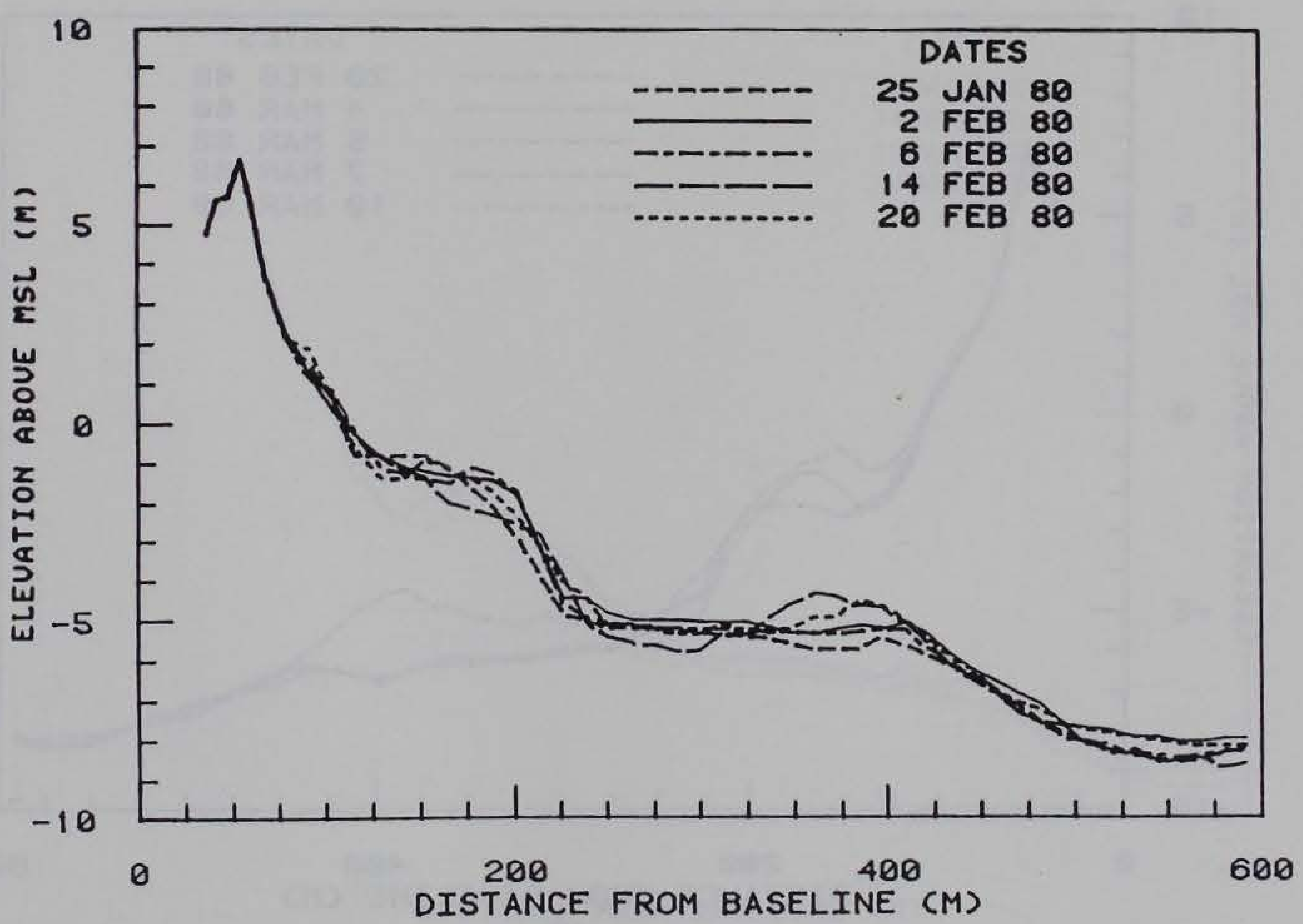


b. South side

Figure C1. FRF pier profiles for January 1980

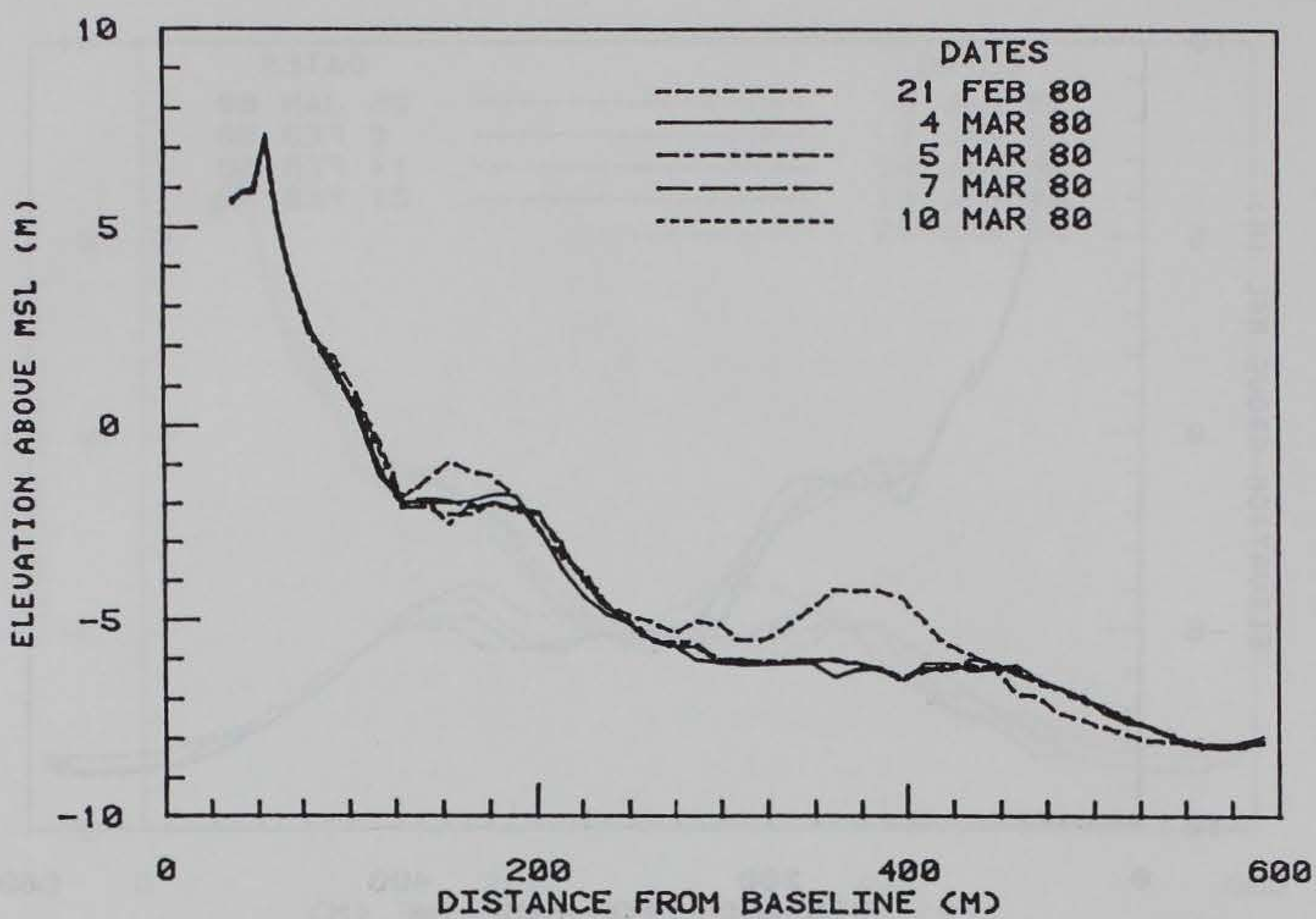


a. North side

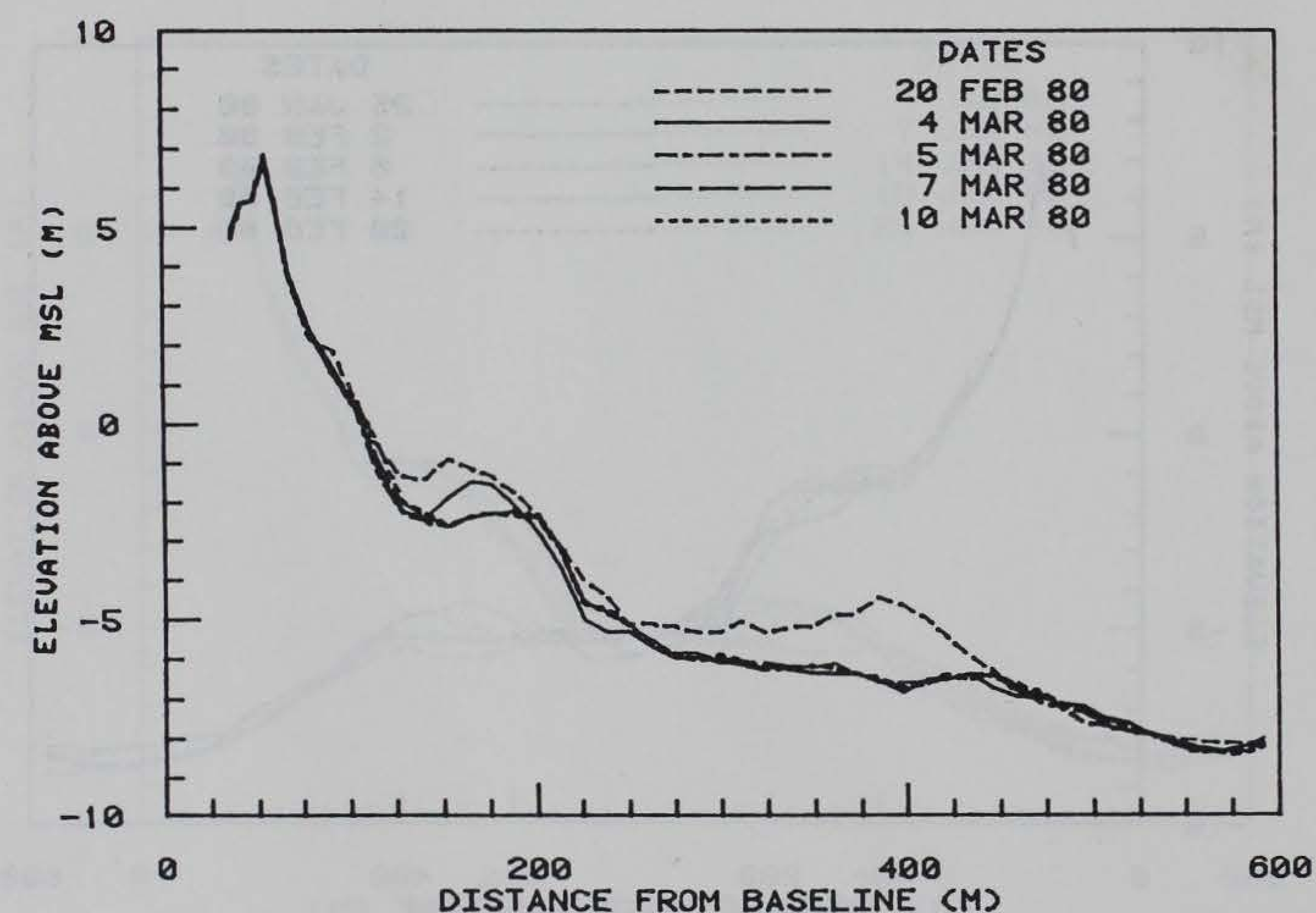


b. South side

Figure C2. FRF pier profiles for February 1980

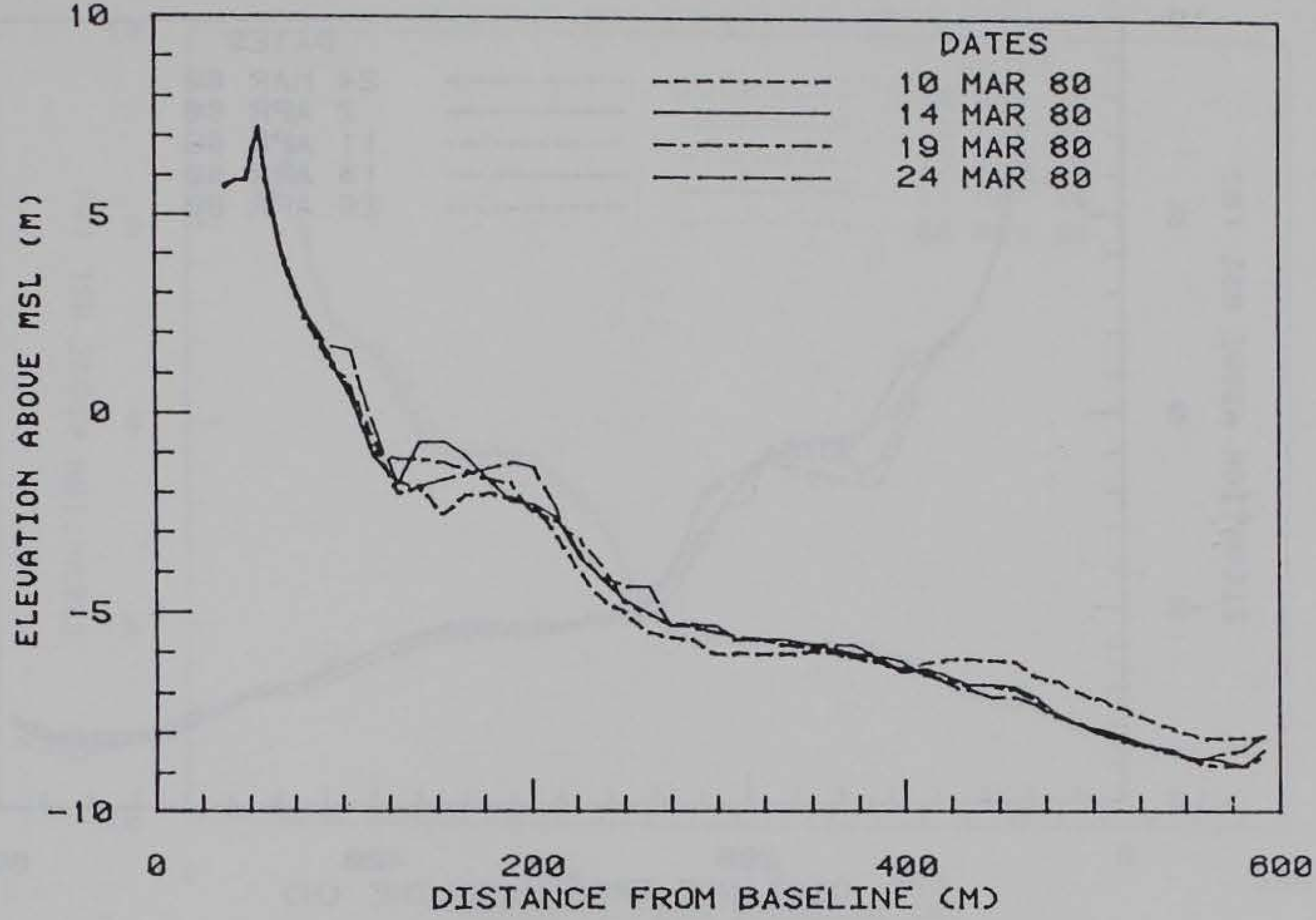


a. North side (to 10 March)

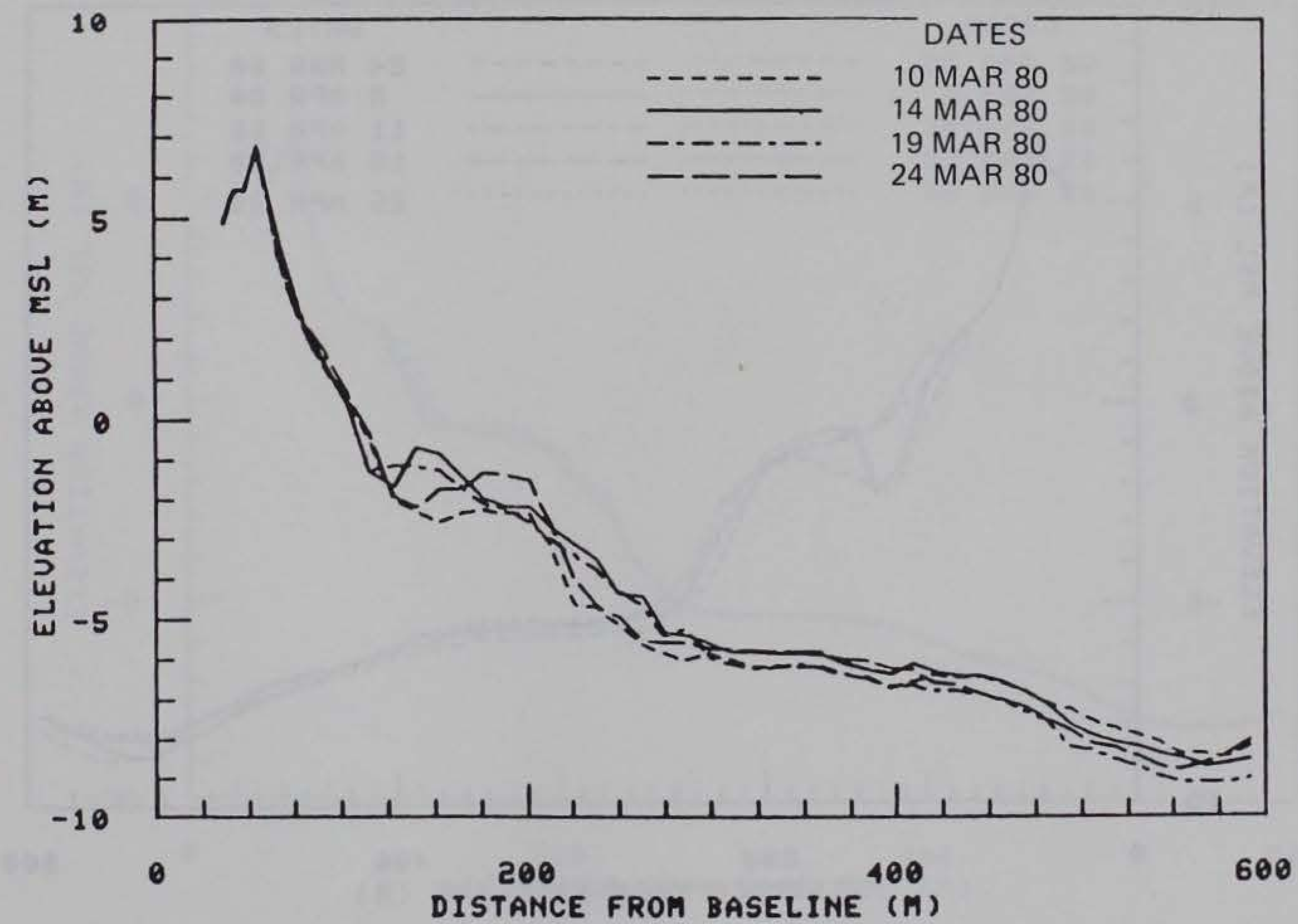


b. South side (to 10 March)

Figure C3. FRF profiles for March 1980 (Sheet 1 of 2)

