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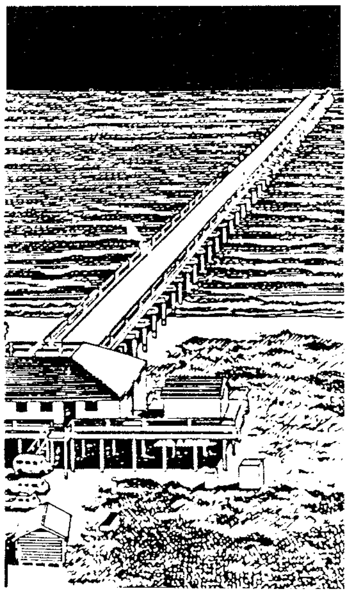

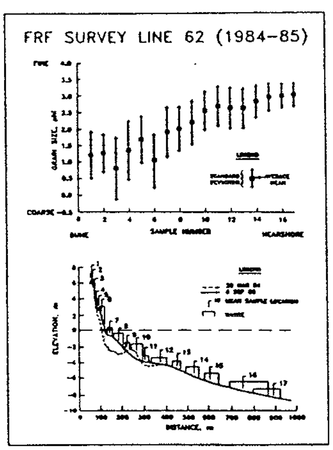


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# LONG–TERM PROFILE AND SEDIMENT MORPHODYNAMICS: FIELD RESEARCH FACILITY CASE HISTORY

by

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Surface sediment grab samples were collected along one profile line at the Field Research Facility (FRF) at Duck, NC, over a 17.8-month period from March 1984 to September 1985. Profile surveys were taken about every 2 weeks, with sediment samples collected approximately once a month. Extra profile and sediment samples were collected after storms. This comprehensive data set of beach profiles, sediment, and wave and weather conditions provides a unique opportunity to examine natural profile changes and resulting changes in sediment grain-size distribution along the entire length of an active profile and to test and evaluate models of beach profile/sediment interactions to changing coastal processes. Spatial changes indicate that the most active part of the profile at the FRF is the bar/trough area that alternately moves seaward after storms and migrates landward during fair weather wave conditions. The highest variability in sediment grain-size distributions occurred on the subaerial beach and foreshore area. The most stable sediment distributions occurred on

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the most stable nearshore area, seaward of 450 m from the baseline. High wave activity caused foreshore erosion and sediment migration seaward and alongshore. After high energy events, the sediments became coarser and more poorly sorted. Lower energy wave conditions for long periods of time created conditions of landward migration of the inner bar and accretion on the foreshore, with deposition of finer sediments. Any modeling effort requiring grain-size data should evaluate the cross shore variability of that particular beach and choose either a composite of the subaerial berm/foreshore portion of the beach or total profile to characterize the sediment distribution. Since most equations require a single value, the use of a beach or profile composite mean is suggested to give the best representation.

# PREFACE

This report provides a summary of long-term profile and sediment morphodynamics using data collected at the Field Research Facility (FRF) of the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). This research was authorized by Headquarters, US Army Corps of Engineers (HQUSACE), under Civil Works Coastal Geology and Geotechnology Program Work Unit 32540, "Use of Geological Characteristics to Interpret Coastal Processes." Funds were provided through the WES, CERC, Coastal Geology and Geotechnical Program under the management of Dr. C. Linwood Vincent. The HQUSACE Technical Monitor was Mr. John F. C. Sanda.

This report was prepared by Dr. Donald K. Stauble, Research Physical Scientist, Team Leader, Coastal Geology Unit (CGU), Coastal Structures and Evaluation Branch (CS&E), Engineering Development Division (EDD), CERC, under the direct supervision of Ms. Joan Pope, Chief, CS&E, and under the general supervision of Mr. Thomas W. Richardson, Chief, EDD; Dr. James R. Houston, Director, CERC; and Mr. Charles C. Calhoun, Jr., Assistant Director, CERC.

Mr. William A. Birkemeier, Chief, FRF, provided data on beach profiles, sediment grain size, and waves and tides collected at the FRF. Computer analysis and graphics were performed by Ms. Karen R. Pitchford, CS&E, and Ms. Lynn Bessonette, Ms. Michelle Kindhart, Mr. Cory Kindhart, Ms. Claire Livingston, and Ms. Elizabeth Sprehe of the CGU.

Dr. Robert W. Whalin was Director of WES during the publication of this report. COL Leonard G. Hassell, EN, was Commander and Deputy Director.

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# LONG-TERM PROFILE AND SEDIMENT MORPHODYNAMICS: FIELD RESEARCH FACILITY CASE HISTORY

## PART I: INTRODUCTION

1. This report provides an examination of the interaction between long-term beach and nearshore profile changes and sediment grain-size distributions across the profile. At the present, there is little guidance on the modeling of sediment grain-size parameters in cross-shore changes in the beach profile. This is the first report on the use of geological characteristics in interpretation of coastal processes. It will focus on the morphodynamics (the change in morphology due to the dynamics of coastal processes) of an oceanfront beach over a 535-day period. The beach is constantly reshaping its profile and sediment composition as it is being influenced by ever changing wave, wind, tides, and longshore currents. A better understanding of this complex interaction is needed to improve beachfront erosion control and storm protection project design.

2. A unique data set of long beach profiles stretching from the dune out 1,000 m into the nearshore is being collected on a continuous basis at the Field Research Facility (FRF) of the US Army Engineer Waterways Experiment Station (WES), Coastal Engineering Research Center (CERC). This facility was established to provide research and development capability for field studies in coastal processes and shoreline response. As part of the operation, a long-term data set of waves, currents, tides, atmospheric conditions, and beach profile changes is continuously being collected. As a supplement to this data collection, surface sediment grab samples were collected along one profile line over a 17.8-month period from March 1984 to September 1985. Profile surveys were taken on an approximately 2-week schedule, with the sediment samples collected approximately once a month. Extra profiles and sediment samples were collected after storms.

3. This continuing collection of data is unique in providing a long-term data set of accurate profile response to coastal processes. With the addition of sediment samples for the study period, spatial coverage is provided along the profile over a long temporal period, with concomitant wave, weather, and water-level information. This comprehensive data set provides a

unique opportunity to examine the natural profile changes and resulting changes in the sediment grain size distribution along the entire length of the active profile and to test and evaluate models of beach profile/sediment interactions to changing coastal processes.

4. The FRF is located just north of the village of Duck, NC, on a narrow barrier spit that is part of the outer banks barrier island and spit complex fronting the Atlantic Ocean (Figure 1). The facility contains a shore-normal 561-m-long research pier and 1,200 m of beachfront. General information on the FRF is found in Birkemeier et al. (1985), and information on the geology is found in Meisburger and Judge (1989).

5. The data used in this report were collected on Profile Line 62, located 489.21 m north of the pier as shown on Figure 2. This line is located outside the influence of the pier (Miller, Birkemeier, and DeWall 1983). Data on profiles have been collected on a continuous basis on this line (as well as three others) since January 1981 (Howd and Birkemeier 1987). A systematic collection of sediment data began on 20 March 1984 and continued until 6 September 1985. During this study period, 41 profiles were surveyed, with 21 containing sediment data. The sampling period extended across the seasonal cycle at the FRF, which is somewhat typical of most US east coast beaches, consisting of extratropical storms (northeasters) commonly occurring during the winter months from September to May with fair weather conditions during the summer months. No tropical storms (occurring in the summer months from June to October) impacted the area during the study period. Only a few extratropical storms of major proportion occurred during the study.

