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# A COLLECTION OF STORM EROSION FIELD DATA


by

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This report presents a collection of field survey data that quantifies the effects of 13 unique storm events on from two to seven beaches along the North Atlantic coast of the United States. The beaches include Nauset Beach, Massachusetts; Misquamicut Beach, Rhode Island; Westhampton and Jones Beaches, New York; and Long Beach Island, Atlantic City, and Ludlam Beach, New Jersey. From 7 to 19 profile lines were surveyed at each site permitting reliable estimates of the average change to be computed for each beach and storm. Beach change data are presented in terms of plotted profile cross sections, above mean sea level (msl) volume changes, shoreline changes, and slope changes. In addition, shallow-water wave hindcasts for each survey interval and storm are presented along with measured water level data (tide plus surge).

The data document not only the large beach changes that can occur during storms but also reveal the amount of variation that occurs between profile lines and between different

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localities. Median volume changes varied from 3.8 to -31.4 $m^3/m$ with a single profile maximum of -150 $m^3/m$ (measured along the south jetty of Absecon Inlet, Atlantic City). Above msl volume changes were the best indicator of a storm's effect. Changes in slope and shoreline (computed at msl) were surprisingly insensitive to storm effects. Of the 588 profile changes included in the study, 78.2 percent eroded based on volume losses whereas only 55.1 percent had erosional shorelines.

Though the data are widely scattered, volumetric changes correlate better with measured peak water levels than with the hindcast wave heights, a finding consistent with present models of storm erosion.

Keywords: Beach erosion. Sto

# PREFACE

This report presents field survey data collected between 1962 and 1978 that document the effects of storms on seven beaches on the east coast of the United States. The data have been used to quantify the magnitude of storm-induced changes in terms of sediment gains and losses to the beach face. Expectations are that this unique data set will also be used in developing and evaluating models for predicting the large and often dramatic changes caused by coastal storms.

This report was prepared at the Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES) as part of the Storm Erosion Studies Work Unit (No. 31467), Shore Protection and Restoration Program, Coastal Engineering Area, Civil Works Research and Development. Technical Monitors were Mr. John H. Lockhart, Jr., and Mr. John G. Housley, Headquarters, US Army Corps of Engineers.

Mr. William A. Birkemeier, Ms. Rebecca J. Savage, and Mr. Michael W. Leffler, all of CERC's Field Research Facility (FRF) Group, prepared this report under the supervision of Mr. Curt Mason, Chief, FRF, Mr. Thomas Richardson, Chief, Engineering Division, Dr. Linwood Vincent, Program Manager, and Dr. James Houston, Chief, CERC. Dr. Cyril Galvin, Mr. Rudolph Savage, Mr. Allen DeWall, Dr. Craig Everts, Ms. Karen Jacobs, and Ms. Jennifer Miller also contributed to either the planning of the project or to the processing of the data, particularly during the beginning of this study.

Commander and Director of WES upon publication of this report was COL Dwayne G. Lee, CE. Dr. Robert W. Whalin was Technical Director.


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CONTENTS


| | Page |
|---|---|
| PREFACE | 1 |
| PART I: INTRODUCTION | 4 |
| Background | 4 |
| Purpose and Scope | 4 |
| PART II: FIELD DATA COLLECTION | 7 |
| Profile Data | 7 |
| Wave Data | 13 |
| Storm Surge | 16 |
| PART III: LOCALITY DESCRIPTIONS | 18 |
| Nauset Beach, Massachusetts | 18 |
| Misquamicut Beach, Rhode Island | 20 |
| Westhampton Beach, New York | 22 |
| Jones Beach, New York | 23 |
| Long Beach Island, New Jersey | 25 |
| Atlantic City, New Jersey | 27 |
| Ludlam Beach, New Jersey | 29 |
| PART IV: DISCUSSION | 31 |
| Shoreline and Slope Changes | 31 |
| Volumetric Changes | 33 |
| Influence of Waves and Tides on Volume Changes | 37 |
| PART V: SUMMARY | 40 |
| REFERENCES | 41 |
| BIBLIOGRAPHY | 44 |
| Locality Reports | 44 |
| Other Reports | 44 |
| APPENDIX A: DATA SUMMARY FOR THE STORM OF 3 NOVEMBER 1962 | A1 |
| APPENDIX B: DATA SUMMARY FOR THE STORM OF 6 NOVEMBER 1963 | B1 |
| APPENDIX C: DATA SUMMARY FOR THE STORM OF 13 JANUARY 1964 | C1 |
| APPENDIX D: DATA SUMMARY FOR THE STORM OF 16 SEPTEMBER 1967 | D1 |
| APPENDIX E: DATA SUMMARY FOR THE STORM OF 12 MARCH 1968 | E1 |
| APPENDIX F: DATA SUMMARY FOR THE STORM OF 12 NOVEMBER 1968 | F1 |

Page

APPENDIX G: DATA SUMMARY FOR THE STORM OF 2 FEBRUARY 1970 . . . . . G1

APPENDIX H: DATA SUMMARY FOR THE STORM OF 17 DECEMBER 1970 . . . . . H1

APPENDIX I: DATA SUMMARY FOR THE STORM OF 19 FEBRUARY 1972 . . . . . I1

APPENDIX J: DATA SUMMARY FOR THE STORM OF 17-22 MARCH 1973 . . . . . J1

APPENDIX K: DATA SUMMARY FOR THE STORM OF 14 OCTOBER 1977 . . . . . K1

APPENDIX L: DATA SUMMARY FOR THE STORM OF 19 DECEMBER 1977 . . . . . L1

APPENDIX M: DATA SUMMARY FOR THE STORM OF 6 FEBRUARY 1978 . . . . . M1

APPENDIX N: DESCRIPTION OF DATA TAPE FORMAT . . . . . N1

# A COLLECTION OF STORM EROSION FIELD DATA

## PART I: INTRODUCTION

### Background

1. Though beaches are constantly being remolded by waves, winds, and tides, the largest and most dramatic changes occur during storms. Storms not only remove large quantities of sediment from the beach, but also cause significant damage to residential property, commercial developments, and recreational areas. Interest in storm effects date to the early history of coastal engineering; however, the ability to predict storm erosion is still highly empirical. Recent efforts by Hughes and Chiu (1981), Kriebel (1982, 1986), Kriebel and Dean (1985), Balsillie (1986), and Vellinga (1983, 1986) to estimate storm changes show promise, but more research is required. Prediction efforts have been hampered by a general lack of storm erosion data, particularly data on large storms. Minimum data requirements to quantify storm effects include field surveys collected before and immediately after a particular storm along with concurrent wave and water level measurements.

### Purpose and Scope

2. The purpose of this report is to document storm erosion data collected by the US Army Corps of Engineers between 1962 and 1978 and to quantify the effects of 13 storm events at from two to seven east coast beaches. Beach profiles along with wave and water level data are included. Expectations are that this unique data set will be used to develop and evaluate models for predicting changes to beaches caused by coastal storms.

3. The Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES) and its predecessor, the Beach Erosion Board (BEB), have a long history of interest in storm effects. The first major program, the "Storm Warning Program," resulted from Congressional

hearings and public interest following the Ash Wednesday Storm of March 1962. This storm devastated major portions of the east coast from North Carolina to Rhode Island and caused the loss of several lives. The Storm Warning Program was a cooperative effort between the Corps and the National Weather Service (NWS). The objectives of the program were to:

a. Measure, through repetitive surveys, visual observations, and gage measurements, the effects of storms at different localities.

b. Better predict storm occurrences and intensities.

c. Estimate the storm damage potentials.

4. Beaches selected for this study included those areas most seriously damaged by the March 1962 storm. The Corps' responsibilities in the effort evolved into the Beach Evaluation Program (BEP), and other localities were added. The objective of the BEP was to document, through monthly surveys of each study site, patterns of erosion and accretion. Most of the BEP field surveys ended in 1972.

5. In 1975 a field-oriented project, the "Storm Erosion Studies," was initiated specifically to study coastal storms and to predict their effects (Birkemeier 1979). The surveys resulting from this project were unique because of the timeliness of the poststorm surveys which usually followed the storms by only 1 or 2 days. During the 3 years from 1975 to 1978, three storms of significance were monitored at two of the original BEP sites in New Jersey.

6. The seven study beaches are shown in Figure 1. The seven sites include Nauset Beach, Massachusetts; Jones and Westhampton Beaches, New York; Misquamicut, Rhode Island; and Long Beach Island, Atlantic City, and Ludlam Beach, New Jersey. Published reports and papers which summarize the long- and short-term changes at these localities are listed in the Bibliography. These reports include general information about the locality, a discussion of storm effects, documentation of the profile lines, and listings of the survey data.

7. The present study differs from previous treatments of the data in two respects. Whereas the earlier locality reports addressed changes at a specific beach, this report presents data from a number of beaches for

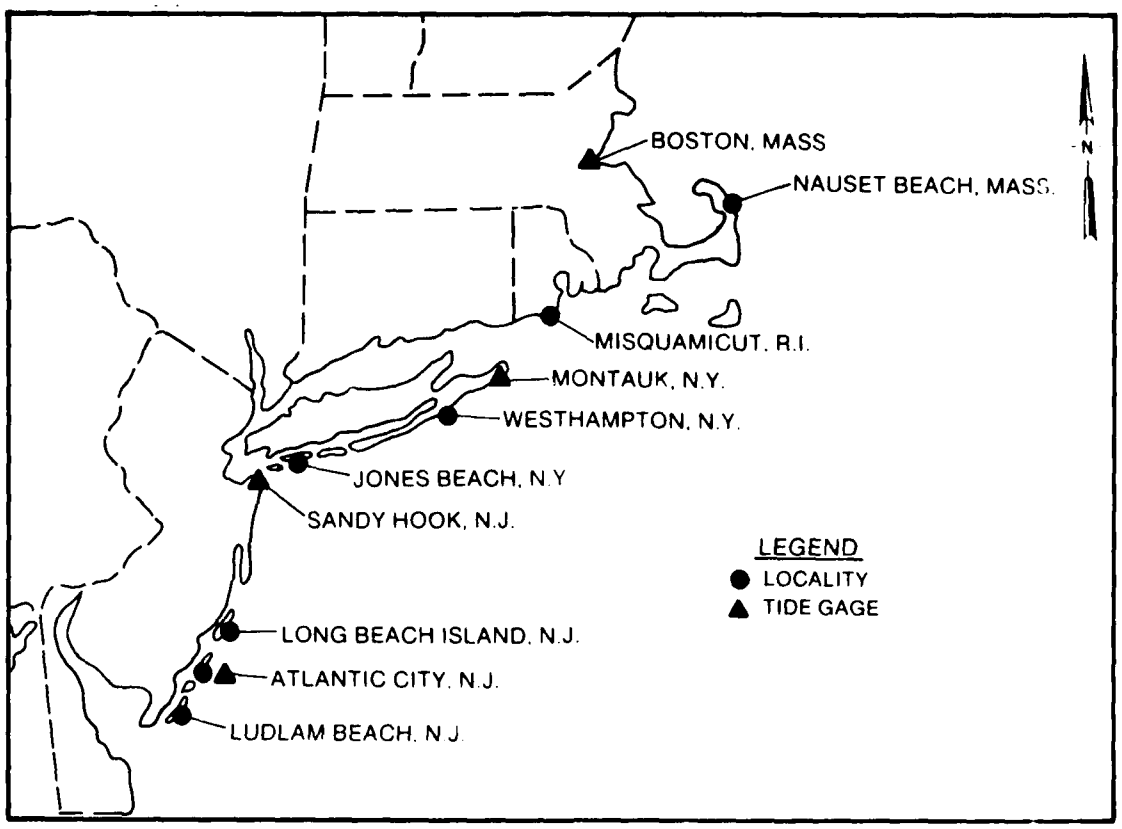


Figure 1. Location map of study sites and tide gages

specific storms. Therefore, the effect of individual storms can be compared and studied at beaches with different characteristics (i.e. slope, sediment size, beach width, etc.). Secondly, this study makes use of the Phase III hindcast wave data generated by the Wave Information Study (WIS) of CERC (Jensen 1983). These hindcast data provide a consistent estimate of the significant wave height at 3-hr intervals for each period between the BEP surveys. Actual water level measurements from the tide gages shown in Figure 1, for each of the storms, are also presented.

8. This report is organized into five parts and 14 appendixes. Part II describes the methods of collection, analysis, and presentation of the data. Part III introduces the seven localities and their characteristics and discusses their response to storms in general. Part IV presents results of the analysis of the data, including summary and extreme statistics. Part V summarizes the report. Appendixes A through M present data from each of the 13 storms. Appendix N addresses how to obtain magnetic tape copies of the data and describes the data format.

## PART II: FIELD DATA COLLECTION

### Profile Data

9. Profile data were collected from regular surveys of several profile lines (beach cross sections) at each of the localities shown in Figure 1. Surveys were usually conducted monthly but some were either made weekly or immediately after storms. Profile lines were established with permanent monuments of known location and elevation. The landward end of the profile generally began at the dune, boardwalk, or bluff, depending on beach morphology. Points were surveyed every 8 to 15 m and at breaks in the slope. When possible, surveys were required to reach a depth of -0.6 m below the vertical datum. Except for Jones Beach and Westhampton, all survey data were collected relative to geodetic mean sea level (msl) as defined by the 1929 National Geodetic Vertical Datum (NGVD) using a tape to measure distance and a level (or a transit) to measure elevation. Data from Jones Beach and Westhampton were collected relative to local mean low water (mlw) using stadia readings to measure distance. Note that for this report, all survey and water level data have been adjusted to geodetic msl.

10. Though field procedures varied during the 10 years of surveying, most data were recorded in fieldbooks, transferred to optical scanning sheets, and sent to CERC for processing. Measurements were made in feet with distances rounded to the nearest foot (0.305 m) and elevations to the nearest tenth of a foot (0.031 m). Documentation of the survey benchmarks and a discussion of survey techniques can be found along with the actual data in each of the locality reports listed in the Bibliography.

11. The data included in Table 1 are a subset of all the BEP and Storm Erosion Studies data. To determine which data to include, all past storms and associated survey intervals were identified using written records, logbooks, and historical weather maps. Then the wave hindcast data generated by the WIS (Jensen 1983) were used to determine the significance of the storm based on the height and duration of storm waves and to determine if other storms had also occurred during the interval between the surveys. Except for the specific cases noted in Table 1, data were not included if several storms occurred within the interval or if the poststorm survey was completed more than a week after the event. Because of the large amount of data collected

Table 1

Summary of Storms

| Appendix Code | Storm Date | Beach | Survey Dates | | Survey Numbers | Remarks |
|---|---|---|---|---|---|---|
| A | 3 Nov 62 | Long Beach Island | 23 Oct 62 | 8 Nov 62 | 5,7 | Two storms in the survey interval |
| | | Atlantic City | 1 Nov 62 | 9 Nov 62 | 2,3 | |
| | | Ludlam Beach | 1 Nov 62 | 7 Nov 62 | 8,9 | |
| B | 6 Nov 63 | Long Beach Island | 25 Oct 63 | 15 Nov 63 | 31,32 | Several minor storms also in the |
| | | Atlantic City | 28 Oct 63 | 14 Nov 63 | 27,28 | survey interval |
| | | Ludlam Beach | 30 Oct 63 | 13 Nov 63 | 33,34 | |
| C | 13 Jan 64 | Long Beach Island | 27 Dec 63 | 15 Jan 64 | 33,34 | Three storms in 6 day period, last |
| | | Atlantic City | 31 Dec 63 | 17 Jan 64 | 29,30 | was most significant |
| | | Ludlam Beach | 7 Jan 64 | 15 Jan 64 | 35,36 | |
| D | 16 Sep 67 | Atlantic City | 15 Sep 67 | 19 Sep 67 | 50,51 | |
| | | Ludlam Beach | 14 Sep 67 | 18 Sep 67 | 57,58 | |
| E | 13 Mar 68 | Misquamicut | 8 Mar 68 | 14 Mar 68 | 81,82 | |
| | | Westhampton Beach | 6 Mar 68 | 14 Mar 68 | 51,52 | |
| | | Jones Beach | 11 Mar 68 | 18 Mar 68 | 53,54 | |
| | | Atlantic City | 7 Mar 68 | 13 Mar 68 | 60,61 | |
| F | 12 Nov 68 | Long Beach Island | 23 Oct 68 | 13 Nov 68 | 60,61 | Two minor storms in survey interval |
| | | Atlantic City | 25 Oct 68 | 15 Nov 68 | 64,65 | |
| | | Ludlam Beach | 24 Oct 68 | 14 Nov 68 | 64,65 | |
| G | 2 Feb 70 | Misquamicut | 28 Jan 70 | 4 Feb 70 | 106,107 | Two minor storms in survey interval |
| | | Jones Beach | 27 Jan 70 | 6 Feb 70 | 72,73 | |
| | | Atlantic City | 28 Jan 70 | 4 Feb 70 | 84,85 | |
| H | 17 Dec 70 | Nauset Beach | 10 Dec 70 | 18 Dec 70 | 3,4 | |
| | | Misquamicut | 9 Dec 70 | 23 Dec 70 | 119,120 | |
| | | Westhampton Beach | 1 Dec 70 | 18 Dec 70 | 81,82 | |
| | | Jones Beach | 10 Dec 70 | 20 Dec 70 | 82,83 | |
| | | Long Beach Island | 7 Dec 70 | 18 Dec 70 | 77,78 | |
| | | Atlantic City | 9 Dec 70 | 18 Dec 70 | 96,97 | |
| | | Ludlam Beach | 10 Dec 70 | 18 Dec 70 | 81,82 | |
| I | 19 Feb 72 | Nauset Beach | 8 Feb 72 | 25 Feb 72 | 14,15 | |
| | | Misquamicut | 14 Feb 72 | 25 Feb 72 | 130,131 | |
| | | Westhampton Beach | 5 Feb 72 | 22 Feb 72 | 93,94 | |
| | | Jones Beach | 6 Feb 72 | 24 Feb 72 | 97,98 | |
| | | Long Beach Island | 15 Feb 72 | 23 Feb 72 | 89,90 | |
| | | Atlantic City | 14 Feb 72 | 22 Feb 72 | 107,108 | |
| | | Ludlam Beach | 16 Feb 72 | 23 Feb 72 | 94,95 | |
| J | 17-22 Mar 1973 | Nauset Beach | 13 Mar 73 | 27 Mar 73 | 25,26 | Nauset Beach storm on 22 March. |
| | | Westhampton Beach | 16 Mar 73 | 24 Mar 73 | 104,105 | Based on wave hindcasts, the |
| | | Jones Beach | 12 Mar 73 | 25 Mar 73 | 108,109 | 22 March storm was a minor event |
| | | Long Beach Island | 14 Mar 73 | 25 Mar 73 | 98,99 | at the other locations. |
| | | Atlantic City | 16 Mar 73 | 25 Mar 73 | 116,117 | |
| K | 14 Oct 77 | Long Beach Island | 13 Oct 77 | 15 Oct 77 | 112,113 | |
| | | Ludlam Beach | 11 Oct 77 | 16 Oct 77 | 122,123 | |
| L | 19 Dec 77 | Long Beach Island | 11 Dec 77 | 20 Dec 77 | 118,119 | |
| | | Ludlam Beach | 10 Dec 77 | 21 Dec 77 | 127,128 | |
| M | 6 Feb 78 | Long Beach Island | 22 Dec 77 | 9 Feb 78 | 120,121 | |
| | | Ludlam Beach | 22 Dec 77 | 8 Feb 78 | 129,130 | |

by the BEP and the Storm Erosion Studies and because of the many steps required in processing the data, there is a high potential for erroneous or misleading data. To minimize the effect of survey and data transcription errors on computed storm changes (which are especially sensitive to single- or multiple-point errors), all data in the appendixes have been carefully examined for quality and consistency. Obvious errors, such as random "spikes" in elevation, indicative of level-rod reading errors, or long "jumps" in distance caused by taping errors have been removed. Surveys with serious uncorrectable errors such as wider poststorm than prestorm dunes, or surveys that did not close at the landward end have, for the most part, been dropped. Some errors have undoubtedly survived even this careful editing, so caution should be exercised when using data from single profile lines, particularly where an extreme change is shown.

12. The changes caused by each of the storms are presented in the appendixes, which include cross-sectional plots of the survey data (Figure 2) and tables giving the following parameters which were calculated for each profile line and summarized as follows:

a. The slope of the foreshore (at msl) of both prestorm and poststorm surveys (negative, seaward sloping).

b. The change in foreshore slope (negative, steeper slope) .

c. The change in msl shoreline position (negative, shoreline retreat).

d. Volume change above msl by 0.5-m contour slices (negative, erosion).

e. Total volume change above msl (negative, erosion).

Note that volume quantities are actually computed cross-sectional areas multiplied by a unit length of beach (1 m). Foreshore slopes, shoreline positions, and volume changes were computed using the Beach Profile Analysis System (Fleming and DeWall 1982). If required, the position of the shoreline (msl intercept) was extrapolated using the last two survey points but only if the last surveyed point was below an elevation of 0.6 m. The total volume change above msl was computed only if a msl intercept was computed. Volume change computations were terminated at a maximum elevation of 18 m, a fact that nominally affects a few profile lines on Nauset Beach.

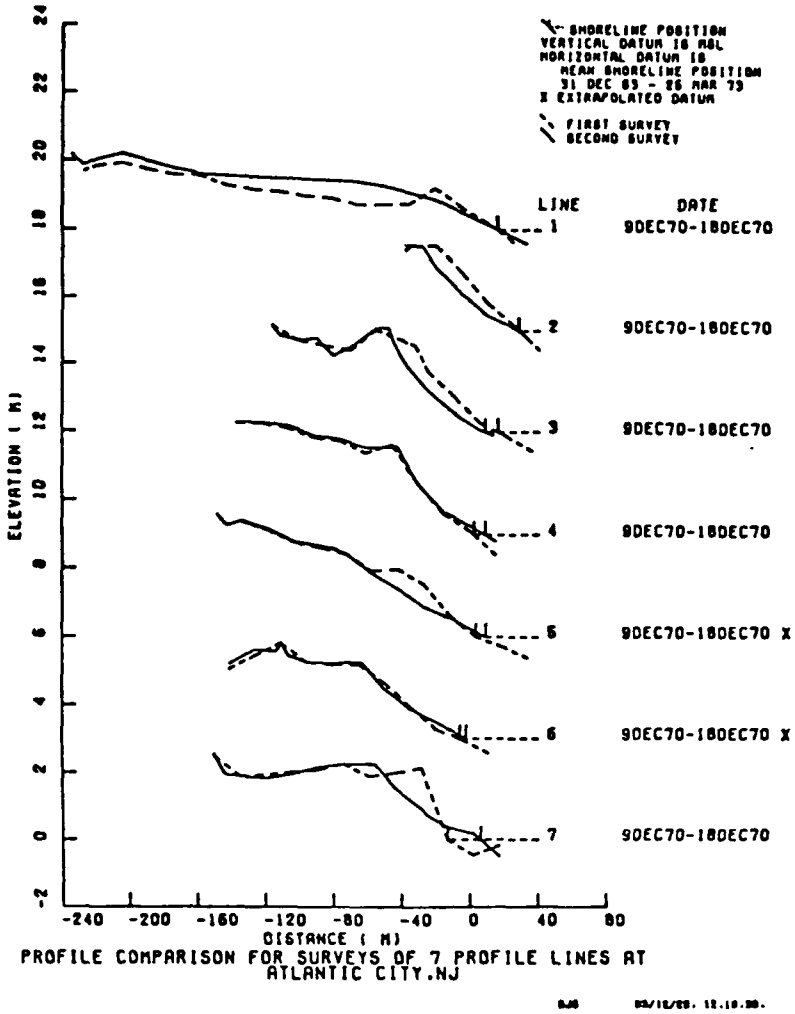


Figure 2. Example cross-section plot

13. In order to quantify the effect of each storm, a number of summary statistics have been computed for each table. These include the mean and standard deviation along with the median, tri-mean, high hinge, and low hinge values. These last four parameters, defined by Tukey (1977), are more robust (less sensitive to extreme values) than are the mean and standard deviation, and they provide a measure of the distribution of the changes among the different profile lines. They are particularly useful for summarizing profile changes along a beach because of the natural and occasionally unnatural variation that occurs between lines. Single lines may be affected by local structures, inlets, or survey errors to the point of biasing a mean value of the volume or shoreline change. However, a single profile change will have little impact on the median change.

14. Using definitions given by Tukey (1977), the high and low hinges define the 25 and 75 percent cutoffs, respectively. Together they provide a good measure of the distribution of the changes by defining the range of the mid-50 percent of the data. Their difference, or "hinge range," is a convenient measure of variability. To further include a measure of the distribution in a single parameter, Tukey also defines the "tri-mean" as:

$$\text{Tri-mean} = \frac{\text{low hinge} + 2(\text{median}) + \text{high hinge}}{4}$$

Note that although these measures focus on the central 50 percent of the data, they do not ignore the importance of the extreme values. In fact, values that are outside the hinges (outliers) are clearly identified and usually require individual attention. Example shoreline, slope, and volume change tables, which include these summary statistics for the data in Figure 2, are shown in Tables 2 and 3.

15. The usefulness of these statistics is illustrated in Figure 3, which is a "box and whisker" plot that graphically illustrates the distribution of values given for each column in Table 3. It is quite clear

Table 2
Example of Shoreline and Slope Tables

Shoreline and Slope Changes at Atlantic City, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m)[1] | Foreshore Slope First Survey[2] | Foreshore Slope Second Survey[2] | Foreshore Slope Change[3] |
|---|---|---|---|---|---|---|
| 1 | 9 Dec 70 | 18 Dec 70 | 0.74 | -0.038 | -0.024 | 0.014 |
| 2 | 9 Dec 70 | 18 Dec 70 | -1.12 | -0.050 | -0.036 | 0.014 |
| 3 | 9 Dec 70 | 18 Dec 70 | -7.50 | -0.026 | -0.020 | 0.006 |
| 4 | 9 Dec 70 | 18 Dec 70 | 6.49 | -0.046 | -0.030 | 0.016 |
| 5 | 9 Dec 70 | 18 Dec 70 X | 5.86 | -0.040 | -0.026 | 0.014 |
| 6 | 9 Dec 70 | 18 Dec 70 X | 3.70 | -0.020 | -0.028 | -0.008 |
| 7 | 9 Dec 70 | 18 Dec 70 | 19.40 | -0.140 | -0.044 | 0.096 |
| Median | | | 3.70 | -0.040 | -0.028 | 0.014 |
| Tri-Mean | | | 3.35 | -0.040 | -0.029 | 0.024 |
| High Hinge | | | 6.18 | -0.032 | -0.025 | 0.056 |
| Low Hinge | | | -0.19 | -0.048 | -0.033 | 0.010 |
| Mean | | | 3.94 | -0.051 | -0.030 | 0.033 |
| Standard Deviation | | | 8.33 | 0.040 | 0.008 | 0.044 |

Note: X = Extrapolated shoreline intercept

1 - Negative value indicates shoreline retreat.
2 - Negative value indicates seaward sloping.
3 - Negative value indicates steeper slope.

Table 3

Example of Unit Volume Change Tables

Unit Volume Changes ($m^3/m$) Between Contours*
Atlantic City, N.J.
from 9 Dec 70 to 18 Dec 70

| Profile Line | Total Changes | | 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Contours (m) above MSL | | | | | | | | | | | | | |
| 1 | 61.20 | | -1.26 | 8.46 | 38.11 | 12.96 | 2.93 | | | | | | | | | |
| 2 | -23.09 | | -2.48 | -4.47 | -5.51 | -6.04 | -4.82 | 0.23 | | | | | | | | |
| 3 | -27.38 | | -3.86 | -5.14 | -5.59 | -5.11 | -7.15 | -0.91 | 0.38 | | | | | | | |
| 4 | 9.76 | | 2.35 | 0.64 | -0.03 | 0.11 | 1.54 | 3.20 | 1.95 | | | | | | | |
| 5 | -16.87 | X | 1.25 | -3.39 | -7.83 | -9.00 | -0.13 | 1.62 | 0.62 | 0.00 | | | | | | |
| 6 | 3.54 | X | 2.94 | 0.44 | -1.49 | -0.97 | 3.32 | -0.70 | | | | | | | | |
| 7 | -15.60 | | 5.15 | -3.16 | -7.35 | -12.60 | 2.33 | 0.03 | | | | | | | | |
| Median | -15.60 | | 1.25 | -3.16 | -5.51 | -5.11 | 1.54 | 0.13 | 0.62 | 0.00 | | | | | | |
| Tri-mean | -11.13 | | 0.82 | -2.43 | -4.56 | -4.54 | 0.81 | 0.30 | 0.76 | 0.00 | | | | | | |
| High Hinge | 6.65 | | 2.64 | 0.54 | -0.76 | -0.43 | 2.63 | 1.62 | 1.29 | 0.00 | | | | | | |
| Low Hinge | -19.98 | | -1.87 | -3.93 | -6.47 | -7.52 | -2.48 | -0.70 | 0.50 | 0.00 | | | | | | |
| Mean | -1.21 | | 0.58 | -0.95 | 1.47 | -2.95 | -0.28 | 0.58 | 0.98 | 0.00 | | | | | | |
| Std Dev | 30.70 | | 3.23 | 4.72 | 16.41 | 8.27 | 4.11 | 1.56 | 0.85 | 0.00 | | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.
* - Negative values indicate a volume loss.

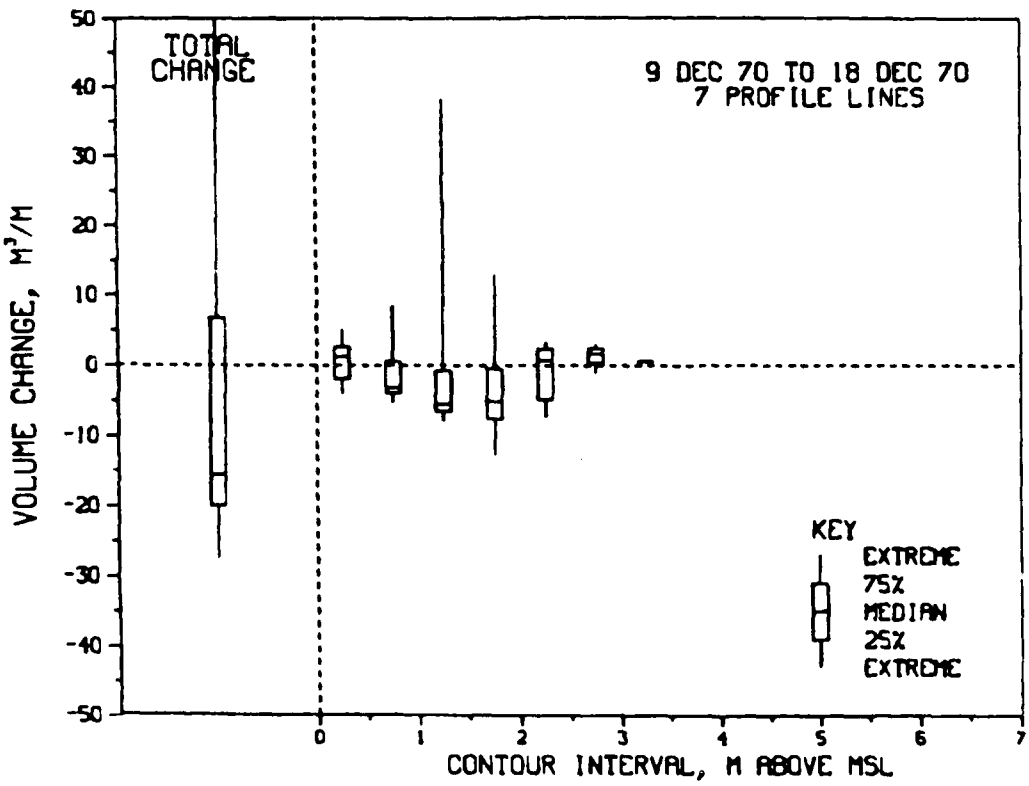


Figure 3. Example figure showing the distribution of volume changes by contour for Atlantic City, N.J.

from the overall changes that although the median change was for -15.6 $m^3/m$ of erosion, one profile showed in excess of 50 $m^3/m$ of accretion. From Table 3, this was profile line 1, which is located adjacent to the south jetty of Absecon Inlet and tends to experience much greater changes than the other profile lines. The plot also indicates that most of this accretion occurred between the 1- and 1.5-m contours. As expected, the mean overall volume change of -1.21 was greatly affected by profile line 1 while the median was not affected.

16. Though this report uses the median to typify the storm changes, for planning purposes in estimating erosion it may be better and more conservative to use the low hinge values.

## Wave Data

17. One major shortcoming of many beach profile studies is the lack of consistent wave information. Though daily visual wave observations and wave gage records at many of the BEP localities are available, they are neither consistent nor frequent enough for intercomparisons between different localities. The Phase III of the WIS for the Atlantic coast (Jensen 1983) provides hindcasts of wave height, period, and direction every 3 hours at stations located every 16 km (10 nautical miles) along the east coast. The data cover the 20-year period from 1956 through 1975, and include the 10 years of the BEP surveys. Hindcast data do not exist for the data collected under the Storm Erosion Studies.

18. The Phase III hindcast is the final of three phases. In Phase I (Corson et al. 1981) deepwater wave data were hindcast from surface air pressure and wind data over the Atlantic Ocean. Phase II (Corson et al. 1982) took the Phase I deepwater hindcasts and accounted for the sheltering effects and local wind sea growth of the Continental Shelf. Phase III is a transformation of the Phase II results into shallow water (10 m). Note that the current formulation of the hindcast data does not include waves generated by hurricanes and tropical cyclones. Figure 4 identifies the Phase III locations used for this study.

19. Several important assumptions are used during the generation of Phase III data:

a. Sea-to-swell transformations are considered as separate processes, and the two wave populations are independent.

b. Swell acts as a unidirectional, monochromatic wave.

c. Shoreline has straight, parallel bottom contours.

d. No extra energy sources were added to existing Phase II conditions.

These assumptions appear reasonable since hindcasted wave heights compare well with gage measurements.

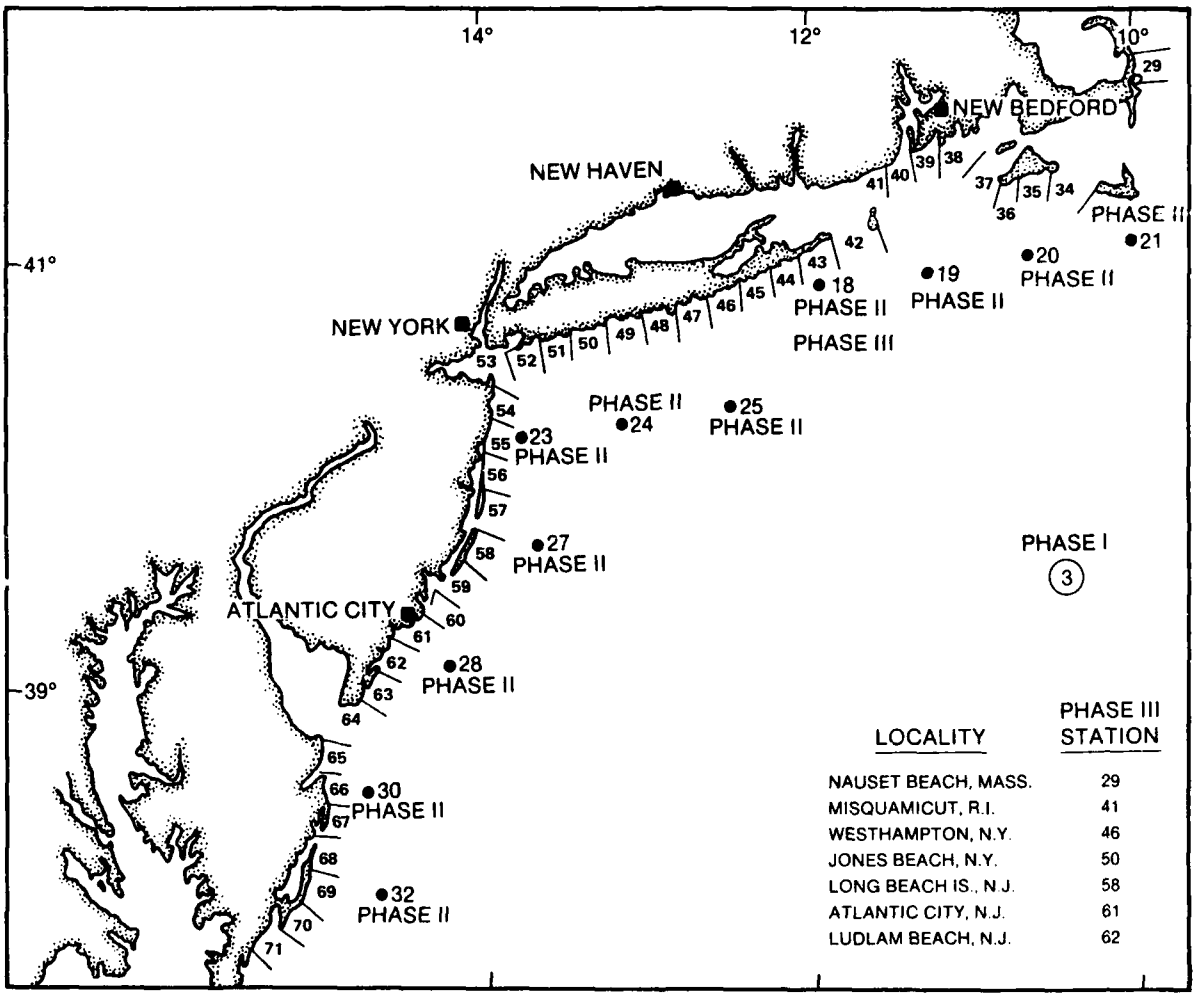


Figure 4. Location of Phase I, II, and III wave hindcast stations

20. The hindcasted Phase III data included for each storm and locality differ from that reported by Jensen (1983) in two ways: (a) wave heights were computed for a water depth of 9.15 m (30 ft), 1 m shallower; and (b) the sea and swell conditions have been combined. Also, a special hindcast run was made for Misquamicut because of the natural sheltering offered by Long Island

and by Block Island. Figure 5 is a sample wave hindcast time-history for Atlantic City. Note that the time period plotted corresponds to the time between the prestorm and poststorm surveys, and the x-axis tick marks correspond to noon on the date given.

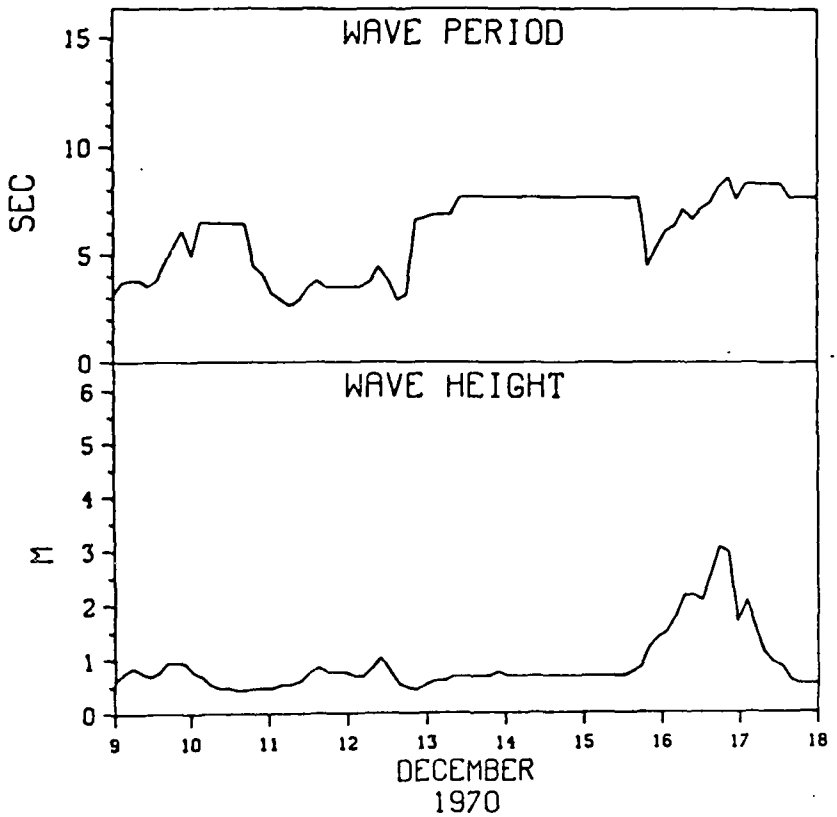


Figure 5. Example plot of hindcasted wave data for Atlantic City, N.J.

21. A major benefit of the complete coverage offered by the hindcast data is that it permits examination of all the wave conditions which occurred between the selected surveys. Therefore, it was possible to determine if more than one storm had occurred. Similarly, it should be possible to examine the sequence of prior storms for any period or year. Though not yet considered, the relative intensity and prior storm history may be important in understanding and predicting a storm's impact.

22. In addition to presenting the maximum hindcasted wave height for each storm and locality, an estimate was made both of the return period of the maximum wave height and of the storm wave duration. The return period

was computed based on the 20-year hindcast and the maximum wave height per storm event. Wave duration was defined as the period in hours that the wave height exceeded a height equal to the 20-year average height plus one standard deviation.

## Storm Surge

23. A number of studies of storm effects have identified the storm surge (defined as the increase in water level caused by the storm) as the primary force causing beach erosion and coastal flooding (Richardson 1977; Vellinga 1983, 1986; Dean 1976; Hughes and Chiu 1981). The height of the storm surge results from a combination of variables including the astronomical tide, wind stress, atmospheric pressure effects, earth's rotation, wave setup, and bottom hydrography (Shore Protection Manual (SPM) 1984). In addition to causing severe flooding, the storm surge allows waves to attack upper portions of the beach which are not usually subject to wave attack. It is also an important factor in dune breaching and overwash, especially on low-lying beaches.

24. This report presents actual water level measurements from gages at Boston, Montauk Point, Sandy Hook, and Atlantic City (Figure 1). These gages provide hourly measurements of the water level through each of the storms studied. Although these gages provide an accurate measure of the water level at each gage site, they provide only a relative measure of the actual water level occurring on the study beaches. This results from different gage locations and depths, sheltering, wave setup, and wave runup. Besides quantifying the storm surge height, the water level time-history also allows a comparison of the surge level and the storm duration between sites (allowing for variation between gage locations). A sample water level time-history plot is shown in Figure 6. Unlike the wave plots, the water level time-histories show only a few days before and after the storm.

25. For each storm and tide gage the surge height and the peak water level were computed. The peak water level is the highest water level, relative to msl, recorded during the storm. The surge height is the difference between the actual and predicted water level at the time of peak water level. The surge-return period of each storm was also estimated using curves given by Ebersole (1982) for each tide gage.

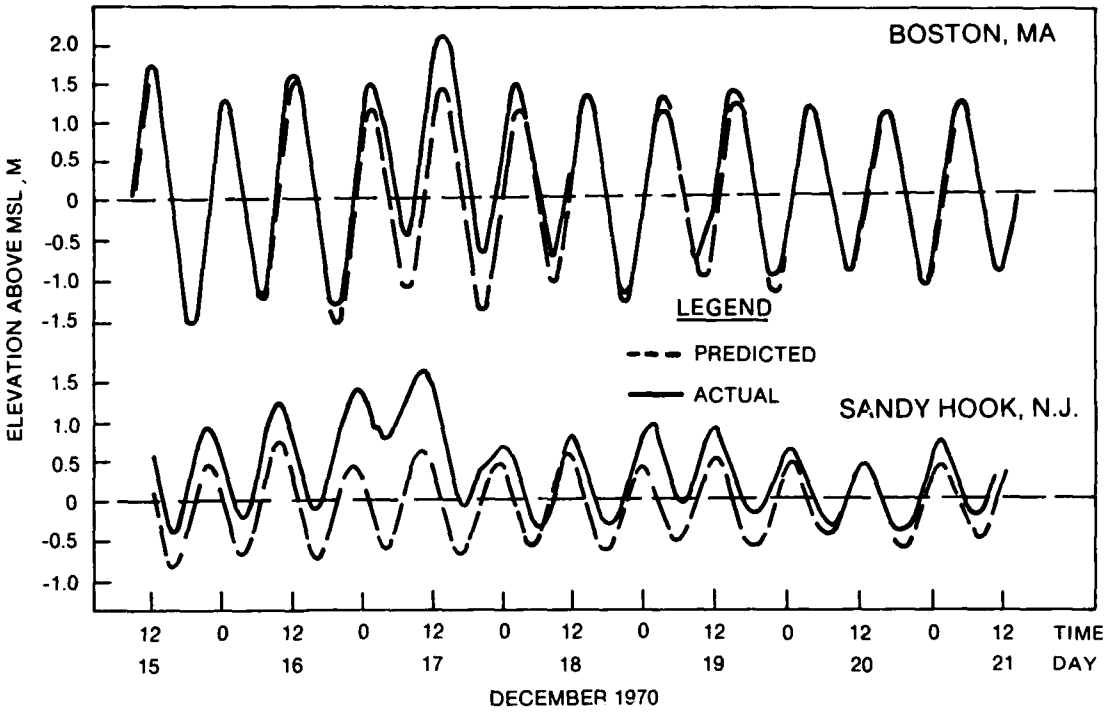


Figure 6. Example time-history of predicted and actual water levels for Atlantic City, N.J.

## PART III: LOCALITY DESCRIPTIONS

26. Each of the seven sites is unique according to morphology, shoreline orientation, and incident wave climate. This part presents a general description of each locality along with a discussion on how they respond to storms. Basic characteristics of the localities are given in Table 4.

Table 4

Characteristics of the Study Beaches

| Beach | Length (km) | Number of Profiles | Berm Elevation (m) | Annual Average Wave Height (m) | Tide Range* Average (m) | Tide Range* Spring (m) | Sediment Type |
|---|---|---|---|---|---|---|---|
| Nauset Beach, Mass. | 16.7 | 13 | 3.2 | 0.70 ± 0.51 | 2.0 | 2.4 | medium/coarse |
| Misquamicut, R.I. | 4.9 | 7 | 2.1 | 0.79 ± 0.47 | 0.8 | 1.0 | medium |
| Westhampton, N.Y. | 15.0 | 11 | 2.5 | 0.74 ± 0.43 | 0.9 | 1.1 | medium/coarse |
| Jones Beach, N.Y. | 21.9 | 15 | 2.8 | 0.72 ± 0.41 | 1.1 | 1.3 | fine/medium |
| Long Beach IS, N.J. | 20.3 | 21 | 2.4 | 0.73 ± 0.41 | 1.3 | 1.6 | medium |
| Atlantic City, N.J. | 4.5 | 7 | 2.1 | 0.70 ± 0.39 | 1.3 | 1.6 | fine/medium |
| Ludlam Beach, N.J. | 11.8 | 19 | 2.0 | 0.66 ± 0.39 | 1.3 | 1.6 | medium |

* US Department of Commerce (1982).

### Nauset Beach, Massachusetts

27. Nauset Beach differs from the other localities in that 10 of the 13 profile lines (Figure 7) are backed by a steep bluff which is composed of glacial material deposited during the Wisconsin glaciation. Bluff heights range from approximately 15 to 25 m above msl. The shoreline orientation ranges from 5 to 25 deg west of north. The average foreshore slope is 1:12. Tides are semidiurnal with an average range of 2 m and a spring range of 2.4 m. Based on data in the National Oceanic and Atmospheric Administration (NOAA) tide tables (US Department of Commerce 1982) predicted high tide heights at Nauset Beach are -0.85 lower than those predicted for Boston, the closest tide gage. Profile lines backed by the bluff have the steepest beachface slopes. Historic rates show a 1 m/year recession of the coastline. Net longshore transport is toward the south. There are no coastal protection structures along Nauset Beach (Miller 1985).

28. Because of the bluffs, survey errors were more likely to occur on these profile lines because of the difficulty of accurately surveying the

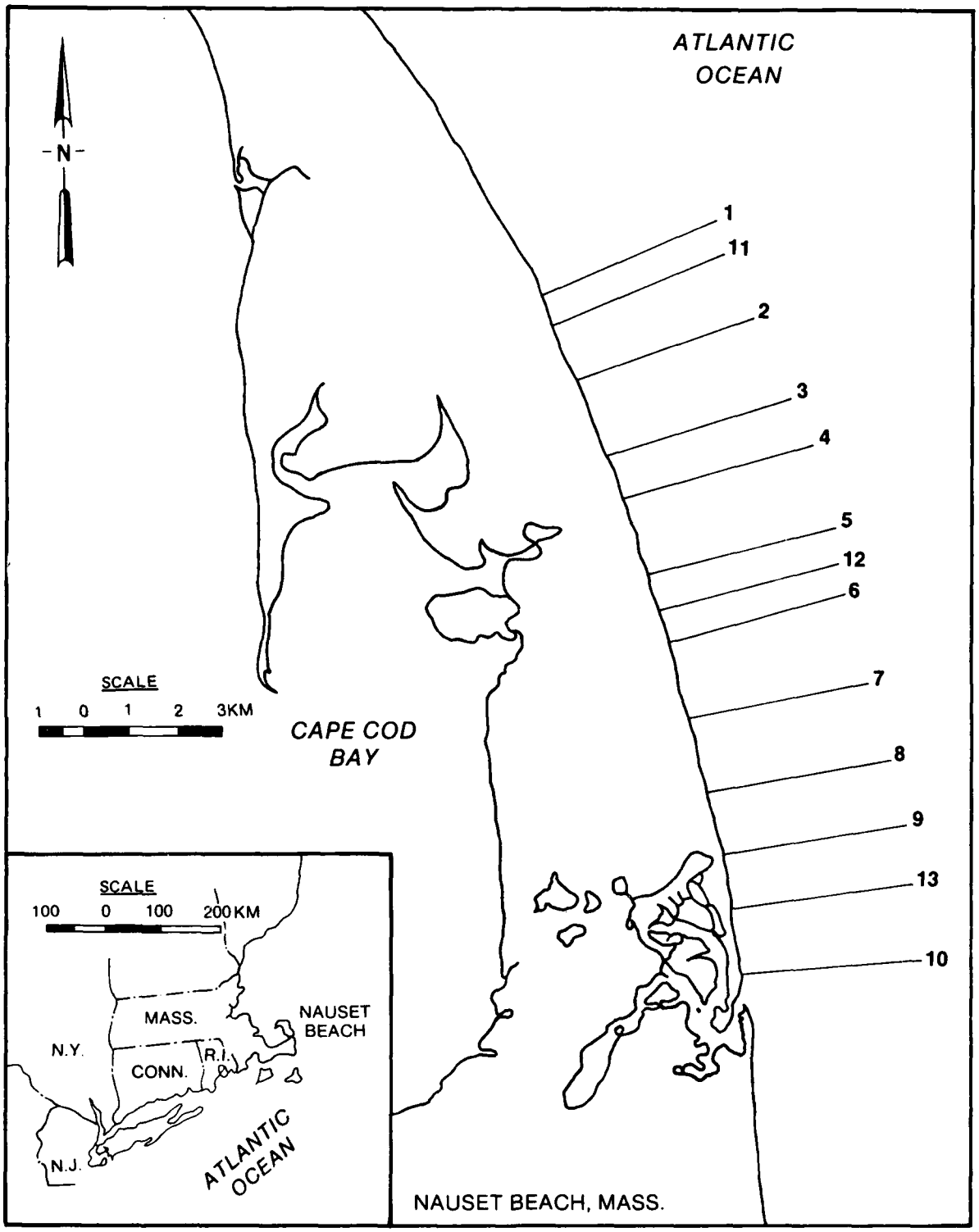


Figure 7. Profile line location map for Nauset Beach, Mass.

bluff and beach from benchmarks on top of the bluff. Though most of the data appear reasonable, errors in determining the edge of the bluff were found to have had a large impact on computed volume changes.

29. During the Nauset Beach surveys (1970 to 1974), only three storms were monitored with sufficient detail for inclusion in this report. The data indicate that this locality is highly erosive and unstable. Median poststorm volume change (for three events) was -20.7 $m^3/m$. Most of the erosion occurred high on the profile lines, either between the 1.5- and 3.0-m contours or from the bluff. Interestingly, the beach tended to widen; median shoreline change for the three storms was 2.6 m. Foreshore slopes generally flattened after storms with a median slope change of 0.024.

30. Profile line 3 had the highest overall erosion rate at Nauset Beach. Median storm profile loss at this line was -49.0 $m^3/m$. Profile line 3 also experienced the largest single change of any profile line for this locality losing -80.2 $m^3/m$ of sand after the storm of 19 February 1972 (the largest event documented in this study). The peak water level reached 1.9 m above msl at Boston (1.2 m surge) with a surge-return period of approximately 12 years. Volume changes ranged from -80.2 $m^3/m$ at profile line 3 to 15.9 $m^3/m$ at profile line 6. The median for the 10 profile lines was -22.8 $m^3/m$.

## Misquamicut Beach, Rhode Island

31. Misquamicut Beach, a stable low-lying barrier island, is located on the southern coast of Rhode Island (Figure 8). The island spans 8.5 km from Watch Hill Point to Weekapaug Point, and faces south. Winnapaug Pond separates the barrier from Rhode Island Sound on the west. Because of sheltering from Long Island and Block Island, Misquamicut Beach is most affected by storms from the east and south-southeast. Based on visual observations, net longshore transport is toward the west. The beach tends to be wide ranging from 100 to 150 m with a foreshore slope which varies from 1:15 during the summer to 1:25 during the winter. A well-developed dune runs the length of the study area with heights up to 6 m. Misquamicut Beach is heavily developed with houses and commercial buildings constructed on or near the frontal dunes. At one time, restoration projects included beach fill on the upper portions of the beach, mechanical grading to flatten the foreshore, and the barricading of property with junk cars. It is likely that a jetty

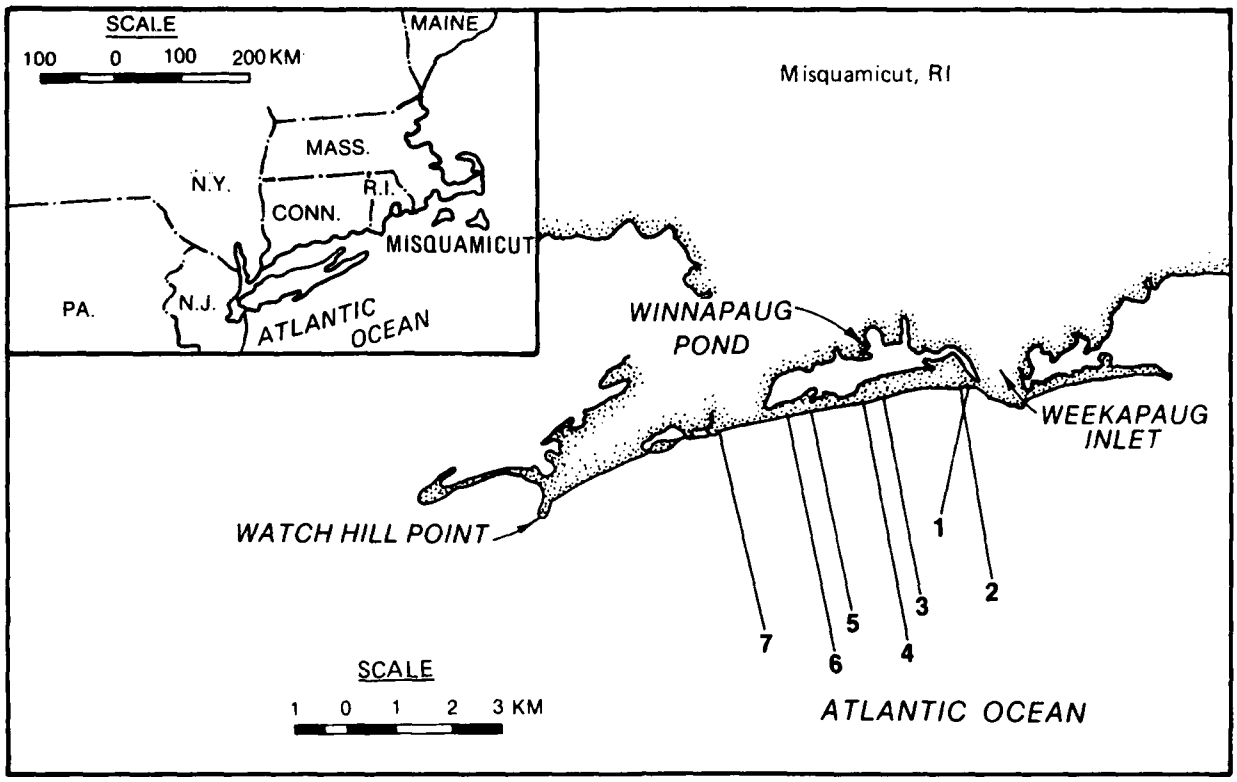


Figure 8. Profile line location map for Misquamicut Beach, R.I.

located on Weekapaug Inlet, to the east, affects two of the profile lines (Morton et al. 1984).

32. Storm changes at Misquamicut showed the least amount of variation between the seven profile lines (Figure 8) than at any of the other localities. The largest variation occurred during the 19 February 1972 storm (from 13.6 to -11.51 $m^3/m$). Median change for the four storms was -5.0 $m^3/m$. Profile lines 8 and 5 showed the most significant losses with median storm volume changes of -9.5 $m^3/m$ and -12.2 $m^3/m$, respectively. Most of the loss occurred on the lower contours, between 0 and 2 m. When the beach eroded, the sand moved offshore and the shoreline receded. Median poststorm shoreline movement was -2.6 m. Slope changes were negligible.

33. The largest median loss (-10.5 $m^3/m$) occurred during the 17 December 1970 storm, which produced maximum wave heights of 4.2 m concurrent with the peak water level. Profile line 5 eroded the most with a sediment loss of -20.0 $m^3/m$, the second largest loss at this site. The largest storm, in terms of wave height, occurred on 19 February 1972; but it caused a

median volume loss of only -5.6 $m^3/m$. This event did cause the greatest range of change on the beach (from -11.5 $m^3/m$ at profile line 2 to 13.6 $m^3/m$ at profile line 8).

## Westhampton Beach, New York

34. Westhampton Beach is part of a barrier island complex on the south shore of Long Island, N.Y. (Figure 9). It is bordered by Shinnecock Inlet to the east and Moriches Inlet to the west. Shinnecock and Moriches Bays separate it from Long Island. Because of its shoreline orientation of N70 degrees E, it is most affected by storms approaching from the southeast. Net longshore transport is to the west at an estimated rate of 230,000 $m^3$/year (DeWall 1979).

35. The width of the beach averaged between 75 and 100 m from the frontal dune to the shoreline. A well-developed dune system runs the length of the island with crest elevations between 4.6 and 7.6 m. Several attempts have been made to stabilize the beach and to maintain the dunes. Twin jetties were built at both inlets with revetments along the western shore of each inlet. After major storms, several dune construction and beachfill efforts were initiated to restore the beach. Between 1965 and 1967, 15 groins were constructed to further stabilize the beach. Eleven of these groins are located between profile lines 6 and 9.

36. The data from Westhampton Beach indicated that it was prone to storm erosion. Overall, median change for the four storms was -19.2 $m^3/m$, second only to Nauset Beach. The greatest changes occurred low on the beach between the 0- and 2-m contours. As a result the shoreline tended to recede, median shoreline movement was -2.1 m, and foreshore slope changes were negligible. Except for the 18 March 1973 storm, the groin field between profile lines 6 and 9 tended to reduce erosion. Median change for profile lines 6 through 9 was -11.4 $m^3/m$, 40 percent less than the overall median loss.

37. The largest single change (-43.9 $m^3/m$) occurred at profile line 6, which was located within the groin field during the 18 March 1973 storm; however, the 19 February 1972 storm produced the most significant changes along the entire locality. Median volume change was -22.8 $m^3/m$ with an extreme loss of -40.0 $m^3/m$. The range in variation was fairly small (-1.1 to

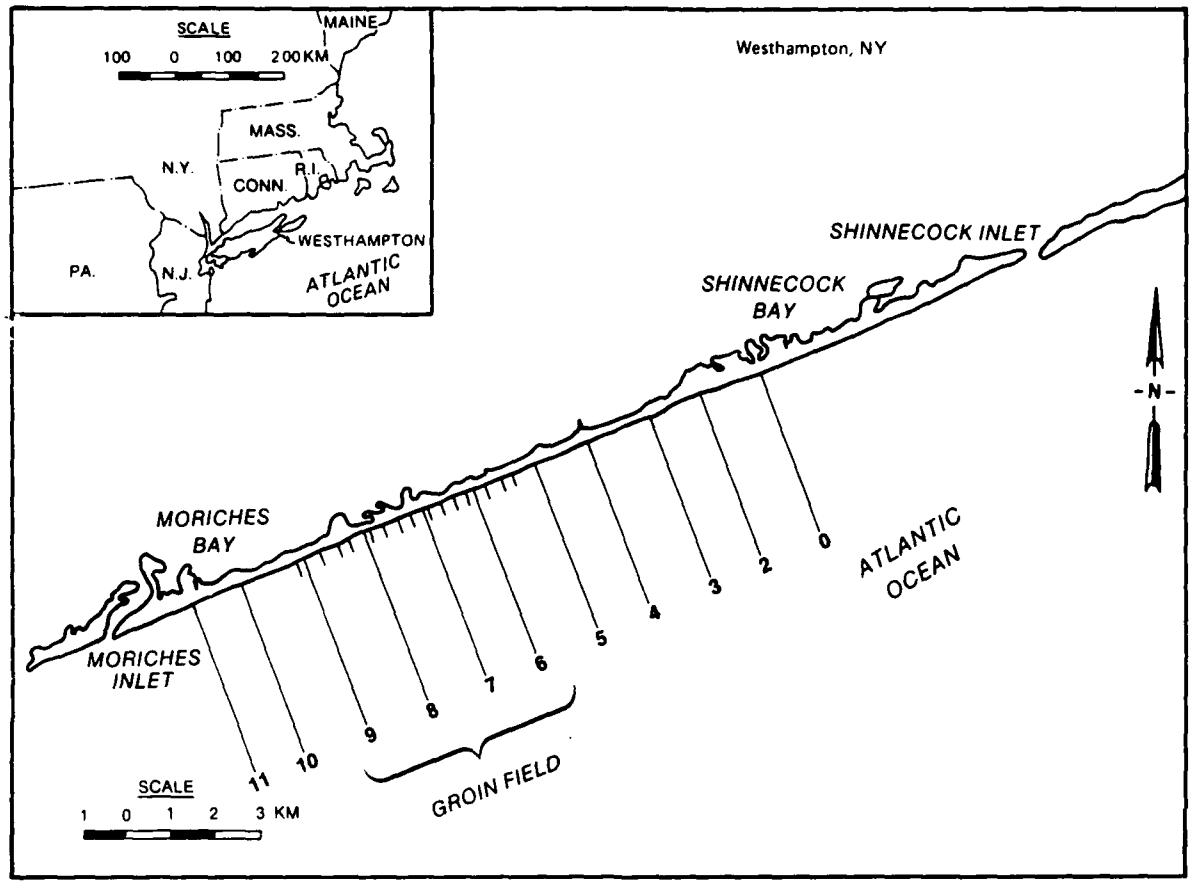


Figure 9. Profile line location map for Westhampton Beach, N.Y.

-40.0 $m^3/m$). Wider variation occurred during the 17 December 1970 storm, from -43.2 $m^3/m$ at profile line 4 to 14.8 $m^3/m$ within the groin field at profile line 7.

## Jones Beach, New York

38. Jones Beach is located on the southern coast of Long Island (Figure 10). The island averages less than 1 km in width and is bordered by Jones Inlet on the west and Fire Island Inlet on the east. Great South Bay, South Oyster Bay, and East Bay separate Jones Beach from Long Island. The

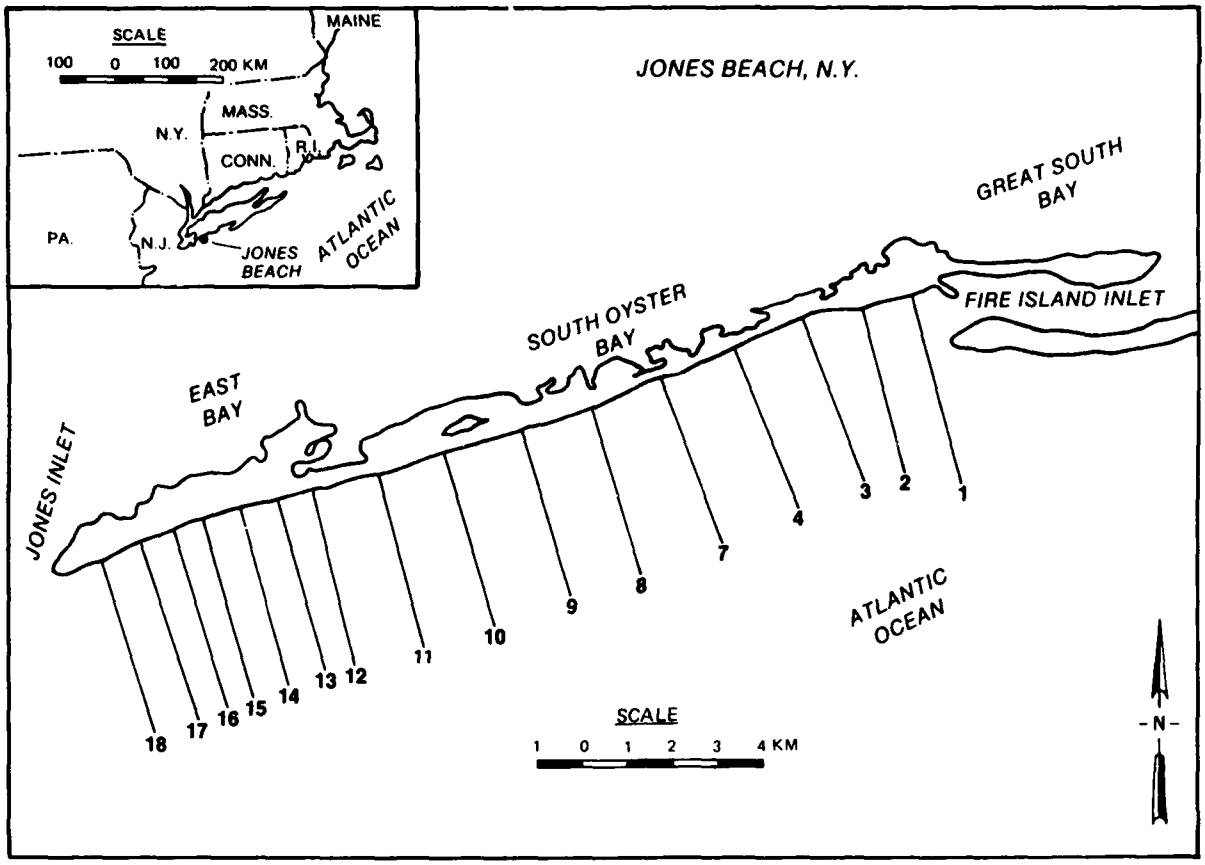


Figure 10. Profile line location map for Jones Beach, N.Y.

beach is orientated N73 degrees E and has an average beach foreshore gradient of 1:10. Net longshore transport is to the west. Most of the beach is backed by a duneline which reaches 8 m in height. Though a popular recreational beach, only a few shore stabilization structures exist (Morton, Bohlen, and Aubrey 1986).

39. For the five storms studied, Jones Beach experienced the lowest median erosion of the seven localities (-2.9 $m^3/m$). Although the median loss was not large, Jones Beach was highly variable experiencing large ranges of erosion and accretion. Significant sediment losses generally occurred low on the berm between the 0.5- to 2.0-m contours.

40. The 18 March 1973 storm produced the largest range of volume changes varying from a loss of -37.1 $m^3/m$ at profile line 18 to an accretion of 57.4 $m^3/m$ at nearby profile line 16. The median change was only -2.5 $m^3/m$. The largest change resulted from the 17 December 1970 storm which caused a median volume change of -16.7 $m^3/m$ and a single change -48.2 $m^3/m$ on profile line 4. During this storm the peak water level was 1.6 m.

## Long Beach Island, New Jersey

41. Long Beach Island (Figure 11) is oriented N29 degrees E with a predominate easterly wave and wind exposure. The long, narrow island is bordered by Barnegat Inlet on the north and Beach Haven Inlet on the south. Three shallow bays, Barnegat Bay, Manahawkin Bay, and Little Egg Harbor, separate the island from the mainland. Net longshore transport is toward the south at an estimated rate of 115,000 $m^3$/year (Miller, Aubrey, and Karpen 1980).

42. A continuous dune system with crest heights of 5 to 8 m runs the length of the island. Average foreshore beach slope is 1:15. Beach cusps and ridge and runnel features are common. More than 100 groins have been constructed along the island in an effort to reduce erosion. All profile lines are located within 250-m of a groin (Miller, Aubrey, and Karpen 1980).

43. Long Beach Island was greatly affected by storms, experiencing a median post[illegible] profile change for the 10 storms studied of -16.0 $m^3/m$. The profile ch[illegible]s varied considerably both along the beach and between storms. Profile line 10 eroded consistently, having a median storm change of -22.0 $m^3/m$. The southern profile lines (18 through 21) tended to be more stable.

44. Median shoreline change for the 10 storms was only 1.2 m, indicating general shoreline stability. This small movement in the msl intercept is interesting considering the large volumetric losses. The stable shoreline may have resulted from the rapid poststorm recovery such as reported by Birkemeier (1979) for this site. This might also explain why most of the erosion occurred between the 1.0- and 2.5-m contours. Median slope changes were small but indicated a slight flattening of the foreshore.

45. Storm changes at Long Beach Island were more variable than at the other sites. The storms with the largest magnitude did not necessarily

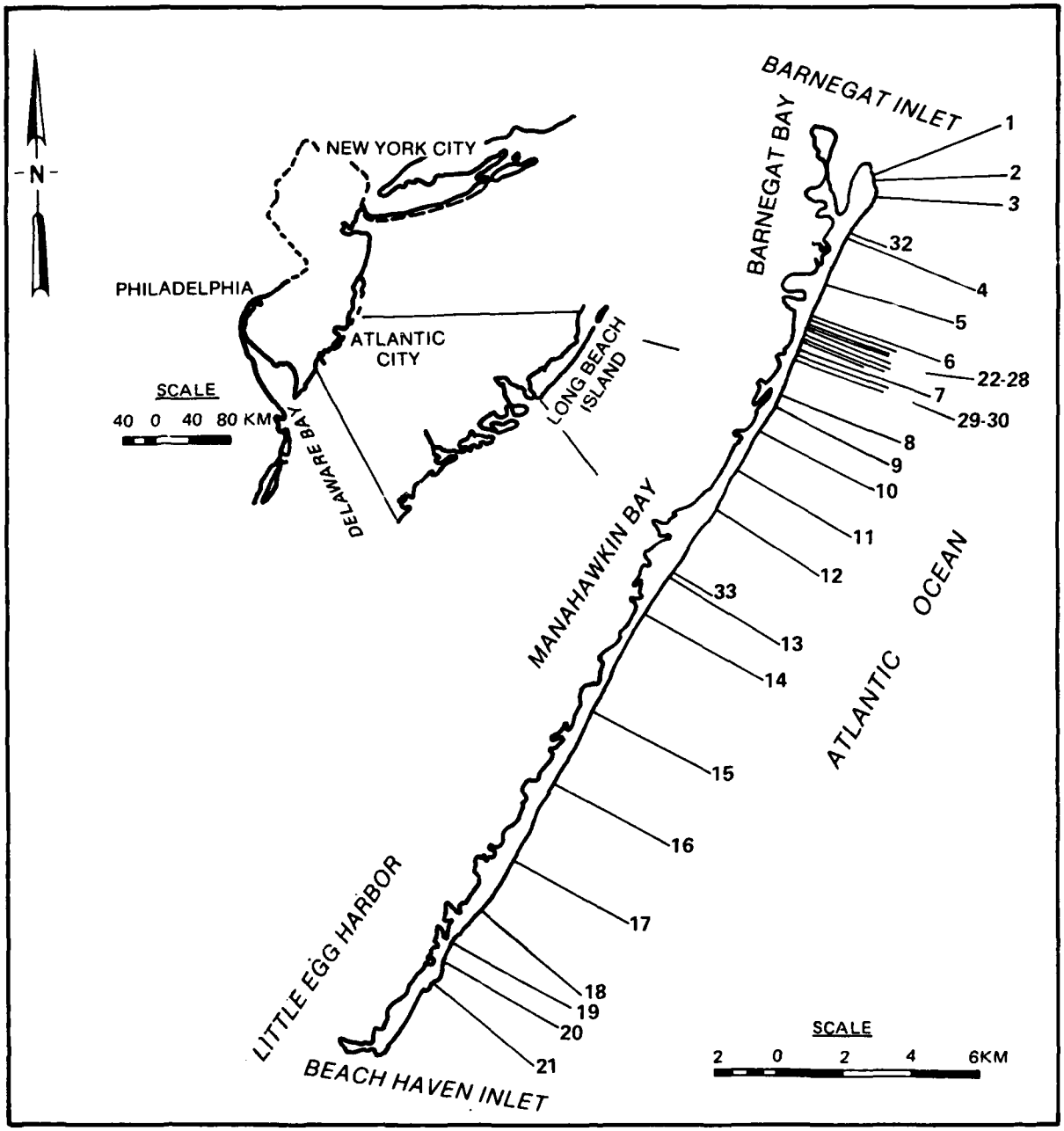


Figure 11. Profile line location map for Long Beach Island, N.J.

produce the largest changes. Smaller storms caused the greatest variability in volumetric changes between profile lines, possibly a result of the position of the profile lines relative to the groins.

46. The largest median change, -28.2 $m^3/m$, resulted from the 13 January 1964 storm. This storm also caused the largest range in volume changes, from -69.2 $m^3/m$ at profile line 8 to 6.6 $m^3/m$ at profile line 21 (the only line which accreted).

47. Of the 10 storms, 3 were monitored by the Storm Erosion Study. Though fewer profiles were surveyed during these storms, surveys were usually conducted just prior to the storm and within 2 days after each event, minimizing the effect of poststorm recovery. This is evident in the median volume changes; median loss for these three storms was -22.3 $m^3/m$ compared with the overall median loss of -9.7 $m^3/m$. Interestingly, the median shoreline change was positive in two of the storms. Median slope change for the three storms showed a flattening of the foreshore gradient by 0.015.

## Atlantic City, New Jersey

48. Atlantic City is located on Absecon Island, a drumstick-shaped barrier island (Figure 12) that is bordered by Great Egg Harbor Inlet to the south and Absecon Inlet to the north. Lakes Bay separates the barrier from the mainland. The study area includes the northern 5 km of the island which is oriented N64 degrees E. Using wave data from a gage at Atlantic City, Thompson (1977) reported an average wave height of 0.8 m with an 8-sec period. This agrees well with the hindcast wave data in Table 1.

49. Atlantic City has a wide, flat beach bordered on the west by a boardwalk. According to McCann (1981), average annual shoreline movement is -0.7 m. A number of beach-fill projects have been placed on the beach to control erosion and they have affected the average shoreline movement (Everts, DeWall, and Czerniak 1974). Many structures cross the beach including piers, groins, and storm drains.

50. Based on the 10 storms studied, Atlantic City experienced large losses. Median poststorm erosion for this site was -11.3 $m^3/m$. Profile line 1, located adjacent to and downdrift of the south jetty of Absecon Inlet, experienced the largest and greatest range of changes. The median change at profile line 1 was -30.1 $m^3/m$ varying from -150.8 $m^3/m$ on 6 November 1963 to 61.2 $m^3/m$ on 17 December 1970. Both median shoreline and slope changes were negligible for the storms considered.