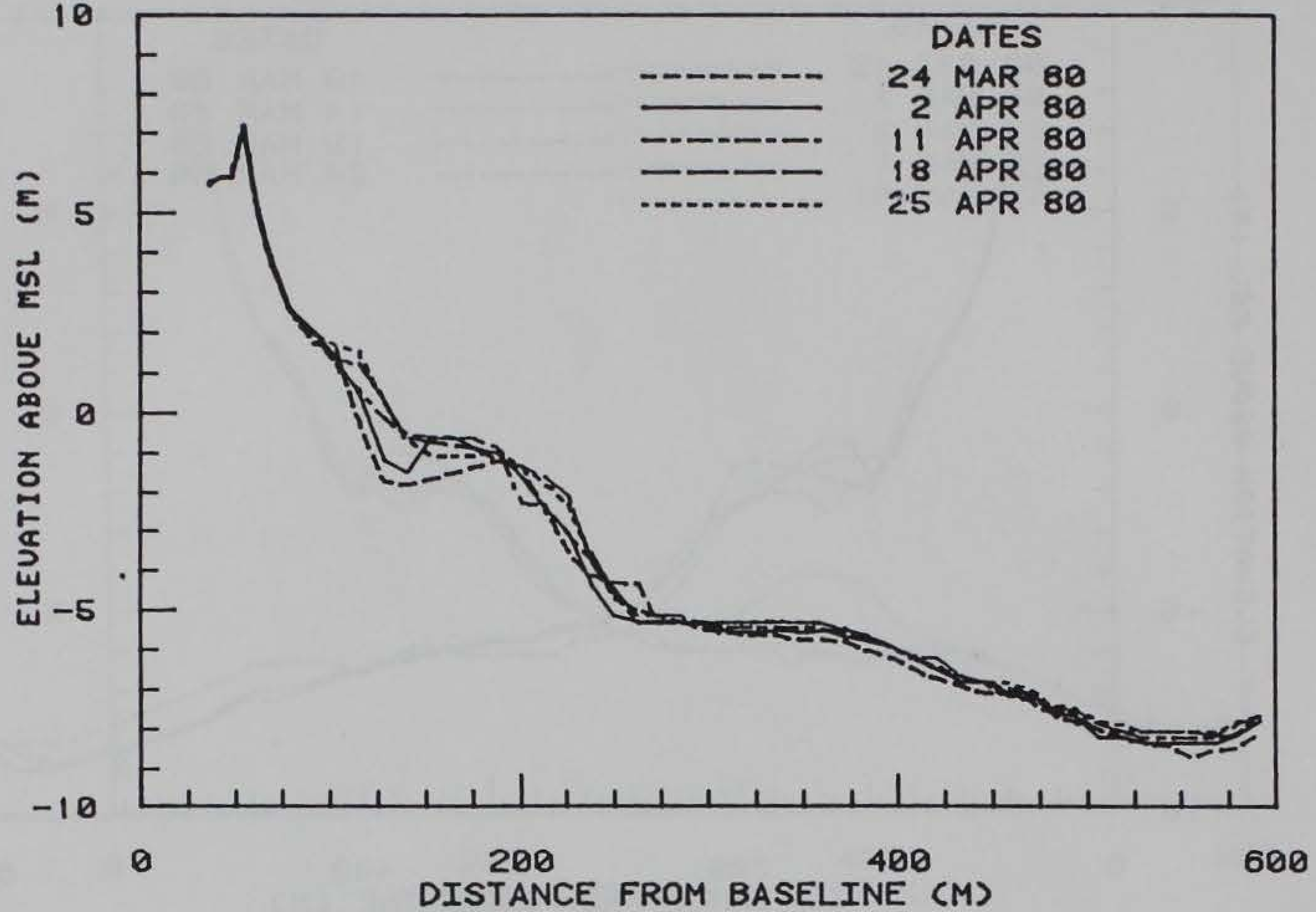


c. North side (10-24 March)

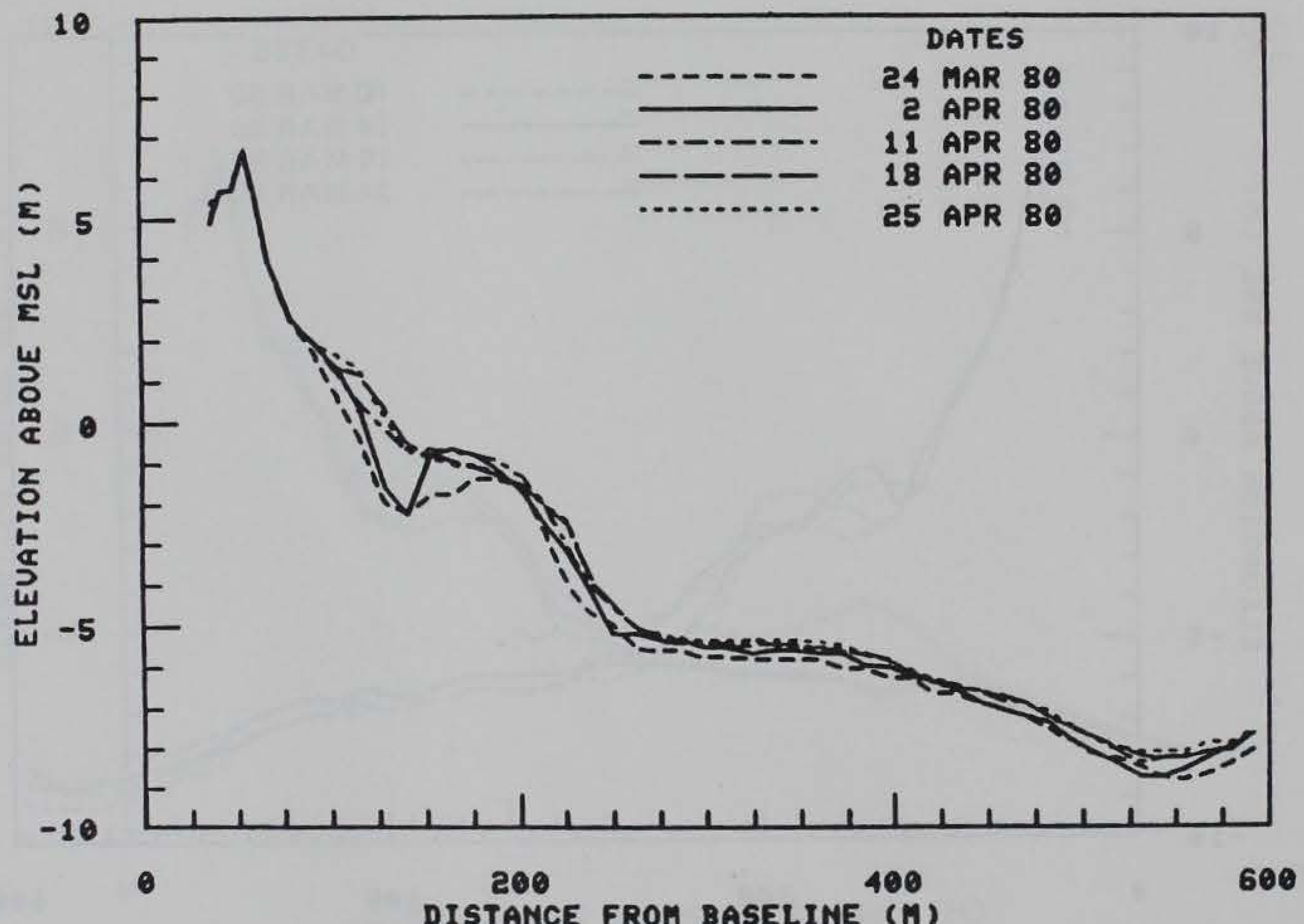


d. South side (10-24 March)

Figure C3. (Sheet 2 of 2)