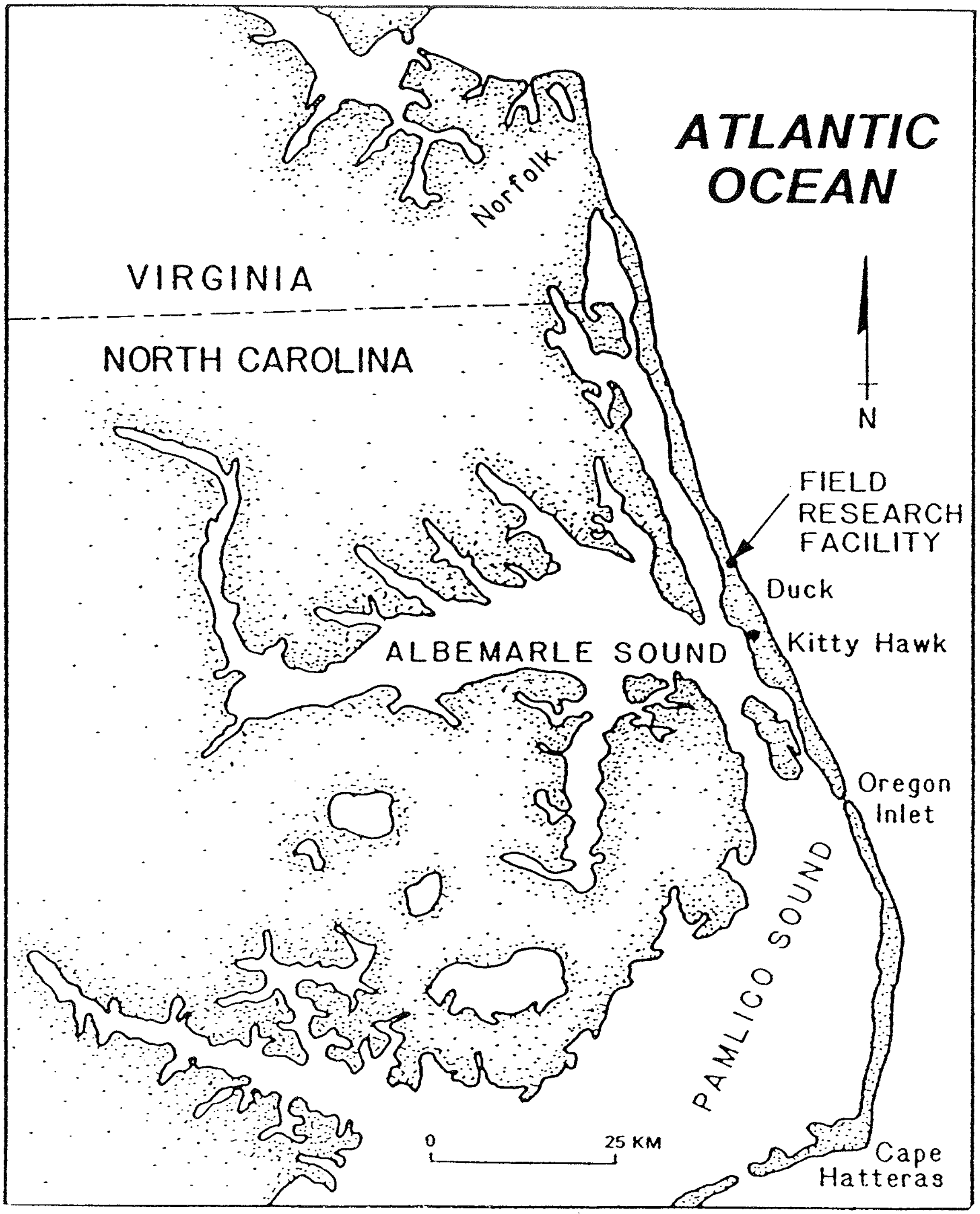



Figure 1. Location map of the FRF

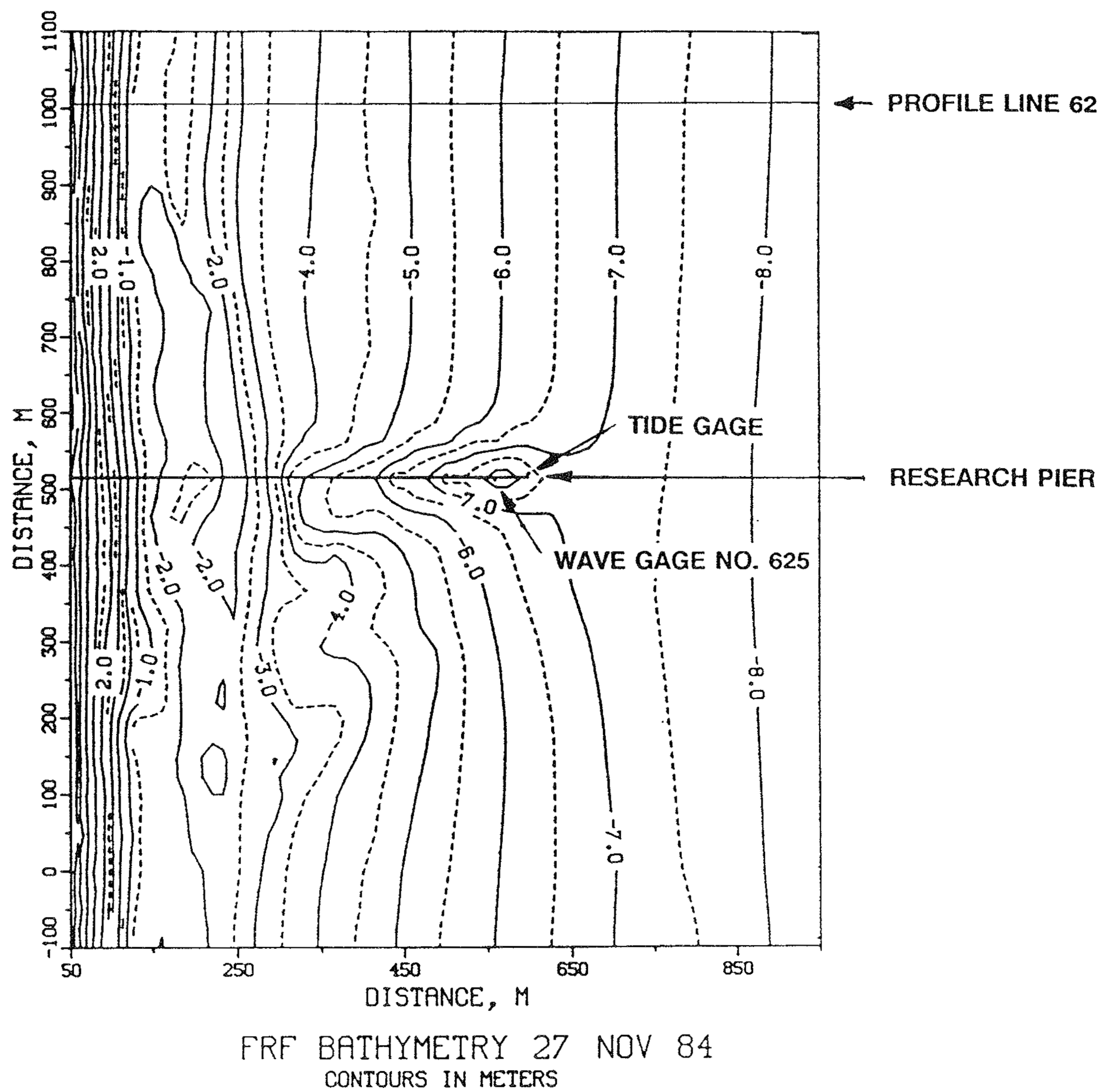



Figure 2. Location of Profile Line 62 on plan view of FRF survey area

## PART II: PROFILE DATA

6. The beach profile data were collected from a shore-parallel baseline landward of the dune out to a depth of between -8 to -9 m, which extended up to 1,000 m seaward of the baseline on the longer profiles. All profiles were referenced to the 1929 National Geodetic Vertical Datum (NGVD). Collection was approximately biweekly, but varied between each individual profile. Some profiles closely bracketed storm events.

7. All profiles were surveyed using the FRF Coastal Research Amphibious Buggy (CRAB) for the subaqueous portion of the profile. (See Birkemeier and Mason (1984) for details on the CRAB.) The dry beach and dune portions of the profile were surveyed by standard rod method, placing the rod at regular intervals or breaks in slope along the profile between the regular intervals (Howd and Birkemeier 1987). A Zeiss Elta-2 electronic surveying instrument was used to collect the profile data.

8. Pertinent data on the profiles used in this report are given in Table 1. The time scale of these data allows resolution from a few days to 17.8 months. Howd and Birkemeier (1987) described five profile configurations found at the FRF ranging from a minimal to a triple bar. Four of these profile types were observed during the study ranging from (a) the minimal bar feature, with a concave profile shape; (b) single inner bar centering around 200 m seaward of the baseline; (c) double bar with a prominent inner bar and a lower relief outer bar centering around 350 m from the baseline; and (d) triple bar with two bars in the inner region between 100 and 200 m, and the outer bar around 350 m. Figure 3 shows an example profile from each of the four categories. The most common profile type during the study period was the single inner bar. The profile data were analyzed and plotted using the Interactive Survey Reduction Program (ISRP) as described in Birkemeier (1984).

Table 1

Summary of Profile Data

| Date | Profile No. | Length m | Profile Type | Sediments Collected |
|---|---|---|---|---|
| 20 Mar 84 | 141 | 934.1 | Double Bar | yes |
| 2 Apr 84 | 143 | 980.2 | Double Bar | no |
| 6 Apr 84 | 144 | 924.3 | Double Bar | no |
| 13 Apr 84 | 145 | 1055.5 | Double Bar | no |
| 25 Apr 84 | 146 | 950.5 | Triple Bar | no |
| 9 May 84 | 147 | 926.6 | Triple Bar | no |
| 14 May 84 | 148 | 926.0 | Triple Bar | no |
| 24 May 84 | 149 | 977.9 | Triple Bar | no |
| 1 Jun 84 | 150 | 965.3 | Inner Bar | no |
| 13 Jun 84 | 151 | 1005.4 | Inner Bar | no |
| 28 Jun 84 | 152 | 983.3 | Inner Bar | no |
| 9 Jul 84 | 153 | 991.3 | Inner Bar | no |
| 21 Jul 84 | 154 | 987.2 | Inner Bar | no |
| 27 Jul 84 | 155 | 983.1 | Inner Bar | no |
| 11 Aug 84 | 156 | 987.6 | Inner Bar | yes* |
| 30 Aug 84 | 157 | 988.8 | Minimal Bar | no |
| 6 Sep 84 | 158 | 925.9 | Minimal Bar | no |
| 10 Sep 84 | 159 | 687.3 | Inner Bar | yes |
| 20 Sep 84 | 160 | 976.2 | Inner Bar | yes |
| 2 Oct 84 | 161 | 903.0 | Inner Bar | yes |
| 7 Oct 84 | 162 | 678.0 | Inner Bar | no |
| 16 Oct 84 | 163 | 786.6 | Inner Bar | yes |
| 29 Oct 84 | 165 | 992.2 | Inner Bar | yes |
| 27 Nov 84 | 167 | 966.7 | Inner Bar | yes |
| 13 Dec 84 | 168 | 928.9 | Inner Bar | no |
| 2 Jan 85 | 169 | 934.8 | Minimal Bar | yes |
| 5 Jan 85 | 170 | 755.1 | Inner Bar | yes |
| 25 Jan 85 | 171 | 911.4 | Inner Bar | yes |
| 14 Feb 85 | 173 | 944.8 | Inner Bar | yes |
| 1 Mar 85 | 174 | 926.8 | Inner Bar | yes |
| 15 Mar 85 | 175 | 981.3 | Inner Bar | yes |
| 26 Mar 85 | 176 | 809.5 | Inner Bar | no |
| 23 Apr 85 | 178 | 1017.0 | Minimal Bar | no |
| 9 May 85 | 179 | 920.2 | Inner Bar | yes |
| 31 May 85 | 180 | 941.3 | Inner Bar | yes |
| 20 Jun 85 | 181 | 946.4 | Inner Bar | yes |
| 15 Jul 85 | 182 | 990.8 | Inner Bar | yes |
| 24 Jul 85 | 184 | 780.7 | Inner Bar | no |
| 7 Aug 85 | 185 | 919.4 | Inner Bar | yes |
| 21 Aug 85 | 186 | 965.2 | Inner Bar | yes |
| 3 Sep 85 | 187 | 995.9 | Minimal Bar | no |
| 6 Sep 85 | 188 | 968.9 | Minimal Bar | yes |

* Above NGVD only.