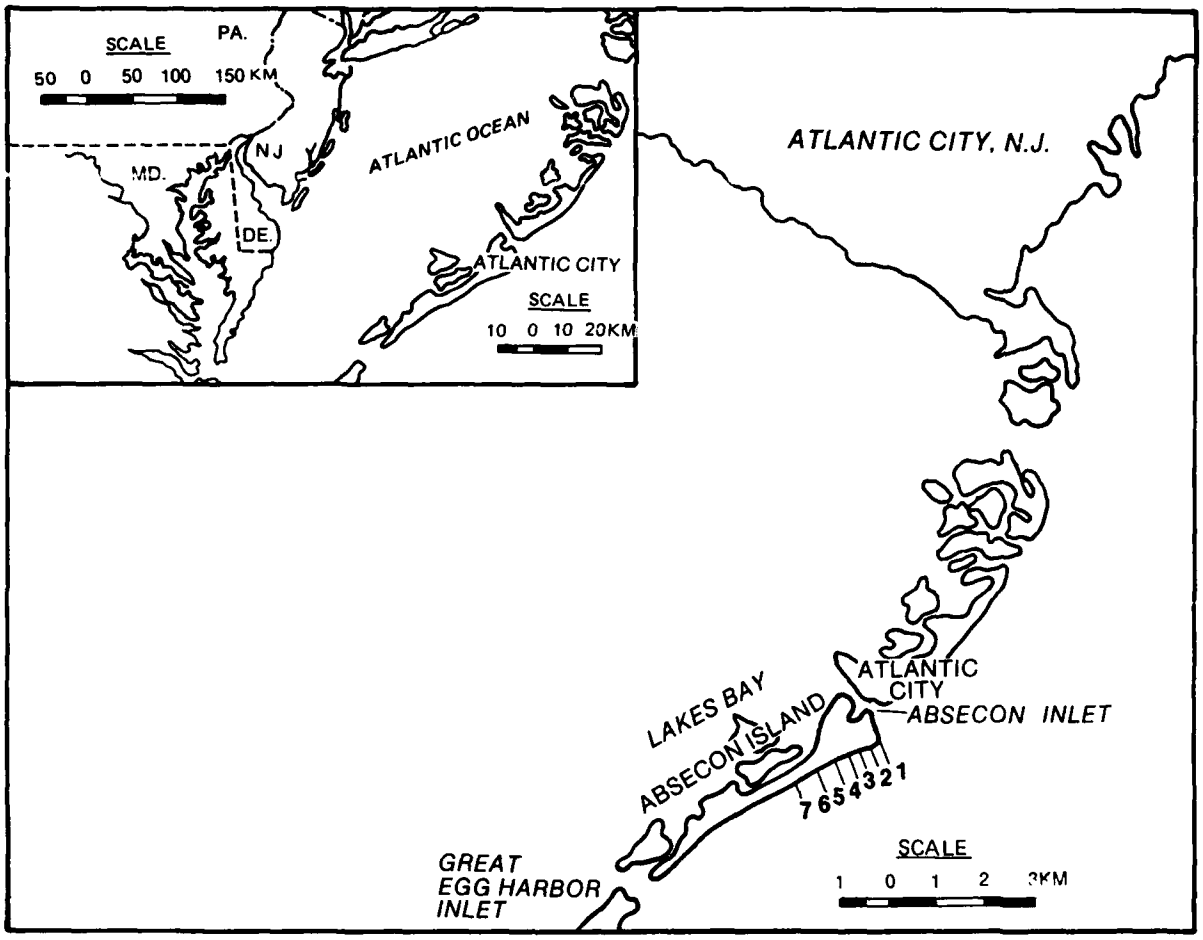


Figure 12. Profile line location map for Atlantic City, N.J.

51. The highest median erosion (-25.2 $m^3/m$) occurred during the 6 November 1963 storm. This minor event, with a surge-return period of once every 1.2 years, did not significantly affect the other localities. The storm with the highest waves and peak water level (19 February 1972) caused all the lines to erode but the median erosion (-9.4 $m^3/m$) was less than the overall median. Profile change during this storm varied from -45.7 $m^3/m$ on profile line 11 to -5.2 $m^3/m$ on profile line 2.

## Ludlam Beach, New Jersey

52. Ludlam Beach (Figure 13) is oriented N34 degrees E with a beach width of approximately 75 m and a mild foreshore slope (1:43). The island, which varies between 400 to 1,600 m in width, is bordered by Corson Inlet to the north and Townsend Inlet to the south. Ludlam Bay and a series of tidal marshes separate the island from the mainland. Net longshore transport is to the south. The beach covers a layer of peat which limits erosion during severe storms on some of the northern profile lines. Coastal dunes with heights up to 4.6 m exist on the northern portion of the island. Average shoreline change was approximately -2.5 m/year during the study period (Everts, DeWall, and Czerniak 1980). A seawall and groin field is located in the central part of the island. This groin field has been regularly extended southward in an attempt to halt downdrift erosion. Everts (1979) showed that the groin field had been effective in stabilizing the shore.

53. Ludlam Beach experienced less erosion than most of the study sites with an overall median change for the 10 storms of -7.5 $m^3/m$. Profile lines 5 and 16 through 19 tended to erode the most; profile lines 2, 3, and 11 through 13 (within the groin field) were more stable. Most erosion occurred between msl and the 2-m contour. Changes were low enough on the beach to cause erosion of the shoreline. Median shoreline movement was -2.2 m. Slope changes were negligible.

54. The storm causing the highest median volume change (-24.7 $m^3/m$) occurred on 12 November 1968. The largest single profile loss as well as the widest range of changes occurred 16 September 1967. Profile line 17 eroded -61.2 $m^3/m$, and profile line 10 accreted 28.3 $m^3/m$. This event had a surge-return period of only once every 1.6 years. The largest storm of the study, with a surge-return period of 13 years, occurred on 19 February 1972 and caused a low median volume change of only -8.4 $m^3/m$.

55. The storms after 1975 were monitored by the Storm Erosion Studies. Though fewer profile lines were surveyed, volume changes were generally greater for these three storms with a median change of -17.6 $m^3/m$. Using data from the 19 December 1977 storm, Birkemeier (1979) showed that poststorm recovery at Ludlam Beach was not as rapid as that found at Long Beach Island.

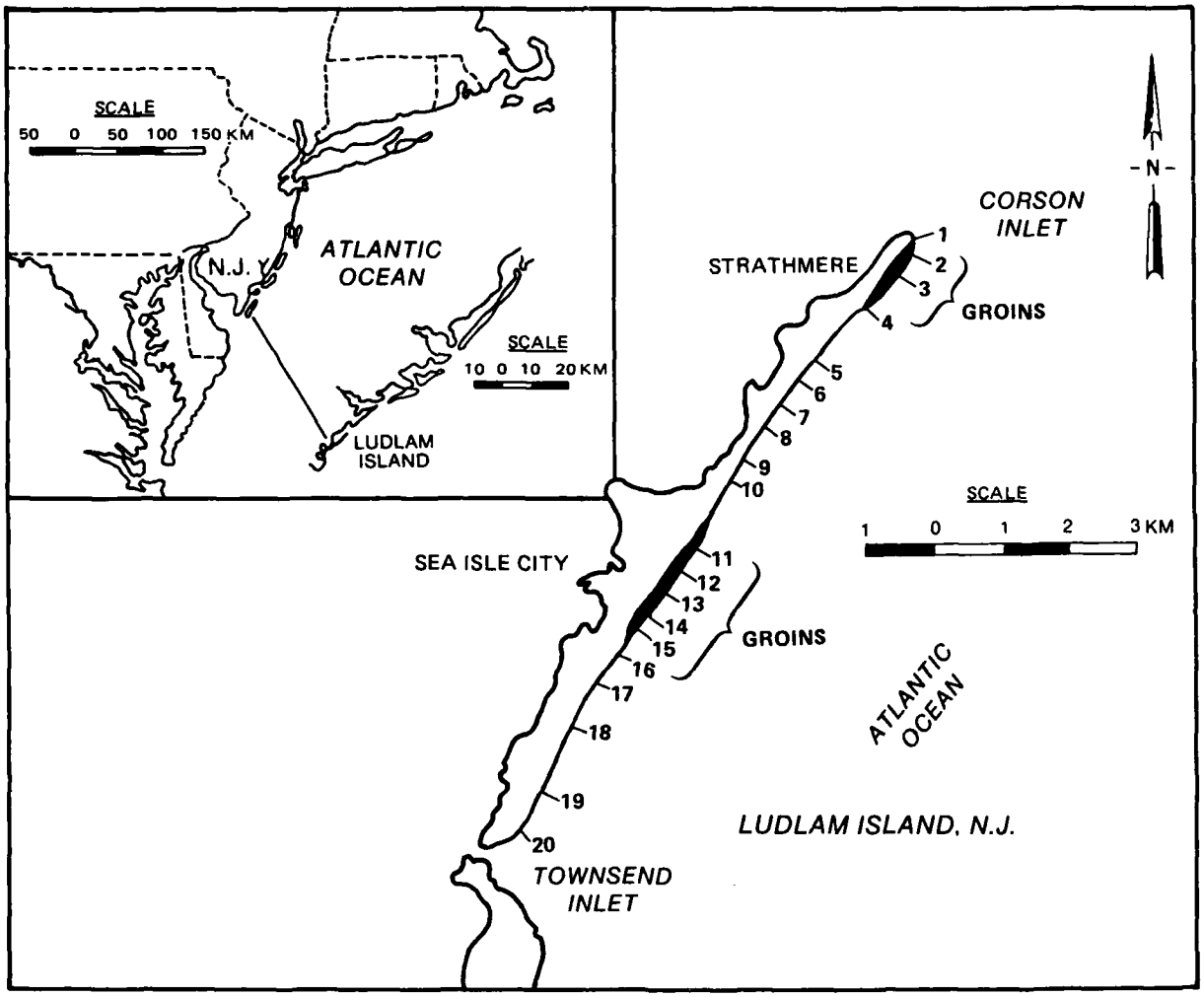


Figure 13. Profile line location map for Ludlam Beach, N.J.

## PART IV: DISCUSSION

56. The appendixes include data for 46 unique combinations of 13 storms from 7 localities. Three storms are reported for Nauset Beach, four each for Misquamicut and Westhampton, five for Jones Beach, and ten for Atlantic City, Ludlam Beach, and Long Beach Island. Results are based on 94 profile lines and nearly 1,100 individual profile line surveys. This unique collection of data provides an overview of the shape, magnitude, and variation of storm-induced beach changes. In this part, the data set will be examined and a number of relationships will be discussed. The discussion will center on "median changes" defined as the median change (e.g. median volume change) of all the profiles on a particular beach for a particular storm. The "median storm change" will also be discussed and is defined as the median change computed from the medians of a number of storms.

57. Table 5 summarizes the data from individual storms listed in the appendixes. This table is similar to Table 4-6 in the SPM (1984) but includes updated and additional data.

### Shoreline and Slope Changes

58. One major finding of the study is the relative insensitivity of both the msl shoreline position and the beach slope at msl to storm changes. This was found to be generally true regardless of locality or storm. Of the 549 profile-survey combinations for which a msl shoreline change could be computed, 81 percent eroded based on volumetric changes (regardless of magnitude) while only 54 percent of the lines had erosional shorelines. Although poststorm recovery (which would affect the shoreline position) is certainly a factor on the 46 percent of the lines which showed shoreline accretion, there is considerable evidence indicating that the shoreline position acts as a pivot point. A number of examples of this can be seen in the profile plots throughout the appendixes. Profile line 9 from Long Beach Island during the 12 November 1968 storm (Appendix F) is a good example with a volume loss of -44.5 $m^3/m$ and a shoreline change of less than 1 m. Of course, many exceptions exist and positive and negative shoreline changes up to 30 m were measured.

Table 5

Summary of Storm Erosion Survey Data

| Storm Date Appendix | Beach | Survey Dates From | Survey Dates To | Peak Water Level* (m) | Surge Return Period (yrs) | Peak Wave** Height (m) | Peak Wave** Period (sec) | Peak Wave** Duration (hrs) | Median Changes Shoreline (m) | Median Changes Slope | Median Changes Volume ($m^3/m$) | Mean Volume Change ($m^3/m$) | Number of Profiles Eroded/ Accreted | Range of Volume Change ($m^3/m$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 Nov 62 | LBI | 23 Oct 62 | 8 Nov 62 | 1.5 | 2.3 | 3.5 | 9.1 | 32 | 0.8 | 0.022 | -11.0 | -7.4 | 11/7 | -34.1 26.0 |
| A | ATLANT | 1 Nov 62 | 9 Nov 62 | 1.5 | 2.3 | 3.6 | 9.3 | 34 | 9.8 | 0.007 | -9.5 | -7.4 | 5/2 | -3.7 8.3 |
| | LUDLAM | 1 Nov 62 | 7 Nov 62 | 1.5 | 2.3 | 3.7 | 9.3 | 29 | 6.0 | 0.002 | -5.2 | -5.5 | 15/4 | -22.2 17.8 |
| 6 Nov 63 | LBI | 25 Oct 63 | 15 Nov 63 | 1.4 | 1.2 | 2.4 | 7.1 | 27 | -3.5 | -0.020 | -1.3 | -5.3 | 10/7 | -59.9 12.9 |
| B | ATLANT | 28 Oct 63 | 14 Nov 63 | 1.4 | 1.2 | 2.4 | 7.5 | 36 | -14.0 | 0.001 | -25.2 | -42.9 | 6/1 | -150.8 0.5 |
| | LUDLAM | 30 Oct 63 | 13 Nov 63 | 1.4 | 1.2 | 2.4 | 7.5 | 26 | -0.7 | 0.001 | -4.4 | -5.1 | 13/5 | -26.3 20.0 |
| 13 Jan 64 | LBI | 27 Dec 63 | 15 Jan 64 | 1.5 | 1.6 | 4.6 | 9.9 | 35 | -0.4 | 0.035 | -28.2 | -29.1 | 17/1 | -69.2 6.6 |
| C | ATLANT | 31 Dec 63 | 17 Jan 64 | 1.5 | 1.6 | 3.7 | 10.3 | 31 | 4.3 | 0.004 | -13.1 | -20.4 | 3/1 | -55.5 0.2 |
| | LUDLAM | 7 Jan 64 | 15 Jan 64 | 1.5 | 1.6 | 4.6 | 10.3 | 35 | -3.7 | 0.014 | -22.2 | -18.2 | 17/2 | -43.3 11.5 |
| 16 Sep 67 | ATLANT | 15 Sep 67 | 19 Sep 67 | 1.4 | 1.6 | 2.2 | - | 27 | -0.2 | -0.003 | -15.1 | -8.2 | 5/2 | -41.7 38.7 |
| D | LUDLAM | 14 Sep 67 | 18 Sep 67 | 1.4 | 1.6 | 2.7 | 7.7 | 17 | 4.0 | -0.003 | -6.6 | -8.5 | 13/6 | -61.2 28.3 |
| 13 Mar 68 | MISQ | 8 Mar 68 | 14 Mar 68 | 0.7 | <1 | 3.0 | 8.0 | 25 | -1.0 | 0.008 | -4.3 | -4.4 | 6/0 | -8.0 -1.2 |
| E | WEST | 6 Mar 68 | 14 Mar 68 | 0.7 | <1 | 3.0 | 8.0 | 22 | -2.0 | 0.053 | -3.8 | -4.6 | 10/1 | -15.0 2.3 |
| | JONES | 11 Mar 68 | 18 Mar 68 | 1.2 | <1 | 3.0 | 7.4 | 26 | -1.5 | -0.007 | -2.9 | -3.0 | 6/3 | -31.7 23.9 |
| | ATLANT | 7 Mar 68 | 13 Mar 68 | 1.1 | <1 | 3.0 | 7.8 | 30 | -3.1 | 0.000 | -3.0 | -2.3 | 4/3 | -18.7 13.5 |
| 12 Nov 68 | LBI | 23 Oct 68 | 13 Nov 68 | 1.6 | 8.0 | 2.9 | 7.7 | 28 | -1.4 | -0.004 | -26.4 | -25.0 | 15/3 | -57.0 2.4 |
| F | ATLANT | 25 Oct 68 | 15 Nov 68 | 1.6 | 8.0 | 2.4 | 6.8 | 22 | -1.8 | -0.002 | -19.7 | -19.4 | 7/0 | -32.1 -8.1 |
| | LUDLAM | 24 Oct 68 | 14 Nov 68 | 1.6 | 8.0 | 2.8 | 6.8 | 11 | -6.1 | 0.002 | -24.7 | -25.3 | 19/0 | -44.4 -1.0 |
| 2 Feb 70 | MISQ | 28 Jan 70 | 4 Feb 70 | 0.6 | <1 | 3.5 | 7.6 | 81 | -2.9 | 0.004 | -7.4 | -7.6 | 7/0 | -14.5 -0.8 |
| G | JONES | 27 Jan 70 | 6 Feb 70 | 1.1 | <1 | 2.6 | 8.0 | 23 | -1.3 | 0.001 | 2.6 | 9.2 | 7/8 | -26.3 55.4 |
| | ATLANT | 28 Jan 70 | 4 Feb 70 | 1.1† | - | 2.5 | - | 20 | -6.1 | 0.012 | -8.6 | -6.3 | 6/1 | -12.7 10.6 |
| 17 Dec 70 | NAUSET | 10 Dec 70 | 18 Dec 70 | 1.3 | 1.2 | 3.3 | 7.9 | 32 | 0.6 | 0.006 | -20.6 | -20.2 | 9/1 | -48.1 22.0 |
| H | MISQ | 9 Dec 70 | 23 Dec 70 | 1.2 | 1.2 | 4.2 | 9.4 | 30 | -8.0 | -0.012 | -10.5 | -10.0 | 7/0 | -20.0 -0.1 |
| | WEST | 1 Dec 70 | 18 Dec 70 | 1.2 | 1.2 | 3.9 | 9.3 | 34 | 4.3 | -0.003 | -15.5 | -13.0 | 9/2 | -43.2 14.8 |
| | JONES | 10 Dec 70 | 20 Dec 70 | 1.6 | 1.2 | 4.0 | 9.4 | 32 | -1.4 | -0.014 | -16.7 | -18.4 | 13/2 | -48.2 6.0 |
| | LBI | 7 Dec 70 | 18 Dec 70 | 1.6† | - | 3.5 | 8.9 | 39 | 3.1 | 0.022 | -8.5 | -11.1 | 15/2 | -57.1 11.7 |
| | ATLANT | 9 Dec 70 | 18 Dec 70 | 1.6† | - | 3.1 | 8.2 | 41 | 3.7 | 0.014 | -15.6 | -1.2 | 4/3 | -27.4 61.2 |
| | LUDLAM | 10 Dec 70 | 18 Dec 70 | 1.6† | - | 2.8 | 8.2 | 33 | -5.1 | 0.006 | -5.2 | -6.5 | 16/3 | -47.2 13.3 |
| 19 Feb 72 | NAUSET | 8 Feb 72 | 25 Feb 72 | 1.9 | ~15 | 5.1 | 10.4 | 61 | 4.1 | 0.022 | -22.8 | -23.4 | 7/3 | -80.2 15.9 |
| I | MISQ | 14 Feb 72 | 25 Feb 72 | 1.5 | 6.0 | 5.5 | 11.4 | 38 | -0.3 | -0.004 | -5.6 | -3.5 | 5/2 | -11.5 13.6 |
| | WEST | 5 Feb 72 | 22 Feb 72 | 1.5 | 6.0 | 5.5 | 10.9 | 44 | -2.2 | 0.021 | -22.8 | -21.6 | 11/0 | -40.0 -1.1 |
| | JONES | 6 Feb 72 | 24 Feb 72 | 2.0 | 6.0 | 5.5 | 10.5 | 36 | 0.7 | 0.003 | -14.1 | -10.8 | 12/3 | -36.2 27.7 |
| | LBI | 15 Feb 72 | 23 Feb 72 | 1.8 | ~13 | 4.3 | 9.0 | 52 | 1.7 | -0.025 | -4.0 | -1.1 | 12/6 | -13.9 34.3 |
| | ATLANT | 14 Feb 72 | 22 Feb 72 | 1.8 | ~13 | 4.3 | 9.0 | 34 | -0.2 | 0.000 | -9.4 | -14.8 | 7/0 | -45.7 -5.2 |
| | LUDLAM | 16 Feb 72 | 23 Feb 72 | 1.8 | ~13 | 4.3 | 9.0 | 56 | 1.5 | 0.004 | -8.4 | -7.8 | 16/3 | -21.0 5.1 |
| 17-22 Mar | NAUSET | 13 Mar 73 | 27 Mar 73 | 1.2 | <1 | 4.0 | 9.4 | 67 | 2.6 | 0.024 | -5.0 | -9.9 | 6/3 | -49.0 13.6 |
| 1973 | WEST | 16 Mar 73 | 24 Mar 73 | 1.4† | <1 | 4.0 | 9.4 | 52 | -20.2 | -0.011 | -31.4 | -25.8 | 10/1 | -48.9 9.9 |
| J | JONES | 12 Mar 73 | 25 Mar 73 | 1.4 | <1 | 4.1 | 9.9 | 42 | -11.4 | -0.013 | -2.5 | -3.0 | 6/4 | -36.4 57.4 |
| | LBI | 14 Mar 73 | 25 Mar 73 | 1.3 | 1.0 | 2.6 | 8.2 | 29 | -3.3 | 0.010 | -6.5 | -4.0 | 13/4 | -30.0 43.6 |
| | ATLANT | 16 Mar 73 | 25 Mar 73 | 1.3 | 1.0 | 3.3 | 8.5 | 37 | 11.2 | 0.016 | -3.5 | -11.1 | 5/2 | -58.1 13.0 |
| 14 Oct 77 | LBI | 13 Oct 77 | 15 Oct 77 | 1.8 | 2.0 | - | - | - | 5.0 | 0.015 | -26.2 | -21.9 | 9/0 | -34.6 -7.9 |
| K | LUDLAM | 11 Oct 77 | 16 Oct 77 | 1.8 | 2.0 | - | - | - | -4.7 | -0.006 | -14.8 | -16.2 | 13/0 | -31.2 -5.1 |
| 19 Dec 77 | LBI | 11 Dec 77 | 20 Dec 77 | 1.4 | 3.5 | 3.0†† | - | - | 1.6 | 0.061 | -21.0 | -21.8 | 6/0 | -34.5 -9.8 |
| L | LUDLAM | 10 Dec 77 | 21 Dec 77 | 1.4 | 3.5 | 2.3‡ | - | - | -8.6 | 0.002 | -17.6 | -16.7 | 13/0 | -26.5 -8.9 |
| 6 Feb 78 | LBI | 22 Dec 77 | 9 Feb 78 | 1.7 | 2.6 | - | - | - | -1.4 | 0.012 | -22.3 | -15.9 | 8/1 | -41.4 27.6 |
| M | LUDLAM | 22 Dec 77 | 8 Feb 78 | 1.7 | 2.6 | - | - | - | 2.4 | 0.009 | -3.4 | -5.4 | 9/4 | -32.1 9.2 |

| Locality | | Tide gage used |
|---|---|---|
| NAUST | Nauset Beach, Cape Cod, Mass. | Boston Harbor, Mass. |
| MISQ | Misquamicut Beach, R.I. | Montauk Pt., N.Y. |
| WEST | Westhampton Beach, N.Y. | Montauk Pt., N.Y. |
| JONES | Jones Beach, N.Y. | Sandy Hook, N.J. |
| LBI | Long Beach Island, N.J. | Atlantic City, N.J. |
| ATLANT | Atlantic City, N.J. | Atlantic City, N.J. |
| LUDLAM | Ludlam Beach, N.J. | Atlantic City, N.J. |

notes: a "-" indicates unknown data
* - measured above NGVD
** - hindcasted wave heights at 9 m depth
† - water level data from Sandy Hook, N.J.
†† - based on visual breaking wave height
‡ - gage measurement in 10 m water depth

59. Figure 14 shows the distribution of shoreline changes by storm and locality. The median shoreline change for the 46 cases was low, only -0.9 m with a hinge range of 4.8 m (+1.7 m to -3.1 m). Median shoreline changes with an absolute value less than 2 m were recorded for 39 percent of the cases. Only 8 percent of the cases had median shoreline changes with an absolute value greater than 10 m. The smallest and most consistent shoreline changes occurred at Misquamicut Beach. The other localities with longer shorelines and more profile lines show greater variation.

60. It is interesting to note that the range of variation between cases (indicated by the heights of the boxes in Figure 14) is relatively small. This further supports the relative insensitivity of the shoreline position to storms, at least for the data included in this report. Figure 15 plots the distribution of median shoreline changes for the storms at each locality. Of the localities with 10 storms, Long Beach Island is the most stable with the greatest variation at Atlantic City.

61. Measurements of the slope at the msl intercept were similarly insensitive. Of the 46 cases, 56 percent had median slope changes with an absolute value less than 0.01 while in 28 percent of the cases, the slope became milder with positive slope changes greater than 0.01. Steeper poststorm slopes occurring in 13 percent of the cases may be attributed to low elevation recovery. The effect of recovery could possibly be reduced by computing the slope at a slightly higher elevation on the profile than msl. Median slope changes were smallest at the flatter beaches such as Ludlam Beach and Atlantic City and greatest at the steeper beaches of Nauset Beach, Westhampton, and Long Beach Island.

## Volumetric Changes

62. Unlike the shoreline changes, the volume changes (Figure 16) show both more erosion and more variation between profile lines and between storms. In 11 of the 46 cases, all of the profile lines eroded; with one exception, median volume changes for all storms and localities were negative. While this is not surprising considering the context of this study, it is interesting that during the 2 February 1970 storm, over one-half of the profile lines on Jones Beach (surveyed just 4 days after the storm) accreted, resulting in a positive median volume change. This was not an insignificant

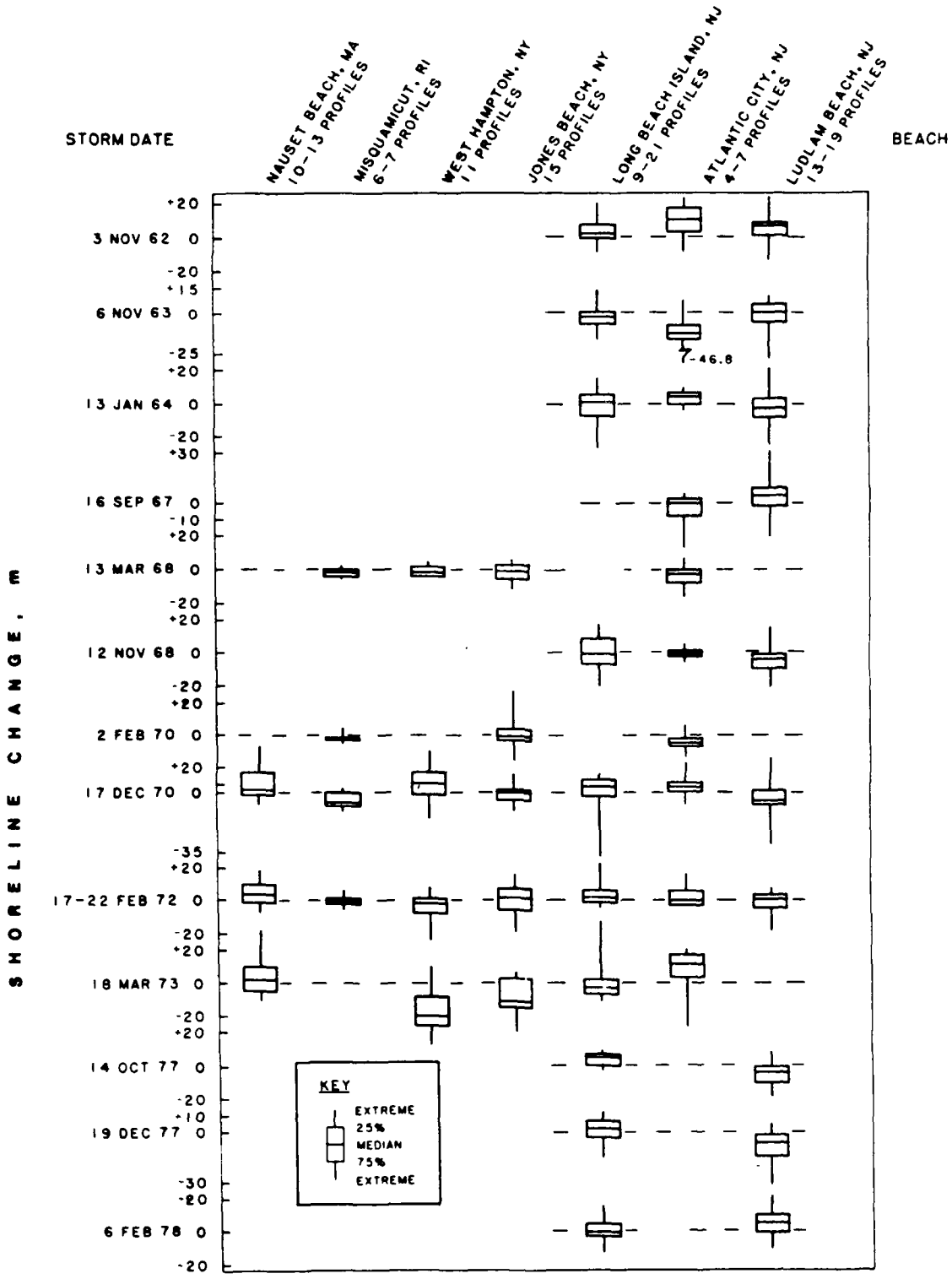


Figure 14. Box and whisker diagram of the median shoreline change for all localities and storms

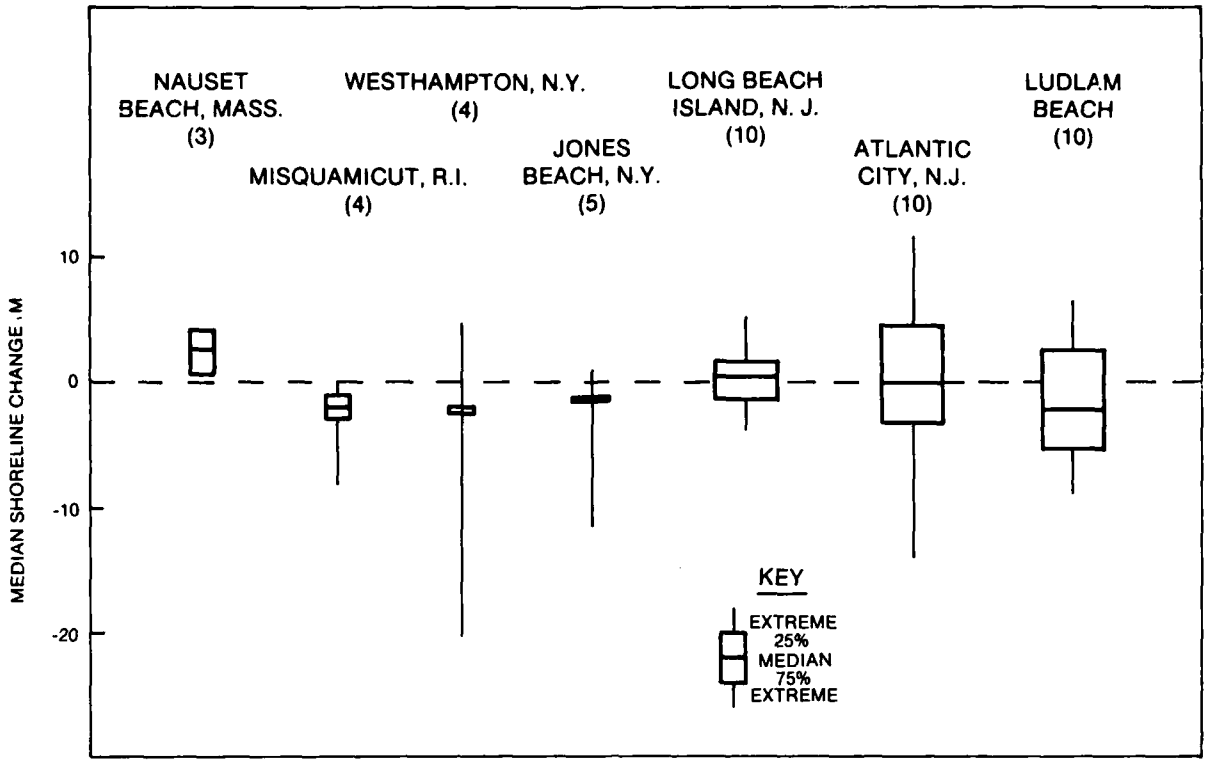


Figure 15. Median shoreline change for all storms at each locality. (Number in parens and width of box indicate the number of storms.)

storm since individual lines experienced large losses. Median volume change for the 46 cases was -10 $m^3/m$.

63. The largest median volume change (-31.4 $m^3/m$ on 18 March 1973) occurred at Westhampton Beach. Individual profile changes, represented by the extreme values, were quite large, up to -150 $m^3/m$ for profile line 1 at Atlantic City. Probably as a result of its sheltered location, Misquamicut eroded the least and had the least variation between profile lines. Misquamicut and Ludlam Beach had the smallest ranges in variation between profile lines whereas Nauset Beach and Jones Beach had relatively large ranges. Because the number of beaches surveyed for each storm varied considerably, it is difficult to compare storms. However, Figure 16 illustrates the large amount of variation which naturally occurs between beaches subjected to the same storm.

64. Figure 17 illustrates the distribution of median volume change for the storms at each locality Although the number of storms differs for each

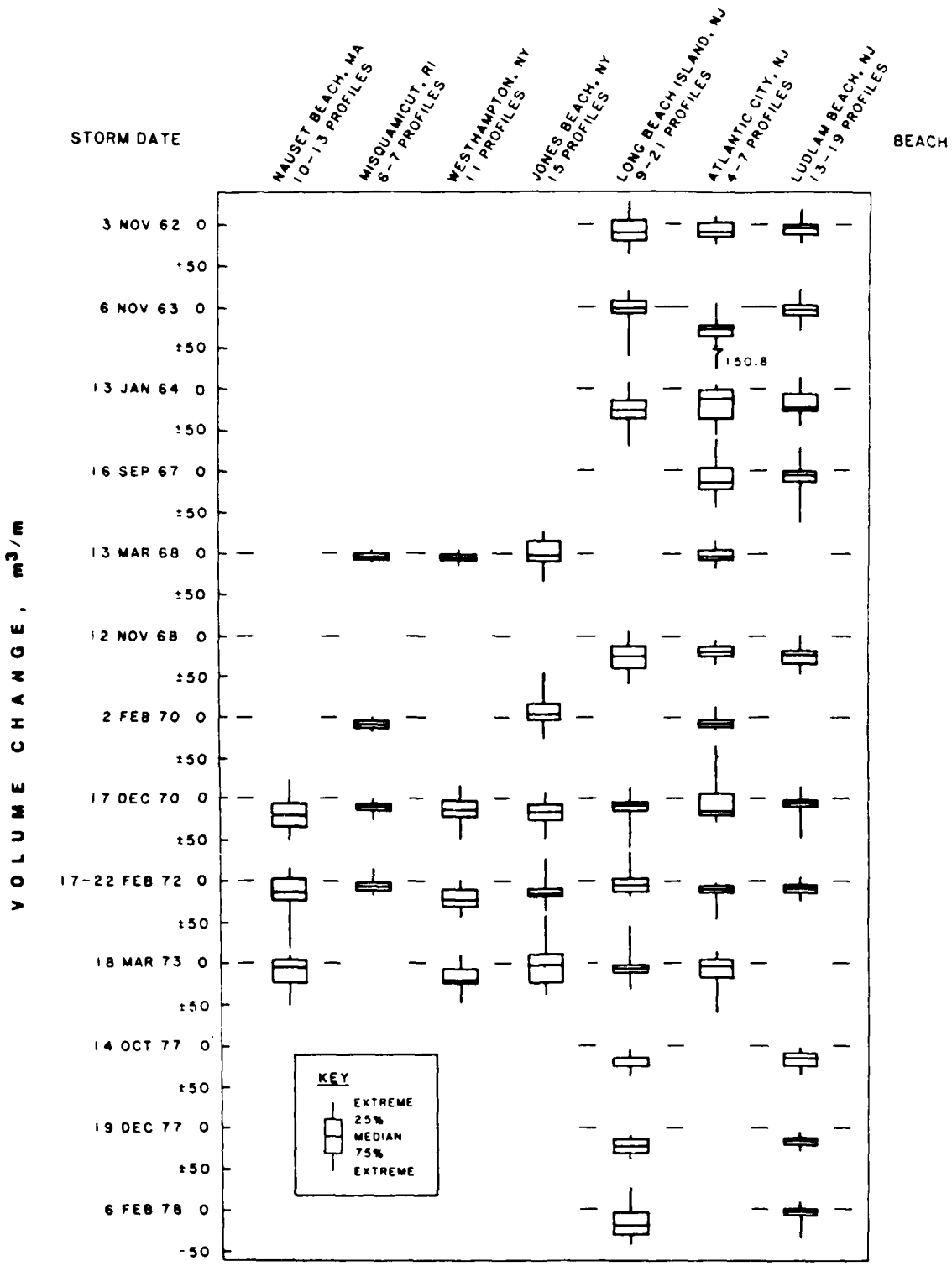


Figure 16. Box and whisker diagram of the median volume change for all localities and storms

locality, Figure 17 provides a relative measure of how each site responds to storms. The greatest variation between storms was recorded at Long Beach Island, the longest locality. Misquamicut and Atlantic City, with the fewest profile lines, showed the least variation. Jones Beach, with the lowest median storm change, had considerable variation between storms.

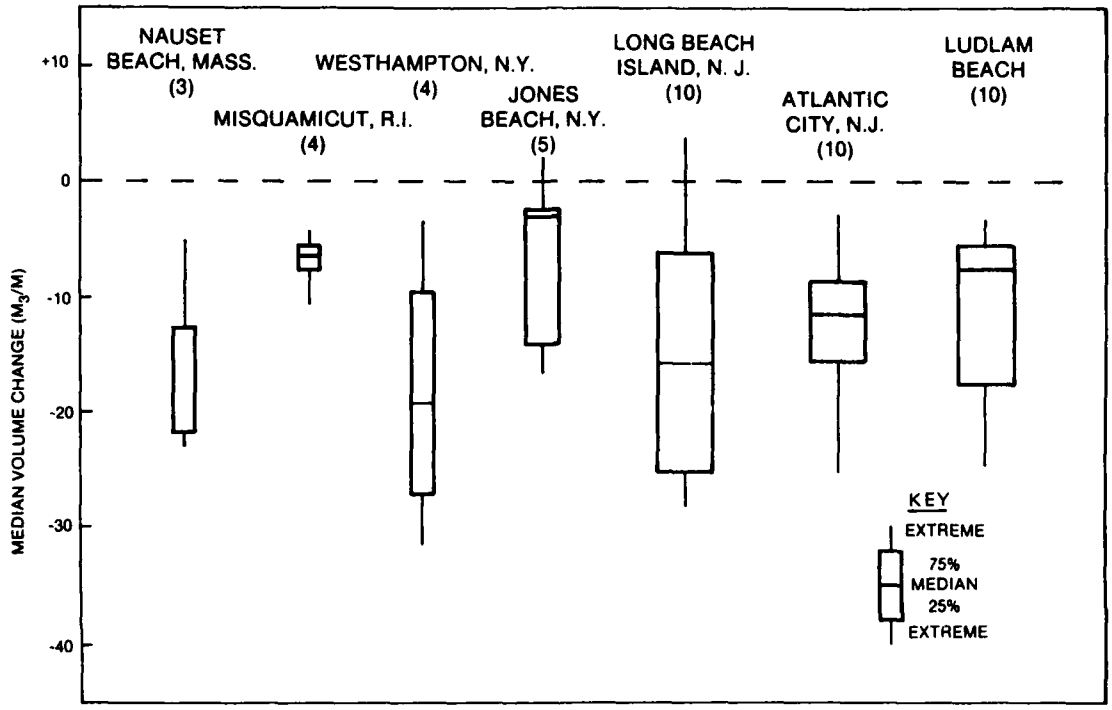


Figure 17. Median volume change for all storms at each locality. (Number in parens and width of box indicate the number of storms.)

## Influence of Waves and Tides on Volume Changes

65. An attempt was made to empirically relate median volume, shoreline, and slope changes to the peak wave and water level parameters. Figures 18 and 19 show two of the more interesting relationships which were developed. Figure 18 plots the relationship between the peak water level and the median volume change above NGVD. Though the data are scattered, they display a slight linear trend (simple regression coefficient, $r = -0.36$). The need for additional data, particularly during severe surge levels, is readily apparent since these data only represent a small range of surge

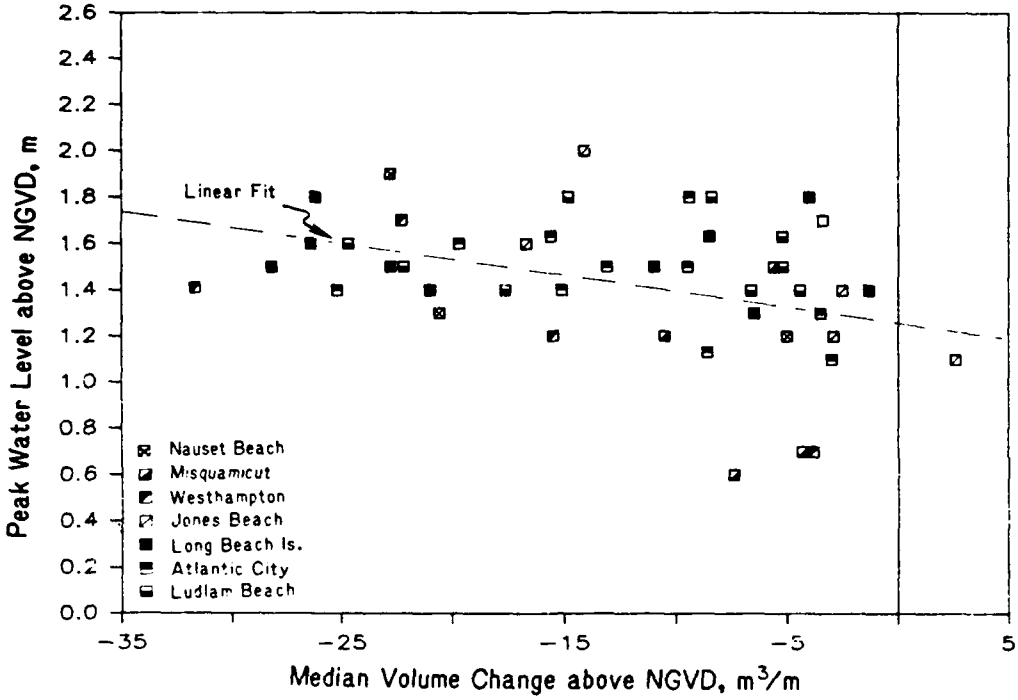


Figure 18. Variation between median volume change and the peak water level

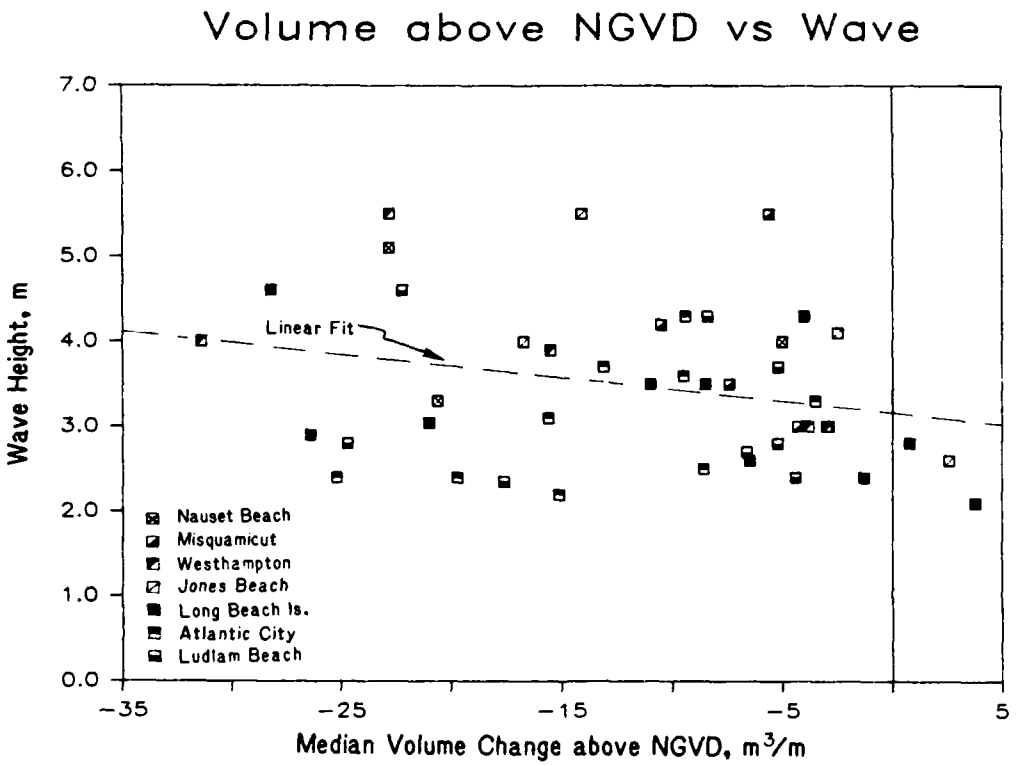


Figure 19. Variation between median volume change and peak wave height

levels, from 0.4 to 1.4 m, which is typical of moderate east coast storms. Not surprisingly, the relationship between peak wave height and volume change above NGVD (Figure 19) is more scattered ($r = -0.20$), reinforcing the importance of water level in controlling storm erosion.

66. Several other relationships were also investigated using a variety of parameters including wave height squared (related to wave energy) and mean profile changes. Though the correlation coefficients changed, none indicated significantly improved relationships. Though not tested, Balsillie (1986) has recently proposed a promising relationship between above-msl erosion and the storm surge height squared multiplied by the rise time of the surge (related to storm duration).

67. The lack of fit shown in Figures 18 and 19 is not unexpected considering that storm erosion is dependent not only on the peak wave and water level but also on: storm duration, water level at the site, sediment size, presence or absence of offshore bars, effect of prior storms, and other variables. Future research on the effects of these factors along with data documenting severe storms is required.

## PART V: SUMMARY

68. Predicting the effects of storms on beaches is one of the most important and difficult problems facing coastal engineers. Unfortunately, there are insufficient data worldwide to test and evaluate storm erosion models. This report presents a detailed collection of data which quantifies the effects of 13 storms on 7 different east coast beaches. The data have been carefully selected and edited from a larger collection of beach surveys made by CERC between 1962 to 1978.

69. Included in this report are figures which document the wave and tide conditions during each storm along with actual profile cross sections. Additional tables summarize volume, shoreline, and beach slope changes. These data can be used for many purposes including the following:

a. Estimating the amount of erosion for similar storms and beaches; and the range of changes that may occur along a beach.

b. Testing and verifying models of erosion based on profile shape, volume, slope, etc.

c. Examining the vertical erosion of the beach face and changes in beach width.

Though the primary intent of this report is to present the data in a usable format, analysis of the data revealed some interesting relationships.

70. Of the parameters examined, median volume change above NGVD was the best indicator of a storm's effect. Shoreline position and beach slope changes were less informative. This appeared to result from the shoreline position acting as a pivot point with erosion occurring on higher contours. These data also quantify the considerable amount of alongshore variation which occurs during storms. Although some profile lines eroded for each of the 46 cases, accretion was measured in all but 11 instances. Three cases had positive median volume changes. Using simple linear regression, the peak water level was found to be a weak, though linear, predictor of median volume change.

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Everts, C. H. 1972. "Beach Changes on Western Long Island," Coastal Geomorphology, State University of New York, Binghamton, NY.

## APPENDIX A: DATA SUMMARY FOR THE STORM OF 3 NOVEMBER 1962

1. The 3 November 1962 storm is documented through its effects on the three New Jersey localities including Long Beach Island, Atlantic City, and Ludlam Beach. Peak hindcast wave heights for this event ranged from 3.5 to 3.7 m with a maximum storm tide of 1.5 m above msl. A surge of 0.9 m coincided with the storm waves. At all localities poststorm surveys were conducted within five days after the storm, and only one major event occurred within the survey interval.

2. All three localities experienced net erosion after this storm. Long Beach Island eroded the most with a median volume change of -11.0 $m^3/m$. This locality also showed the most variation between profiles with a hinge range of 24.6 $m^3/m$. Volumetric losses on the beaches primarily occurred between the 0.5- and 2.0-m contours. Median shoreline changes were all positive, indicating shoreline accretion. Slope changes were negligible with the exception of Long Beach Island which flattened 0.022. At Ludlam Beach profile lines 7 to 10 showed evidence of peat outcrops near the shoreline.

3. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.

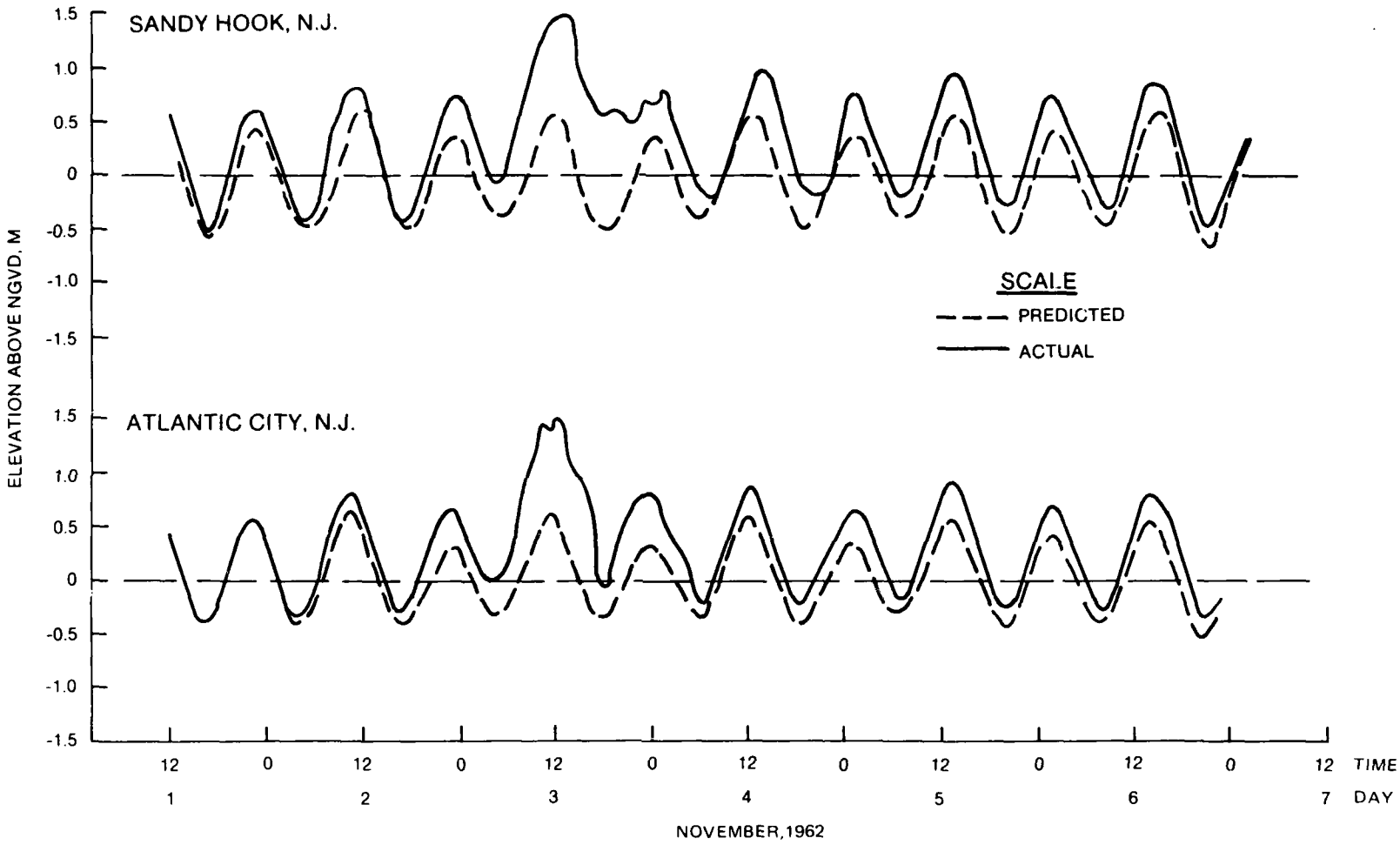



Figure A1. Predicted and actual water levels for 1-6 November 1962

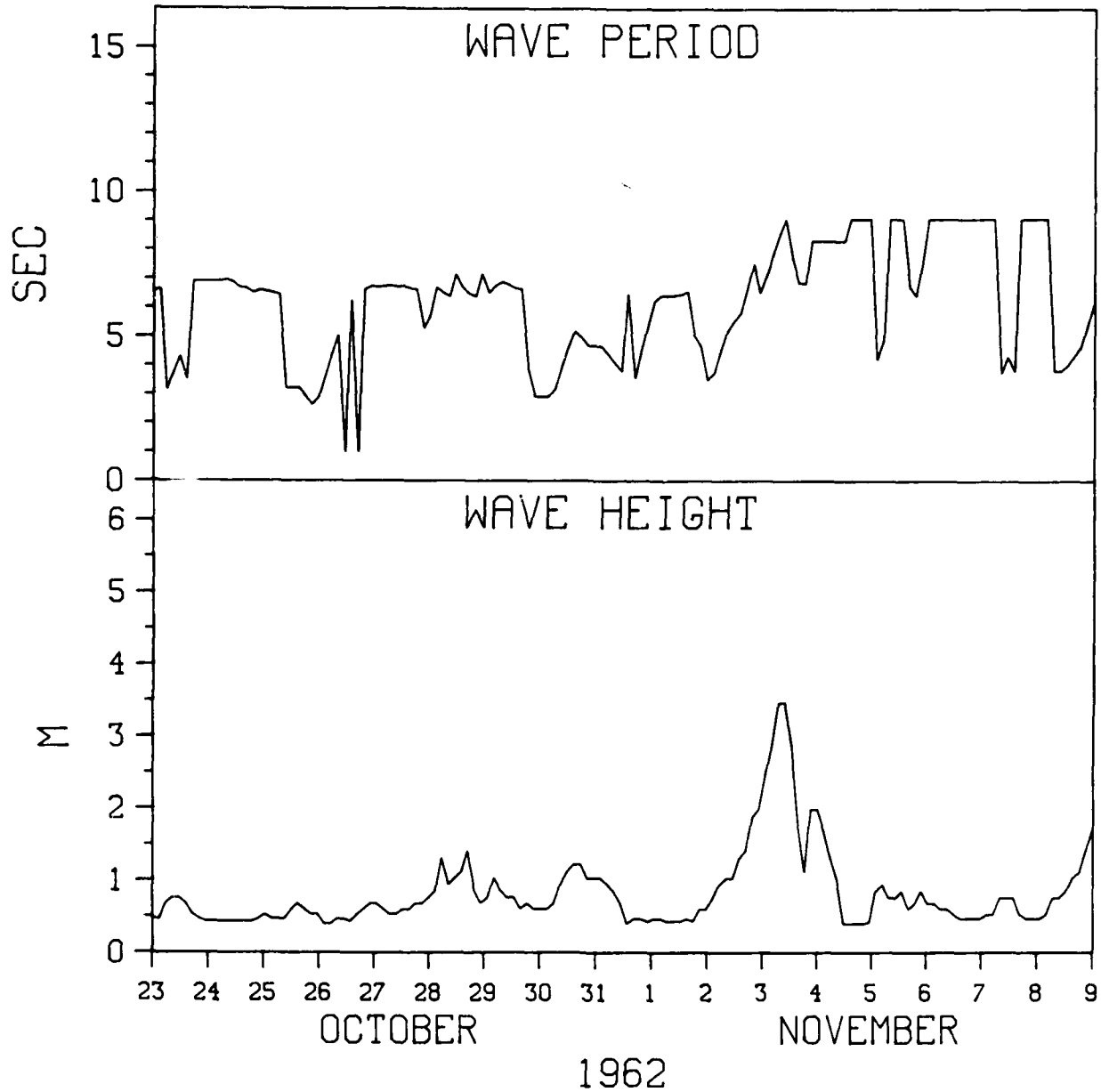
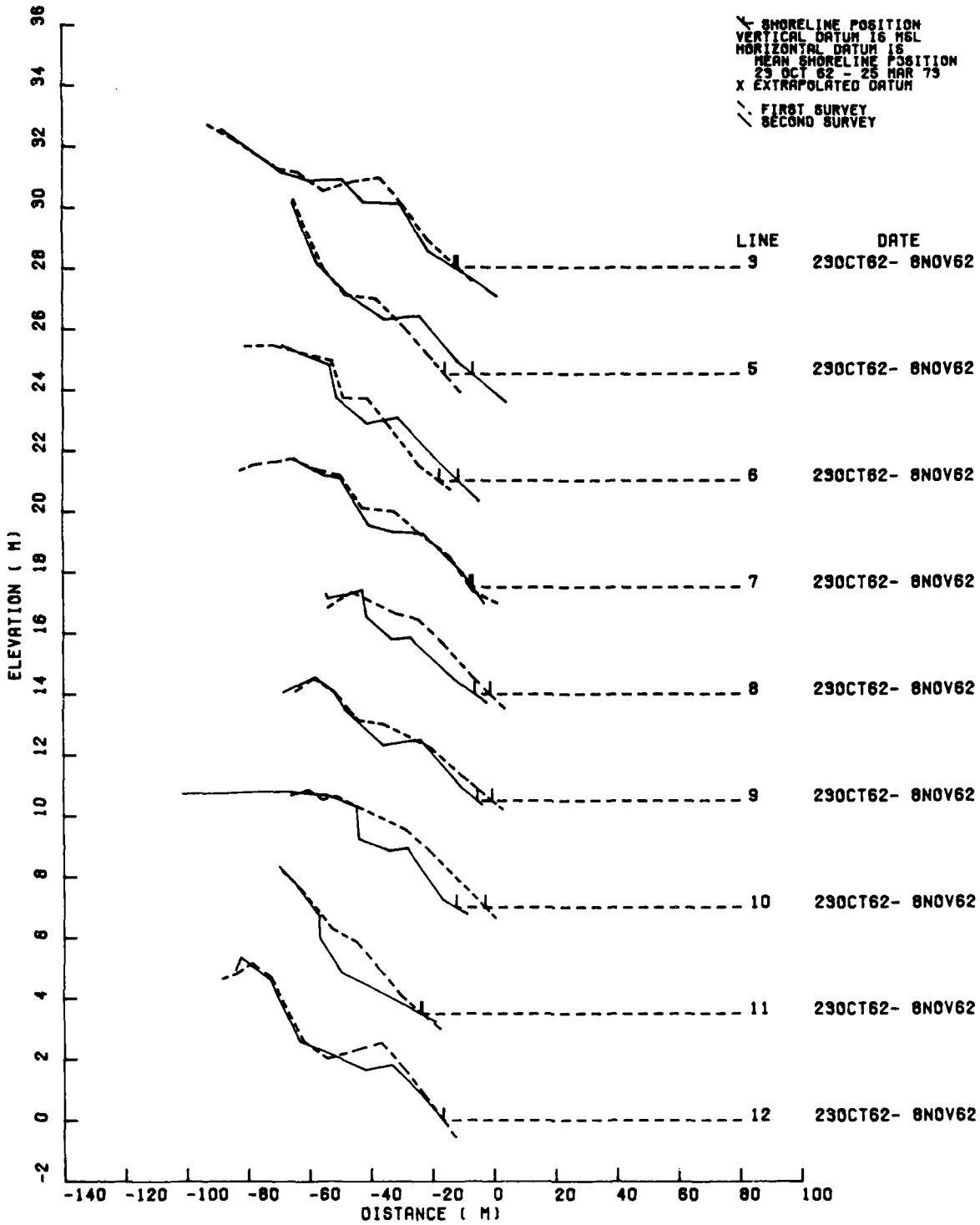
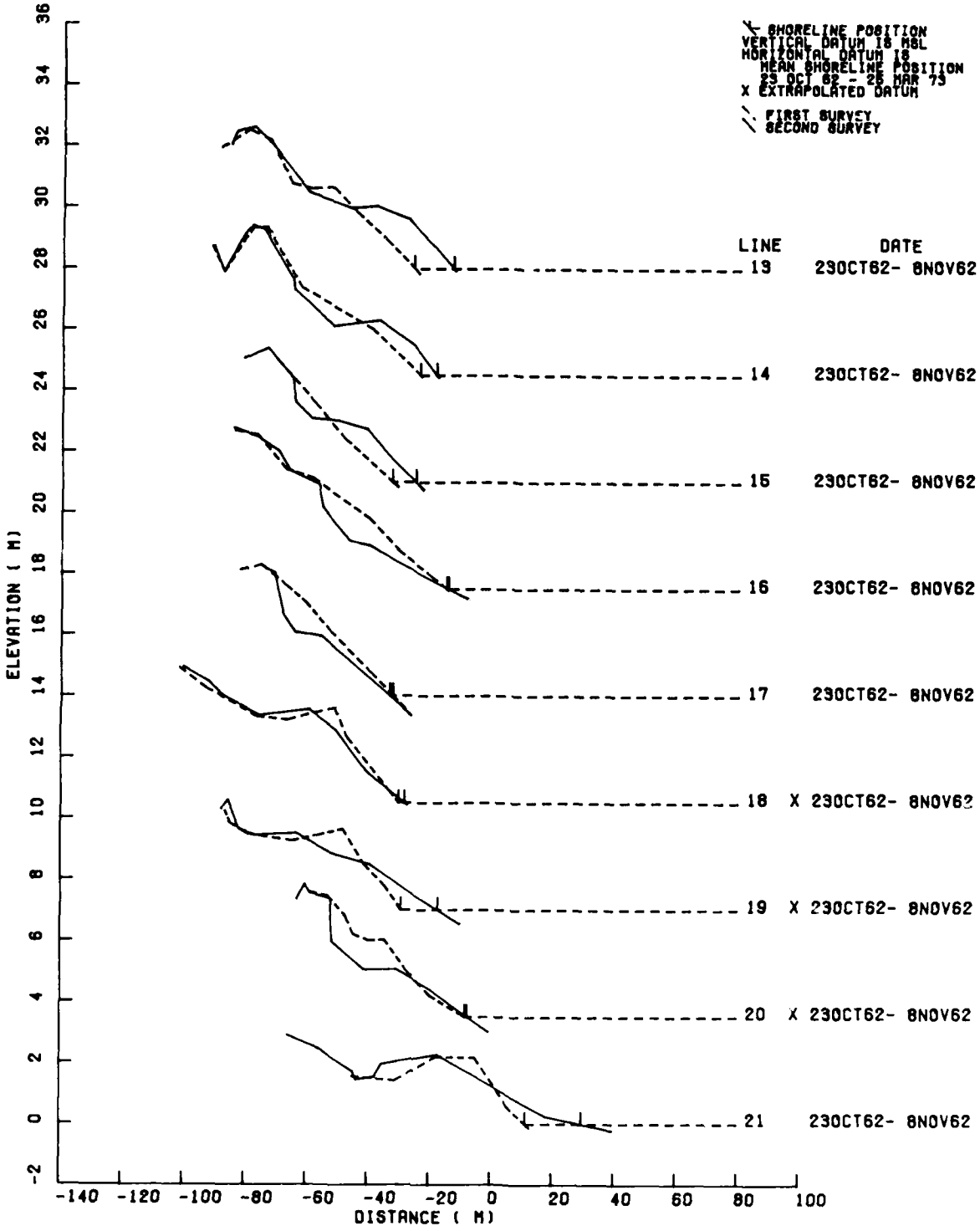



Figure A2. Hindcasted wave data for Long Beach Island, N. J.




a. Profile lines 3-12

Figure A3. Profile comparisons for surveys at Long Beach Island, N. J. (Continued)




b. Profile lines 13-21

Figure A3. (Concluded)

Table A1

Shoreline and Slope Changes at Long Beach Island, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 3 | 23 Oct 62 | 8 Nov 62 | -0.98 | -0.096 | -0.064 | 0.032 |
| 5 | 23 Oct 62 | 8 Nov 62 | 9.09 | -0.118 | -0.085 | 0.033 |
| 6 | 23 Oct 62 | 8 Nov 62 | 6.23 | -0.079 | -0.100 | -0.021 |
| 7 | 23 Oct 62 | 8 Nov 62 | 0.89 | -0.154 | -0.145 | 0.009 |
| 8 | 23 Oct 62 | 8 Nov 62 | -4.91 | -0.100 | -0.074 | 0.026 |
| 9 | 23 Oct 62 | 8 Nov 62 | -4.83 | -0.083 | -0.086 | -0.003 |
| 10 | 23 Oct 62 | 8 Nov 62 | -9.40 | -0.104 | -0.062 | 0.043 |
| 11 | 23 Oct 62 | 8 Nov 62 | -0.42 | -0.088 | -0.055 | 0.033 |
| 12 | 23 Oct 62 | 8 Nov 62 | -0.05 | -0.139 | -0.122 | 0.017 |
| 13 | 23 Oct 62 | 8 Nov 62 | 12.83 | -0.106 | -0.122 | -0.016 |
| 14 | 23 Oct 62 | 8 Nov 62 | 5.35 | -0.098 | -0.136 | -0.038 |
| 15 | 23 Oct 62 | 8 Nov 62 | 7.66 | -0.093 | -0.097 | -0.004 |
| 16 | 23 Oct 62 | 8 Nov 62 | 0.54 | -0.083 | -0.051 | 0.032 |
| 17 | 23 Oct 62 | 8 Nov 62 | -1.00 | -0.107 | -0.089 | 0.018 |
| 18 | 23 Oct 62 X | 8 Nov 62 | 1.92 | -0.129 | -0.083 | 0.046 |
| 19 | 23 Oct 62 X | 8 Nov 62 | 11.99 | -0.147 | -0.063 | 0.085 |
| 20 | 23 Oct 62 X | 8 Nov 62 | 0.77 | -0.060 | -0.072 | -0.012 |
| 21 | 23 Oct 62 | 8 Nov 62 | 18.14 | -0.096 | -0.021 | 0.074 |
| Median | | | 0.83 | -0.099 | -0.084 | 0.022 |
| Tri-Mean | | | 2.09 | -0.101 | -0.083 | 0.018 |
| High Hinge | | | 7.66 | -0.088 | -0.063 | 0.033 |
| Low Hinge | | | -0.98 | -0.118 | -0.100 | -0.004 |
| Mean | | | 2.99 | -0.104 | -0.085 | 0.020 |
| Standard Deviation | | | 6.98 | 0.025 | 0.032 | 0.032 |

Note: X = Extrapolated shoreline intercept.

Table A2

Unit Volume Changes ($m^3/m$) Between Contours
Long Beach Island, N.J.
from 23 Oct 62 to 8 Nov 62

| Profile Line | Total Changes | 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Contours (m) above MSL | | | | | | | | | | | | | |
| 3 | -11.33 | | -1.14 | -1.45 | -0.83 | -0.52 | -4.53 | -2.38 | -1.00 | 0.07 | 0.44 | 0.00 | | | |
| 5 | 9.10 | | 4.14 | 3.86 | 3.98 | 2.37 | -2.92 | -0.09 | -0.02 | -0.59 | -0.58 | -0.50 | -0.42 | -0.13 | |
| 6 | 4.06 | | 3.45 | 3.59 | 3.19 | 2.39 | -3.75 | -2.67 | -0.81 | -0.94 | -0.39 | | | | |
| 7 | -10.59 | | 0.39 | -0.13 | -0.21 | -1.83 | -6.15 | -1.22 | -0.45 | -1.01 | 0.02 | | | | |
| 8 | -26.75 | | -2.89 | -3.54 | -3.99 | -5.51 | -7.83 | -3.88 | 0.89 | | | | | | |
| 9 | -12.47 | | -2.36 | -1.82 | -1.14 | -1.41 | -5.01 | -1.06 | -0.41 | 0.70 | 0.04 | | | | |
| 10 | -34.12 | | -5.29 | -4.93 | -4.22 | -4.28 | -8.56 | -5.79 | -1.21 | 0.16 | | | | | |
| 11 | -25.64 | | -1.07 | -3.15 | -5.83 | -6.23 | -5.62 | -2.75 | -0.67 | -0.36 | -0.06 | 0.10 | | | |
| 12 | -13.09 | | -0.15 | -0.42 | -0.88 | -5.01 | -4.98 | -0.57 | -0.53 | -0.48 | -0.42 | -0.28 | 0.63 | | |
| 13 | 26.03 | | 6.57 | 6.77 | 6.97 | 6.16 | -2.59 | -0.26 | 1.06 | 0.36 | 0.61 | 0.38 | | | |
| 14 | 2.41 | | 3.03 | 3.74 | 3.58 | -1.41 | -3.48 | -1.83 | -0.63 | -0.31 | -0.18 | -0.10 | | | |
| 15 | 11.07 | | 3.89 | 4.10 | 4.68 | 4.06 | -2.44 | -2.52 | -0.72 | 0.02 | 0.00 | | | | |
| 16 | -23.55 | | -0.62 | -2.10 | -3.48 | -6.33 | -6.10 | -4.50 | -1.54 | -0.43 | 0.97 | 0.53 | 0.05 | | |
| 17 | -20.08 | | -0.74 | -1.22 | -1.66 | -2.16 | -5.55 | -4.94 | -3.11 | -0.80 | 0.10 | | | | |
| 18 | -0.62 | X | 0.43 | -0.63 | -1.18 | -1.09 | -1.20 | 0.20 | 0.46 | 1.35 | 1.04 | | | | |
| 19 | 3.85 | X | 4.84 | 2.74 | 1.46 | -2.60 | -3.78 | 0.13 | 1.01 | 0.05 | | | | | |
| 20 | -20.60 | X | 0.74 | 1.12 | -0.28 | -6.59 | -8.26 | -4.02 | -2.44 | -0.76 | -0.11 | | | | |
| 21 | 10.07 | | 5.47 | 2.33 | -0.07 | 2.50 | -0.16 | 0.00 | | | | | | | |
| Median | -10.96 | | 0.41 | -0.27 | -0.56 | -1.62 | -4.76 | -2.11 | -0.63 | -0.34 | 0.01 | 0.00 | 0.05 | -0.13 | |
| Tri-mean | -9.61 | | 0.91 | 0.30 | 0.11 | -1.47 | -4.63 | -2.09 | -0.57 | -0.31 | 0.07 | 0.01 | 0.06 | -0.13 | |
| High Hinge | 4.06 | | 3.89 | 3.59 | 3.19 | 2.37 | -2.92 | -0.26 | -0.02 | 0.11 | 0.44 | 0.24 | 0.34 | -0.13 | |
| Low Hinge | -20.60 | | -1.07 | -1.82 | -1.66 | -5.01 | -6.10 | -3.88 | -1.00 | -0.67 | -0.18 | -0.19 | -0.18 | -0.13 | |
| Mean | -7.35 | | 1.04 | 0.49 | 0.01 | -1.53 | -4.61 | -2.12 | -0.60 | -0.19 | 0.11 | 0.02 | 0.09 | -0.13 | |
| Std Dev | 16.34 | | 3.22 | 3.19 | 3.42 | 3.81 | 2.32 | 1.90 | 1.13 | 0.63 | 0.49 | 0.36 | 0.53 | 0.00 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

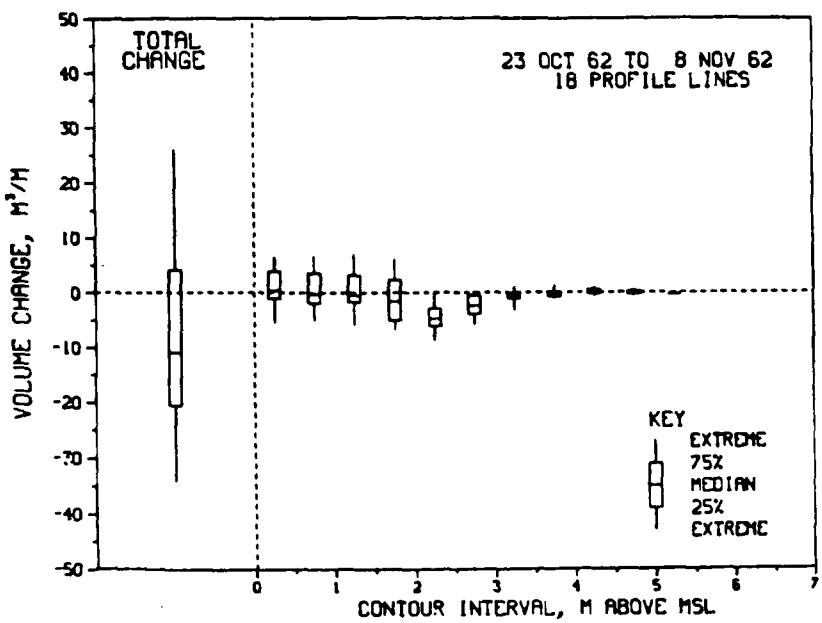



Figure A4. Distribution of volume changes by contour for Long Beach Island, N. J.

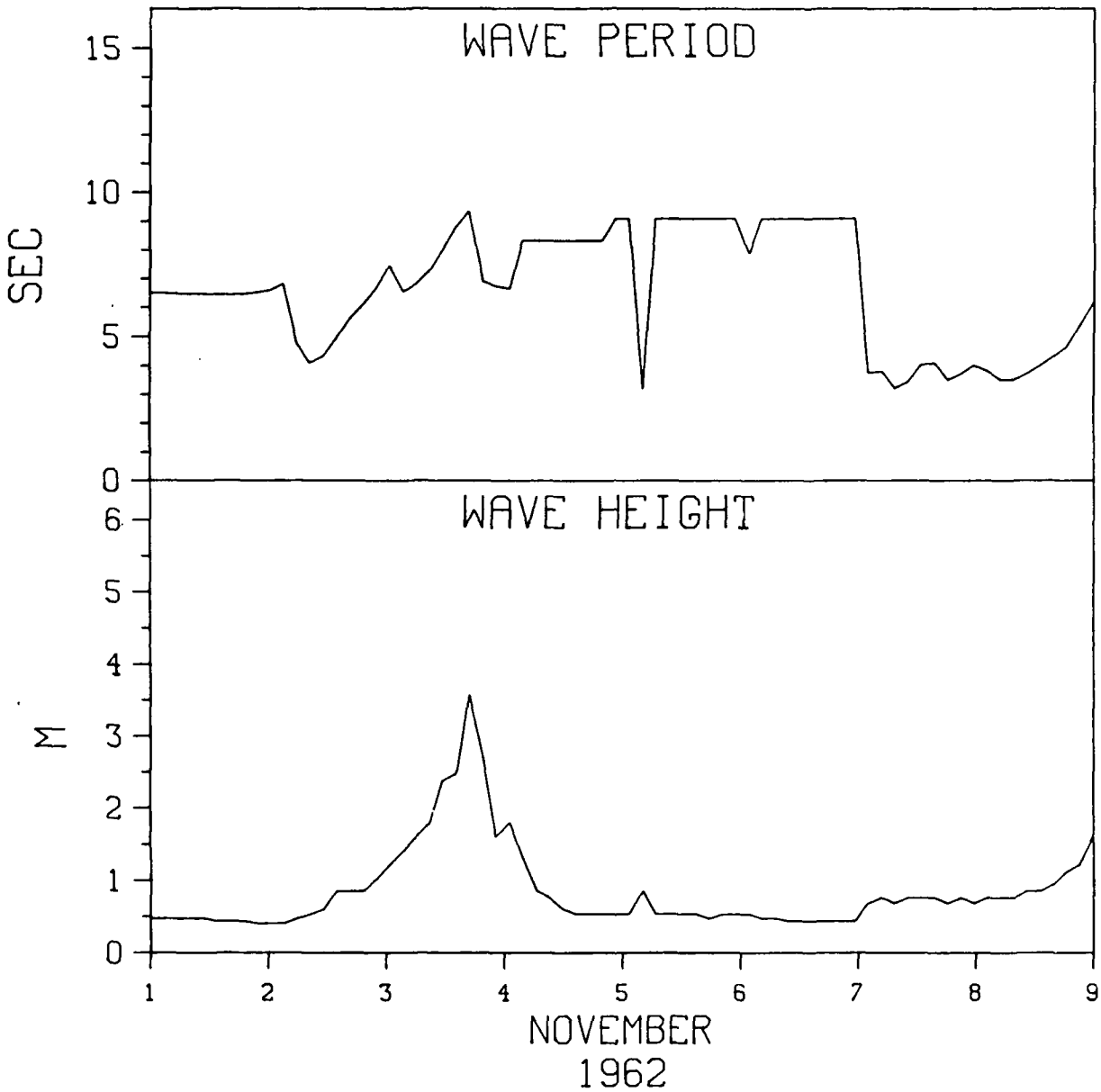



Figure A5. Hindcasted wave data for Atlantic City, N. J.