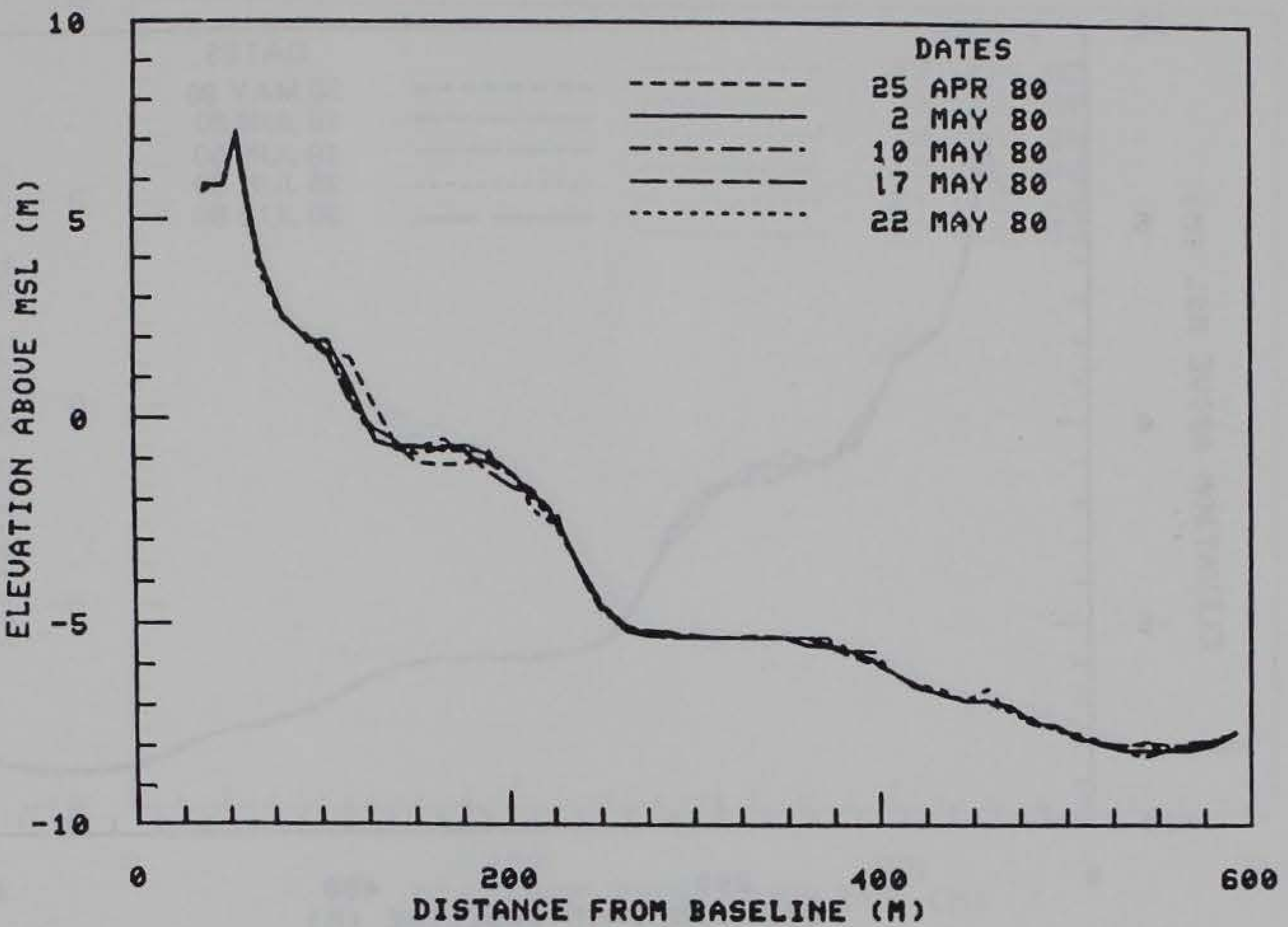


a. North side

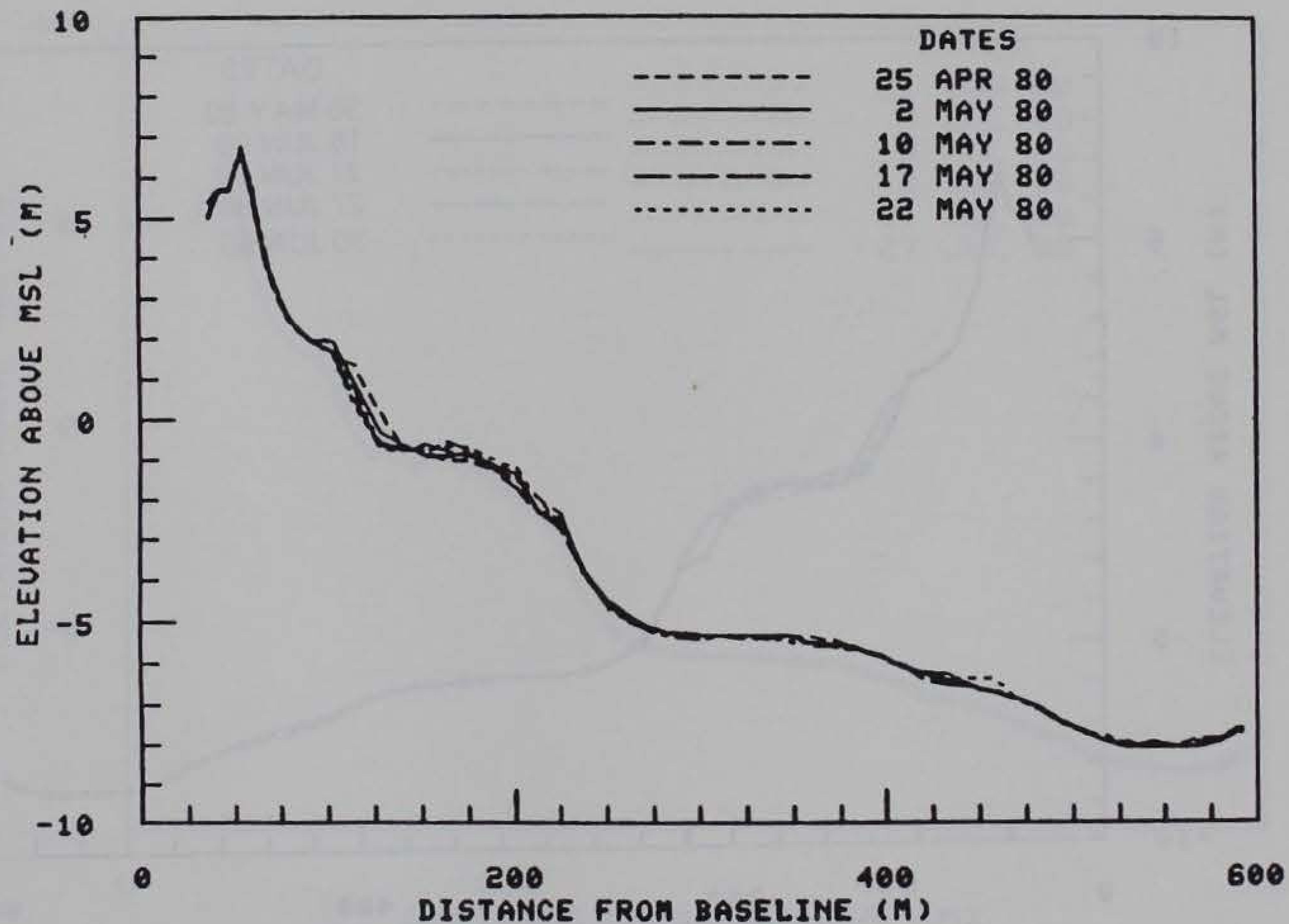


b. South side

Figure C4. FRF pier profiles for April 1980

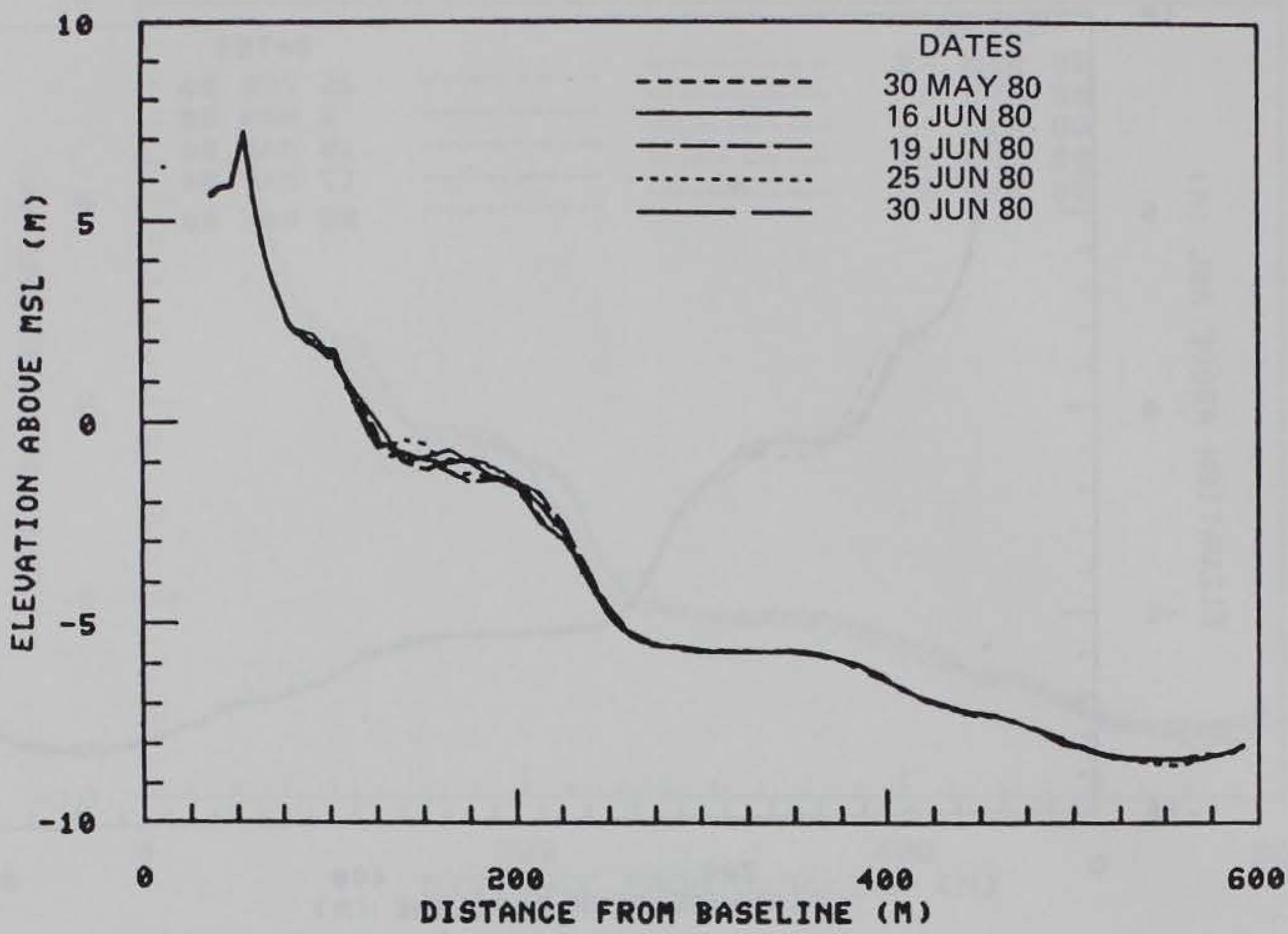


a. North side

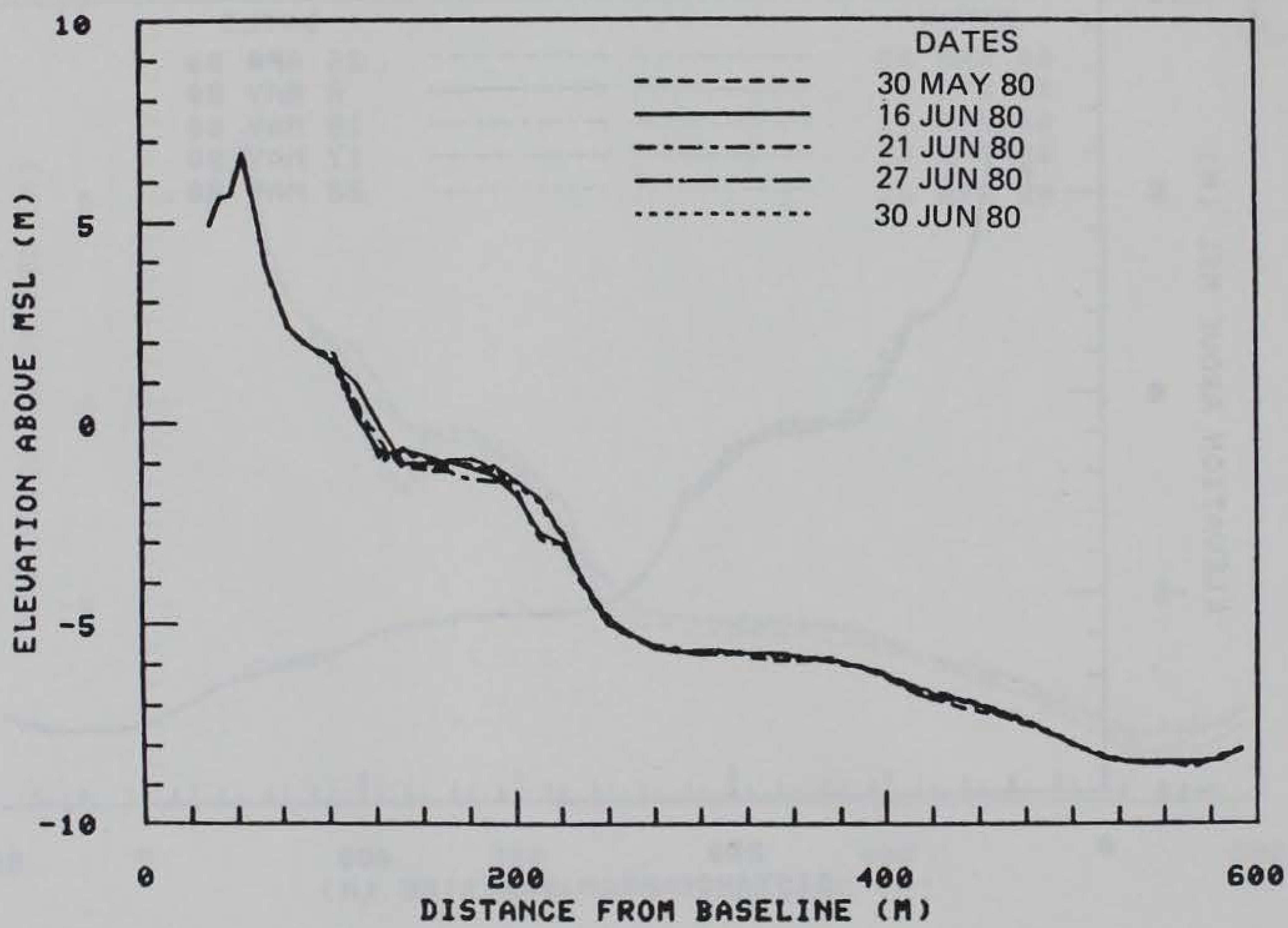


b. South side

Figure C5. FRF profiles for May 1980

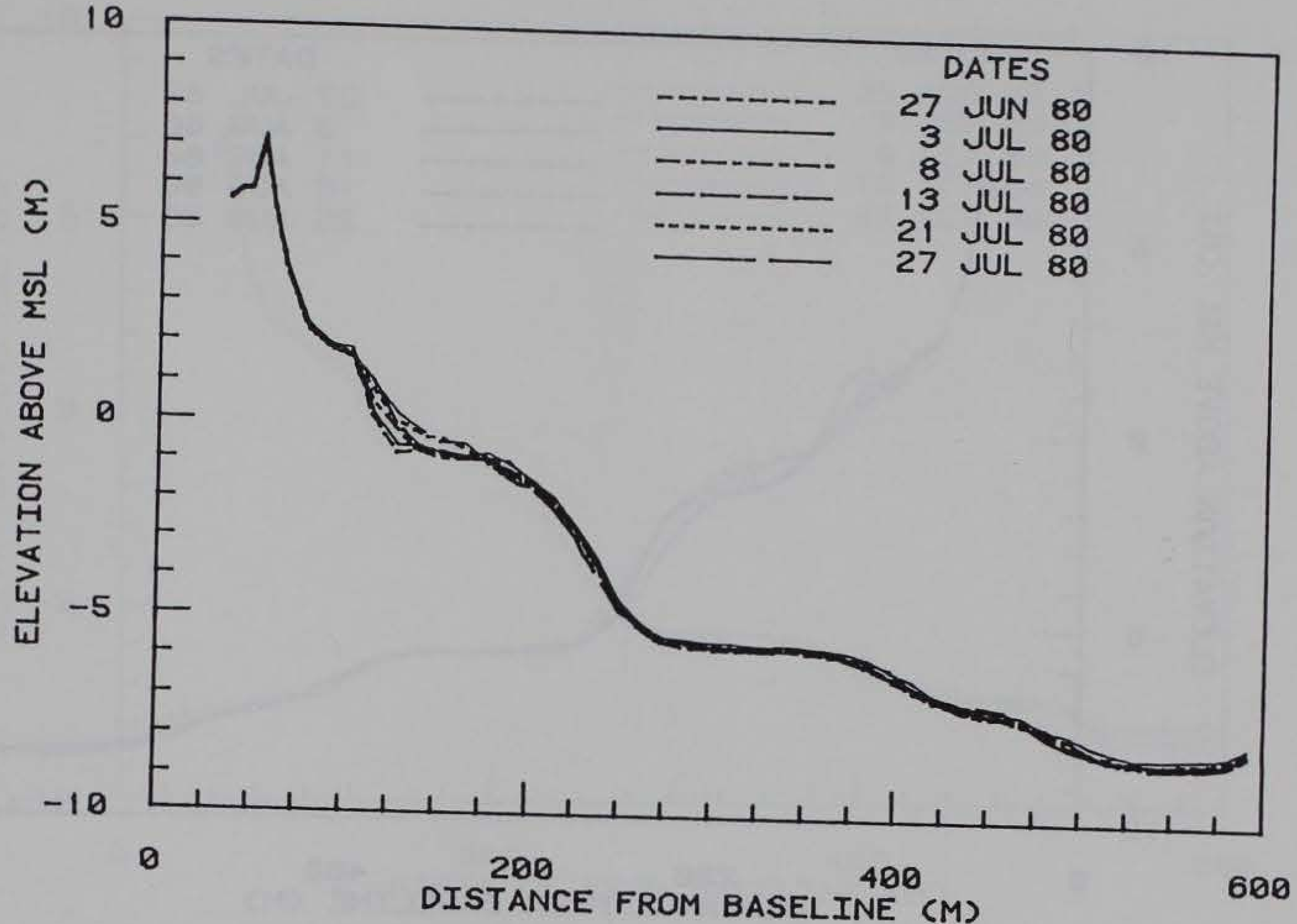


a. North side

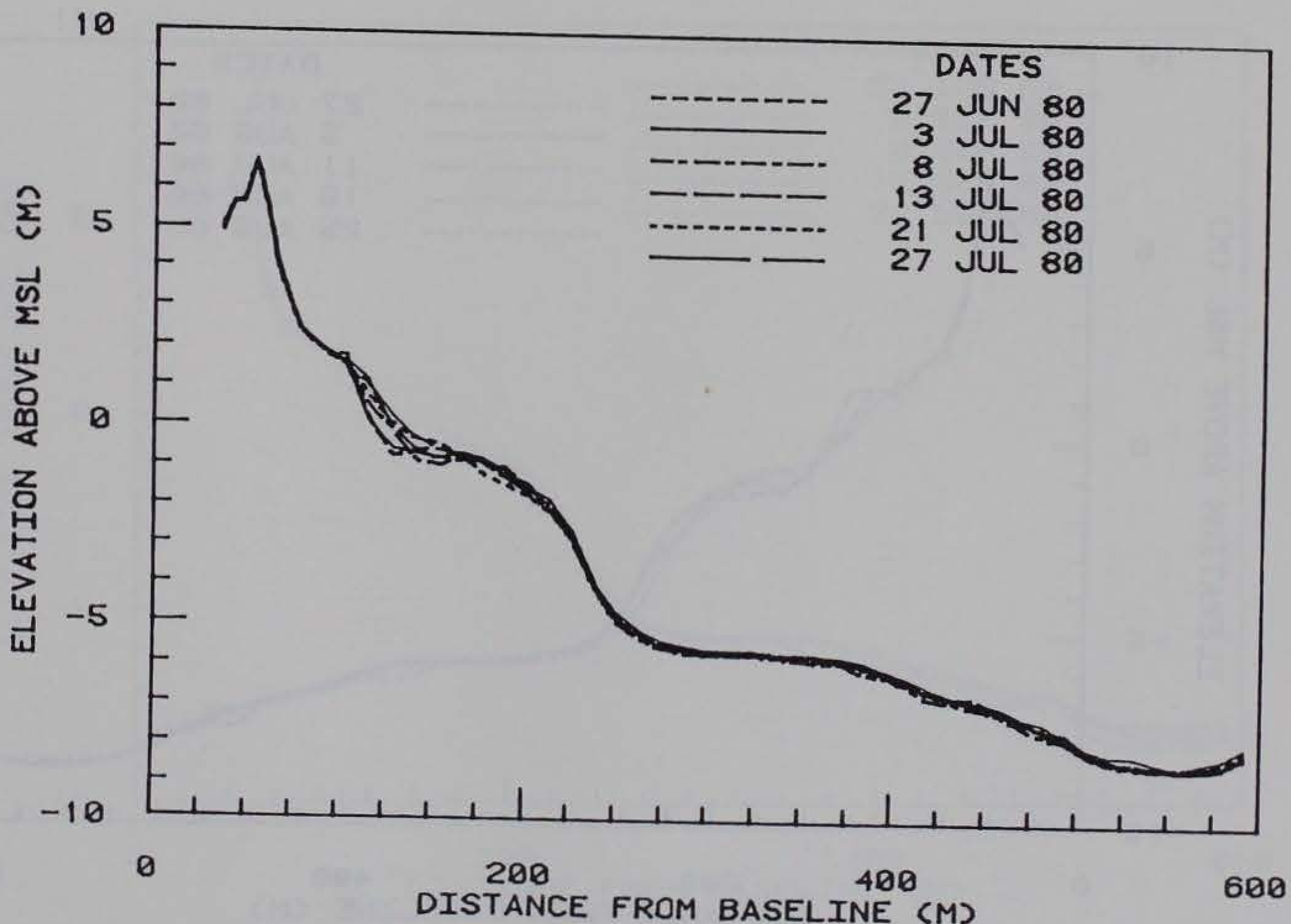


b. South side

Figure C6. FRF profiles for June 1980

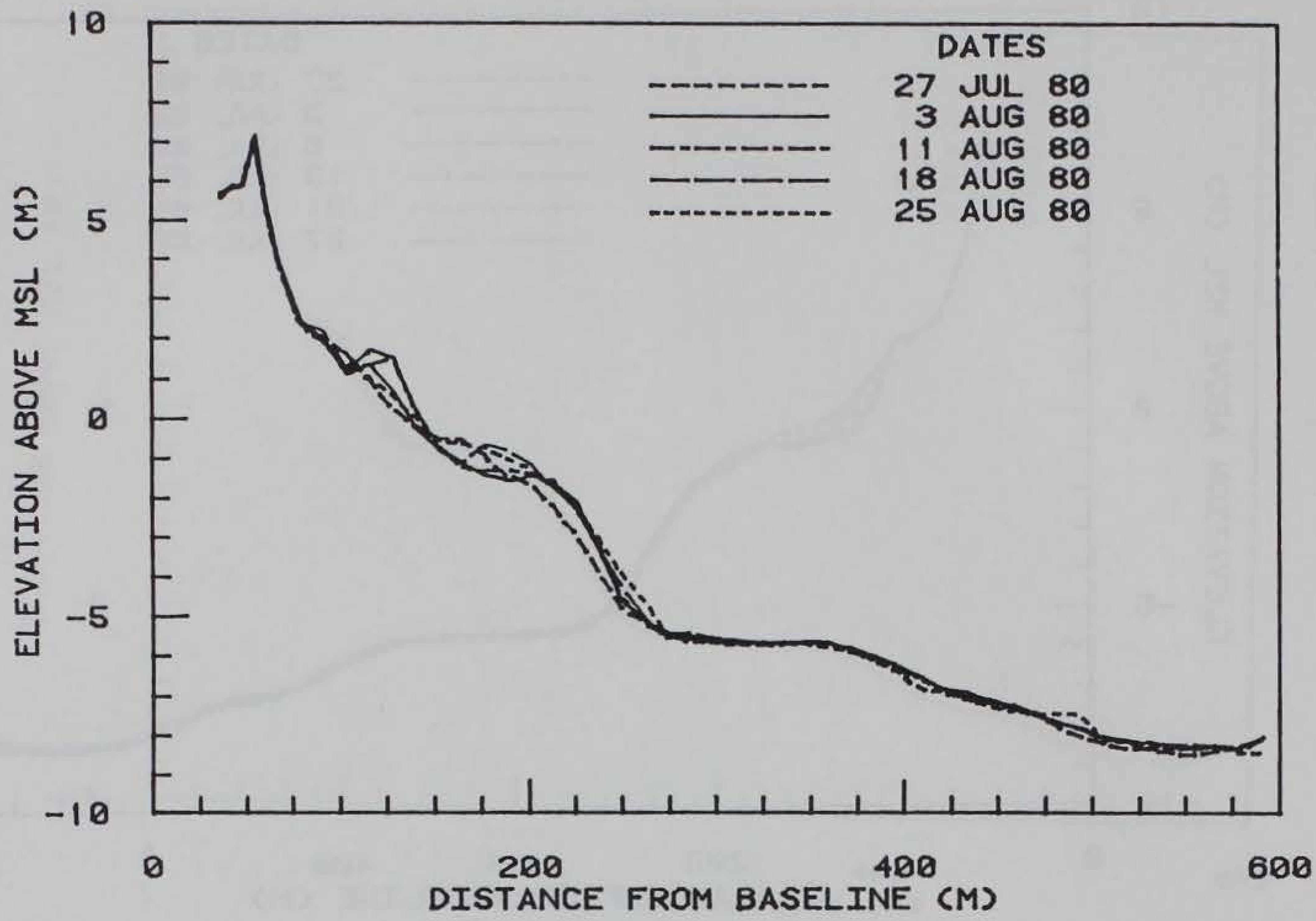