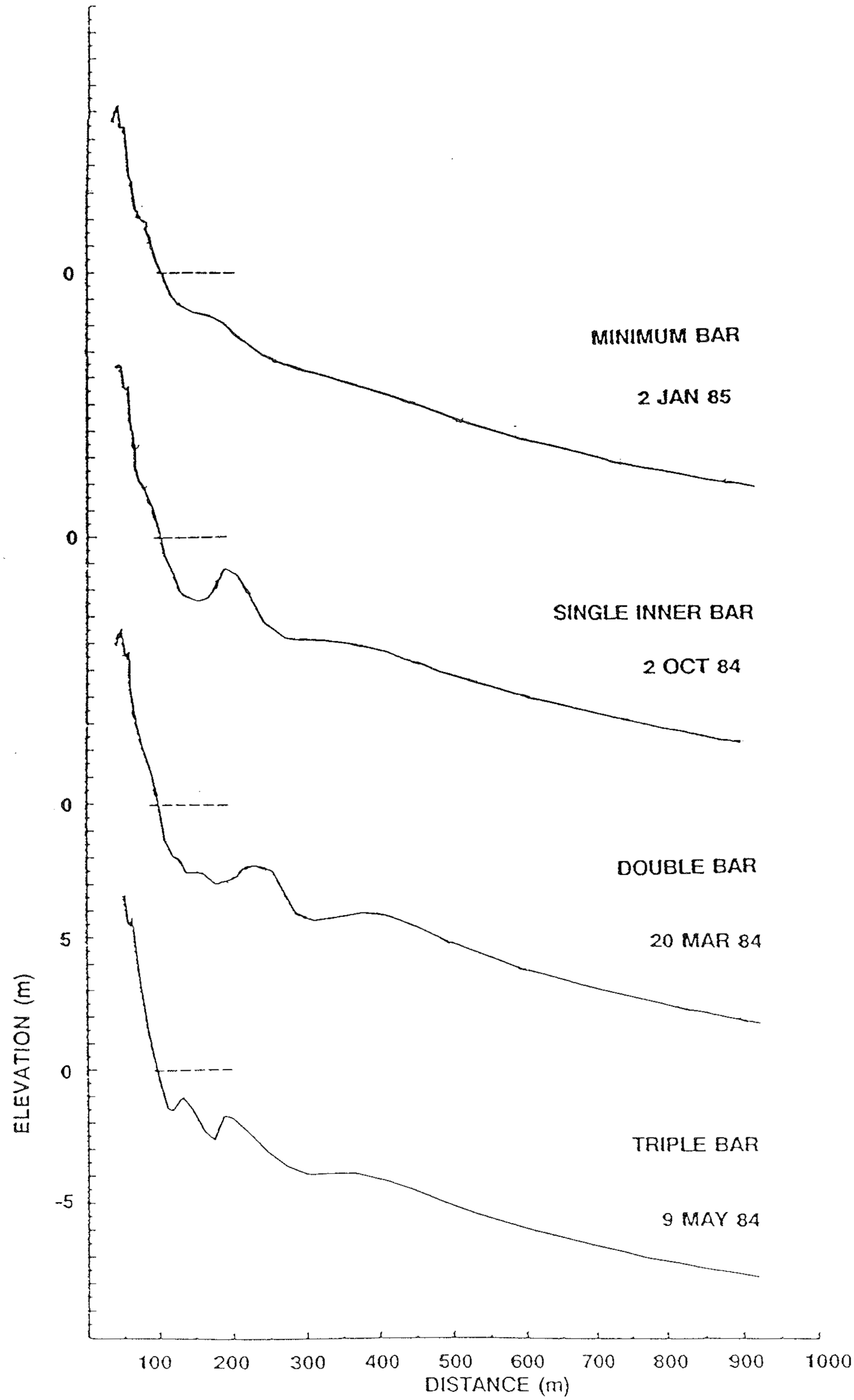



Figure 3. Examples of typical profile configurations during study

## PART III: SEDIMENT DATA

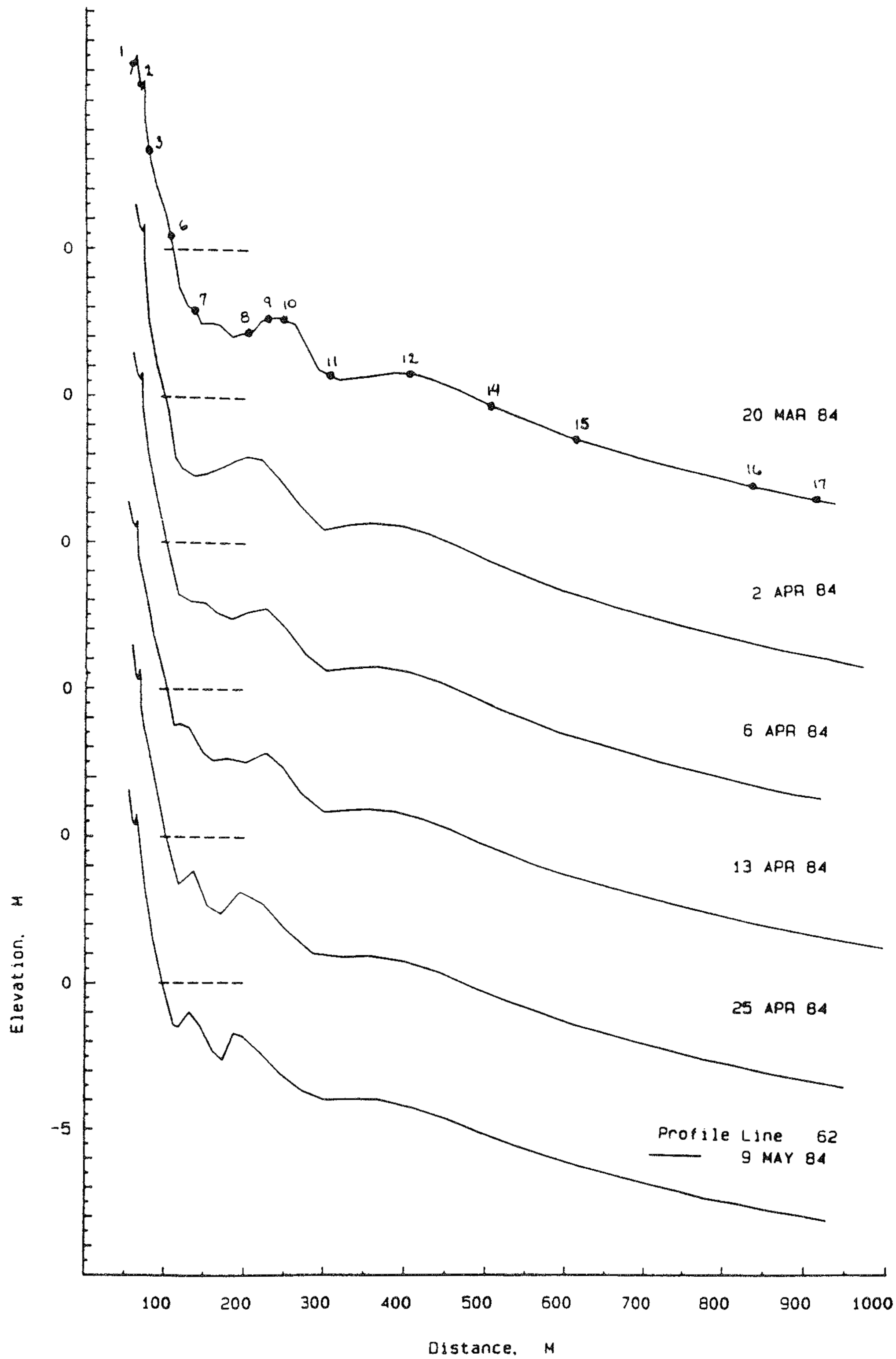
9. Surface grab sediment samples were collected across 21 of the profiles during the study period. On the subaerial beach, sediment was collected from the surface at selected sites along the profile. Most of the sampling was done concurrent with the profile survey. On rare occasions, the sediment was collected 1 day after the profile. The subaqueous samples (below wading depth) were collected from the CRAB with the use of a Ponar Grab Sampler. Approximately 100 to 200 g of sample was collected by both methods and bagged for laboratory analysis.

10. The distribution of sample stations for each profile is shown on Figure 4 along with the profile. Samples were not taken on every profile survey. Samples were first collected on 20 March 1984, but were not collected on a regular basis until 11 August 1984. After that point, samples were collected about once a month for the next 13 months, with more frequent collection bracketing storms or other periods of profile change.

11. Sediment sampling stations consisted of two locations in the dune area, four on the berm and intertidal area, four in the region of the inner bar and trough area, and seven in the nearshore area from the seaward edge of the inner bar to the limit of the profile. Except for the 11 August 1984 survey, when no samples below NGVD were collected, this sampling scheme was followed. Occasional sample stations were not collected during the study period for various reasons. A total of 316 individual samples were collected and analyzed.

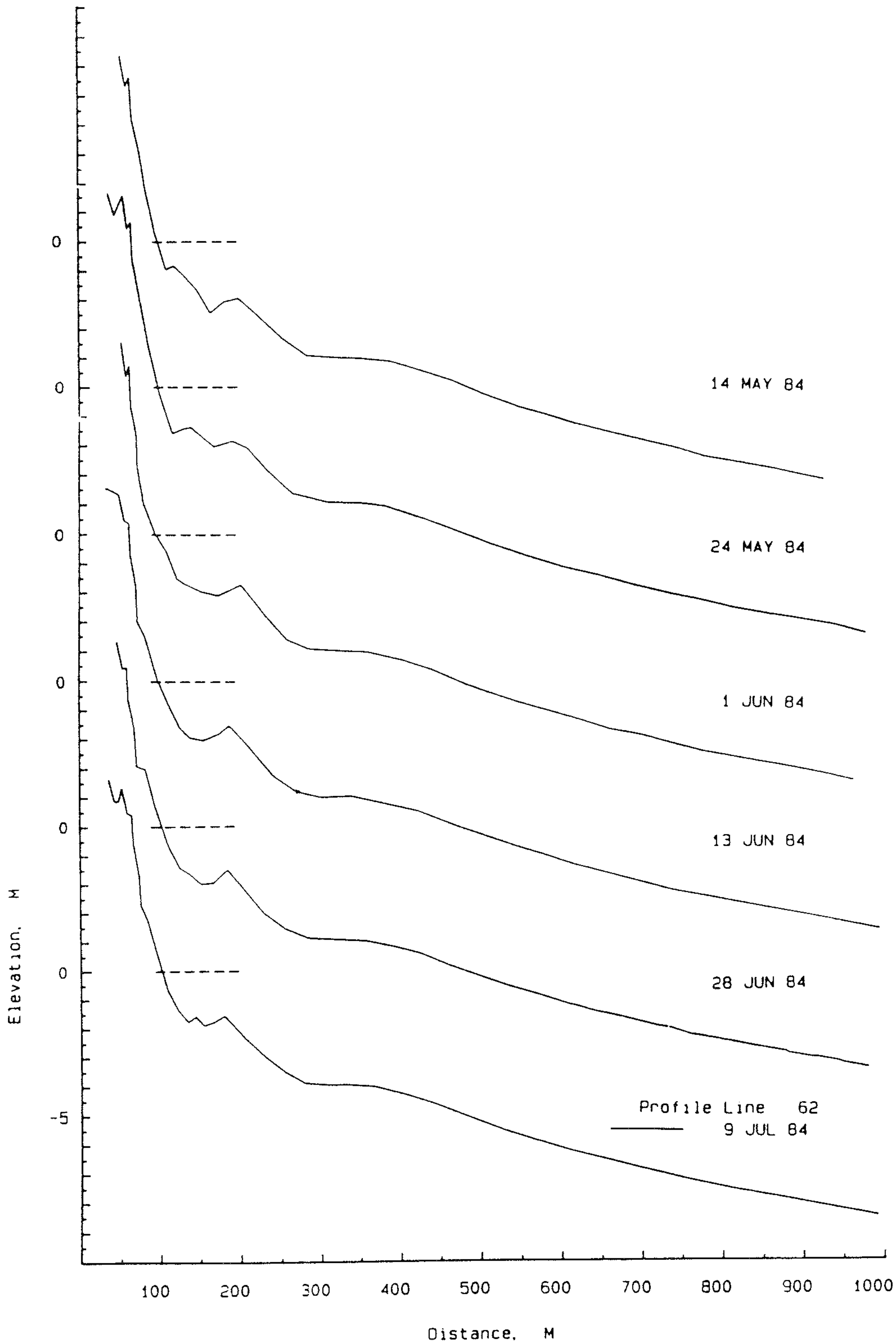
12. Laboratory procedures consisted of washing each sample to remove salt content and oven drying and splitting the sample down to approximately 20 g. Since the FRF beach is a high-energy open ocean beach, little fine-grained silt and clay material was deposited. Therefore, less than 5 percent of any sample contained silt-size material, and no fine-grained size analysis was needed. The dried, split sample was sieved using a sonic sifter with 1/4-phi ($\phi$) interval nest of sieves (Underwood 1988). Table 2 shows the comparison of standard sieve mesh numbers, millimetre and phi units, along with the Unified Soils and Wentworth Classifications to aid the reader in interpretation of the sediment data.