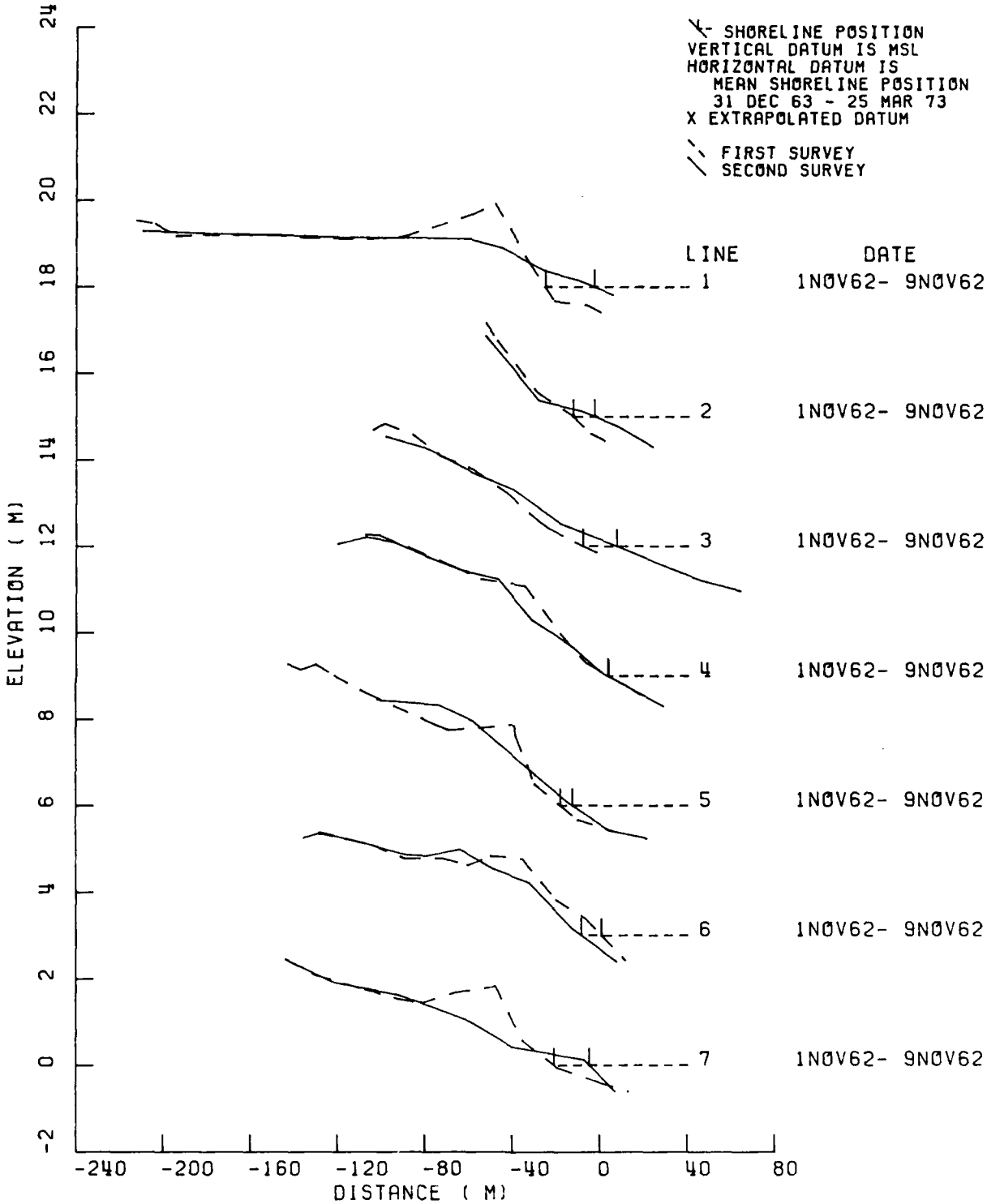



Figure A6. Profile comparisons for surveys at Atlantic City, N. J.

Table A3

Shoreline and Slope Changes at Atlantic City, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 1 Nov 62 | 9 Nov 62 | 22.40 | -0.076 | -0.021 | 0.056 |
| 2 | 1 Nov 62 | 9 Nov 62 | 9.82 | -0.048 | -0.021 | 0.028 |
| 3 | 1 Nov 62 | 9 Nov 62 | 15.47 | -0.024 | -0.020 | 0.004 |
| 4 | 1 Nov 62 | 9 Nov 62 | -0.33 | -0.029 | -0.027 | 0.002 |
| 5 | 1 Nov 62 | 9 Nov 62 | 5.55 | -0.042 | -0.034 | 0.007 |
| 6 | 1 Nov 62 | 9 Nov 62 | -9.26 | -0.052 | -0.037 | 0.015 |
| 7 | 1 Nov 62 | 9 Nov 62 | 16.12 | -0.040 | -0.051 | -0.011 |
| Median | | | 9.82 | -0.042 | -0.027 | 0.007 |
| Tri-Mean | | | 9.51 | -0.042 | -0.028 | 0.010 |
| High Hinge | | | 15.79 | -0.035 | -0.021 | 0.022 |
| Low Hinge | | | 2.61 | -0.050 | -0.036 | 0.003 |
| Mean | | | 8.54 | -0.044 | -0.030 | 0.014 |
| Standard Deviation | | | 10.83 | 0.017 | 0.011 | 0.022 |

Note: X = Extrapolated shoreline intercept.

Table A4

Unit Volume Changes ($m^3/m$) Between Contours
Atlantic City, N.J.
from 1 Nov 62 to 9 Nov 62

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -18.40 | 5.79 | -2.65 | -16.51 | -5.03 | | | | | | | | | | |
| 2 | -3.81 | 0.80 | -1.27 | -1.49 | -1.67 | -0.18 | | | | | | | | | |
| 3 | 7.44 | 6.36 | 3.77 | 2.37 | -0.75 | -1.89 | -2.42 | | | | | | | | |
| 4 | -9.53 | 0.44 | -0.41 | -3.57 | -4.56 | -0.03 | -0.48 | -0.92 | | | | | | | |
| 5 | 8.28 | 2.63 | 0.68 | -3.19 | 0.26 | 7.90 | 0.00 | 0.00 | | | | | | | |
| 6 | -11.81 | -5.03 | -3.13 | -4.26 | 0.20 | 0.41 | | | | | | | | | |
| 7 | -23.71 | 2.58 | -6.93 | -14.51 | -5.13 | 0.28 | | | | | | | | | |
| Median | -9.53 | 2.58 | -1.27 | -3.57 | -1.67 | 0.13 | -0.48 | -0.46 | | | | | | | |
| Tri-mean | -8.09 | 2.50 | -1.32 | -4.72 | -2.10 | 0.12 | -0.66 | -0.46 | | | | | | | |
| High Hinge | 1.82 | 4.21 | 0.14 | -2.34 | -0.28 | 0.41 | -0.24 | 0.00 | | | | | | | |
| Low Hinge | -15.10 | 0.62 | -2.89 | -9.39 | -4.80 | -0.18 | -1.45 | -0.92 | | | | | | | |
| Mean | -7.36 | 1.94 | -1.42 | -5.88 | -2.38 | 1.08 | -0.97 | -0.46 | | | | | | | |
| Std Dev | 12.18 | 3.82 | 3.35 | 6.95 | 2.45 | 3.44 | 1.28 | 0.65 | | | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

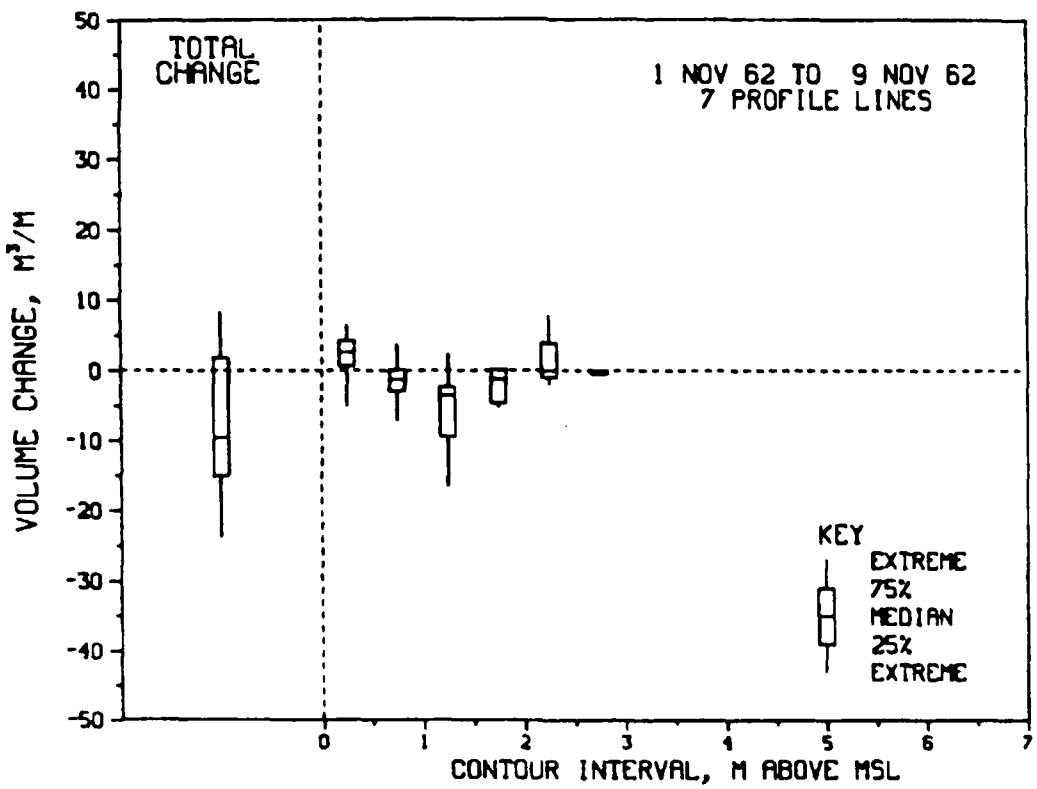



Figure A7. Distribution of volume changes by contour for Atlantic City, N. J.

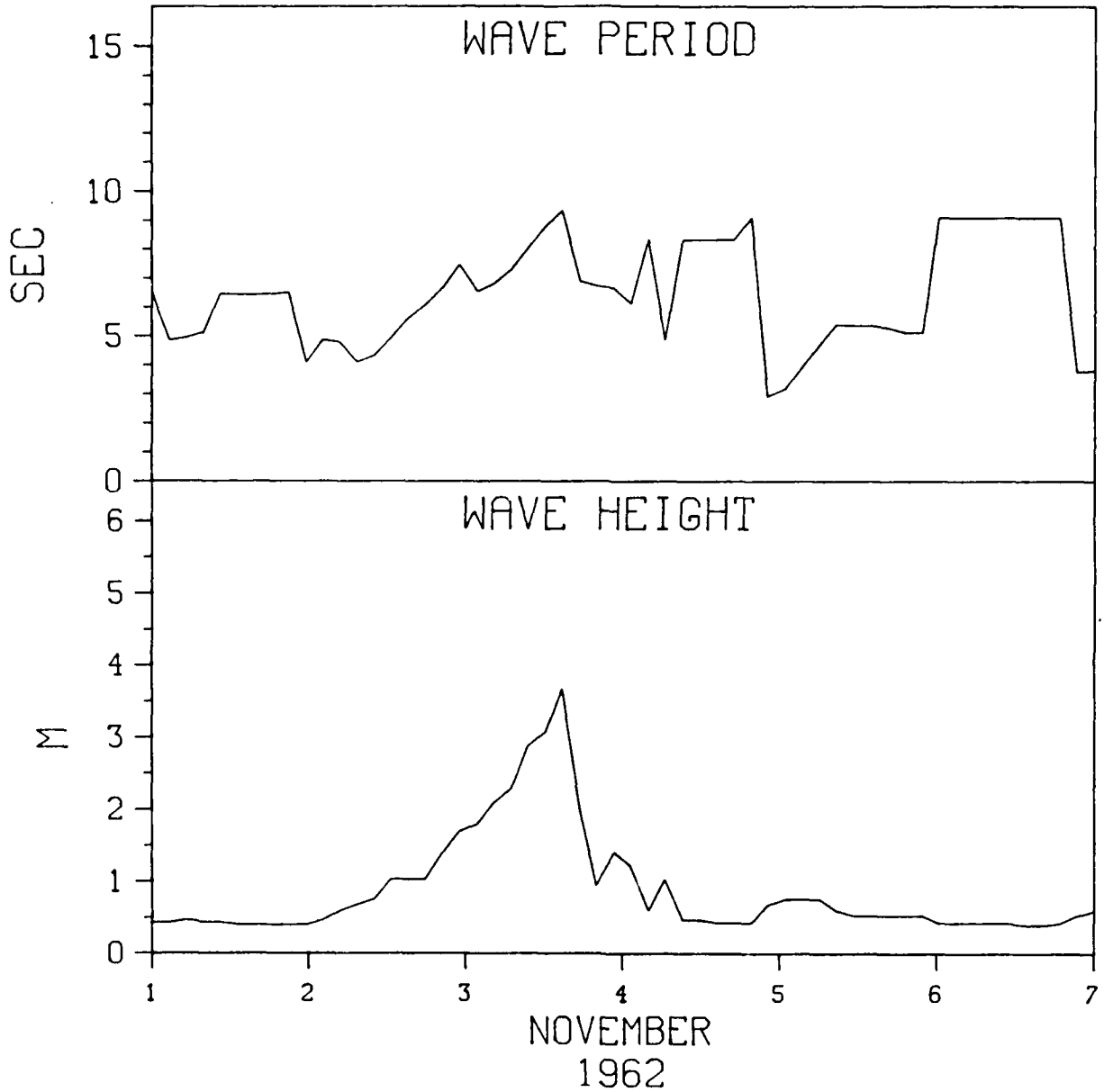
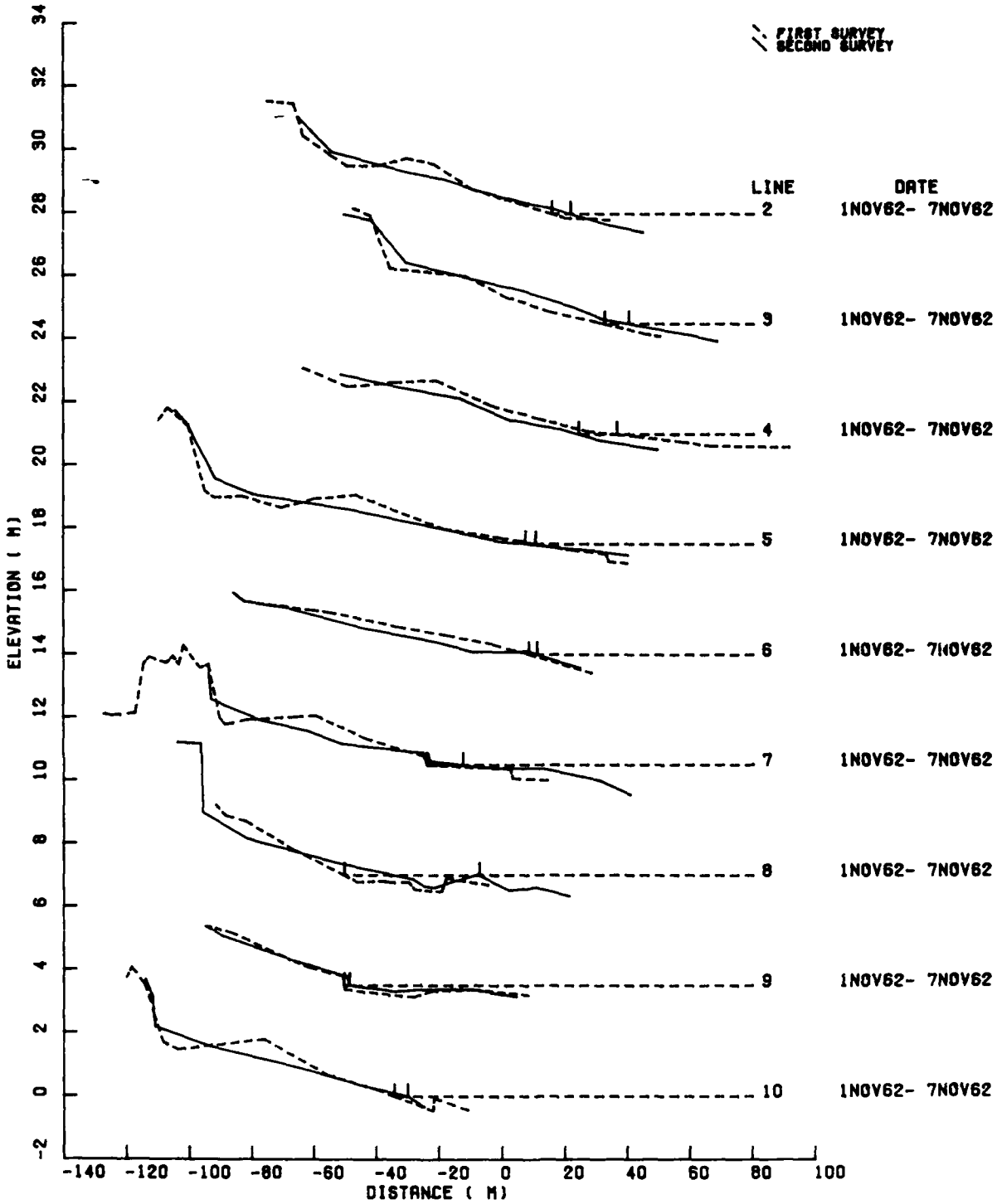
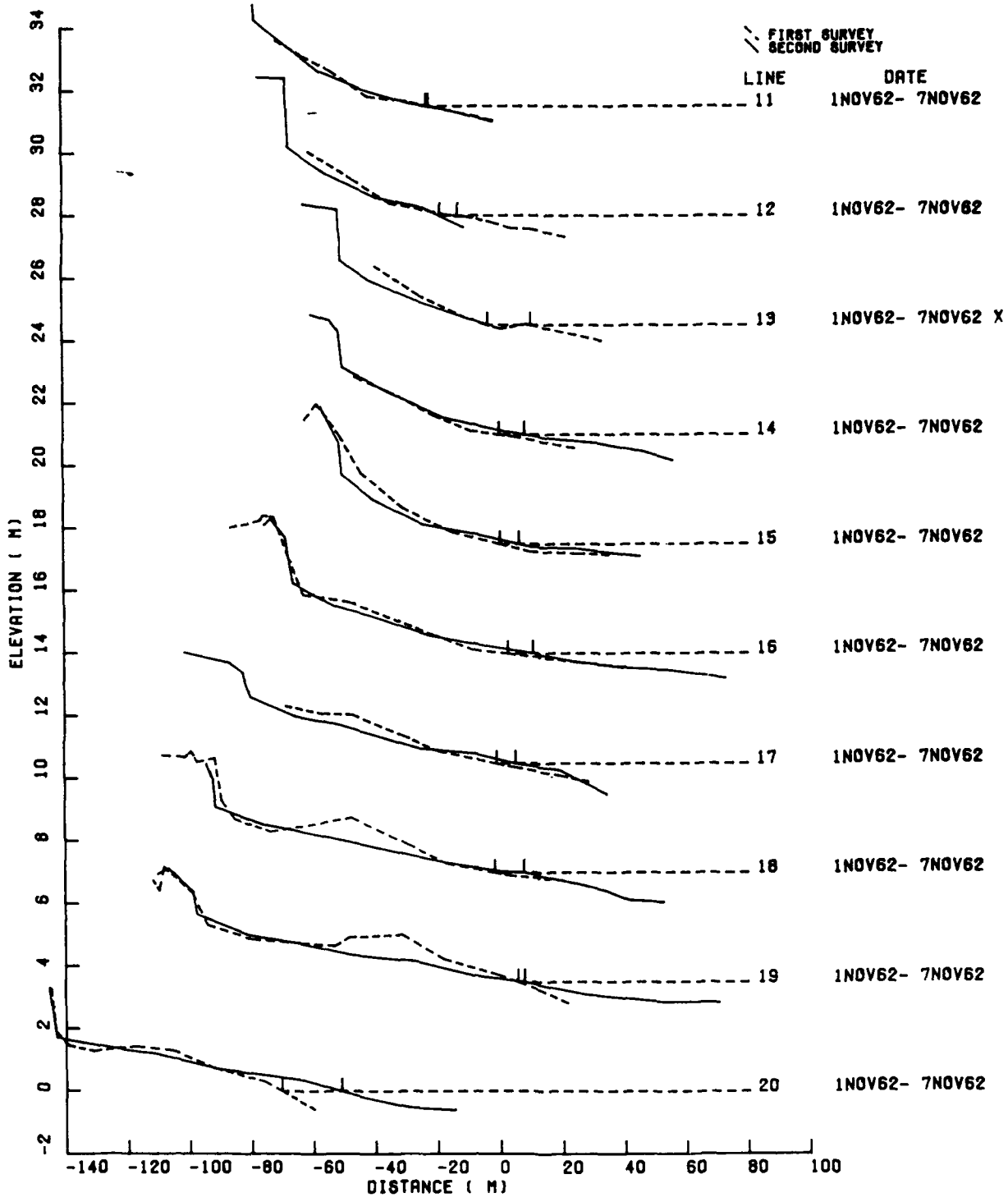



Figure A8. Hindcasted wave data for Ludlam Beach, N. J.




a. Profile lines 2-10

Figure A9. Profile comparisons for surveys at Ludlam Beach, N. J. (Continued)




b. Profile lines 11-20

Figure A9. (Concluded)

Table A5

Shoreline and Slope Changes at Ludlam Beach, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 2 | 1 Nov 62 | 7 Nov 62 | 6.00 | -0.031 | -0.029 | 0.002 |
| 3 | 1 Nov 62 | 7 Nov 62 | 7.67 | -0.024 | -0.018 | 0.006 |
| 4 | 1 Nov 62 | 7 Nov 62 | -12.19 | -0.010 | -0.029 | -0.020 |
| 5 | 1 Nov 62 | 7 Nov 62 | -3.30 | -0.019 | -0.011 | 0.008 |
| 6 | 1 Nov 62 | 7 Nov 62 | 2.67 | -0.029 | -0.031 | -0.002 |
| 7 | 1 Nov 62 | 7 Nov 62 | 11.37 | -0.300 | -0.012 | 0.288 |
| 8 | 1 Nov 62 | 7 Nov 62 | 42.96 | -0.050 | -0.052 | -0.002 |
| 9 | 1 Nov 62 | 7 Nov 62 | 1.70 | -0.700 | -0.450 | 0.250 |
| 10 | 1 Nov 62 | 7 Nov 62 | 4.34 | -0.037 | -0.023 | 0.014 |
| 11 | 1 Nov 62 | 7 Nov 62 | -0.76 | -0.020 | -0.016 | 0.004 |
| 12 | 1 Nov 62 | 7 Nov 62 | -5.67 | -0.010 | -0.049 | -0.039 |
| 13 | 1 Nov 62 | 7 Nov 62 X | -13.56 | -0.022 | -0.035 | -0.013 |
| 14 | 1 Nov 62 | 7 Nov 62 | 8.09 | -0.014 | -0.017 | -0.004 |
| 15 | 1 Nov 62 | 7 Nov 62 | 6.02 | -0.026 | -0.024 | 0.002 |
| 16 | 1 Nov 62 | 7 Nov 62 | 7.96 | -0.011 | -0.020 | -0.008 |
| 17 | 1 Nov 62 | 7 Nov 62 | 5.97 | -0.022 | -0.024 | -0.003 |
| 18 | 1 Nov 62 | 7 Nov 62 | 9.21 | -0.020 | -0.004 | 0.015 |
| 19 | 1 Nov 62 | 7 Nov 62 | 2.13 | -0.036 | -0.013 | 0.023 |
| 20 | 1 Nov 62 | 7 Nov 62 | 19.37 | -0.055 | -0.028 | 0.026 |
| Median | | | 5.97 | -0.024 | -0.024 | 0.002 |
| Tri-Mean | | | 5.11 | -0.026 | -0.024 | 0.004 |
| High Hinge | | | 8.03 | -0.020 | -0.017 | 0.015 |
| Low Hinge | | | 0.47 | -0.037 | -0.030 | -0.004 |
| Mean | | | 5.26 | -0.076 | -0.047 | 0.029 |
| Standard Deviation | | | 12.05 | 0.164 | 0.098 | 0.086 |

Note: X = Extrapolated shoreline intercept.

Table A6

Unit Volume Changes ($m^3/m$) Between Contours
Ludlam Beach, N.J.
from 1 Nov 62 to 7 Nov 62

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 0.27 | 1.96 | 0.00 | -4.78 | 0.38 | 1.58 | 1.11 | 0.01 | 0.00 | | | | | | |
| 3 | 17.76 | 4.31 | 5.62 | 2.18 | 3.30 | 2.25 | 1.11 | -0.68 | -0.33 | | | | | | |
| 4 | -12.49 | -4.21 | -3.42 | -4.53 | -0.32 | 0.00 | | | | | | | | | |
| 5 | -0.61 | -2.10 | -3.14 | -5.31 | 5.42 | 2.03 | 1.34 | 0.71 | 0.26 | 0.18 | | | | | |
| 6 | -17.12 | -5.83 | -6.85 | -4.23 | -0.21 | | | | | | | | | | |
| 7 | -9.61 | 1.29 | -5.61 | -6.92 | 2.48 | -0.56 | -0.28 | -0.02 | 0.00 | | | | | | |
| 8 | -3.64 | 4.75 | -0.47 | -4.30 | -3.37 | -0.25 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| 9 | -1.94 | 0.70 | 0.39 | -1.50 | -1.53 | | | | | | | | | | |
| 10 | -6.31 | 0.56 | -1.40 | -6.65 | 0.30 | 0.11 | 0.15 | 0.54 | 0.07 | 0.00 | | | | | |
| 11 | -0.80 | 0.93 | -0.15 | -1.49 | -0.24 | 0.15 | 0.00 | 0.00 | | | | | | | |
| 12 | -5.20 | 0.65 | -1.22 | -2.61 | -2.00 | -0.01 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| 13 | -6.76 | X -0.37 | -1.92 | -3.33 | -1.14 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | |
| 14 | 4.33 | 3.38 | 0.64 | -0.06 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | |
| 15 | -11.63 | 2.30 | -1.77 | -2.56 | -3.31 | -3.12 | -1.93 | -0.87 | -0.41 | 0.04 | | | | | |
| 16 | -2.92 | 3.35 | -1.28 | -2.81 | -1.39 | -0.42 | -0.37 | 0.19 | 0.44 | -0.63 | | | | | |
| 17 | -10.78 | 2.60 | -3.56 | -6.81 | -3.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | |
| 18 | -20.80 | 0.62 | -5.49 | -10.65 | -1.49 | -1.26 | -0.96 | -1.21 | -0.36 | | | | | | |
| 19 | -22 24 | -3.39 | -9.43 | -11.92 | 1.91 | -0.44 | 0.03 | 0.97 | 0.03 | | | | | | |
| 20 | 6.16 | 7.39 | 0.37 | -1.92 | 0.56 | -0.05 | -0.15 | -0.04 | | | | | | | |
| Median | -5.20 | 0.93 | -1.40 | -4.23 | -0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| Tri-mean | -5.58 | 1.23 | -1.59 | -4.17 | -0.38 | -0.08 | -0.03 | 0.02 | 0.01 | 0.01 | | | | | |
| High Hinge | -0.71 | 2.97 | -0.08 | -2.24 | 0.47 | 0.11 | 0.09 | 0.10 | 0.03 | 0.04 | | | | | |
| Low Hinge | -11.20 | 0.09 | -3.49 | -5.98 | -1.51 | -0.42 | -0.22 | -0.03 | 0.00 | 0.00 | | | | | |
| Mean | -5.49 | 0.99 | -2.04 | -4.22 | -0.17 | 0.00 | 0.00 | -0.02 | -0.02 | -0.07 | | | | | |
| Std Dev | 9.60 | 3.23 | 3.31 | 3.40 | 2.28 | 1.22 | 0.78 | 0.54 | 0.23 | 0.28 | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

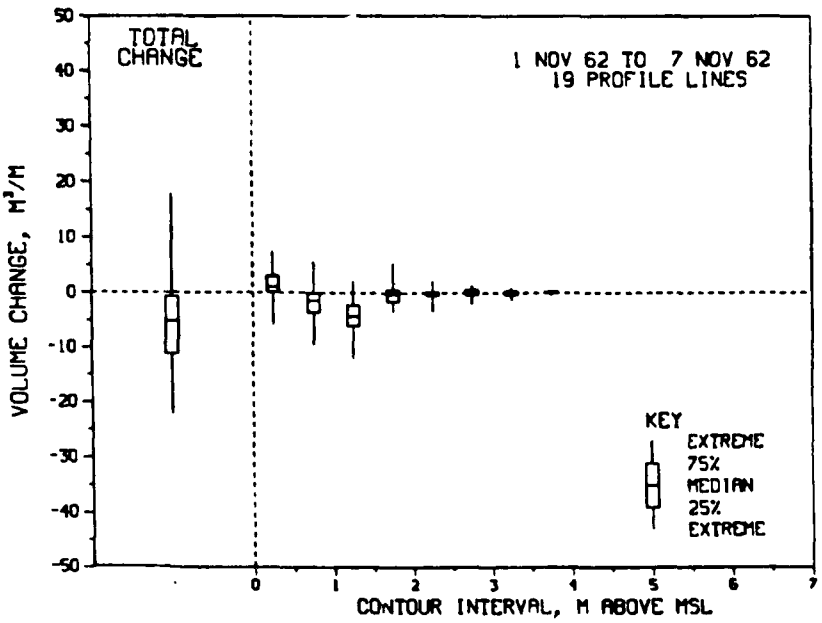



Figure A10. Distribution of volume changes by contour for Ludlam Beach, N. J.

## APPENDIX B: DATA SUMMARY FOR THE STORM OF 6 NOVEMBER 1963

1. The 6 November 1963 storm is documented through its effects on the New Jersey localities, including Long Beach Island, Atlantic City, and Ludlam Beach. Development of the storm system is shown on the surface weather maps. Peak high tide at the Atlantic City gage measured 1.4 m above msl with a surge greater than 0.7 m. Hindcasted wave heights ranged from 2.4 to 2.7 m. At all sites, storm waves reached shore during the period of maximum surge, which occurred approximately 12 hr prior to the peak tide. Two storm events are evident in the wave time series with the minor peak occurring 1 week prior to the major storm. Poststorm surveys were conducted 1 week after the second event.

2. This storm had minor effects on a majority of the profile lines at Long Beach Island and Ludlam Beach. Median volume changes were small with hinge ranges of 10 to 17 $m^3/m$. Atlantic City, however, significantly eroded with a median volume change of -25.2 $m^3/m$. Even though there was a large range between the extremes at Atlantic City, the hinge range was only 16 $m^3/m$. The most significant erosion occurred lower on the berm from the 0.0- to 1.5-m contour intervals at Long Beach Island and Ludlam Beach, whereas the entire berm from the 0.0- to 3.0-m contour eroded at Atlantic City. The loss of 150.4 $m^3/m$ of material on profile line 1 is the largest single profile change of all the data presented in this study. This line is affected by its proximity to the south jetty of Absecon Inlet.

3. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.

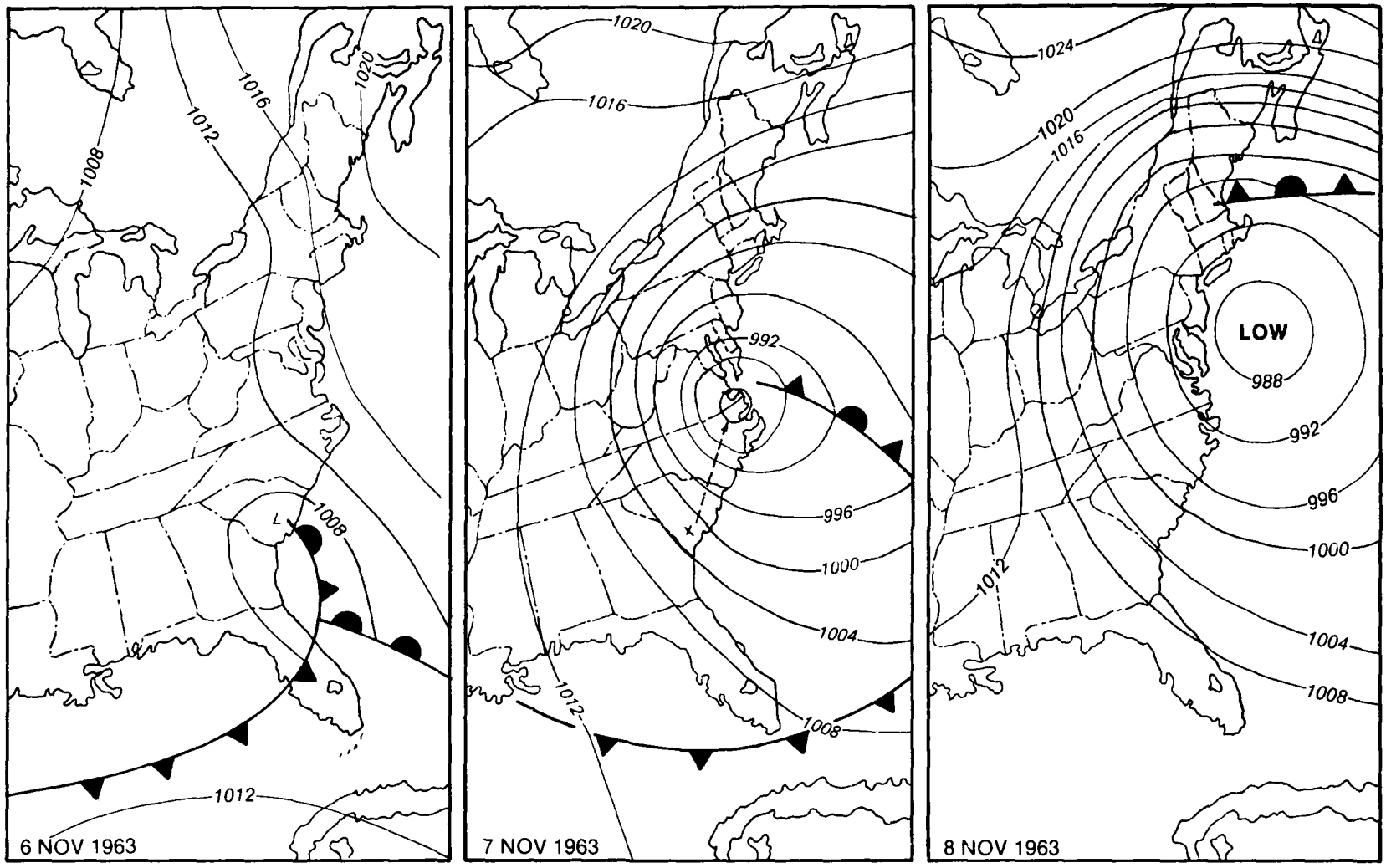



Figure B1. Synoptic weather maps at 0700 EST showing movement of the storm from 6-8 November 1963 (from Bosserman and Dolan 1968)

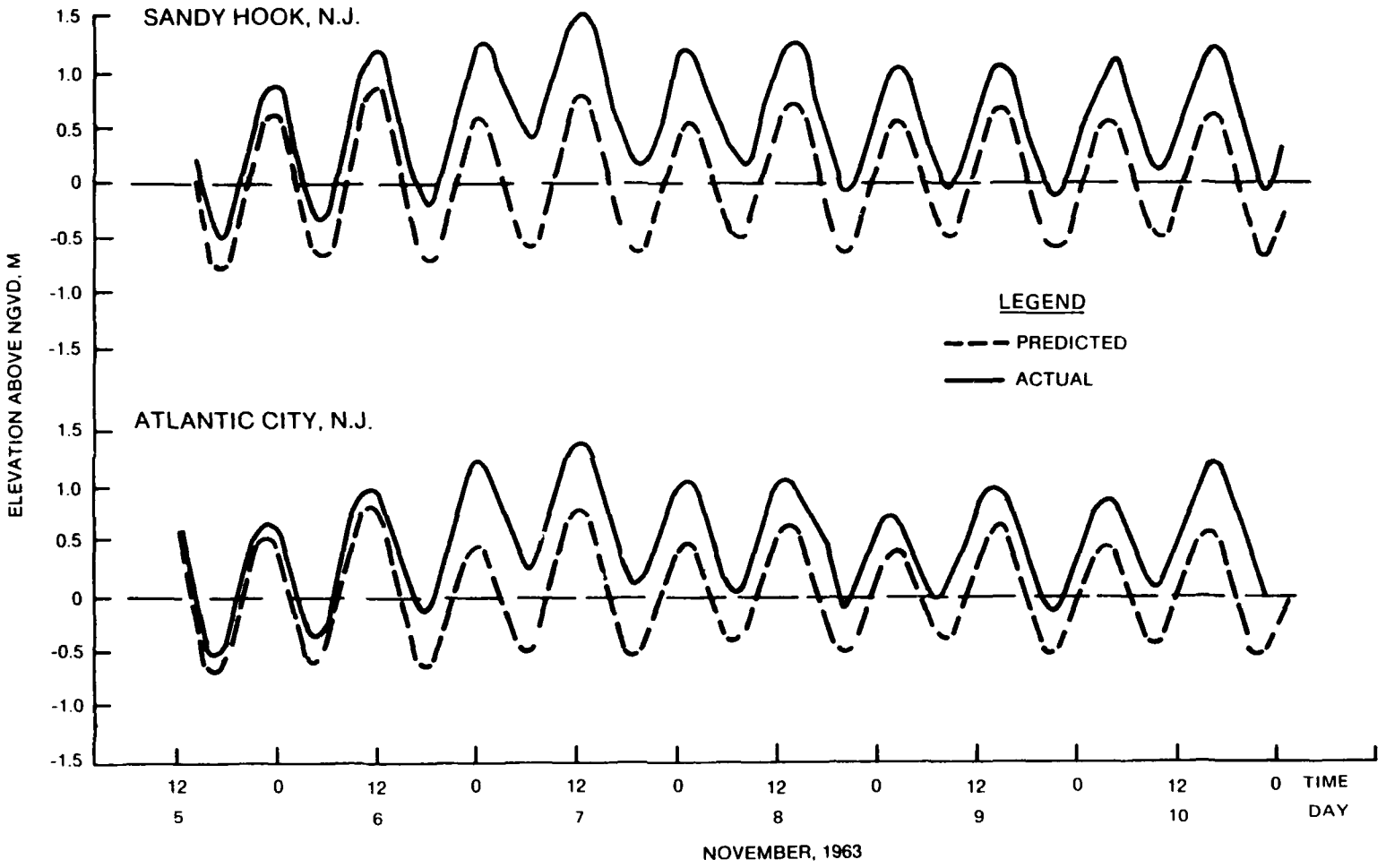



Figure B2. Predicted and actual water levels for 5-10 November 1963

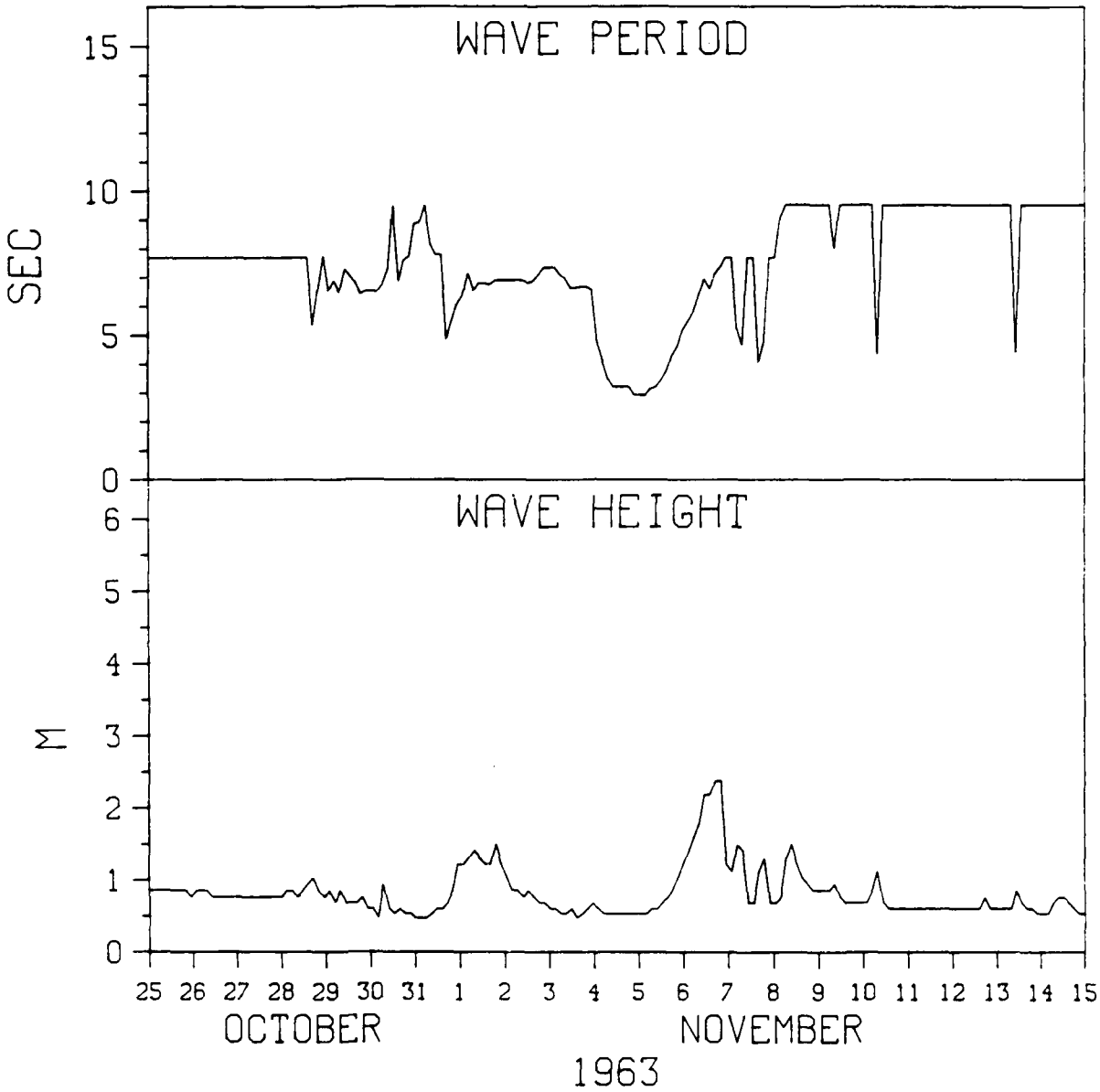
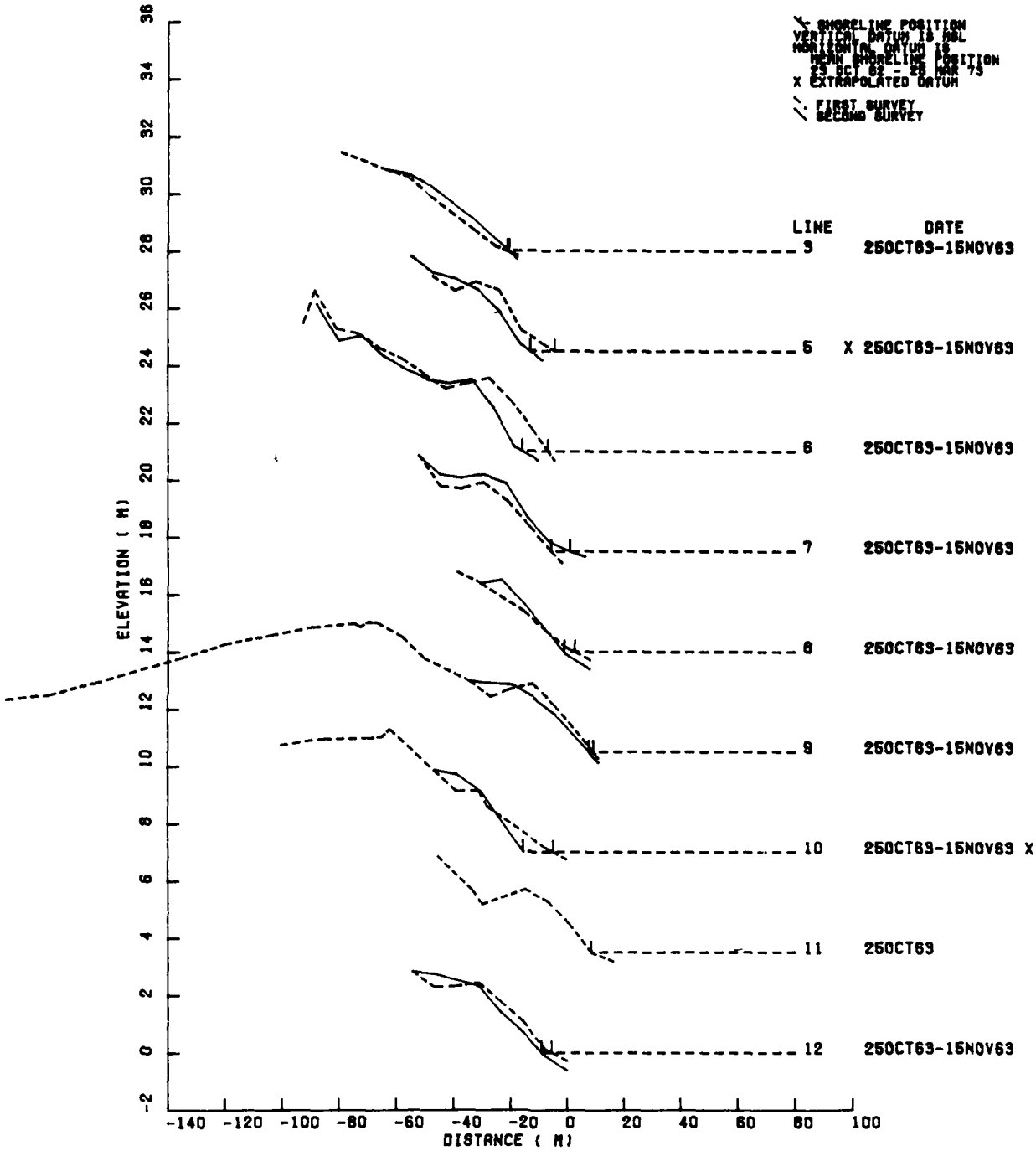
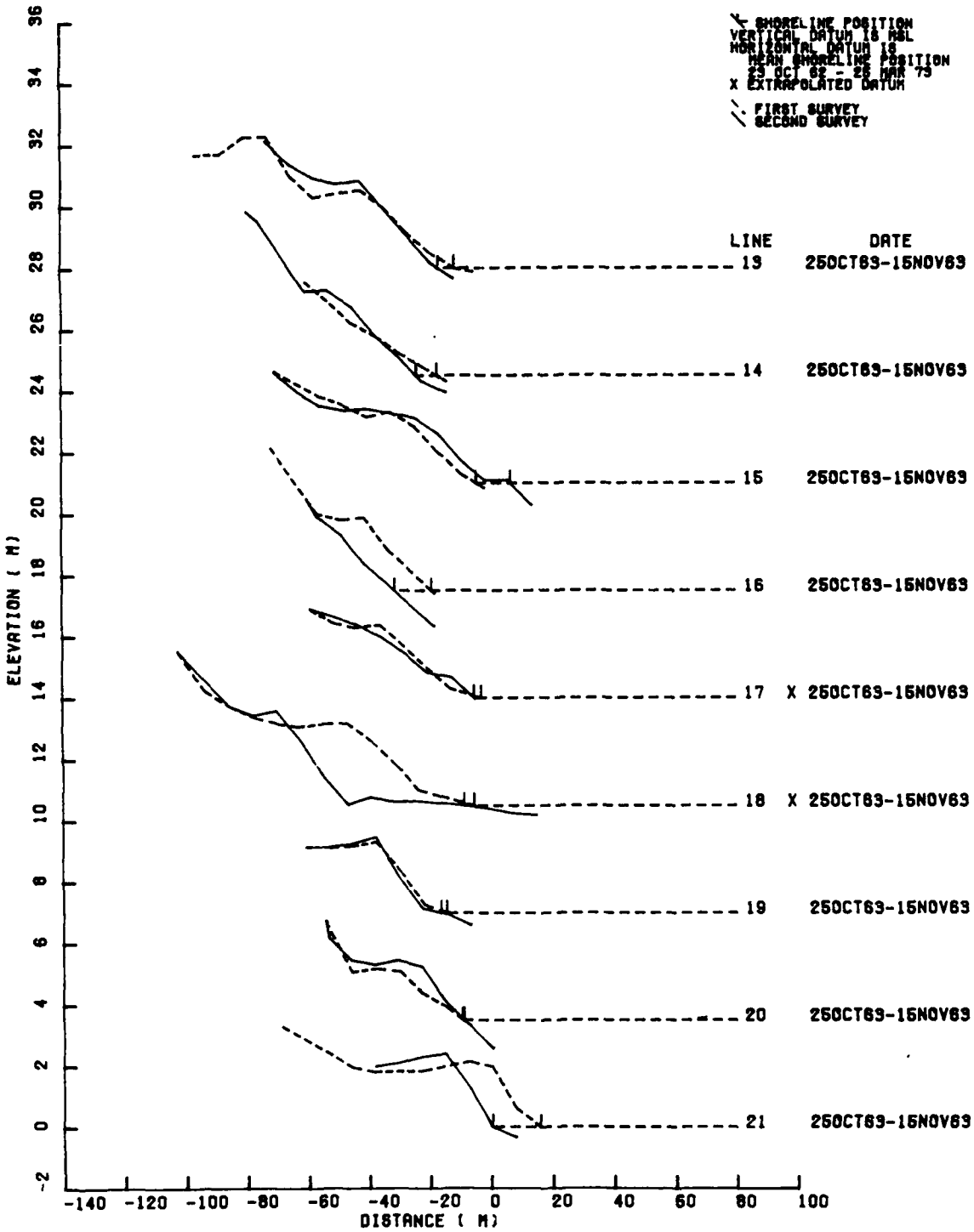



Figure B3. Hindcasted wave data for Long Beach Island, N. J.




a. Profile lines 3-12

Figure B4. Profile comparisons for surveys at Long Beach Island, N. J. (Continued)




b. Profile lines 13-21

Figure B4. (Concluded)

Table B1

Shoreline and Slope Changes at Long Beach Island, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 3 | 25 Oct 63 | 15 Nov 63 | 0.61 | -0.042 | -0.092 | -0.049 |
| 5 | 25 Oct 63 X | 15 Nov 63 | -8.81 | -0.062 | -0.072 | -0.010 |
| 6 | 25 Oct 63 | 15 Nov 63 | -9.10 | -0.140 | -0.056 | 0.084 |
| 7 | 25 Oct 63 | 15 Nov 63 | 6.58 | -0.111 | -0.046 | 0.064 |
| 8 | 25 Oct 63 | 15 Nov 63 | -3.71 | -0.052 | -0.118 | -0.067 |
| 9 | 25 Oct 63 | 15 Nov 63 | -1.55 | -0.120 | -0.110 | 0.010 |
| 10 | 25 Oct 63 | 15 Nov 63 X | -10.62 | -0.054 | -0.143 | -0.088 |
| 12 | 25 Oct 63 | 15 Nov 63 | -3.49 | -0.052 | -0.108 | -0.056 |
| 13 | 25 Oct 63 | 15 Nov 63 | -5.24 | -0.063 | -0.068 | -0.005 |
| 14 | 25 Oct 63 | 15 Nov 63 | -6.76 | -0.063 | -0.104 | -0.042 |
| 15 | 25 Oct 63 | 15 Nov 63 | 11.11 | -0.058 | -0.104 | -0.046 |
| 16 | 25 Oct 63 | 15 Nov 63 | -12.17 | -0.094 | -0.088 | 0.006 |
| 17 | 25 Oct 63 X | 15 Nov 63 | -2.39 | -0.030 | -0.092 | -0.062 |
| 18 | 25 Oct 63 X | 15 Nov 63 | -3.27 | -0.028 | -0.010 | 0.018 |
| 19 | 25 Oct 63 | 15 Nov 63 | -1.83 | -0.038 | -0.025 | 0.013 |
| 20 | 25 Oct 63 | 15 Nov 63 | 0.46 | -0.080 | -0.100 | -0.020 |
| 21 | 25 Oct 63 | 15 Nov 63 | -15.55 | -0.077 | -0.175 | -0.098 |
| Median | | | -3.49 | -0.062 | -0.092 | -0.020 |
| Tri-Mean | | | -4.33 | -0.064 | -0.090 | -0.022 |
| High Hinge | | | -1.55 | -0.052 | -0.068 | 0.010 |
| Low Hinge | | | -8.81 | -0.080 | -0.108 | -0.056 |
| Mean | | | -3.86 | -0.068 | -0.089 | -0.020 |
| Standard Deviation | | | 6.60 | 0.032 | 0.041 | 0.050 |

Note: X = Extrapolated shoreline intercept.

Table B2

Unit Volume Changes ($m^3/m$) Between Contours
Long Beach Island, N.J.
from 25 Oct 63 to 15 Nov 63

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 10.81 | 1.38 | 2.08 | 2.38 | 2.39 | 1.97 | 0.62 | 0.00 | | | | | | | |
| 5 | -9.83 | X -3.86 | -2.03 | -1.98 | -2.82 | -0.15 | 1.01 | 0.00 | | | | | | | |
| 6 | -28.70 | -5.14 | -4.82 | -4.28 | -3.94 | -1.86 | -1.58 | -2.11 | -1.10 | -2.25 | -0.95 | -0.67 | 0.00 | | |
| 7 | 16.46 | 1.88 | 1.13 | 1.18 | 1.85 | 6.80 | 3.36 | 0.26 | | | | | | | |
| 8 | 5.88 | -0.90 | 0.17 | 0.96 | 2.35 | 3.31 | 0.00 | | | | | | | | |
| 9 | -3.11 | -0.87 | -1.06 | -1.32 | -2.03 | 2.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 10 | -1.32 | X -4.13 | -2.27 | -0.46 | 0.60 | 2.96 | 1.98 | 0.00 | 0.00 | 0.00 | | | | | |
| 12 | -2.43 | -1.29 | -1.60 | -2.05 | -1.57 | 1.52 | 2.56 | | | | | | | | |
| 13 | 7.67 | -2.18 | -0.99 | -0.37 | -0.23 | 2.23 | 7.45 | 1.78 | 0.21 | -0.23 | | | | | |
| 14 | 2.43 | -2.55 | -0.90 | 0.14 | 2.21 | 2.82 | 0.72 | -0.01 | 0.00 | 0.00 | 0.00 | 0.00 | | | |
| 15 | 7.94 | 3.12 | 2.44 | 2.72 | 2.51 | 1.59 | -2.97 | -1.36 | -0.11 | | | | | | |
| 16 | -29.60 | -6.17 | -6.32 | -5.95 | -5.98 | -5.09 | -0.10 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 17 | -0.53 | X 1.23 | 0.72 | -1.01 | -1.68 | -0.92 | 1.13 | | | | | | | | |
| 18 | -59.90 | X -12.37 | -13.73 | -13.27 | -12.31 | -11.17 | -0.27 | 0.51 | 1.38 | 0.98 | 0.35 | 0.00 | | | |
| 19 | -1.58 | -1.11 | -0.85 | -0.87 | -0.33 | 1.58 | | | | | | | | | |
| 20 | 12.94 | 0.55 | 2.15 | 3.56 | 7.11 | 0.18 | -0.58 | -0.03 | | | | | | | |
| 21 | -16.48 | -6.86 | -5.61 | -5.64 | -2.32 | 3.95 | 0.00 | 0.00 | | | | | | | |
| Median | -1.32 | -1.29 | -0.99 | -0.87 | -0.33 | 1.59 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | |
| Tri-mean | -1.20 | -1.54 | -0.88 | -0.71 | -0.19 | 1.46 | 0.50 | 0.00 | 0.01 | -0.03 | 0.00 | -0.08 | 0.00 | | |
| High Hinge | 7.67 | 0.55 | 0.72 | 0.96 | 2.21 | 2.82 | 1.56 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | | |
| Low Hinge | -9.83 | -4.13 | -2.27 | -2.05 | -2.32 | -0.15 | -0.19 | -0.01 | -0.05 | -0.12 | 0.00 | -0.34 | 0.00 | | |
| Mean | -5.26 | -2.31 | -1.85 | -1.54 | -0.83 | 0.70 | 0.83 | -0.07 | 0.05 | -0.21 | -0.12 | -0.22 | 0.00 | | |
| Std Dev | 19.24 | 3.86 | 4.01 | 4.04 | 4.26 | 4.01 | 2.33 | 0.90 | 0.67 | 0.98 | 0.49 | 0.39 | 0.00 | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

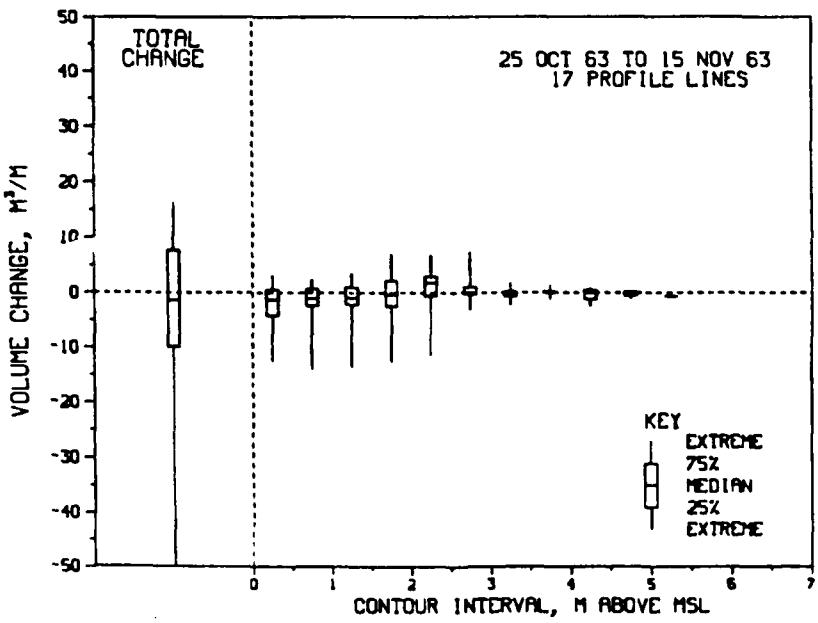



Figure B5. Distribution of volume changes by contour for Long Beach Island, N. J.

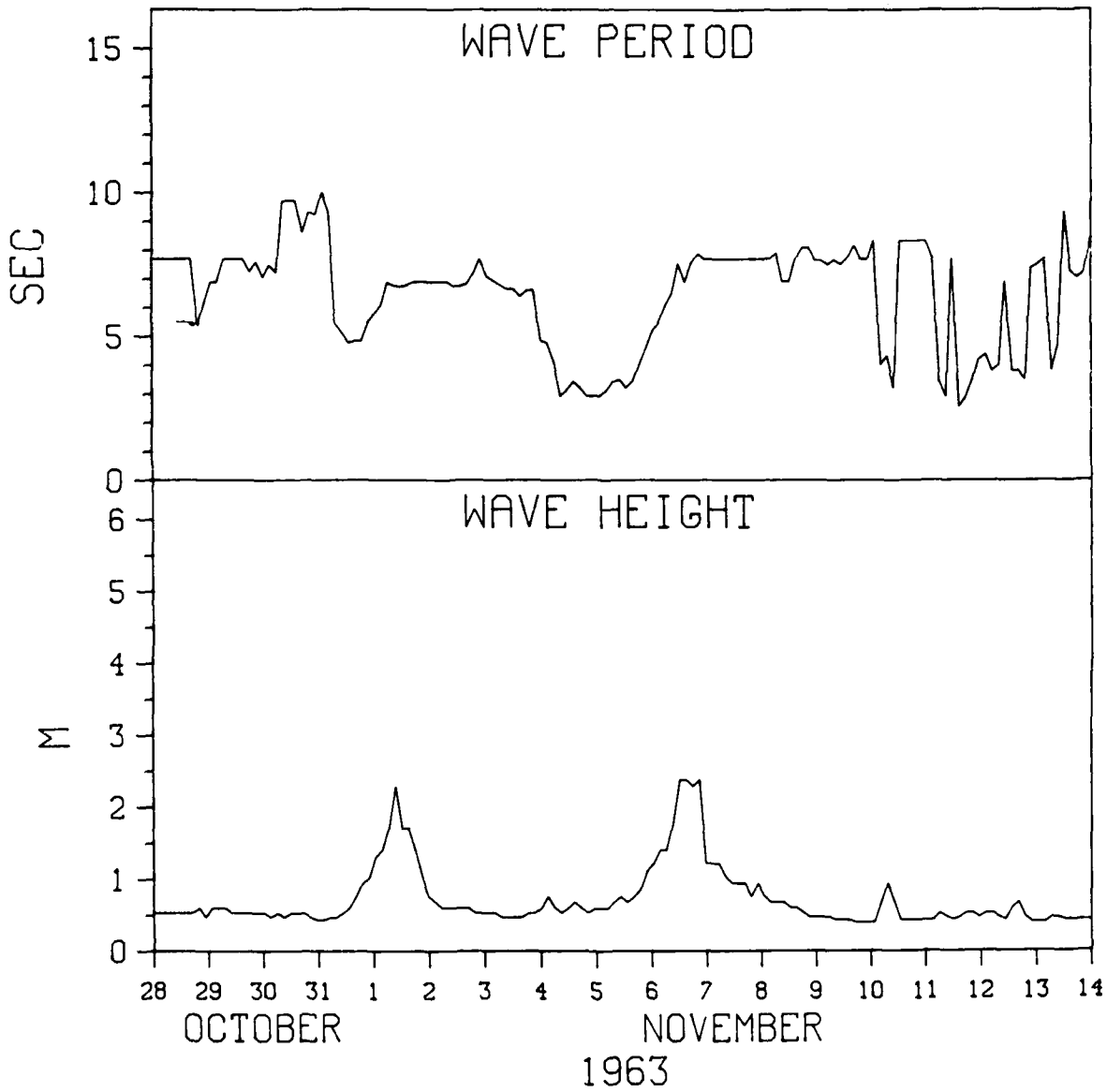



Figure B6. Hindcasted wave data for Atlantic City, N. J.

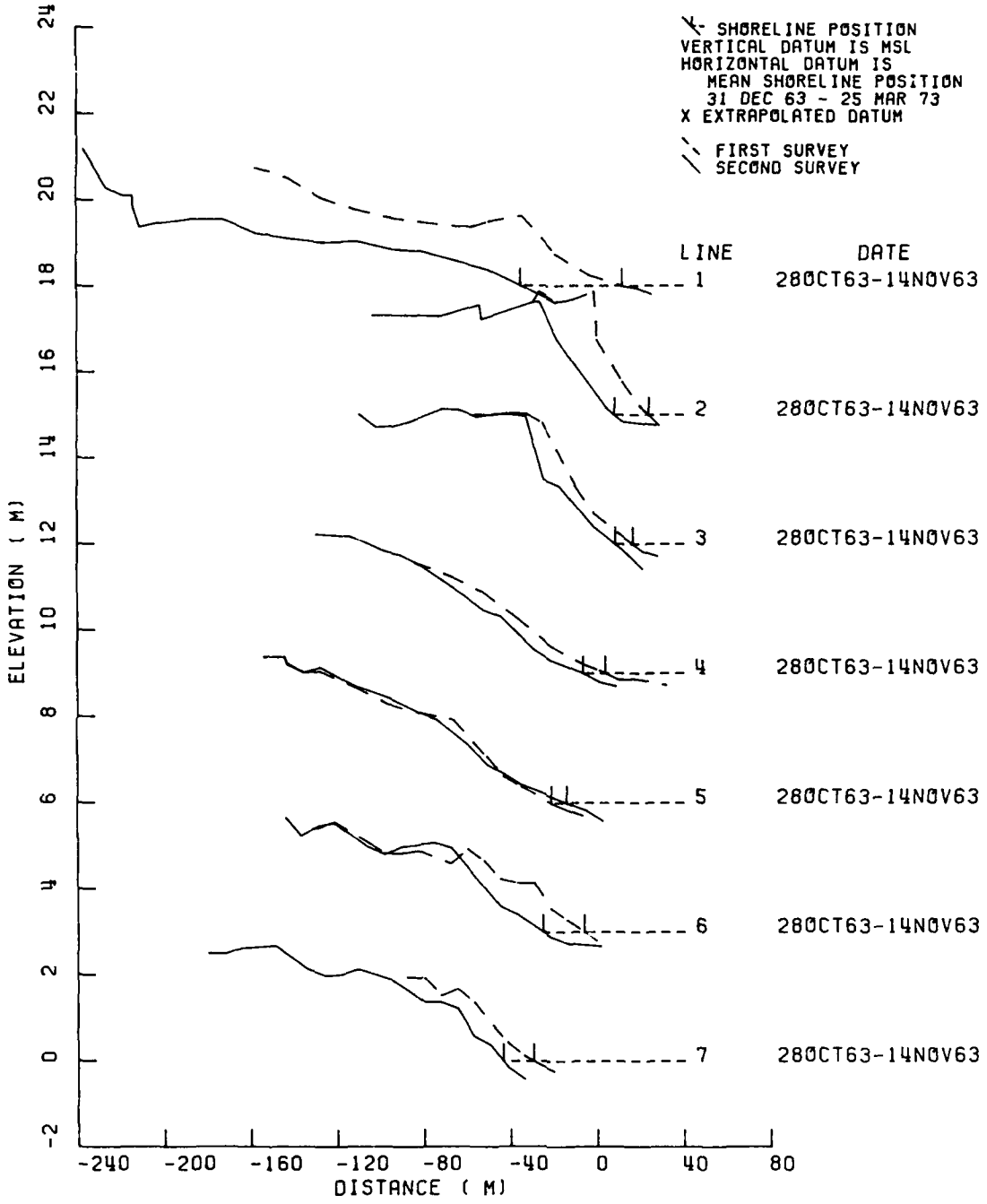



Figure B7. Profile comparisons for surveys at Atlantic City, N. J.

Table B3

Shoreline and Slope Changes at Atlantic City, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 28 Oct 63 | 14 Nov 63 | -46.79 | -0.016 | -0.025 | -0.009 |
| 2 | 28 Oct 63 | 14 Nov 63 | -15.85 | -0.050 | -0.042 | 0.008 |
| 3 | 28 Oct 63 | 14 Nov 63 | -8.08 | -0.038 | -0.040 | -0.003 |
| 4 | 28 Oct 63 | 14 Nov 63 | -10.23 | -0.023 | -0.020 | 0.003 |
| 5 | 28 Oct 63 | 14 Nov 63 | 7.06 | -0.027 | -0.020 | 0.007 |
| 6 | 28 Oct 63 | 14 Nov 63 | -18.98 | -0.035 | -0.034 | 0.001 |
| 7 | 28 Oct 63 | 14 Nov 63 | -14.00 | -0.028 | -0.065 | -0.037 |
| Median | | | -14.00 | -0.028 | -0.034 | 0.001 |
| Tri-Mean | | | -13.64 | -0.029 | -0.033 | 0.000 |
| High Hinge | | | -9.16 | -0.025 | -0.023 | 0.005 |
| Low Hinge | | | -17.41 | -0.037 | -0.041 | -0.006 |
| Mean | | | -15.27 | -0.031 | -0.035 | -0.004 |
| Standard Deviation | | | 16.25 | 0.011 | 0.016 | 0.016 |

Note: X = Extrapolated shoreline intercept.

Table B4

Unit Volume Changes ($m^3/m$) Between Contours
Atlantic City, N.J.
from 28 Oct 63 to 14 Nov 63

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -150.85 | -21.92 | -31.49 | -58.16 | -25.64 | -11.80 | -1.85 | 0.00 | | | | | | | |
| 2 | -51.40 | -8.07 | -8.12 | -8.63 | -9.34 | -11.19 | -6.05 | | | | | | | | |
| 3 | -25.20 | -3.92 | -2.96 | -3.95 | -6.03 | -4.78 | -3.28 | -0.28 | | | | | | | |
| 4 | -22.34 | -5.47 | -4.58 | -3.94 | -5.38 | -2.92 | -0.04 | 0.00 | | | | | | | |
| 5 | 0.53 | 2.00 | -0.30 | -1.76 | -3.02 | 1.83 | 1.26 | 0.52 | | | | | | | |
| 6 | -26.46 | -9.70 | -11.52 | -7.34 | 2.51 | -0.31 | -0.10 | | | | | | | | |
| 7 | -24.61 | -5.42 | -5.96 | -7.23 | -6.00 | 0.00 | 0.00 | | | | | | | | |
| Median | -25.20 | -5.47 | -5.96 | -7.23 | -6.00 | -2.92 | -0.10 | 0.00 | | | | | | | |
| Tri-mean | -28.20 | -6.12 | -6.38 | -6.60 | -5.97 | -3.49 | -0.70 | 0.03 | | | | | | | |
| High Hinge | -23.48 | -4.67 | -3.77 | -3.95 | -4.20 | -0.16 | -0.02 | 0.26 | | | | | | | |
| Low Hinge | -38.93 | -8.89 | -9.82 | -7.99 | -7.69 | -7.98 | -2.57 | -0.14 | | | | | | | |
| Mean | -42.90 | -7.50 | -9.28 | -13.00 | -7.56 | -4.17 | -1.44 | 0.06 | | | | | | | |
| Std Dev | 49.92 | 7.36 | 10.44 | 20.06 | 8.77 | 5.44 | 2.51 | 0.33 | | | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

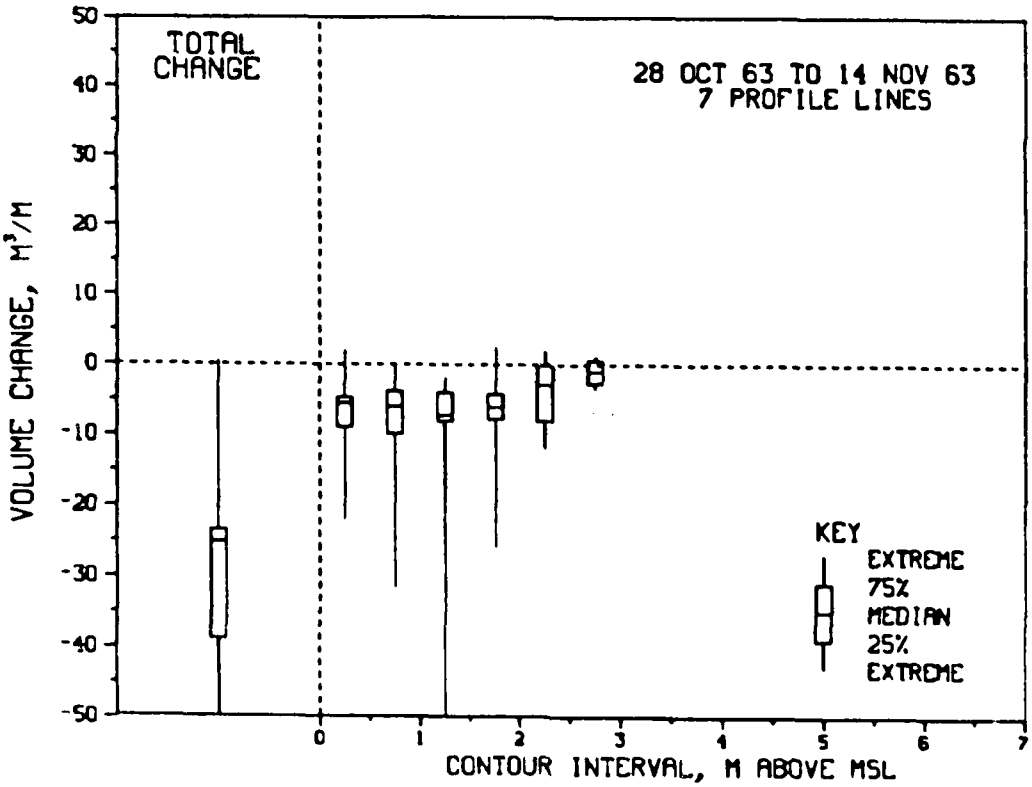



Figure B8. Distribution of volume changes by contour for Atlantic City, N. J.