a. North side

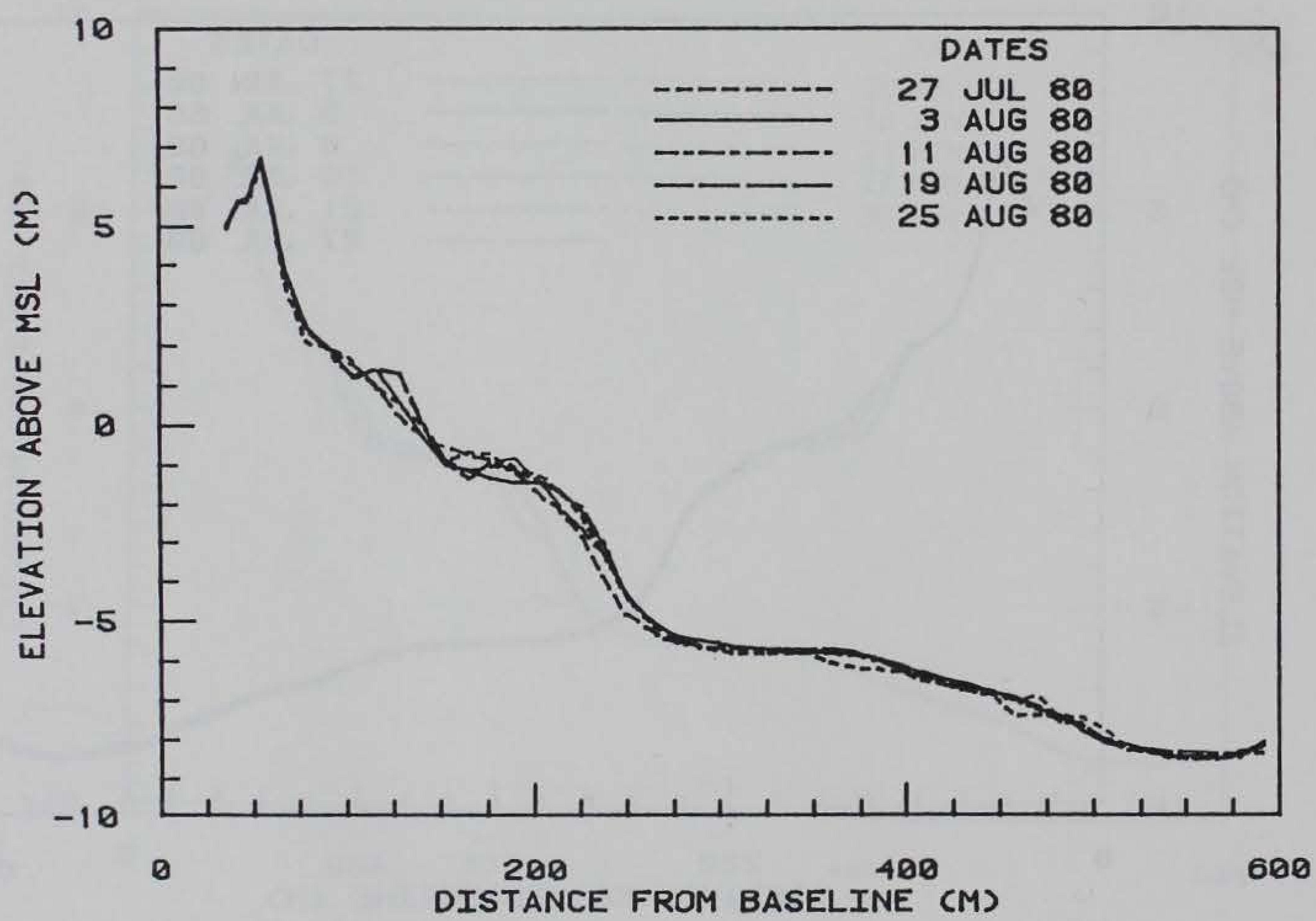


b. South side

Figure C7. FRF profiles for July 1980

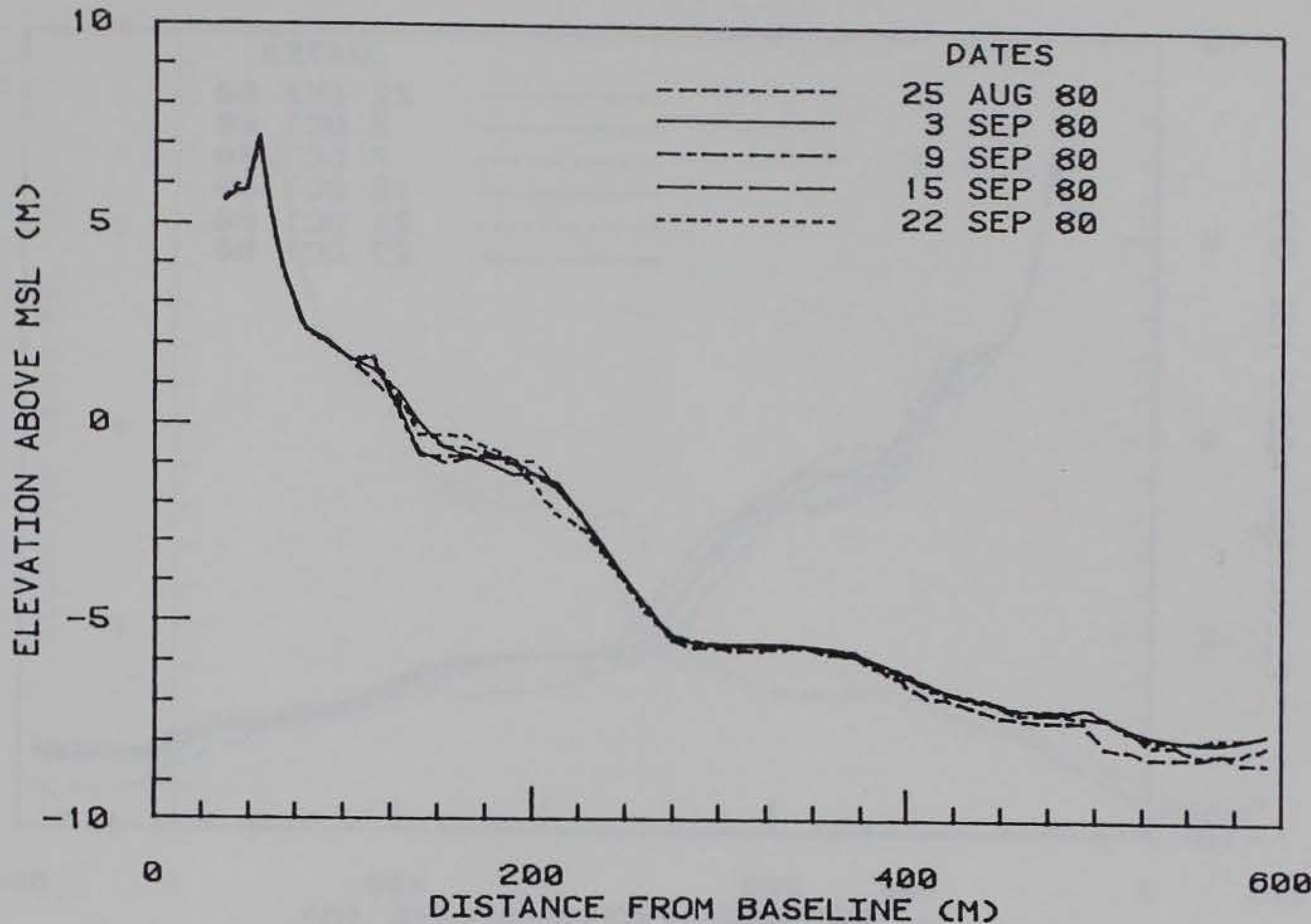


a. North side

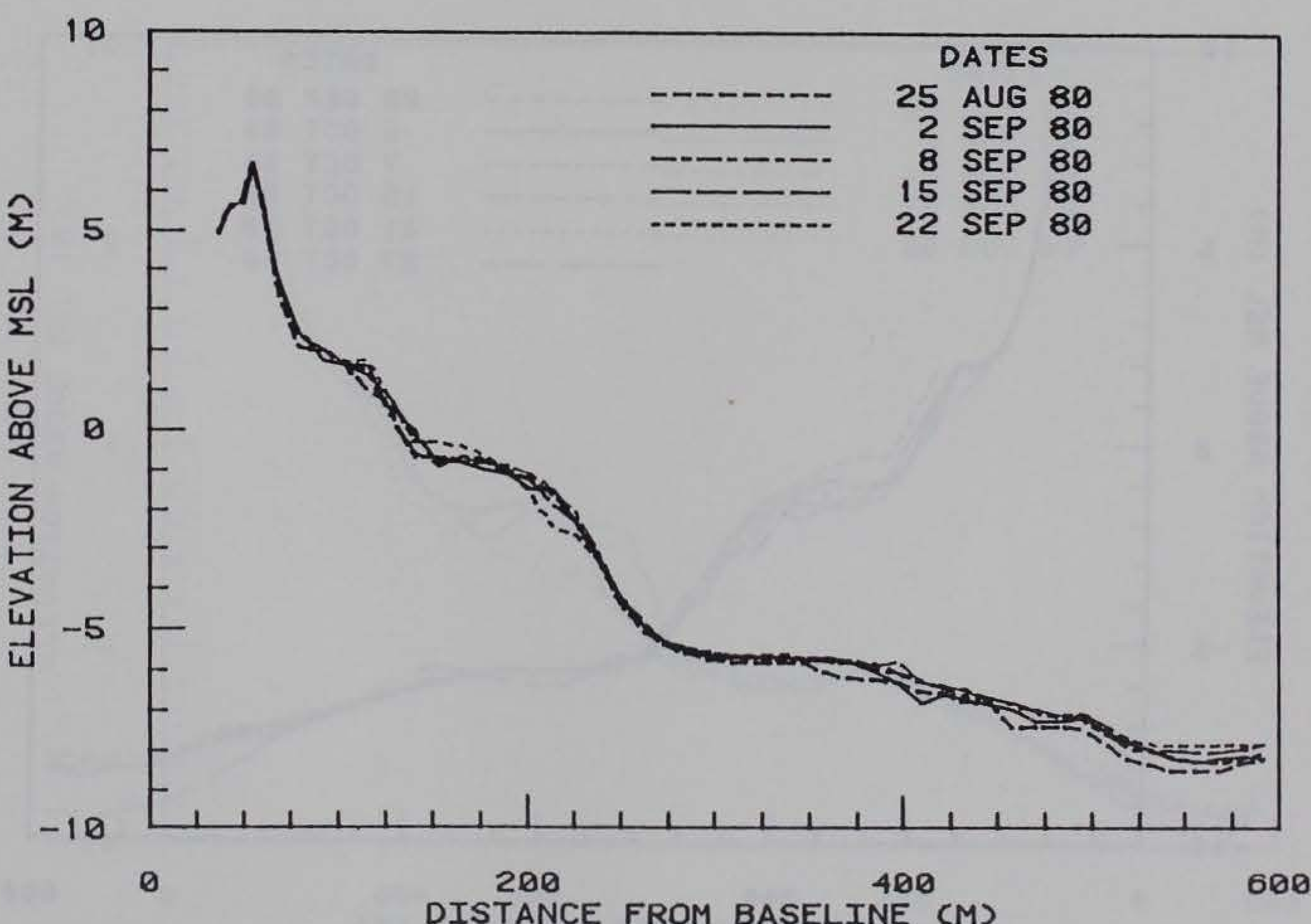


b. South side

Figure C8. FRF pier profiles for August 1980

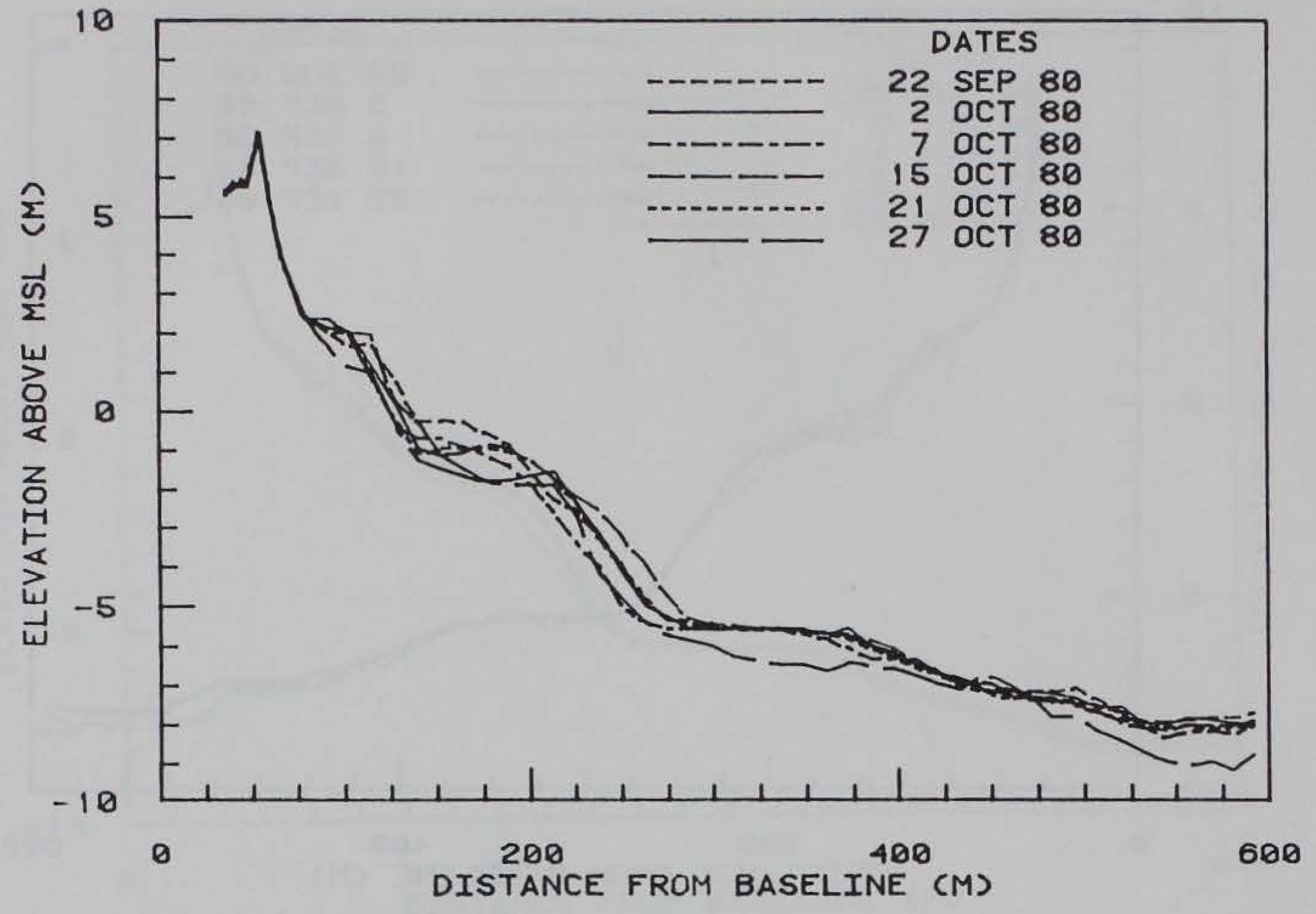


a. North side

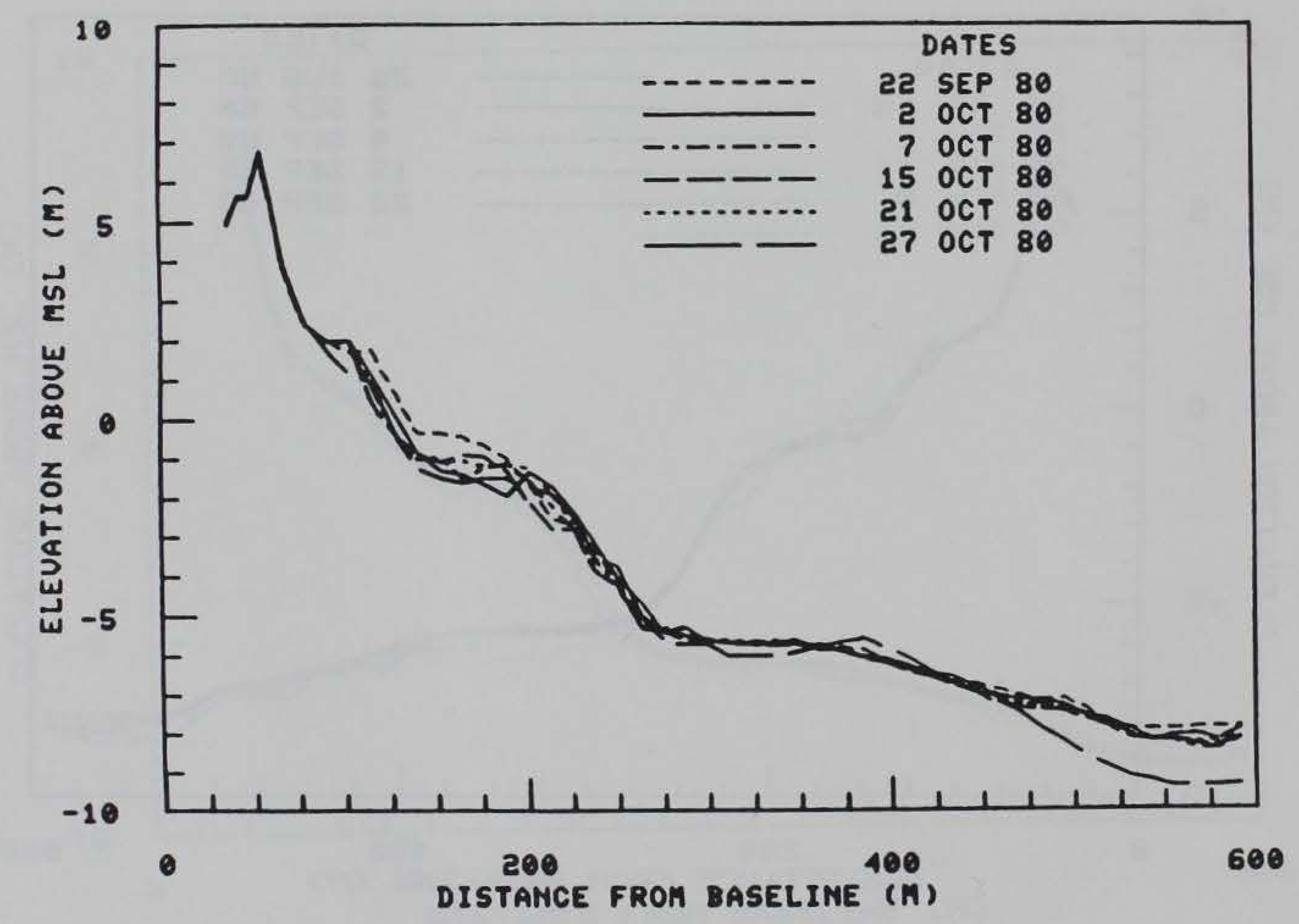


b. South side

Figure C9. FRF pier profiles for September 1980

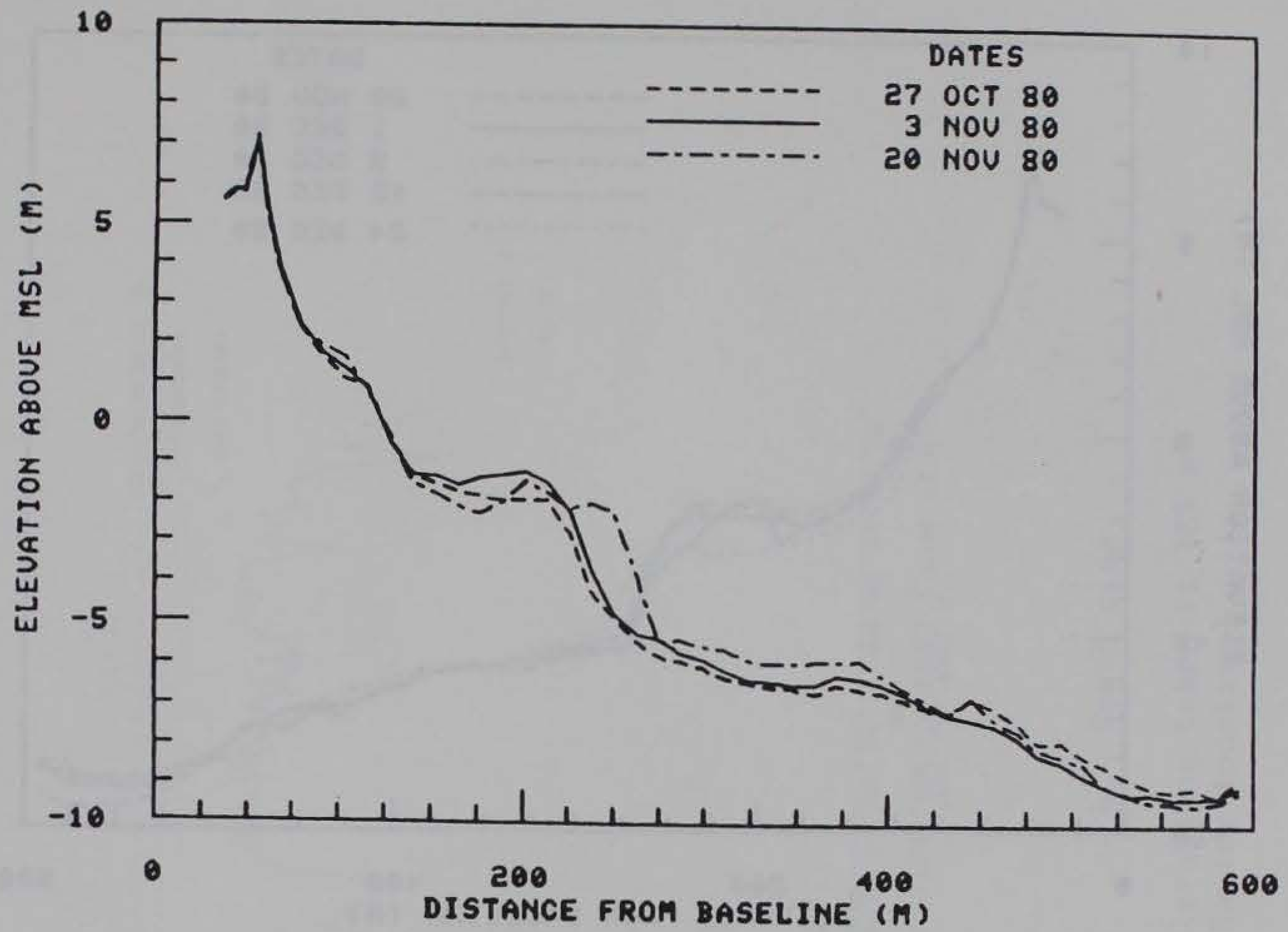


a. North side

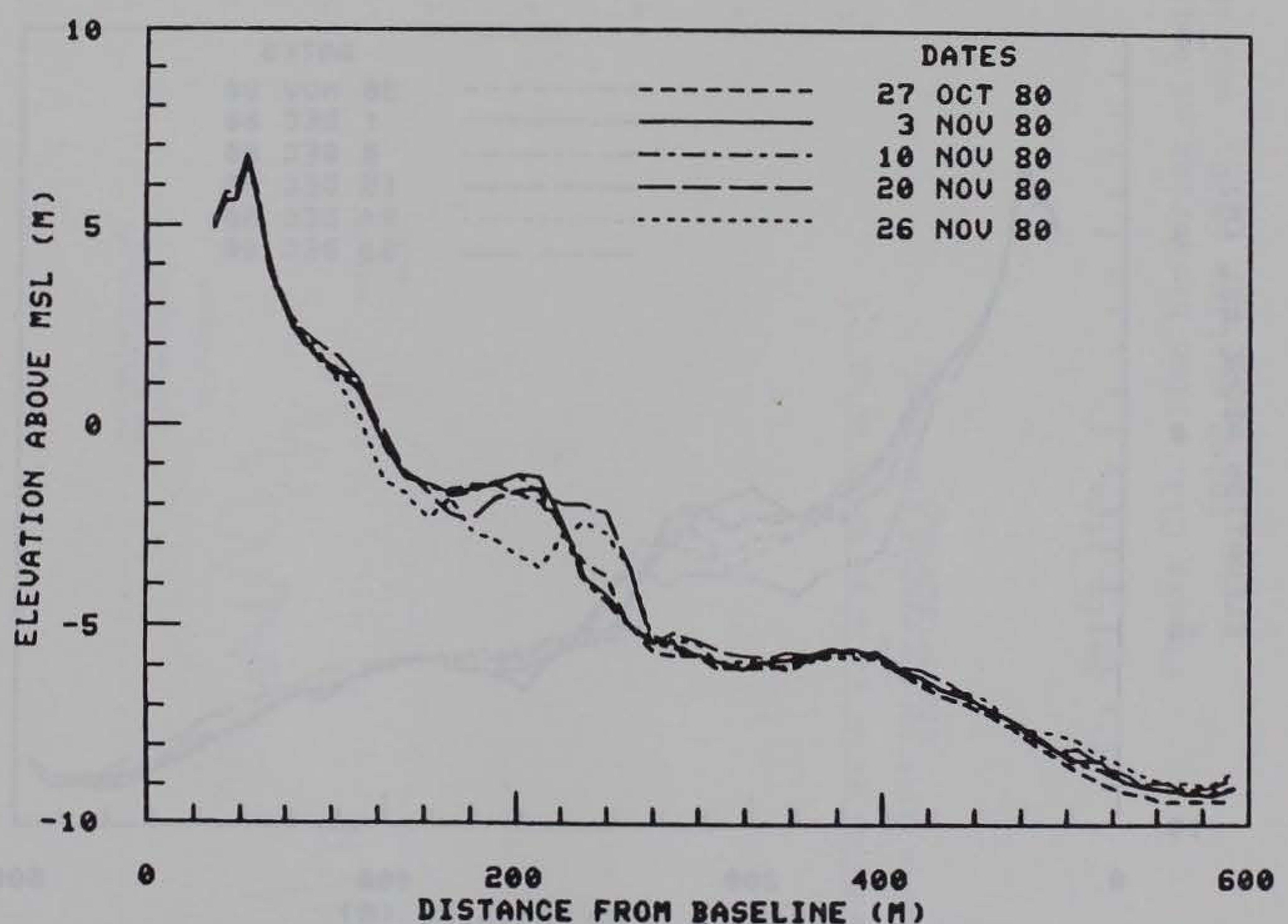