13. Grain-size distributions and sediment statistics were calculated using the Interactive Sediment Analysis Program (ISAP), as described in Anders



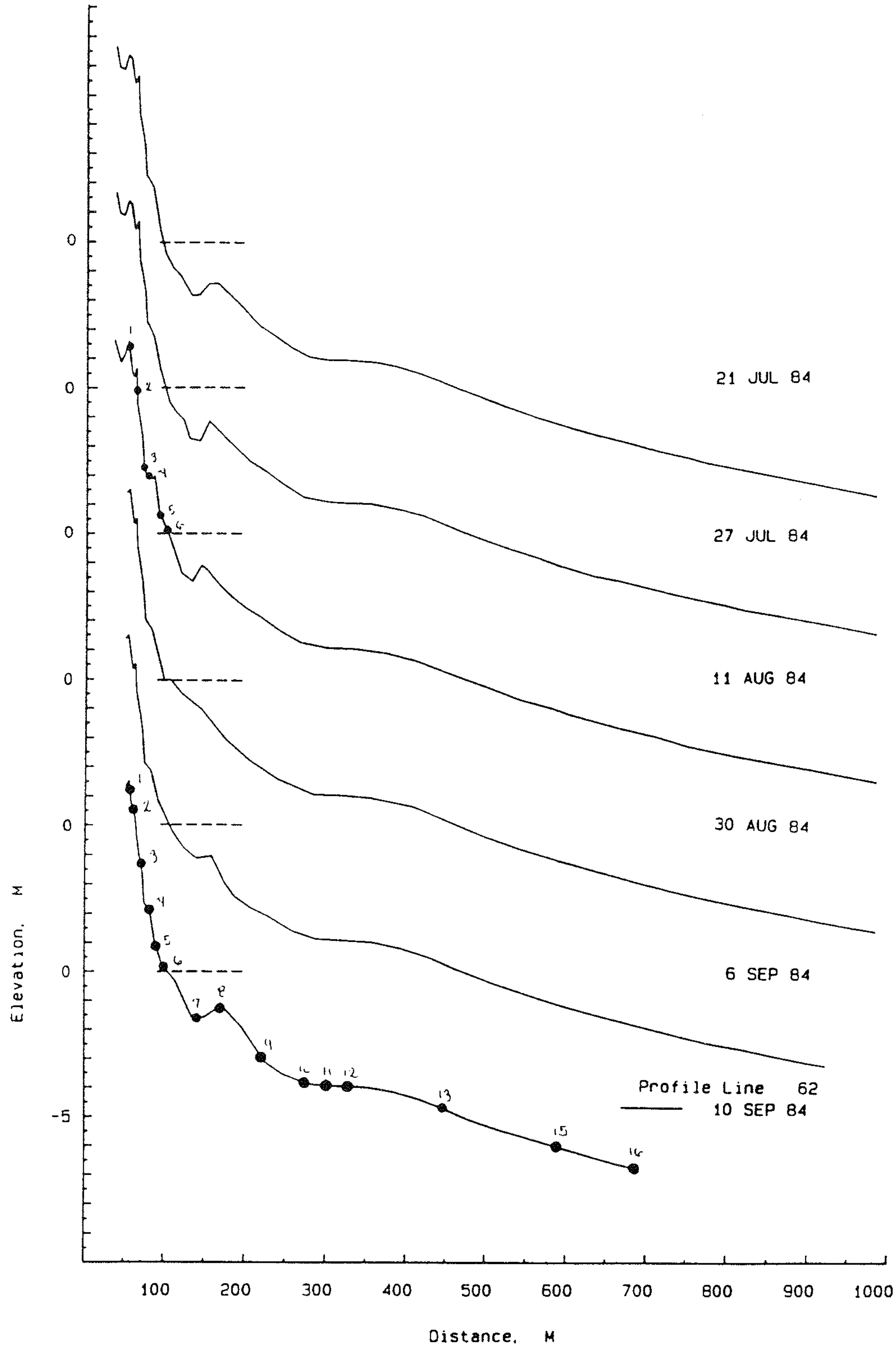

a. March to May 1984

Figure 4. Profiles and sediment sampling locations from 20 March 1984 to 6 September 1985 (Sheet 1 of 7)



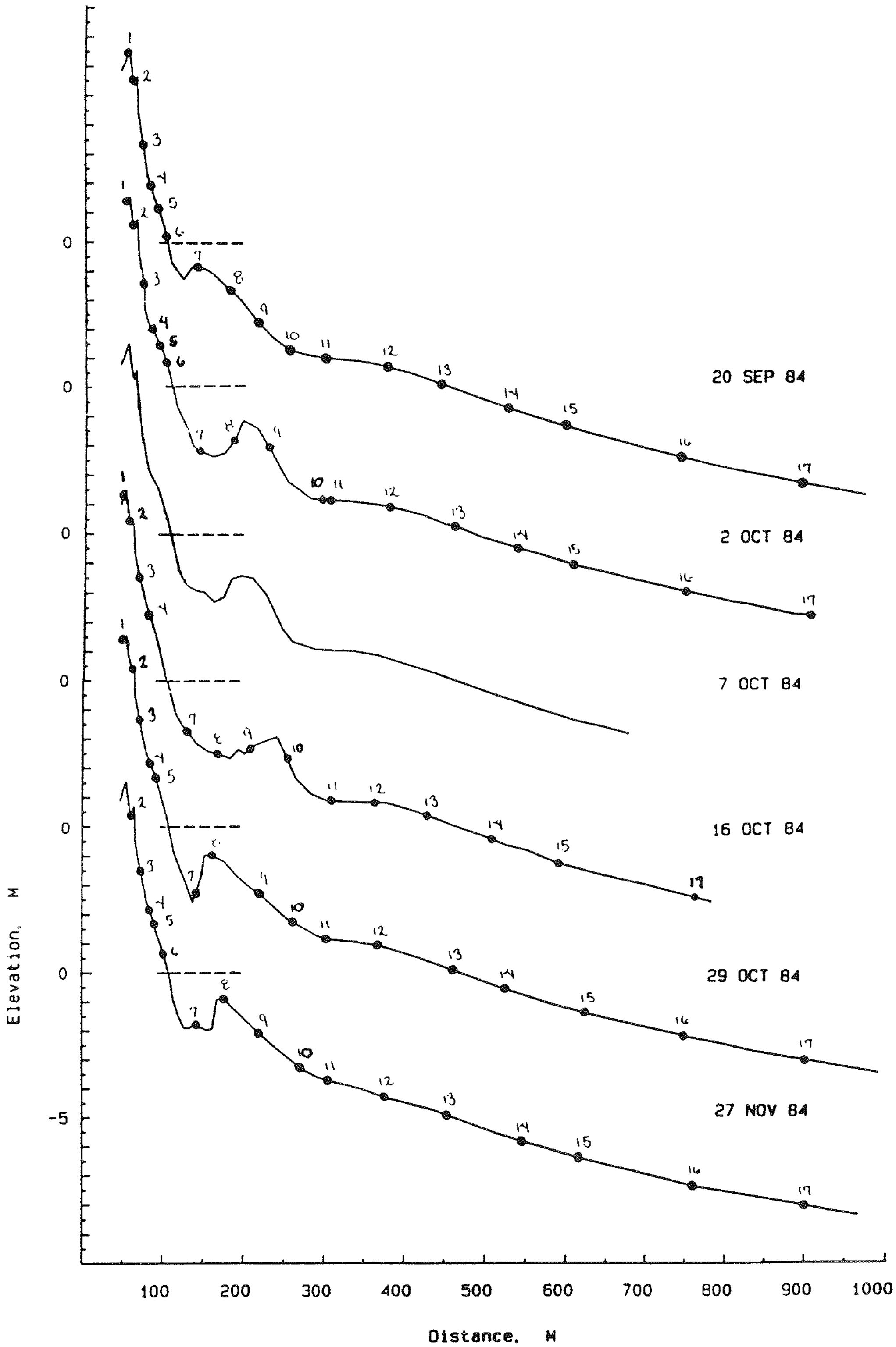

b. May to July 1984

Figure 4. (Sheet 2 of 7)



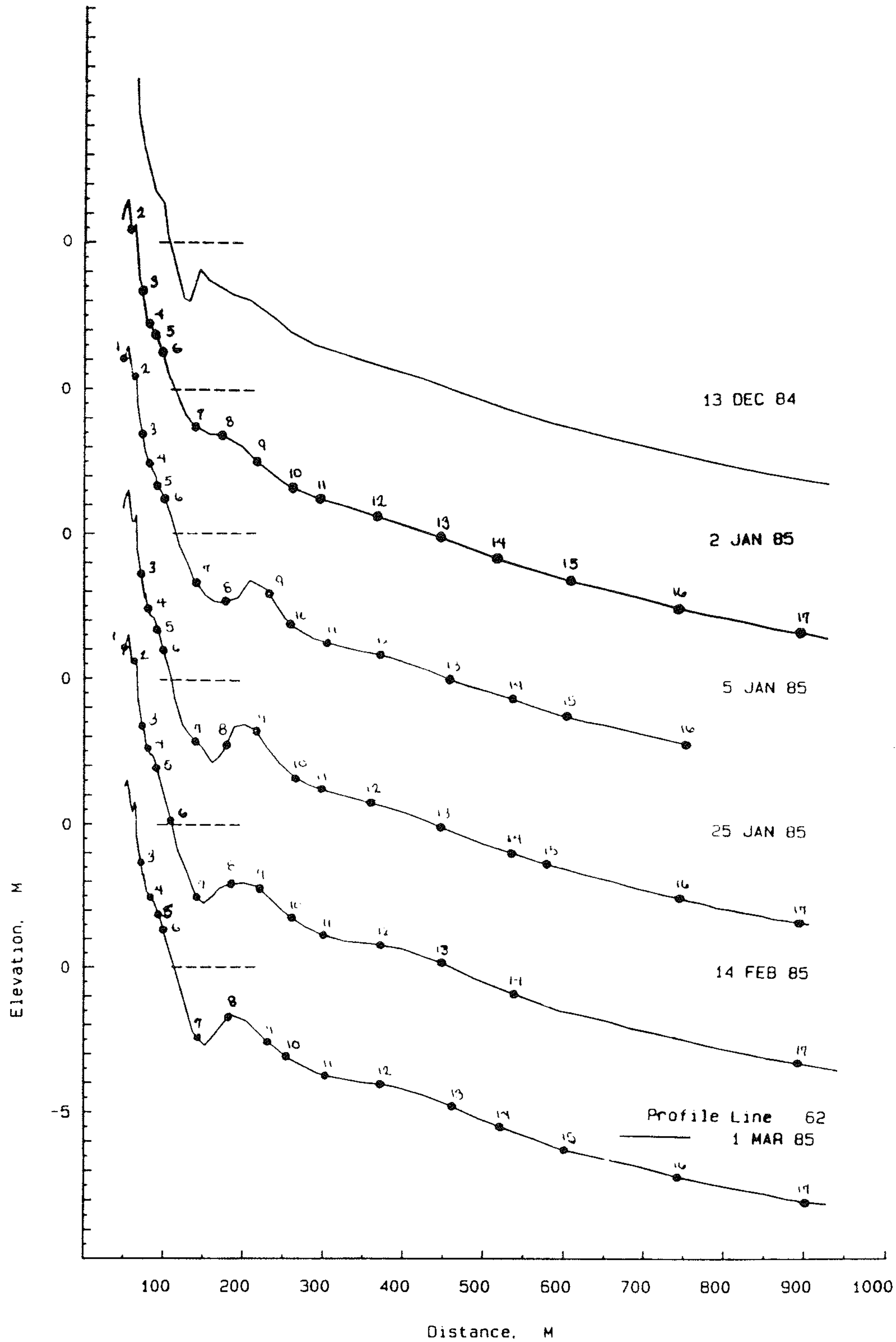

c. July to September 1984

Figure 4. (Sheet 3 of 7)