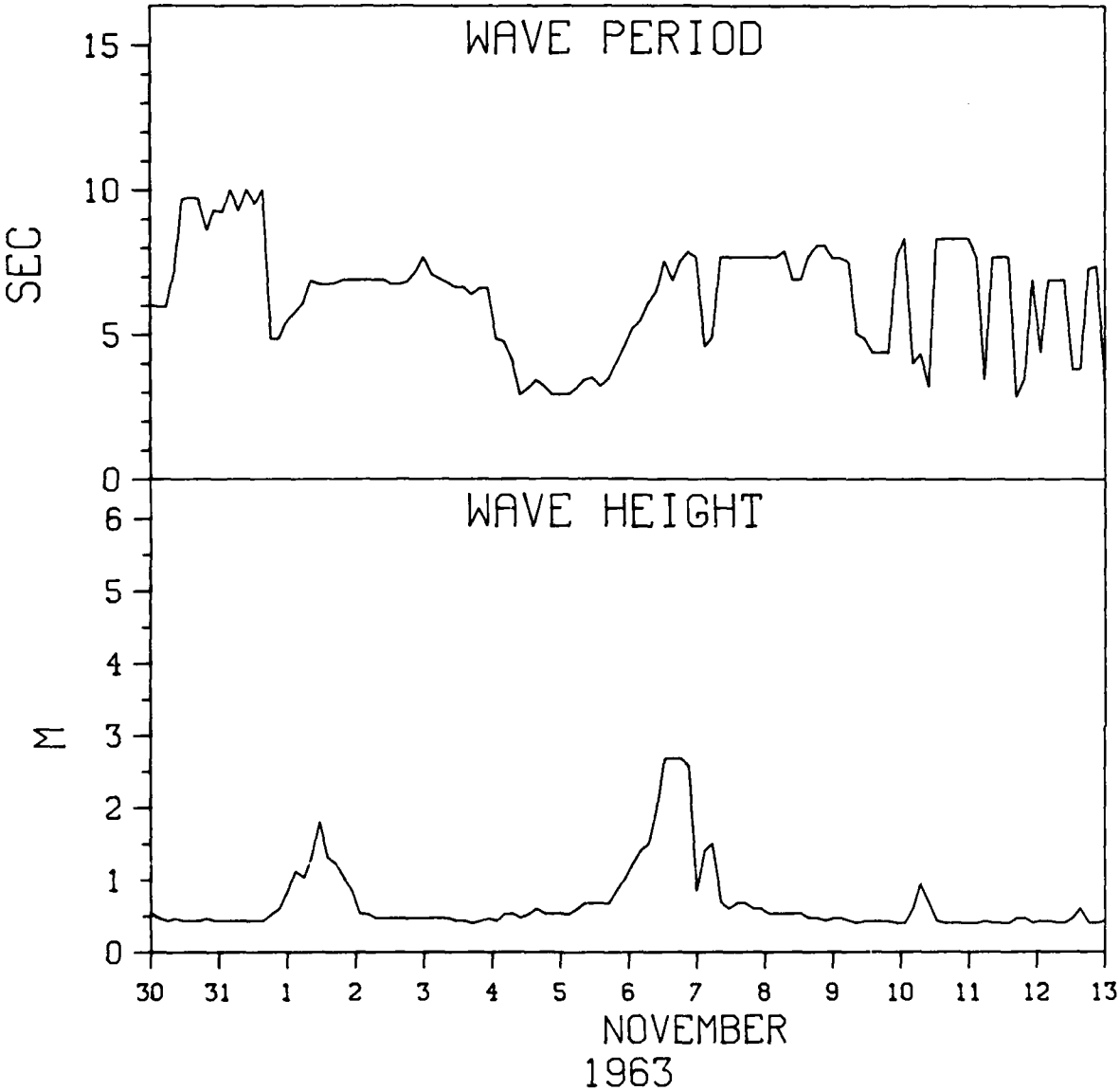
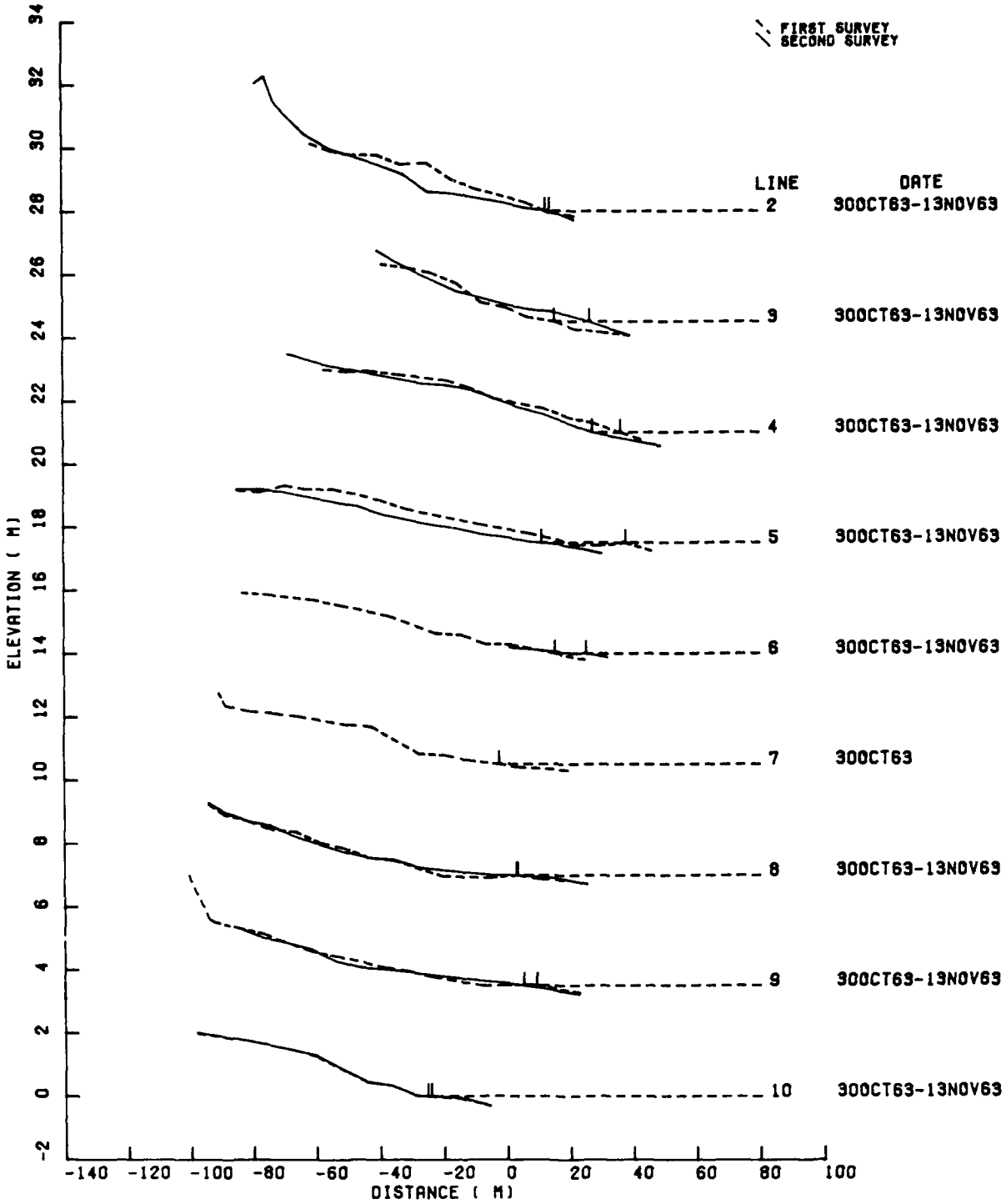
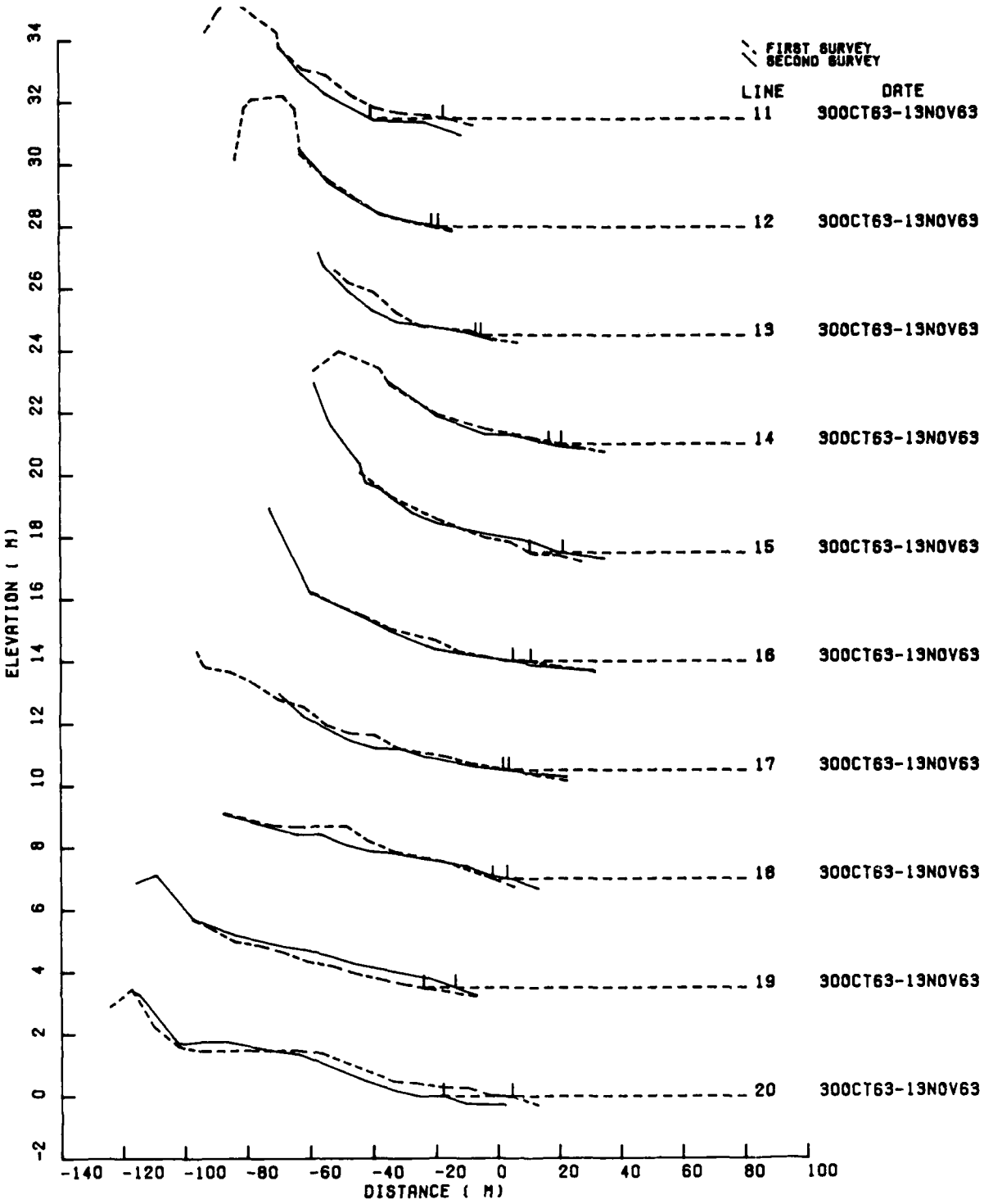



Figure B9. Hindcasted wave data for Ludlam Beach, N. J.




a. Profile lines 2-10

Figure B10. Profile comparisons for surveys at Ludlam Beach, N. J. (Continued)




b. Profile lines 11-20

Figure B10. (Concluded)

Table B5

Shoreline and Slope Changes at Ludlam Beach, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 2 | 30 Oct 63 | 13 Nov 63 | 1.39 | -0.044 | -0.012 | 0.032 |
| 3 | 30 Oct 63 | 13 Nov 63 | 11.21 | -0.018 | -0.034 | -0.016 |
| 4 | 30 Oct 63 | 13 Nov 63 | -8.97 | -0.034 | -0.037 | -0.003 |
| 5 | 30 Oct 63 | 13 Nov 63 | -26.67 | 0.011 | -0.008 | -0.019 |
| 6 | 30 Oct 63 | 13 Nov 63 | 9.88 | -0.020 | -0.004 | 0.016 |
| 8 | 30 Oct 63 | 13 Nov 63 | 0.31 | 0.011 | 0.000 | -0.011 |
| 9 | 30 Oct 63 | 13 Nov 63 | -4.12 | -0.016 | -0.016 | 0.000 |
| 10 | 30 Oct 63 | 13 Nov 63 | 1.17 | -0.008 | -0.006 | 0.002 |
| 11 | 30 Oct 63 | 13 Nov 63 | -23.26 | -0.019 | -0.054 | -0.035 |
| 12 | 30 Oct 63 | 13 Nov 63 | 2.11 | -0.024 | -0.022 | 0.002 |
| 13 | 30 Oct 63 | 13 Nov 63 | -1.72 | -0.039 | -0.028 | 0.011 |
| 14 | 30 Oct 63 | 13 Nov 63 | -4.06 | -0.020 | -0.024 | -0.004 |
| 15 | 30 Oct 63 | 13 Nov 63 | 10.72 | -0.052 | -0.016 | 0.036 |
| 16 | 30 Oct 63 | 13 Nov 63 | -5.79 | 0.000 | -0.013 | -0.013 |
| 17 | 30 Oct 63 | 13 Nov 63 | -1.83 | -0.018 | -0.012 | 0.005 |
| 18 | 30 Oct 63 | 13 Nov 63 | 4.72 | -0.040 | -0.017 | 0.023 |
| 19 | 30 Oct 63 | 13 Nov 63 | 10.22 | -0.019 | -0.035 | -0.016 |
| 20 | 30 Oct 63 | 13 Nov 63 | -22.25 | -0.004 | 0.000 | 0.004 |
| Median | | | -0.71 | -0.019 | -0.016 | 0.001 |
| Tri-Mean | | | -0.62 | -0.020 | -0.017 | 0.000 |
| High Hinge | | | 4.72 | -0.008 | -0.008 | 0.011 |
| Low Hinge | | | -5.79 | -0.034 | -0.028 | -0.013 |
| Mean | | | -2.61 | -0.020 | -0.019 | 0.001 |
| Standard Deviation | | | 11.51 | 0.018 | 0.014 | 0.018 |

Note: X = Extrapolated shoreline intercept.

Table B6

Unit Volume Changes ($m^3/m$) Between Contours
Ludlam Beach, N.J.
from 30 Oct 63 to 13 Nov 63

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | -19.14 | -3.39 | -7.47 | -6.91 | -2.02 | 0.65 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| 3 | 4.57 | 5.38 | 0.82 | -2.38 | 0.51 | 0.24 | | | | | | | | | |
| 4 | -9.92 | -3.90 | -2.50 | -0.71 | -3.48 | 0.67 | | | | | | | | | |
| 5 | -26.21 | -6.93 | -7.67 | -7.45 | -4.16 | | | | | | | | | | |
| 6 | -0.20 | -0.20 | 0.00 | 0.00 | 0.00 | | | | | | | | | | |
| 8 | 1.43 | 2.32 | -1.09 | -0.98 | 0.88 | 0.30 | | | | | | | | | |
| 9 | -1.01 | 2.55 | -2.84 | 0.09 | -0.81 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | |
| 10 | 0.82 | 0.05 | 0.20 | 0.30 | 0.27 | 0.00 | | | | | | | | | |
| 11 | -14.28 | -6.28 | -3.74 | -3.54 | -0.71 | -0.01 | 0.00 | 0.00 | 0.00 | | | | | | |
| 12 | 0.00 | 0.54 | -0.30 | -0.56 | -0.08 | 0.40 | -0.01 | 0.00 | 0.00 | 0.00 | | | | | |
| 13 | -9.47 | -1.06 | -3.22 | -3.64 | -1.50 | -0.05 | 0.00 | | | | | | | | |
| 14 | -3.46 | -2.43 | -1.42 | 0.01 | 0.38 | 0.00 | 0.00 | | | | | | | | |
| 15 | 1.96 | 4.17 | 0.34 | -1.59 | -0.53 | -0.58 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | |
| 16 | -5.34 | -1.54 | -2.77 | -0.63 | -0.25 | -0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 17 | -10.31 | -2.42 | -3.28 | -2.84 | -1.69 | -0.08 | 0.00 | 0.00 | 0.00 | | | | | | |
| 18 | -12.01 | 1.19 | -1.94 | -5.89 | -5.19 | -0.18 | | | | | | | | | |
| 19 | 20.03 | 7.23 | 5.95 | 4.54 | 2.09 | 0.22 | 0.00 | 0.00 | 0.00 | | | | | | |
| 20 | -8.77 | -10.29 | -4.15 | -3.73 | 5.98 | 1.59 | 1.27 | 0.56 | | | | | | | |
| Median | -4.10 | -0.63 | -2.22 | -1.29 | -0.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | |
| Tri-mean | -4.57 | -0.58 | -1.93 | -1.55 | -0.52 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | |
| High Hinge | 0.82 | 2.32 | 0.00 | 0.00 | 0.38 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | |
| Low Hinge | -10.31 | -3.39 | -3.28 | -3.64 | -1.69 | -0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | |
| Mean | -5.07 | -0.83 | -1.95 | -2.00 | -0.57 | 0.19 | 0.13 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | | | |
| Std Dev | 10.23 | 4.44 | 3.10 | 2.92 | 2.46 | 0.49 | 0.38 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

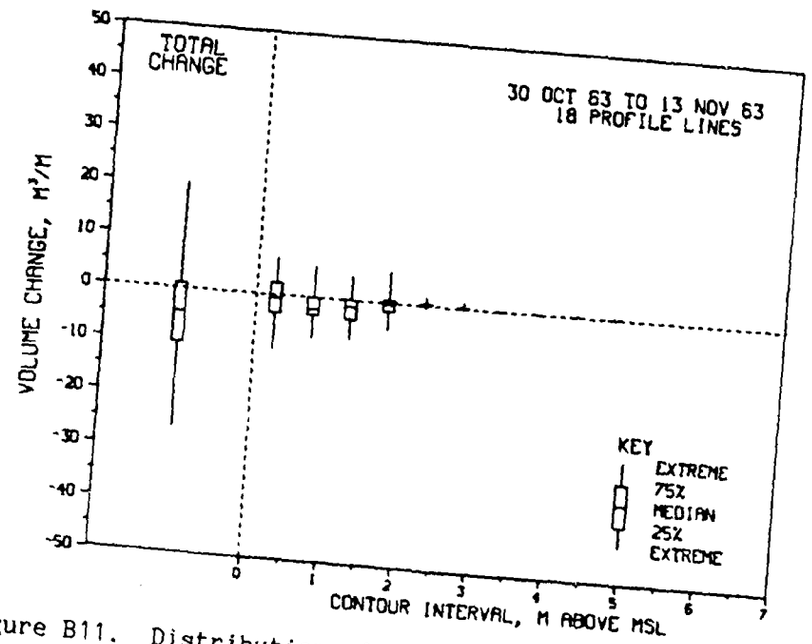



Figure B11. Distribution of volume changes by contour for Ludlam Beach, N. J.

## APPENDIX C: DATA SUMMARY FOR THE STORM OF 13 JANUARY 1964

1. The 13 January 1964 storm's effects were documented for the three New Jersey sites including Long Beach Island, Atlantic City, and Ludlam Beach. This storm was a significant event primarily caused by the large waves and tides. Wave heights at the three localities ranged from 3.7 to 4.6 m. A storm tide of 1.6 m and surge of 0.8 m were recorded at the Atlantic City tide gage. Water levels remained extremely high throughout the storm, never dropping below msl as predicted for the intermediate low water. Several smaller storms can be seen in the wave record during the survey interval and may have had some effect on beach change. The poststorm surveys, however, were conducted only a few days after the major event.

2. All sites significantly eroded after this storm with Long Beach Island experiencing the greatest median volume change of -28.2 $m^3/m$. All sites showed a large variation between the profiles with Atlantic City having the greatest hinge range of 37 $m^3/m$. Atlantic City experienced the least median volume change of the three sites. Erosion occurred high on the berm between the 0- and 2.5-m contours. Shoreline changes were variable throughout, and slope changes were negligible with the exception of Long Beach Island which flattened 0.035.

3. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.

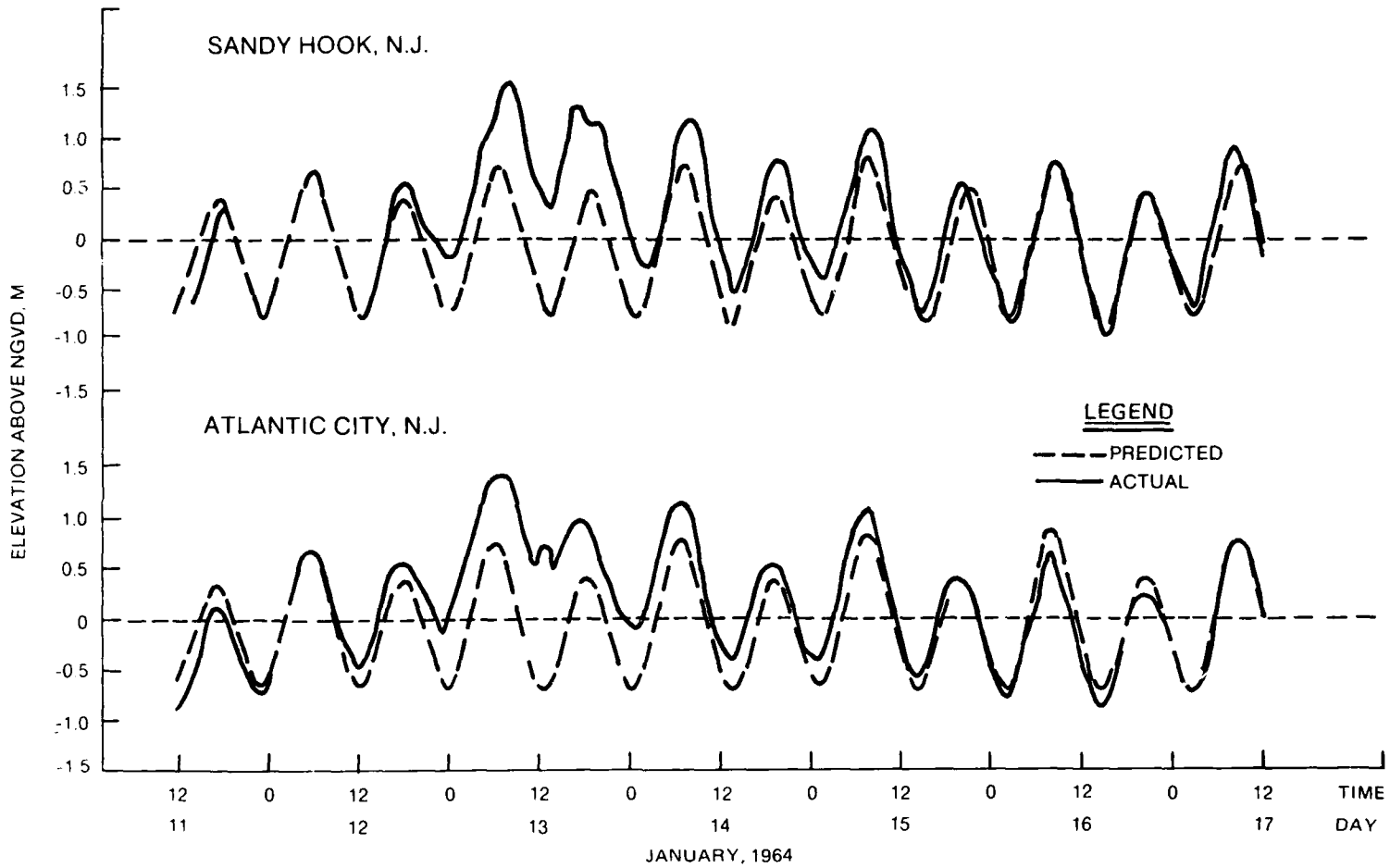



Figure C1. Predicted and actual water levels for 11-17 January 1964

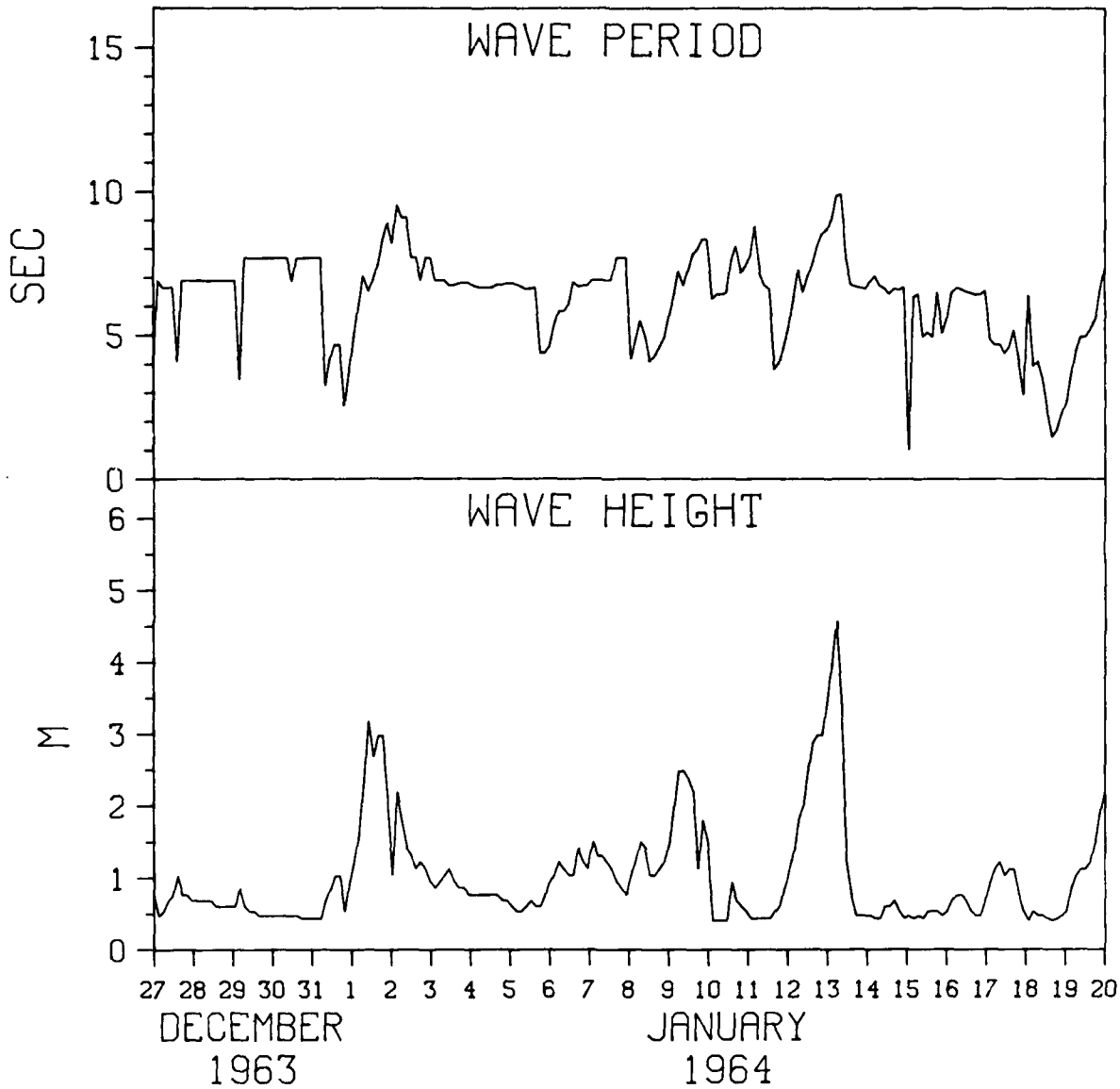
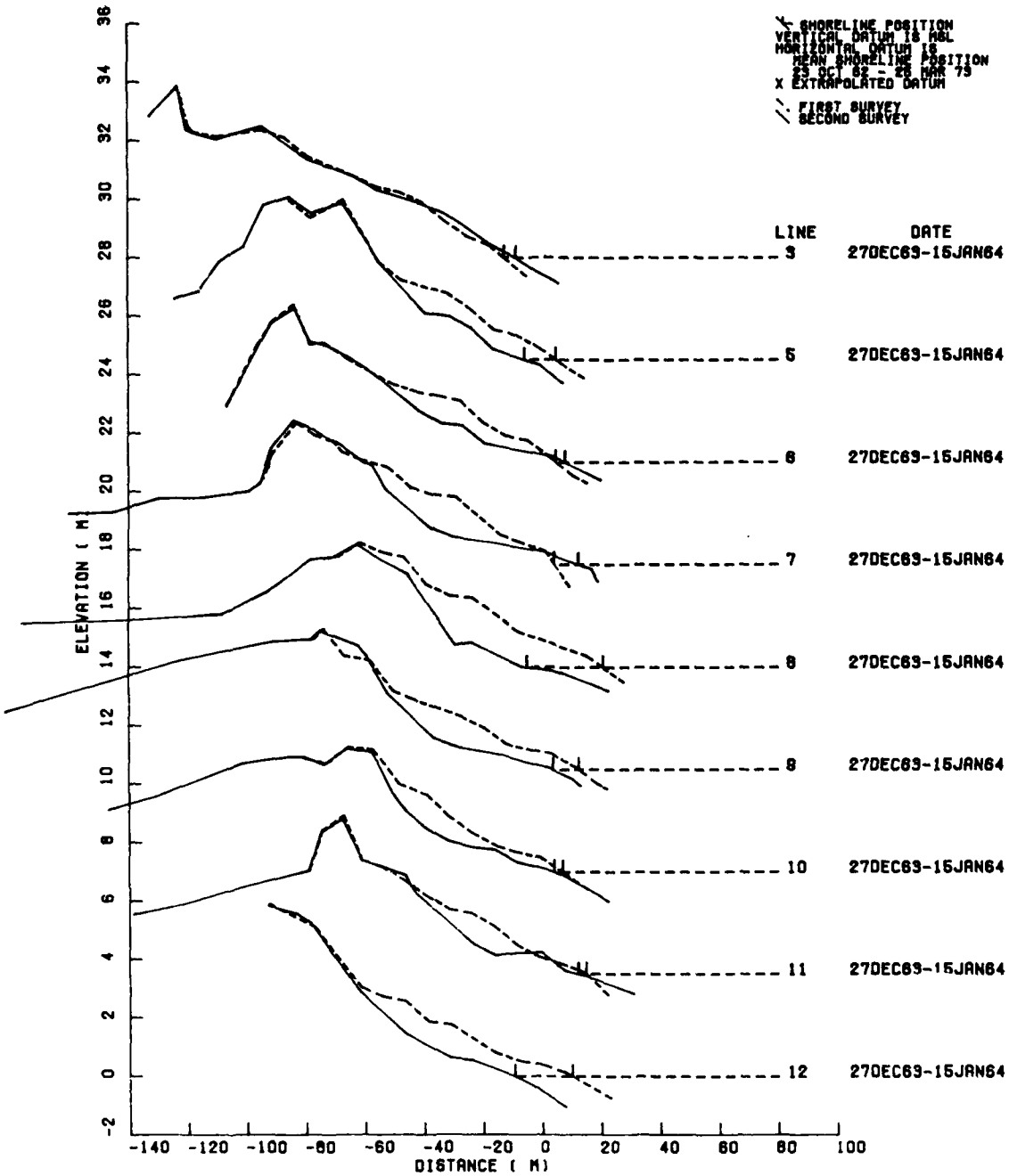
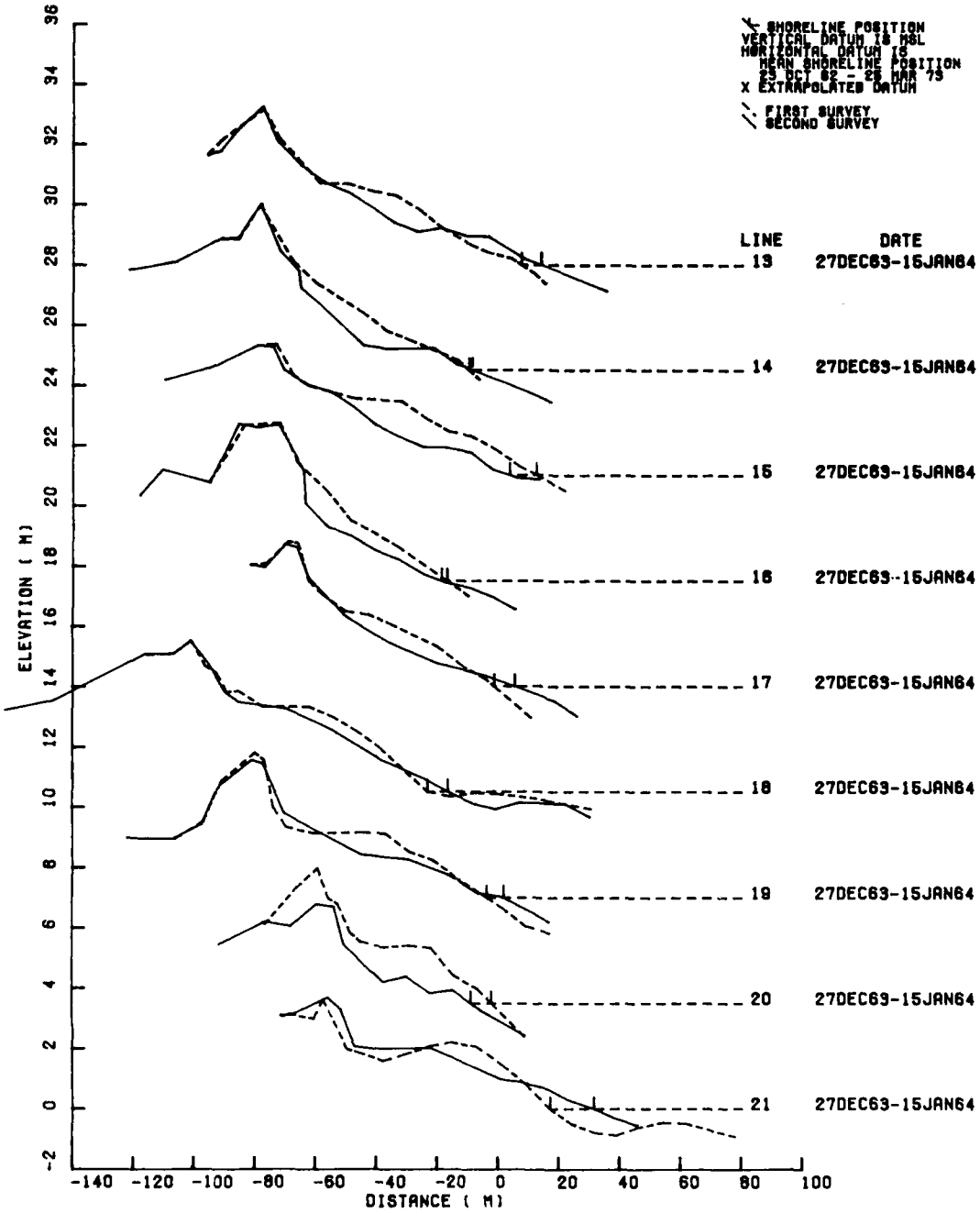



Figure C2. Hindcasted wave data for Long Beach Island, N. J.




a. Profile lines 3-12

Figure C3. Profile comparisons for surveys at Long Beach Island, N. J. (Continued)




b. Profile lines 13-21

Figure C3. (Concluded)

Table C1

Shoreline and Slope Changes at Long Beach Island, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 3 | 27 Dec 63 | 15 Jan 64 | 4.00 | -0.083 | -0.052 | 0.031 |
| 5 | 27 Dec 63 | 15 Jan 64 | -10.60 | -0.072 | -0.035 | 0.037 |
| 6 | 27 Dec 63 | 15 Jan 64 | 3.14 | -0.080 | -0.052 | 0.028 |
| 7 | 27 Dec 63 | 15 Jan 64 | 8.09 | -0.150 | -0.035 | 0.115 |
| 8 | 27 Dec 63 | 15 Jan 64 | -25.85 | -0.071 | -0.015 | 0.056 |
| 9 | 27 Dec 63 | 15 Jan 64 | -8.98 | -0.079 | -0.046 | 0.033 |
| 10 | 27 Dec 63 | 15 Jan 64 | -2.81 | -0.065 | -0.031 | 0.035 |
| 11 | 27 Dec 63 | 15 Jan 64 | -2.66 | -0.100 | -0.028 | 0.072 |
| 12 | 27 Dec 63 | 15 Jan 64 | -19.48 | -0.057 | -0.039 | 0.018 |
| 13 | 27 Dec 63 | 15 Jan 64 | 6.50 | -0.068 | -0.036 | 0.032 |
| 14 | 27 Dec 63 | 15 Jan 64 | 1.08 | -0.088 | -0.037 | 0.050 |
| 15 | 27 Dec 63 | 15 Jan 64 | -8.79 | -0.053 | -0.033 | 0.020 |
| 16 | 27 Dec 63 | 15 Jan 64 | -1.77 | -0.071 | -0.038 | 0.034 |
| 17 | 27 Dec 63 | 15 Jan 64 | 6.78 | -0.086 | -0.037 | 0.049 |
| 18 | 27 Dec 63 | 15 Jan 64 | 6.71 | -0.094 | -0.057 | 0.038 |
| 19 | 27 Dec 63 | 15 Jan 64 | 5.59 | -0.067 | -0.054 | 0.013 |
| 20 | 27 Dec 63 | 15 Jan 64 | -6.78 | -0.104 | -0.073 | 0.031 |
| 21 | 27 Dec 63 | 15 Jan 64 | 14.38 | -0.100 | -0.035 | 0.065 |
| Median | | | -0.35 | -0.080 | -0.037 | 0.035 |
| Tri-Mean | | | -0.75 | -0.080 | -0.040 | 0.038 |
| High Hinge | | | 6.50 | -0.068 | -0.033 | 0.050 |
| Low Hinge | | | -8.79 | -0.094 | -0.052 | 0.031 |
| Mean | | | -1.75 | -0.083 | -0.040 | 0.042 |
| Standard Deviation | | | 10.26 | 0.022 | 0.014 | 0.024 |

Note: X = Extrapolated shoreline intercept.

Table C2

Unit Volume Changes ($m^3/m$) Between Contours
Long Beach Island, N.J.
from 27 Dec 63 to 15 Jan 64

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | -0.49 | 1.13 | 1.76 | 1.95 | 0.08 | -1.84 | -0.40 | -0.93 | -0.95 | -0.76 | -0.35 | -0.17 | 0.00 | | |
| 5 | -33.13 | -7.00 | -6.48 | -4.12 | -7.79 | -6.45 | -1.68 | -0.17 | 0.02 | -0.09 | 0.02 | 0.56 | 0.05 | | |
| 6 | -26.99 | -0.89 | -6.60 | -4.48 | -6.15 | -6.64 | -1.30 | 0.04 | -0.06 | -0.14 | -0.21 | -0.56 | | | |
| 7 | -36.15 | 1.42 | -5.40 | -10.05 | -10.41 | -9.33 | -4.32 | -2.19 | 1.04 | 1.71 | 1.38 | | | | |
| 8 | -69.15 | -14.34 | -14.52 | -12.45 | -10.42 | -8.10 | -2.80 | -2.44 | -3.47 | -0.61 | | | | | |
| 9 | -38.31 | -6.72 | -9.97 | -10.50 | -8.65 | -4.81 | -1.48 | -0.67 | 1.15 | 3.09 | 0.25 | | | | |
| 10 | -34.73 | -3.78 | -4.17 | -6.51 | -6.34 | -6.08 | -4.37 | -1.56 | -0.98 | -0.94 | | | | | |
| 11 | -22.90 | -1.38 | -3.49 | -7.05 | -6.58 | -3.38 | -1.15 | 0.74 | 0.40 | -0.02 | -0.26 | -0.73 | | | |
| 12 | -47.68 | -9.82 | -9.07 | -9.69 | -8.36 | -6.04 | -3.53 | -0.70 | -0.56 | -0.44 | -0.32 | 0.47 | 0.38 | | |
| 13 | -14.20 | 3.10 | 4.76 | -3.92 | -7.13 | -6.42 | -1.15 | -0.27 | -1.52 | -1.54 | -0.25 | 0.14 | | | |
| 14 | -29.40 | -0.58 | -5.00 | -7.01 | -5.77 | -4.71 | -3.38 | -1.11 | -0.74 | -0.73 | -0.36 | -0.01 | 0.00 | | |
| 15 | -44.45 | -5.01 | -6.23 | -11.36 | -9.91 | -9.22 | -0.93 | -0.19 | -0.93 | -0.67 | | | | | |
| 16 | -26.44 | -2.04 | -3.24 | -4.70 | -5.22 | -4.93 | -4.48 | -2.38 | -0.08 | 0.59 | 0.65 | -0.61 | | | |
| 17 | -19.03 | 1.49 | -3.06 | -5.92 | -6.11 | -4.32 | -0.24 | 0.37 | 0.03 | -0.60 | -0.67 | | | | |
| 18 | -12.58 | 2.45 | -0.03 | -2.47 | -3.39 | -4.11 | -3.43 | -1.89 | -0.39 | 0.52 | 0.17 | 0.00 | | | |
| 19 | -14.77 | 0.19 | -0.96 | -4.88 | -9.37 | -1.08 | 1.84 | 1.18 | 0.26 | -0.90 | -1.05 | | | | |
| 20 | -60.47 | -4.95 | -10.30 | -13.06 | -11.48 | -2.07 | -4.78 | -7.14 | -5.05 | -1.64 | | | | | |
| 21 | 6.61 | 5.11 | 1.21 | -4.36 | -1.50 | -0.40 | 1.80 | 4.27 | 0.48 | | | | | | |
| Median | -28.19 | -1.13 | -4.59 | -6.22 | -6.86 | -4.87 | -1.58 | -0.69 | -0.23 | -0.60 | -0.25 | -0.01 | 0.03 | | |
| Tri-mean | -27.37 | -1.47 | -4.18 | -6.71 | -7.21 | -4.89 | -1.90 | -0.81 | -0.29 | -0.50 | -0.17 | -0.11 | 0.07 | | |
| High Hinge | -14.77 | 1.42 | -0.96 | -4.36 | -5.77 | -3.38 | -0.93 | 0.04 | 0.26 | -0.02 | 0.17 | 0.14 | 0.22 | | |
| Low Hinge | -38.31 | -5.01 | -6.60 | -10.05 | -9.37 | -6.45 | -3.53 | -1.89 | -0.95 | -0.76 | -0.35 | -0.56 | 0.00 | | |
| Mean | -29.13 | -2.31 | -4.49 | -6.70 | -6.92 | -5.00 | -1.99 | -0.84 | -0.63 | -0.19 | -0.08 | -0.10 | 0.11 | | |
| Std Dev | 19.25 | 4.96 | 4.80 | 3.88 | 3.09 | 2.59 | 2.03 | 2.23 | 1.52 | 1.17 | 0.61 | 0.46 | 0.18 | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

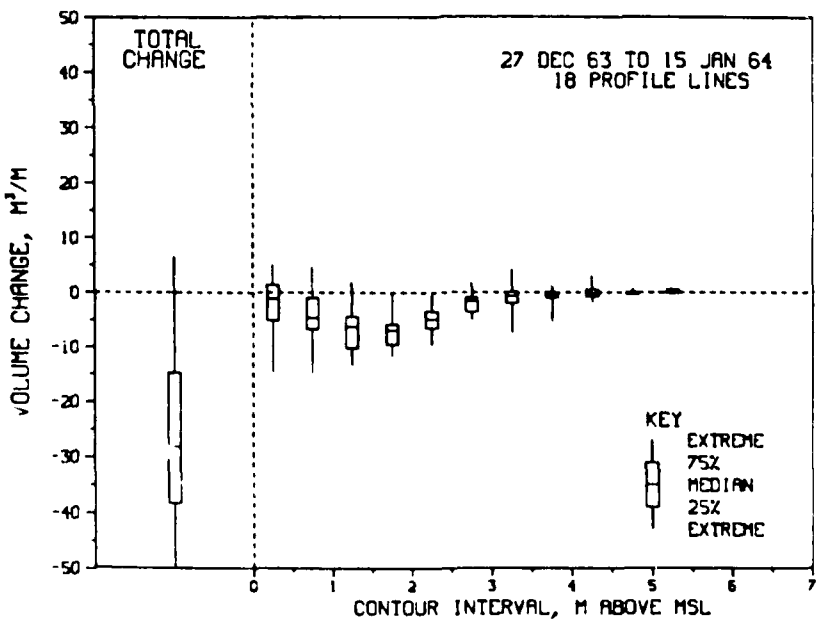



Figure C4. Distribution of volume changes by contour for Long Beach Island, N. J.

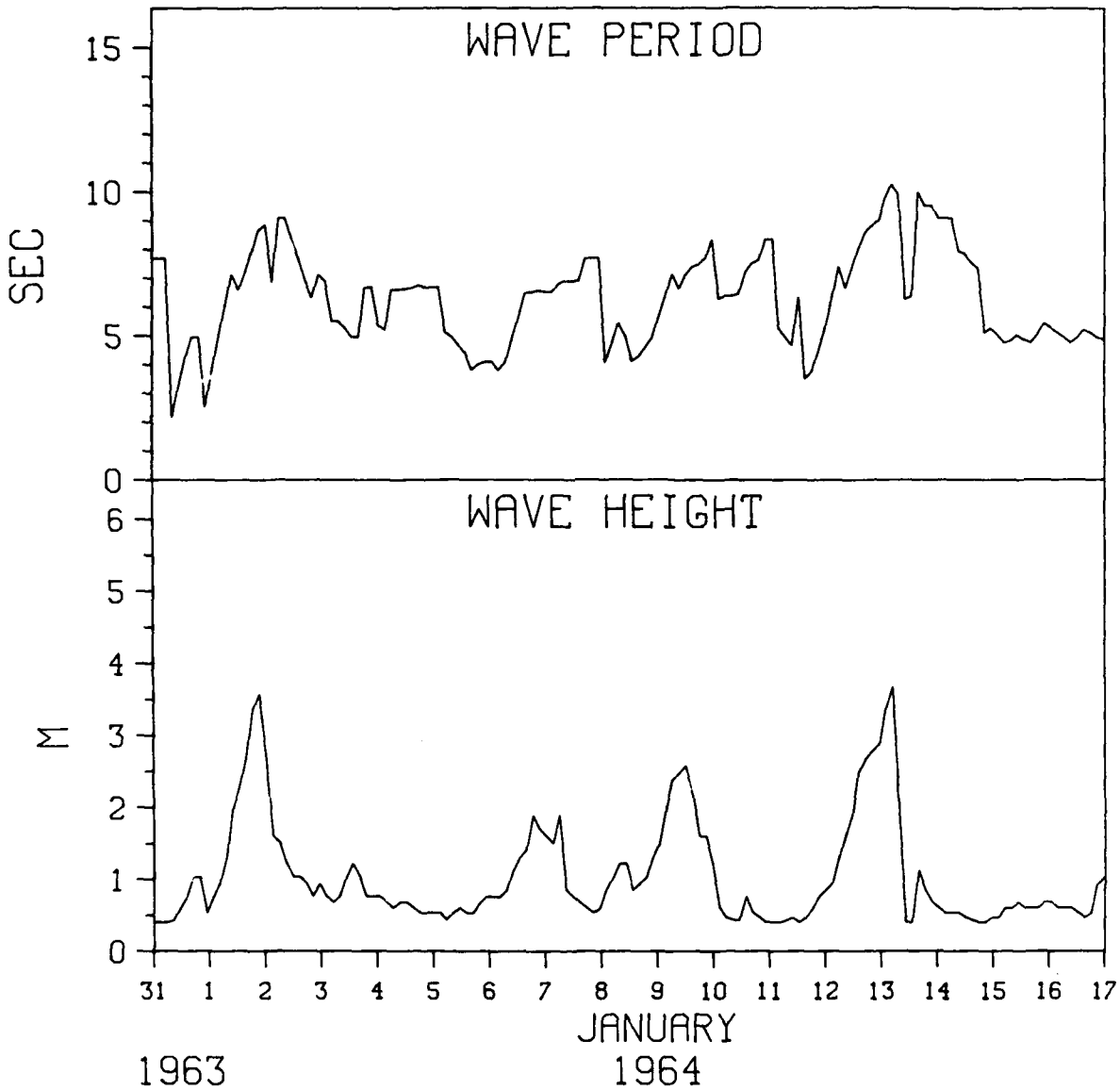



Figure C5. Hindcasted wave data for Atlantic City, N. J.

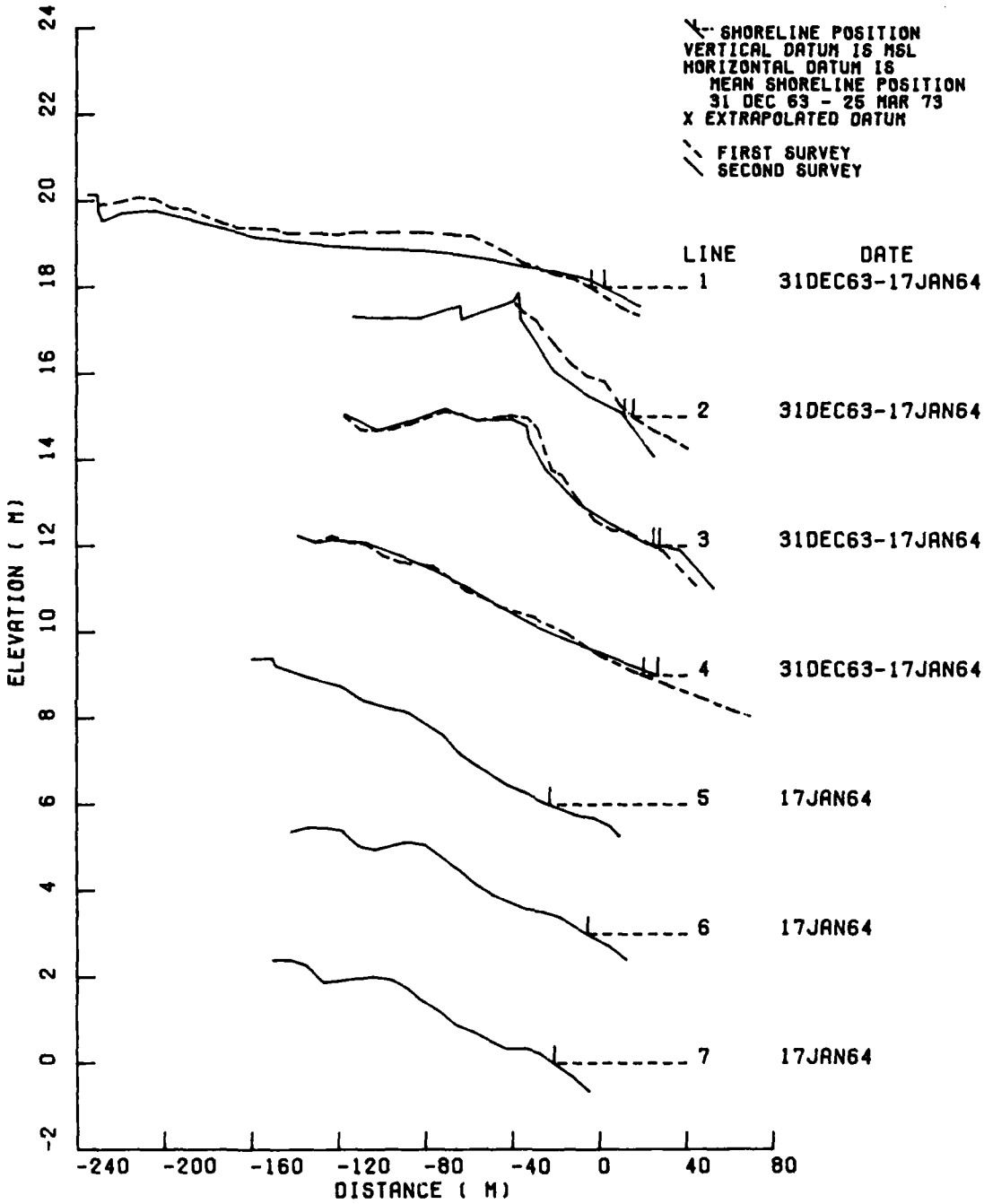



Figure C6. Profile comparisons for surveys at Atlantic City, N. J.

Table C3

Shoreline and Slope Changes at Atlantic City, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 31 Dec 63 | 17 Jan 64 | 5.96 | -0.034 | -0.027 | 0.007 |
| 2 | 31 Dec 63 | 17 Jan 64 | -4.19 | -0.042 | -0.067 | -0.026 |
| 3 | 31 Dec 63 | 17 Jan 64 | 2.70 | -0.029 | -0.010 | 0.019 |
| 4 | 31 Dec 63 | 17 Jan 64 | 6.40 | -0.020 | -0.019 | 0.001 |
| Median | | | 4.33 | -0.032 | -0.023 | 0.004 |
| Tri-Mean | | | 3.53 | -0.031 | -0.027 | 0.002 |
| High Hinge | | | 6.18 | -0.025 | -0.015 | 0.013 |
| Low Hinge | | | -0.74 | -0.038 | -0.047 | -0.013 |
| Mean | | | 2.72 | -0.031 | -0.031 | 0.000 |
| Standard Deviation | | | 4.89 | 0.009 | 0.025 | 0.019 |

Note: X = Extrapolated shoreline intercept.

Table C4

Unit Volume Changes ($m^3/m$) Between Contours
Atlantic City, N.J.
from 31 Dec 63 to 17 Jan 64

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -55.51 | | 1.78 | -15.86 | -28.06 | -12.68 | -0.69 | | | | | | | | |
| 2 | -21.70 | | -3.34 | -7.09 | -5.22 | -3.99 | -2.46 | 0.40 | | | | | | | |
| 3 | -4.52 | | 0.26 | 1.04 | -1.29 | -1.89 | -2.46 | -0.78 | 0.60 | | | | | | |
| 4 | 0.15 | | 2.44 | -1.36 | -3.18 | 0.37 | -0.16 | 2.28 | -0.24 | | | | | | |
| Median | -13.11 | | 1.02 | -4.22 | -4.20 | -2.94 | -1.58 | 0.40 | 0.18 | | | | | | |
| Tri-mean | -16.75 | | 0.65 | -5.02 | -6.82 | -3.74 | -1.51 | 0.49 | 0.18 | | | | | | |
| High Hinge | -2.18 | | 2.11 | -0.16 | -2.24 | -0.76 | -0.43 | 1.34 | 0.60 | | | | | | |
| Low Hinge | -38.60 | | -1.54 | -11.48 | -16.64 | -8.34 | -2.46 | -0.19 | -0.24 | | | | | | |
| Mean | -20.39 | | 0.29 | -5.82 | -9.44 | -4.55 | -1.44 | 0.63 | 0.18 | | | | | | |
| Std Dev | 25.22 | | 2.58 | 7.51 | 12.52 | 5.71 | 1.19 | 1.54 | 0.59 | | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

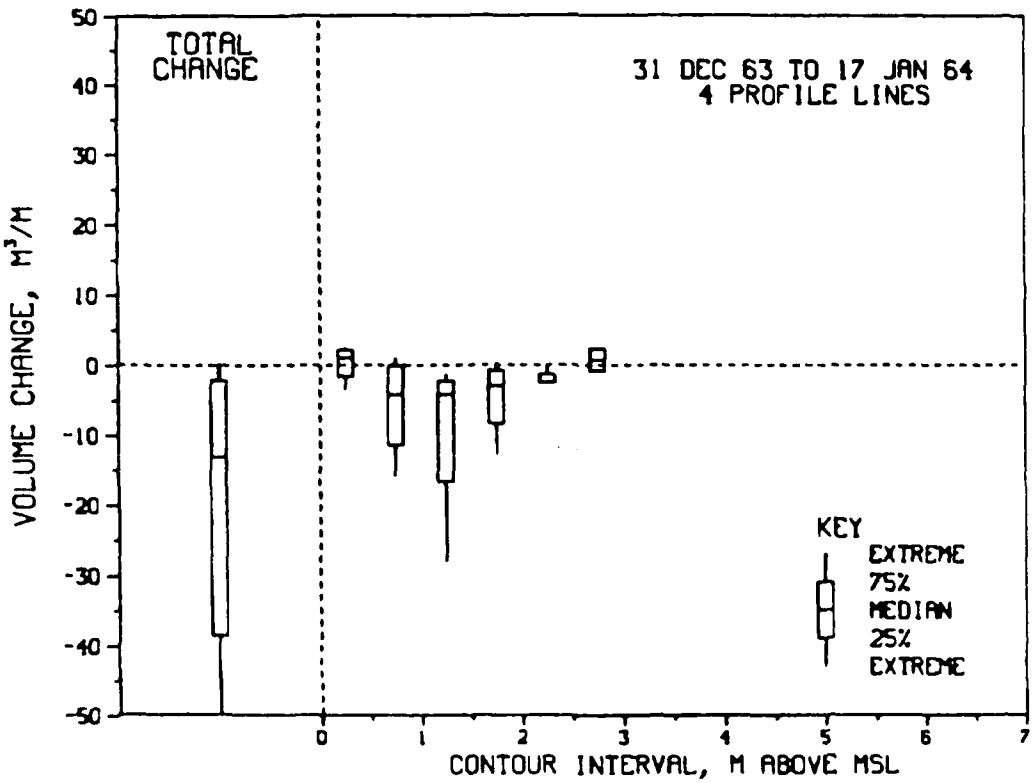



Figure C7. Distribution of volume changes by contour for Atlantic City, N. J.

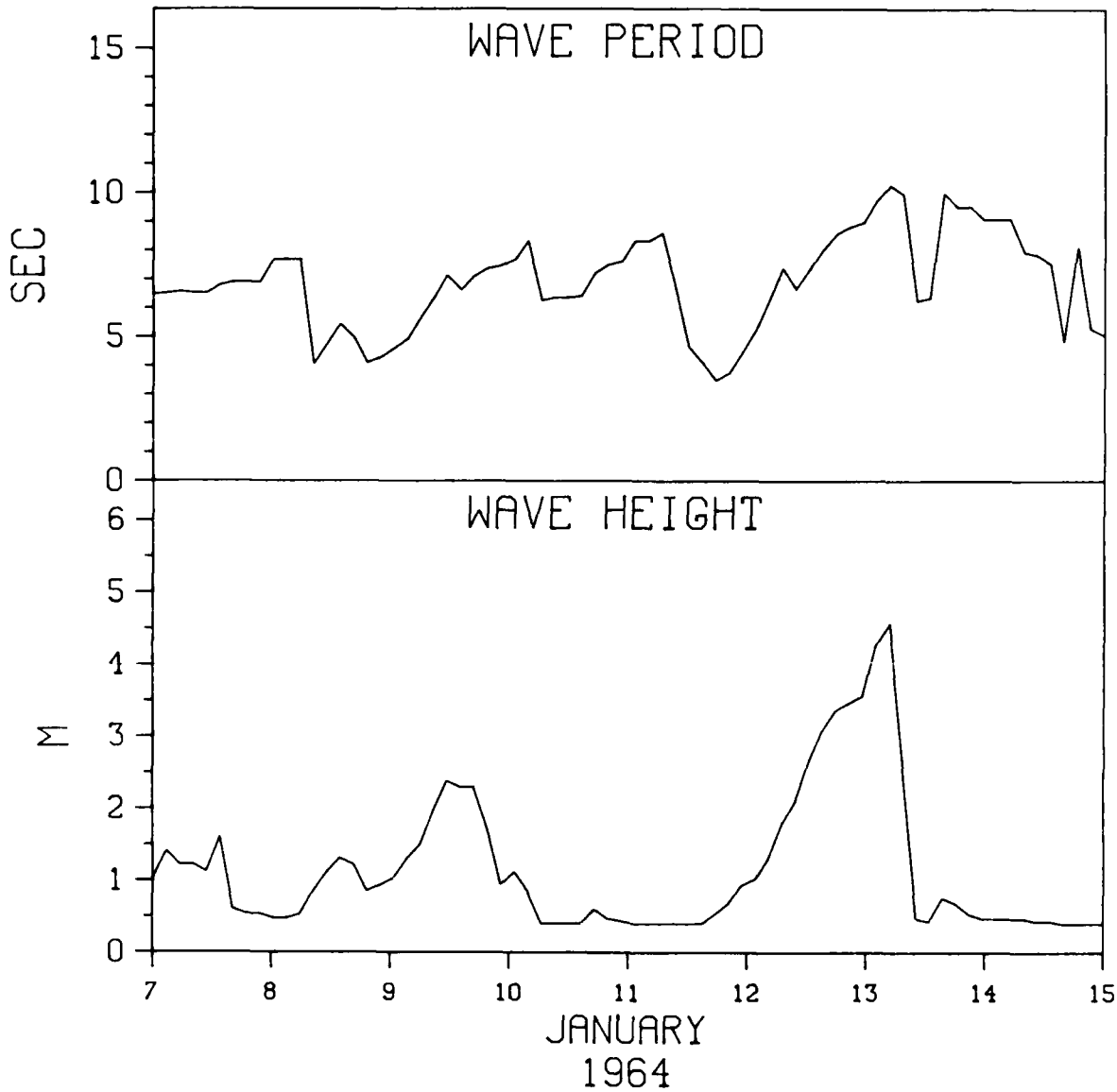
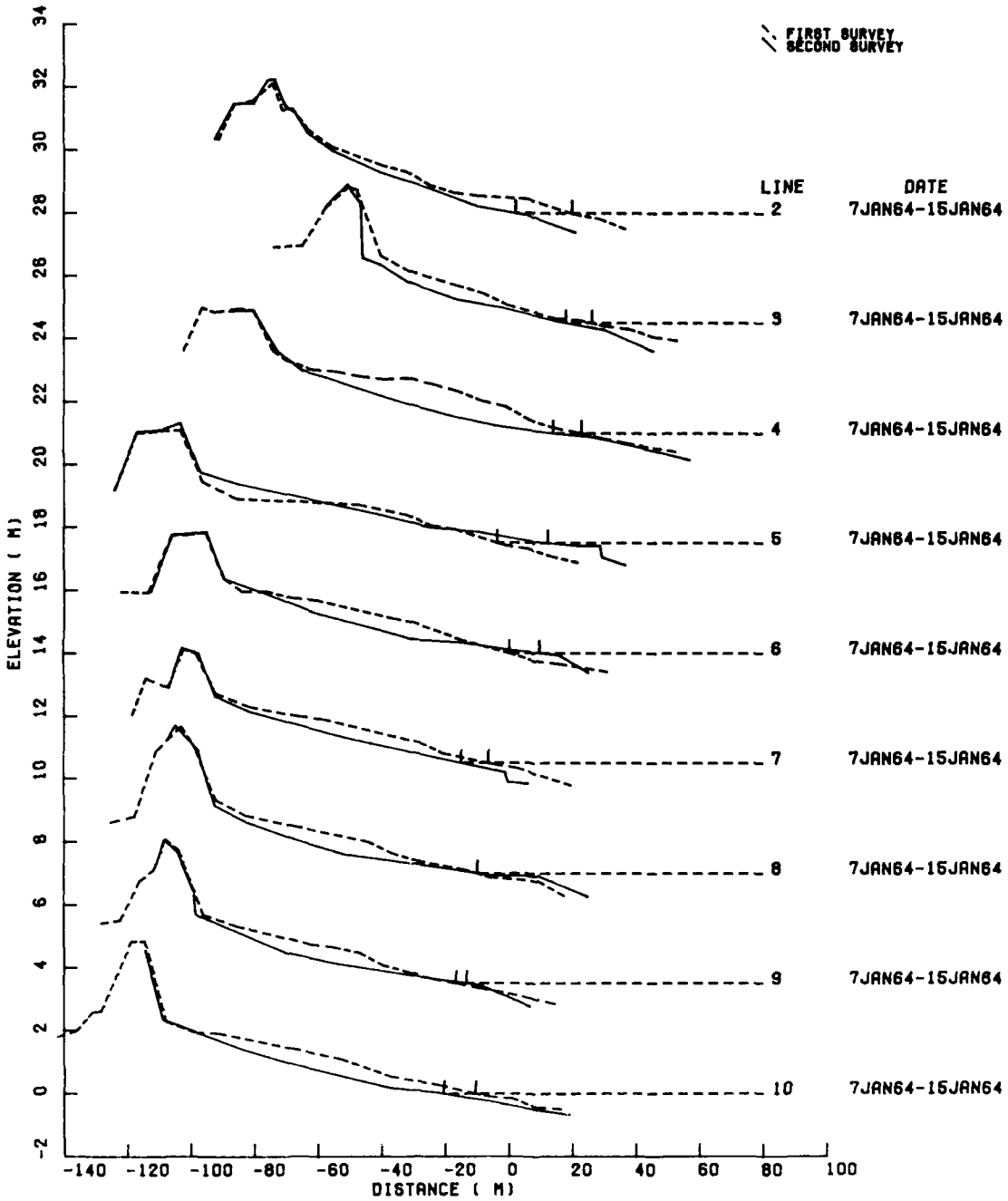
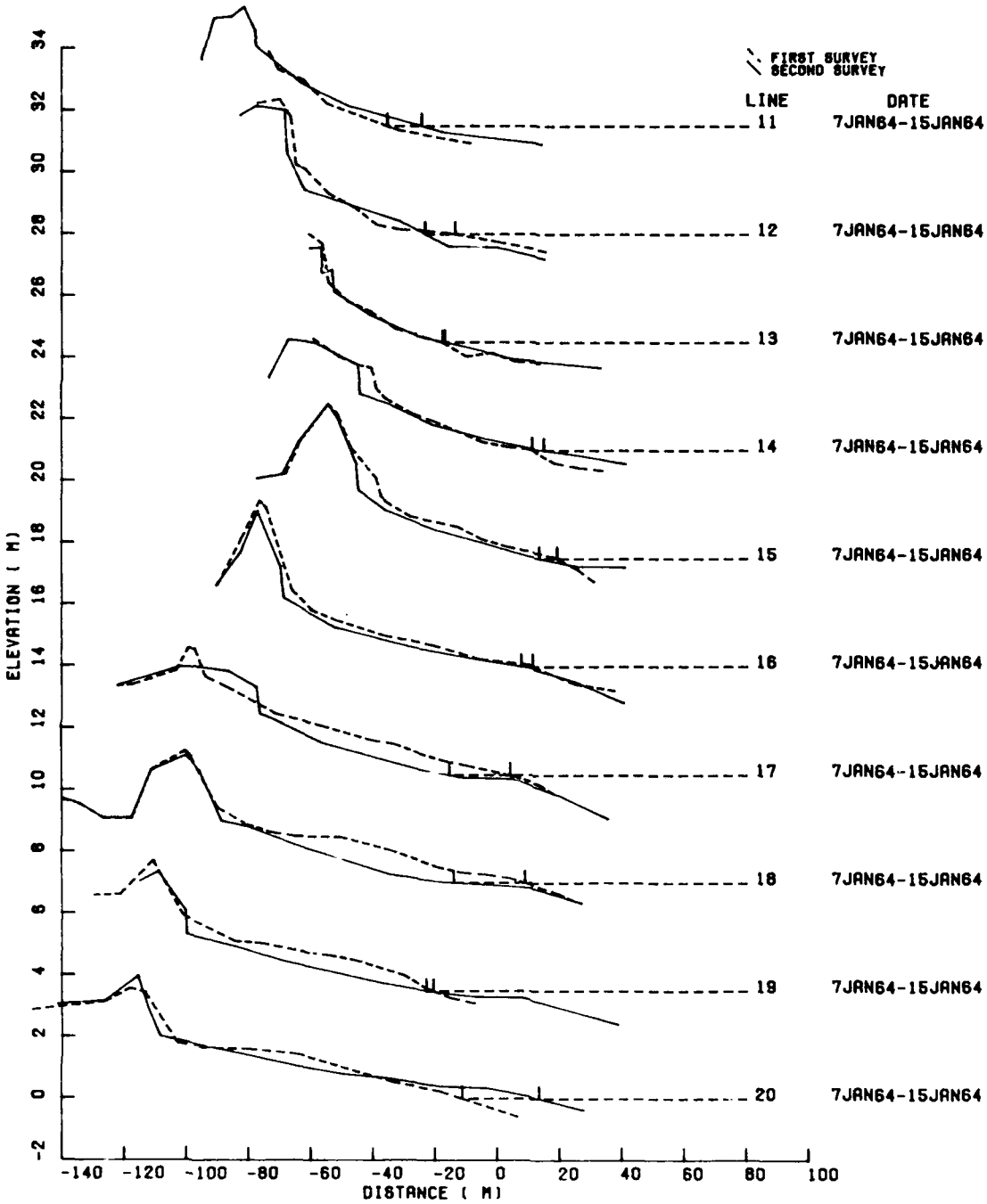



Figure C8. Hindcasted wave data for Ludlam Beach, N. J.




a. Profile lines 2-10

Figure C9. Profile comparisons for surveys at Ludlam Beach, N. J. (Continued)




b. Profile lines 11-20

Figure C9. (Concluded)

Table C5

Shoreline and Slope Changes at Ludlam Beach, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 2 | 7 Jan 64 | 15 Jan 64 | -17.74 | -0.032 | -0.018 | 0.014 |
| 3 | 7 Jan 64 | 15 Jan 64 | -8.20 | -0.025 | -0.018 | 0.007 |
| 4 | 7 Jan 64 | 15 Jan 64 | -8.89 | -0.024 | -0.010 | 0.014 |
| 5 | 7 Jan 64 | 15 Jan 64 | 15.93 | -0.032 | -0.010 | 0.022 |
| 6 | 7 Jan 64 | 15 Jan 64 | 9.45 | -0.027 | -0.010 | 0.017 |
| 7 | 7 Jan 64 | 15 Jan 64 | -8.56 | -0.022 | -0.022 | 0.000 |
| 8 | 7 Jan 64 | 15 Jan 64 | 0.15 | -0.031 | -0.016 | 0.015 |
| 9 | 7 Jan 64 | 15 Jan 64 | 3.27 | -0.020 | -0.014 | 0.006 |
| 10 | 7 Jan 64 | 15 Jan 64 | -9.95 | -0.024 | -0.018 | 0.006 |
| 11 | 7 Jan 64 | 15 Jan 64 | 11.07 | -0.038 | -0.028 | 0.010 |
| 12 | 7 Jan 64 | 15 Jan 64 | -9.63 | -0.018 | -0.052 | -0.034 |
| 13 | 7 Jan 64 | 15 Jan 64 | 0.69 | -0.030 | -0.022 | 0.008 |
| 14 | 7 Jan 64 | 15 Jan 64 | 3.81 | -0.056 | -0.014 | 0.042 |
| 15 | 7 Jan 64 | 15 Jan 64 | -5.74 | -0.052 | -0.020 | 0.032 |
| 16 | 7 Jan 64 | 15 Jan 64 | -3.70 | -0.041 | -0.016 | 0.025 |
| 17 | 7 Jan 64 | 15 Jan 64 | -19.54 | -0.022 | -0.018 | 0.004 |
| 18 | 7 Jan 64 | 15 Jan 64 | -22.84 | -0.031 | -0.006 | 0.025 |
| 19 | 7 Jan 64 | 15 Jan 64 | -2.29 | -0.040 | -0.018 | 0.022 |
| 20 | 7 Jan 64 | 15 Jan 64 | 24.64 | -0.033 | -0.026 | 0.007 |
| Median | | | -3.70 | -0.031 | -0.016 | 0.014 |
| Tri-Mean | | | -3.28 | -0.030 | -0.015 | 0.014 |
| High Hinge | | | 3.54 | -0.024 | -0.008 | 0.022 |
| Low Hinge | | | -9.26 | -0.036 | -0.021 | 0.007 |
| Mean | | | -2.53 | -0.031 | -0.017 | 0.013 |
| Standard Deviation | | | 12.15 | 0.010 | 0.011 | 0.016 |

Note: X = Extrapolated shoreline intercept.

Table C6

Unit Volume Changes ($m^3/m$) Between Contours
Ludlam Beach, N.J.
from 7 Jan 64 to 15 Jan 64

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | -18.09 | -10.71 | -2.64 | -3.48 | -2.19 | -0.78 | 0.03 | 0.39 | 0.63 | 0.66 | | | | | |
| 3 | -23.26 | -2.67 | -5.53 | -5.88 | -3.03 | -2.78 | -1.90 | -1.08 | -0.24 | -0.15 | | | | | |
| 4 | -43.26 | -7.80 | -12.83 | -13.97 | -9.06 | -0.22 | 0.57 | 0.34 | -0.29 | | | | | | |
| 5 | 11.47 | 3.02 | -2.85 | 1.61 | 6.59 | 1.15 | 0.35 | 0.43 | 1.17 | | | | | | |
| 6 | -21.19 | -1.26 | -8.77 | -8.46 | -3.09 | 0.51 | -0.18 | -0.09 | 0.15 | | | | | | |
| 7 | -22.52 | -4.65 | -8.02 | -7.35 | -2.71 | -0.53 | 0.04 | 0.47 | 0.23 | | | | | | |
| 8 | -23.89 | -2.71 | -8.70 | -8.16 | -3.27 | -1.08 | -0.22 | 0.01 | 0.22 | -0.03 | 0.05 | | | | |
| 9 | -22.62 | -1.43 | -8.42 | -7.77 | -2.85 | -1.16 | -0.38 | -0.15 | -0.22 | -0.24 | 0.00 | | | | |
| 10 | -32.48 | -8.30 | -8.83 | -9.35 | -4.46 | 0.09 | -0.37 | -0.37 | -0.37 | -0.36 | -0.16 | | | | |
| 11 | 6.83 | 4.33 | 2.31 | -0.03 | 0.29 | -0.08 | 0.00 | 0.00 | 0.00 | | | | | | |
| 12 | -6.70 | 2.11 | 1.61 | -1.86 | -2.59 | -1.09 | -1.18 | -1.07 | -0.80 | -1.83 | | | | | |
| 13 | -1.98 | -0.02 | -0.32 | -0.27 | 0.01 | 0.24 | -0.48 | -1.16 | 0.02 | | | | | | |
| 14 | -5.73 | 1.91 | -0.79 | -0.86 | -2.41 | -2.47 | -0.90 | -0.09 | -0.12 | | | | | | |
| 15 | -17.28 | -2.79 | -3.21 | -2.99 | -2.09 | -3.06 | -2.23 | -0.53 | -0.04 | -0.13 | -0.21 | | | | |
| 16 | -22.23 | -2.08 | -3.98 | -3.26 | -1.62 | -2.07 | -1.23 | -1.30 | -1.86 | -1.92 | -2.00 | -0.91 | | | |
| 17 | -26.26 | -10.00 | -9.93 | -8.14 | -4.34 | -0.29 | 4.26 | 4.90 | -2.55 | -0.17 | | | | | |
| 18 | -41.95 | -13.71 | -11.85 | -11.79 | -2.04 | -1.19 | -0.06 | 0.03 | -0.58 | -0.76 | | | | | |
| 19 | -32.06 | -5.29 | -10.56 | -9.13 | -4.88 | -1.42 | 0.72 | 0.38 | -1.55 | -0.33 | | | | | |
| 20 | -1.87 | 8.85 | -1.62 | -7.69 | -0.83 | -1.81 | -1.21 | 0.80 | 1.64 | | | | | | |
| Median | -22.23 | -2.67 | -5.53 | -7.35 | -2.59 | -1.08 | -0.22 | 0.00 | -0.12 | -0.24 | -0.16 | -0.91 | | | |
| Tri-mean | -18.94 | -2.74 | -5.50 | -6.36 | -2.55 | -0.98 | -0.36 | -0.02 | -0.13 | -0.29 | -0.13 | -0.91 | | | |
| High Hinge | -6.22 | 0.94 | -2.13 | -2.42 | -1.83 | -0.15 | 0.04 | 0.38 | 0.19 | -0.14 | 0.00 | -0.91 | | | |
| Low Hinge | -25.08 | -6.55 | -8.80 | -8.31 | -3.18 | -1.62 | -1.04 | -0.45 | -0.47 | -0.56 | -0.21 | -0.91 | | | |
| Mean | -18.16 | -2.80 | -5.52 | -5.73 | -2.35 | -0.95 | -0.23 | 0.10 | -0.24 | -0.48 | -0.46 | -0.91 | | | |
| Std Dev | 15.09 | 5.66 | 4.62 | 4.30 | 2.96 | 1.14 | 1.34 | 1.31 | 0.98 | 0.77 | 0.87 | 0.00 | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

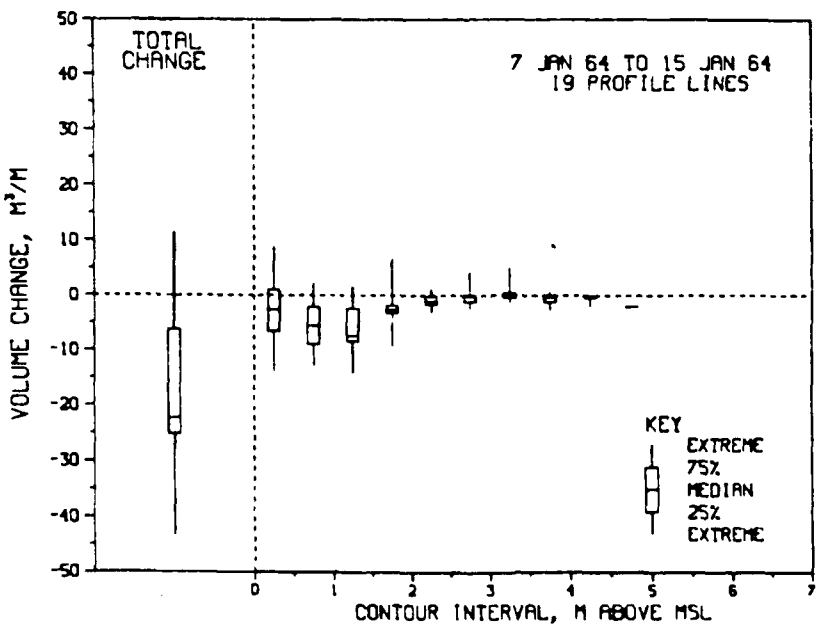



Figure C10. Distribution of volume changes by contour for Ludlam Beach, N. J.

## APPENDIX D: DATA SUMMARY FOR THE STORM OF 16 SEPTEMBER 1967

1. Two New Jersey sites were monitored after the 16 September 1967 event, Atlantic City and Ludlam Beach. Wave heights ranged from 2.2 to 2.7 m. A peak storm tide of 1.4 m above msl and surge of 0.8 m were recorded at the Atlantic City tide gage. Neither of the two sites experienced maximum wave heights during the peak storm tide. No other events occurred between the survey intervals.

2. Atlantic City experienced the greatest median volume change at -15.6 $m^3/m$ and showed the greatest variation between the profiles. The hinge range for Atlantic City was 23 $m^3/m$ which is quite large for only seven profile lines. The major losses on the beach occurred from the 0- to 1.5-m contour intervals. At Ludlam Beach, consistent berm erosion occurred at profile lines 5 through 9. Profile line 10 with a similar prestorm profile experienced a high accretion, possibly the result of a poststorm surveying problem. The greatest erosion occurred downdrift (south) of the Sea Isle City groin field.

3. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.

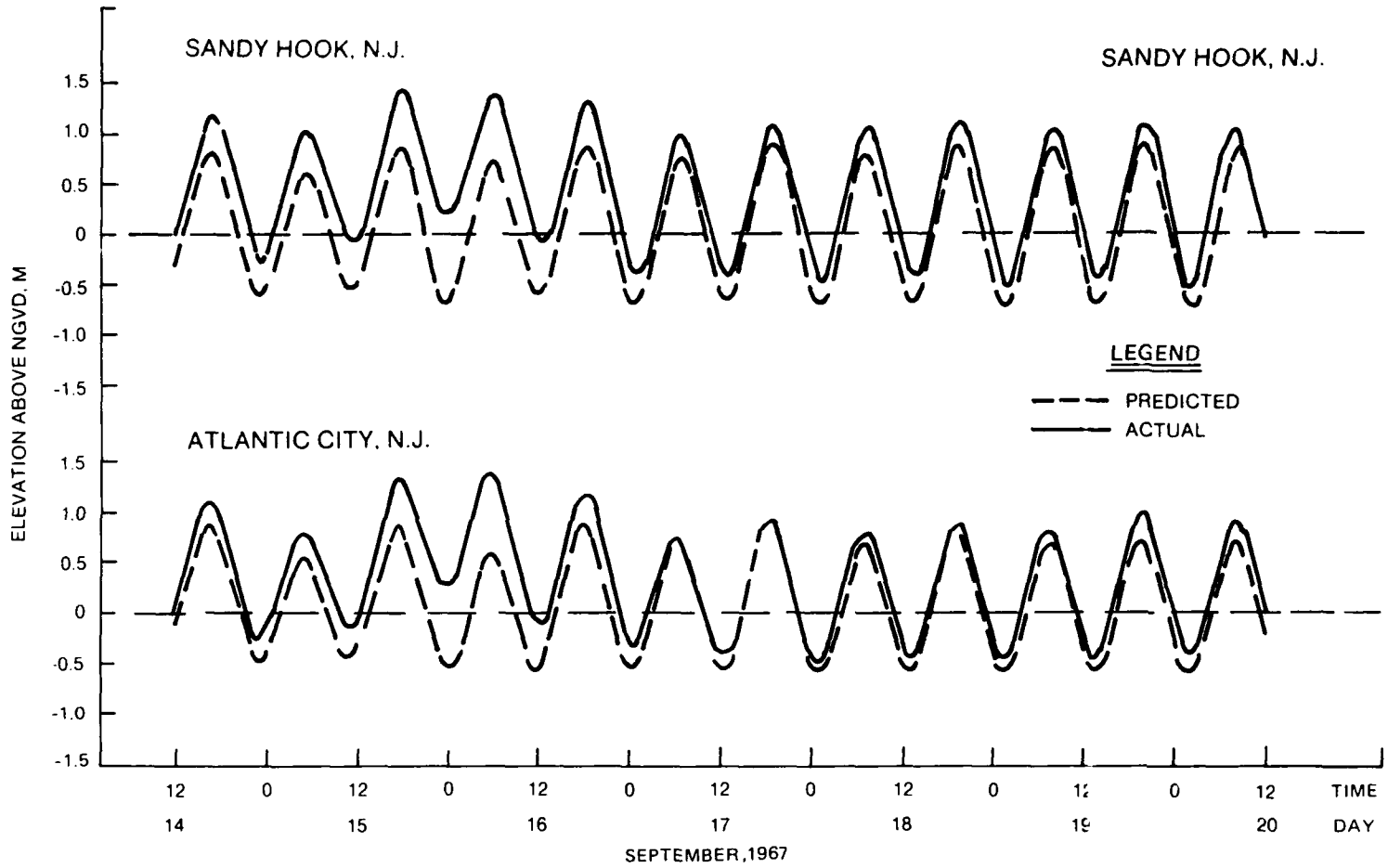



Figure D1. Predicted and actual water levels for 14-20 September 1967

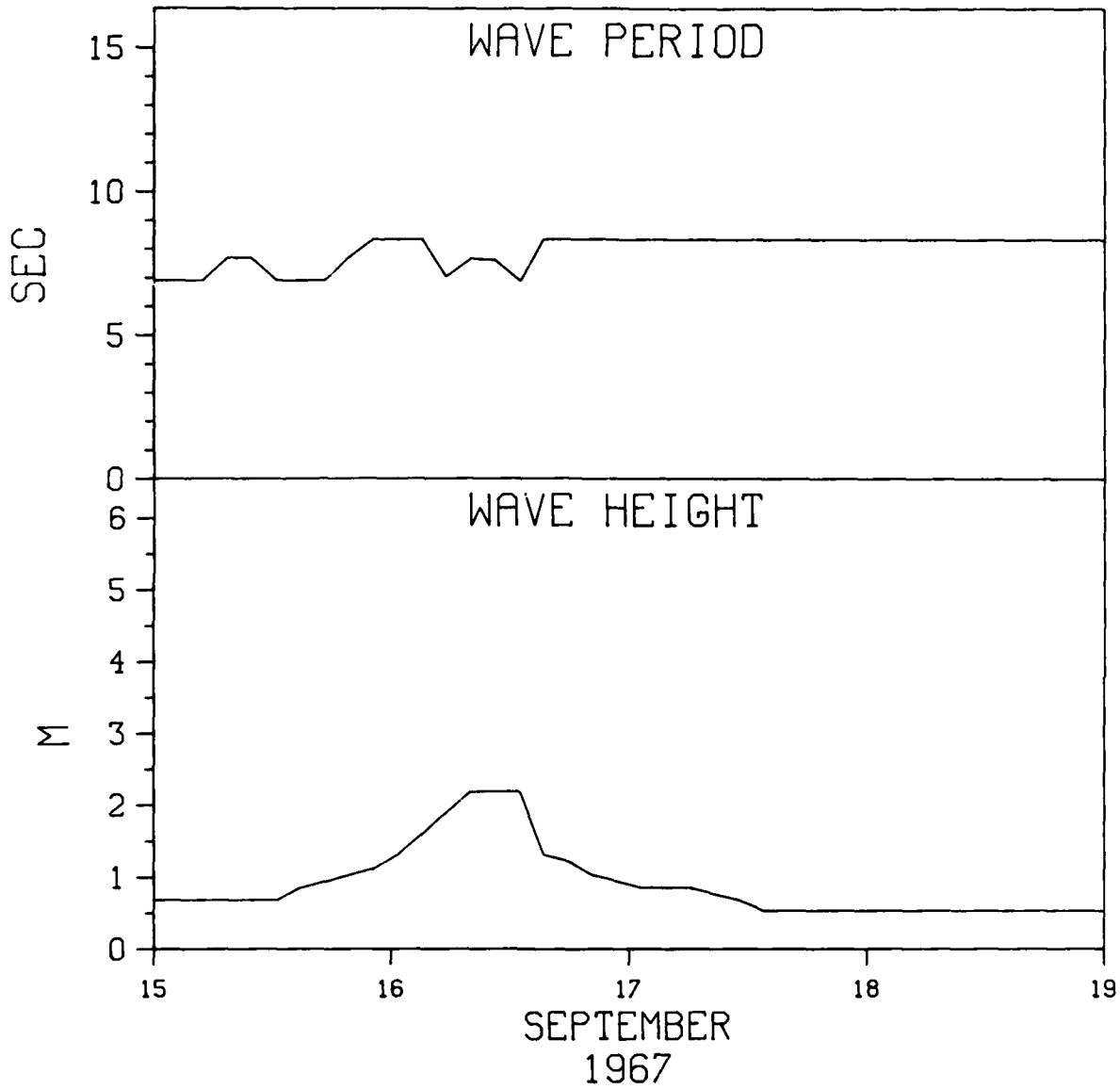



Figure D2. Hindcasted wave data for Atlantic City, N.J.