b. South side

Figure C10. FRF pier profiles for October 1980

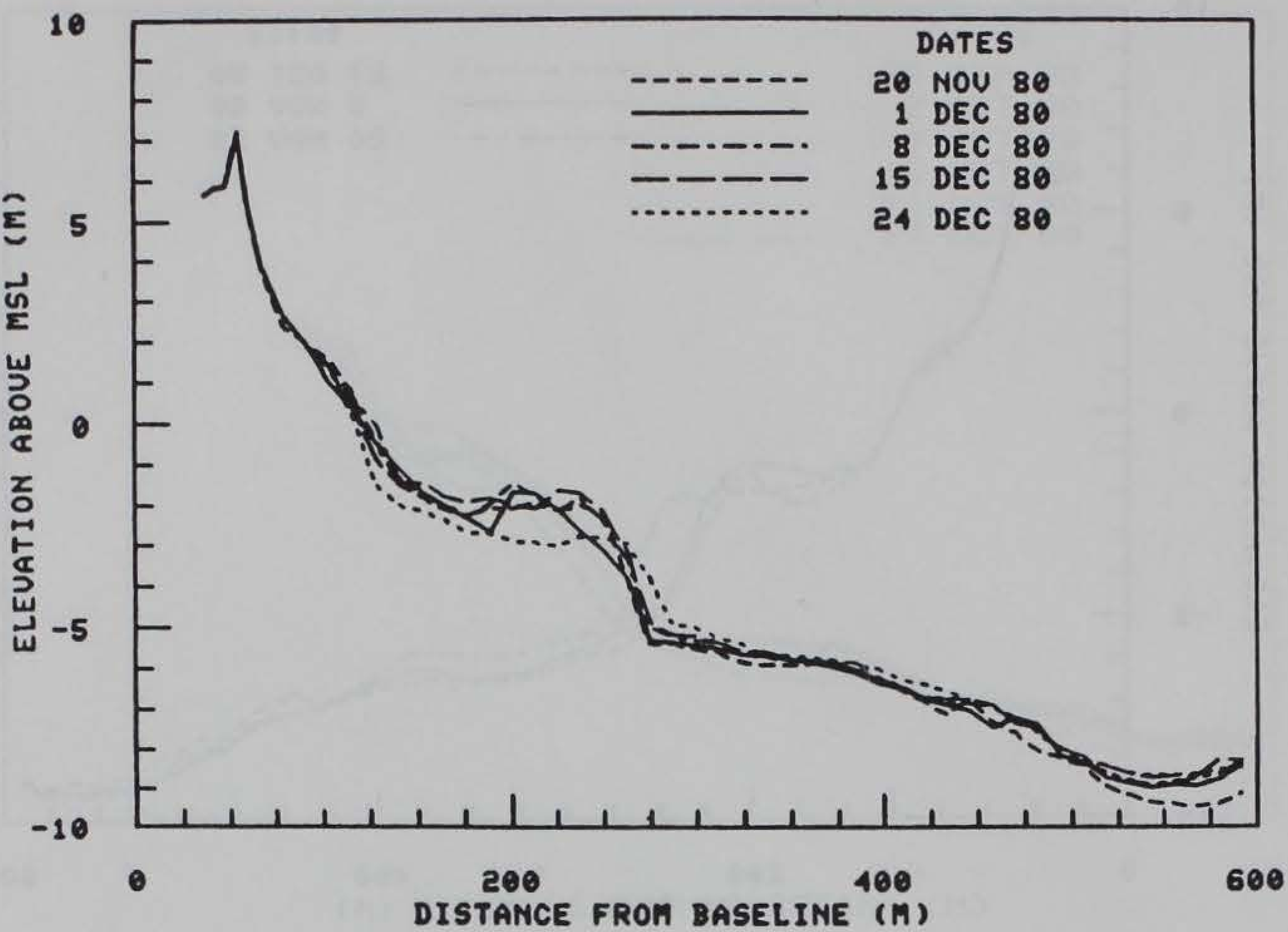


a. North side

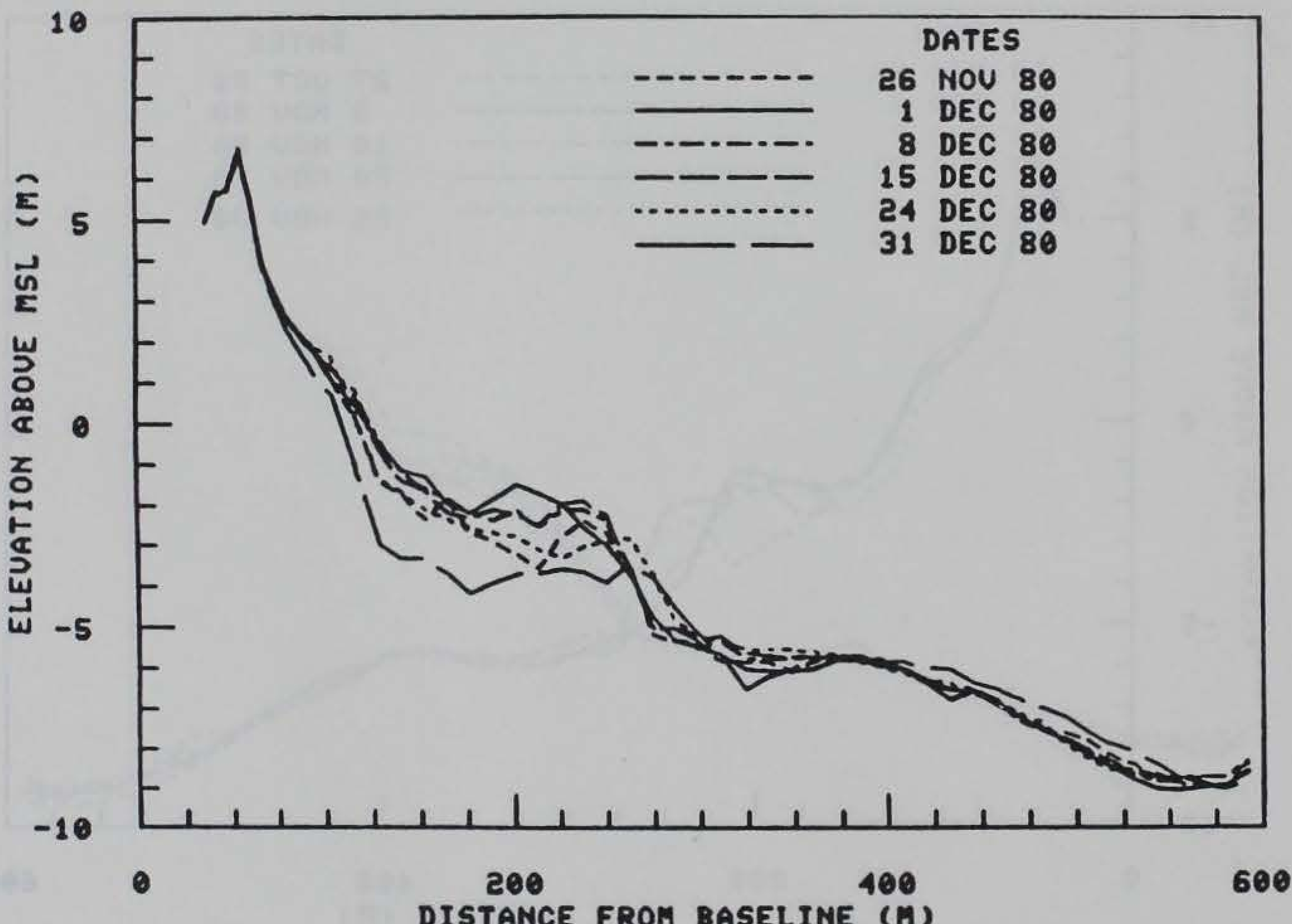


b. South side

Figure C11. FRF pier profiles for November 1980

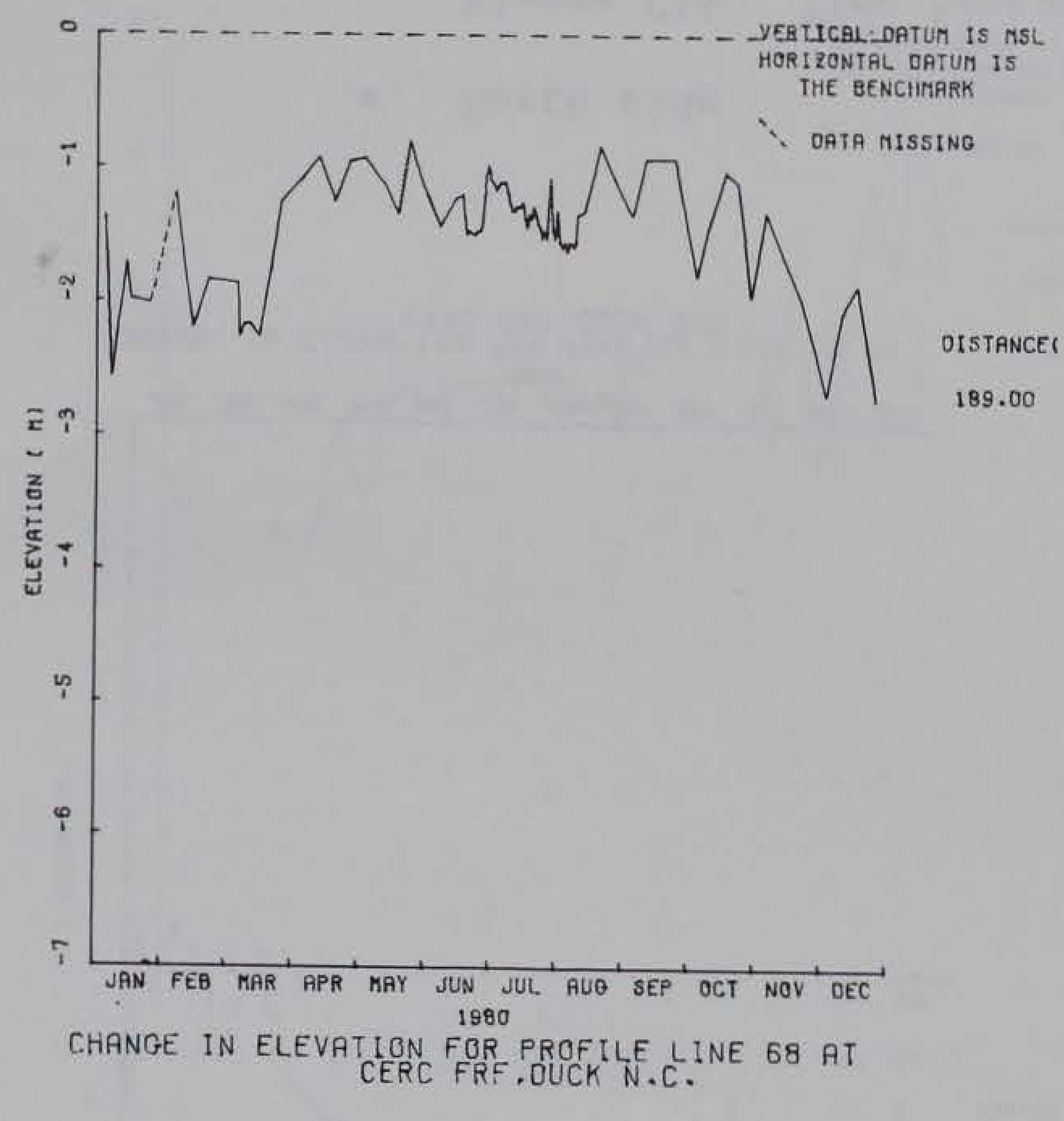


a. North side

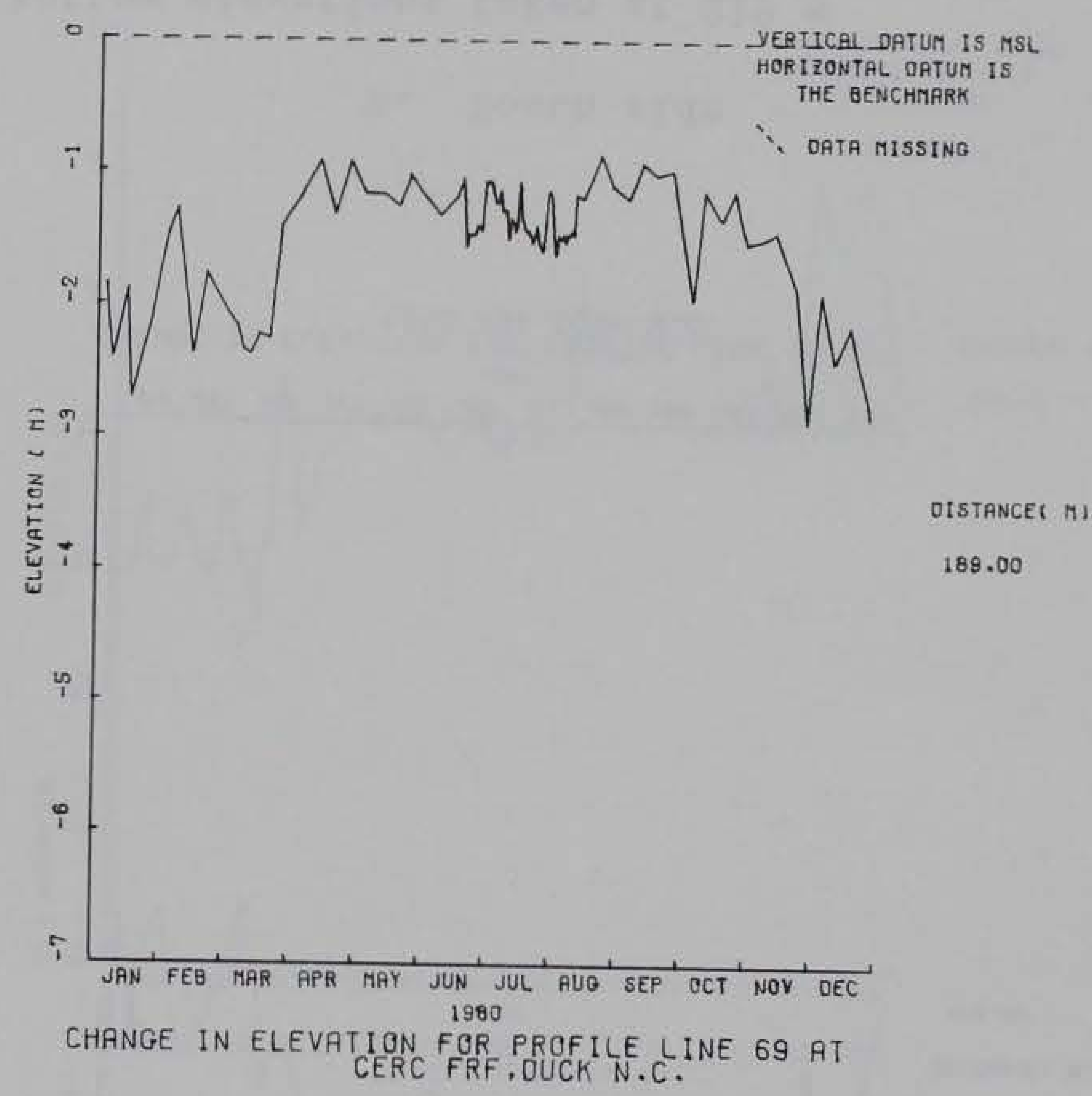


b. South side

Figure C12. FRF pier profiles for December 1980

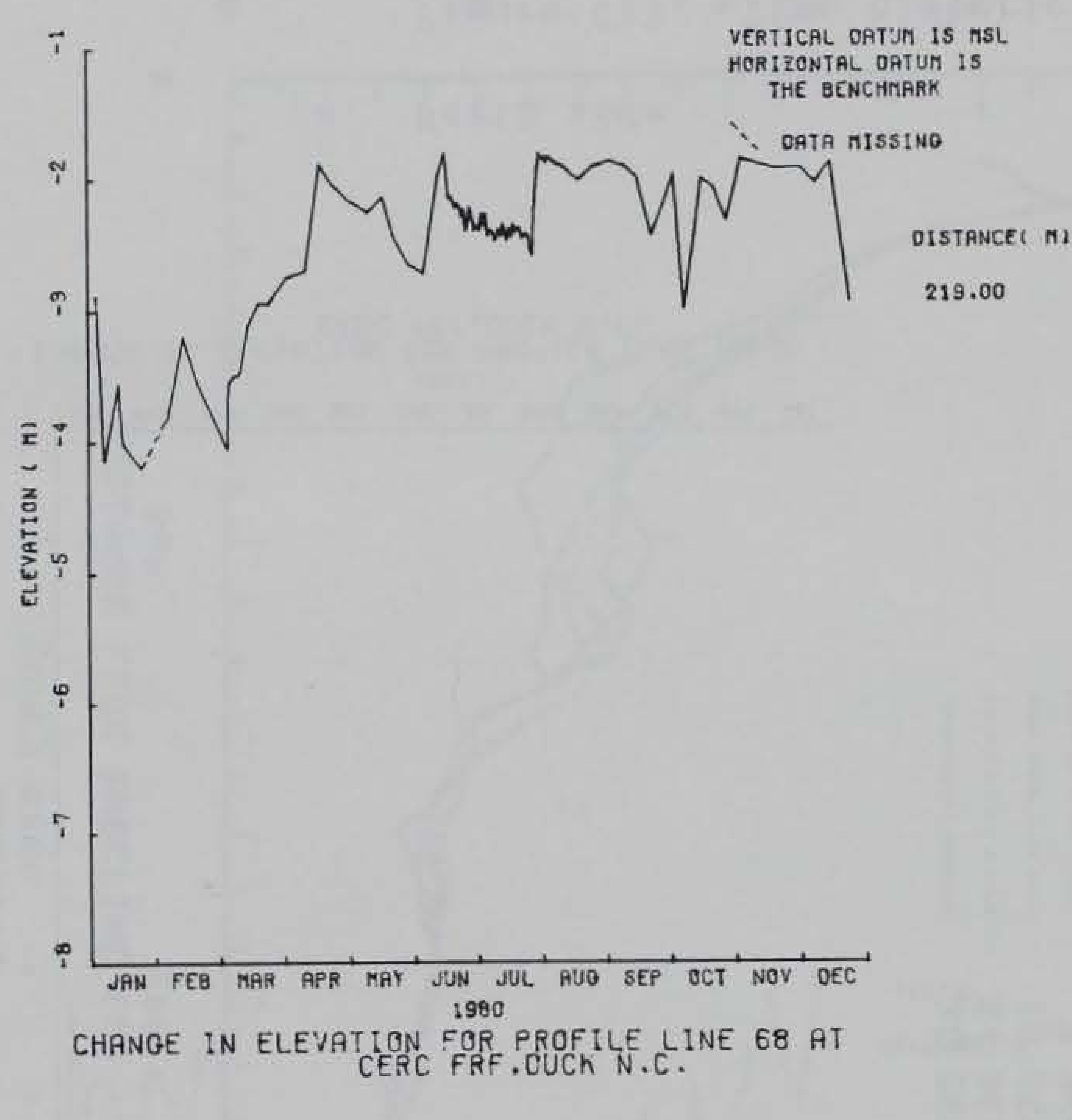


a. North side

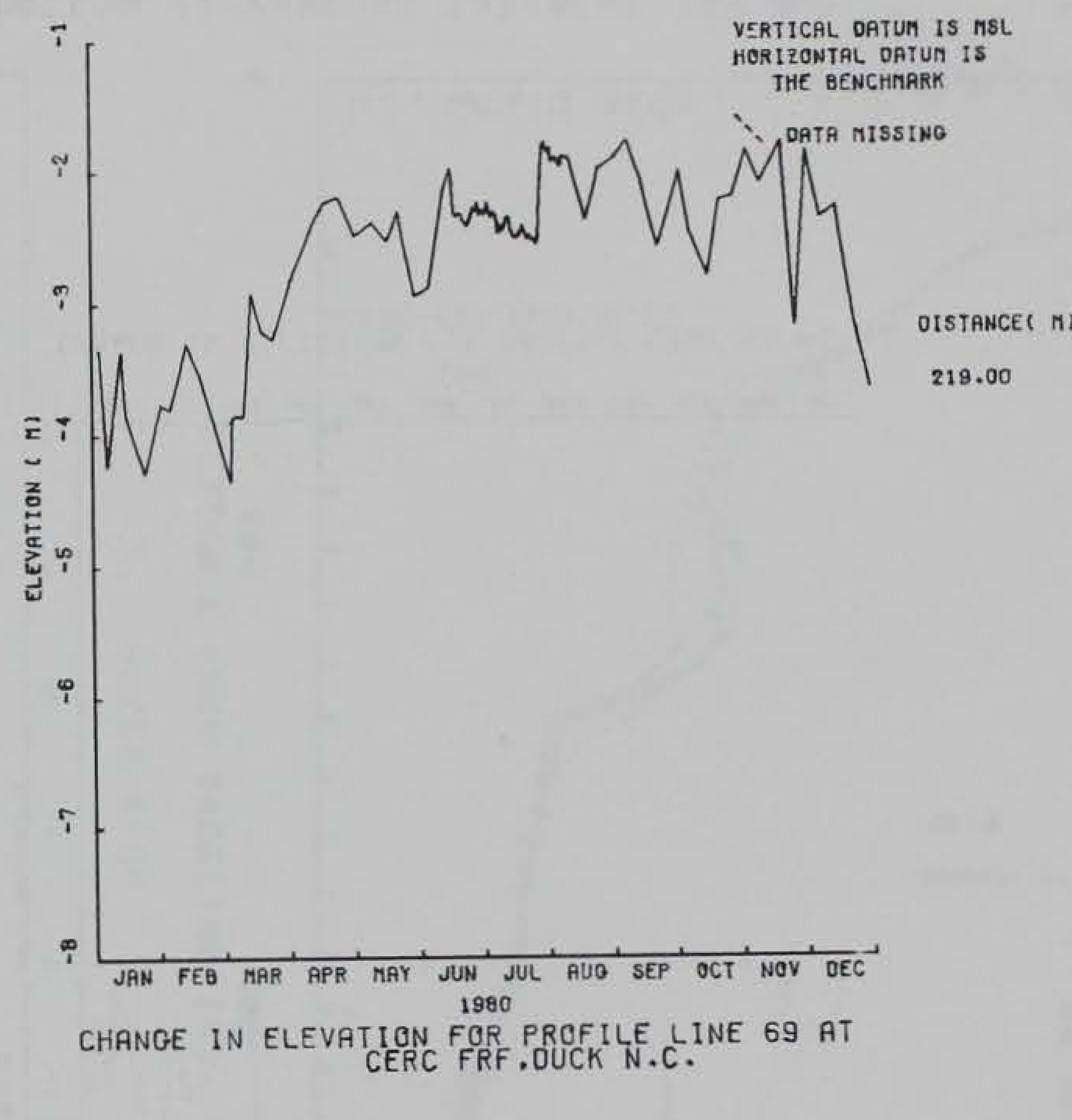


b. South side