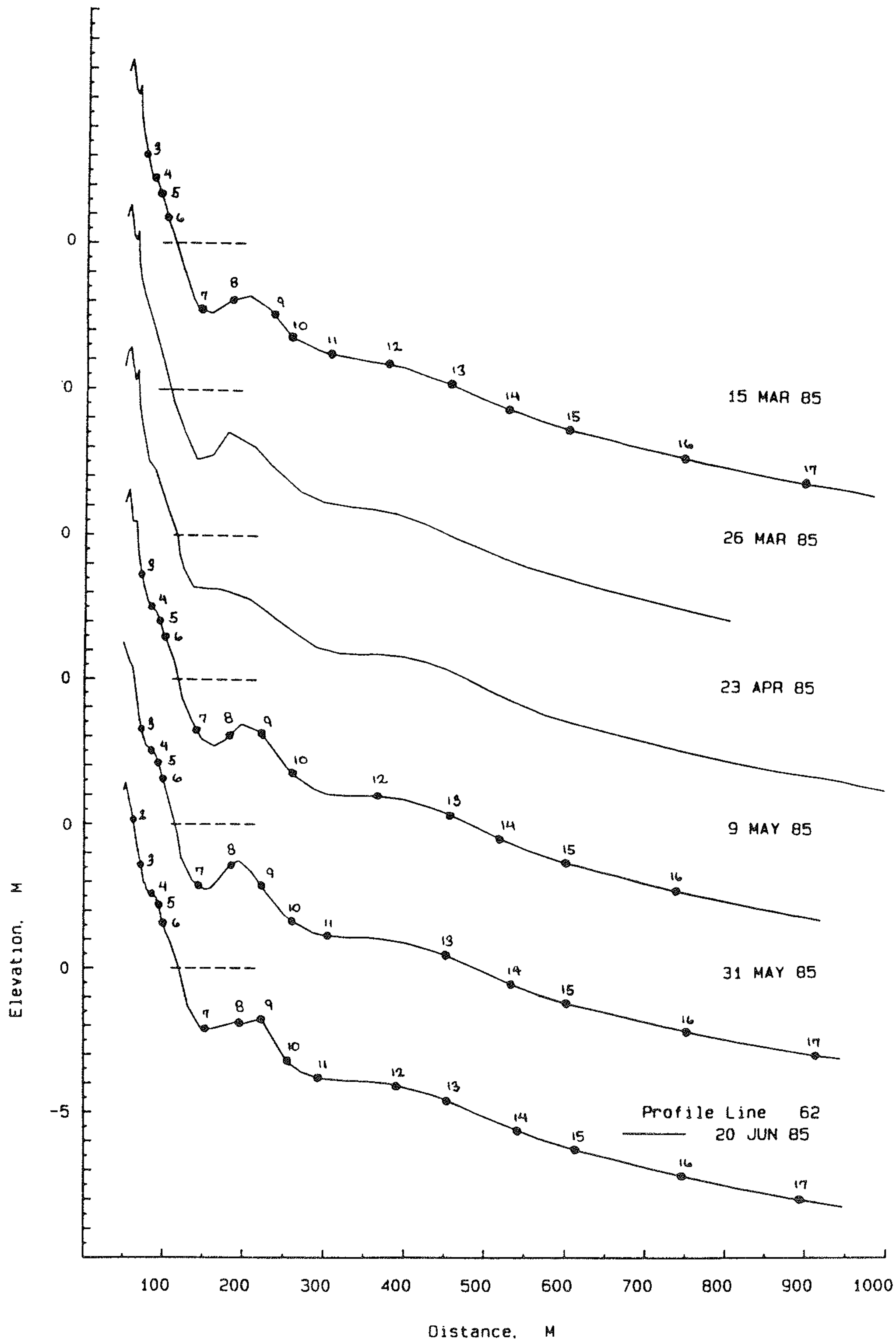

d. September through November 1984

Figure 4. (Sheet 4 of 7)



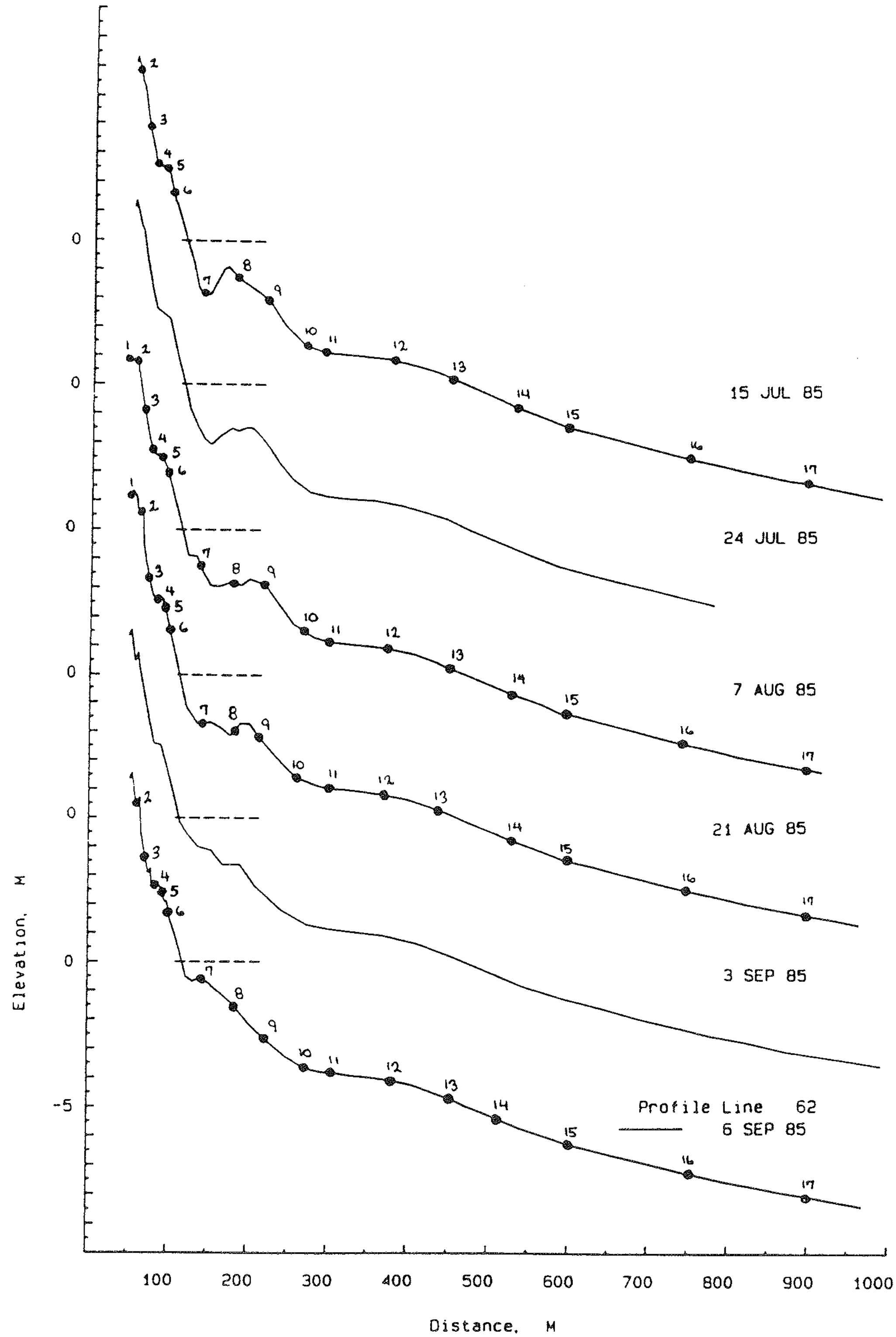

e. December 1984 to March 1985

Figure 4. (Sheet 5 of 7)




f. March through June 1985

Figure 4. (Sheet 6 of 7)




g. July to September 1985

Figure 4. (Sheet 7 of 7)

Table 2

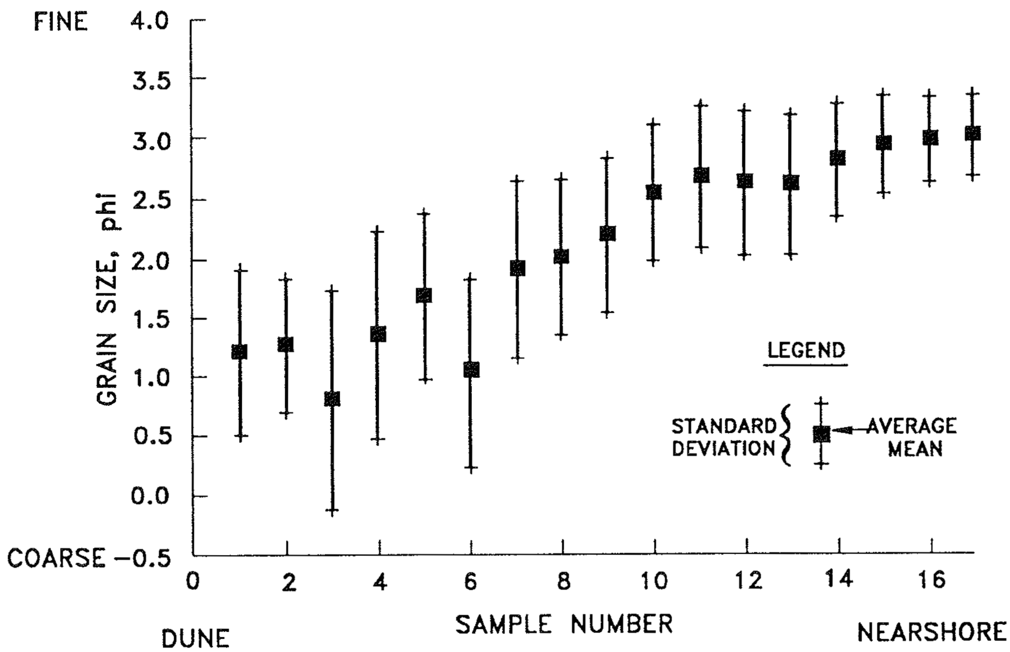
Conversion Chart of Sediment Grain-Size Classifications

| UNIFIED SOILS CLASSIFICATION | | ASTM MESH | MM SIZE | PHI SIZE | WENTWORTH CLASSIFICATION | |
|---|---|---|---|---|---|---|
| | | | 4096.00 | -12.0 | | |
| | | | 1024.00 | -10.0 | BOULDER | |
| | | | 256.00 | -8.0 | | |
| COBBLE | | | 128.00 | -7.0 | | G |
| | | | 107.64 | -6.75 | COBBLE | |
| | | | 90.51 | -6.5 | | |
| | | | 76.00 | -6.25 | | |
| | | | 64.00 | -6.0 | | R |
| | | | 58.82 | -5.75 | | |
| COARSE GRAVEL | | | 45.26 | -5.5 | | |
| | | | 38.00 | -5.25 | | |
| | | | 32.00 | -5.0 | | A |
| | | | 26.91 | -4.75 | | |
| | | | 22.63 | -4.5 | | |
| | | | 19.00 | -4.25 | PEBBLE | |
| | | | 16.00 | -4.0 | | V |
| | | | 13.45 | -3.75 | | |
| FINE GRAVEL | | | 11.31 | -3.5 | | |
| | | | 9.51 | -3.25 | | |
| | | 2.5 | 8.00 | -3.0 | | E |
| | | 3 | 6.73 | -2.75 | | |
| | | 3.5 | 5.66 | -2.5 | | |
| | | 4 | 4.76 | -2.25 | | |
| | | 5 | 4.00 | -2.0 | | L |
| | Coarse | 6 | 3.36 | -1.75 | | |
| | | 7 | 2.85 | -1.5 | GRANULE | |
| | | 8 | 2.35 | -1.25 | | |
| S | | 10 | 2.00 | -1.0 | | |
| | | 12 | 1.68 | -0.75 | Very Coarse | |
| | | 14 | 1.41 | -0.5 | | |
| | | 16 | 1.19 | -0.25 | | |
| A | Medium | 18 | 1.00 | 0.0 | | S |
| | | 20 | 0.84 | 0.25 | | |
| | | 25 | 0.71 | 0.5 | Coarse | |
| | | 30 | 0.59 | 0.75 | | |
| N | | 35 | 0.50 | 1.0 | | A |
| | | 40 | 0.42 | 1.25 | | |
| | | 45 | 0.35 | 1.5 | Medium | |
| | | 50 | 0.30 | 1.75 | | |
| D | | 60 | 0.25 | 2.0 | | N |
| | | 70 | 0.210 | 2.25 | | |
| | Fine | 80 | 0.177 | 2.5 | Fine | |
| | | 100 | 0.149 | 2.75 | | |
| | | 120 | 0.125 | 3.0 | | D |
| | | 140 | 0.105 | 3.25 | Very Fine | |
| | | 170 | 0.088 | 3.5 | | |
| | | 200 | 0.074 | 3.75 | | |
| | | 230 | 0.0625 | 4.0 | | |
| | | 270 | 0.053 | 4.25 | | |
| | | 325 | 0.044 | 4.5 | | |
| SILT | | 400 | 0.037 | 4.75 | SILT | |
| | | | 0.031 | 5.0 | | M |
| | | | 0.0156 | 6.0 | | |
| | | | 0.0078 | 7.0 | | |
| | | | 0.0039 | 8.0 | | |
| | | | 0.0020 | 9.0 | | U |
| | | | 0.00098 | 10.0 | CLAY | |
| CLAY | | | 0.00049 | 11.0 | | |
| | | | 0.00024 | 12.0 | | |
| | | | 0.00012 | 13.0 | COLLOID | D |
| | | | 0.00006 | 14.0 | | |