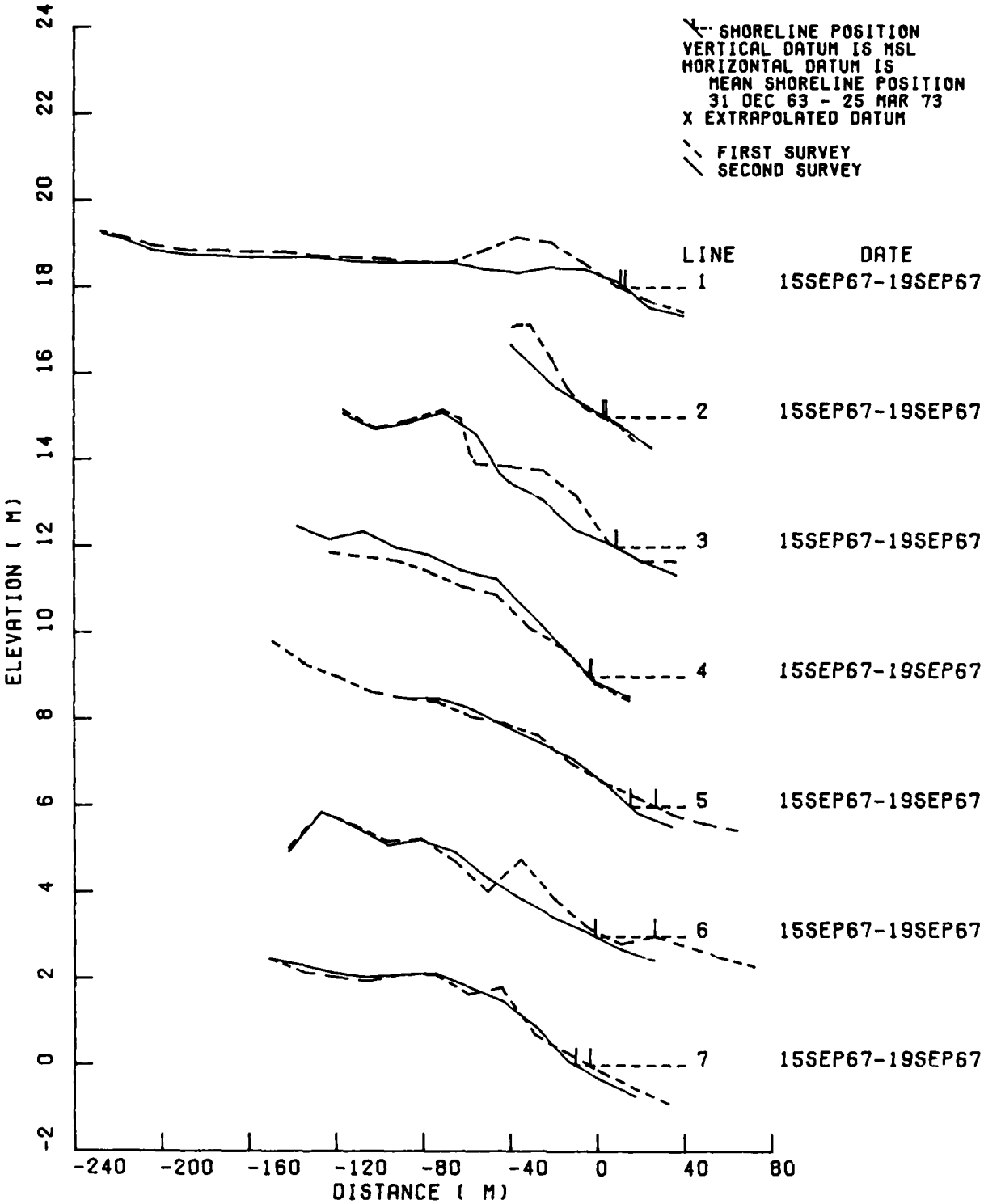



Figure D3. Profile comparisons for surveys at Atlantic City, N. J.

Table D1

Shoreline and Slope Changes at Atlantic City, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 15 Sep 67 | 19 Sep 67 | 2.15 | -0.022 | -0.040 | -0.018 |
| 2 | 15 Sep 67 | 19 Sep 67 | 1.43 | -0.025 | -0.028 | -0.003 |
| 3 | 15 Sep 67 | 19 Sep 67 | -0.17 | -0.029 | -0.027 | 0.001 |
| 4 | 15 Sep 67 | 19 Sep 67 | 0.78 | -0.054 | -0.052 | 0.002 |
| 5 | 15 Sep 67 | 19 Sep 67 | -11.68 | -0.025 | -0.046 | -0.021 |
| 6 | 15 Sep 67 | 19 Sep 67 | -27.27 | 0.012 | -0.026 | -0.038 |
| 7 | 15 Sep 67 | 19 Sep 67 | -6.53 | -0.028 | -0.028 | 0.000 |
| Median | | | -0.17 | -0.025 | -0.028 | -0.003 |
| Tri-Mean | | | -2.09 | -0.026 | -0.032 | -0.006 |
| High Hinge | | | 1.10 | -0.024 | -0.028 | 0.001 |
| Low Hinge | | | -9.11 | -0.029 | -0.043 | -0.020 |
| Mean | | | -5.90 | -0.024 | -0.035 | -0.011 |
| Standard Deviation | | | 10.70 | 0.019 | 0.011 | 0.015 |

Note: X = Extrapolated shoreline intercept.

Table D2

Unit Volume Changes ($m^3/m$) Between Contours
Atlantic City, N.J.
*from 15 Sep 67 to 19 Sep 67*

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -41.72 | -4.47 | -34.15 | -3.10 | | | | | | | | | | | |
| 2 | -15.59 | 0.34 | -2.94 | -5.47 | -6.36 | -1.16 | | | | | | | | | |
| 3 | -24.70 | -3.01 | -7.04 | -9.76 | -6.38 | 3.71 | -0.92 | -1.30 | | | | | | | |
| 4 | 38.70 | 0.30 | 0.92 | 3.26 | 3.90 | 9.82 | 13.93 | 6.57 | | | | | | | |
| 5 | -0.64 | -3.40 | 0.69 | 0.23 | -1.94 | 3.78 | 0.00 | 0.00 | 0.00 | | | | | | |
| 6 | -17.34 | -3.47 | -7.11 | -5.94 | 1.50 | -1.90 | -0.42 | | | | | | | | |
| 7 | 4.04 | -1.86 | 1.28 | -0.63 | -0.02 | 5.27 | | | | | | | | | |
| Median | -15.59 | -3.01 | -2.94 | -3.10 | -0.98 | 3.74 | -0.21 | 0.00 | 0.00 | | | | | | |
| Tri-mean | -12.63 | -2.56 | -3.04 | -3.03 | -1.71 | 2.90 | 1.47 | 0.66 | 0.00 | | | | | | |
| High Hinge | 1.70 | -0.78 | 0.81 | -0.20 | 1.50 | 5.27 | 6.97 | 3.29 | 0.00 | | | | | | |
| Low Hinge | -21.02 | -3.43 | -7.07 | -5.70 | -6.36 | -1.16 | -0.67 | -0.65 | 0.00 | | | | | | |
| Mean | -8.18 | -2.22 | -6.91 | -3.06 | -1.55 | 3.25 | 3.15 | 1.76 | 0.00 | | | | | | |
| Std Dev | 25.63 | 1.90 | 12.54 | 4.39 | 4.19 | 4.33 | 7.20 | 4.22 | 0.00 | | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

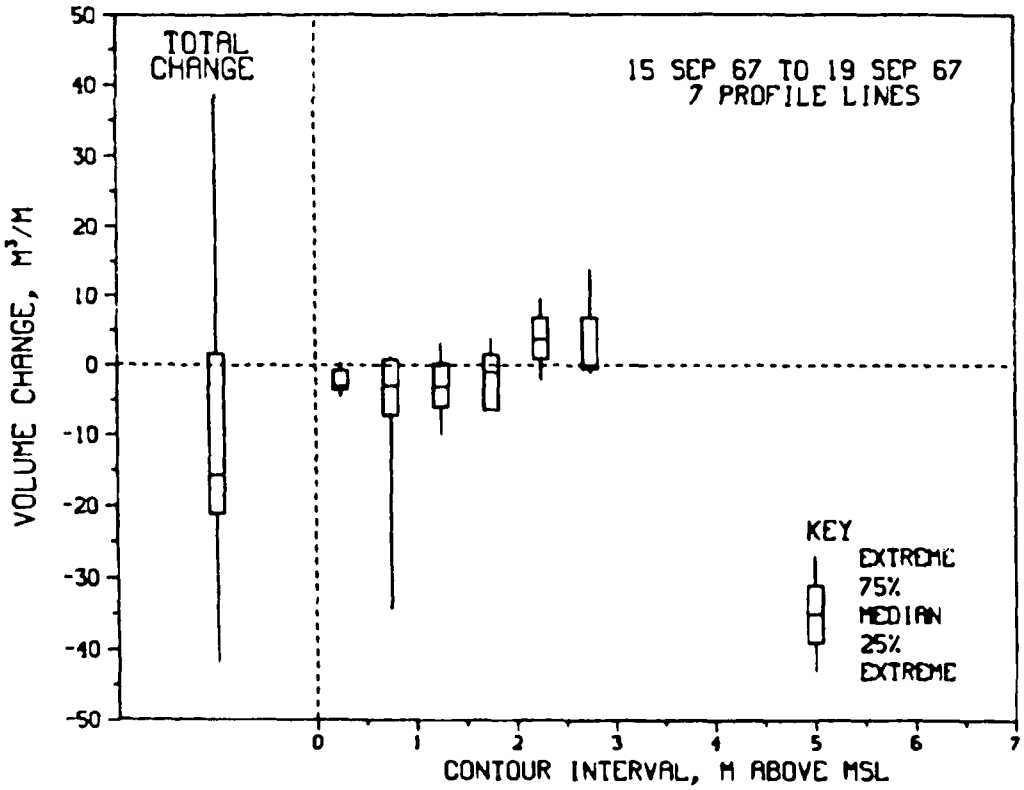



Figure D4. Distribution of volume changes by contour for Atlantic City, N. J.

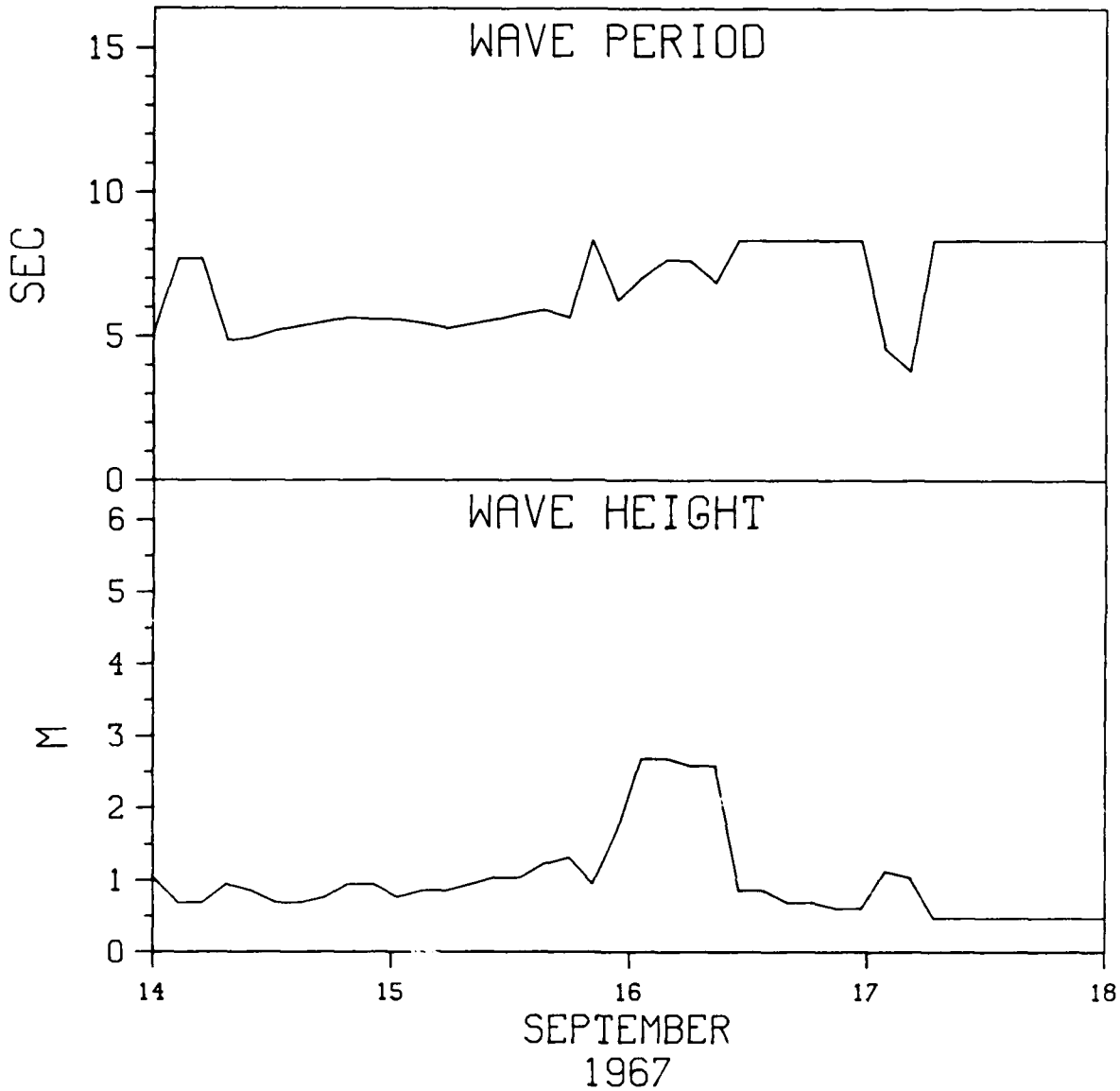
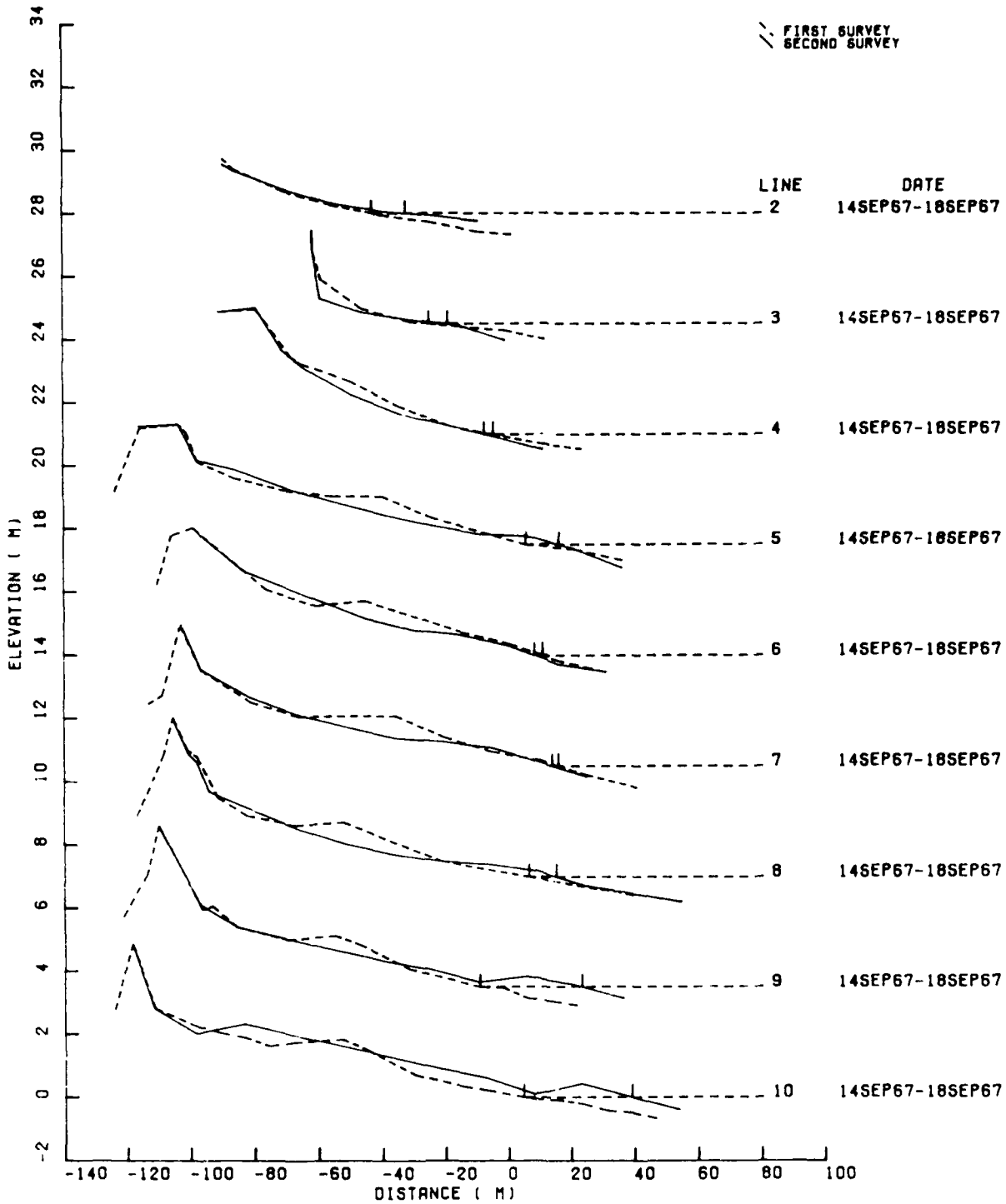
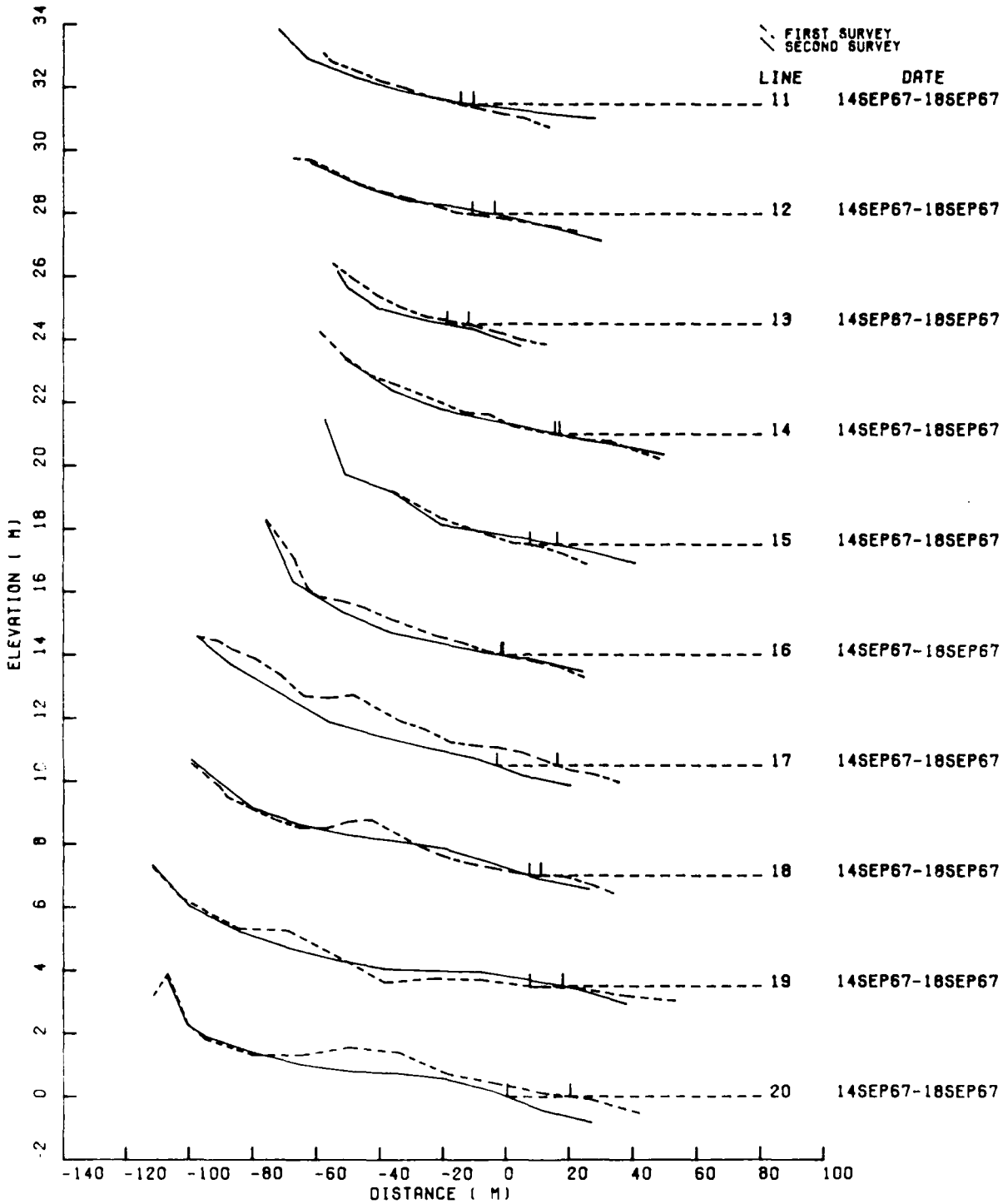



Figure D5. Hindcasted wave data for Ludlam Beach, N. J.




a. Profile lines 2-10

Figure D6. Profile comparisons for surveys at Ludlam Beach, N. J. (Continued)




b. Profile lines 11-20

Figure D6. (Concluded)

Table D3

Shoreline and Slope Changes at Ludlam Beach, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 2 | 14 Sep 67 | 18 Sep 67 | 10.58 | -0.020 | -0.008 | 0.011 |
| 3 | 14 Sep 67 | 18 Sep 67 | 5.91 | -0.010 | -0.010 | 0.000 |
| 4 | 14 Sep 67 | 18 Sep 67 | -2.86 | -0.019 | -0.024 | -0.005 |
| 5 | 14 Sep 67 | 18 Sep 67 | 10.55 | -0.028 | -0.026 | 0.002 |
| 6 | 14 Sep 67 | 18 Sep 67 | -2.67 | -0.035 | -0.037 | -0.003 |
| 7 | 14 Sep 67 | 18 Sep 67 | -1.99 | -0.031 | -0.031 | 0.000 |
| 8 | 14 Sep 67 | 18 Sep 67 | 8.73 | -0.018 | -0.031 | -0.013 |
| 9 | 14 Sep 67 | 18 Sep 67 | 32.66 | -0.026 | -0.028 | -0.002 |
| 10 | 14 Sep 67 | 18 Sep 67 | 34.36 | -0.018 | -0.027 | -0.009 |
| 11 | 14 Sep 67 | 18 Sep 67 | 3.99 | -0.024 | -0.014 | 0.010 |
| 12 | 14 Sep 67 | 18 Sep 67 | 7.11 | -0.012 | -0.020 | -0.008 |
| 13 | 14 Sep 67 | 18 Sep 67 | -6.77 | -0.018 | -0.018 | 0.000 |
| 14 | 14 Sep 67 | 18 Sep 67 | 1.45 | -0.018 | -0.022 | -0.003 |
| 15 | 14 Sep 67 | 18 Sep 67 | 8.64 | -0.012 | -0.020 | -0.008 |
| 16 | 14 Sep 67 | 18 Sep 67 | -0.73 | -0.024 | -0.014 | 0.010 |
| 17 | 14 Sep 67 | 18 Sep 67 | -19.20 | -0.038 | -0.033 | 0.005 |
| 18 | 14 Sep 67 | 18 Sep 67 | -3.59 | -0.012 | -0.034 | -0.022 |
| 19 | 14 Sep 67 | 18 Sep 67 | 10.36 | -0.014 | -0.020 | -0.006 |
| 20 | 14 Sep 67 | 18 Sep 67 | -20.02 | -0.014 | -0.039 | -0.025 |
| Median | | | 3.99 | -0.018 | -0.024 | -0.003 |
| Tri-Mean | | | 3.69 | -0.018 | -0.024 | -0.003 |
| High Hinge | | | 9.54 | -0.012 | -0.016 | 0.004 |
| Low Hinge | | | -2.77 | -0.025 | -0.031 | -0.008 |
| Mean | | | 4.03 | -0.020 | -0.023 | -0.003 |
| Standard Deviation | | | 13.69 | 0.009 | 0.010 | 0.010 |

Note: X = Extrapolated shoreline intercept.

Table D4

Unit Volume Changes ($m^3/m$) Between Contours
Ludlam Beach, N.J.
from 14 Sep 67 to 18 Sep 67

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2.20 | 2.01 | 0.72 | -0.28 | -0.25 | | | | | | | | | | |
| 3 | -5.47 | -0.13 | -3.36 | -1.60 | -0.36 | -0.04 | 0.02 | | | | | | | | |
| 4 | -11.62 | -0.80 | -2.81 | -3.71 | -3.01 | -0.68 | -0.48 | -0.29 | 0.16 | | | | | | |
| 5 | -8.02 | 2.15 | -5.09 | -8.92 | 0.52 | 3.17 | 0.35 | -0.39 | 0.19 | | | | | | |
| 6 | -11.64 | -1.31 | -4.79 | -8.23 | 0.36 | 2.53 | 0.04 | -0.13 | -0.11 | 0.00 | | | | | |
| 7 | -13.77 | 0.09 | -3.13 | -11.87 | -0.76 | 1.09 | 0.50 | 0.09 | 0.11 | 0.11 | | | | | |
| 8 | -11.20 | 4.93 | -4.90 | -8.95 | -2.00 | 1.72 | -0.56 | -0.63 | -0.60 | -0.12 | -0.10 | 0.00 | | | |
| 9 | 1.88 | 9.39 | 0.04 | -6.35 | -0.70 | -0.72 | 0.06 | 0.07 | 0.05 | 0.03 | 0.01 | 0.00 | | | |
| 10 | 28.27 | 13.40 | 7.76 | 1.79 | 3.81 | 2.22 | -0.46 | -0.12 | -0.08 | -0.04 | 0.00 | | | | |
| 11 | -4.61 | -0.25 | -2.39 | -1.91 | -0.06 | 0.00 | | | | | | | | | |
| 12 | 0.40 | 1.94 | -0.68 | -0.58 | -0.28 | | | | | | | | | | |
| 13 | -9.45 | -3.13 | -3.38 | -2.42 | -0.52 | | | | | | | | | | |
| 14 | -6.55 | 0.41 | -2.76 | -2.88 | -1.06 | -0.26 | 0.00 | 0.00 | | | | | | | |
| 15 | -0.03 | 2.97 | -1.90 | -0.94 | -0.15 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | |
| 16 | -20.61 | -2.63 | -5.29 | -5.04 | -2.03 | -1.27 | -1.79 | -1.51 | -0.86 | -0.19 | | | | | |
| 17 | -61.19 | -10.54 | -9.31 | -11.24 | -11.31 | -6.05 | -4.57 | -4.97 | -3.06 | -0.14 | | | | | |
| 18 | 0.28 | 2.07 | 3.15 | -6.29 | -1.69 | 0.89 | 1.15 | 0.81 | 0.19 | | | | | | |
| 19 | 4.49 | 14.46 | 0.72 | -5.03 | -4.73 | -0.99 | -0.30 | 0.20 | 0.16 | | | | | | |
| 20 | -34.12 | -6.60 | -11.02 | -16.78 | 0.83 | -0.01 | -0.18 | -0.21 | -0.15 | | | | | | |
| Median | -6.55 | 0.41 | -2.81 | -5.03 | -0.52 | 0.00 | 0.00 | -0.13 | 0.00 | -0.04 | 0.00 | 0.00 | | | |
| Tri-mean | -6.10 | 0.58 | -2.70 | -5.10 | -0.75 | 0.17 | -0.11 | -0.14 | 0.00 | -0.05 | -0.01 | 0.00 | | | |
| High Hinge | 0.34 | 2.56 | -0.32 | -1.75 | -0.11 | 1.40 | 0.05 | 0.07 | 0.16 | 0.01 | 0.00 | 0.00 | | | |
| Low Hinge | -11.63 | -1.05 | -4.85 | -8.57 | -1.85 | -0.70 | -0.47 | -0.39 | -0.15 | -0.13 | -0.05 | 0.00 | | | |
| Mean | -8.46 | 1.50 | -2.55 | -5.33 | -1.23 | 0.10 | -0.41 | -0.51 | -0.31 | -0.05 | -0.03 | 0.00 | | | |
| Std Dev | 17.69 | 6.05 | 4.18 | 4.75 | 2.98 | 2.10 | 1.31 | 1.38 | 0.89 | 0.11 | 0.06 | 0.00 | | | |

*Note: Data not reaching MSL are not included in column or row statistics.*
X = Extrapolated shoreline intercept.

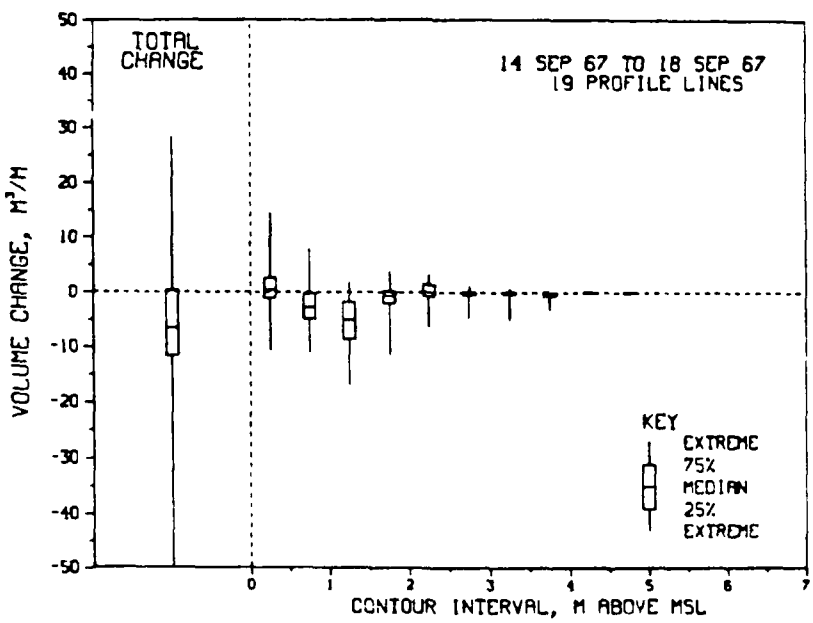



Figure D7. Distribution of volume changes by contour for Ludlam Beach, N. J.

## APPENDIX E: DATA SUMMARY FOR THE STORM OF 12 MARCH 1968

1. The storm of 12 March 1968 was documented through its effects on Misquamicut, Jones Beach, and Atlantic City. The development of the storm is shown on the synoptic weather map. This event was minor, producing peak high tides of only 1.1 to 1.2 m above msl with an associated 0.4-m surge. Wave heights ranged from 2.8 to 3.0 m. Along the northern beaches, peak tide and maximum wave heights coincided, but were slightly out of phase at Atlantic City. Only one storm occurred between the surveys, and poststorm profiling was completed within a few days after the storm.

2. Misquamicut experienced the greatest median volume change, but eroded only -4.3 $m^3/m$. All shorelines receded after this event and slope changes were generally small except at Westhampton where the median slope change was 0.053. The profile lines at Jones Beach showed the greatest variability with a hinge range of around 22.8 $m^3/m$.

3. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.

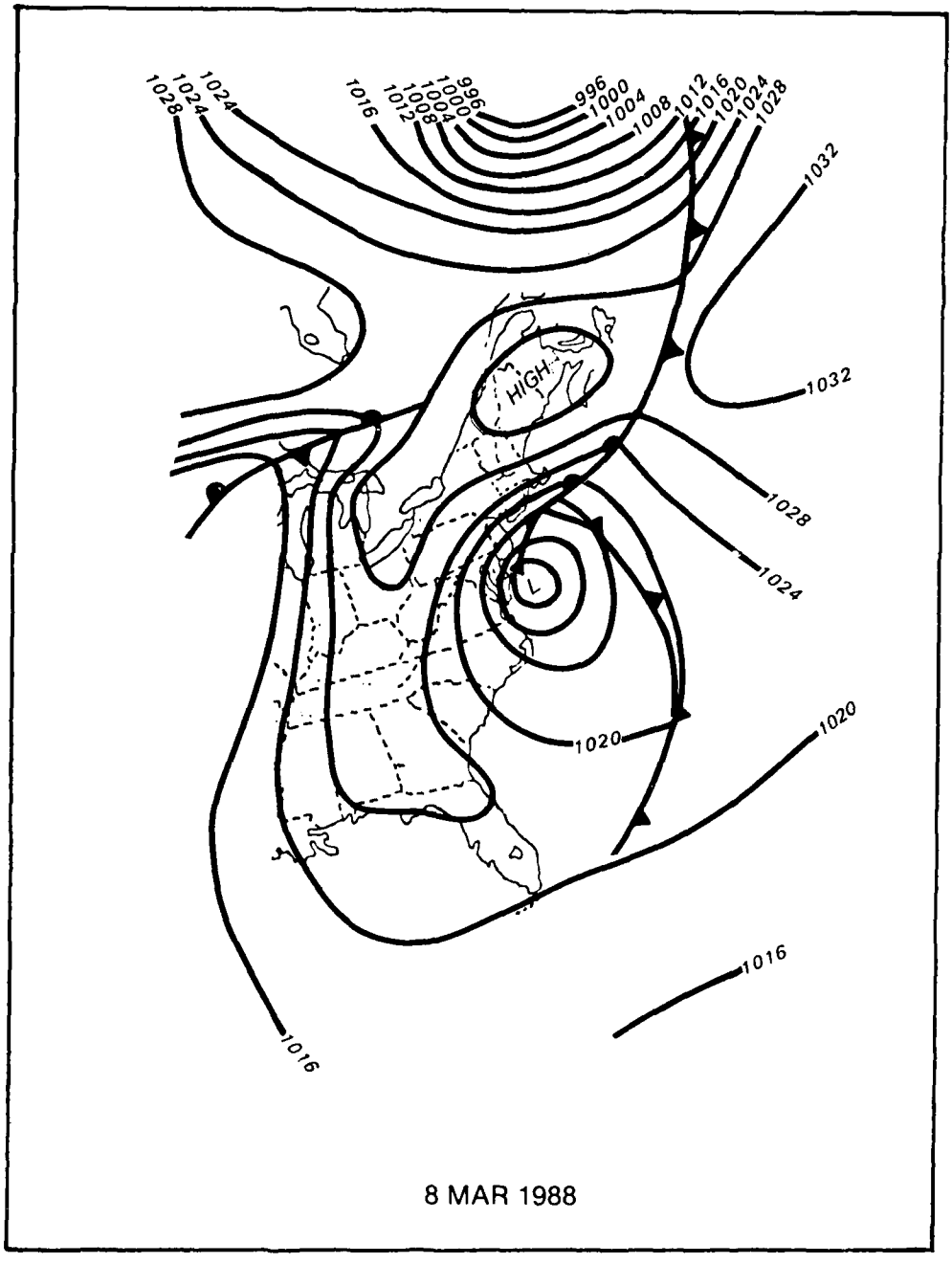



Figure E1. Synoptic weather map at 0700 for 8 March 1968

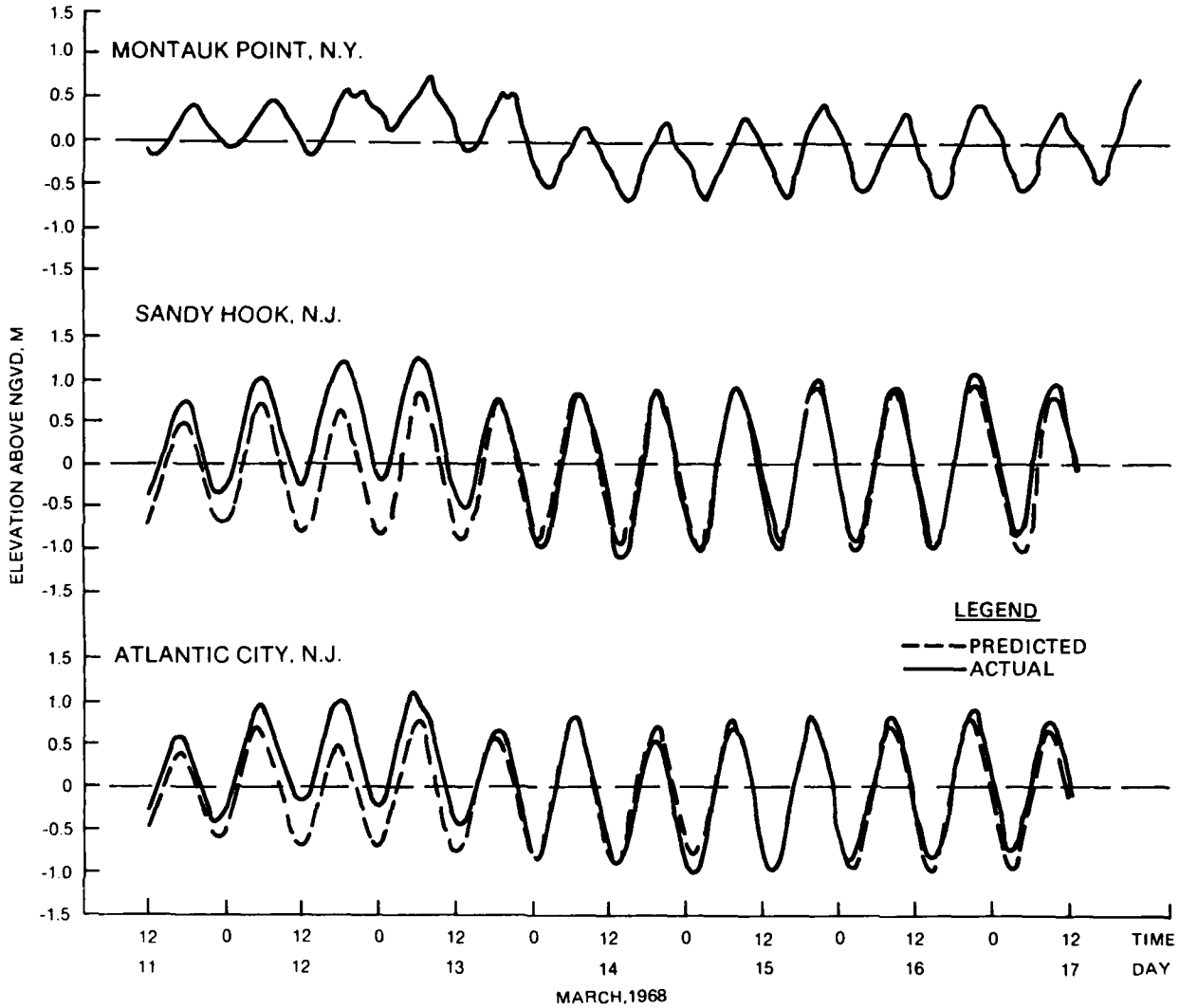



Figure E2. Predicted and actual water levels for 11-17 March 1968

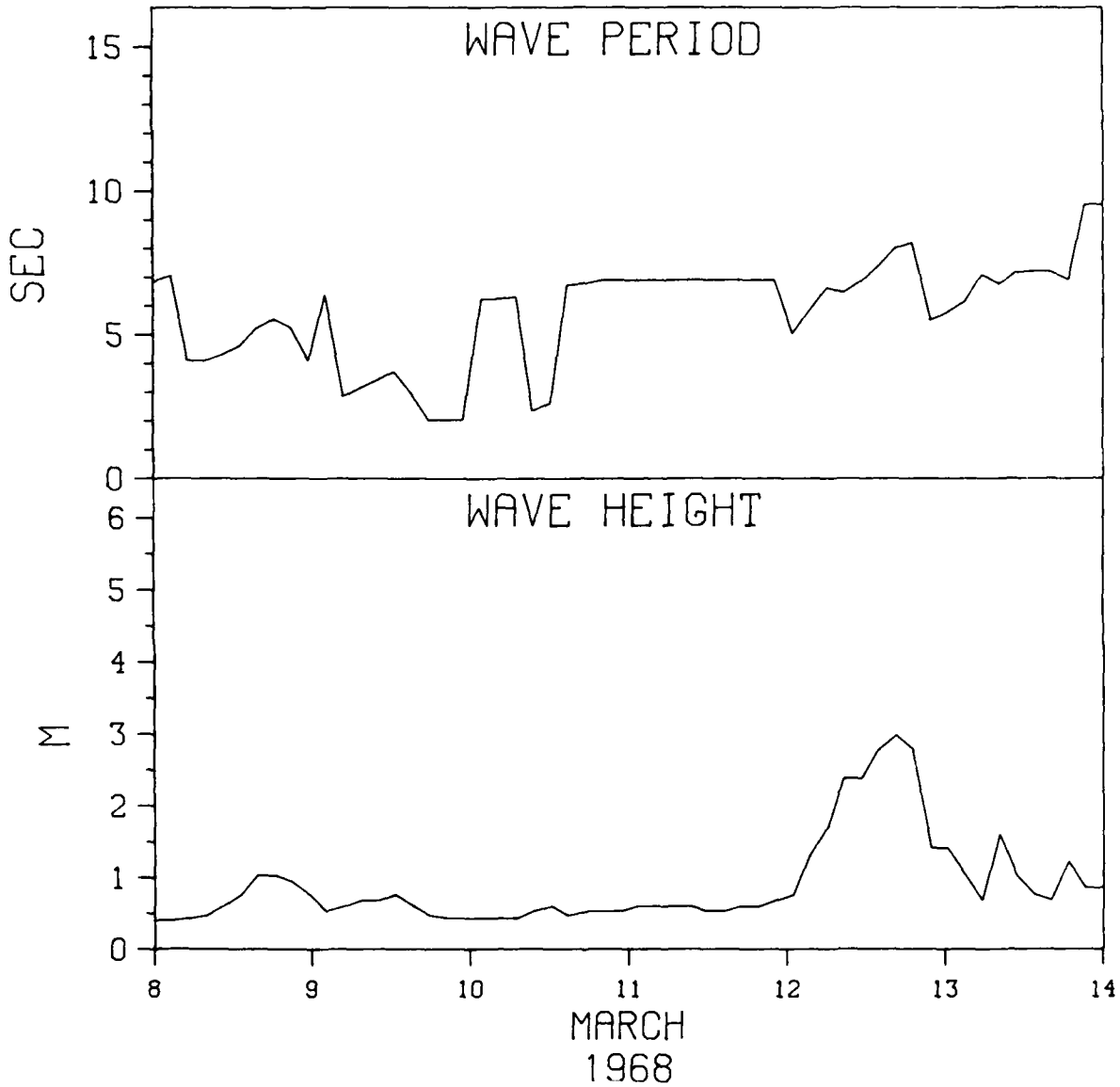



Figure E3. Hindcasted wave data for Misquamicut, R. I.

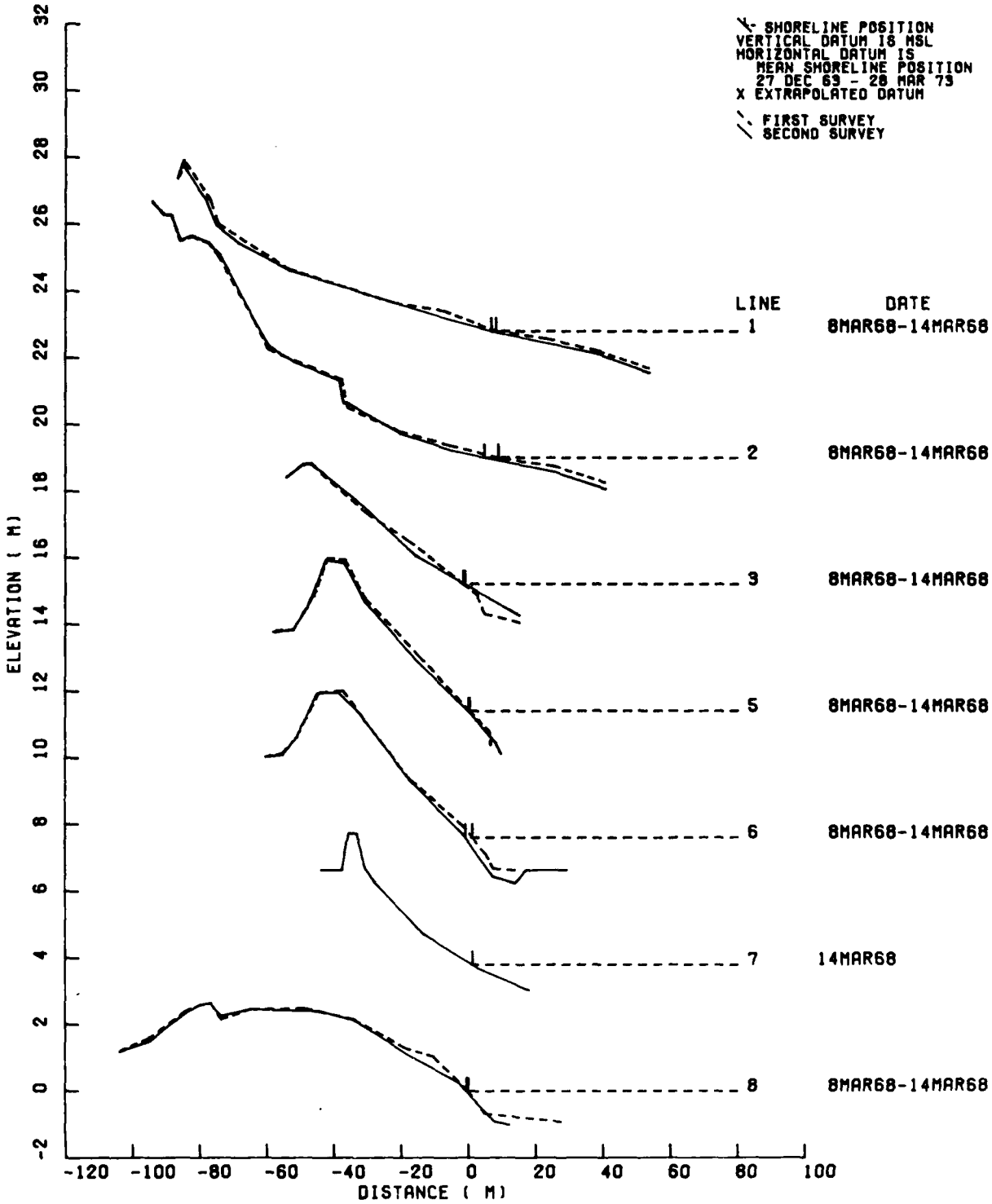



Figure E4. Profile comparisons for surveys at Misquamicut, R. I.

Table E1

Shoreline and Slope Changes at Misquamicut, R.I.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 8 Mar 68 | 14 Mar 68 | -1.39 | -0.039 | -0.028 | 0.011 |
| 2 | 8 Mar 68 | 14 Mar 68 | -4.15 | -0.025 | -0.022 | 0.004 |
| 3 | 8 Mar 68 | 14 Mar 68 | 0.48 | -0.081 | -0.058 | 0.022 |
| 5 | 8 Mar 68 | 14 Mar 68 | -0.31 | -0.110 | -0.098 | 0.012 |
| 6 | 8 Mar 68 | 14 Mar 68 | -2.05 | -0.122 | -0.141 | -0.020 |
| 8 | 8 Mar 68 | 14 Mar 68 | -0.52 | -0.100 | -0.108 | -0.008 |
| Median | | | -0.95 | -0.091 | -0.078 | 0.008 |
| Tri-Mean | | | -1.07 | -0.083 | -0.073 | 0.005 |
| High Hinge | | | -0.31 | -0.039 | -0.028 | 0.012 |
| Low Hinge | | | -2.05 | -0.110 | -0.108 | -0.008 |
| Mean | | | -1.32 | -0.080 | -0.076 | 0.004 |
| Standard Deviation | | | 1.64 | 0.039 | 0.047 | 0.015 |

Note: X = Extrapolated shoreline intercept.

Table E2

Unit Volume Changes ($m^3/m$) Between Contours
Misquamicut Beach, R.I.
from 8 Mar 68 to 14 Mar 68

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -7.96 | -1.95 | -1.49 | -0.12 | -0.37 | -0.84 | -1.17 | -0.51 | -0.55 | -0.61 | -0.38 | 0.03 | | | |
| 2 | -1.17 | -2.30 | -0.74 | 0.66 | -0.13 | -0.46 | -0.58 | 0.42 | 0.23 | 0.13 | 0.19 | 0.27 | 0.34 | 0.82 | |
| 3 | -1.86 | -0.35 | -1.45 | -1.33 | -0.27 | 0.63 | 0.54 | 0.30 | 0.07 | | | | | | |
| 5 | -5.12 | -0.29 | -0.58 | -0.86 | -0.93 | -0.90 | -0.65 | -0.33 | -0.04 | -0.21 | -0.33 | | | | |
| 6 | -3.48 | -1.07 | -0.88 | -0.51 | -0.16 | -0.14 | -0.21 | 0.05 | 0.05 | -0.61 | | | | | |
| 8 | -6.76 | -0.38 | -2.02 | -2.26 | -1.28 | -0.84 | 0.02 | | | | | | | | |
| Median | -4.30 | -0.73 | -1.16 | -0.69 | -0.32 | -0.65 | -0.39 | 0.05 | 0.05 | -0.41 | -0.33 | 0.15 | 0.34 | 0.82 | |
| Tri-mean | -4.31 | -0.94 | -1.14 | -0.70 | -0.43 | -0.57 | -0.35 | 0.02 | 0.03 | -0.37 | -0.27 | 0.15 | 0.34 | 0.82 | |
| High Hinge | -1.86 | -0.35 | -0.74 | -0.12 | -0.16 | -0.14 | 0.02 | 0.30 | 0.07 | -0.04 | -0.07 | 0.27 | 0.34 | 0.82 | |
| Low Hinge | -6.76 | -1.95 | -1.49 | -1.33 | -0.93 | -0.84 | -0.65 | -0.33 | -0.04 | -0.61 | -0.36 | 0.03 | 0.34 | 0.82 | |
| Mean | -4.39 | -1.06 | -1.19 | -0.74 | -0.52 | -0.43 | -0.34 | -0.01 | -0.05 | -0.33 | -0.17 | 0.15 | 0.34 | 0.82 | |
| Std Dev | 2.70 | 0.88 | 0.55 | 1.01 | 0.47 | 0.59 | 0.59 | 0.40 | 0.30 | 0.36 | 0.32 | 0.17 | 0.00 | 0.00 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

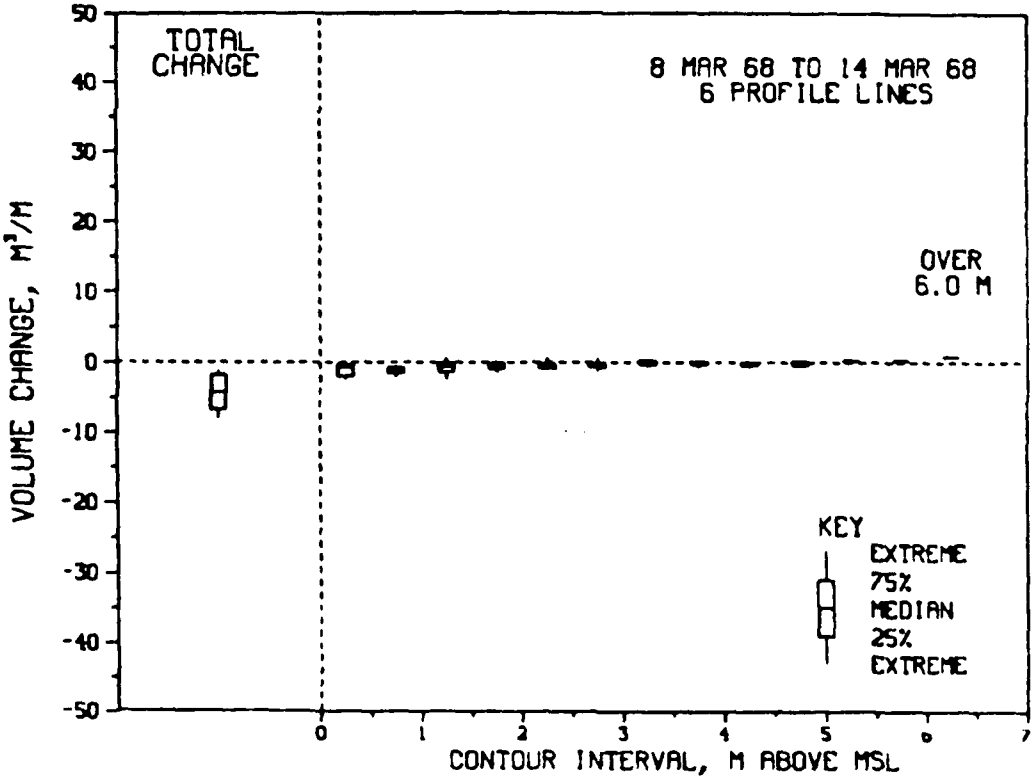



Figure E5. Distribution of volume changes by contour for Misquamicut, R. I.

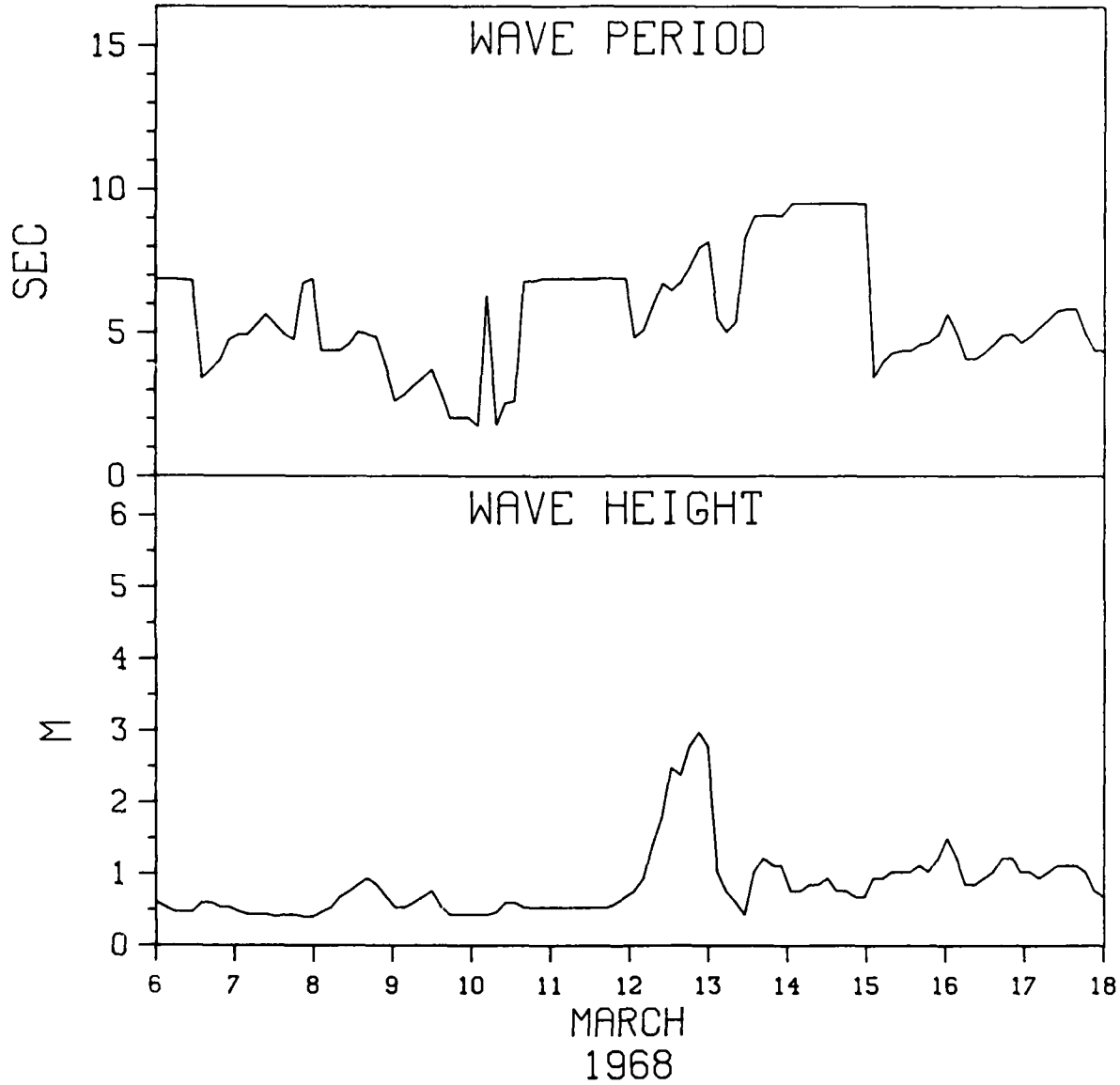



Figure E6. Hindcasted data for Westhampton, N. Y.

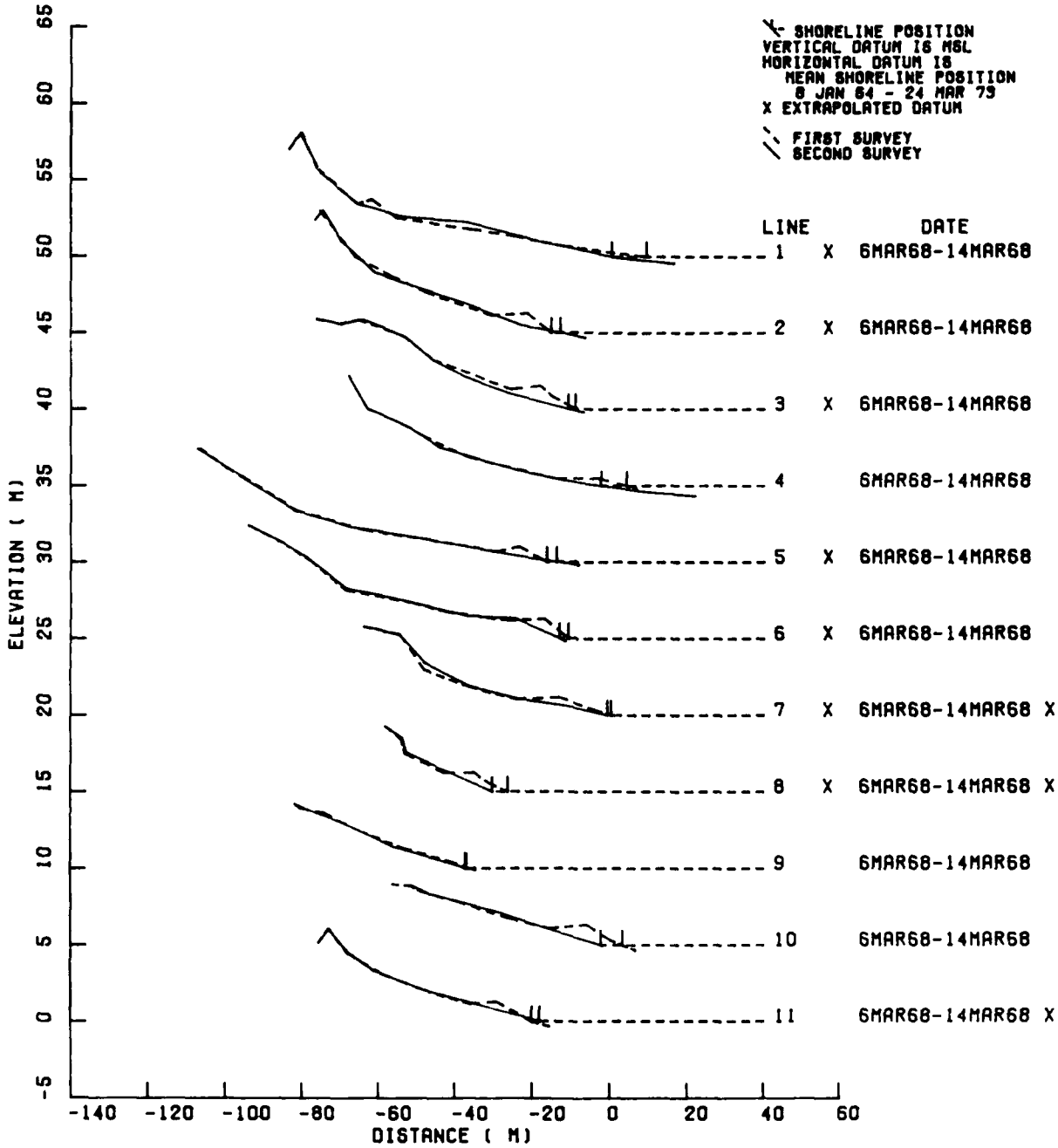



Figure E7. Profile comparisons for surveys at Westhampton, N. Y.

Table E3

Shoreline and Slope Changes at Westhampton, N.Y.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 6 Mar 68 X | 14 Mar 68 | -8.86 | -0.032 | -0.052 | -0.020 |
| 2 | 6 Mar 68 X | 14 Mar 68 | 2.18 | -0.207 | -0.050 | -0.157 |
| 3 | 6 Mar 68 X | 14 Mar 68 | -1.95 | -0.140 | -0.140 | 0.087 |
| 4 | 6 Mar 68 | 14 Mar 68 | -6.74 | -0.069 | -0.034 | 0.034 |
| 5 | 6 Mar 68 X | 14 Mar 68 | 2.35 | -0.139 | -0.036 | 0.103 |
| 6 | 6 Mar 68 X | 14 Mar 68 | -2.32 | -0.206 | -0.114 | 0.092 |
| 7 | 6 Mar 68 X | 14 Mar 68 X | -1.01 | -0.087 | -0.060 | 0.027 |
| 8 | 6 Mar 68 X | 14 Mar 68 X | -3.96 | -0.114 | -0.107 | 0.008 |
| 9 | 6 Mar 68 | 14 Mar 68 | 0.37 | -0.125 | -0.072 | 0.053 |
| 10 | 6 Mar 68 | 14 Mar 68 | -5.58 | -0.100 | -0.077 | 0.023 |
| 11 | 6 Mar 68 | 14 Mar 68 | 1.97 | -0.140 | -0.068 | 0.072 |
| Median | | | -1.95 | -0.125 | -0.060 | 0.053 |
| Tri-Mean | | | -1.88 | -0.121 | -0.061 | 0.055 |
| High Hinge | | | 1.17 | -0.094 | -0.051 | 0.090 |
| Low Hinge | | | -4.77 | -0.140 | -0.075 | 0.025 |
| Mean | | | -2.14 | -0.124 | -0.066 | 0.058 |
| Standard Deviation | | | 3.81 | 0.053 | 0.026 | 0.050 |

Note: X = Extrapolated shoreline intercept.

Table E4

Unit Volume Changes ($m^3/m$) Between Contours
Westhampton Beach, N.Y.
from 6 Mar 68 to 14 Mar 68

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.31 | X | -2.89 | -0.46 | 0.46 | 3.07 | 4.54 | 0.19 | -1.85 | -0.28 | -0.10 | -0.16 | -0.21 | | |
| 2 | -5.01 | X | -0.80 | -3.46 | -1.22 | 0.93 | 0.95 | 0.54 | -0.35 | -1.05 | -0.75 | 0.06 | 0.14 | | |
| 3 | -15.03 | X | -2.00 | -3.97 | -4.98 | -1.78 | -1.56 | -0.85 | -0.21 | -0.04 | 0.06 | 0.03 | 0.27 | | |
| 4 | -5.94 | | -4.49 | -0.34 | -0.24 | 0.26 | -0.43 | -0.68 | -0.15 | 0.10 | -0.06 | 0.06 | 0.03 | | |
| 5 | -5.78 | X | -1.23 | -2.88 | -0.26 | 0.43 | -0.02 | -0.42 | -0.34 | -0.26 | -0.26 | -0.27 | -0.27 | | |
| 6 | -2.52 | X | -1.65 | -2.62 | -0.88 | 0.08 | 0.17 | 0.89 | 0.60 | 0.26 | 0.22 | 0.18 | 0.23 | | |
| 7 | -0.92 | X | -1.17 | -3.59 | -0.82 | 0.44 | 0.79 | 1.48 | 1.06 | 0.51 | 0.32 | 0.13 | -0.07 | | |
| 8 | -3.58 | X | -2.06 | -2.50 | -0.92 | 0.67 | 0.58 | 0.21 | 0.22 | 0.21 | 0.00 | | | | |
| 9 | -3.79 | | -0.51 | -0.85 | -0.77 | -0.59 | -0.17 | -0.15 | -0.56 | -0.23 | 0.04 | | | | |
| 10 | -8.14 | | -3.25 | -4.84 | -2.32 | 0.80 | 0.84 | 0.26 | 0.14 | 0.23 | | | | | |
| 11 | -2.62 | X | 0.05 | -1.83 | -0.96 | 0.25 | -0.08 | -0.05 | -0.18 | -0.11 | 0.15 | 0.11 | 0.03 | | |
| Median | -3.79 | | -1.65 | -2.62 | -0.88 | 0.43 | 0.17 | 0.19 | -0.18 | -0.04 | 0.02 | 0.06 | 0.03 | | |
| Tri-mean | -4.00 | | -1.69 | -2.53 | -0.84 | 0.44 | 0.26 | 0.12 | -0.13 | -0.03 | 0.02 | 0.04 | 0.03 | | |
| High Hinge | -2.57 | | -0.99 | -1.34 | -0.51 | 0.74 | 0.81 | 0.40 | 0.18 | 0.22 | 0.15 | 0.12 | 0.19 | | |
| Low Hinge | -5.86 | | -2.47 | -3.53 | -1.09 | 0.16 | -0.13 | -0.28 | -0.34 | -0.25 | -0.10 | -0.06 | -0.14 | | |
| Mean | -4.64 | | -1.82 | -2.49 | -1.17 | 0.41 | 0.51 | 0.13 | -0.15 | -0.06 | -0.04 | 0.02 | 0.02 | | |
| Std Dev | 4.43 | | 1.32 | 1.48 | 1.44 | 1.16 | 1.52 | 0.68 | 0.73 | 0.41 | 0.30 | 0.15 | 0.20 | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

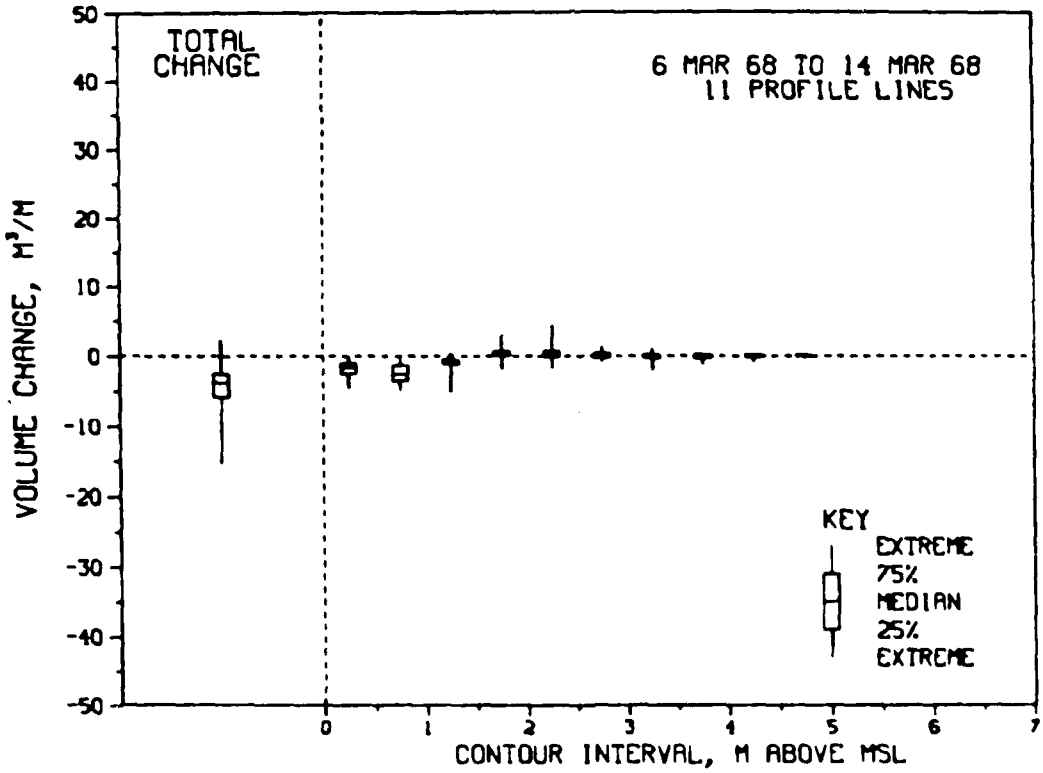



Figure E8. Distribution of volume changes by contour for Westhampton, N. Y.

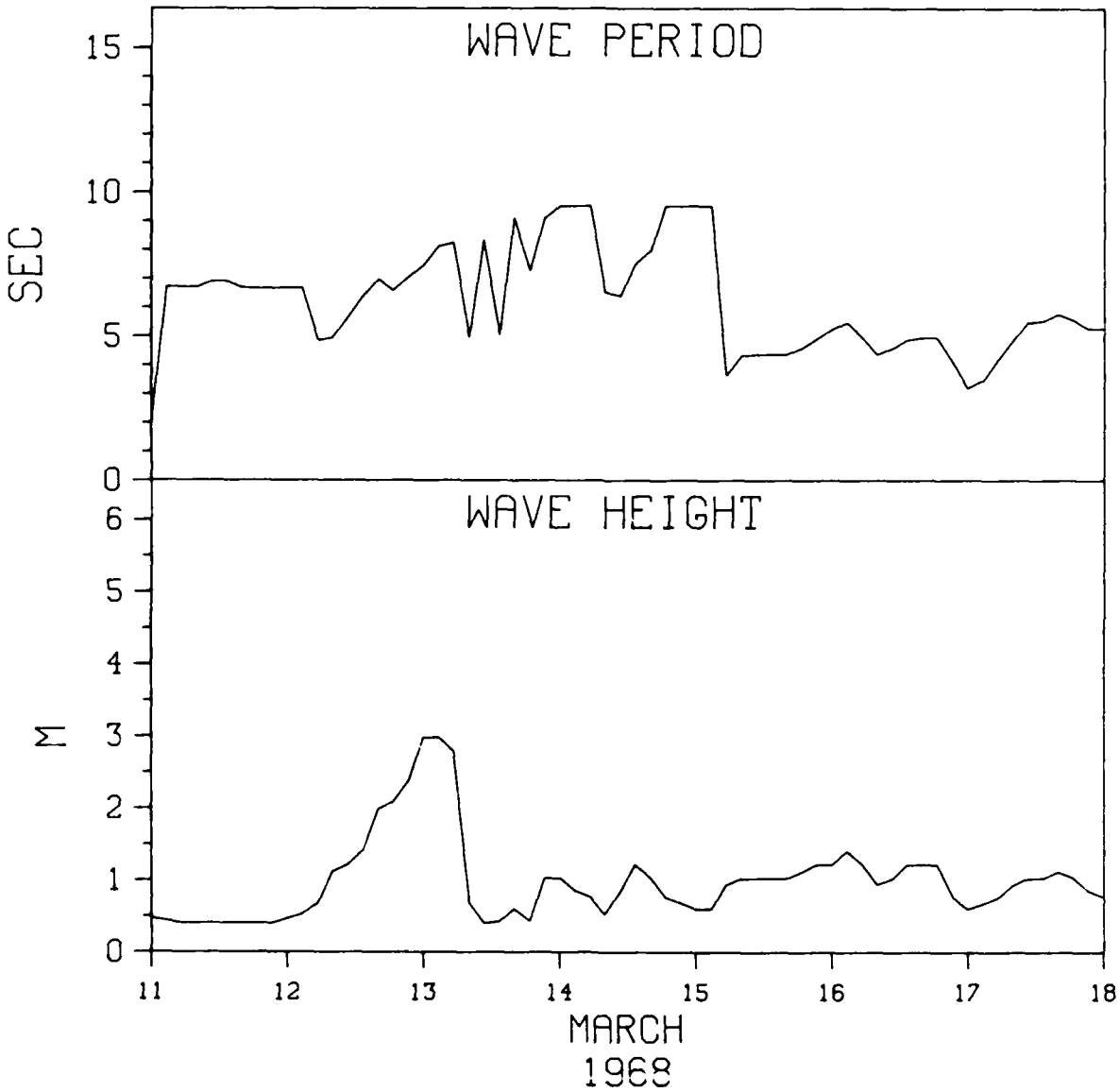



Figure E9. Hindcasted wave data for Jones Beach, N. Y.