Figure C13. Time histories of bottom elevations taken at 189 m (pier station 6+20: nearshore Baylor location)

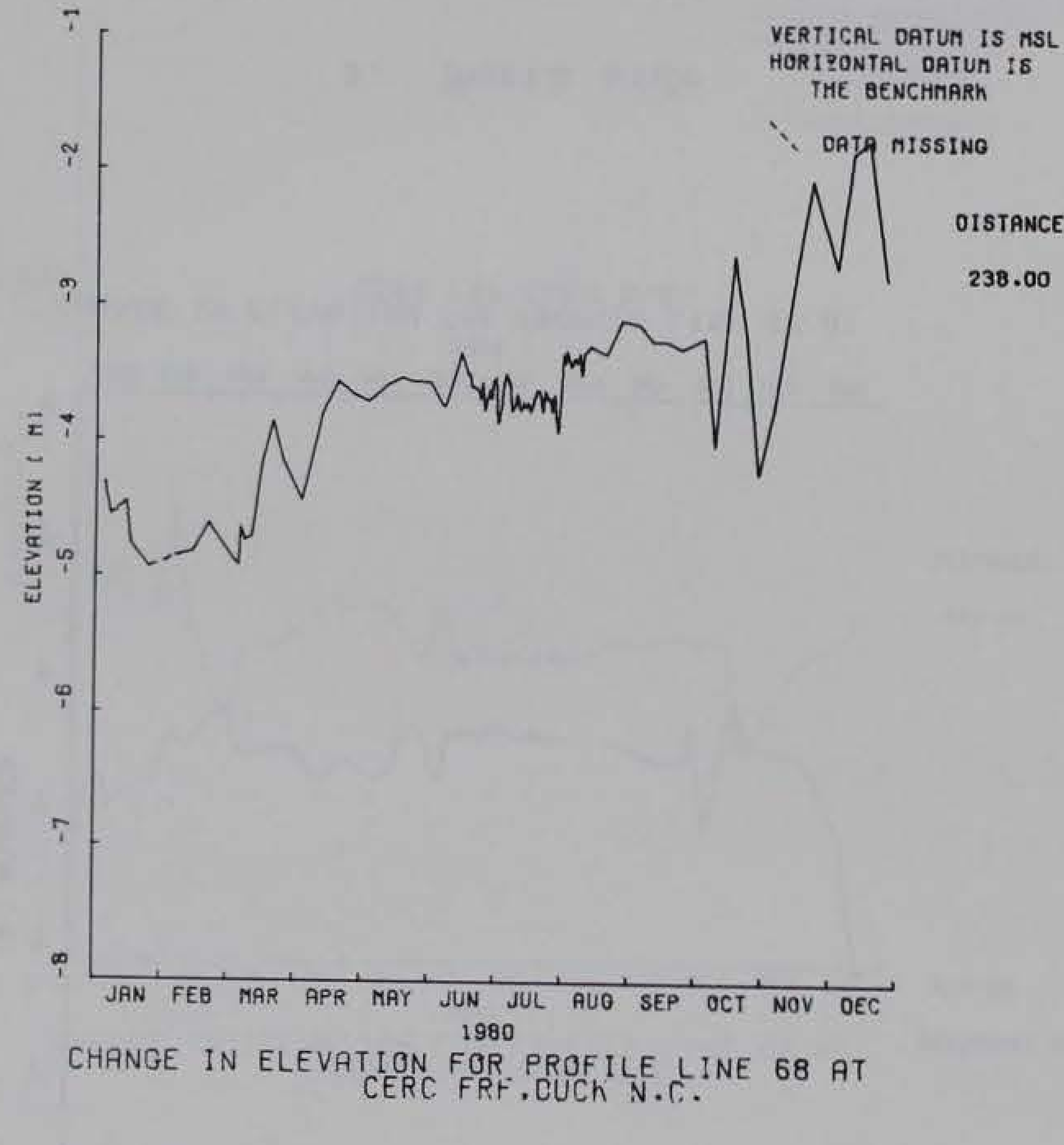


a. North side

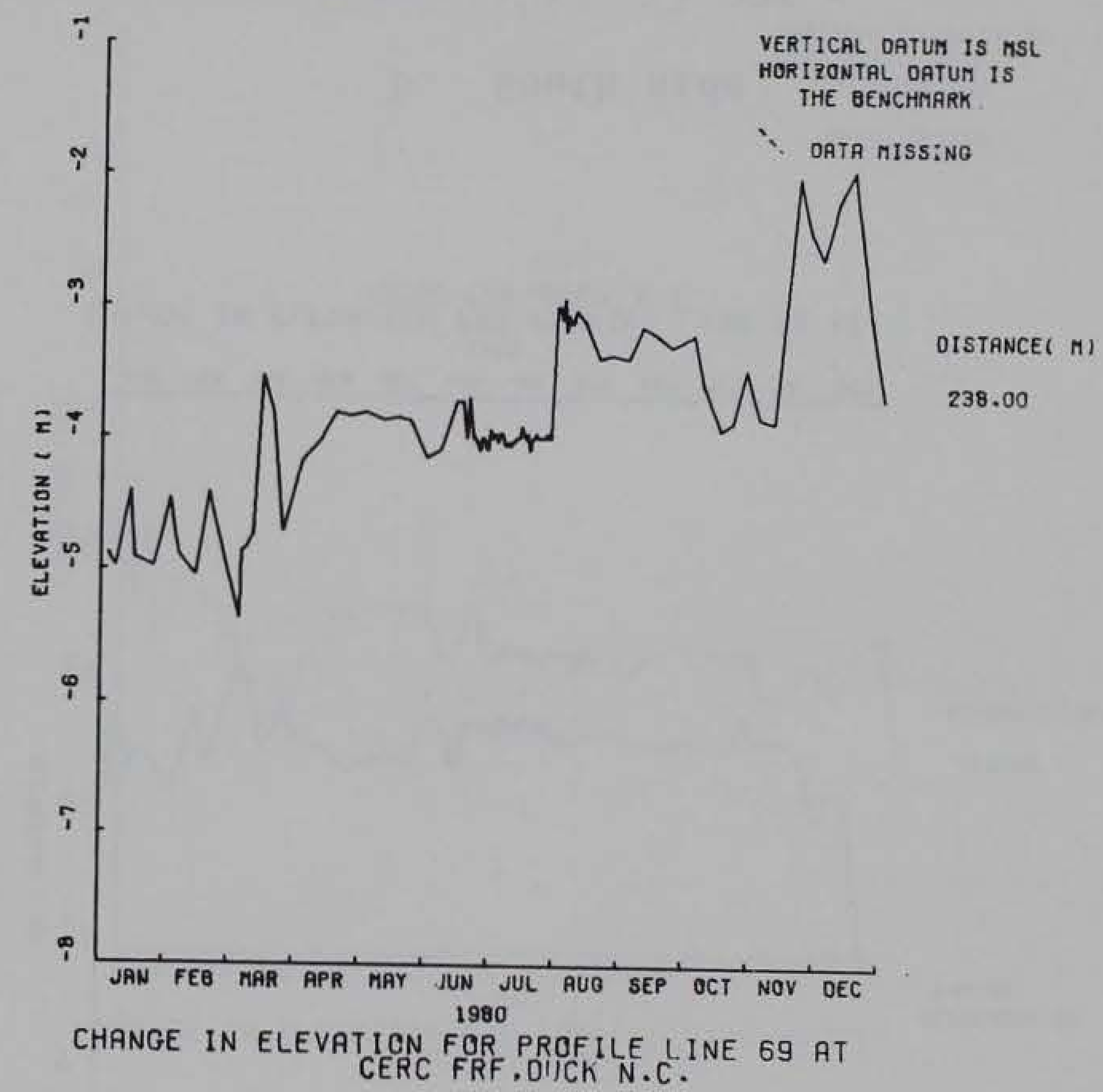


b. South side

Figure C14. Time histories of bottom elevations taken at 219 m (pier station 7+20)

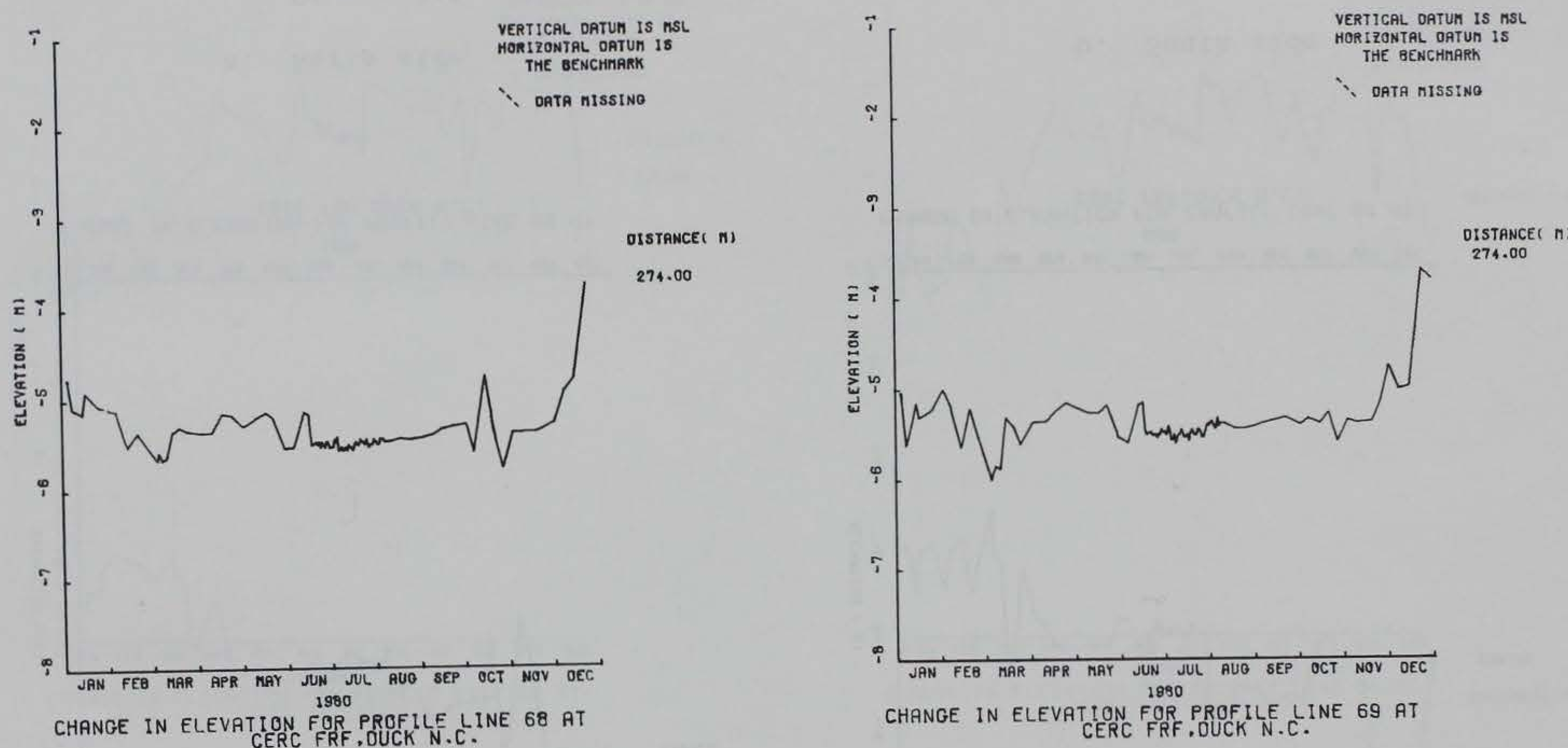


a. North side



b. South side

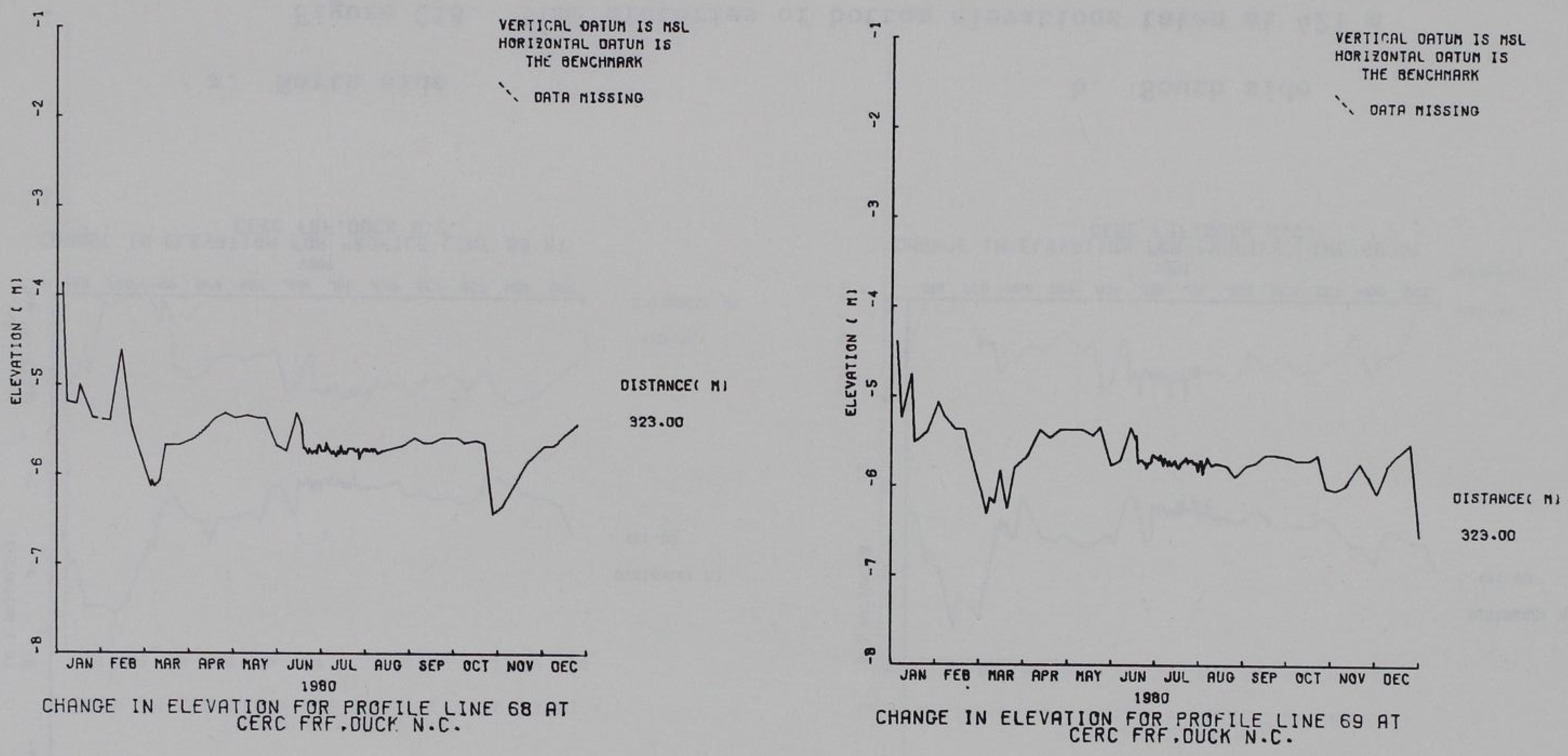
Figure C15. Time histories of bottom elevations taken at 238 m (pier station 7+80)