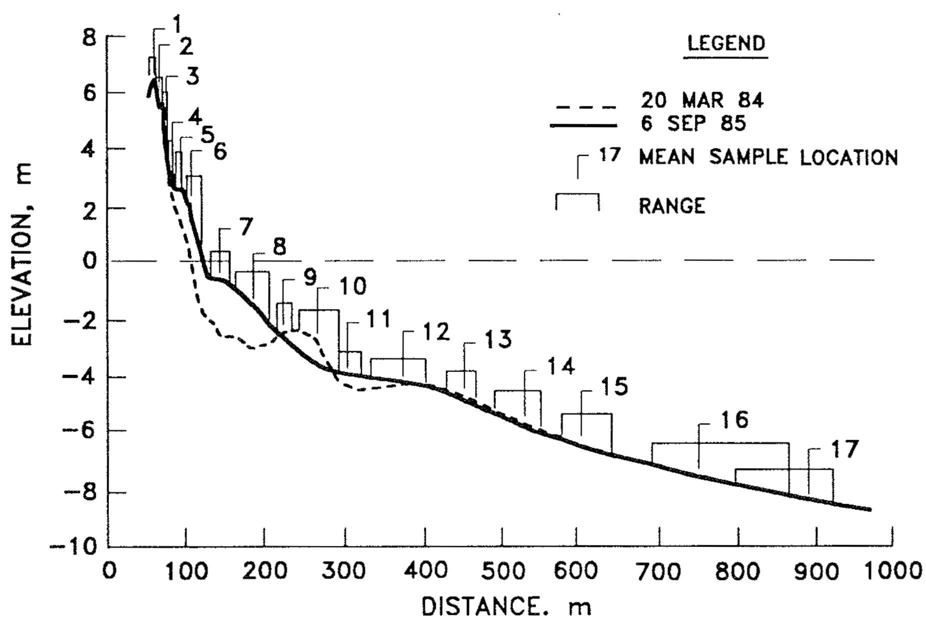
et al. (in preparation). The output of the program provided several sediment size statistics and provided graphic capability to produce frequency, cumulative frequency, histograms, and probability curves of the individual sediment samples. Mean and sorting values included in this report were calculated using the method of moments (Friedman and Sanders 1978). The median values were calculated by graphic formulas (Folk 1974). The program also calculated composite samples, combining individual samples mathematically to produce composite sediment statistics and graphics.

14. Sediment sample statistics are used to characterize the sediment grain-size distribution. Beach sediments can be composed of several types of minerals such as quartz, feldspar, carbonate shell material, and heavy minerals. The FRF beach contains primarily quartz sand with secondary components of rock fragments of granule size, some shell material, heavy minerals, mica, glauconite pellets, and foraminiferal tests (Meisburger and Judge 1989). The main statistical descriptors used here to describe the sediment are the first moment (mean grain size), second moment (standard deviation representing the degree of sorting), and the median or $D_{50}$. While these values are good single-value descriptors of the sediment, the entire grain-size distribution is needed to show the variation that encompasses the size range common to this coast. Grain-size distributions are illustrated using a frequency curve.

15. The sediment sampling scheme attempted to locate the sample at the same distance seaward of the baseline during each sampling period. Figure 5 shows the average locations of the 17 samples with the range at each station. For the most part, the 21 sediment sampling periods collected sediment within a narrow across-profile position. The sampling positions varied more in the nearshore area as the spacing between stations increased. The first and last profiles are plotted to show the envelope of elevation change and position of the berm, bar, and trough relative to the station locations with time. The general trend was for the sediment to become finer in the offshore direction. An average of all the means for each station from Station 1 in the dune to Station 17 in the nearshore region showed this trend (Figure 5), except for Station 3 at the base of the dune and Station 6 on the foreshore, which were coarser than the surrounding stations. The stations on the beach (Stations 3 through 6) had the highest range of standard deviation. The narrowest range in standard deviation over the study period occurred in the far nearshore region (Stations 14 through 17).




a. Average mean grain-size distribution with standard deviation across profile




b. Mean and range of sample locations shown on envelope of profiles over study period

Figure 5. FRF Survey Line 62, 1984-1985

16. Bascom (1959) characterized the variation in grain-size distributions across several Pacific Coast beaches. Based on a reference sample located in the midtide beach face, the trend was for samples landward of this reference point on the berm to be coarser and then to become finer into the dune area. In the offshore direction, samples at the plunge point (just seaward of the backwash, shore break interaction area) were the coarsest, with a fining of samples with increasing depth and distance offshore. The largest grain sizes are found at the areas of highest turbulence, with decrease in size with decreasing turbulence. The mean size distribution at the FRF generally fits this model. The mean grain size becomes progressively finer in the offshore direction. Samples were not consistently collected at the plunge point at the base of the foreshore for this experiment, so the coarsest sediment may have been missed.

17. A somewhat anomalous condition exists at the FRF in that the coarsest material measured was located at Station 3 in the vicinity of the base of the dune rather than the top of the summer berm as found by Bascom (1959). The mean of the dune samples also was coarser than some of the beach samples, possibly because the dunes were man-made in the 1930's by a Work Projects Administration project and were not solely a product of eolian transport.

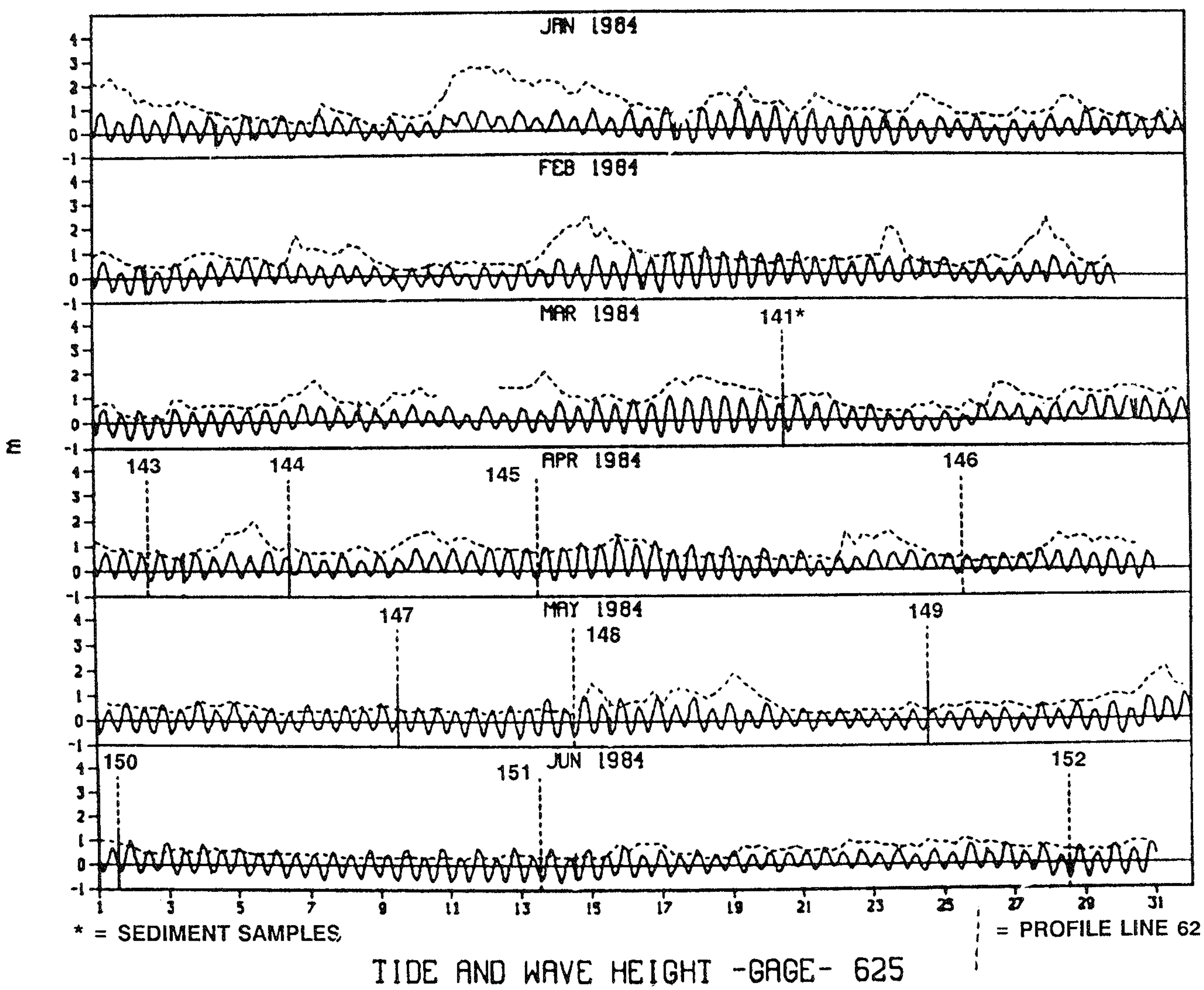
## PART IV: WAVE AND WATER LEVEL DATA

18. Wave heights and periods have been collected at the FRF on a continuous basis at various gages. Gage 625, a Baylor wave staff located near the end of the research pier (Figure 2), was used in this study, since it had the most complete data during the study period. Data were sampled at 4 Hz, every 6 hr for 20 min, with hourly readings during storms (Howd and Birkemeier 1987). During some storms, Gage 625 was in the breaker zone and gave breaking wave readings. During these times and when the gage was otherwise inoperable, data were transformed into the pier from Gage 620, a Waverider buoy located in 18 m of water, some 2.1 km eastward from the baseline on the dune, directly in line with the pier (Birkemeier et al. 1985). These data were transformed into the depth of the pier using a method developed by Hallermeier (1983).

19. A tide gage maintained by the National Oceanographic and Atmospheric Administration, National Ocean Service (NOAA/NOS), at the seaward end of the pier (Figure 2) recorded the water levels due to tidal fluctuations and storm surge. The total water level was used to give an identification of storm surge as a forcing function to profile and sediment change.