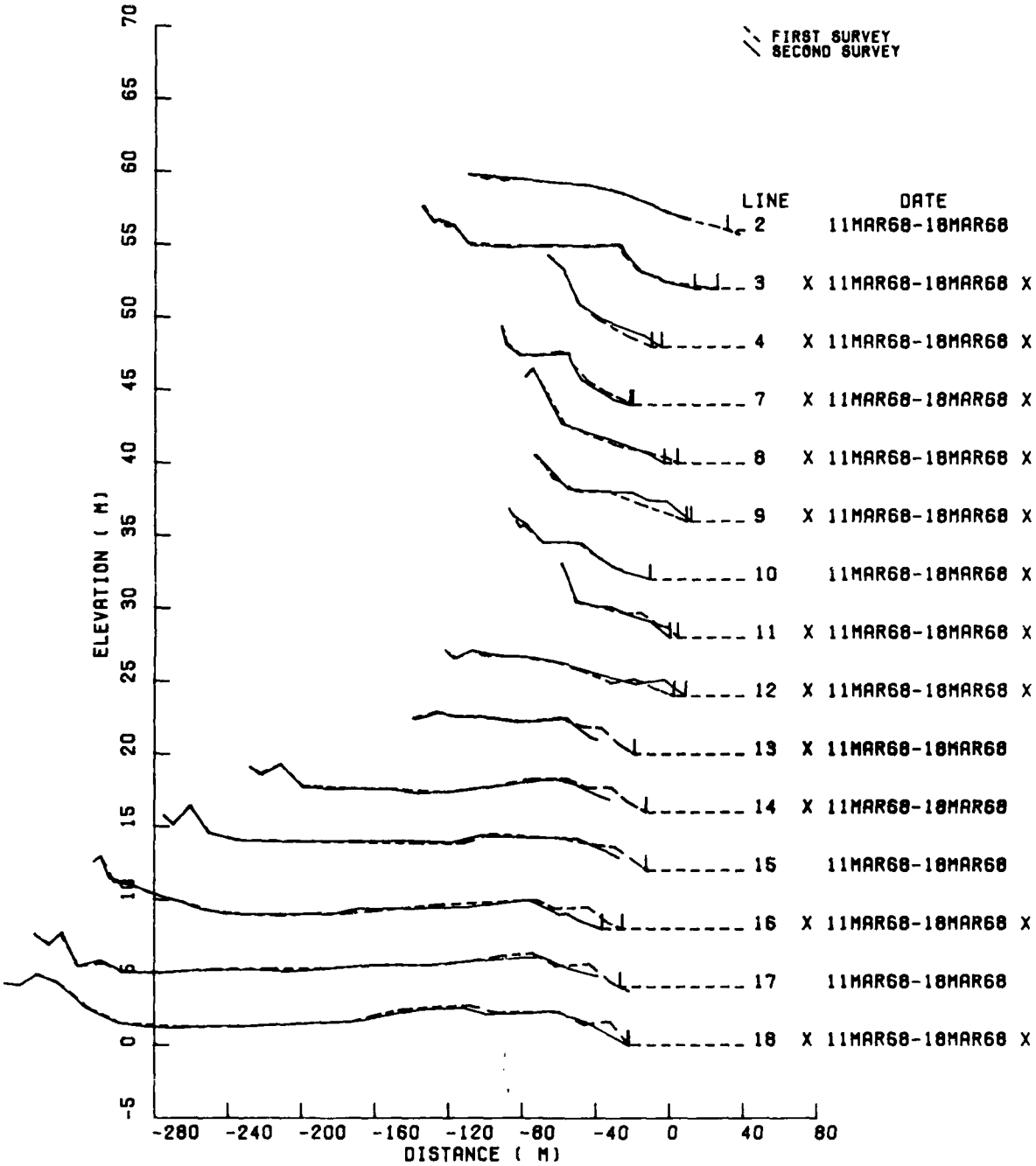



Figure E10. Profile comparsions for surveys at Jones Beach, N.Y.

Table E5

Shoreline and Slope Changes at Jones Beach, N.Y.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 3 | 11 Mar 68 X | 18 Mar 68 X | -12.15 | -0.016 | -0.029 | 0.024 |
| 4 | 11 Mar 68 | 18 Mar 68 X | 5.35 | -0.055 | -0.079 | -0.024 |
| 7 | 11 Mar 68 X | 18 Mar 68 X | -1.50 | -0.069 | -0.040 | 0.029 |
| 8 | 11 Mar 68 | 18 Mar 68 X | -7.12 | -0.067 | -0.073 | -0.007 |
| 9 | 11 Mar 68 X | 18 Mar 68 X | 2.54 | -0.053 | -0.106 | -0.053 |
| 11 | 11 Mar 68 X | 18 Mar 68 X | -4.37 | -0.125 | -0.106 | 0.019 |
| 12 | 11 Mar 68 X | 18 Mar 68 X | 6.46 | -0.050 | -0.092 | -0.042 |
| 16 | 11 Mar 68 | 18 Mar 68 X | -11.06 | -0.057 | -0.047 | 0.010 |
| 18 | 11 Mar 68 X | 18 Mar 68 X | -0.56 | -0.160 | -0.070 | 0.090 |
| Median | | | -1.50 | -0.057 | -0.073 | 0.007 |
| Tri-Mean | | | -1.89 | -0.059 | -0.071 | 0.005 |
| High Hinge | | | 2.54 | -0.053 | -0.047 | 0.019 |
| Low Hinge | | | -7.12 | -0.069 | -0.092 | -0.024 |
| Mean | | | -2.49 | -0.072 | -0.071 | 0.001 |
| Standard Deviation | | | 6.74 | 0.043 | 0.028 | 0.043 |

Note: X=Extrapolated Shoreline Intercept.

Table E6

Unit Volume Changes ($m^3/m$) Between Contours
Jones Beach, N.Y.
from 11 Mar 68 to 18 Mar 68

| Profile Line | Total Changes | | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | | | -0.42 | -0.28 | 0.15 | -0.36 | 0.68 | | | | | | | |
| 3 | -2.90 | X | -2.85 | 0.51 | 0.16 | 0.59 | 0.73 | -2.77 | -0.12 | 0.20 | 1.14 | -0.12 | -0.33 | -0.04 | | |
| 4 | 13.16 | X | 3.36 | 4.24 | 3.02 | 1.57 | 0.67 | 0.09 | 0.20 | 0.15 | 0.10 | 0.05 | -0.01 | -0.15 | -0.11 | |
| 7 | -9.65 | X | -1.92 | -1.65 | -1.38 | -1.37 | -0.74 | -0.10 | -0.99 | -0.84 | -0.34 | -0.21 | -0.11 | | | |
| 8 | -1.79 | X | -3.26 | -0.47 | 2.22 | 1.76 | 0.59 | -0.62 | -0.64 | -0.53 | -0.42 | -0.31 | -0.20 | -0.05 | 0.12 | |
| 9 | 23.88 | X | 2.45 | 5.45 | 7.76 | 5.14 | 0.28 | 0.67 | 1.01 | 0.58 | 0.51 | 0.03 | | | | |
| 10 | | | | | -0.02 | 0.23 | 0.47 | 0.06 | 0.51 | 1.55 | 0.38 | | | | | |
| 11 | -4.87 | X | -2.37 | -1.94 | -2.18 | -0.11 | 1.12 | 0.21 | 0.15 | 0.08 | 0.03 | 0.14 | 0.00 | | | |
| 12 | 17.00 | X | 4.37 | 5.41 | 3.13 | 1.38 | 1.11 | 1.61 | 0.00 | | | | | | | |
| 13 | | | | | 0.00 | -4.50 | -1.72 | | | | | | | | | |
| 14 | | | | | -9.10 | -7.22 | -3.65 | -0.28 | | | | | | | | |
| 15 | | | | | -4.02 | 5.17 | -0.88 | -0.24 | -0.13 | -0.11 | | | | | | |
| 16 | -30.62 | X | -6.00 | -5.99 | -9.48 | -9.67 | 0.10 | 0.38 | 0.86 | -0.56 | -0.30 | -0.05 | | | | |
| 17 | | | | | -8.67 | 0.85 | -3.80 | 0.14 | 0.29 | | | | | | | |
| 18 | -31.68 | X | -1.28 | -3.29 | -8.60 | -1.77 | -11.31 | -4.21 | -0.50 | -0.32 | -0.32 | -0.08 | | | | |
| Median | -2.90 | | -1.92 | -0.47 | -0.42 | 0.23 | 0.15 | -0.02 | 0.15 | -0.02 | 0.03 | -0.06 | -0.11 | -0.05 | 0.00 | |
| Tri-mean | -0.57 | | -1.06 | 0.34 | -1.49 | 0.09 | -0.09 | -0.05 | 0.17 | -0.09 | 0.03 | -0.06 | -0.11 | -0.06 | 0.00 | |
| High Hinge | 13.16 | | 2.45 | 4.24 | 1.19 | 1.48 | 0.63 | 0.21 | 0.51 | 0.20 | 0.38 | 0.04 | -0.01 | -0.05 | 0.12 | |
| Low Hinge | -9.65 | | -2.85 | -1.94 | -6.31 | -1.57 | -1.30 | -0.36 | -0.13 | -0.53 | -0.32 | -0.16 | -0.20 | -0.10 | -0.11 | |
| Mean | -3.05 | | -0.83 | 0.26 | -1.84 | -0.55 | -1.13 | -0.39 | 0.10 | 0.02 | 0.09 | -0.07 | -0.13 | -0.08 | 0.00 | |
| Std Dev | 19.42 | | 3.46 | 4.01 | 5.20 | 4.04 | 3.22 | 1.45 | 0.59 | 0.68 | 0.52 | 0.15 | 0.14 | 0.06 | 0.16 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

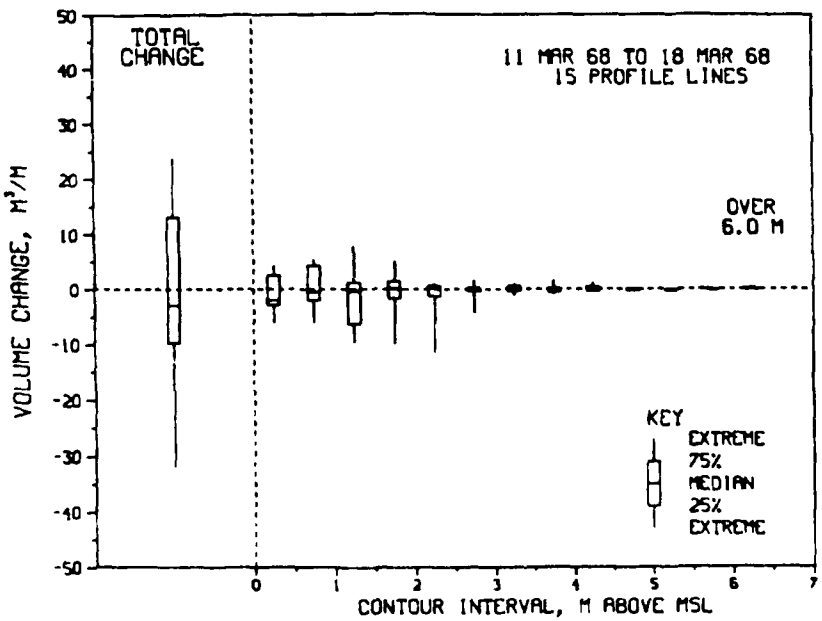



Figure E11. Distribution of volume changes by contour for Jones Beach, N. Y.

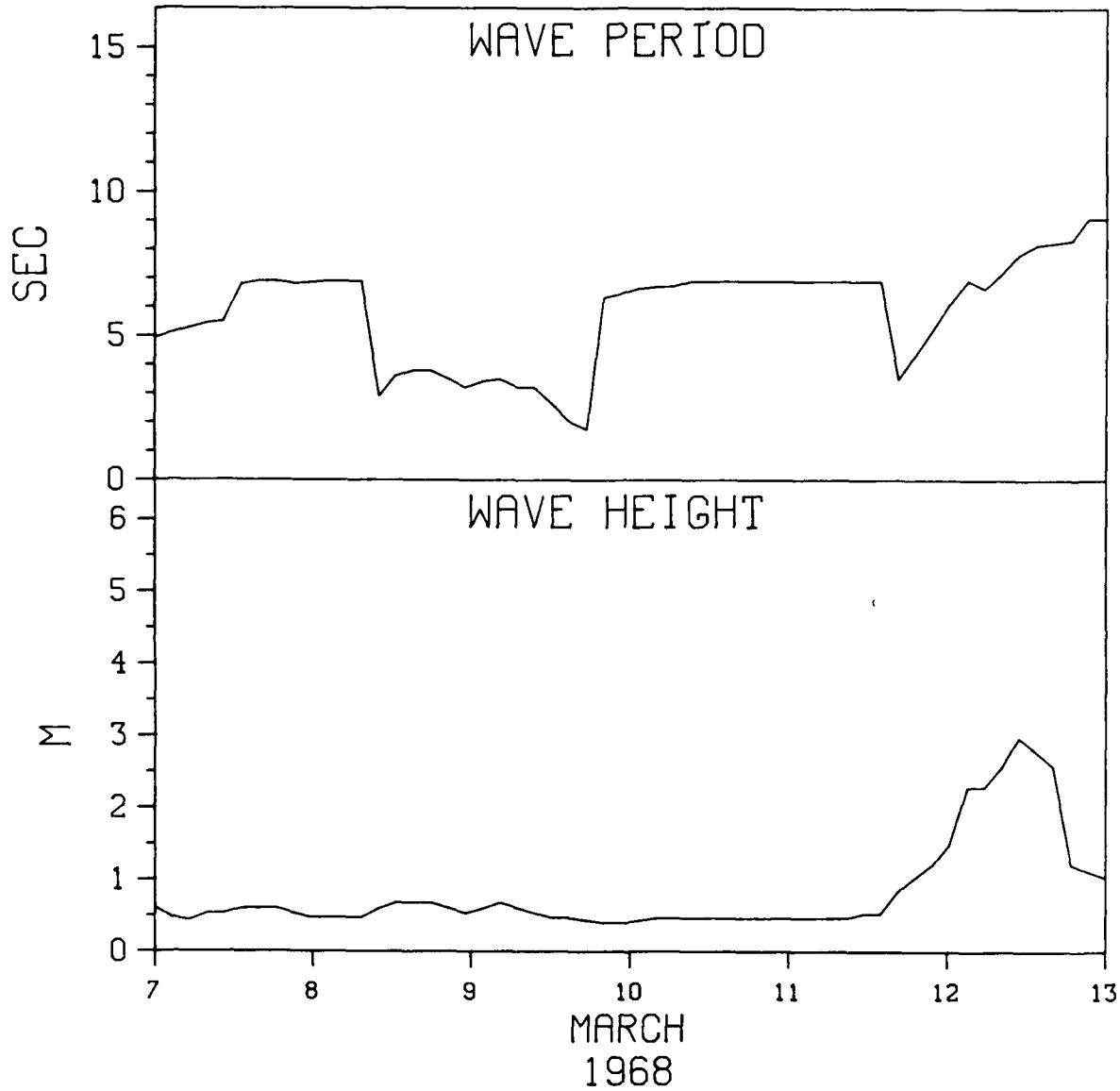



Figure E12. Hindcasted wave data for Atlantic City, N. J.

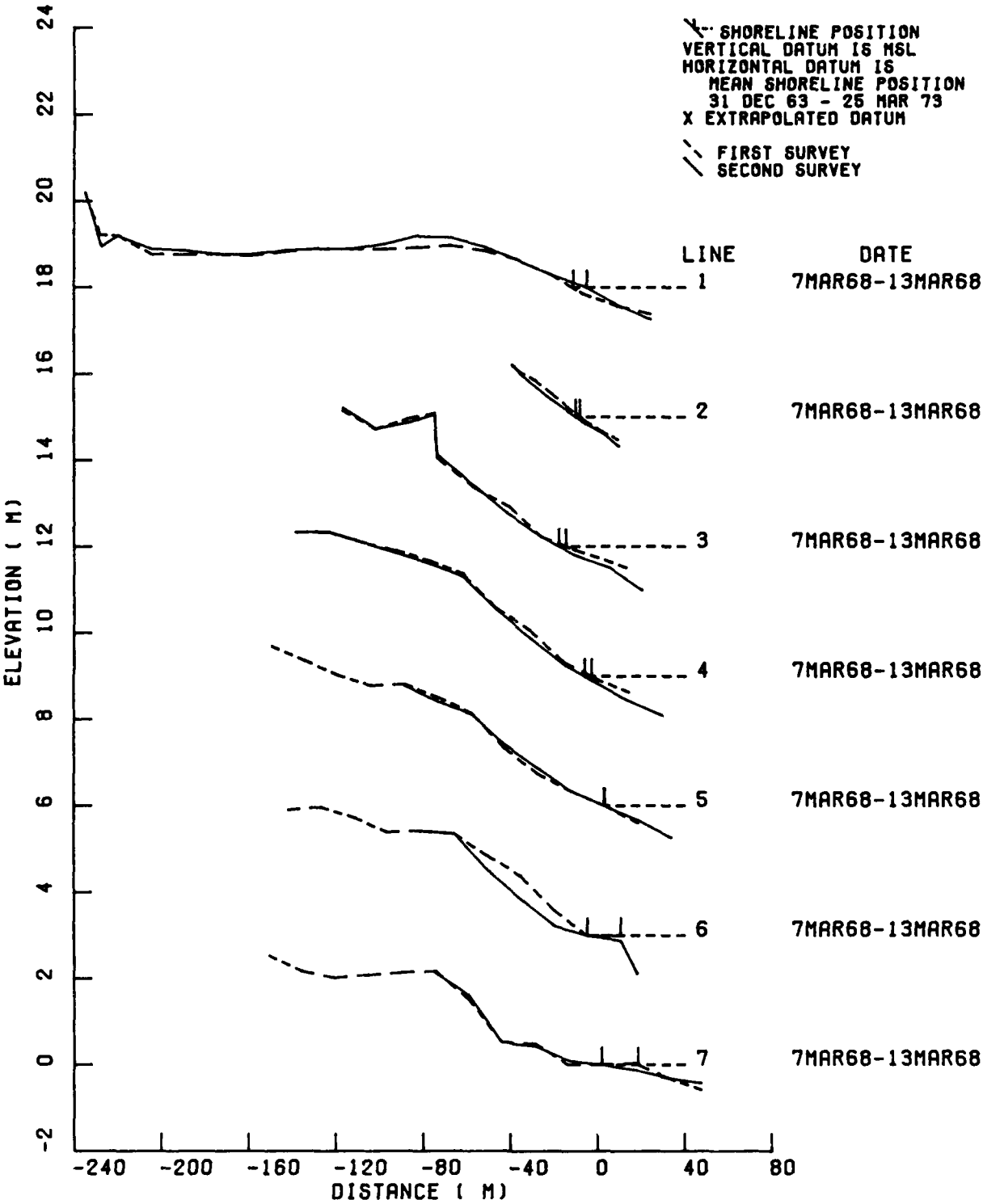



Figure E13. Profile comparisons for surveys of 7 profile lines at Atlantic City, N. J.

Table E7

Shoreline and Slope Changes at Atlantic City, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 7 Mar 68 | 13 Mar 68 | 6.17 | -0.030 | -0.028 | 0.002 |
| 2 | 7 Mar 68 | 13 Mar 68 | -1.95 | -0.040 | -0.036 | 0.004 |
| 3 | 7 Mar 68 | 13 Mar 68 | -3.26 | -0.020 | -0.028 | -0.008 |
| 4 | 7 Mar 68 | 13 Mar 68 | -3.10 | -0.026 | -0.028 | -0.002 |
| 5 | 7 Mar 68 | 13 Mar 68 | -0.31 | -0.022 | -0.022 | 0.000 |
| 6 | 7 Mar 68 | 13 Mar 68 | -15.24 | 0.000 | -0.014 | -0.014 |
| 7 | 7 Mar 68 | 13 Mar 68 | -16.63 | -0.022 | -0.006 | 0.016 |
| Median | | | -3.10 | -0.022 | -0.022 | 0.000 |
| Tri-Mean | | | -4.14 | -0.023 | -0.021 | -0.001 |
| High Hinge | | | -1.13 | -0.021 | -0.010 | 0.003 |
| Low Hinge | | | -9.25 | -0.028 | -0.028 | -0.005 |
| Mean | | | -4.90 | -0.023 | -0.020 | 0.000 |
| Standard Deviation | | | 8.19 | 0.012 | 0.012 | 0.009 |

Note: X = Extrapolated shoreline intercept.

Table E8

Unit Volume Changes ($m^3/m$) Between Contours
Atlantic City, N.J.
from 7 Mar 68 to 13 Mar 68

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13.54 | 0.92 | 8.97 | 3.81 | -0.17 | 0.00 | | | | | | | | | |
| 2 | -3.12 | -1.39 | -1.61 | -0.12 | | | | | | | | | | | |
| 3 | -2.98 | -0.66 | -1.81 | -0.31 | 0.69 | 0.09 | -1.04 | 0.06 | | | | | | | |
| 4 | -7.28 | -1.17 | -1.62 | -1.47 | -0.40 | -0.90 | -1.70 | -0.02 | | | | | | | |
| 5 | 0.94 | 0.07 | 1.46 | 1.20 | 0.29 | -1.23 | -0.85 | 0.00 | 0.00 | | | | | | |
| 6 | -18.72 | -3.61 | -4.91 | -5.85 | -3.66 | -0.70 | 0.00 | | | | | | | | |
| 7 | 1.34 | 0.33 | 0.09 | 0.46 | 0.56 | -0.10 | 0.00 | | | | | | | | |
| Median | -2.98 | -0.66 | -1.61 | -0.12 | 0.06 | -0.40 | -0.85 | 0.00 | 0.00 | | | | | | |
| Tri-mean | -2.50 | -0.60 | -1.04 | -0.07 | 0.07 | -0.43 | -0.69 | 0.00 | 0.00 | | | | | | |
| High Hinge | 1.14 | 0.20 | 0.78 | 0.83 | 0.56 | 0.00 | 0.00 | 0.03 | 0.00 | | | | | | |
| Low Hinge | -5.20 | -1.28 | -1.71 | -0.89 | -0.40 | -0.90 | -1.04 | -0.01 | 0.00 | | | | | | |
| Mean | -2.33 | -0.79 | 0.08 | -0.33 | -0.45 | -0.47 | -0.72 | 0.01 | 0.00 | | | | | | |
| Std Dev | 9.75 | 1.49 | 4.38 | 2.94 | 1.63 | 0.55 | 0.73 | 0.04 | 0.00 | | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

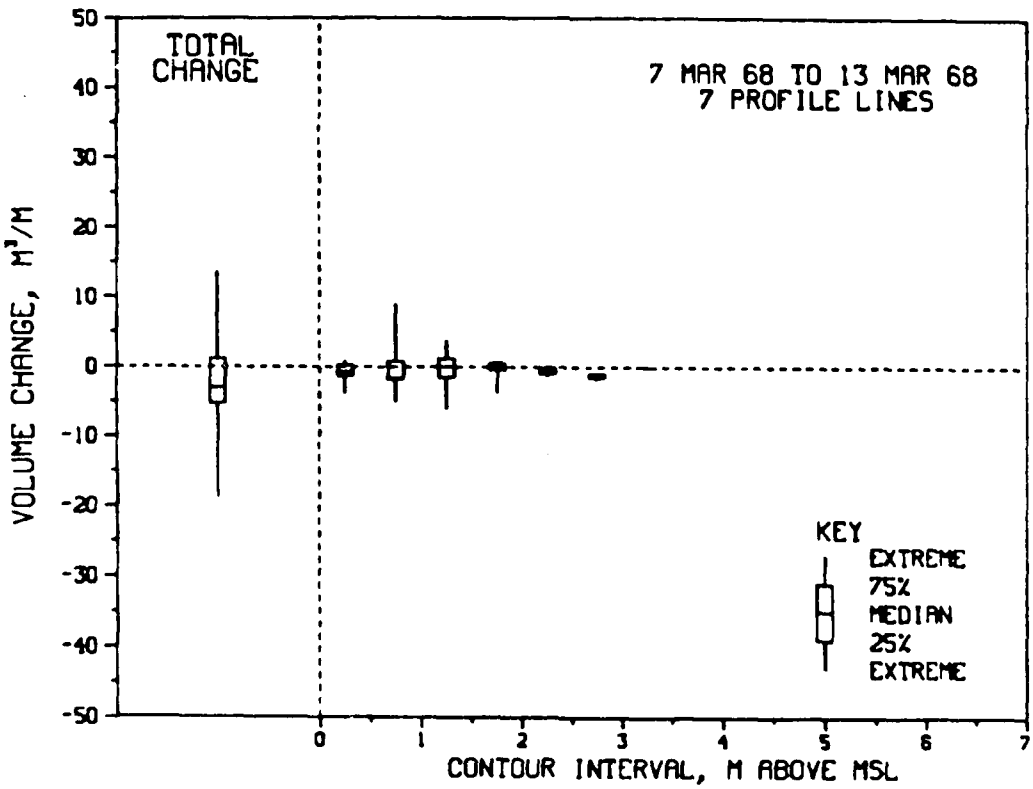


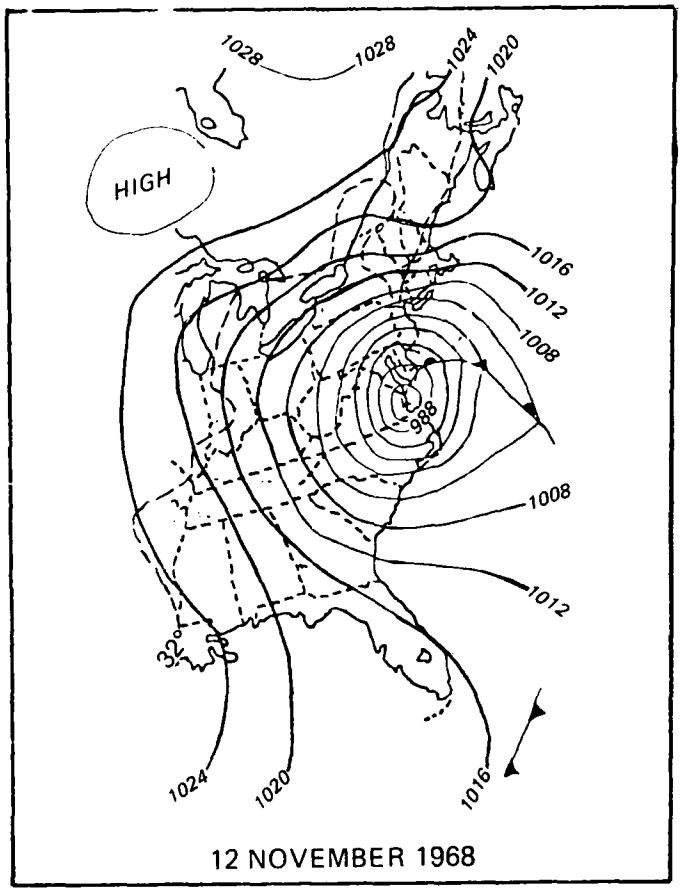

*Figure E14. Distribution of volume changes by contour for Atlantic City, N. J.*

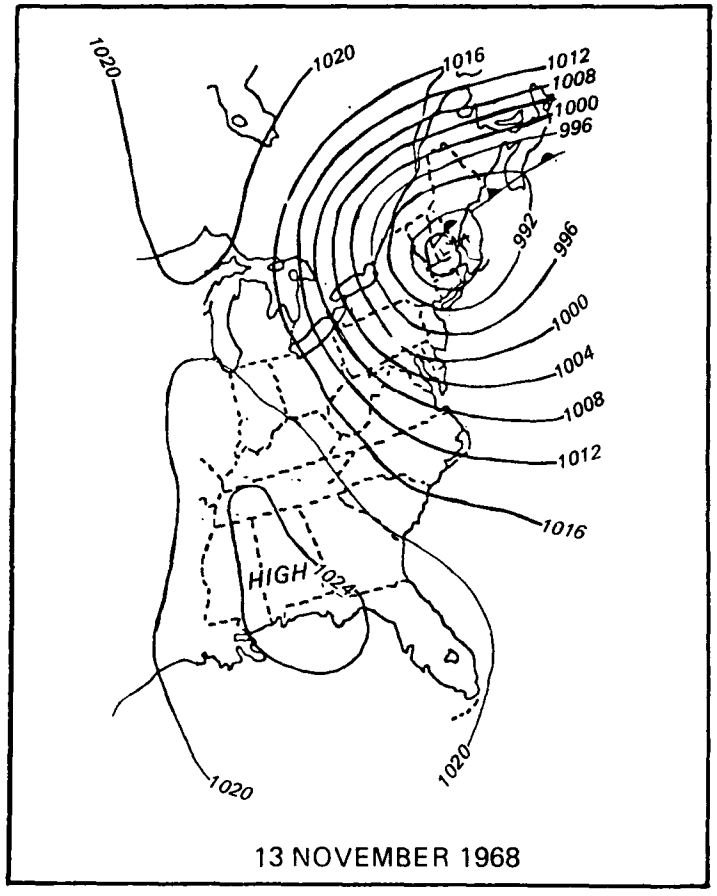
## APPENDIX F: DATA SUMMARY FOR THE STORM OF 12 NOVEMBER 1968

4. The 12 November 1968 storm was recorded through its effects on the three New Jersey localities of Long Beach Island, Atlantic City, and Ludlam Beach. The low pressure cell was well developed and migrated up the eastern coast during 12 to 13 November 1968 as shown on the synoptic weather maps. This event was highly significant with a peak water level of 1.6 m and an associated surge of 1.2 m at Atlantic City. Maximum hindcast wave heights ranged from 2.4 to 2.9 m and coincided with the peak high tide at all sites. However, beach changes cannot be attributed to a single storm system. As can be seen in the hindcast plots, a storm also occurred on 7 November 1968. The hindcast wave heights for this storm were higher than for 12 November 1968 but the tide records indicate a much lower peak water level (only 0.8 m at Sandy Hook). Poststorm surveys were conducted 2 to 3 days after the main event, but the changes probably resulted from the sequence of storms. Only a few of the profile lines show evidence of possible recovery.

5. Erosion was significant at all localities, ranging from -19.7 $m^3/m$ at Atlantic City to -26.4 $m^3/m$ at Long Beach Island. Long Beach Island also had the greatest variability along the beach with a hinge range of 27 $m^3/m$. Significant erosion at these sites occurred high on the beach between the 0- to 2.5-m contour intervals. All shorelines receded, from a median of -1.4 m at Long Beach Island to -6.1 m at Ludlam Beach. Slope changes at msl were minimal at all localities, but the profile cross sections indicate a leveling trend of the upper berm as the sediments moved offshore. This storm is of particular interest in comparing beach changes after a large storm.

6. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.




a. 12 and 13 November 1968

Figure F1. Synoptic weather maps at 0700 for 12-13 November 1968

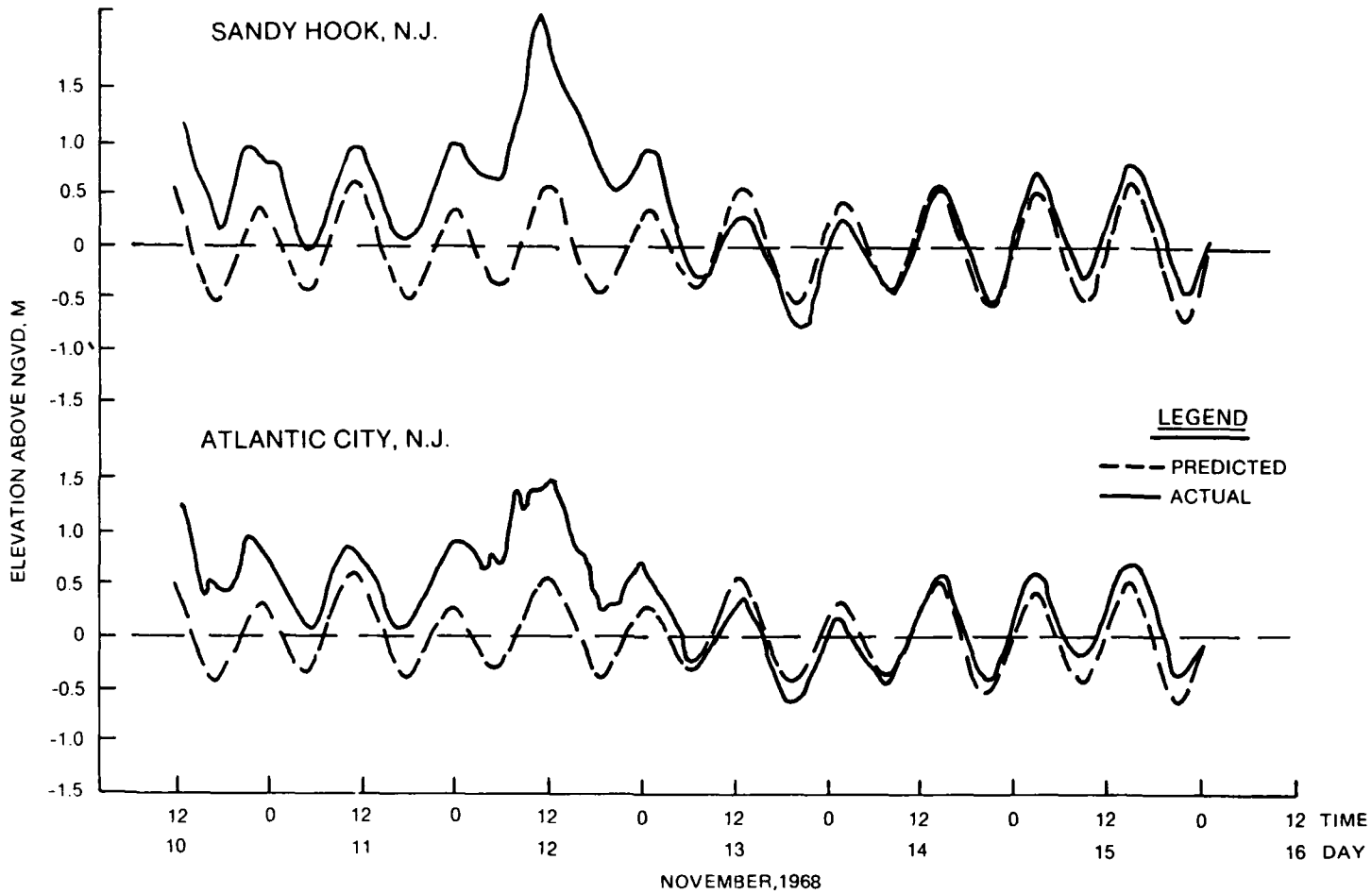



Figure F2. Predicted and actual water levels for 10-15 November 1968

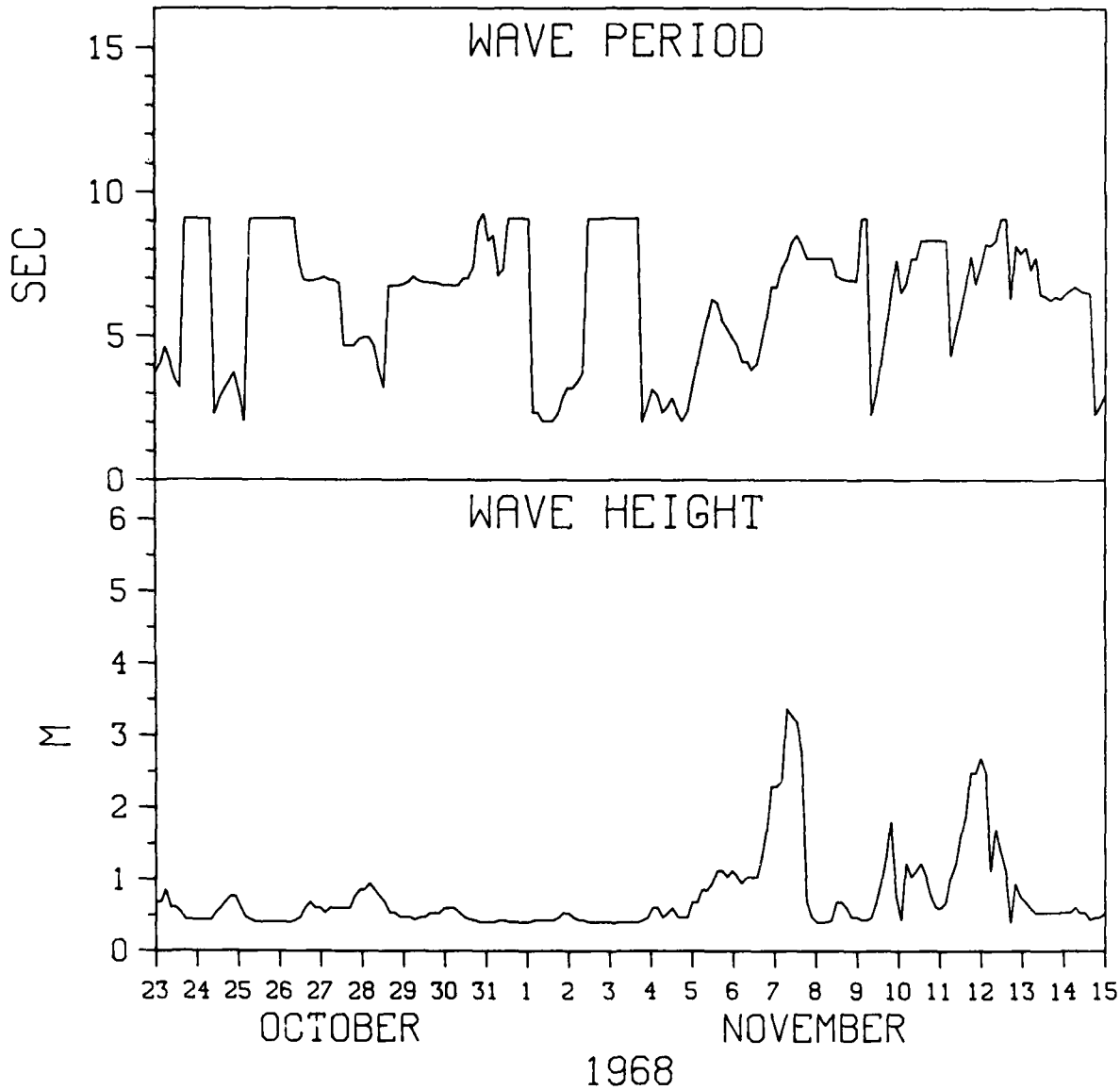
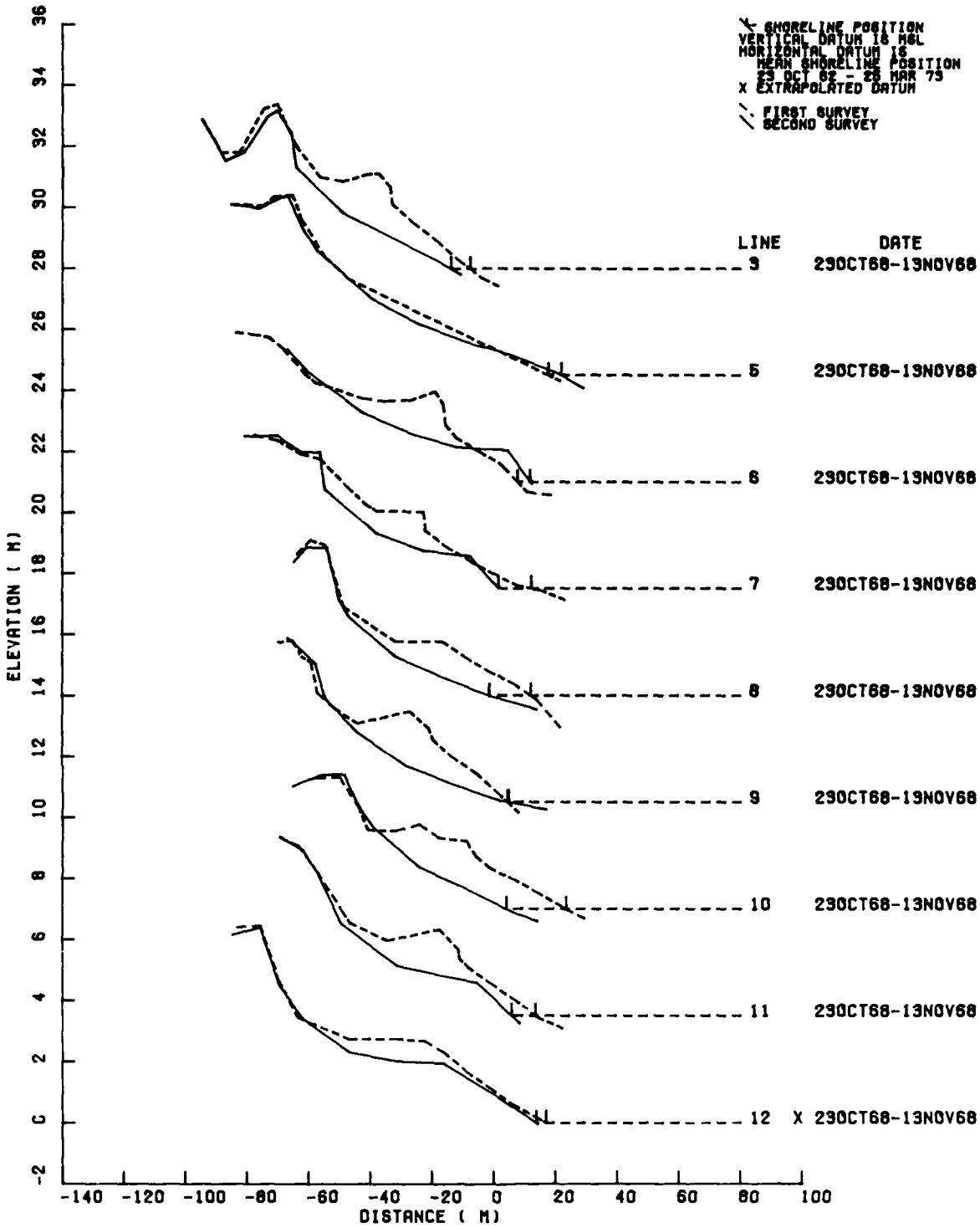
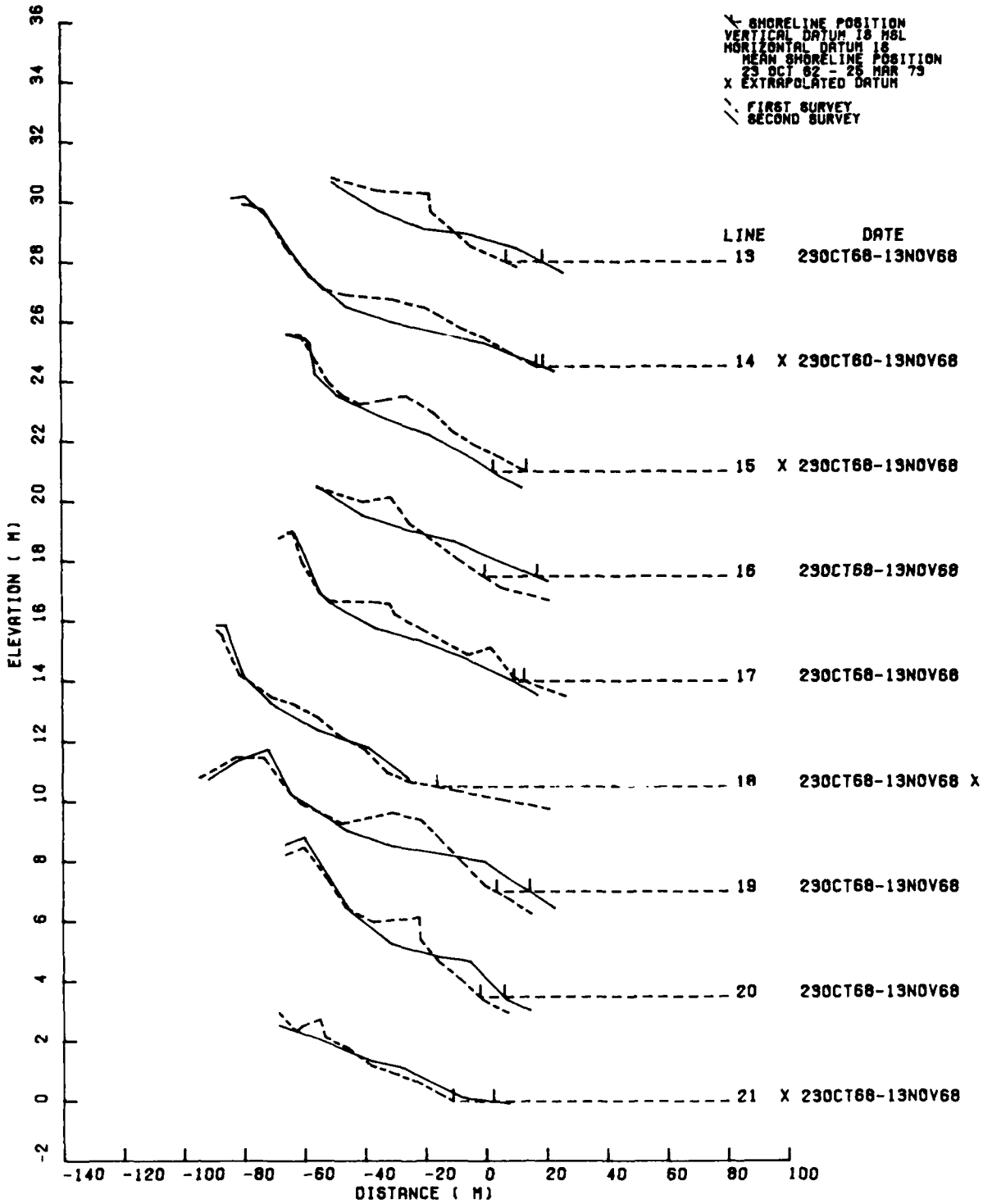



Figure F3. Hindcasted wave data for Long Beach Island, N. J.




a. Profile lines 3-12

Figure F4. Profile comparsions for surveys at Long Beach Island, N. J. (Continued)




b. Profile lines 13-21

Figure F4. (Concluded)

Table F1

Shoreline and Slope Changes at Long Beach Island, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 3 | 23 Oct 68 | 13 Nov 68 | -6.26 | -0.076 | -0.060 | 0.016 |
| 5 | 23 Oct 68 | 13 Nov 68 | 4.25 | -0.049 | -0.060 | -0.011 |
| 6 | 23 Oct 68 | 13 Nov 68 | 4.09 | -0.112 | -0.144 | -0.032 |
| 7 | 23 Oct 68 | 13 Nov 68 | -10.67 | -0.020 | -0.117 | -0.097 |
| 8 | 23 Oct 68 | 13 Nov 68 | -13.45 | -0.068 | -0.040 | 0.028 |
| 9 | 23 Oct 68 | 13 Nov 68 | 0.31 | -0.100 | -0.020 | 0.080 |
| 10 | 23 Oct 68 | 13 Nov 68 | -19.34 | -0.052 | -0.052 | 0.000 |
| 11 | 23 Oct 68 | 13 Nov 68 | -7.73 | -0.076 | -0.100 | -0.024 |
| 12 | 23 Oct 68 X | 13 Nov 68 | -3.17 | -0.056 | -0.068 | -0.012 |
| 13 | 23 Oct 68 | 13 Nov 68 | 11.78 | -0.046 | -0.054 | -0.008 |
| 14 | 23 Oct 68 X | 13 Nov 68 | 2.18 | -0.056 | -0.040 | 0.016 |
| 15 | 23 Oct 68 X | 13 Nov 68 | -11.05 | -0.056 | -0.068 | -0.012 |
| 16 | 23 Oct 68 | 13 Nov 68 | 17.16 | -0.066 | -0.042 | 0.024 |
| 17 | 23 Oct 68 | 13 Nov 68 | -3.35 | -0.036 | -0.048 | -0.012 |
| 18 | 23 Oct 68 | 13 Nov 68 X | -5.51 | -0.020 | -0.076 | -0.056 |
| 19 | 23 Oct 68 | 13 Nov 68 | 10.95 | -0.056 | -0.064 | -0.008 |
| 20 | 23 Oct 68 | 13 Nov 68 | 8.07 | -0.092 | -0.104 | -0.012 |
| 21 | 23 Oct 68 X | 13 Nov 68 | 13.43 | -0.056 | -0.012 | 0.044 |
| Median | | | -1.43 | -0.054 | -0.060 | -0.004 |
| Tri-Mean | | | -0.63 | -0.051 | -0.060 | 0.002 |
| High Hinge | | | 8.07 | -0.020 | -0.042 | 0.028 |
| Low Hinge | | | -7.73 | -0.076 | -0.076 | -0.012 |
| Mean | | | -0.46 | -0.055 | -0.065 | 0.006 |
| Standard Deviation | | | 10.22 | 0.029 | 0.033 | 0.047 |

Note: X = Extrapolated shoreline intercept.

Table F2

Unit Volume Changes ($m^3/m$) Between Contours
Long Beach Island, N.J.
from 23 Oct 68 to 13 Nov 68

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | -57.05 | -3.69 | -5.50 | -7.36 | -9.20 | -10.11 | -11.25 | -3.19 | -2.68 | -1.13 | -1.36 | -1.58 | | | |
| 5 | -13.42 | 1.68 | 0.01 | -2.56 | -3.65 | -3.29 | -1.88 | -0.08 | -0.05 | -0.61 | -0.74 | -0.58 | -1.67 | | |
| 6 | -23.37 | 2.30 | 3.57 | -2.09 | -7.90 | -12.62 | -8.24 | 0.54 | 0.71 | 0.36 | 0.00 | | | | |
| 7 | -32.84 | -2.72 | -0.11 | -3.25 | -7.80 | -10.22 | -4.67 | -3.84 | -2.05 | 0.69 | 1.07 | 0.06 | | | |
| 8 | -40.23 | -7.99 | -9.67 | -10.88 | -6.94 | -2.05 | -0.80 | -0.33 | -0.20 | -0.03 | -1.18 | -0.16 | | | |
| 9 | -44.48 | -2.68 | -6.77 | -9.37 | -9.99 | -11.42 | -7.05 | 0.17 | 0.89 | 0.80 | 0.77 | 0.17 | | | |
| 10 | -52.96 | -9.89 | -10.53 | -11.09 | -11.40 | -10.65 | -1.43 | 0.29 | 0.43 | 1.31 | | | | | |
| 11 | -44.10 | -3.47 | -2.64 | -4.94 | -11.17 | -13.39 | -5.82 | -1.34 | -0.87 | -0.41 | -0.06 | 0.11 | -0.10 | | |
| 12 | -28.27 | X -1.19 | -0.75 | -1.12 | -2.07 | -13.27 | -8.15 | -0.43 | 0.39 | -0.05 | -0.21 | -0.17 | -0.14 | -1.10 | |
| 13 | -15.27 | 6.28 | 3.71 | -5.18 | -8.97 | -9.64 | -1.47 | | | | | | | | |
| 14 | -26.15 | X 0.27 | -1.84 | -6.90 | -11.21 | -7.59 | -0.05 | -0.09 | 0.26 | 0.33 | 0.12 | 0.16 | 0.39 | | |
| 15 | -34.29 | X -5.15 | -4.70 | -5.25 | -8.63 | -8.35 | -0.96 | -1.15 | -0.37 | 0.43 | -0.16 | | | | |
| 16 | 1.34 | 7.50 | 5.31 | 2.03 | -3.49 | -7.62 | -2.39 | 0.00 | | | | | | | |
| 17 | -26.55 | -2.27 | -5.25 | -3.66 | -6.71 | -7.79 | -3.02 | 0.33 | 0.73 | 0.79 | 0.33 | -0.03 | | | |
| 18 | -1.19 | X 0.58 | 1.92 | 0.97 | -1.39 | -3.40 | -2.93 | -0.55 | 0.51 | 0.88 | 1.09 | 1.13 | | | |
| 19 | -15.97 | 5.42 | 4.36 | -1.97 | -11.16 | -12.89 | -0.77 | 0.24 | 0.12 | -0.33 | 1.01 | | | | |
| 20 | 2.36 | 4.19 | 4.66 | 2.70 | -4.48 | -7.67 | -1.84 | 0.41 | 0.46 | 0.64 | 1.65 | 1.64 | | | |
| 21 | 2.18 | X 3.05 | 2.60 | 2.54 | -0.86 | -3.22 | -1.93 | | | | | | | | |
| Median | -26.35 | -0.46 | -0.43 | -3.45 | -7.85 | -9.00 | -2.16 | -0.09 | 0.26 | 0.36 | 0.06 | 0.06 | -0.12 | -1.10 | |
| Tri-mean | -26.59 | -0.34 | -0.63 | -3.73 | -7.34 | -9.25 | -2.89 | -0.19 | 0.18 | 0.32 | 0.23 | 0.03 | -0.25 | -1.10 | |
| High Hinge | -13.42 | 3.05 | 3.57 | -1.12 | -3.65 | -7.59 | -1.43 | 0.26 | 0.49 | 0.74 | 1.01 | 0.16 | 0.14 | -1.10 | |
| Low Hinge | -40.23 | -3.47 | -5.25 | -6.90 | -9.99 | -11.42 | -5.82 | -0.85 | -0.28 | -0.19 | -0.21 | -0.16 | -0.90 | -1.10 | |
| Mean | -25.01 | -0.43 | -1.20 | -3.74 | -7.06 | -8.62 | -3.59 | -0.56 | -0.11 | 0.24 | 0.17 | 0.07 | -0.38 | -1.10 | |
| Std Dev | 18.80 | 4.80 | 4.98 | 4.31 | 3.57 | 3.66 | 3.20 | 1.27 | 1.03 | 0.66 | 0.89 | 0.83 | 0.89 | 0.00 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

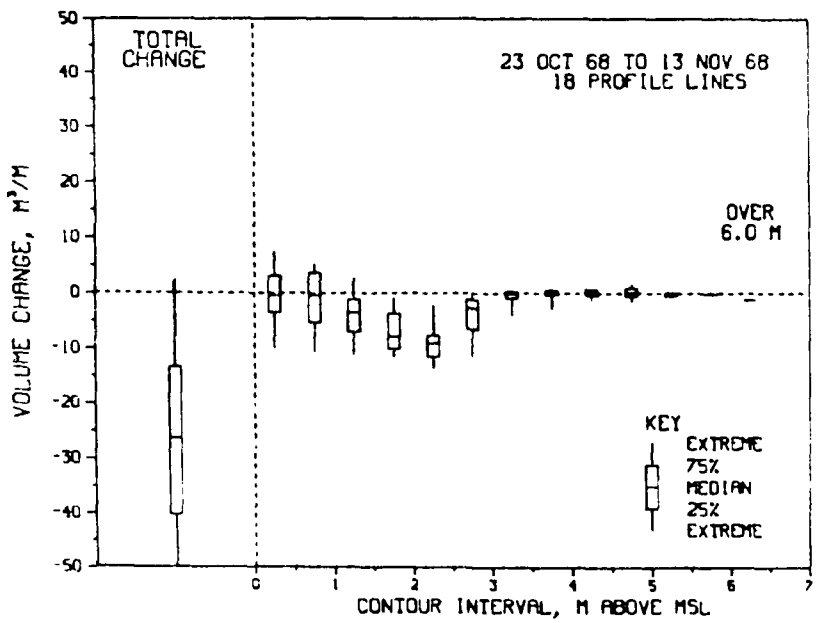



Figure F5. Distribution of volume changes by contour for Long Beach Island, N. J.

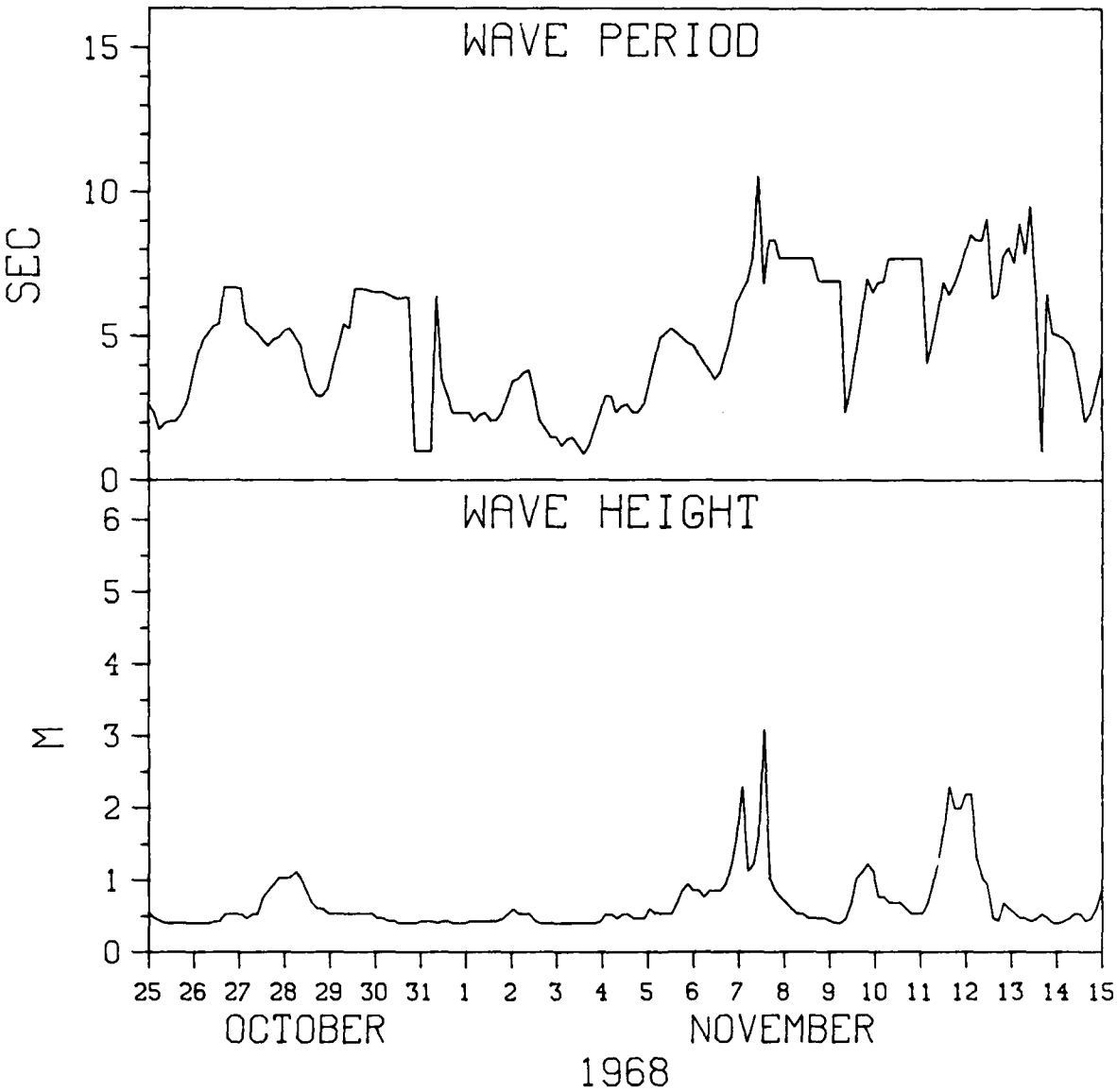



Figure F6. Hindcasted wave data for Atlantic City, N. J.

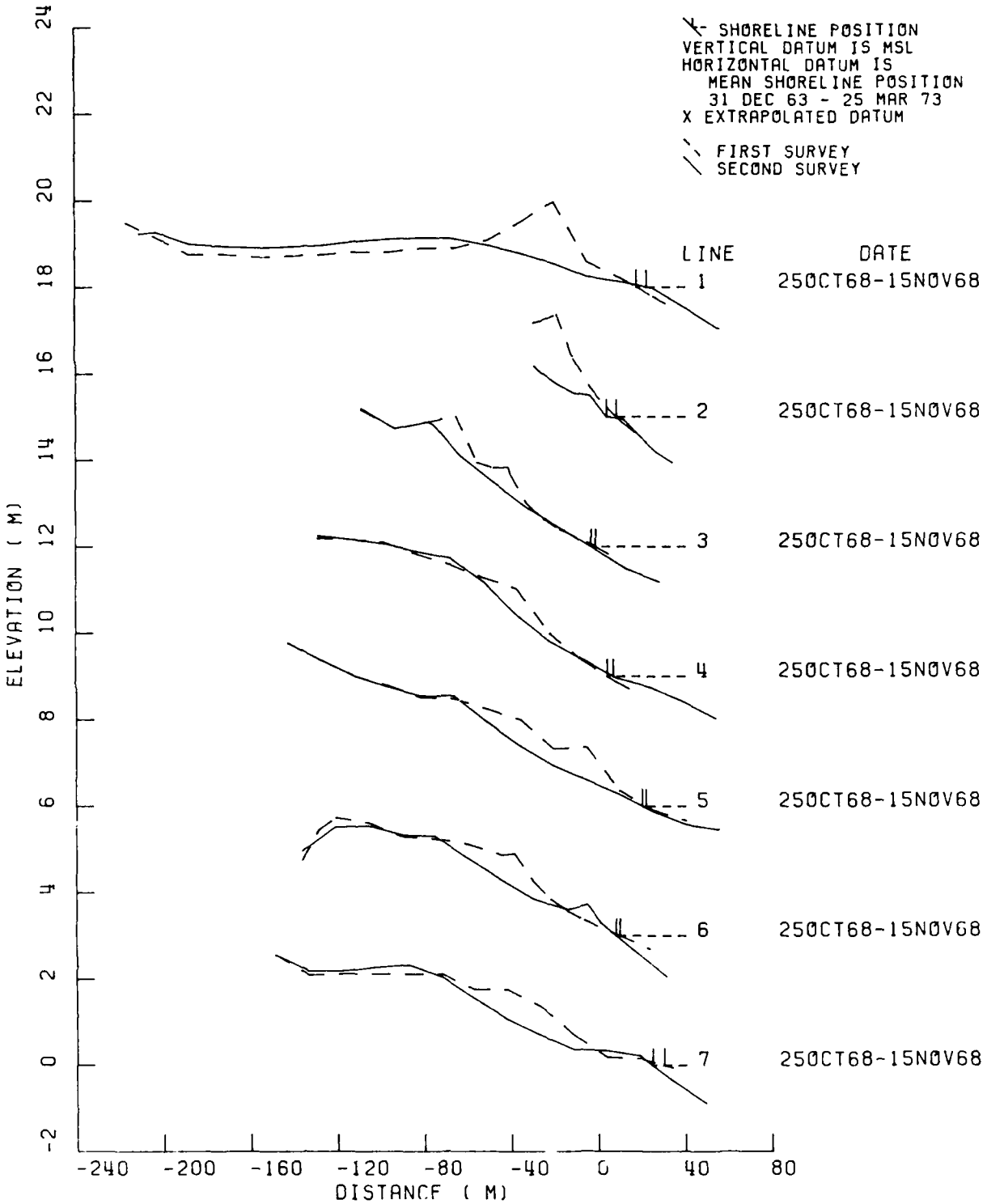



Figure F7. Profile comparisons for surveys at Atlantic City, N. J.

Table F3

Shoreline and Slope Changes at Atlantic City, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 25 Oct 68 | 15 Nov 68 | 4.57 | -0.028 | -0.010 | 0.018 |
| 2 | 25 Oct 68 | 15 Nov 68 | -4.45 | -0.048 | -0.064 | -0.016 |
| 3 | 25 Oct 68 | 15 Nov 68 | -2.11 | -0.028 | -0.030 | -0.002 |
| 4 | 25 Oct 68 | 15 Nov 68 | 2.72 | -0.032 | -0.028 | 0.004 |
| 5 | 25 Oct 68 | 15 Nov 68 | -1.64 | -0.030 | -0.026 | 0.004 |
| 6 | 25 Oct 68 | 15 Nov 68 | -1.75 | -0.022 | -0.042 | -0.020 |
| 7 | 25 Oct 68 | 15 Nov 68 | -5.27 | -0.014 | -0.038 | -0.024 |
| Median | | | -1.75 | -0.028 | -0.030 | -0.002 |
| Tri-Mean | | | -1.56 | -0.028 | -0.032 | -0.005 |
| High Hinge | | | 0.54 | -0.025 | -0.027 | 0.004 |
| Low Hinge | | | -3.28 | -0.031 | -0.040 | -0.018 |
| Mean | | | -1.13 | -0.029 | -0.034 | -0.005 |
| Standard Deviation | | | 3.58 | 0.010 | 0.017 | 0.015 |

Note: X = Extrapolated shoreline intercept.

Table F4

Unit Volume Changes ($m^3/m$) Between Contours
Atlantic City, N.J.
from 25 Oct 68 to 15 Nov 68

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -8.10 | -4.83 | 9.73 | -7.88 | -5.12 | | | | | | | | | | |
| 2 | -28.90 | -1.75 | -6.70 | -9.35 | -7.64 | -3.46 | | | | | | | | | |
| 3 | -17.23 | -0.15 | -0.18 | -3.03 | -5.08 | -3.69 | -5.24 | 0.14 | | | | | | | |
| 4 | -9.27 | 0.74 | -1.57 | -3.53 | -5.32 | -2.29 | 2.55 | 0.15 | | | | | | | |
| 5 | -32.14 | -1.80 | -7.88 | -11.25 | -7.80 | -3.91 | 0.51 | 0.00 | 0.00 | | | | | | |
| 6 | -20.49 | 1.93 | -0.25 | -6.74 | -9.83 | -2.45 | -3.15 | | | | | | | | |
| 7 | -19.74 | 0.19 | -8.14 | -11.71 | -7.21 | 7.12 | 0.00 | | | | | | | | |
| Median | -19.74 | -0.15 | -1.57 | -7.88 | -7.21 | -2.95 | 0.00 | 0.14 | 0.00 | | | | | | |
| Tri-mean | -19.36 | -0.40 | -2.66 | -7.80 | -6.84 | -2.97 | -0.66 | 0.12 | 0.00 | | | | | | |
| High Hinge | -13.25 | 0.47 | -0.22 | -5.13 | -5.22 | -2.29 | 0.51 | 0.15 | 0.00 | | | | | | |
| Low Hinge | -24.69 | -1.77 | -7.29 | -10.30 | -7.72 | -3.69 | -3.15 | 0.07 | 0.00 | | | | | | |
| Mean | -19.41 | -0.81 | -2.14 | -7.64 | -6.86 | -1.45 | -1.07 | 0.10 | 0.00 | | | | | | |
| Std Dev | 9.03 | 2.21 | 6.30 | 3.45 | 1.78 | 4.25 | 3.10 | 0.08 | 0.00 | | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

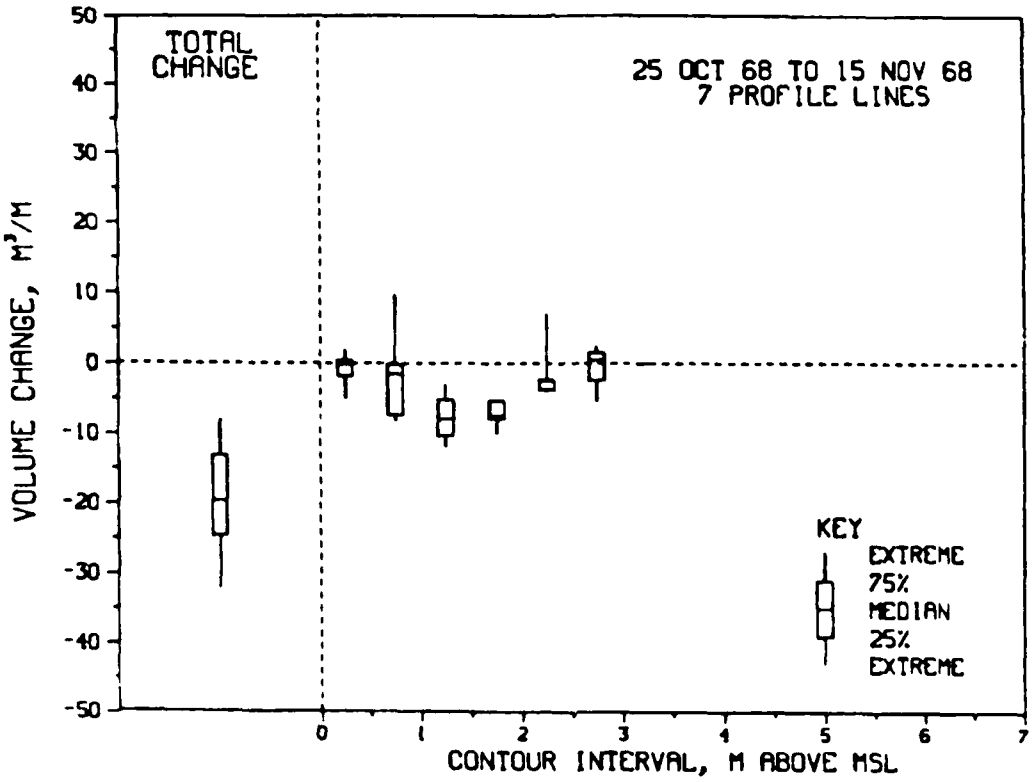



Figure F8. Distribution of volume changes by contour for Atlantic City, N. J.

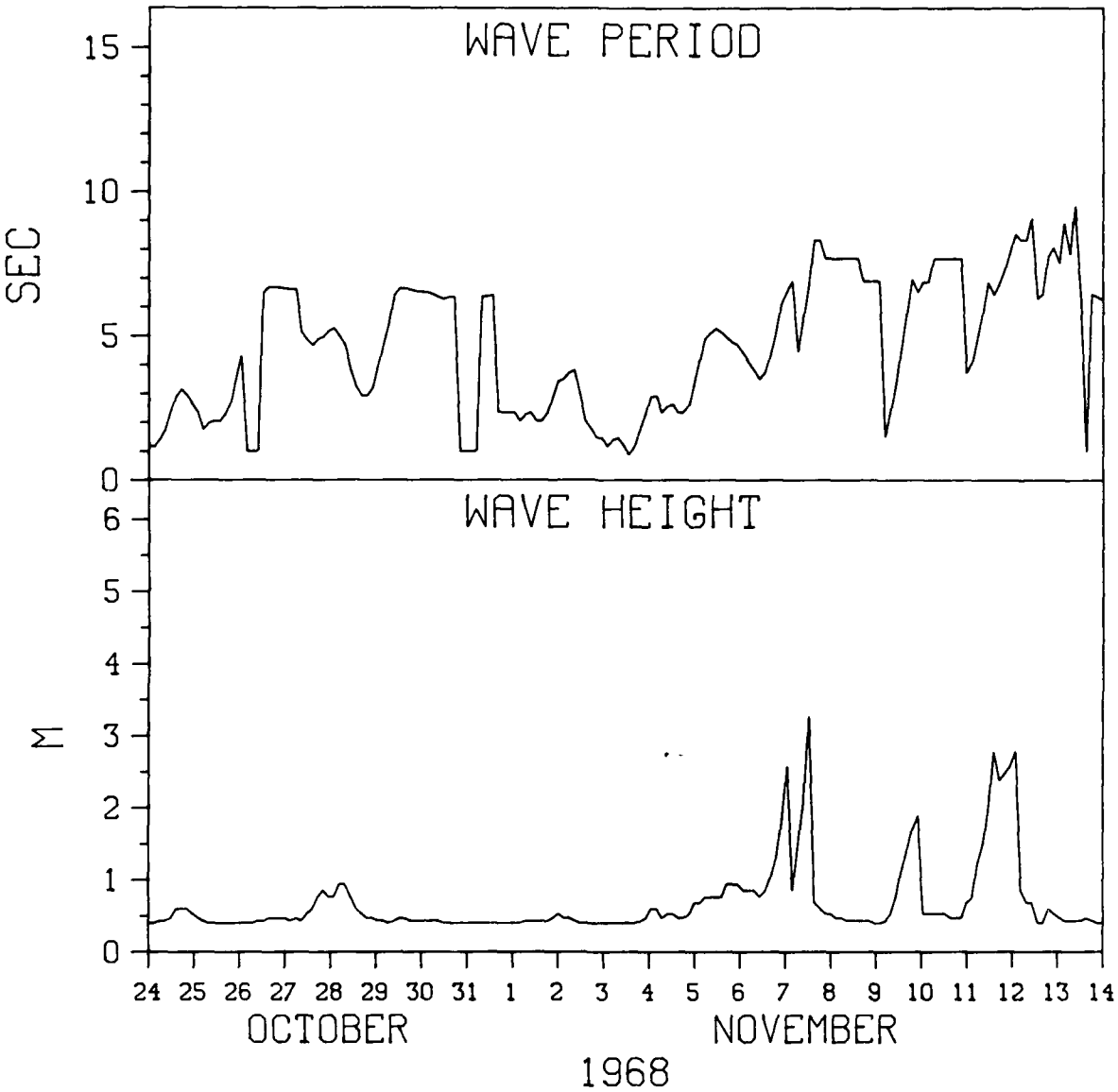
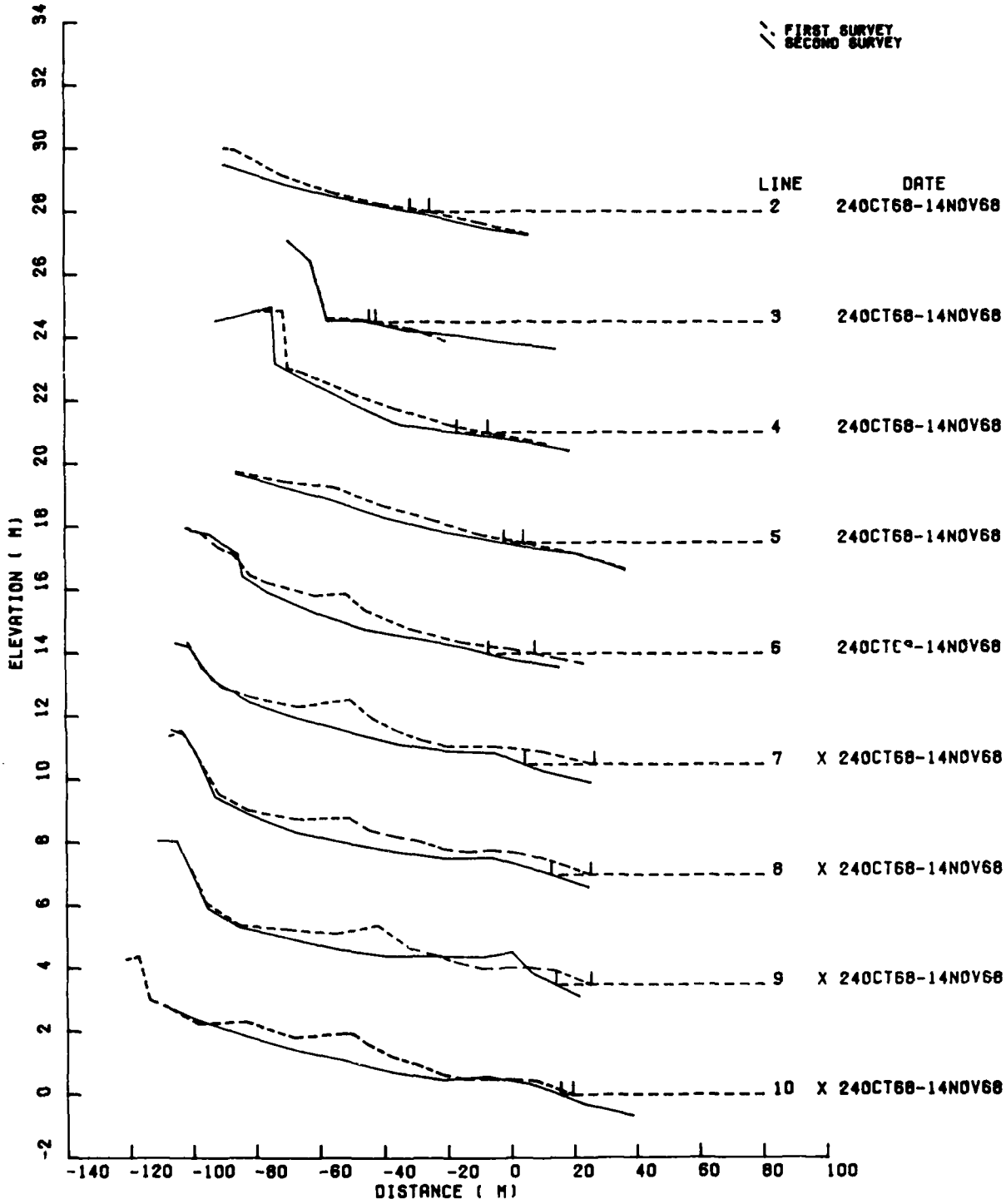
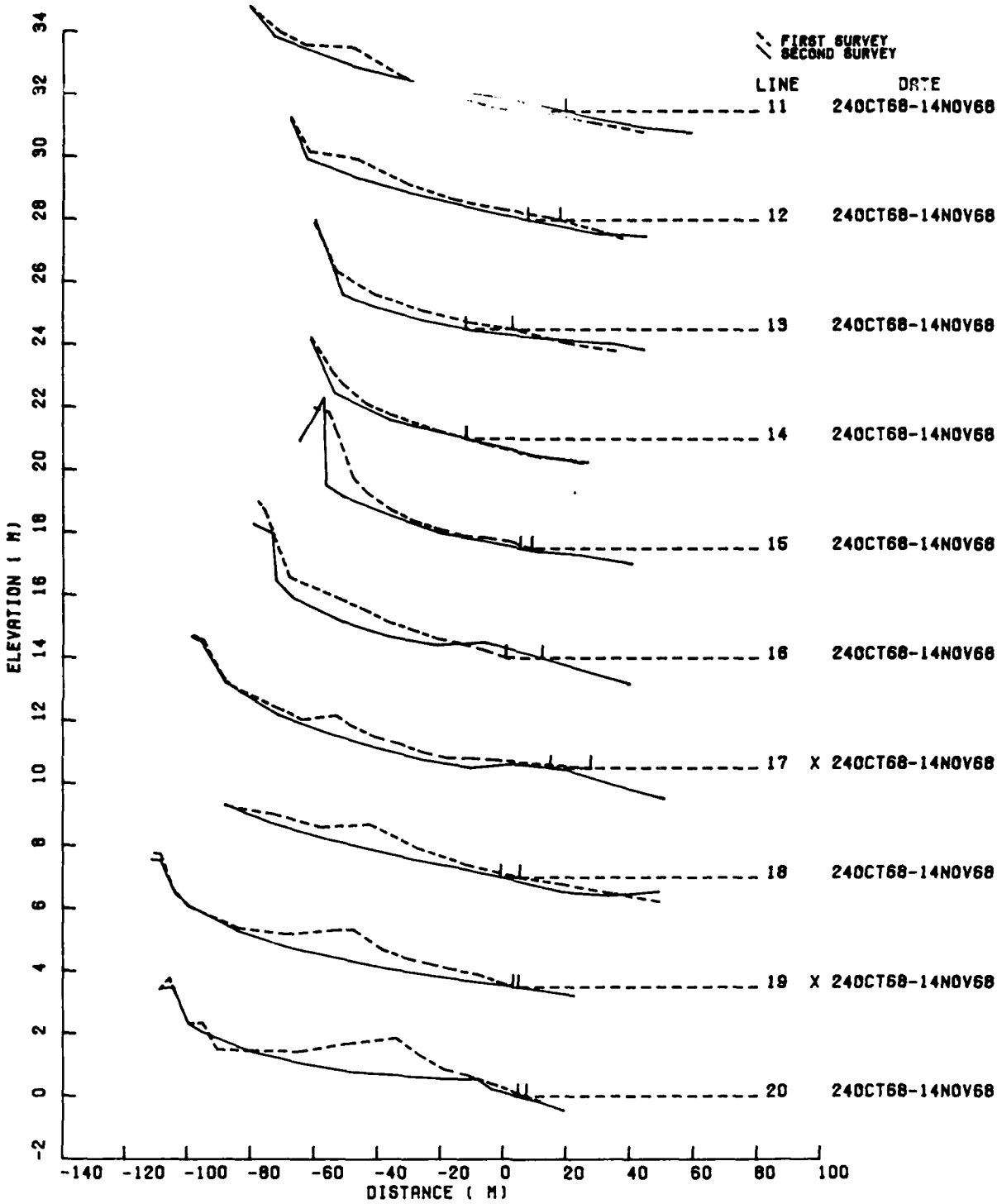



Figure F9. Hindcasted wave data for Ludlam Beach, N. J.




a. Profile lines 2-10

Figure F10. Profile comparsions for surveys at Ludlam Beach, N. J. (Continued)




b. Profile lines 11-20

Figure F10. (Concluded)

Table F5

Shoreline and Slope Changes at Ludlam Beach, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 2 | 24 Oct 68 | 14 Nov 68 | -6.10 | -0.016 | -0.020 | -0.004 |
| 3 | 24 Oct 68 | 14 Nov 68 | -2.03 | -0.020 | -0.024 | -0.004 |
| 4 | 24 Oct 68 | 14 Nov 68 | -9.65 | -0.020 | -0.012 | 0.008 |
| 5 | 24 Oct 68 | 14 Nov 68 | -6.10 | -0.020 | -0.020 | 0.000 |
| 6 | 24 Oct 68 | 14 Nov 68 | -14.65 | -0.020 | -0.026 | -0.006 |
| 7 | 24 Oct 68 X | 14 Nov 68 | -22.13 | -0.024 | -0.038 | -0.014 |
| 8 | 24 Oct 68 X | 14 Nov 68 | -12.50 | -0.036 | -0.034 | 0.002 |
| 9 | 24 Oct 68 X | 14 Nov 68 | -11.13 | -0.040 | -0.050 | -0.010 |
| 10 | 24 Oct 68 X | 14 Nov 68 | -3.81 | -0.040 | -0.040 | 0.000 |
| 11 | 24 Oct 68 | 14 Nov 68 | 13.97 | -0.008 | -0.024 | -0.016 |
| 12 | 24 Oct 68 | 14 Nov 68 | -10.29 | -0.026 | -0.018 | 0.008 |
| 13 | 24 Oct 68 | 14 Nov 68 | -14.86 | -0.016 | -0.020 | -0.004 |
| 14 | 24 Oct 68 | 14 Nov 68 | 0.18 | -0.028 | -0.024 | 0.004 |
| 15 | 24 Oct 68 | 14 Nov 68 | -3.62 | -0.032 | -0.020 | 0.012 |
| 16 | 24 Oct 68 | 14 Nov 68 | 11.52 | -0.036 | -0.030 | 0.006 |
| 17 | 24 Oct 68 X | 14 Nov 68 | -12.70 | -0.008 | -0.012 | -0.004 |
| 18 | 24 Oct 68 | 14 Nov 68 | -6.06 | -0.016 | -0.022 | -0.006 |
| 19 | 24 Oct 68 X | 14 Nov 68 | 1.69 | -0.036 | -0.012 | 0.024 |
| 20 | 24 Oct 68 | 14 Nov 68 | -2.80 | -0.036 | -0.026 | 0.010 |
| Median | | | -6.10 | -0.020 | -0.022 | 0.002 |
| Tri-Mean | | | -6.61 | -0.020 | -0.021 | 0.002 |
| High Hinge | | | -2.42 | -0.008 | -0.012 | 0.009 |
| Low Hinge | | | -11.81 | -0.030 | -0.028 | -0.005 |
| Mean | | | -5.85 | -0.021 | -0.023 | 0.003 |
| Standard Deviation | | | 8.81 | 0.012 | 0.011 | 0.012 |

Note: X = Extrapolated shoreline intercept.