a. North side

b. South side

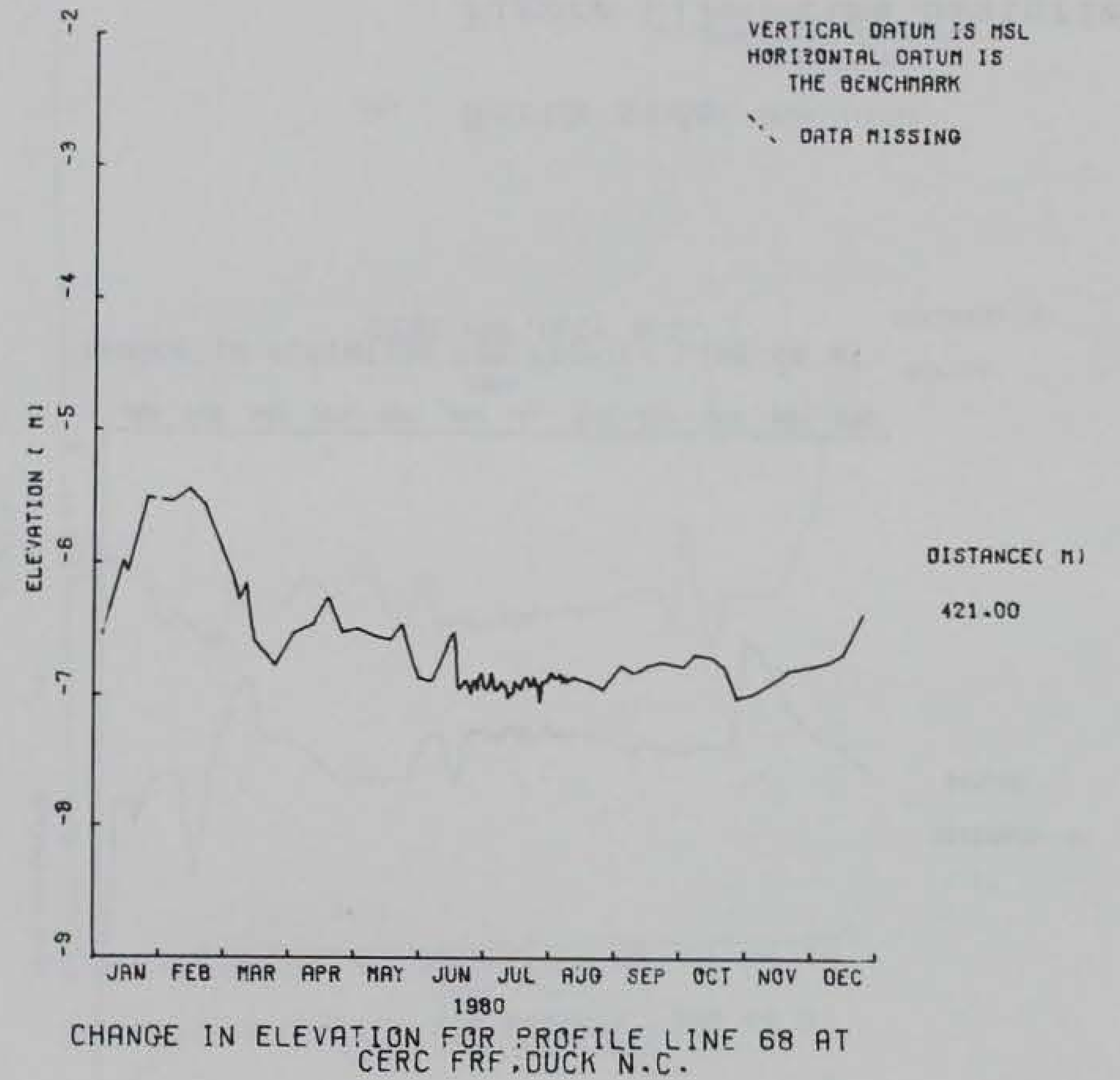
Figure C16. Time histories of bottom elevations taken at 274 m (pier station 9+00)



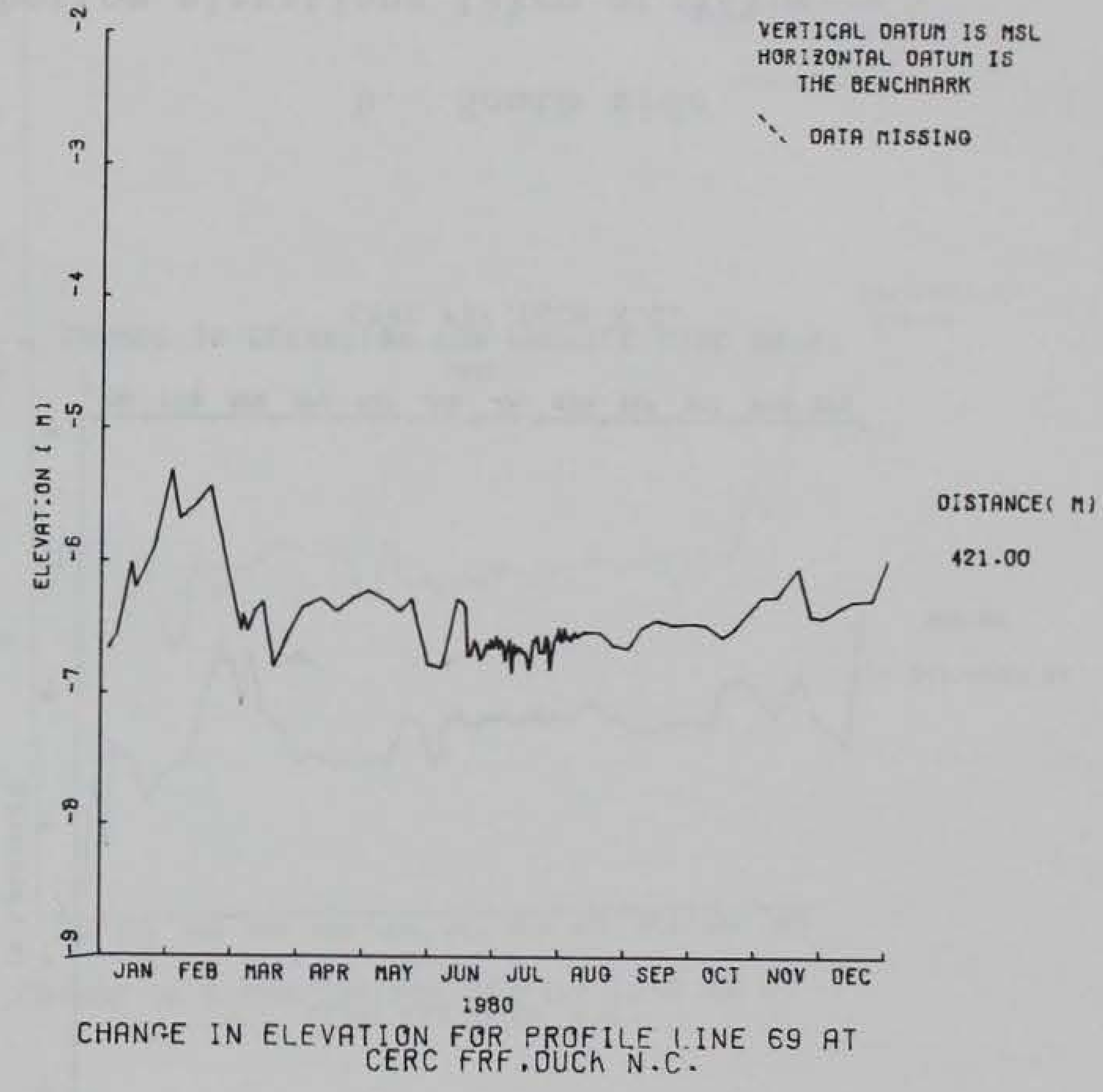
a. North side

b. South side

Figure C17. Time histories of bottom elevations taken at 323 m (pier station 10+60)

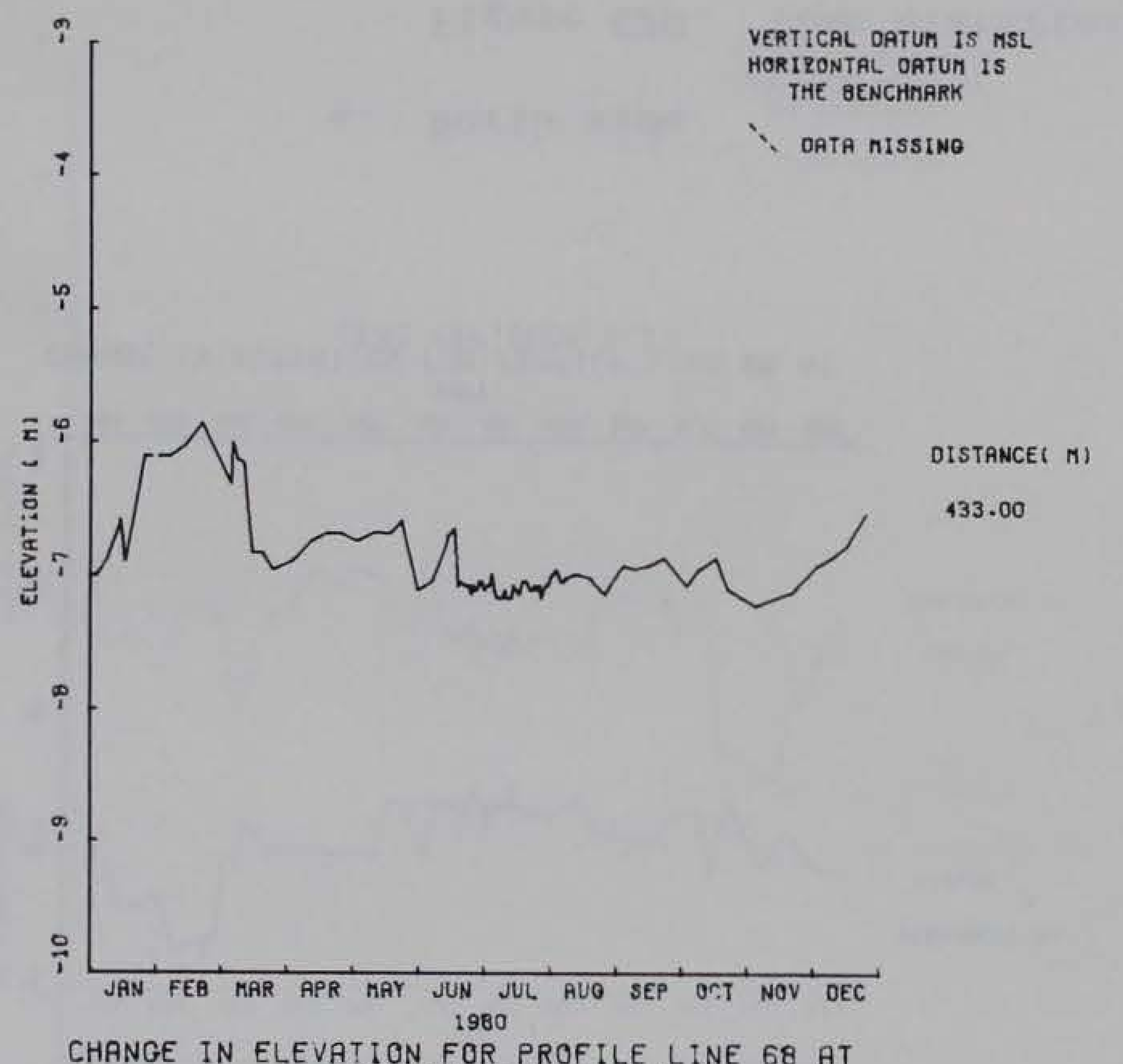


a. North side

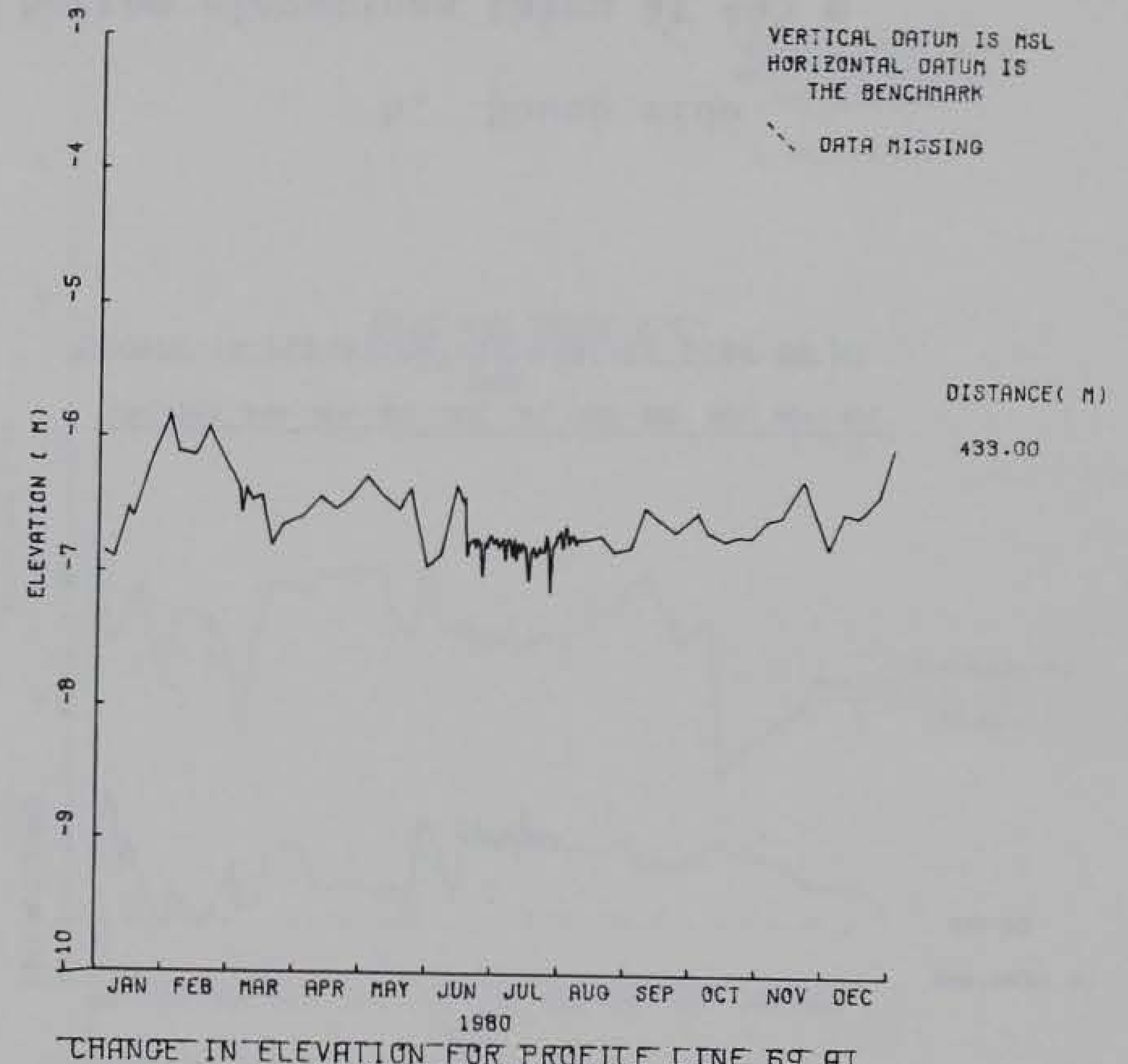


b. South side

Figure C18. Time histories of bottom elevations taken at 421 m (pier station 13+80)