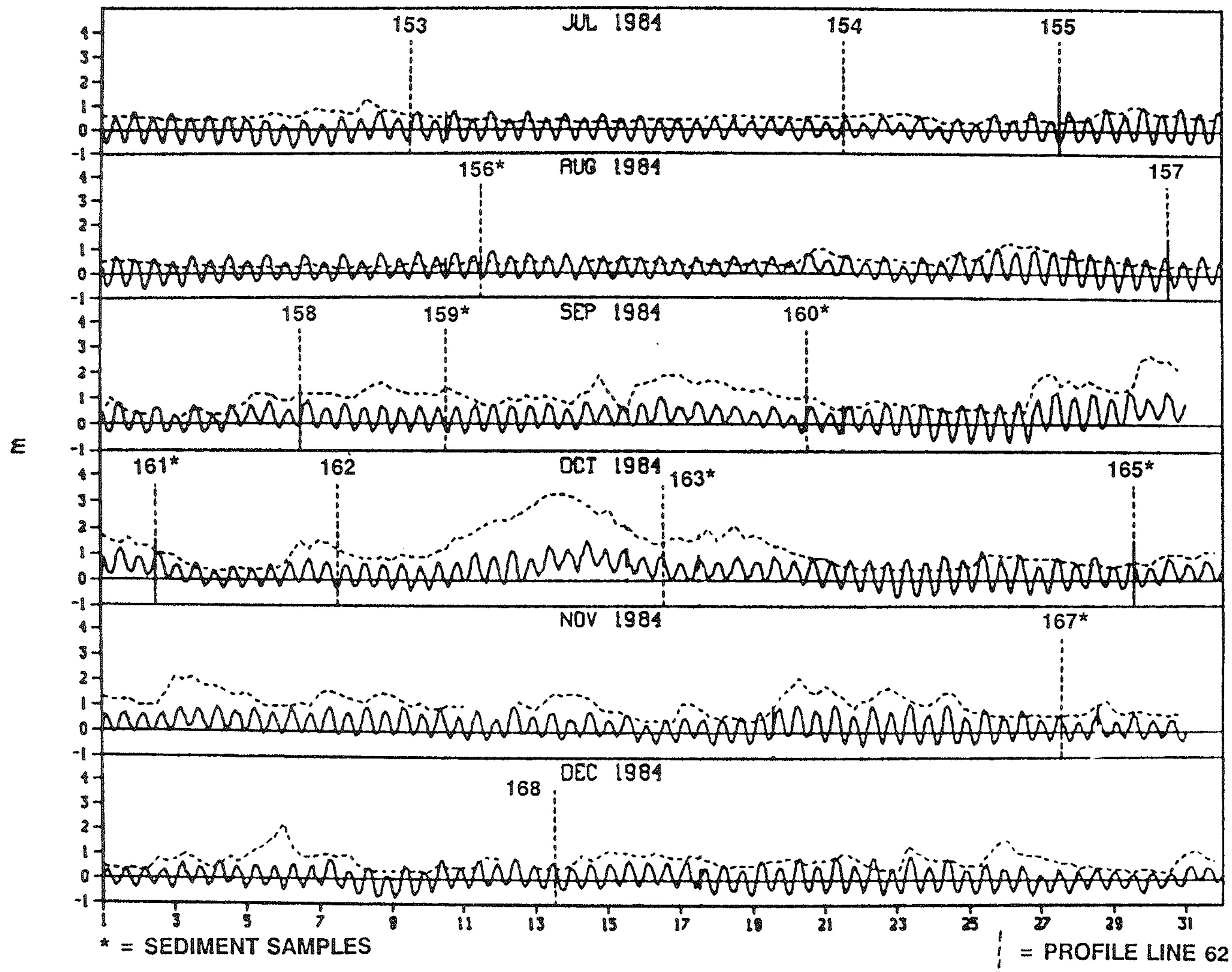
20. Figure 6 shows the time-averaged record of the wave height and water level relative to the profile surveys and sediment sampling. The seasonal cycle in wave height can be seen with low waves occurring during the summer months of June through August. Only one event of higher waves (just reaching 2-m heights) occurred 2-3 August 1985. Higher frequencies of extreme events (waves greater than 2 m and elevation of water level above normal tidal variations) occurred during the fall, winter, and spring months of 1984 and 1985. Approximately one event occurred within each fall, winter, and spring monthly period during the study. Several times during the study, the wave height was greater than 2 m. Some of these events were accompanied with elevated water levels, indicative of a storm surge. The highest waves recorded during the study were greater than 3 m and occurred from 11 to 17 October 1984. Otherwise, the entire study period from March 1984 to September 1985 was relatively free from major storm events.

21. In an effort to identify high wave events that would affect profile change and sediment distribution, wave power was calculated and plotted for the study period (Figure 7). The wave power was calculated from the wave




a. January through June 1984

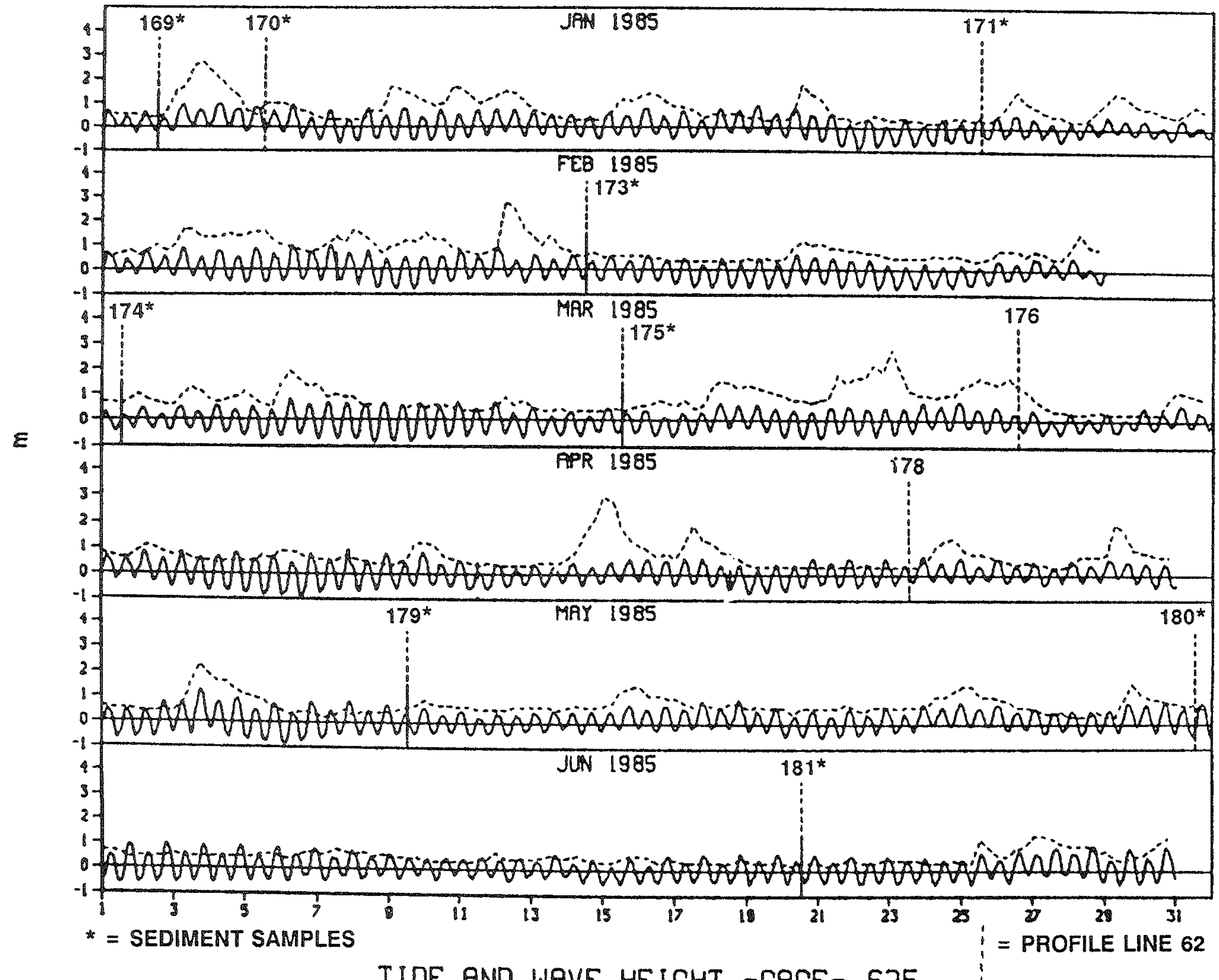
Figure 6. Time line of wave and water level records with profile survey and sediment collection times, tide and wave height, Gage 625 (Sheet 1 of 4)




TIDE AND WAVE HEIGHT -GAGE- 625

b. July through December 1984

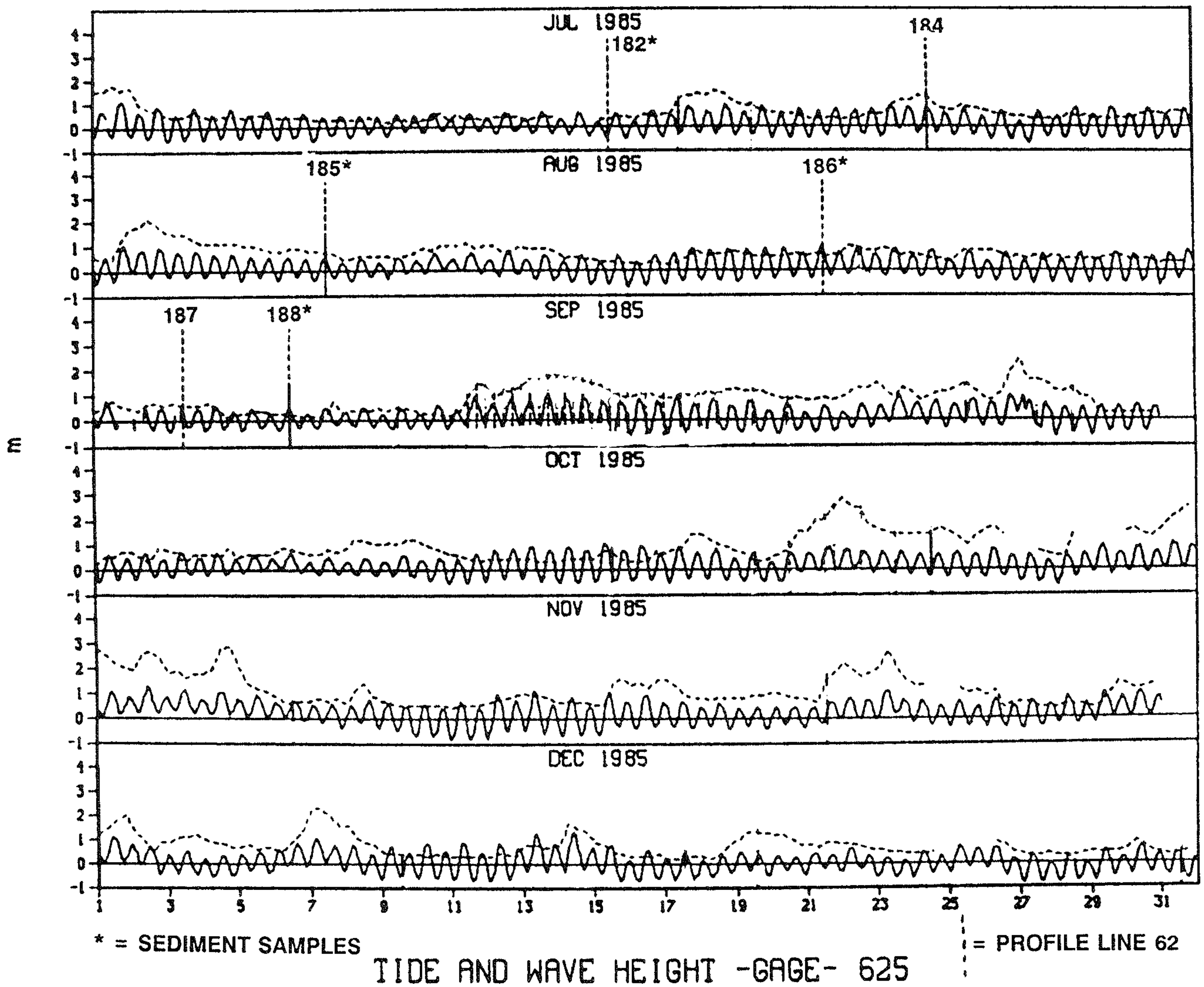
Figure 6. (Sheet 2 of 4)