Table F6

Unit Volume Changes ($m^3/m$) Between Contours
Ludlam Beach, N.J.
from 24 Oct 68 to 14 Nov 68

| Profile Line | Total Changes | | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | -13.94 | | -2.17 | -3.13 | -4.93 | -3.71 | 0.00 | | | | | | | | | |
| 3 | -1.00 | | -0.87 | -0.08 | -0.04 | -0.01 | 0.00 | 0.00 | | | | | | | | |
| 4 | -22.78 | | -6.69 | -5.01 | -3.08 | -1.97 | -1.60 | -1.82 | -1.74 | -0.87 | | | | | | |
| 5 | -22.20 | | -3.76 | -5.77 | -5.68 | -6.04 | -0.95 | | | | | | | | | |
| 6 | -31.34 | | -5.56 | -6.80 | -8.56 | -8.99 | -2.81 | -0.40 | 1.07 | 0.71 | | | | | | |
| 7 | -41.19 | X | -10.46 | -7.66 | -9.69 | -12.39 | -1.04 | -0.03 | 0.16 | -0.08 | | | | | | |
| 8 | -44.45 | X | -6.84 | -13.66 | -12.57 | -9.24 | -1.34 | -0.70 | -0.32 | 0.02 | 0.12 | 0.08 | | | | |
| 9 | -23.21 | X | -4.83 | 6.08 | -13.33 | -9.91 | -0.83 | -0.20 | -0.16 | -0.04 | 0.00 | 0.00 | | | | |
| 10 | -36.79 | X | -2.30 | -6.29 | -11.08 | -13.88 | -3.48 | 0.24 | 0.00 | 0.00 | 0.00 | | | | | |
| 11 | -4.24 | | 7.71 | 1.66 | -3.46 | -6.88 | -2.17 | -0.95 | -0.15 | | | | | | | |
| 12 | -22.81 | | -4.61 | -3.38 | -5.56 | -7.21 | -1.52 | -0.44 | -0.09 | | | | | | | |
| 13 | -17.05 | | -6.36 | -5.65 | -4.10 | -1.02 | -0.16 | 0.05 | 0.19 | | | | | | | |
| 14 | -8.86 | | -0.86 | -2.07 | -2.24 | -1.96 | -1.04 | -0.57 | -0.12 | | | | | | | |
| 15 | -24.72 | | -2.73 | -1.59 | -2.62 | -4.73 | -4.49 | -3.49 | -2.68 | -1.84 | -0.76 | 0.21 | | | | |
| 16 | -27.83 | | 3.73 | -6.67 | -7.32 | -7.12 | -4.67 | -1.92 | -1.14 | -0.42 | -1.49 | -0.81 | | | | |
| 17 | -26.17 | X | -9.00 | -5.54 | -6.81 | -2.95 | -0.89 | -0.22 | -0.23 | -0.33 | -0.20 | | | | | |
| 18 | -30.73 | | -3.59 | -7.28 | -11.63 | -7.21 | -1.02 | | | | | | | | | |
| 19 | -39.96 | X | -5.18 | -10.36 | -13.97 | -9.56 | -0.25 | 0.24 | -0.04 | -0.27 | -0.57 | | | | | |
| 20 | -42.21 | | -1.72 | -12.92 | -22.18 | -3.90 | -0.99 | 0.05 | -0.05 | -0.50 | | | | | | |
| Median | -24.72 | | -3.76 | -5.65 | -6.81 | -6.88 | -1.04 | -0.31 | -0.12 | -0.27 | -0.20 | 0.04 | | | | |
| Tri-mean | -25.78 | | -3.86 | -5.24 | -7.19 | -6.55 | -1.21 | -0.35 | -0.13 | -0.25 | -0.27 | -0.05 | | | | |
| High Hinge | -19.63 | | -1.95 | -2.60 | -3.78 | -3.33 | -0.86 | 0.03 | -0.02 | -0.02 | 0.00 | 0.14 | | | | |
| Low Hinge | -34.07 | | -5.96 | -7.04 | -11.35 | -9.11 | -1.88 | -0.82 | -0.28 | -0.46 | -0.66 | -0.41 | | | | |
| Mean | -25.34 | | -3.48 | -5.06 | -7.83 | -6.25 | -1.54 | -0.63 | -0.35 | -0.33 | -0.41 | -0.13 | | | | |
| Std Dev | 12.59 | | 4.20 | 4.75 | 5.37 | 3.86 | 1.39 | 1.00 | 0.89 | 0.64 | 0.57 | 0.46 | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

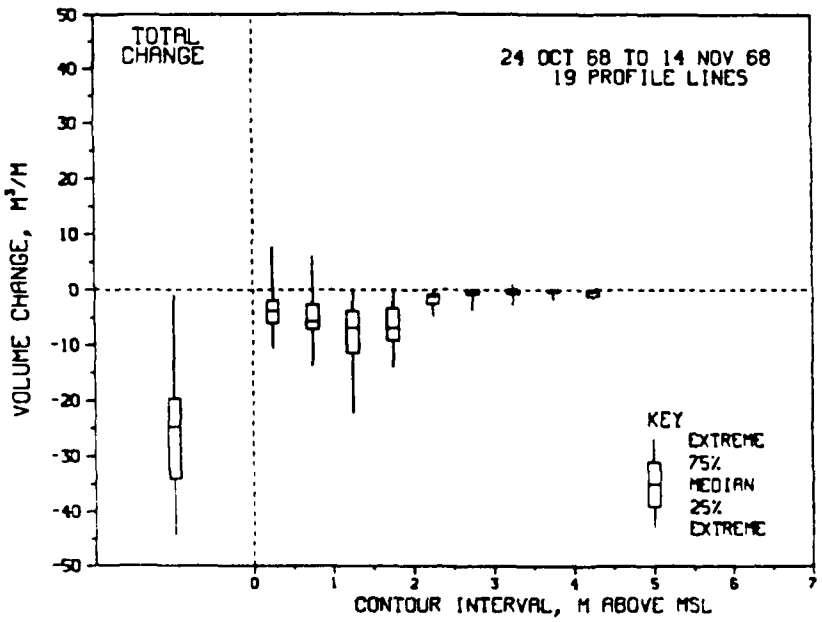


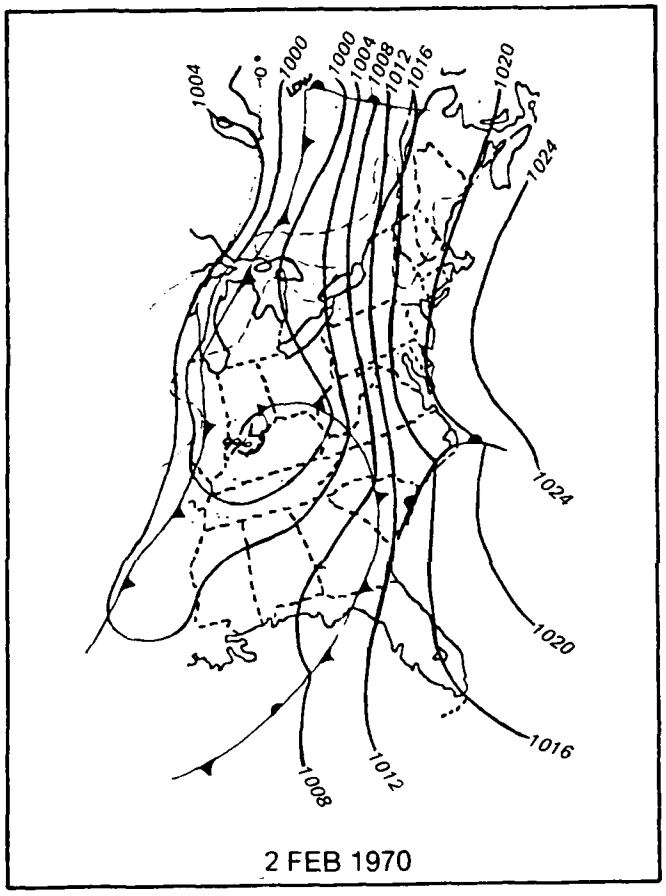

Figure F11. Distribution of volume changes by contour for Ludlam Beach, N. J.

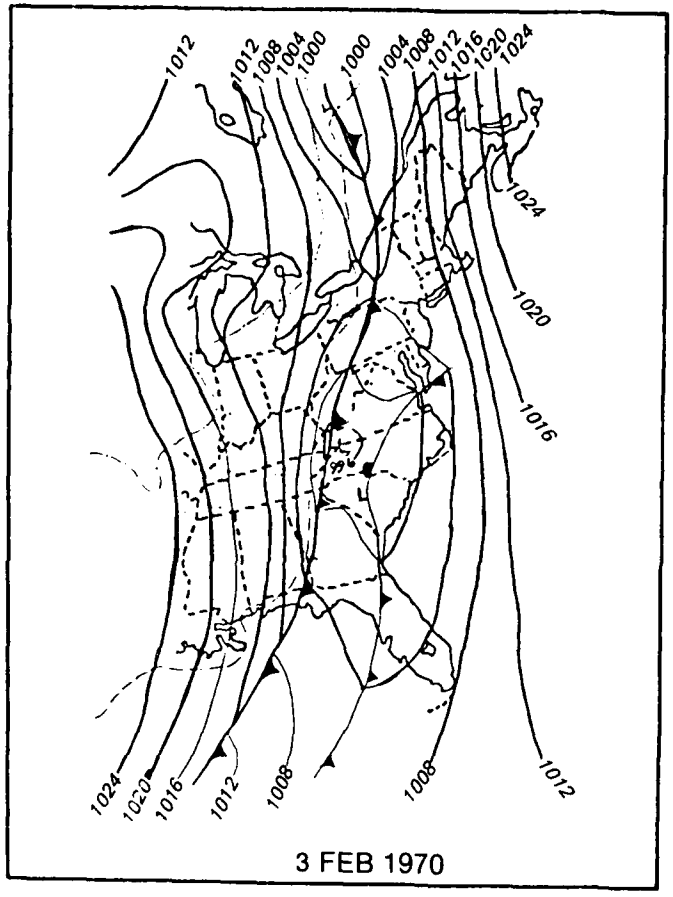
## APPENDIX G: DATA SUMMARY FOR THE STORM OF 2 FEBRUARY 1970

1. The effects of the 2 February 1970 storm were recorded at Misquamicut, Jones Beach, and Atlantic City. Storm tracks are shown in the surface weather maps. This storm was a minor event with a peak water level of 1.1 m at the Sandy Hook gage (the Atlantic City tide gage was inoperative). The storm surge was only 0.4 m indicating an event that occurs several times a year. Wave heights ranged from 2.1 to 3.5 m and were higher at the northern localities. All sites experienced the maximum surge during high waves. Two storms occurred during the survey interval with the second being the most significant. All poststorm surveys were conducted within 2 days after the event.

2. All shorelines receded, ranging from -6.1 m at Atlantic City to -1.3 m at Jones Beach. Slope changes were negligible at all sites except Atlantic City which flattened 0.012. Median volume changes were negative at Misquamicut and Atlantic City, positive at Jones Beach. The three largest changes at Jones beach (profile lines 4, 17, and 18) were positive and in excess of 40 $m^3/m$.

3. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.




a. 2 and 3 February 1970

Figure G1. Synoptic weather maps at 0700 for 2-3 February 1970

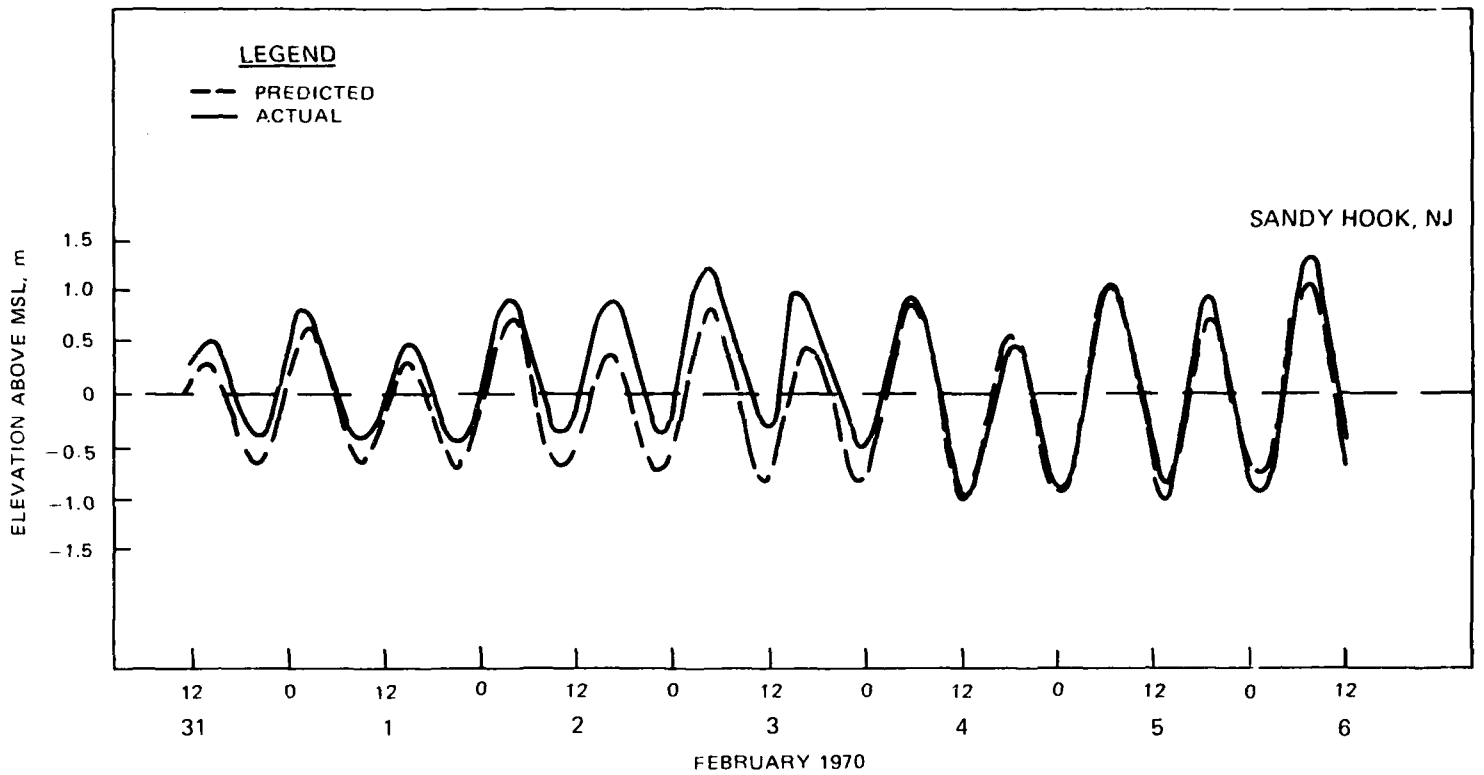



Figure G2. Predicted and actual water levels for 31 January-6 February 1970

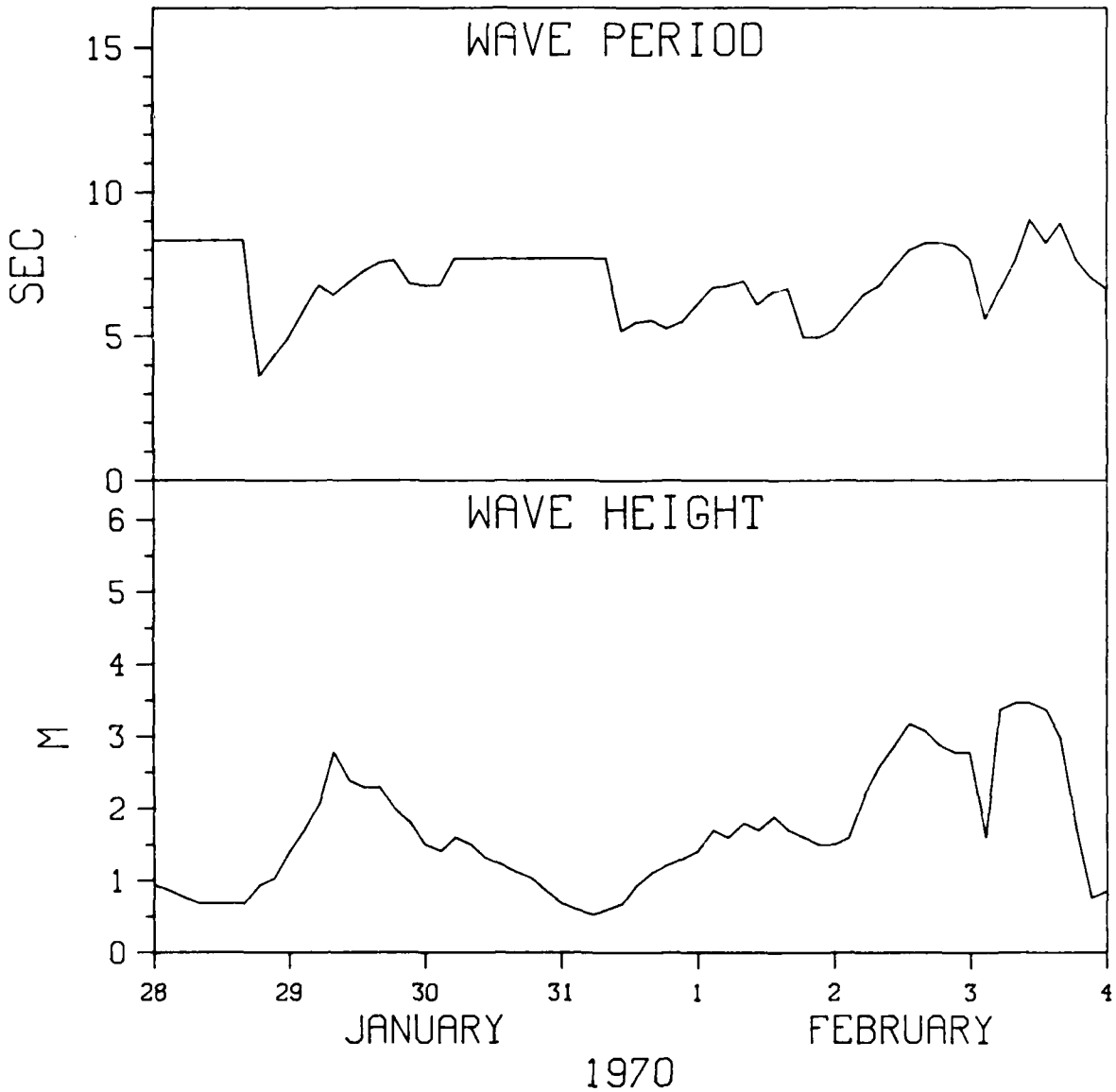



Figure G3. Hindcasted wave data for Misquamicut, R. I.

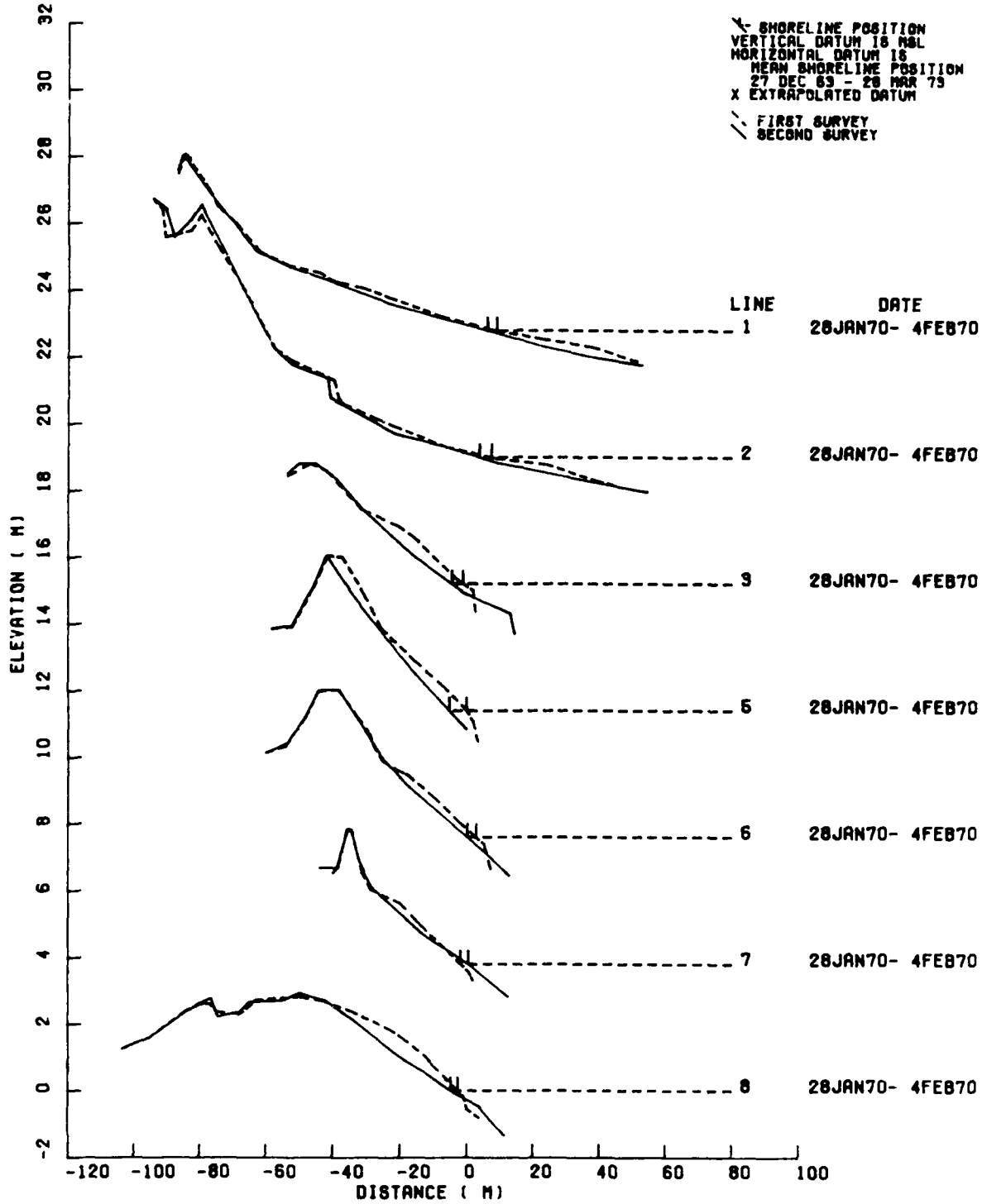



Figure G4. Profile comparisons for surveys at Misquamicut, R. I.

Table G1

Shoreline and Slope Changes at Misquamicut, R.I.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 28 Jan 70 | 4 Feb 70 | -2.87 | -0.018 | -0.026 | -0.008 |
| 2 | 28 Jan 70 | 4 Feb 70 | -3.70 | -0.022 | -0.030 | -0.008 |
| 3 | 28 Jan 70 | 4 Feb 70 | -3.28 | -0.071 | -0.074 | -0.003 |
| 5 | 28 Jan 70 | 4 Feb 70 | -5.17 | -0.171 | -0.110 | 0.061 |
| 6 | 28 Jan 70 | 4 Feb 70 | -2.66 | -0.088 | -0.084 | 0.004 |
| 7 | 28 Jan 70 | 4 Feb 70 | 2.33 | -0.098 | -0.066 | 0.032 |
| 8 | 28 Jan 70 | 4 Feb 70 | -2.13 | -0.103 | -0.072 | 0.031 |
| Median | | | -2.87 | -0.088 | -0.072 | 0.004 |
| Tri-Mean | | | -2.90 | -0.081 | -0.068 | 0.009 |
| High Hinge | | | -2.39 | -0.047 | -0.048 | 0.032 |
| Low Hinge | | | -3.49 | -0.101 | -0.079 | -0.006 |
| Mean | | | -2.49 | -0.082 | -0.066 | 0.016 |
| Standard Deviation | | | 2.34 | 0.052 | 0.030 | 0.026 |

Note: X = Extrapolated shoreline intercept.

Table G2

Unit Volume Changes ($m^3/m$) Between Contours
Misquamicut Beach, R.I.
from 28 Jan 70 to 4 Feb 70

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -7.41 | -1.18 | -2.17 | -1.77 | -1.12 | -0.35 | -0.37 | -0.13 | 0.28 | -0.20 | -0.27 | -0.13 | | | |
| 2 | -0.82 | -0.82 | -2.08 | -0.98 | -0.83 | -0.77 | -0.87 | -0.14 | -0.07 | -0.08 | -0.08 | 0.00 | 0.32 | 5.57 | |
| 3 | -8.32 | -1.85 | -2.61 | -2.92 | -2.22 | -0.11 | 0.29 | 0.67 | 0.43 | | | | | | |
| 5 | -14.52 | -2.58 | -2.40 | -1.85 | -1.19 | -0.56 | -0.68 | -1.29 | -1.63 | -1.87 | -0.47 | | | | |
| 6 | -5.98 | -1.37 | -1.59 | -1.85 | -1.47 | 0.05 | 0.34 | -0.20 | -0.01 | 0.12 | | | | | |
| 7 | -2.15 | 0.55 | -0.67 | -1.23 | -1.38 | 0.12 | 0.45 | 0.07 | -0.04 | -0.02 | | | | | |
| 8 | -13.89 | -1.59 | -3.03 | -3.90 | -3.77 | -2.30 | 0.70 | | | | | | | | |
| Median | -7.41 | -1.37 | -2.17 | -1.85 | -1.38 | -0.35 | 0.29 | -0.13 | -0.02 | -0.08 | -0.27 | -0.06 | 0.32 | 5.57 | |
| Tri-mean | -7.50 | -1.37 | -2.17 | -1.90 | -1.44 | -0.35 | 0.11 | -0.10 | 0.04 | -0.09 | -0.27 | -0.06 | 0.32 | 5.57 | |
| High Hinge | -4.07 | -1.00 | -1.84 | -1.50 | -1.15 | -0.03 | 0.39 | 0.07 | 0.28 | -0.02 | -0.18 | 0.00 | 0.32 | 5.57 | |
| Low Hinge | -11.10 | -1.72 | -2.51 | -2.38 | -1.85 | -0.66 | -0.52 | -0.20 | -0.07 | -0.20 | -0.37 | -0.13 | 0.32 | 5.57 | |
| Mean | -7.58 | -1.26 | -2.08 | -2.07 | -1.71 | -0.56 | -0.02 | -0.17 | -0.17 | -0.41 | -0.27 | -0.06 | 0.32 | 5.57 | |
| Std Dev | 5.26 | 0.97 | 0.77 | 1.01 | 1.01 | 0.83 | 0.61 | 0.64 | 0.74 | 0.82 | 0.20 | 0.09 | 0.00 | 0.00 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

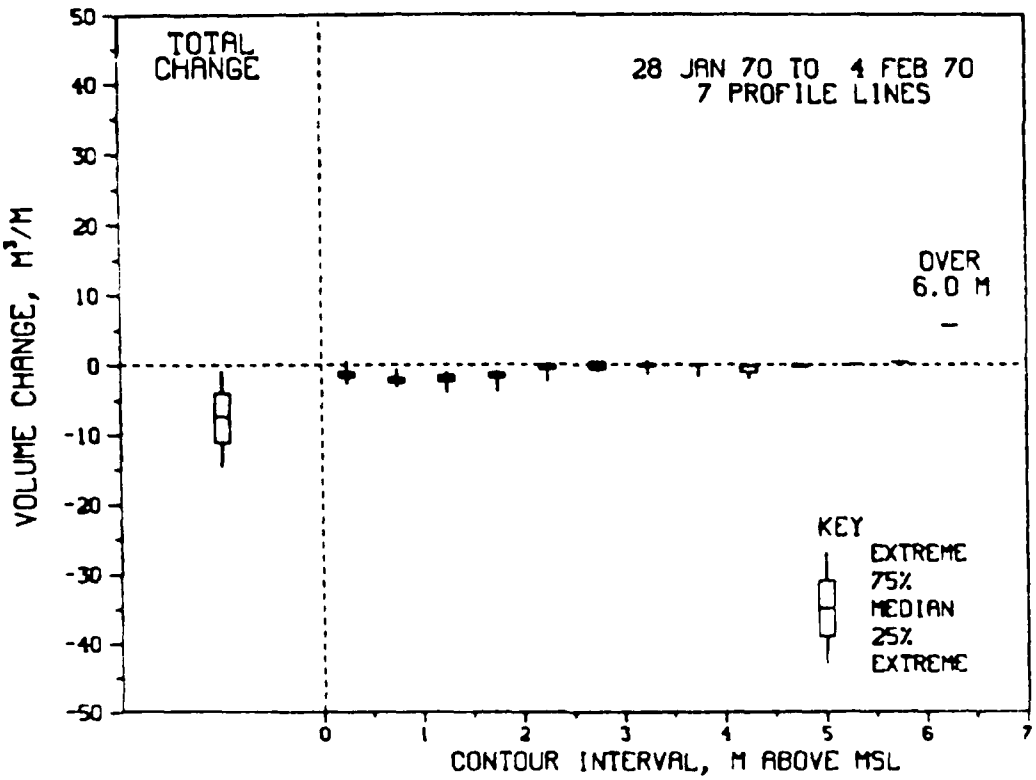



Figure G5. Distribution of volume changes by contour for Misquamicut, R. I.

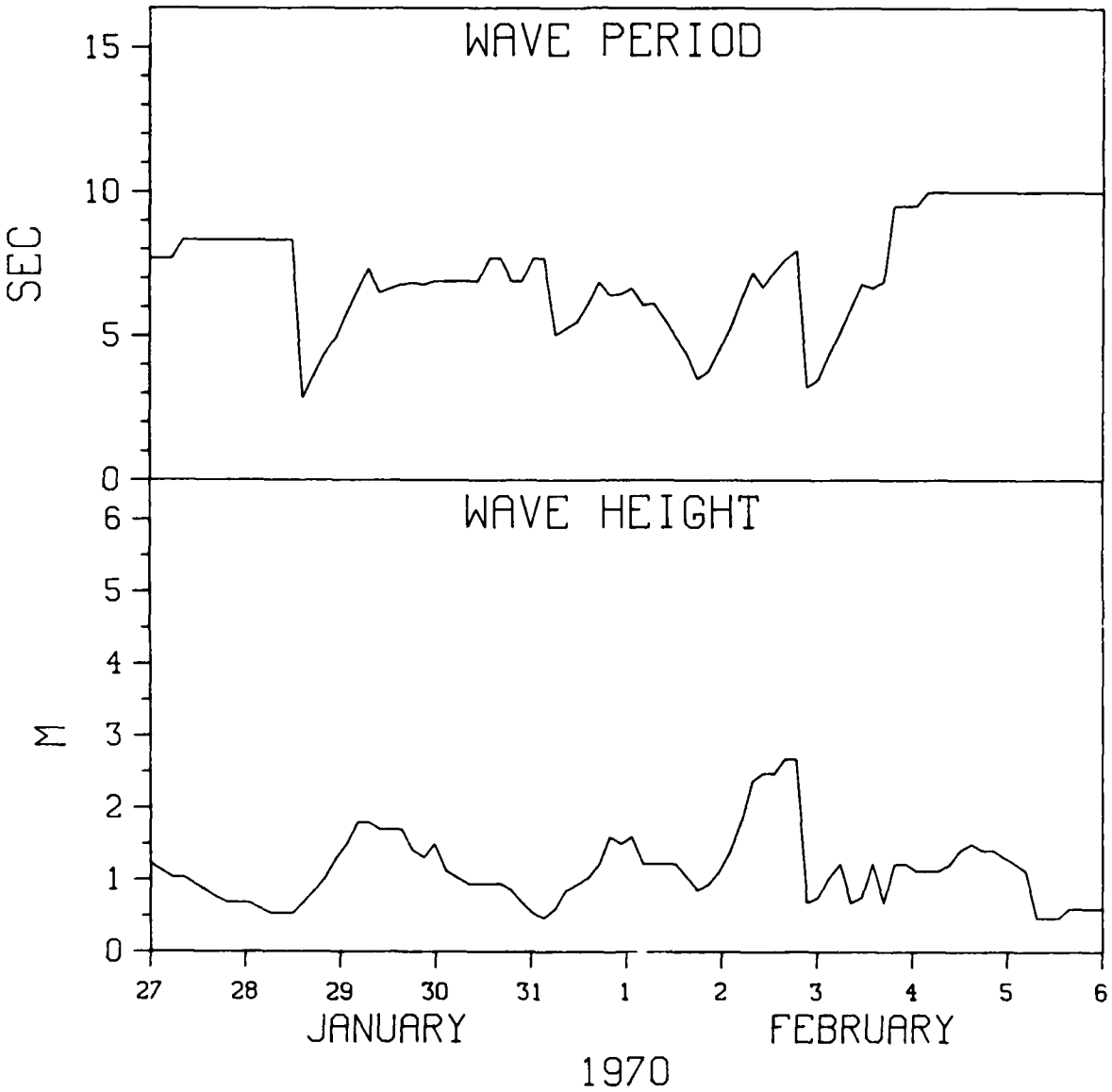



Figure G6. Hindcasted wave data for Jones Beach, N. Y.

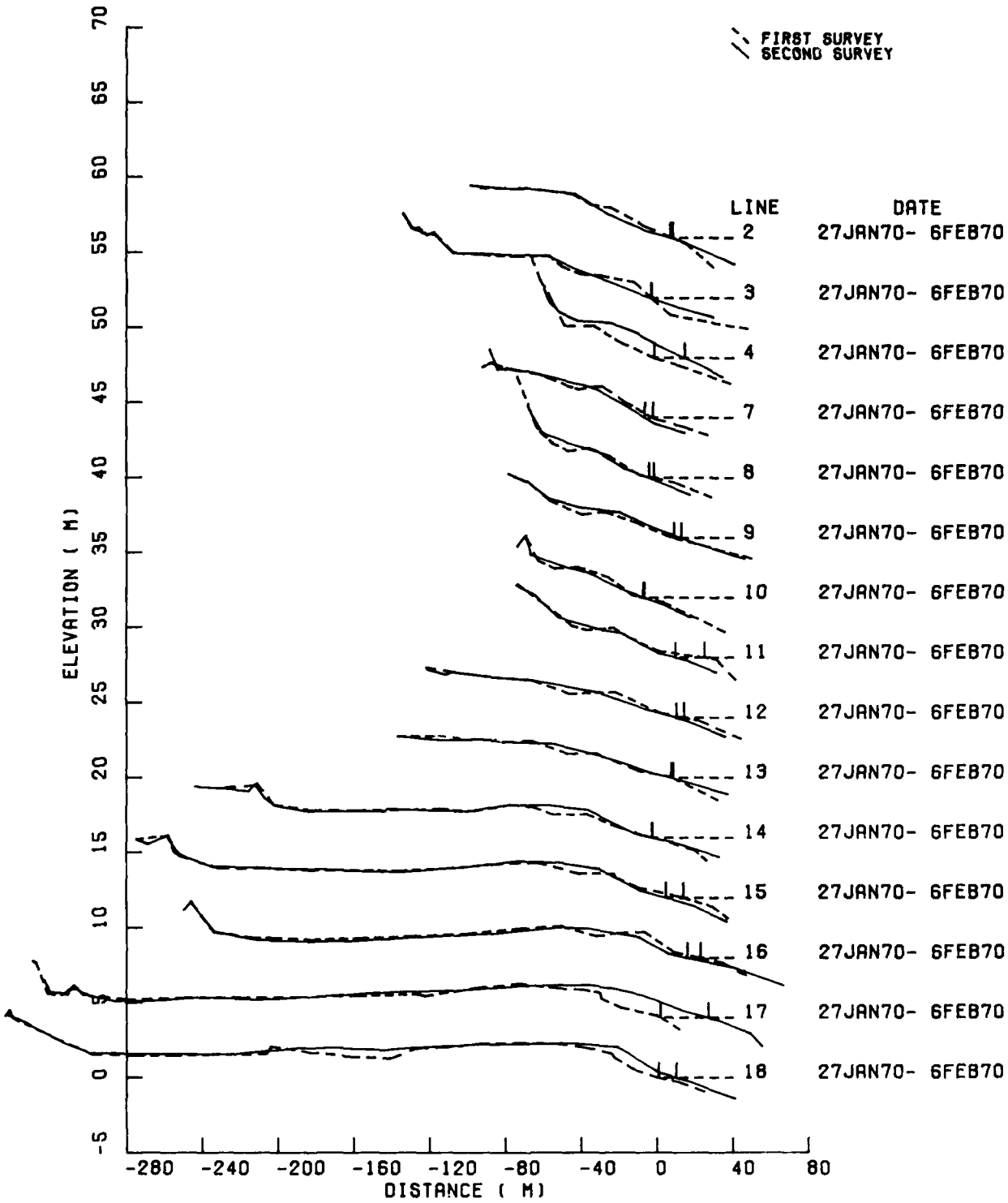



Figure G7. Profile comparisons for surveys at Jones Beach, N. Y.

Table G3

Shoreline and Slope Changes at Jones Beach, N.Y.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 2 | 27 Jan 70 | 6 Feb 70 | -1.34 | -0.053 | -0.037 | 0.016 |
| 3 | 27 Jan 70 | 6 Feb 70 | -0.44 | -0.115 | -0.044 | 0.071 |
| 4 | 27 Jan 70 | 6 Feb 70 | 16.04 | -0.058 | -0.057 | 0.001 |
| 7 | 27 Jan 70 | 6 Feb 70 | -4.16 | -0.070 | -0.078 | -0.008 |
| 8 | 27 Jan 70 | 6 Feb 70 | -2.40 | -0.029 | -0.047 | -0.018 |
| 9 | 27 Jan 70 | 6 Feb 70 | 3.82 | -0.034 | -0.047 | -0.013 |
| 10 | 27 Jan 70 | 6 Feb 70 | 0.77 | -0.028 | -0.047 | -0.019 |
| 11 | 27 Jan 70 | 6 Feb 70 | -15.13 | -0.018 | -0.032 | -0.014 |
| 12 | 27 Jan 70 | 6 Feb 70 | -3.96 | -0.025 | -0.034 | -0.009 |
| 13 | 27 Jan 70 | 6 Feb 70 | -1.28 | -0.063 | -0.032 | 0.031 |
| 14 | 27 Jan 70 | 6 Feb 70 | -0.49 | -0.038 | -0.028 | 0.010 |
| 15 | 27 Jan 70 | 6 Feb 70 | -9.17 | -0.039 | -0.036 | 0.003 |
| 16 | 27 Jan 70 | 6 Feb 70 | -7.07 | -0.028 | -0.028 | 0.000 |
| 17 | 27 Jan 70 | 6 Feb 70 | 25.19 | -0.075 | -0.034 | 0.041 |
| 18 | 27 Jan 70 | 6 Feb 70 | 9.45 | -0.043 | -0.038 | 0.005 |
| Median | | | -1.28 | -0.039 | -0.036 | 0.001 |
| Tri-Mean | | | -1.08 | -0.042 | -0.037 | 0.001 |
| High Hinge | | | 2.30 | -0.029 | -0.032 | 0.013 |
| Low Hinge | | | -4.06 | -0.061 | -0.046 | -0.011 |
| Mean | | | 0.66 | -0.048 | -0.040 | 0.006 |
| Standard Deviation | | | 9.98 | 0.025 | 0.013 | 0.025 |

Note: X=Extrapolated Shoreline Intercept.

Table G4

Unit Volume Changes ($m^3/m$) Between Contours
Jones Beach, N.Y.
from 27 Jan 70 to 6 Feb 70

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | -11.60 | -1.70 | -2.62 | -3.41 | -3.86 | -0.27 | 0.52 | -0.26 | | | | | | | |
| 3 | -5.79 | -1.87 | -4.69 | -4.09 | 2.09 | 1.59 | 2.47 | -0.16 | -0.24 | -0.71 | -0.26 | 0.08 | | | |
| 4 | 42.83 | 7.99 | 8.17 | 8.47 | 7.84 | 9.69 | 2.13 | -0.02 | -0.73 | -0.57 | -0.14 | 0.00 | | | |
| 7 | -1.84 | -1.90 | -1.58 | -1.92 | -1.95 | 3.62 | 1.21 | -0.76 | 0.96 | 0.46 | 0.02 | | | | |
| 8 | 4.82 | -0.29 | -1.23 | -1.36 | 1.09 | 4.27 | 1.41 | 0.45 | 0.42 | 0.08 | -0.01 | 0.00 | | | |
| 9 | 17.02 | 2.03 | 1.72 | 2.42 | 7.33 | 2.76 | 0.44 | 0.24 | 0.11 | -0.03 | | | | | |
| 10 | -3.08 | 0.66 | -1.20 | -2.58 | -1.74 | 2.90 | -0.15 | -0.74 | -0.24 | 0.00 | | | | | |
| 11 | -3.56 | -4.21 | -0.71 | -0.15 | -0.42 | 2.42 | -0.60 | -0.31 | 0.23 | 0.46 | -0.27 | | | | |
| 12 | -2.97 | -1.11 | -2.37 | -3.69 | 4.21 | 2.33 | -0.73 | -1.61 | | | | | | | |
| 13 | 2.55 | 0.07 | 1.43 | 0.19 | 4.24 | 1.15 | -4.53 | | | | | | | | |
| 14 | 6.06 | -0.74 | 1.09 | 2.09 | 6.68 | 1.82 | -0.98 | -3.79 | -0.11 | | | | | | |
| 15 | 9.76 | -3.89 | -1.00 | -0.31 | 8.22 | 8.21 | 0.63 | 0.62 | -2.48 | -0.24 | | | | | |
| 16 | -26.29 | -3.12 | -2.66 | -17.19 | -3.03 | -0.29 | 0.07 | -0.02 | -0.05 | | | | | | |
| 17 | 54.47 | 11.99 | 13.78 | 6.43 | 20.57 | 1.69 | 0.00 | 0.00 | 0.00 | | | | | | |
| 18 | 55.41 | 4.53 | 5.34 | 10.63 | 33.25 | 1.45 | -0.34 | 0.26 | 0.85 | -0.55 | 0.00 | | | | |
| Median | 2.55 | -0.74 | -1.00 | -0.31 | 4.21 | 2.33 | 0.07 | -0.09 | -0.03 | -0.03 | -0.08 | 0.00 | | | |
| Tri-mean | 3.79 | -0.50 | -0.60 | -0.34 | 3.73 | 2.36 | 0.15 | -0.17 | 0.01 | -0.13 | -0.10 | 0.01 | | | |
| High Hinge | 13.39 | 1.35 | 1.58 | 2.26 | 7.59 | 3.26 | 0.92 | 0.24 | 0.32 | 0.08 | 0.00 | 0.04 | | | |
| Low Hinge | -3.32 | -1.88 | -1.97 | -2.99 | -1.08 | 1.52 | -0.47 | -0.74 | -0.24 | -0.55 | -0.26 | 0.00 | | | |
| Mean | 9.19 | 0.56 | 0.90 | -0.30 | 5.63 | 2.89 | 0.10 | -0.44 | -0.11 | -0.12 | -0.11 | 0.03 | | | |
| Std Dev | 23.83 | 4.49 | 4.84 | 6.46 | 9.83 | 2.76 | 1.63 | 1.12 | 0.88 | 0.43 | 0.13 | 0.05 | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

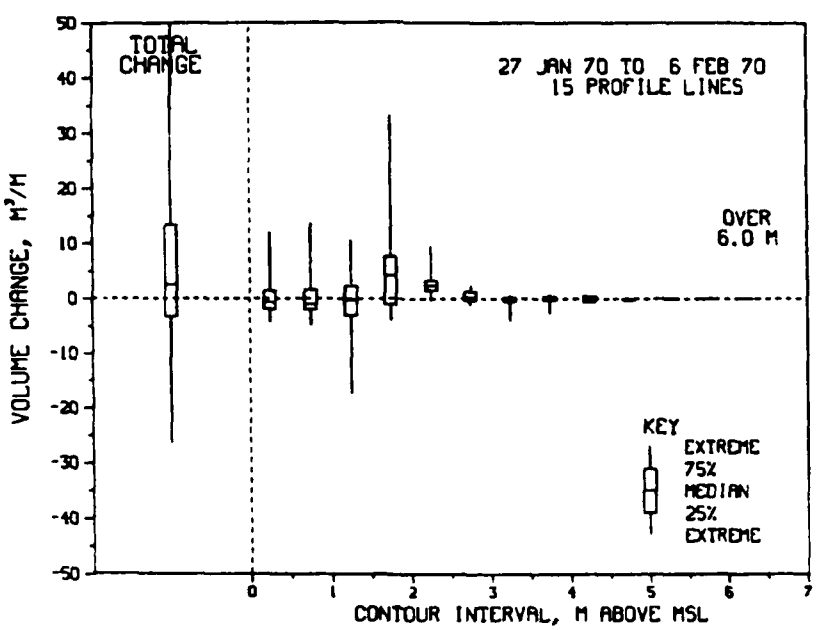



Figure G8. Distribution of volume changes by contour for Jones Beach, N. Y.

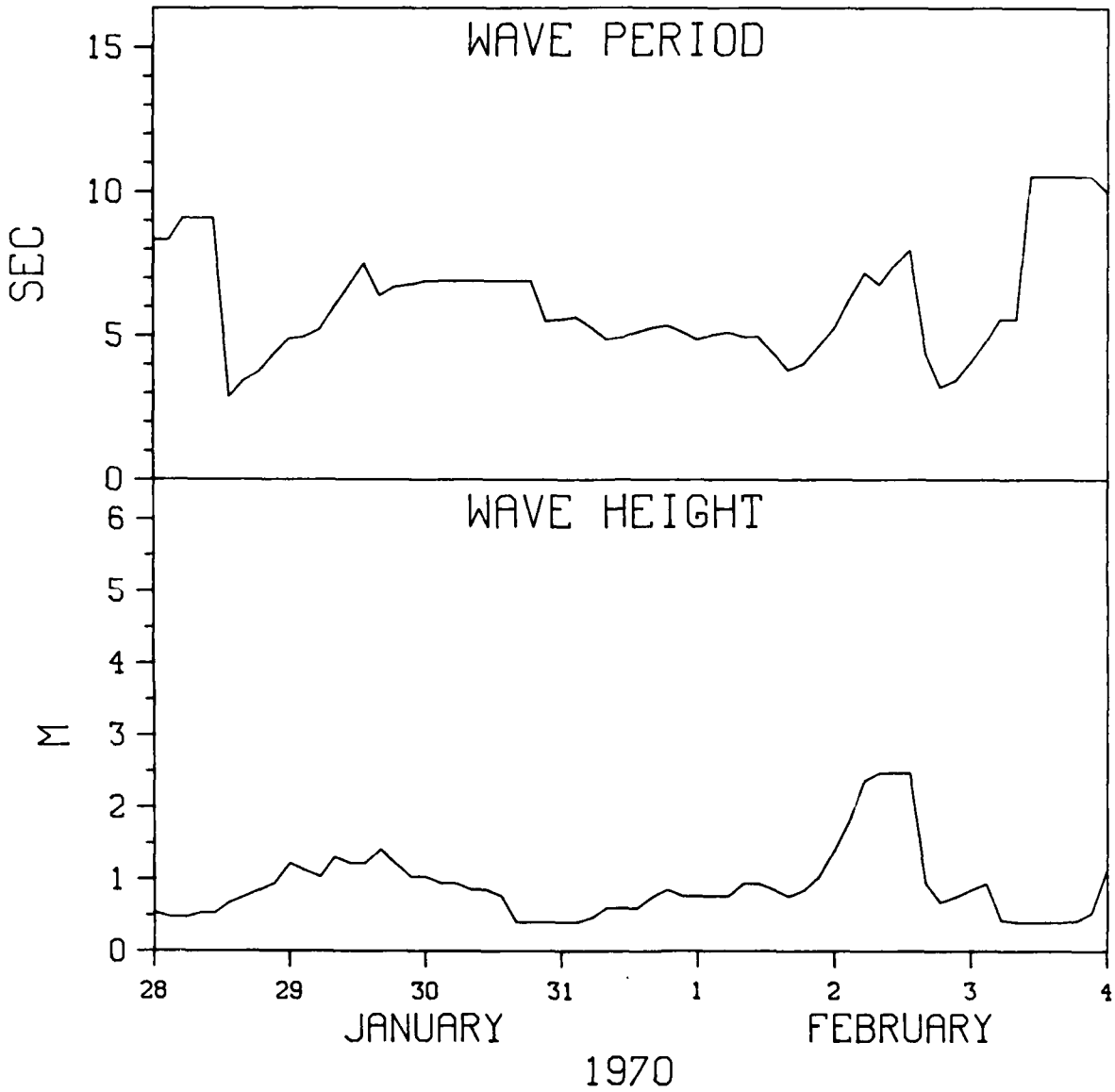



Figure G9. Hindcasted wave data for Atlantic City, N. J.

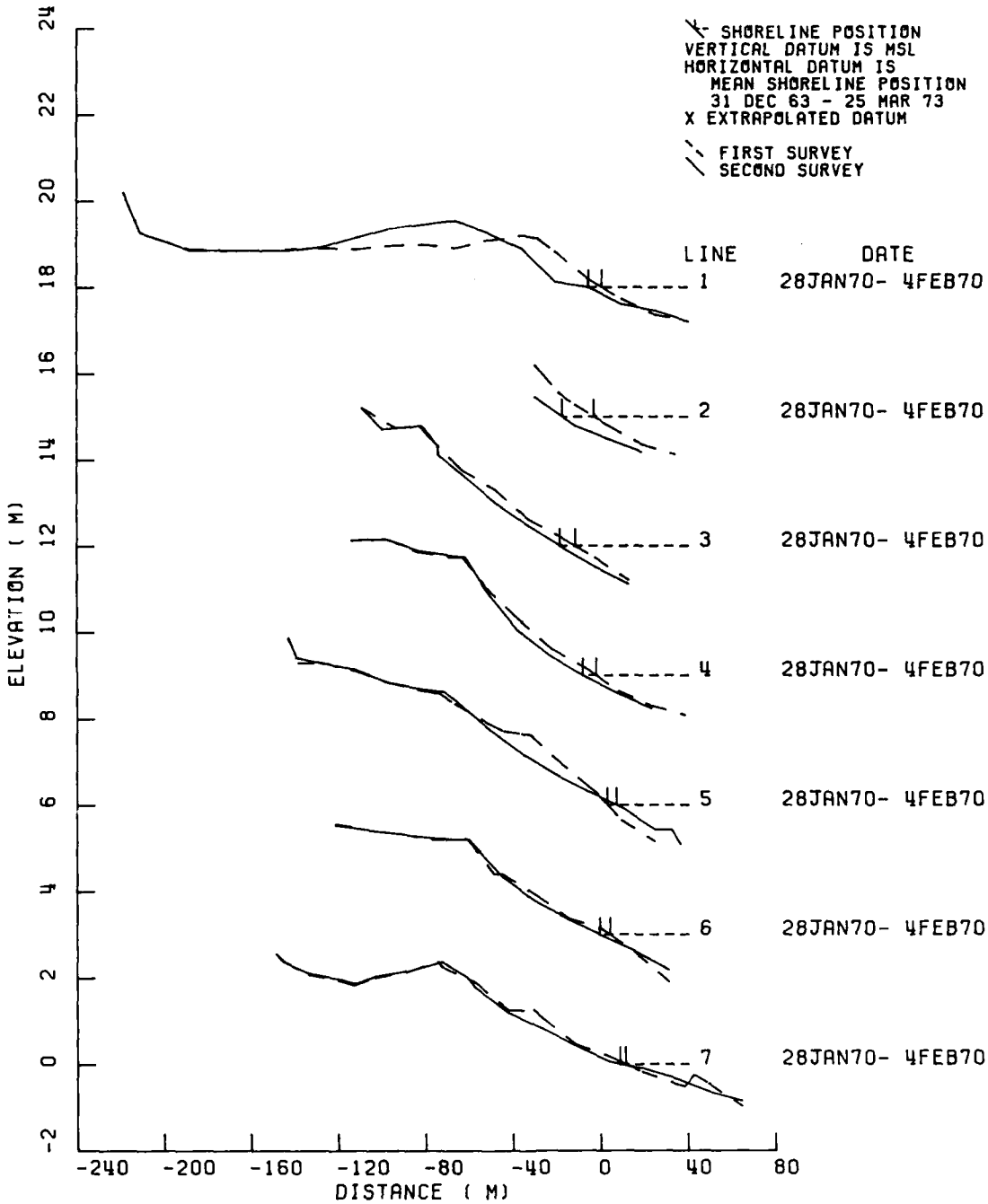



Figure G10. Profile comparisons for surveys of profile lines at Atlantic City, N. J.

Table G5

Shoreline and Slope Changes at Atlantic City, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 28 Jan 70 | 4 Feb 70 | -6.10 | -0.030 | -0.008 | 0.022 |
| 2 | 28 Jan 70 | 4 Feb 70 | -14.50 | -0.032 | -0.036 | -0.004 |
| 3 | 28 Jan 70 | 4 Feb 70 | -7.05 | -0.030 | -0.032 | -0.002 |
| 4 | 28 Jan 70 | 4 Feb 70 | -6.10 | -0.036 | -0.030 | 0.006 |
| 5 | 28 Jan 70 | 4 Feb 70 | 4.11 | -0.055 | -0.024 | 0.031 |
| 6 | 28 Jan 70 | 4 Feb 70 | -4.66 | -0.036 | -0.024 | 0.012 |
| 7 | 28 Jan 70 | 4 Feb 70 | -2.59 | -0.024 | -0.012 | 0.012 |
| Median | | | -6.10 | -0.032 | -0.024 | 0.012 |
| Tri-Mean | | | -5.60 | -0.033 | -0.024 | 0.011 |
| High Hinge | | | -3.62 | -0.030 | -0.018 | 0.017 |
| Low Hinge | | | -6.57 | -0.036 | -0.031 | 0.002 |
| Mean | | | -5.27 | -0.035 | -0.024 | 0.011 |
| Standard Deviation | | | 5.56 | 0.010 | 0.010 | 0.013 |

Note: X = Extrapolated shoreline intercept.

Table G6

Unit Volume Changes ($m^3/m$) Between Contours
Atlantic City, N.J.
from 28 Jan 70 to 4 Feb 70

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10.65 | -7.48 | -4.33 | 22.14 | 0.32 | 0.00 | | | | | | | | | |
| 2 | -10.81 | -6.84 | -3.67 | -0.30 | | | | | | | | | | | |
| 3 | -12.71 | -3.14 | -2.62 | -3.23 | -1.63 | -0.89 | -0.90 | -0.30 | | | | | | | |
| 4 | -8.57 | -3.32 | -2.60 | -2.35 | -1.18 | -0.12 | 0.92 | 0.08 | | | | | | | |
| 5 | -12.69 | -0.69 | -4.39 | -6.46 | -3.66 | 0.49 | 0.99 | 1.00 | 0.03 | | | | | | |
| 6 | -3.42 | -1.81 | -1.79 | -0.79 | 0.82 | 0.28 | -0.13 | | | | | | | | |
| 7 | -6.75 | -1.79 | -2.61 | -3.31 | -0.42 | 1.38 | 0.00 | | | | | | | | |
| Median | -8.57 | -3.14 | -2.62 | -2.35 | -0.80 | 0.14 | 0.00 | 0.08 | 0.03 | | | | | | |
| Tri-mean | -8.49 | -3.29 | -2.96 | -2.13 | -0.73 | 0.16 | 0.20 | 0.15 | 0.03 | | | | | | |
| High Hinge | -5.09 | -1.80 | -2.61 | -0.55 | 0.32 | 0.49 | 0.92 | 0.54 | 0.03 | | | | | | |
| Low Hinge | -11.75 | -5.08 | -4.00 | -3.27 | -1.63 | -0.12 | -0.13 | -0.11 | 0.03 | | | | | | |
| Mean | -6.33 | -3.58 | -3.14 | 0.81 | -0.96 | 0.19 | 0.18 | 0.26 | 0.03 | | | | | | |
| Std Dev | 8.20 | 2.61 | 0.99 | 9.62 | 1.61 | 0.75 | 0.79 | 0.67 | 0.00 | | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

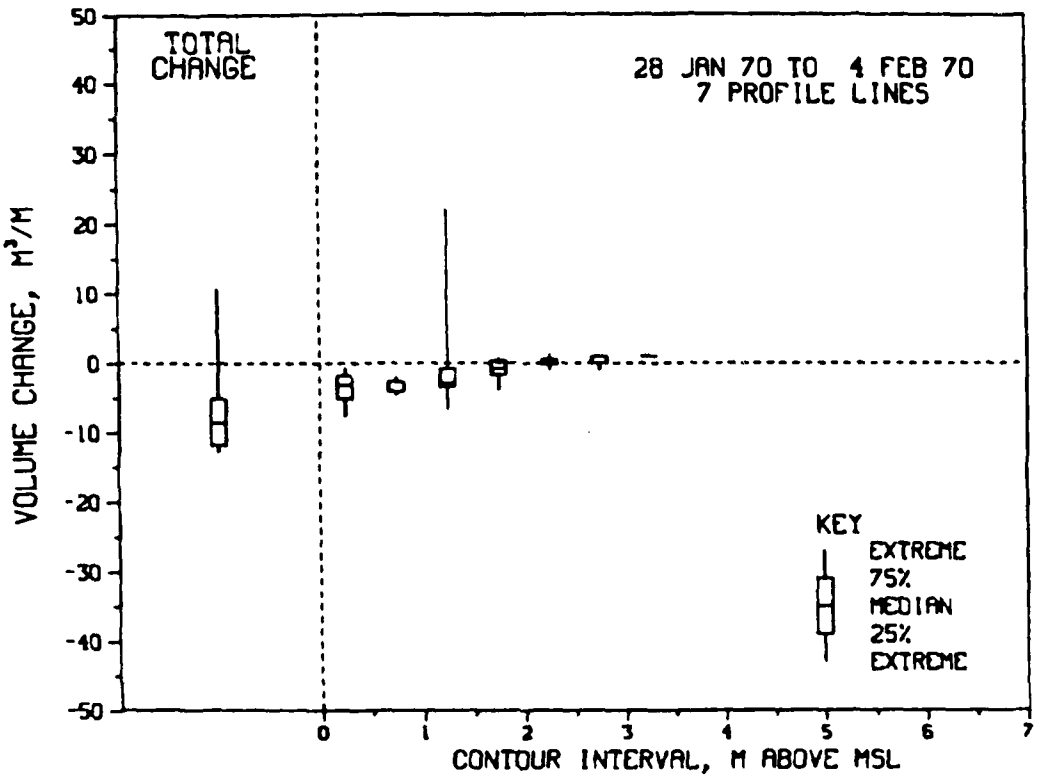



Figure G11. Distribution of volume changes by contour for Atlantic City, N. J.

## APPENDIX H: DATA SUMMARY FOR THE STORM OF 17 DECEMBER 1970

1. The 17 December 1970 storm was monitored at all seven localities and was previously discussed by DeWall, Pritchett, and Galvin (1977). The low pressure system is documented on the synoptic weather map. The present report includes further analysis of the data and new wave data, and uses a better edited version of the original survey data. Wave heights ranged from 2.8 m at Ludlam Beach to 4.2 m at Misquamicut and were generally higher at the northern localities. Tide data were unavailable from Atlantic City, but peak tides at Sandy Hook and Nauset Beach (adjusted from Boston, Massachusetts) ranged from 1.6 to 1.3 m above msl. Poststorm surveys were conducted shortly after the storm, but there is evidence of apparent recovery at Jones Beach and Long Beach Island. Wave time-histories show a minor storm prior to the major event at the four northern localities, whereas the New Jersey sites experienced only the single storm.

2. Shoreline and slope changes were significant, but highly variable between profile lines and between localities. All localities eroded with median changes ranging from -5.2 $m^3/m$ at Ludlam Beach to -20.6 $m^3/m$ at Nauset Beach. In general, the northern sites appear to have lost more sediment higher on the beach (from the 1- to 2.5-m contour), whereas the three New Jersey sites lost sediment lower on the profile (between the 0- and 2.0-m contours). Nauset Beach, the most erosive site, experienced the greatest variation along the beach with a hinge range of 27.2 $m^3/m$. Ludlam Beach, the most stable, was also the least variable with a hinge range of only 6.2 $m^3/m$.

3. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.

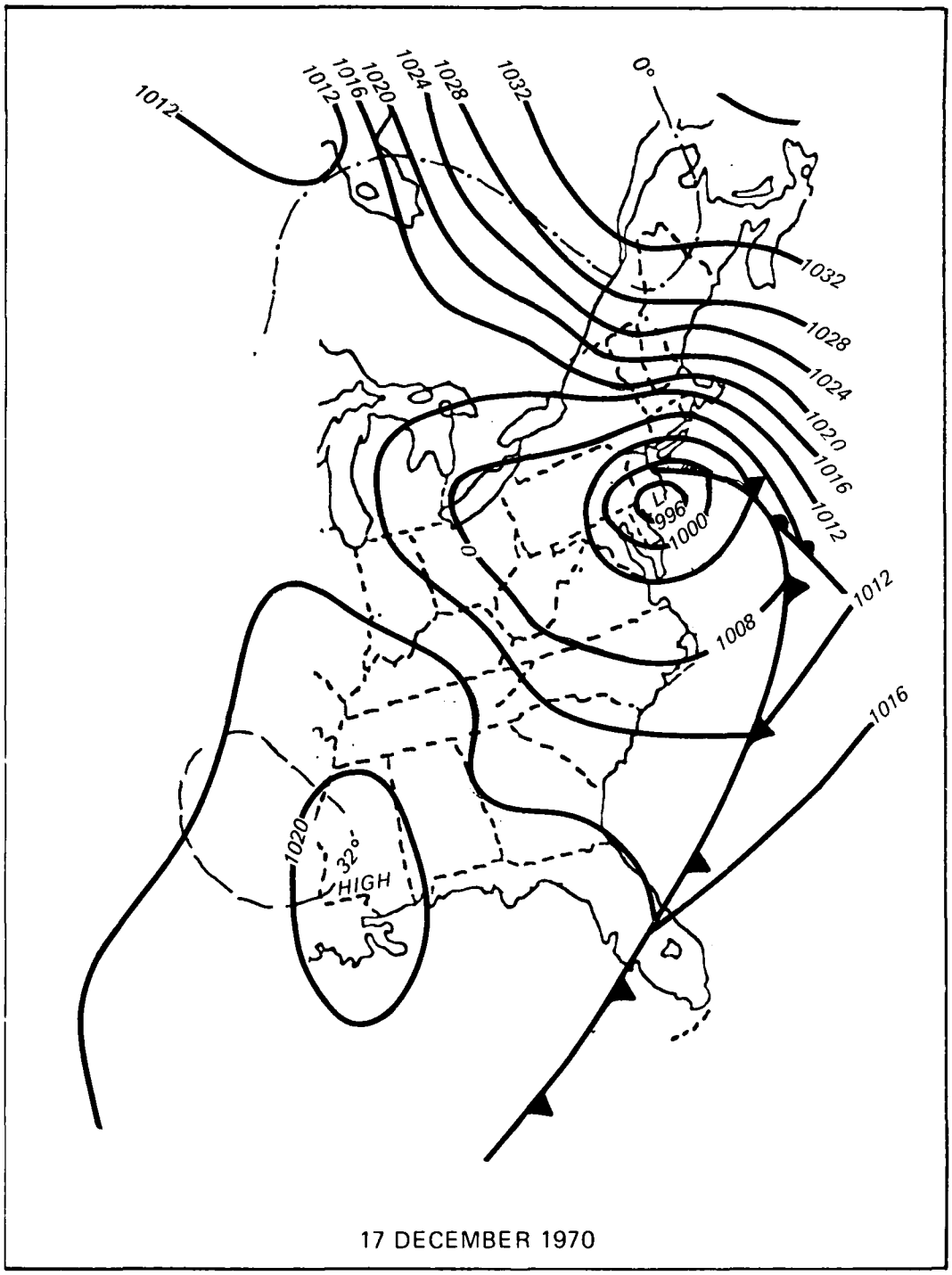



Figure H1. Synoptic weather map at 0700 for 17 December 1970

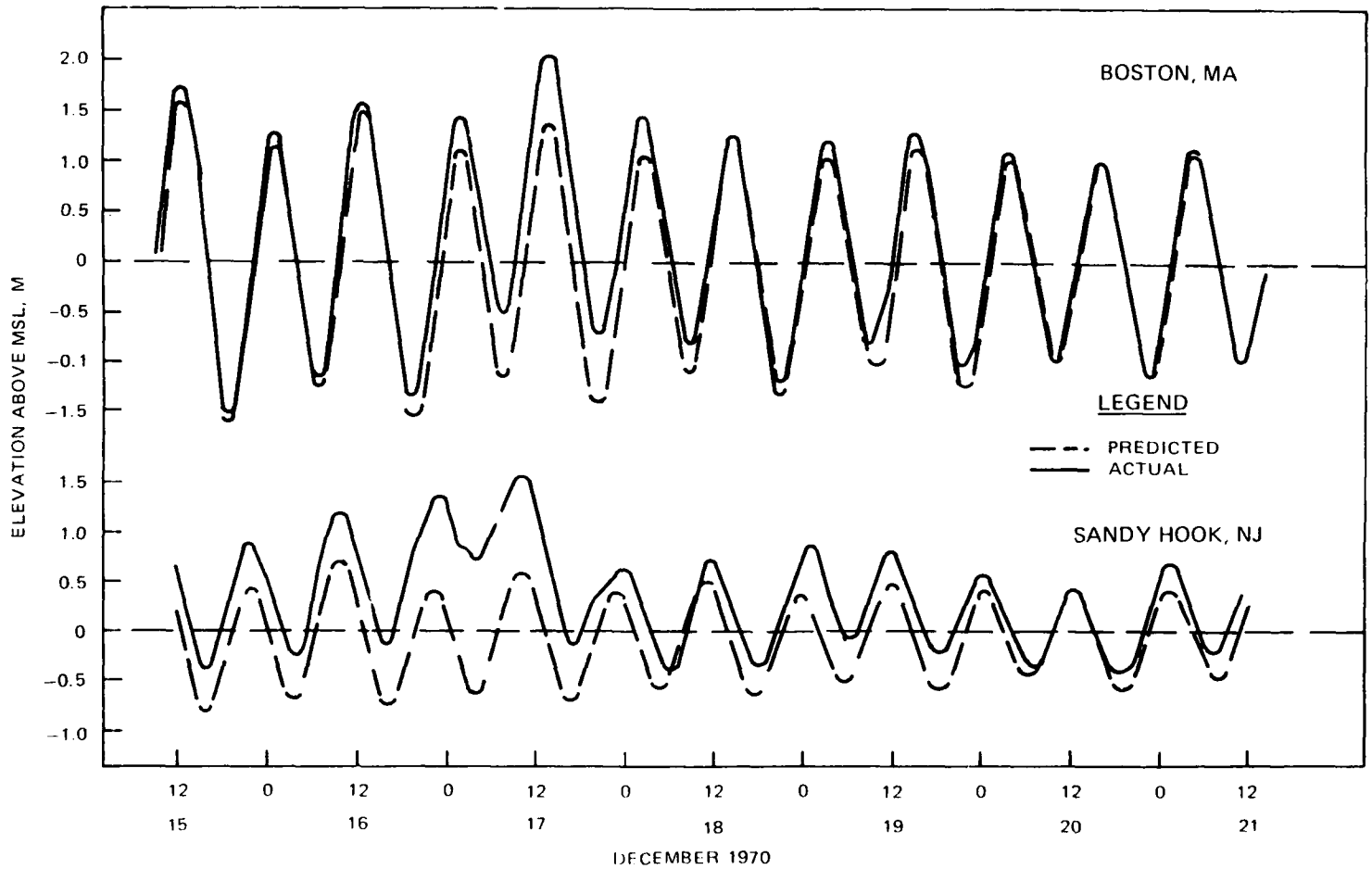



Figure H2. Predicted and actual water levels for 15-21 December 1970

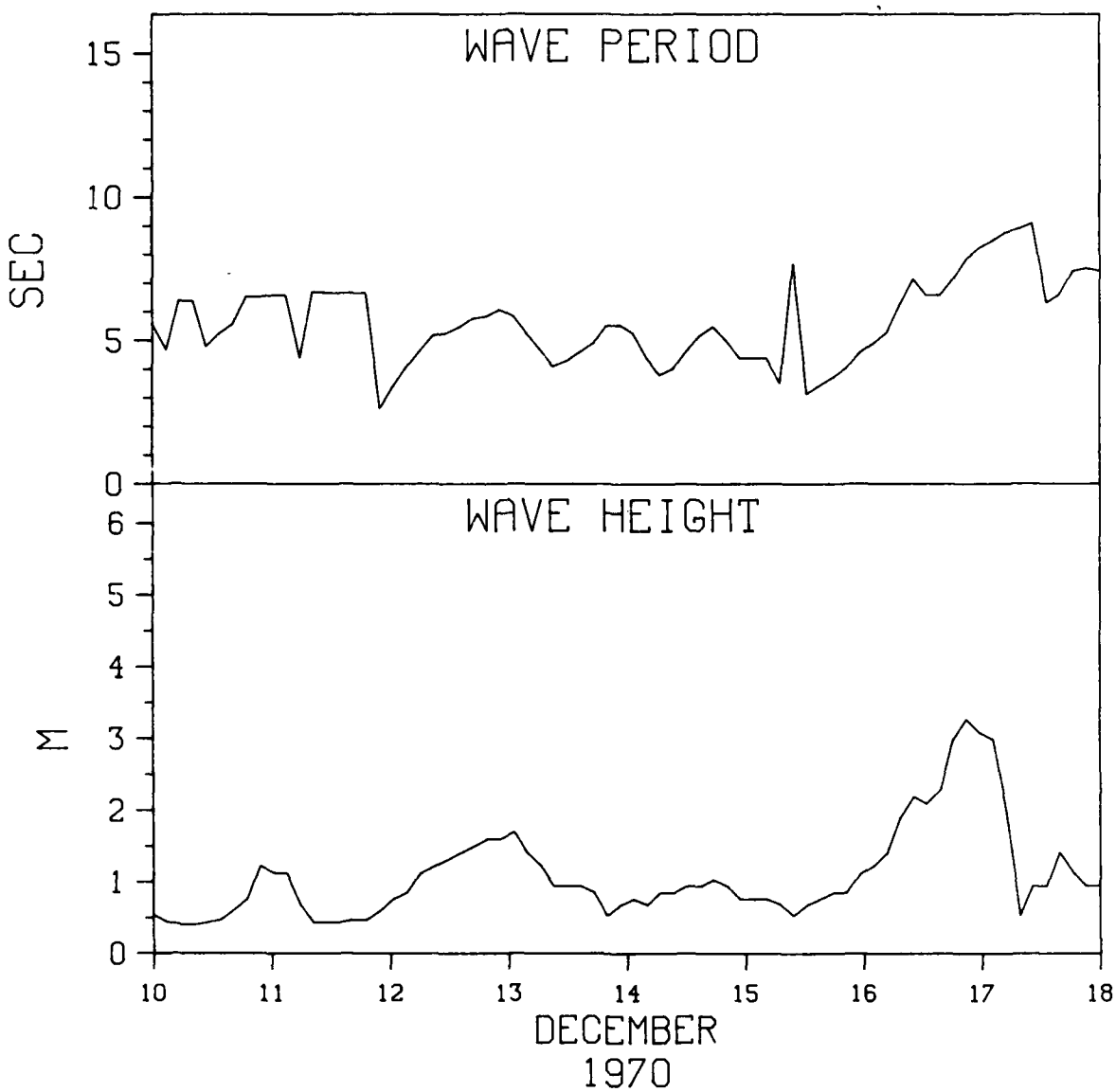



Figure H3. Hindcasted wave data for Nauset Beach, Mass.