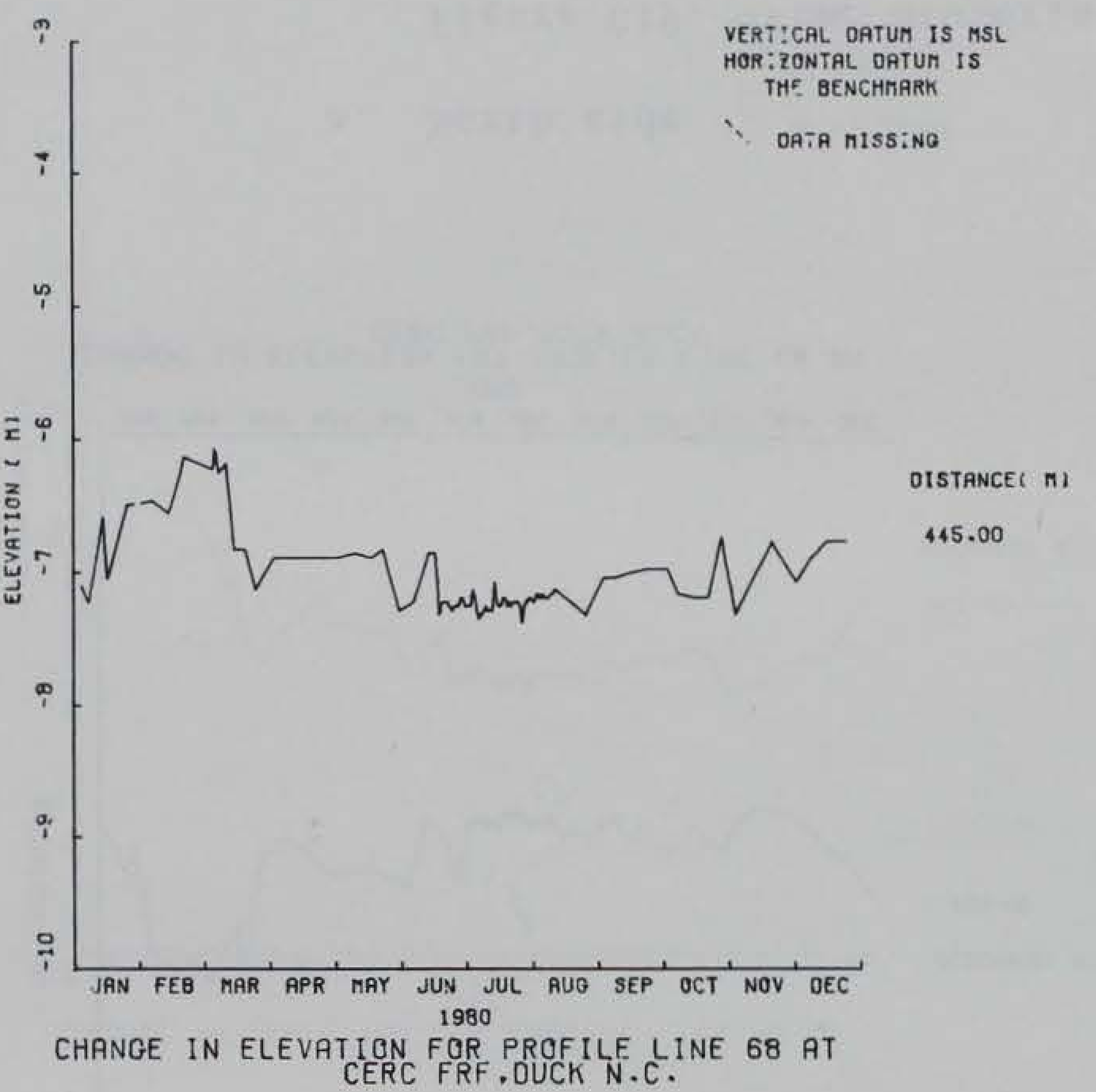


a. North side

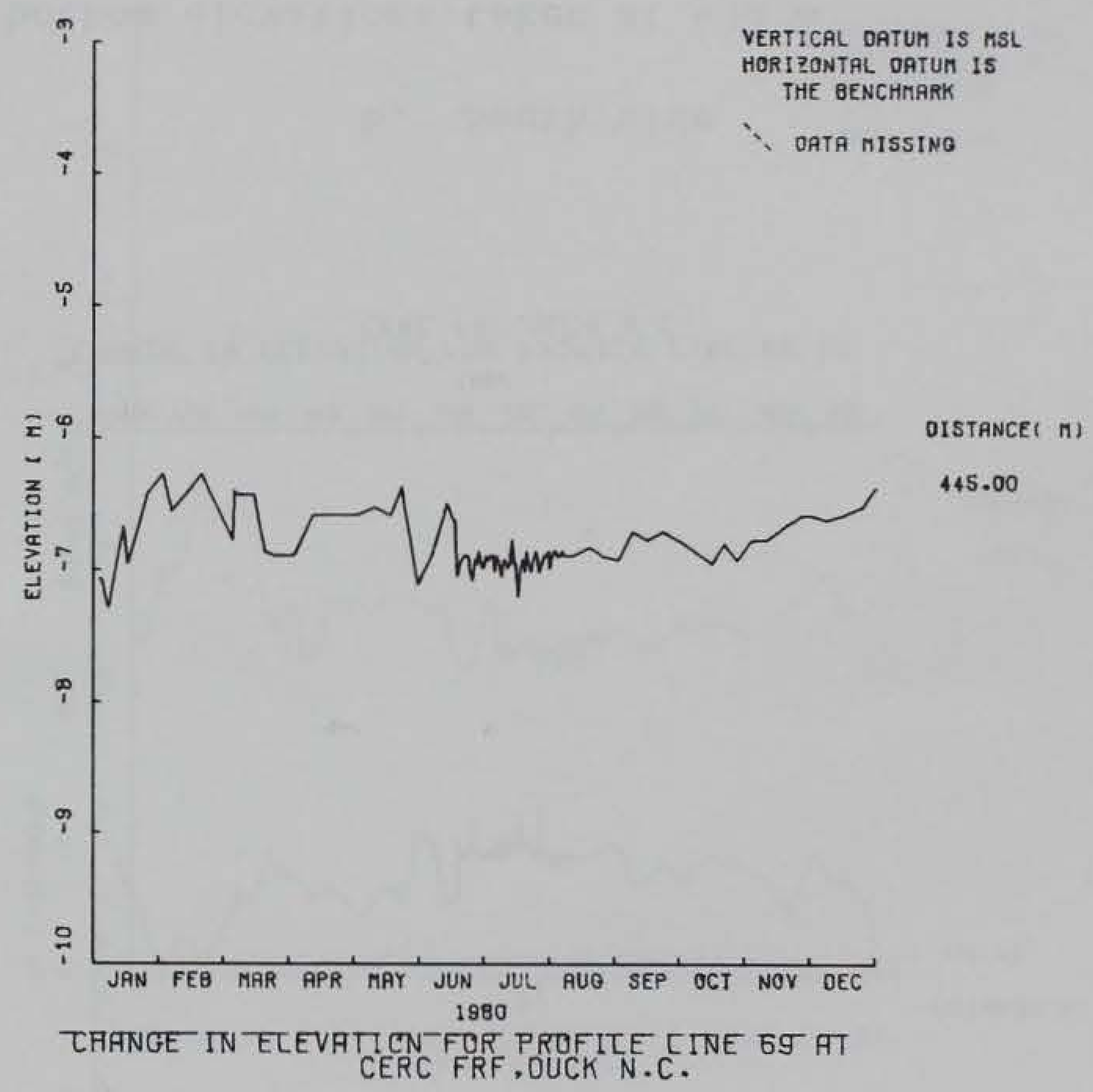


b. South side

Figure C19. Time histories of bottom elevations taken at 433 m (pier station 14+20)

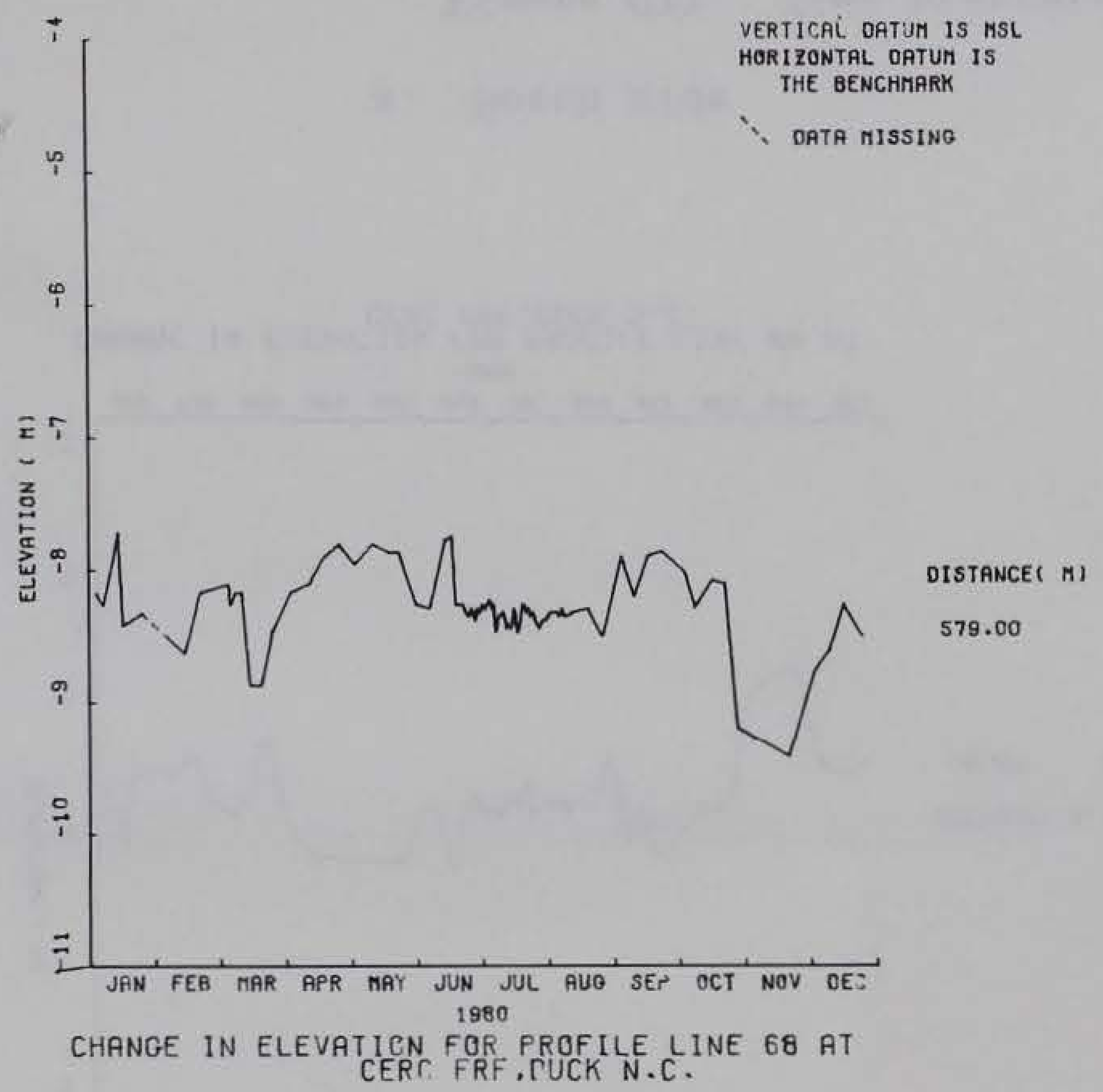


a. North side

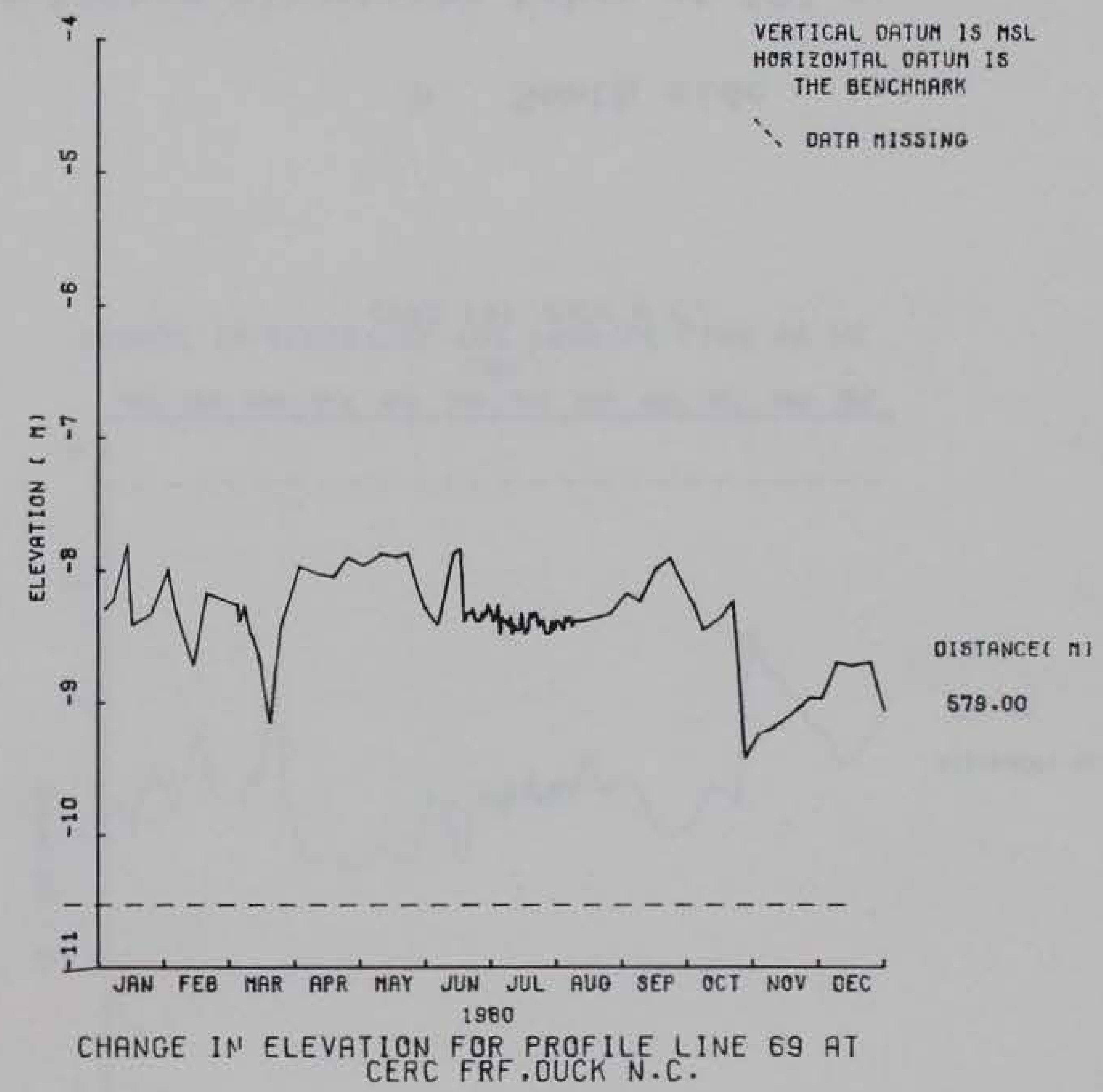


b. South side

Figure C20. Time histories of bottom elevations taken at 445 m
(pier station 14+60)

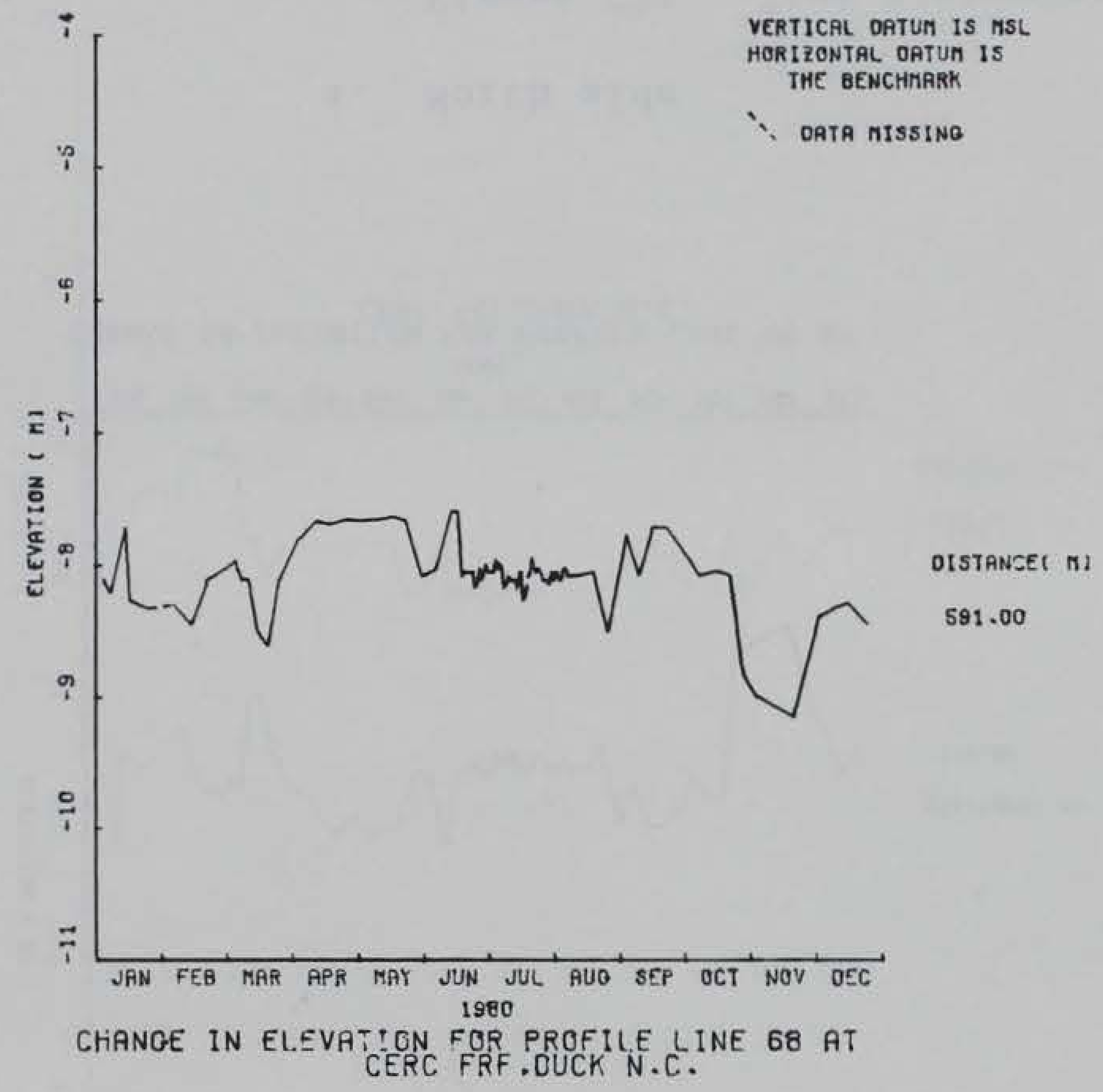


a. North side

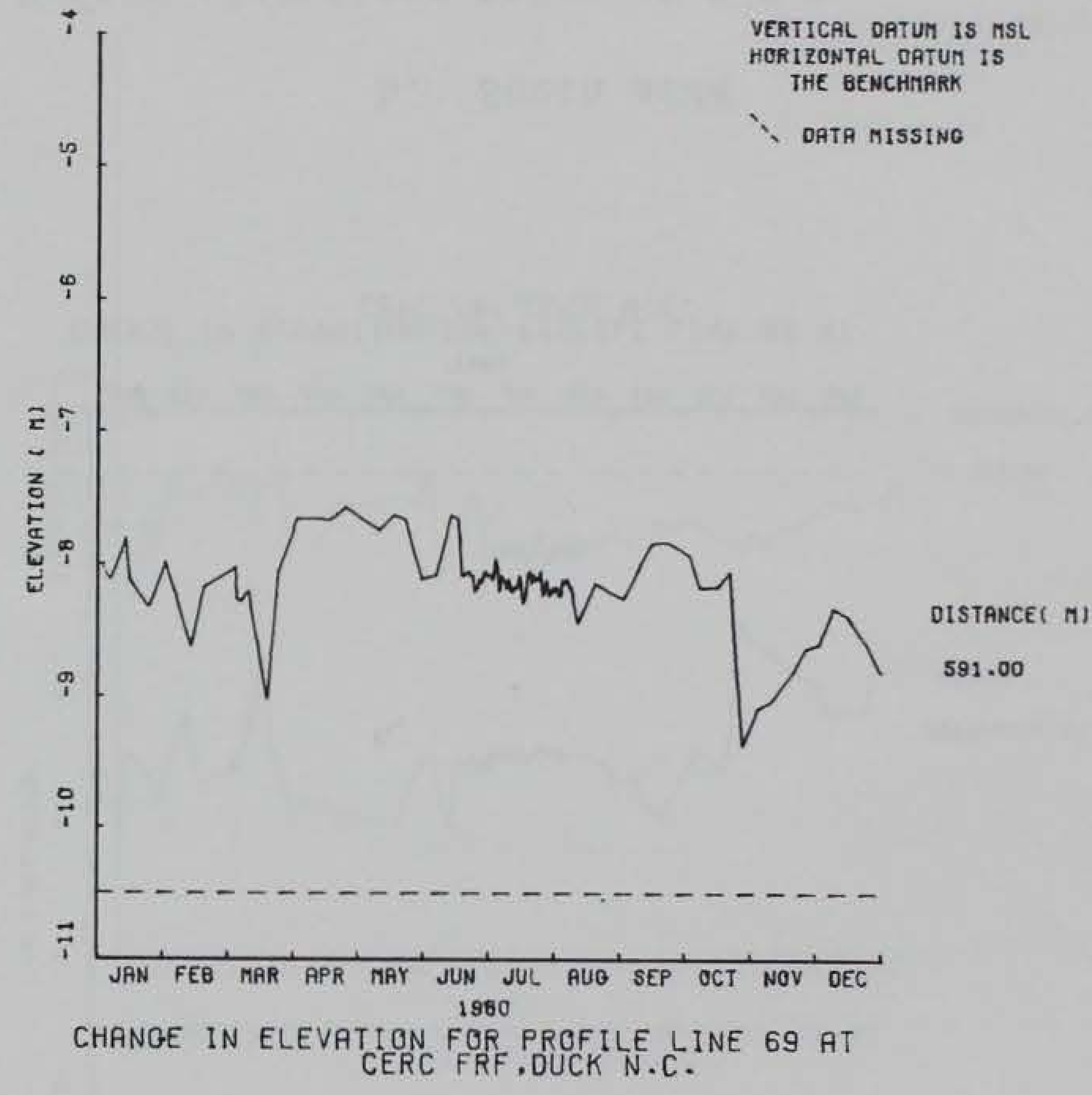


b. South side

Figure C21. Time histories of bottom elevations taken at 579 m (pier end Baylor location)



a. North side



b. South side

Figure C22. Time histories of bottom elevations taken at 591 m (pier station 19+40)