TIDE AND WAVE HEIGHT -GAGE- 625

c. January through June 1985

Figure 6. (Sheet 3 of 4)




d. July through December 1985

Figure 6. (Sheet 4 of 4)

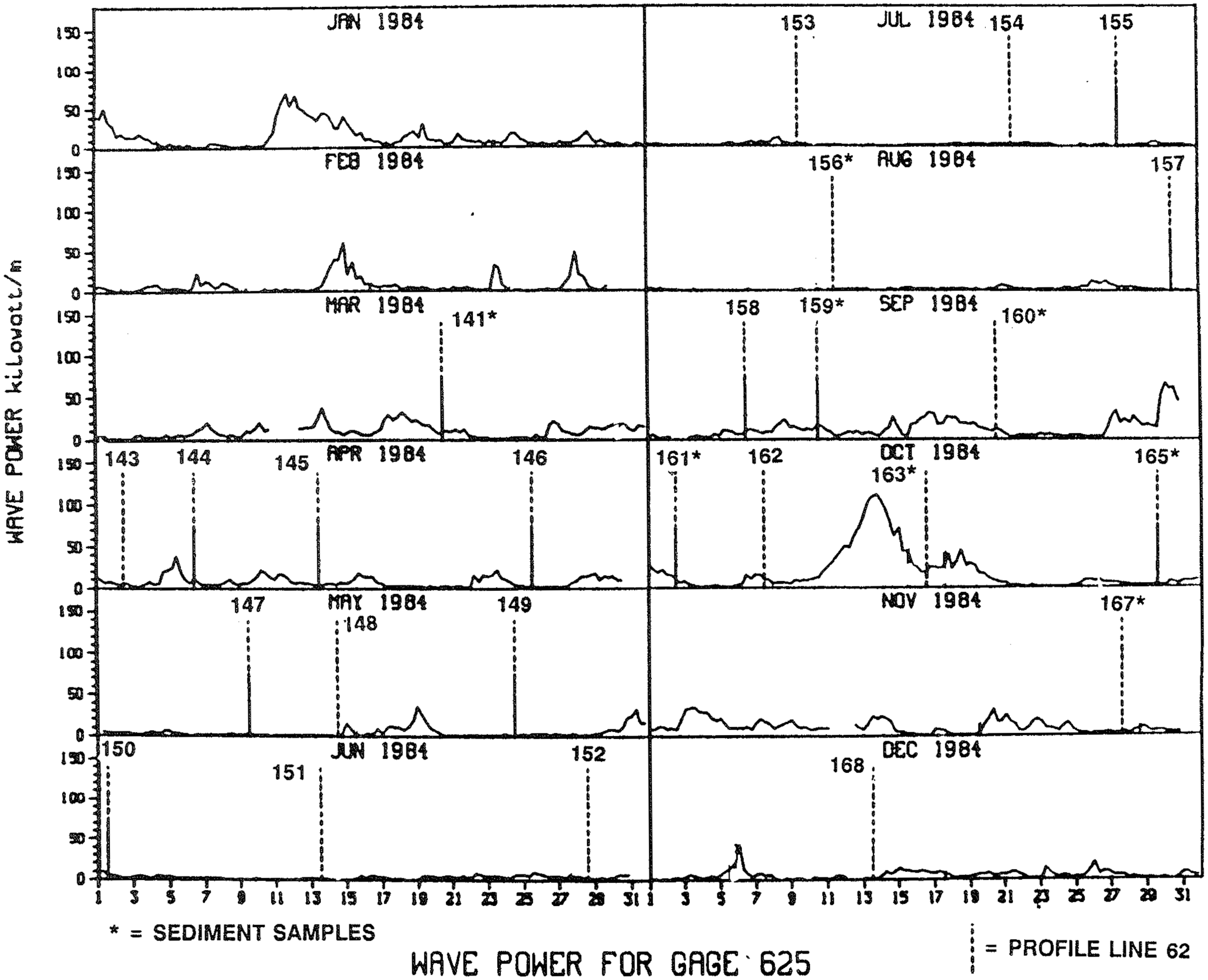



Figure 7. Time line of calculated wave power for Gage 625 with profile survey and sediment collection times (Continued)

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyz |
|---|---|---|---|---|---|---|
| 39 | G | 6217009 | 850105 | | 860515 | LSC |

X Position : 3300.00 Y Position : 748.84

Elevation of Top of Core : -6.30
Length of Core : 0.00
Depth to Top of Sample : 0.00
Depth to Bottom of Sample :

Comments :

Start Weight : 29.150 Final Weight : 29.012 Deviation : 0.473 %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.75 | 6.727 | 0.000 | 0.000 | 0.000 | 1.75 | 0.297 | 4.349 | 14.990 | 35.113 |
| -2.50 | 5.657 | 0.000 | 0.000 | 0.000 | 2.00 | 0.250 | 5.930 | 20.440 | 55.553 |
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 2.25 | 0.210 | 5.190 | 17.889 | 73.442 |
| -2.00 | 4.000 | 0.000 | 0.000 | 0.000 | 2.50 | 0.177 | 4.491 | 15.480 | 88.922 |
| -1.75 | 3.364 | 0.000 | 0.000 | 0.000 | 2.75 | 0.149 | 1.831 | 6.311 | 95.233 |
| -1.50 | 2.828 | 0.000 | 0.000 | 0.000 | 3.00 | 0.125 | 1.070 | 3.688 | 98.921 |
| -1.25 | 2.378 | 0.000 | 0.000 | 0.000 | 3.25 | 0.105 | 0.249 | 0.858 | 99.779 |
| -1.00 | 2.000 | 0.099 | 0.341 | 0.341 | 3.50 | 0.088 | 0.061 | 0.210 | 99.990 |
| -0.75 | 1.682 | 0.041 | 0.141 | 0.483 | 3.75 | 0.074 | 0.000 | 0.000 | 99.990 |
| -0.50 | 1.414 | 0.099 | 0.341 | 0.824 | 4.00 | 0.063 | 0.003 | 0.010 | 100.000 |
| -0.25 | 1.189 | 0.110 | 0.379 | 1.203 | 4.25 | 0.053 | 0.000 | 0.000 | 100.000 |
| 0.00 | 1.000 | 0.090 | 0.310 | 1.513 | 4.50 | 0.044 | 0.000 | 0.000 | 100.000 |
| 0.25 | 0.841 | 0.160 | 0.551 | 2.065 | 4.75 | 0.037 | 0.000 | 0.000 | 100.000 |
| 0.50 | 0.707 | 0.249 | 0.858 | 2.923 | 5.00 | 0.031 | 0.000 | 0.000 | 100.000 |
| 0.75 | 0.595 | 0.351 | 1.210 | 4.133 | 5.25 | 0.026 | 0.000 | 0.000 | 100.000 |
| 1.00 | 0.500 | 0.940 | 3.240 | 7.373 | 5.50 | 0.022 | 0.000 | 0.000 | 100.000 |
| 1.25 | 0.420 | 1.480 | 5.101 | 12.474 | 5.75 | 0.019 | 0.000 | 0.000 | 100.000 |
| 1.50 | 0.354 | 2.219 | 7.649 | 20.123 | 6.00 | 0.016 | 0.000 | 0.000 | 100.000 |

Sample Content by Weight Percent :

| | ;ravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 0.341 | 7.032 | 48.180 | 44.447 | 0.000 | 0.000 |
| Unified Classification | 0.000 | 0.341 | 12.133 | 87.516 | 0.010 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 1.87 | 0.62 | -1.19 | 6.34 |
| Folk Graphic Measures (PHI) | 1.93 | 1.91 | 0.56 | -0.12 | 1.14 |
| Grain Size (mm) | 0.26 | 0.27 | | | |

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyz |
|---|---|---|---|---|---|---|
| 39 | G | 6217010 | 850105 | | 860515 | LSC |

X Position : 3300.00 Y Position : 860.72

Elevation of Top of Core : -10.61
Length of Core : 0.00
Depth to Top of Sample : 0.00
Depth to Bottom of Sample :

Comments :

Start Weight : 62.820 Final Weight : 62.821 Deviation : 0.002 %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.75 | 6.727 | 0.000 | 0.000 | 0.000 | 1.75 | 0.297 | 0.283 | 0.450 | 4.182 |
| -2.50 | 5.657 | 0.000 | 0.000 | 0.000 | 2.00 | 0.250 | 0.829 | 1.320 | 5.501 |
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 2.25 | 0.210 | 3.461 | 5.509 | 11.011 |
| -2.00 | 4.000 | 0.289 | 0.460 | 0.460 | 2.50 | 0.177 | 12.570 | 20.009 | 31.020 |
| -1.75 | 3.364 | 0.000 | 0.000 | 0.460 | 2.75 | 0.149 | 23.162 | 36.870 | 67.890 |
| -1.50 | 2.828 | 0.050 | 0.080 | 0.540 | 3.00 | 0.125 | 15.542 | 24.740 | 92.630 |
| -1.25 | 2.378 | 0.157 | 0.250 | 0.790 | 3.25 | 0.105 | 3.361 | 5.350 | 97.980 |
| -1.00 | 2.000 | 0.063 | 0.100 | 0.890 | 3.50 | 0.088 | 1.018 | 1.620 | 99.600 |
| -0.75 | 1.682 | 0.170 | 0.271 | 1.160 | 3.75 | 0.074 | 0.201 | 0.320 | 99.920 |
| -0.50 | 1.414 | 0.132 | 0.210 | 1.371 | 4.00 | 0.063 | 0.050 | 0.080 | 100.000 |
| -0.25 | 1.189 | 0.151 | 0.240 | 1.611 | 4.25 | 0.053 | 0.000 | 0.000 | 100.000 |
| 0.00 | 1.000 | 0.113 | 0.180 | 1.791 | 4.50 | 0.044 | 0.000 | 0.000 | 100.000 |
| 0.25 | 0.841 | 0.182 | 0.290 | 2.081 | 4.75 | 0.037 | 0.000 | 0.000 | 100.000 |
| 0.50 | 0.707 | 0.302 | 0.481 | 2.561 | 5.00 | 0.031 | 0.000 | 0.000 | 100.000 |
| 0.75 | 0.595 | 0.239 | 0.380 | 2.942 | 5.25 | 0.026 | 0.000 | 0.000 | 100.000 |
| 1.00 | 0.500 | 0.232 | 0.369 | 3.311 | 5.50 | 0.022 | 0.000 | 0.000 | 100.000 |
| 1.25 | 0.420 | 0.132 | 0.210 | 3.521 | 5.75 | 0.019 | 0.000 | 0.000 | 100.000 |
| 1.50 | 0.354 | 0.132 | 0.210 | 3.731 | 6.00 | 0.016 | 0.000 | 0.000 | 100.000 |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 0.890 | 2.421 | 2.190 | 94.499 | 0.000 | 0.000 |
| Unified Classification | 0.000 | 0.890 | 2.631 | 96.399 | 0.080 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 2.53 | 0.64 | -4.17 | 25.49 |
| Folk Graphic Measures (PHI) | 2.63 | 2.62 | 0.33 | -0.13 | 1.24 |
| Grain Size (mm) | 0.16 | 0.17 | | | |