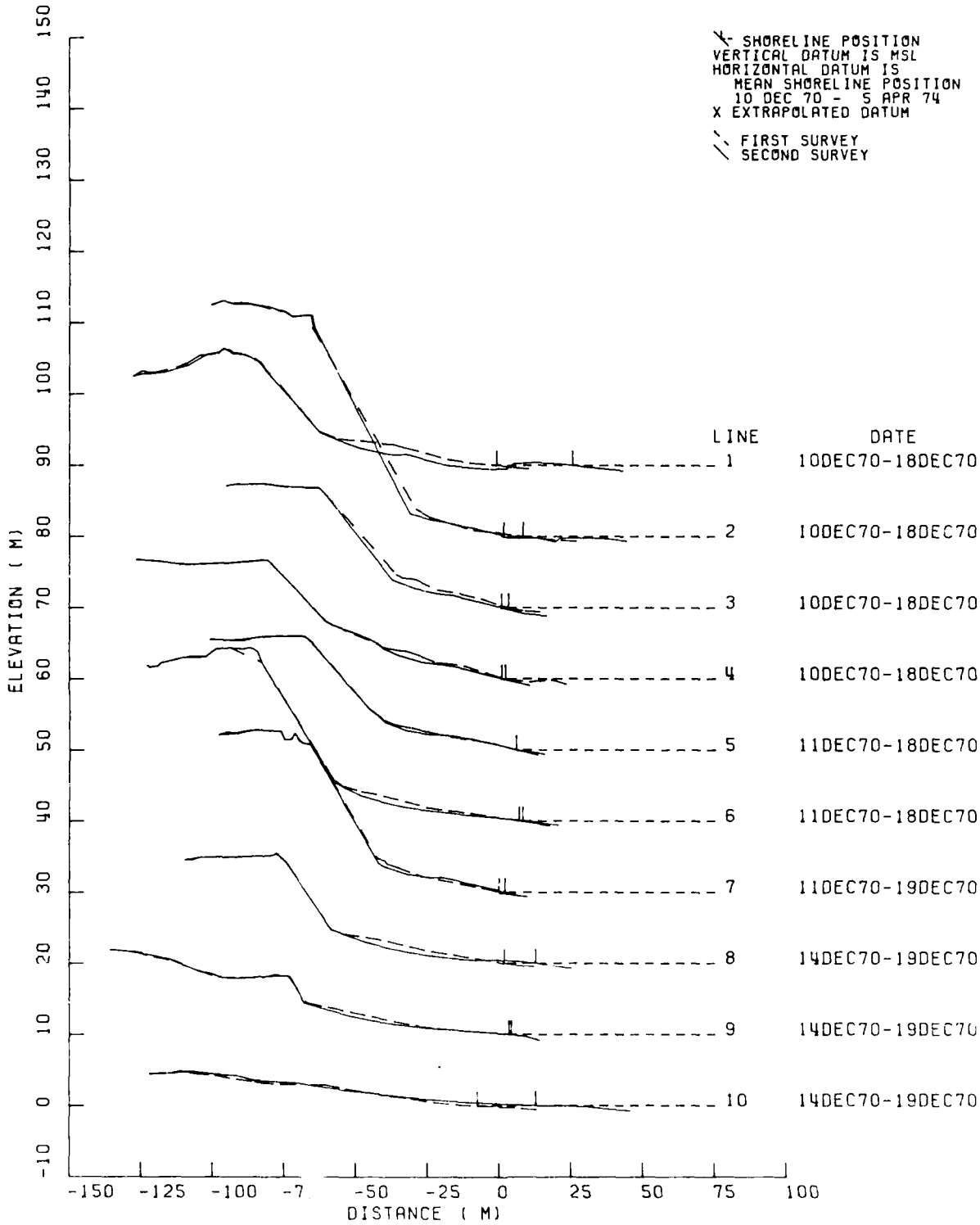



Figure H4. Profile comparisons for surveys of profile lines at Cape Cod, Mass.

Table H1

Shoreline and Slope Changes at Nauset Beach, Mass.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 10 Dec 70 | 18 Dec 70 | 26.44 | -0.052 | -0.040 | 0.012 |
| 2 | 10 Dec 70 | 18 Dec 70 | -6.81 | -0.048 | -0.146 | -0.098 |
| 3 | 10 Dec 70 | 18 Dec 70 | -2.40 | -0.084 | -0.104 | -0.020 |
| 4 | 10 Dec 70 | 18 Dec 70 | -1.29 | -0.120 | -0.104 | 0.016 |
| 5 | 11 Dec 70 | 18 Dec 70 | 0.00 | -0.112 | -0.108 | 0.004 |
| 6 | 11 Dec 70 | 18 Dec 70 | 1.30 | -0.056 | -0.052 | 0.004 |
| 7 | 11 Dec 70 | 19 Dec 70 | 2.10 | -0.104 | -0.108 | -0.004 |
| 8 | 14 Dec 70 | 19 Dec 70 | 10.95 | -0.064 | -0.048 | 0.016 |
| 9 | 14 Dec 70 | 19 Dec 70 | -0.82 | -0.056 | -0.048 | 0.008 |
| 10 | 14 Dec 70 | 19 Dec 70 | 20.32 | -0.020 | -0.012 | 0.008 |
| Median | | | 0.65 | -0.060 | -0.078 | 0.006 |
| Tri-Mean | | | 2.74 | -0.069 | -0.078 | 0.005 |
| High Hinge | | | 10.95 | -0.052 | -0.048 | 0.012 |
| Low Hinge | | | -1.29 | -0.104 | -0.108 | -0.004 |
| Mean | | | 4.98 | -0.072 | -0.077 | -0.005 |
| Standard Deviation | | | 10.77 | 0.032 | 0.042 | 0.034 |

Note: X = Extrapolated shoreline intercept.

Table H2

Unit Volume Changes ($m^3/m$) Between Contours
Nauset Beach, Mass.
from 10 Dec 70 to 18 Dec 70

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -48.11 | -0.86 | -4.49 | -4.11 | -7.25 | -8.10 | -7.88 | -5.20 | -1.12 | -0.42 | -0.15 | -0.11 | -0.11 | -8.31 | |
| 2 | -33.82 | -1.92 | 0.49 | 1.09 | 0.14 | -0.98 | -1.58 | -2.27 | -1.67 | -1.46 | -1.43 | -1.39 | -1.35 | -21.49 | |
| 3 | -42.84 | -1.21 | -1.84 | -2.48 | -2.87 | -3.36 | -3.42 | -3.81 | -4.05 | -2.31 | -1.49 | -1.39 | -1.33 | -13.28 | |
| 4 | -15.44 | -0.81 | -1.08 | -1.43 | -2.36 | -2.33 | -2.98 | -3.37 | -2.88 | -0.95 | -0.04 | 0.30 | 0.47 | 2.00 | |
| 5 | -6.44 | -0.04 | -0.10 | 0.40 | 1.13 | -1.37 | -2.65 | -1.50 | -0.61 | -0.33 | -0.21 | -0.12 | -0.04 | -0.97 | |
| 6 | -29.50 | 0.08 | -1.98 | -3.45 | -3.71 | -4.08 | -4.31 | -4.08 | -3.08 | -1.46 | -0.55 | -0.33 | -0.18 | -2.37 | |
| 7 | -6.58 | 1.08 | 1.23 | 1.86 | 2.34 | -0.31 | -1.62 | -1.79 | -1.67 | -1.39 | -0.50 | -0.28 | -0.27 | -5.26 | |
| 8 | -25.59 | 3.70 | -4.07 | -5.11 | -4.96 | -4.76 | -4.58 | -3.76 | -1.79 | -0.19 | 0.04 | 0.02 | 0.01 | -0.16 | |
| 9 | -15.72 | -0.46 | -1.06 | -2.23 | -3.01 | -3.29 | -3.11 | -2.56 | -1.72 | -0.87 | -0.40 | -0.30 | -0.20 | 3.50 | |
| 10 | 21.96 | 8.26 | 3.47 | 1.00 | -0.15 | -1.57 | -1.86 | 4.30 | 2.50 | 3.27 | 2.74 | | | | |
| Median | -20.66 | -0.25 | -1.07 | -1.83 | -2.61 | -2.81 | -3.05 | -2.96 | -1.69 | -0.91 | -0.31 | -0.28 | -0.18 | -2.37 | |
| Tri-mean | -20.43 | -0.07 | -0.91 | -1.53 | -2.20 | -2.77 | -3.07 | -2.88 | -1.85 | -0.90 | -0.30 | -0.25 | -0.17 | -3.30 | |
| High Hinge | -6.58 | 1.08 | 0.49 | 1.00 | 0.14 | -1.37 | -1.86 | -1.79 | -1.12 | -0.33 | -0.04 | -0.11 | -0.04 | -0.16 | |
| Low Hinge | -33.82 | -0.86 | -1.98 | -3.45 | -3.71 | -4.08 | -4.31 | -3.81 | -2.88 | -1.46 | -0.55 | -0.33 | -0.27 | -8.31 | |
| Mean | -20.21 | 0.78 | -0.94 | -1.45 | -2.07 | -3.01 | -3.40 | -2.40 | -1.61 | -0.61 | -0.20 | -0.40 | -0.33 | -5.15 | |
| Std Dev | 20.51 | 3.05 | 2.39 | 2.43 | 2.94 | 2.28 | 1.88 | 2.62 | 1.76 | 1.51 | 1.16 | 0.59 | 0.61 | 8.06 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

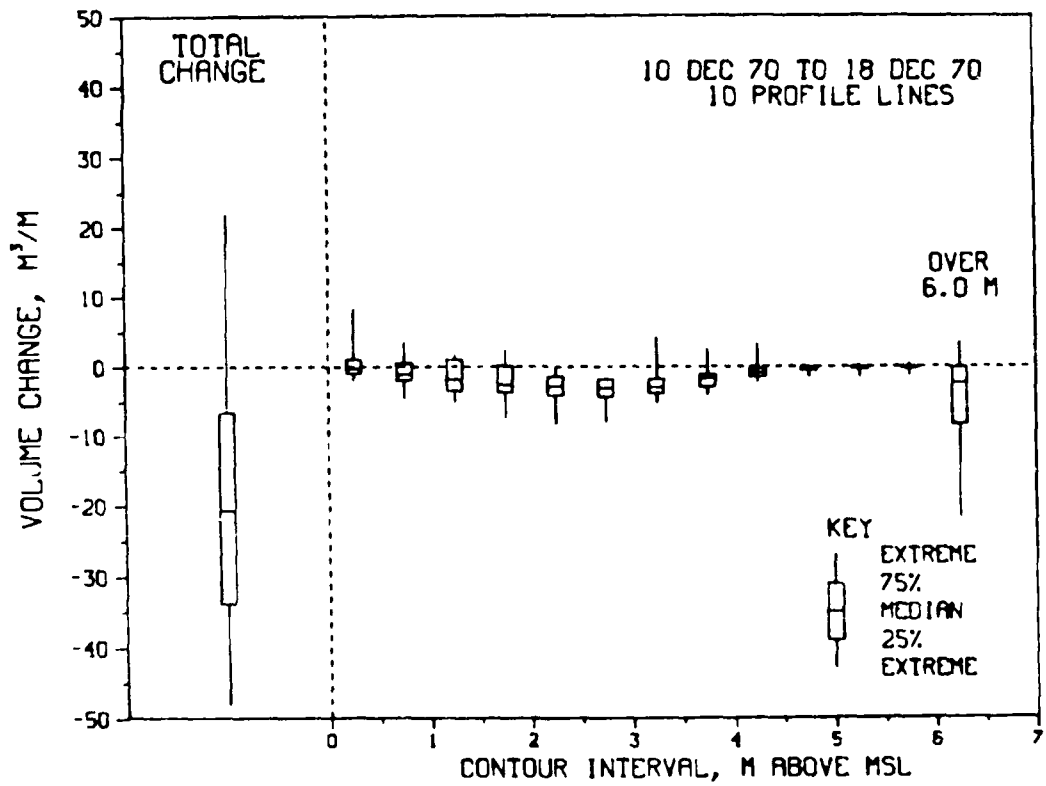



Figure H5. Distribution of volume changes by contour for Nauset Beach, Mass.

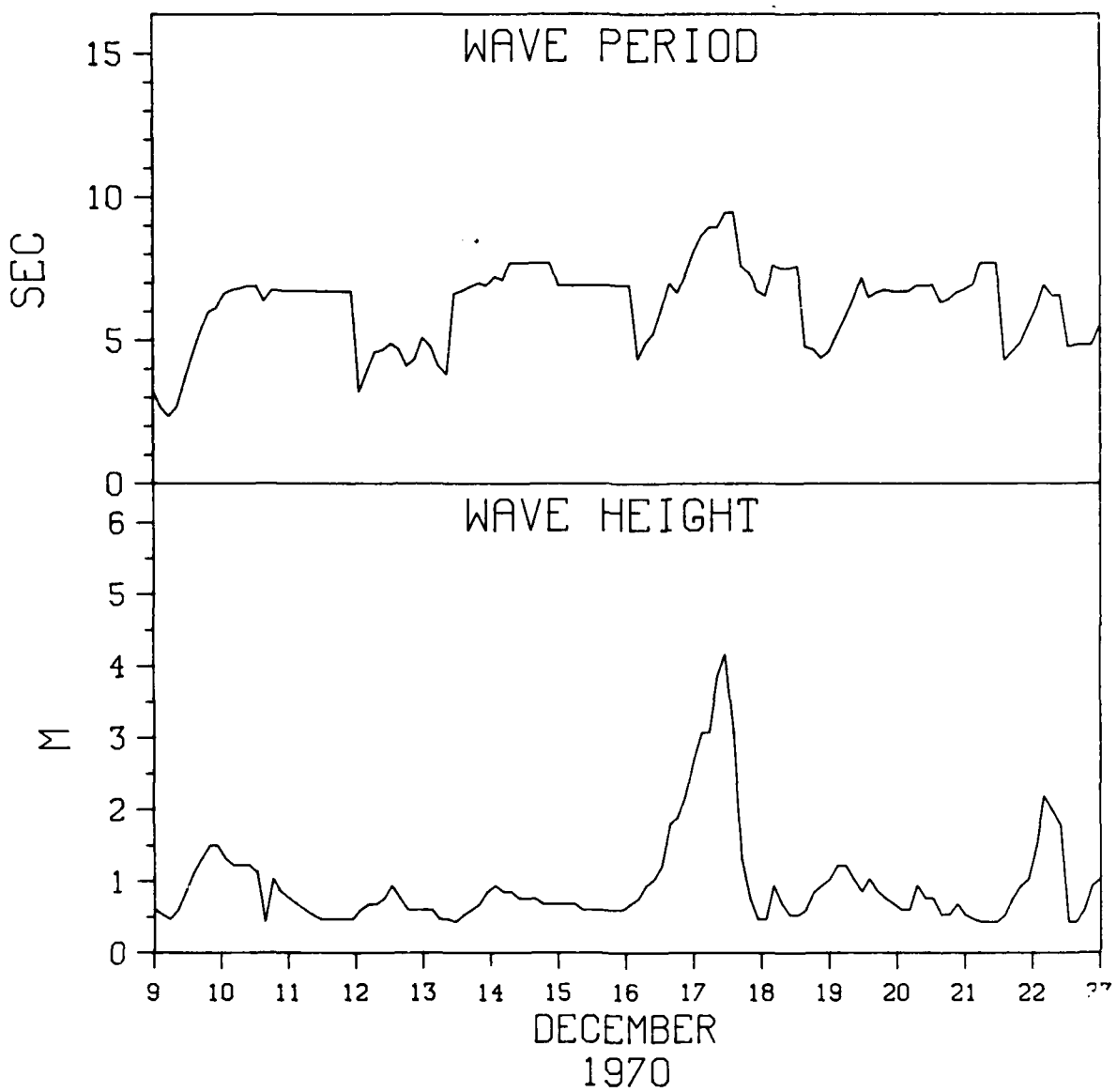



Figure H6. Hindcasted wave data for Misquamicut, R. I.

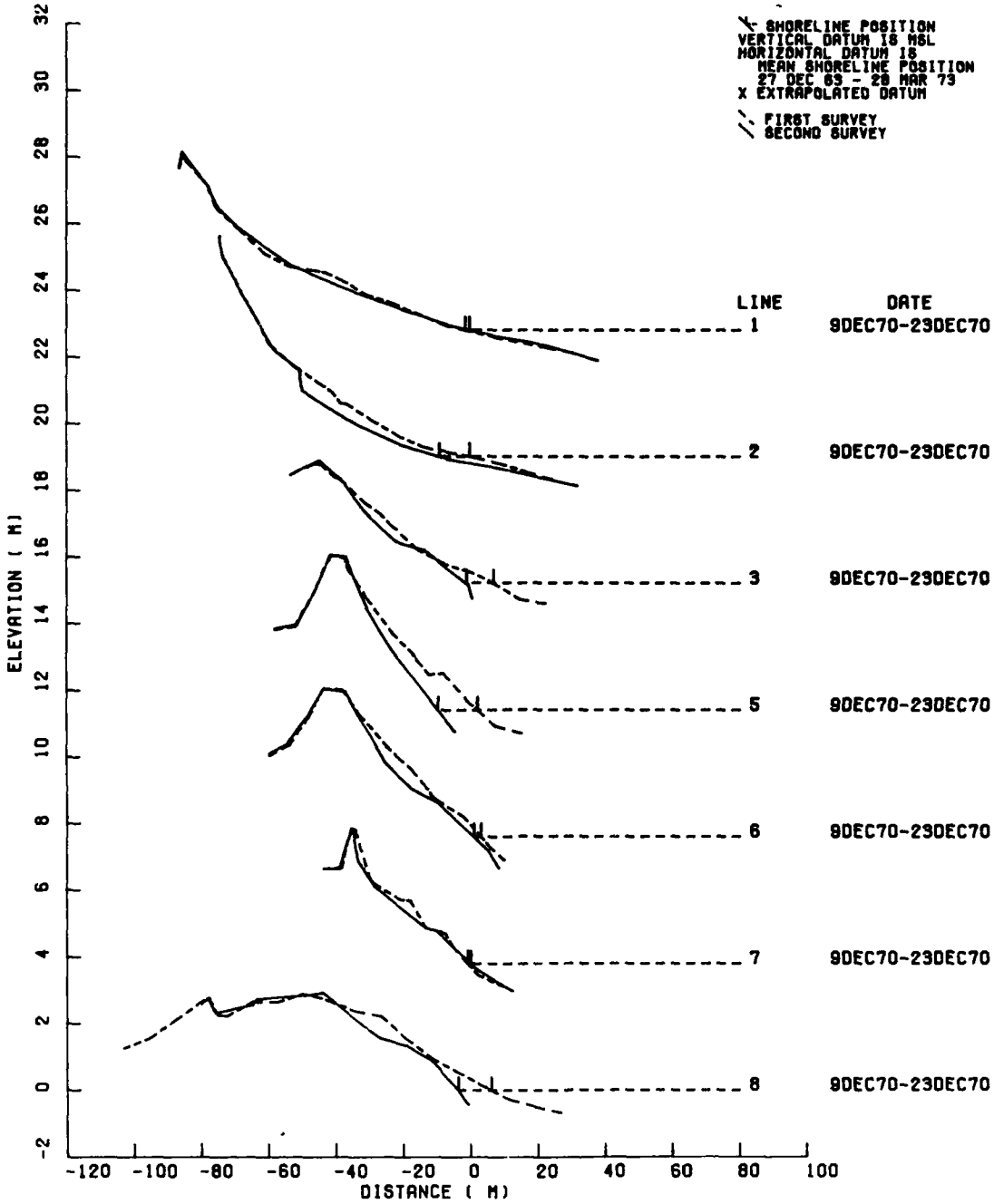



Figure H7. Profile comparisons for surveys at Misquamicut, R. I.

Table H3

Shoreline and Slope Changes at Misquamicut, R.I.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 9 Dec 70 | 23 Dec 70 | 1.27 | -0.024 | -0.024 | 0.000 |
| 2 | 9 Dec 70 | 23 Dec 70 | -8.95 | -0.020 | -0.032 | -0.012 |
| 3 | 9 Dec 70 | 23 Dec 70 | -8.01 | -0.048 | -0.079 | -0.031 |
| 5 | 9 Dec 70 | 23 Dec 70 | -11.66 | -0.092 | -0.134 | -0.042 |
| 6 | 9 Dec 70 | 23 Dec 70 | -2.08 | -0.116 | -0.096 | 0.020 |
| 7 | 9 Dec 70 | 23 Dec 70 | 0.92 | -0.120 | -0.097 | 0.023 |
| 8 | 9 Dec 70 | 23 Dec 70 | -9.76 | -0.052 | -0.150 | -0.098 |
| Median | | | -8.01 | -0.052 | -0.096 | -0.012 |
| Tri-Mean | | | -6.49 | -0.061 | -0.091 | -0.013 |
| High Hinge | | | -0.58 | -0.036 | -0.056 | 0.010 |
| Low Hinge | | | -9.36 | -0.104 | -0.116 | -0.037 |
| Mean | | | -5.47 | -0.067 | -0.087 | -0.020 |
| Standard Deviation | | | 5.37 | 0.042 | 0.047 | 0.042 |

Note: X = Extrapolated shoreline intercept.

Table H4

Unit Volume Changes ($m^3/m$) Between Contours
Misquamicut Beach, R.I.
from 9 Dec 70 to 23 Dec 70

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -0.73 | 0.19 | -0.90 | -1.45 | -1.47 | 1.16 | 0.73 | 0.21 | 0.25 | 0.06 | 0.20 | 0.29 | | | |
| 2 | -15.20 | -3.03 | -2.83 | -3.52 | -3.56 | -2.47 | 0.00 | 0.00 | 0.18 | 0.10 | 0.01 | -0.03 | -0.06 | -0.01 | |
| 3 | -7.29 | -2.89 | 0.05 | -1.21 | -1.93 | -1.50 | -0.46 | 0.38 | 0.27 | | | | | | |
| 5 | -19.98 | -5.49 | -5.16 | -3.03 | -2.59 | -1.58 | -1.32 | -0.84 | -0.21 | 0.18 | 0.08 | | | | |
| 6 | -10.45 | -1.26 | -1.18 | -1.31 | -2.65 | -2.55 | -0.97 | -0.46 | -0.06 | 0.00 | | | | | |
| 7 | -5.01 | 0.22 | -0.41 | -0.63 | -1.96 | -0.61 | -0.40 | -0.68 | -0.49 | -0.05 | | | | | |
| 8 | -11.49 | -3.66 | -1.34 | -1.38 | -3.95 | -2.39 | 1.23 | | | | | | | | |
| Median | -10.45 | -2.89 | -1.18 | -1.38 | -2.59 | -1.58 | -0.40 | -0.23 | 0.06 | 0.06 | 0.08 | 0.13 | -0.06 | -0.01 | |
| Tri-mean | -10.10 | -2.41 | -1.27 | -1.57 | -2.56 | -1.66 | -0.29 | -0.23 | 0.04 | 0.05 | 0.09 | 0.13 | -0.06 | -0.01 | |
| High Hinge | -6.15 | -0.53 | -0.65 | -1.26 | -1.94 | -1.06 | 0.37 | 0.21 | 0.25 | 0.10 | 0.14 | 0.29 | -0.06 | -0.01 | |
| Low Hinge | -13.34 | -3.35 | -2.09 | -2.24 | -3.11 | -2.43 | -0.72 | -0.68 | -0.21 | 0.00 | 0.04 | -0.03 | -0.06 | -0.01 | |
| Mean | -10.02 | -2.27 | -1.68 | -1.79 | -2.59 | -1.42 | -0.17 | -0.23 | -0.01 | 0.06 | 0.10 | 0.13 | -0.06 | -0.01 | |
| Std Dev | 6.41 | 2.10 | 1.78 | 1.06 | 0.90 | 1.33 | 0.90 | 0.50 | 0.30 | 0.09 | 0.10 | 0.23 | 0.00 | 0.00 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

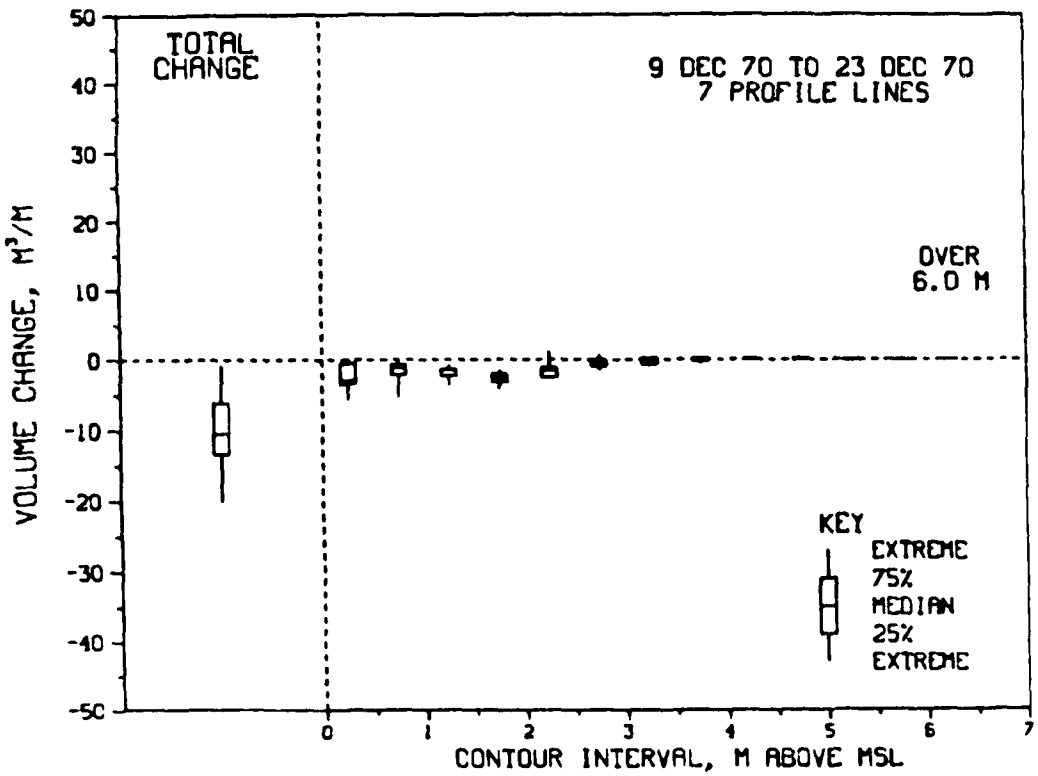



Figure H8. Distribution of volume changes by contour for Misquamicut, R. I.

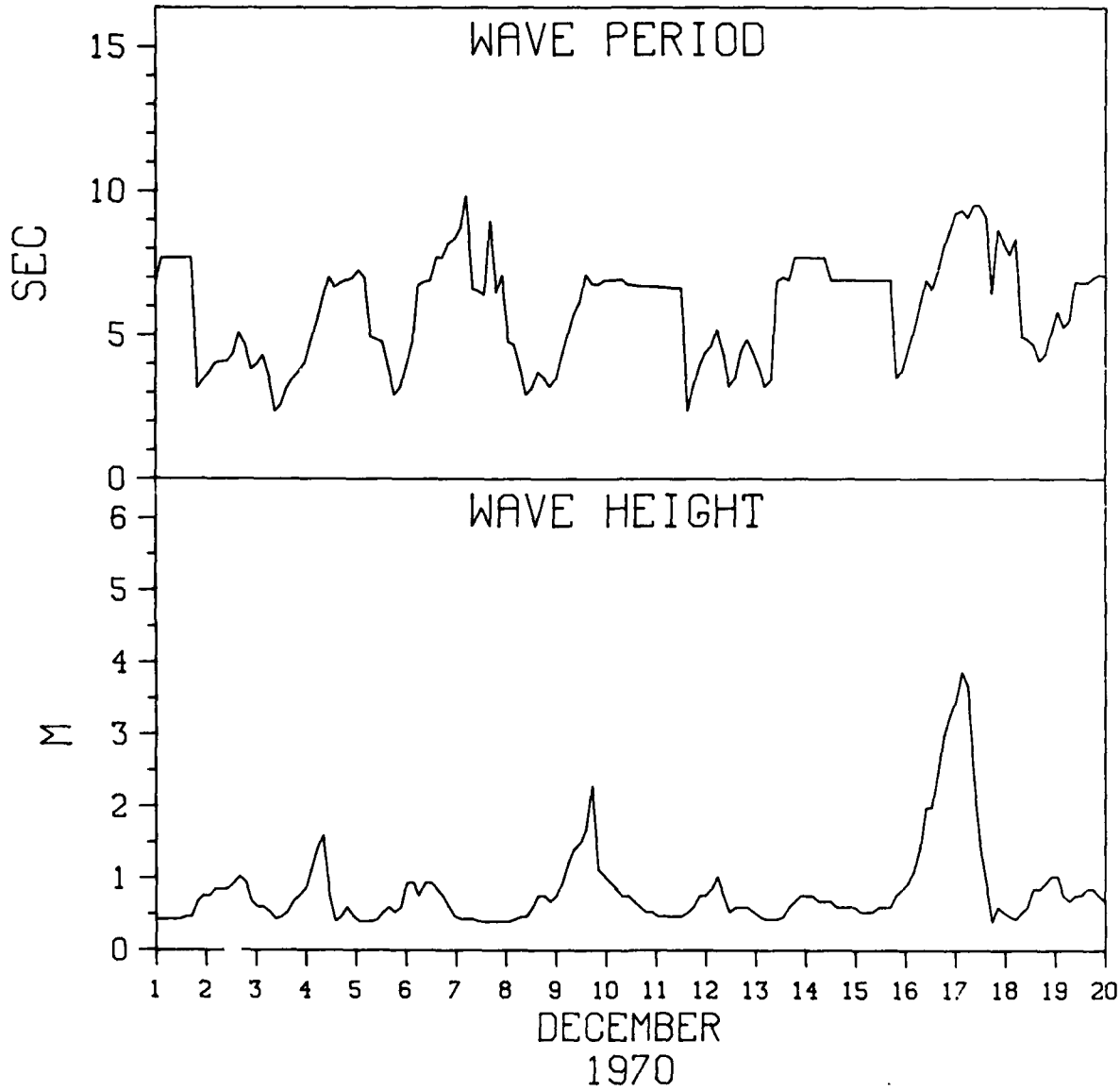



Figure H9. Hindcasted wave data for Westhampton, N. Y.

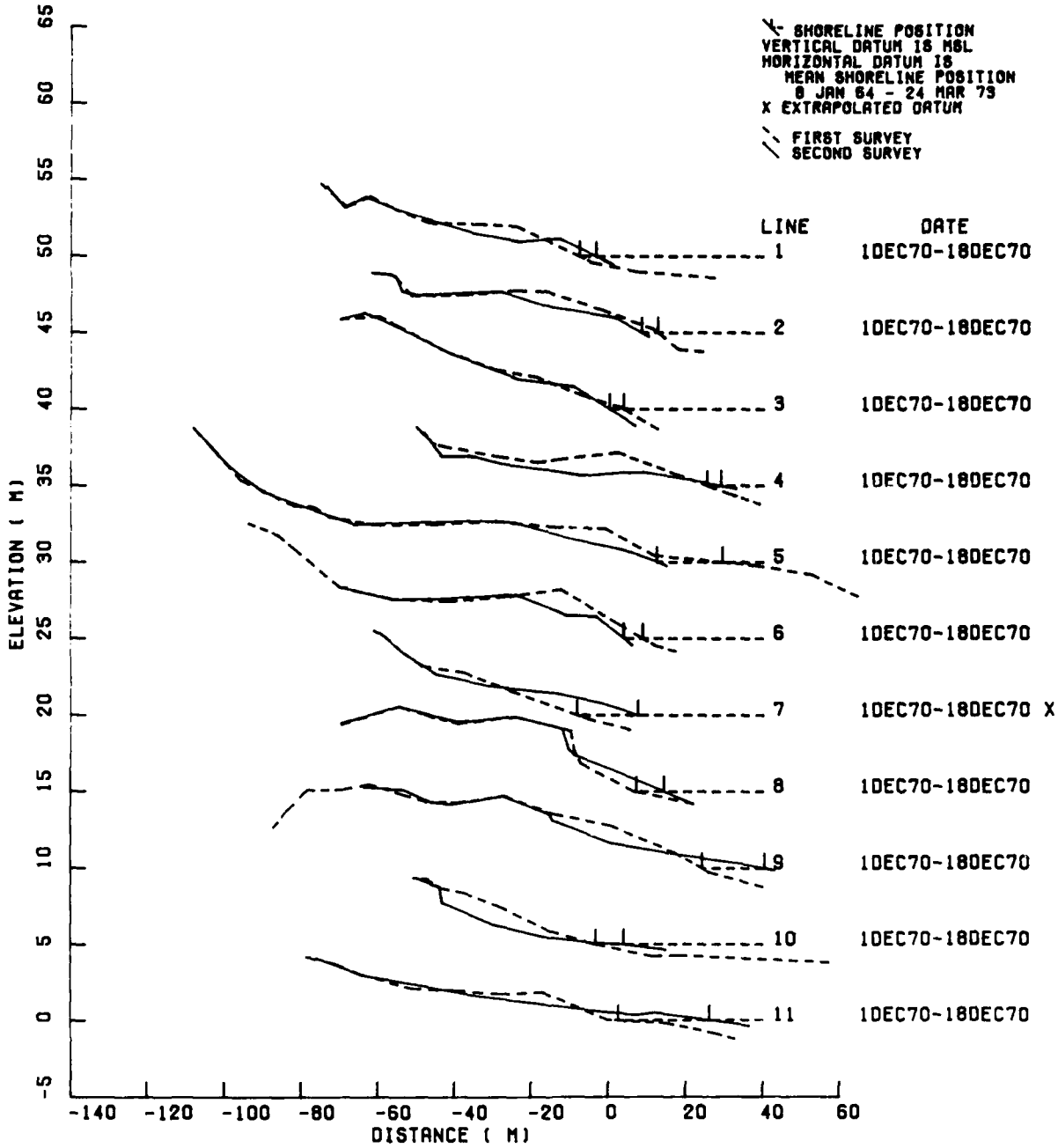



Figure H10. Profile comparisons for surveys at Westhampton, N. Y.

Table H5

Shoreline and Slope Changes at Westhampton, N.Y.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 1 Dec 70 | 18 Dec 70 | 4.33 | -0.122 | -0.124 | -0.003 |
| 2 | 1 Dec 70 | 18 Dec 70 | -4.15 | -0.200 | -0.143 | 0.057 |
| 3 | 1 Dec 70 | 18 Dec 70 | -3.64 | -0.148 | -0.160 | -0.011 |
| 4 | 1 Dec 70 | 18 Dec 70 | 3.43 | -0.093 | -0.046 | 0.047 |
| 5 | 1 Dec 70 | 18 Dec 70 | -16.66 | -0.025 | -0.100 | -0.075 |
| 6 | 1 Dec 70 | 18 Dec 70 | -4.91 | -0.148 | -0.203 | -0.055 |
| 7 | 1 Dec 70 | 18 Dec 70 | 15.69 | -0.094 | -0.083 | 0.010 |
| 8 | 1 Dec 70 | 18 Dec 70 | 7.19 | -0.054 | -0.110 | -0.056 |
| 9 | 1 Dec 70 | 18 Dec 70 | 16.05 | -0.145 | -0.047 | 0.098 |
| 10 | 1 Dec 70 | 18 Dec 70 | 7.06 | -0.054 | -0.013 | 0.041 |
| 11 | 1 Dec 70 | 18 Dec 70 | 23.95 | -0.014 | -0.035 | 0.021 |
| Median | | | 4.33 | -0.094 | -0.100 | 0.003 |
| Tri-Mean | | | 4.05 | -0.097 | -0.095 | 0.000 |
| High Hinge | | | 11.44 | -0.054 | -0.047 | 0.044 |
| Low Hinge | | | -3.89 | -0.147 | -0.134 | -0.038 |
| Mean | | | 4.39 | -0.100 | -0.097 | -0.003 |
| Standard Deviation | | | 11.53 | 0.059 | 0.059 | 0.054 |

Note: X = Extrapolated shoreline intercept.

Table H6

Unit Volume Changes ($m^3/m$) Between Contours
Westhampton Beach, N.Y.
from 1 Dec 70 to 18 Dec 70

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -9.31 | 2.19 | 2.20 | -4.92 | -8.23 | -0.78 | 0.45 | -0.22 | -0.18 | 0.18 | 0.00 | | | | |
| 2 | -19.25 | -2.14 | -1.44 | -2.77 | -5.39 | -5.08 | -2.16 | -0.29 | 0.02 | | | | | | |
| 3 | -4.08 | -1.27 | 0.27 | 1.37 | -0.89 | -2.15 | -0.38 | -0.30 | -0.06 | -0.08 | -0.21 | -0.38 | | | |
| 4 | -43.19 | 0.34 | -7.35 | -17.13 | -13.69 | -4.80 | -0.46 | -0.09 | 0.00 | | | | | | |
| 5 | -22.16 | -4.61 | -2.72 | -5.36 | -7.62 | -4.37 | 2.02 | -0.54 | 0.29 | 0.10 | -0.02 | 0.67 | | | |
| 6 | -20.70 | -2.23 | -1.77 | -1.62 | -5.20 | -5.41 | -3.53 | -0.95 | 0.00 | 0.00 | 0.00 | 0.00 | | | |
| 7 | 14.84 | 7.68 | 7.17 | 5.47 | 0.93 | -2.63 | -3.42 | -0.21 | 0.01 | -0.07 | -0.10 | 0.00 | | | |
| 8 | 11.72 | 3.58 | 3.20 | 2.67 | 1.99 | 0.34 | -0.60 | -0.82 | -0.93 | 0.01 | 1.75 | 0.53 | | | |
| 9 | -15.54 | 6.10 | 1.32 | -2.92 | -5.39 | -5.66 | -5.53 | -2.86 | -0.55 | -1.01 | 1.01 | -0.05 | | | |
| 10 | -32.90 | -0.90 | -3.83 | -5.32 | -5.97 | -6.23 | -5.92 | -3.67 | -0.53 | -0.53 | | | | | |
| 11 | -1.87 | 9.48 | -0.53 | -5.84 | -6.86 | 2.04 | 0.48 | -0.38 | -0.29 | 0.03 | | | | | |
| Median | -15.54 | 0.34 | -0.53 | -2.92 | -5.39 | -4.37 | -0.60 | -0.38 | -0.06 | 0.00 | 0.00 | 0.00 | | | |
| Tri-mean | -13.87 | 0.95 | -0.39 | -2.83 | -5.27 | -3.86 | -1.16 | -0.47 | -0.13 | -0.01 | 0.11 | 0.12 | | | |
| High Hinge | -2.97 | 4.84 | 1.76 | -0.13 | -3.04 | -1.47 | 0.03 | -0.25 | 0.00 | 0.03 | 0.50 | 0.53 | | | |
| Low Hinge | -21.43 | -1.71 | -2.24 | -5.34 | -7.24 | -5.24 | -3.47 | -0.88 | -0.41 | -0.08 | -0.06 | -0.05 | | | |
| Mean | -12.95 | 1.66 | -0.32 | -3.31 | -5.12 | -3.16 | -1.73 | -0.94 | -0.20 | -0.15 | 0.35 | 0.13 | | | |
| Std Dev | 17.60 | 4.55 | 3.86 | 5.88 | 4.45 | 2.74 | 2.58 | 1.19 | 0.35 | 0.38 | 0.74 | 0.39 | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

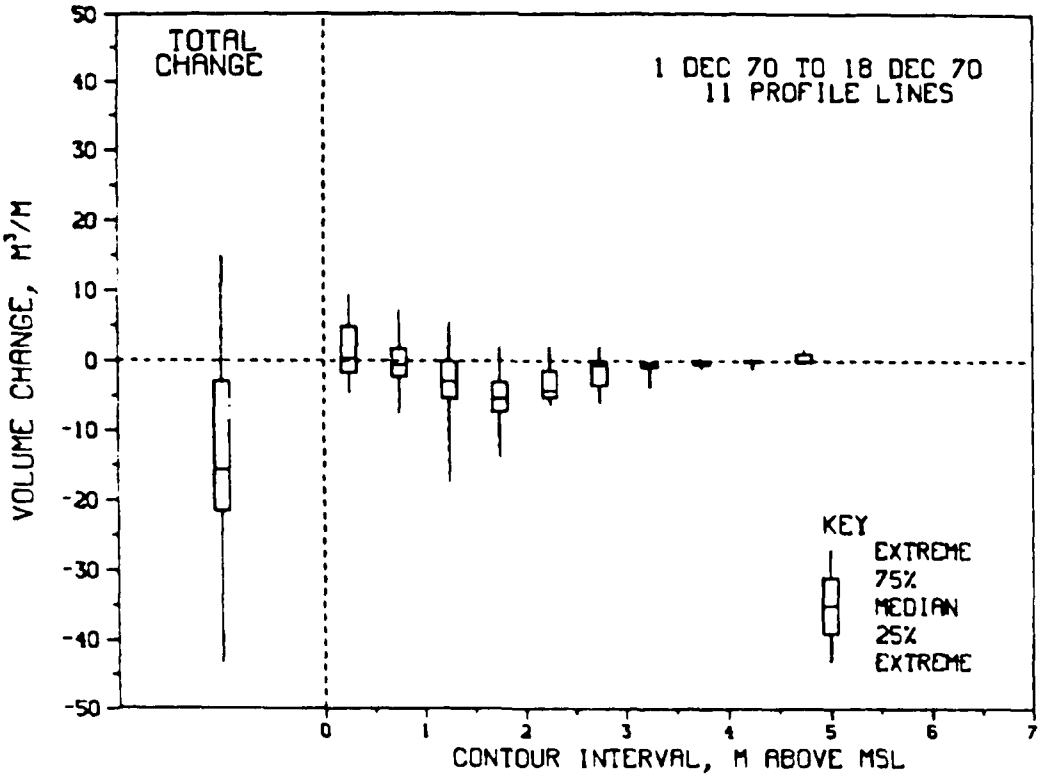



Figure H11. Distribution of volume changes by contour for Westhampton, N. Y.

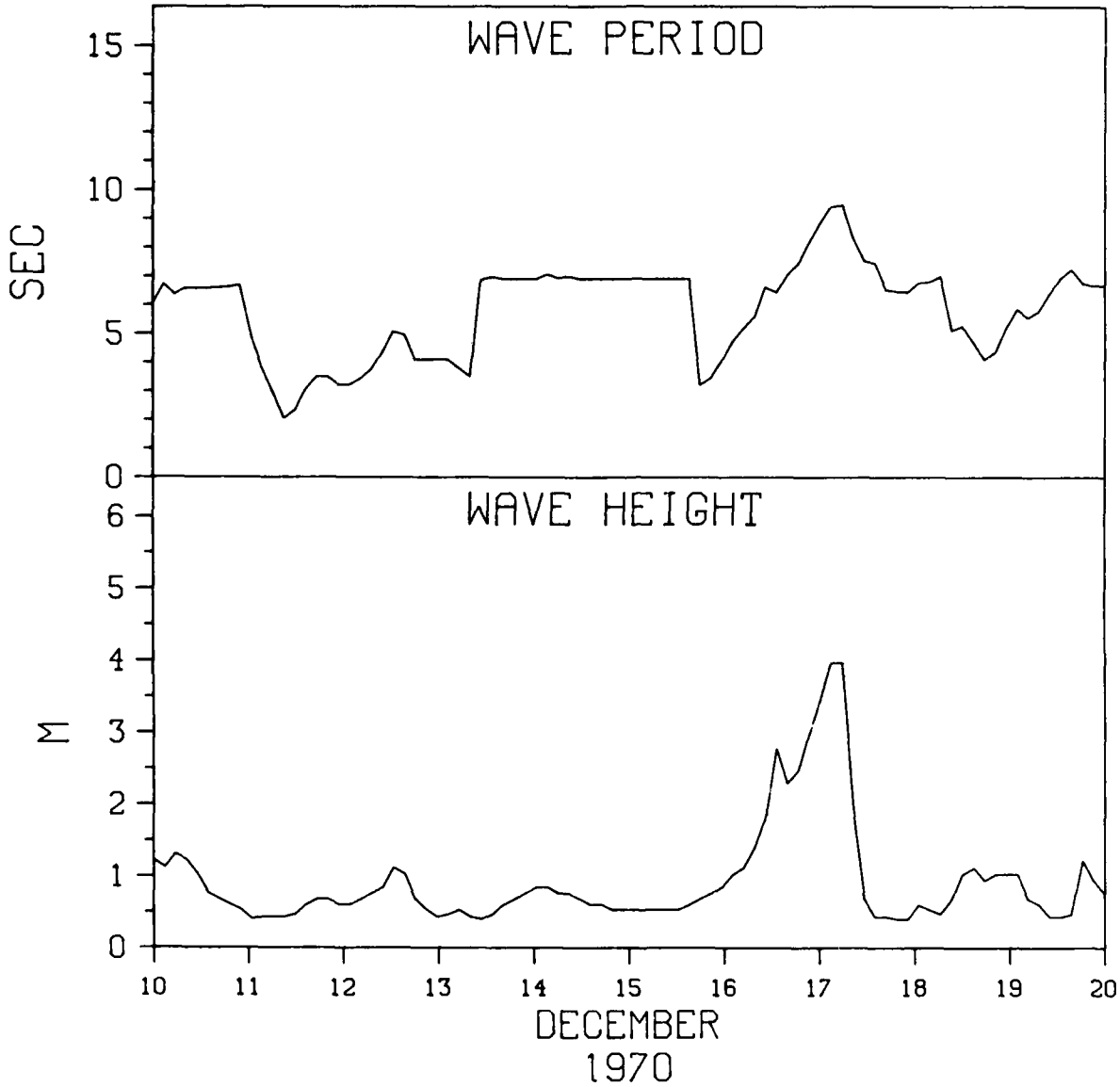



Figure H12. Hindcasted wave data for Jones Beach, N. Y.

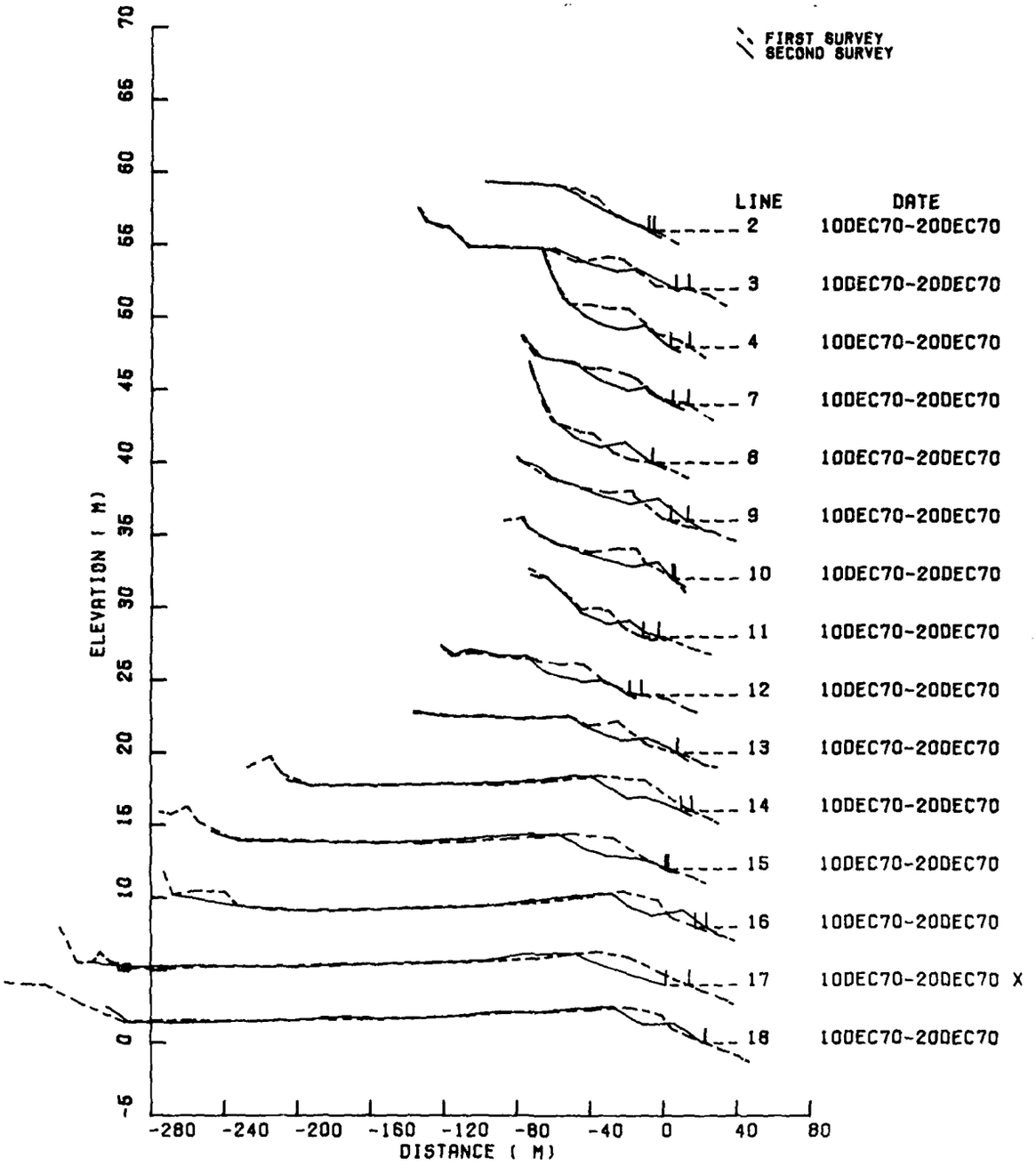



Figure H13. Profile comparisons for surveys at Jones Beach, N. Y.

Table H7

Shoreline and Slope Changes at Jones Beach, N.Y.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 2 | 10 Dec 70 | 20 Dec 70 | -2.84 | -0.047 | -0.077 | -0.030 |
| 3 | 10 Dec 70 | 20 Dec 70 | -6.84 | -0.035 | -0.065 | -0.030 |
| 4 | 10 Dec 70 | 20 Dec 70 | -10.40 | -0.085 | -0.062 | 0.023 |
| 7 | 10 Dec 70 | 20 Dec 70 | -8.46 | -0.078 | -0.055 | 0.023 |
| 8 | 10 Dec 70 | 20 Dec 70 | 0.20 | -0.021 | -0.058 | -0.037 |
| 9 | 10 Dec 70 | 20 Dec 70 | 9.52 | -0.044 | -0.077 | -0.033 |
| 10 | 10 Dec 70 | 20 Dec 70 | -1.14 | -0.160 | -0.080 | 0.080 |
| 11 | 10 Dec 70 | 20 Dec 70 | 8.52 | -0.048 | -0.060 | -0.012 |
| 12 | 10 Dec 70 | 20 Dec 70 | -5.97 | -0.017 | -0.071 | -0.054 |
| 13 | 10 Dec 70 | 20 Dec 70 | -0.11 | -0.034 | -0.090 | -0.056 |
| 14 | 10 Dec 70 | 20 Dec 70 | -5.67 | -0.053 | -0.067 | -0.014 |
| 15 | 10 Dec 70 | 20 Dec 70 | -1.40 | -0.056 | -0.070 | -0.014 |
| 16 | 10 Dec 70 | 20 Dec 70 | 6.11 | -0.052 | -0.071 | -0.019 |
| 17 | 10 Dec 70 | 20 Dec 70 X | -13.01 | -0.055 | -0.033 | 0.021 |
| 18 | 10 Dec 70 | 20 Dec 70 | 0.37 | -0.050 | -0.063 | -0.013 |
| Median | | | -1.40 | -0.050 | -0.067 | -0.014 |
| Tri-Mean | | | -2.23 | -0.049 | -0.067 | -0.014 |
| High Hinge | | | 0.28 | -0.040 | -0.061 | 0.005 |
| Low Hinge | | | -6.41 | -0.056 | -0.074 | -0.032 |
| Mean | | | -2.08 | -0.056 | -0.067 | -0.011 |
| Standard Deviation | | | 6.61 | 0.034 | 0.013 | 0.035 |

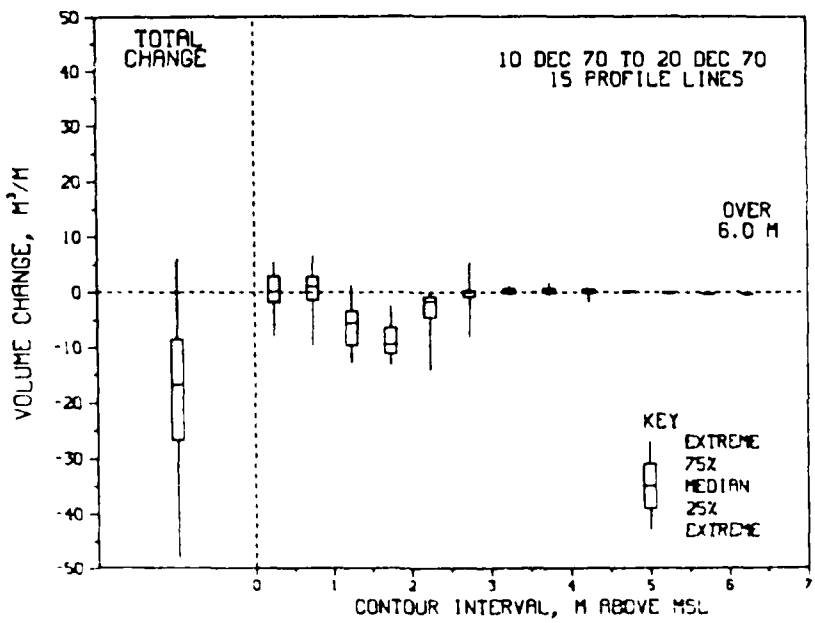
Note: X=Extrapolated Shoreline Intercept.

Table H8

Unit Volume Changes ($m^3/m$) Between Contours
Jones Beach, N.Y.
from 10 Dec 70 to 20 Dec 70

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | -9.93 | -0.76 | 0.27 | -0.53 | -2.44 | -3.53 | -2.66 | -0.28 | | | | | | | |
| 3 | -9.62 | 1.93 | 2.36 | -2.41 | -9.71 | 0.04 | -1.02 | -0.37 | -0.25 | 0.41 | -0.28 | -0.32 | 0.00 | | |
| 4 | -48.16 | -5.16 | -2.29 | -4.34 | -12.73 | -13.97 | -8.12 | -0.32 | -0.47 | -0.14 | 0.12 | -0.05 | -0.30 | -0.39 | |
| 7 | -24.04 | -2.33 | 0.50 | -6.14 | -10.28 | -8.21 | -0.13 | 0.62 | 1.04 | 0.74 | 0.15 | | | | |
| 8 | 3.64 | 3.68 | 6.62 | 0.76 | -6.03 | -3.02 | 0.27 | 0.59 | 0.69 | 0.49 | 0.22 | -0.05 | -0.28 | -0.30 | |
| 9 | 5.97 | 5.64 | 5.80 | 1.32 | -8.94 | -1.49 | 0.68 | 1.34 | 1.74 | -0.12 | | | | | |
| 10 | -21.67 | 0.10 | 1.09 | -9.18 | -13.15 | -0.72 | 0.27 | 0.20 | -0.14 | -0.14 | | | | | |
| 11 | -7.49 | 3.94 | 3.24 | -5.01 | -6.72 | -0.67 | -0.32 | -0.16 | -0.05 | -1.68 | -0.06 | | | | |
| 12 | -23.12 | -1.19 | -0.33 | -9.93 | -12.94 | -4.81 | 5.42 | 0.66 | | | | | | | |
| 13 | -14.05 | 2.07 | 2.16 | -7.84 | -9.38 | -0.90 | -0.16 | | | | | | | | |
| 14 | -36.07 | -3.12 | -6.86 | -12.30 | -9.63 | -4.15 | 0.00 | 0.00 | 0.00 | | | | | | |
| 15 | -29.24 | -0.28 | -4.40 | -11.31 | -11.80 | -0.75 | -0.70 | 0.00 | 0.00 | 0.00 | | | | | |
| 16 | -16.72 | 3.99 | 4.14 | -5.06 | -9.12 | -10.66 | 0.00 | 0.00 | 0.00 | | | | | | |
| 17 | -37.37 | X -7.87 | -9.59 | -12.61 | -5.64 | -1.66 | 0.00 | 0.00 | 0.00 | | | | | | |
| 18 | -7.37 | 0.84 | 2.18 | -5.52 | -3.91 | -0.97 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| Median | -16.72 | 0.10 | 1.09 | -5.52 | -9.38 | -1.66 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | -0.05 | -0.28 | -0.34 | |
| Tri-mean | -17.16 | 0.33 | 0.92 | -5.99 | -9.04 | -2.16 | -0.09 | 0.11 | 0.06 | 0.07 | 0.08 | -0.08 | -0.25 | -0.34 | |
| High Hinge | -8.56 | 2.88 | 2.80 | -3.38 | -6.38 | -0.82 | 0.14 | 0.59 | 0.34 | 0.41 | 0.15 | -0.05 | -0.14 | -0.30 | |
| Low Hinge | -26.64 | -1.76 | -1.31 | -9.56 | -11.04 | -4.48 | -0.51 | -0.16 | -0.09 | -0.14 | -0.06 | -0.19 | -0.29 | -0.39 | |
| Mean | -18.35 | 0.10 | 0.33 | -6.01 | -8.83 | -3.70 | -0.43 | 0.16 | 0.21 | -0.05 | 0.03 | -0.14 | -0.19 | -0.34 | |
| Std Dev | 15.19 | 3.70 | 4.50 | 4.53 | 3.28 | 4.15 | 2.70 | 0.48 | 0.63 | 0.69 | 0.20 | 0.16 | 0.17 | 0.06 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.




Figures H14. Distribution of volume changes by contour for Jones Beach, N. Y.

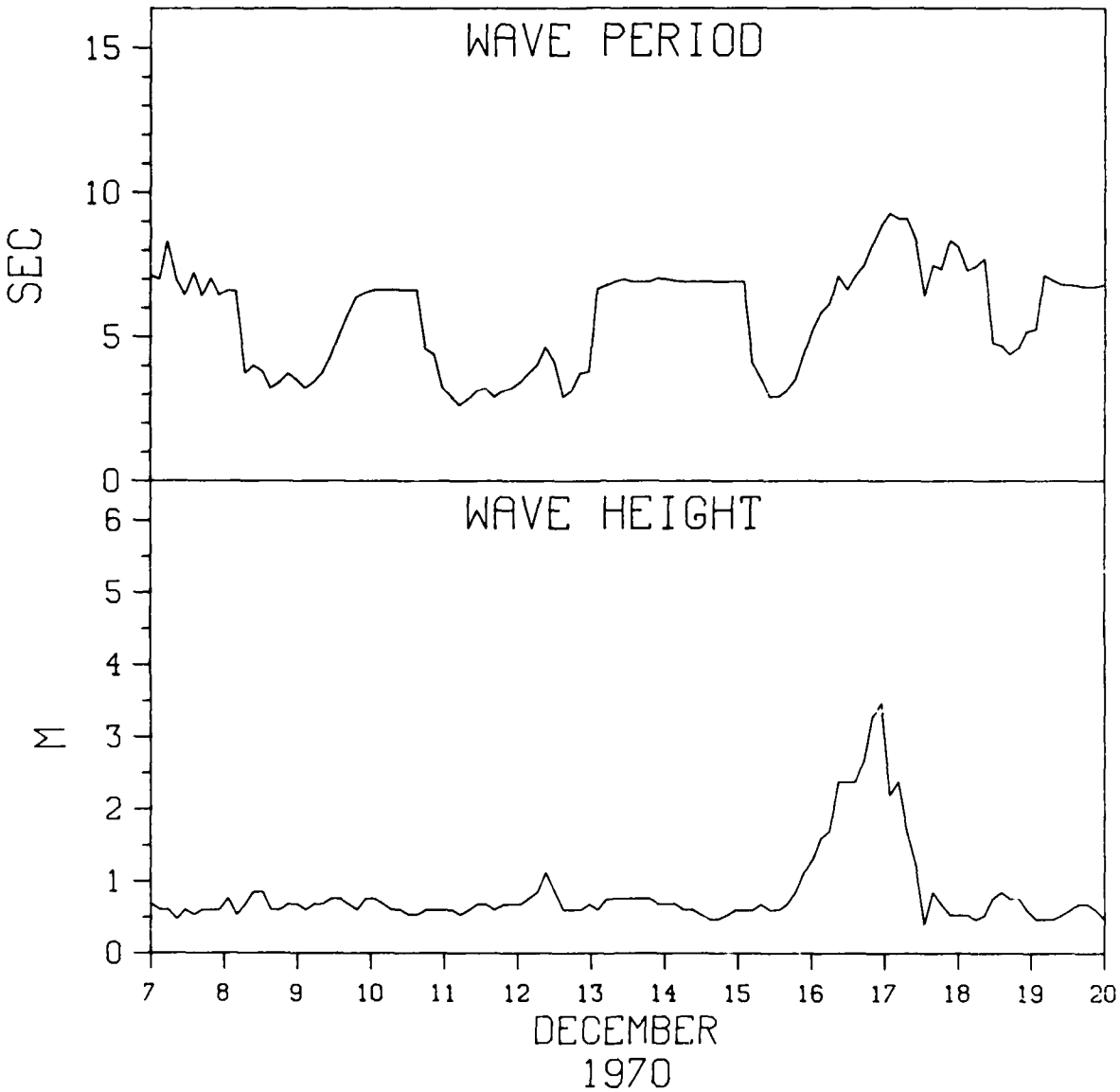
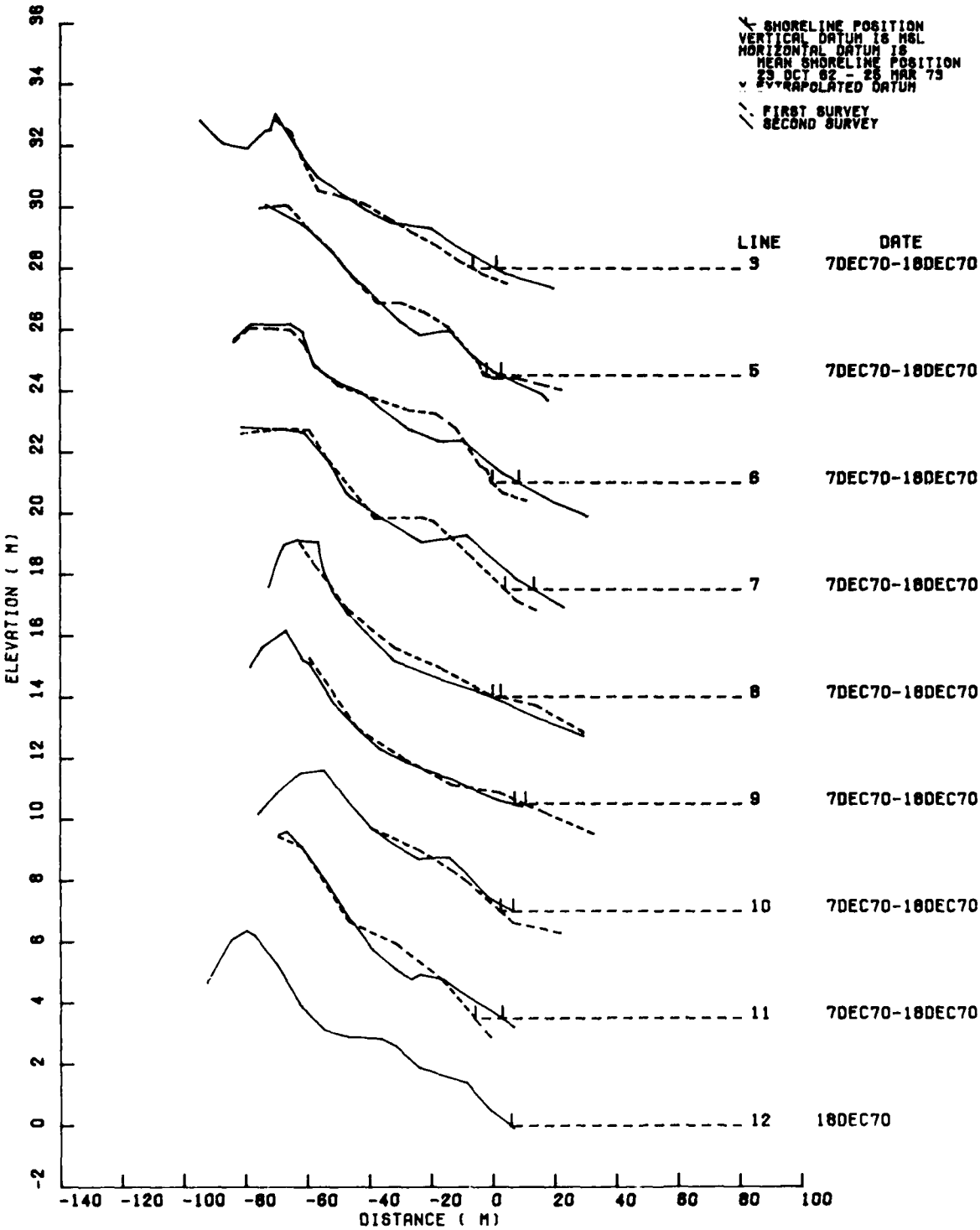
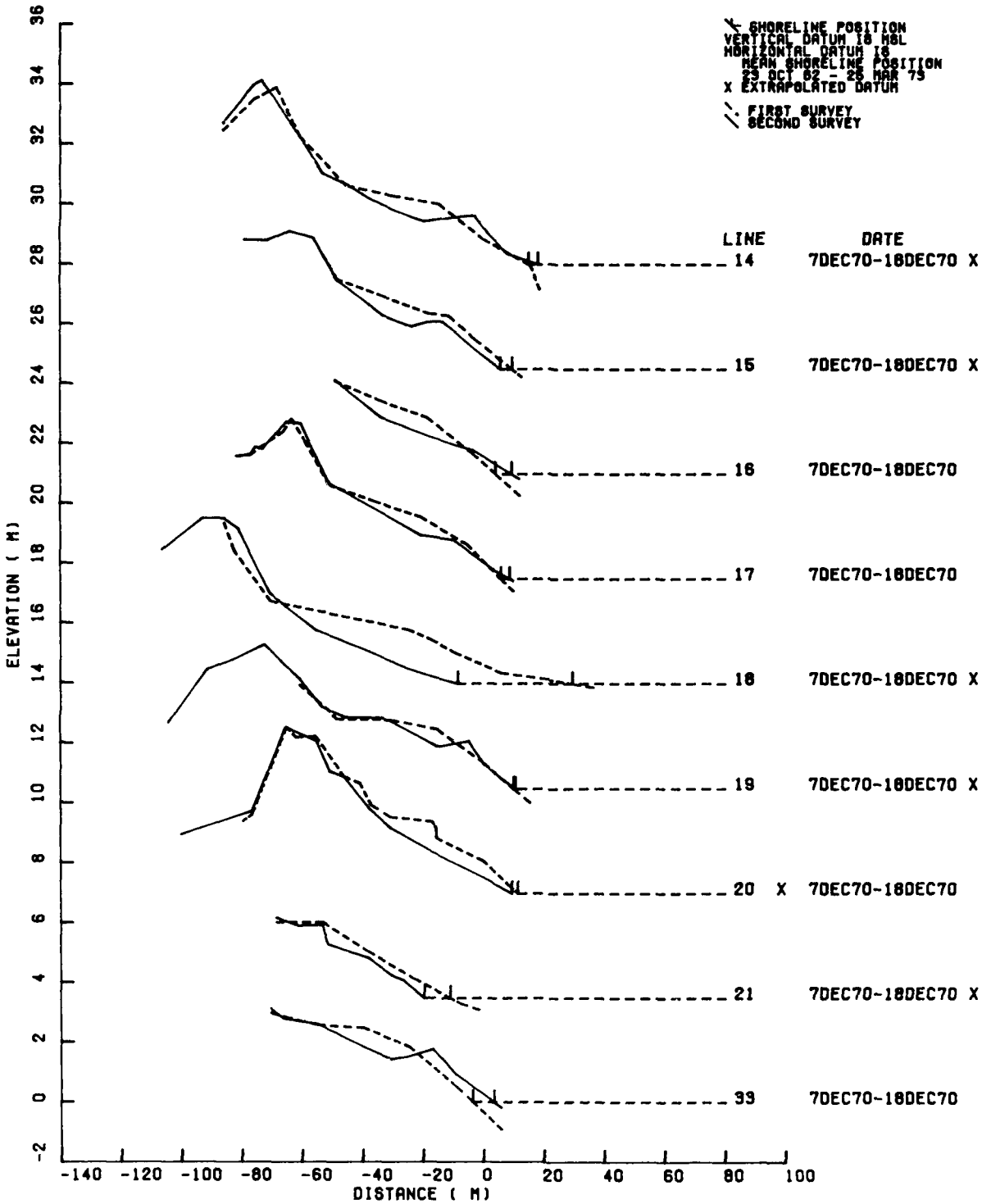



Figure H15. Hindcasted wave data for Long Beach Island, N. J.




a. Profile lines 3-12

Figure H16. Profile comparisons for surveys at Long Beach Island, N. J. (Continued)




b. Profile lines 14-33

Figure H16. (Concluded)

Table H9

Shoreline and Slope Changes at Long Beach Island, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 3 | 7 Dec 70 | 18 Dec 70 | 7.62 | -0.056 | -0.056 | 0.000 |
| 5 | 7 Dec 70 | 18 Dec 70 | 4.73 | -0.033 | -0.046 | -0.013 |
| 6 | 7 Dec 70 | 18 Dec 70 | 8.61 | -0.100 | -0.058 | 0.042 |
| 7 | 7 Dec 70 | 18 Dec 70 | 9.32 | -0.098 | -0.060 | 0.038 |
| 8 | 7 Dec 70 | 18 Dec 70 | -2.54 | -0.024 | -0.048 | -0.024 |
| 9 | 7 Dec 70 | 18 Dec 70 | -3.53 | -0.046 | -0.024 | 0.022 |
| 10 | 7 Dec 70 | 18 Dec 70 | 4.06 | -0.090 | -0.056 | 0.034 |
| 11 | 7 Dec 70 | 18 Dec 70 | 8.81 | -0.122 | -0.072 | 0.050 |
| 14 | 7 Dec 70 | 18 Dec 70 X | 3.08 | -0.056 | -0.036 | 0.020 |
| 15 | 7 Dec 70 | 18 Dec 70 X | -3.88 | -0.082 | -0.080 | 0.002 |
| 16 | 7 Dec 70 | 18 Dec 70 | 5.33 | -0.090 | -0.062 | 0.028 |
| 17 | 7 Dec 70 | 18 Dec 70 | 2.87 | -0.102 | -0.060 | 0.042 |
| 18 | 7 Dec 70 | 18 Dec 70 X | -37.86 | -0.018 | -0.028 | -0.010 |
| 19 | 7 Dec 70 | 18 Dec 70 X | 0.61 | -0.086 | -0.078 | 0.008 |
| 20 | 7 Dec 70 X | 18 Dec 70 | -2.00 | -0.093 | -0.056 | 0.037 |
| 21 | 7 Dec 70 | 18 Dec 70 X | -8.61 | -0.054 | -0.085 | -0.031 |
| 33 | 7 Dec 70 | 18 Dec 70 | 7.05 | -0.096 | -0.074 | 0.022 |
| Median | | | 3.08 | -0.086 | -0.058 | 0.022 |
| Tri-Mean | | | 2.67 | -0.081 | -0.059 | 0.020 |
| High Hinge | | | 7.05 | -0.054 | -0.046 | 0.037 |
| Low Hinge | | | -2.54 | -0.096 | -0.072 | 0.000 |
| Mean | | | 0.22 | -0.073 | -0.056 | 0.016 |
| Standard Deviation | | | 11.11 | 0.031 | 0.019 | 0.025 |

Note: X = Extrapolated shoreline intercept.

Table H10

Unit Volume Changes ($m^3/m$) Between Contours
Long Beach Island, N.J.
from 7 Dec 70 to 18 Dec 70

| Profile Line | Total Changes | | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 11.71 | | 3.71 | 3.30 | 3.00 | -1.22 | 0.07 | 2.10 | 0.70 | 0.21 | -0.30 | 0.12 | 0.02 | | | |
| 5 | -11.35 | | 1.34 | 0.05 | -1.48 | -6.23 | -3.32 | 0.42 | 0.14 | -0.02 | -0.11 | -0.10 | -1.71 | -0.33 | | |
| 6 | -6.82 | | 2.85 | 1.64 | -1.02 | -7.11 | -6.14 | -1.13 | 0.60 | -0.10 | 0.15 | 1.30 | 2.14 | | | |
| 7 | -0.28 | | 3.93 | 3.35 | 3.09 | -3.31 | -4.91 | -0.24 | -1.15 | -0.66 | -0.24 | -0.63 | 0.49 | | | |
| 8 | -9.83 | | -1.48 | -3.85 | -4.18 | -2.00 | -1.33 | -0.68 | -0.33 | 0.18 | 1.07 | 2.26 | 0.51 | | | |
| 9 | -6.57 | | -2.68 | 1.19 | -0.23 | -1.23 | -0.53 | -0.32 | -0.92 | -0.89 | -0.71 | -0.24 | 0.00 | 0.00 | | |
| 10 | 1.76 | | 1.21 | 0.89 | 1.65 | -0.04 | -1.78 | -0.18 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 11 | -5.76 | | 3.62 | 1.71 | -1.18 | -5.33 | -4.84 | -2.30 | 0.26 | 0.38 | 0.38 | 0.30 | 0.12 | 0.94 | 0.18 | |
| 14 | -8.53 | X | 0.47 | 1.30 | 2.28 | -7.47 | -5.37 | -0.56 | -1.61 | -0.82 | -0.15 | 0.63 | 0.77 | 1.80 | 0.20 | |
| 15 | -21.92 | X | -1.98 | -1.99 | -2.11 | -8.54 | -5.30 | -1.96 | -0.05 | 0.02 | 0.00 | 0.00 | | | | |
| 16 | -14.02 | | 2.04 | 0.49 | -3.43 | -6.58 | -4.82 | -1.70 | -0.02 | | | | | | | |
| 17 | -9.61 | | 0.60 | -0.52 | -2.00 | -5.16 | -4.15 | -1.39 | 0.23 | 0.36 | 0.65 | 1.17 | 0.60 | | | |
| 18 | -57.14 | X | -15.78 | -13.85 | -14.51 | -14.71 | -7.33 | 0.28 | 1.14 | 1.68 | 2.22 | 2.28 | 1.45 | 0.00 | | |
| 19 | -3.17 | X | 0.16 | -0.01 | 0.95 | -4.55 | -0.32 | 0.03 | 0.48 | 0.10 | 0.00 | 0.00 | | | | |
| 20 | -27.61 | X | -1.88 | -3.88 | -5.39 | -5.08 | -7.04 | -0.98 | -0.93 | -0.87 | -1.29 | -0.68 | 0.40 | 0.00 | | |
| 21 | -14.69 | X | -3.47 | -2.53 | -2.14 | -3.93 | -2.61 | 0.00 | | | | | | | | |
| 33 | -4.55 | | 3.14 | 2.50 | 2.65 | -5.37 | -6.88 | -0.72 | 0.13 | | | | | | | |
| Median | -8.53 | | 0.60 | 0.49 | -1.18 | -5.16 | -4.82 | -0.56 | 0.06 | 0.01 | 0.00 | 0.06 | 0.49 | 0.00 | 0.19 | |
| Tri-mean | -8.91 | | 0.54 | 0.16 | -0.71 | -5.05 | -4.20 | -0.56 | -0.03 | -0.11 | 0.04 | 0.30 | 0.43 | 0.23 | 0.19 | |
| High Hinge | -4.55 | | 2.85 | 1.64 | 1.65 | -3.31 | -1.78 | 0.00 | 0.37 | 0.21 | 0.38 | 1.17 | 0.69 | 0.94 | 0.20 | |
| Low Hinge | -14.02 | | -1.88 | -1.99 | -2.14 | -6.58 | -5.37 | -1.13 | -0.63 | -0.66 | -0.24 | -0.10 | 0.07 | 0.00 | 0.18 | |
| Mean | -11.08 | | -0.25 | -0.60 | -1.41 | -5.17 | -3.92 | -0.55 | -0.08 | -0.03 | 0.12 | 0.46 | 0.44 | 0.40 | 0.19 | |
| Std Dev | 14.83 | | 4.64 | 4.06 | 4.23 | 3.42 | 2.44 | 1.04 | 0.74 | 0.67 | 0.82 | 0.96 | 0.96 | 0.81 | 0.01 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

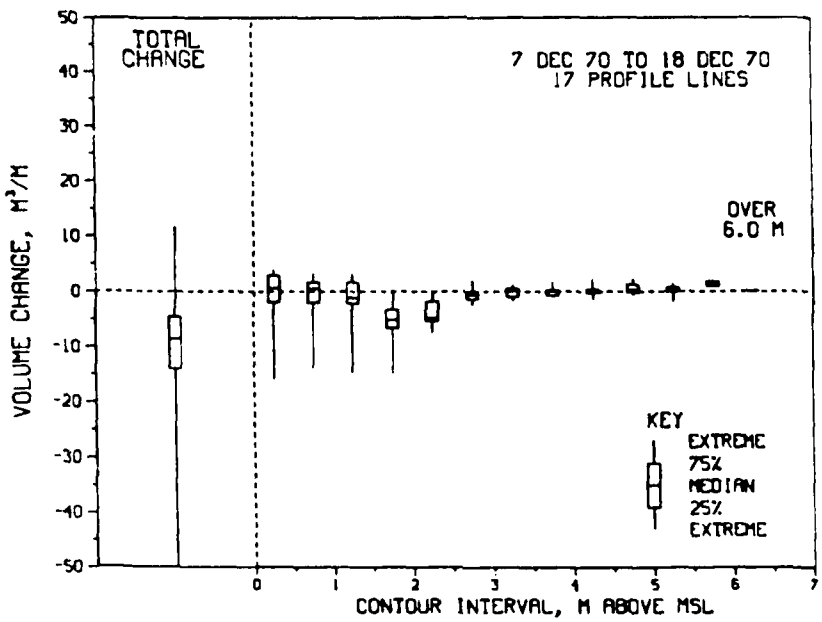



Figure H17. Distribution of volume changes by contour for Long Beach Island, N. J.

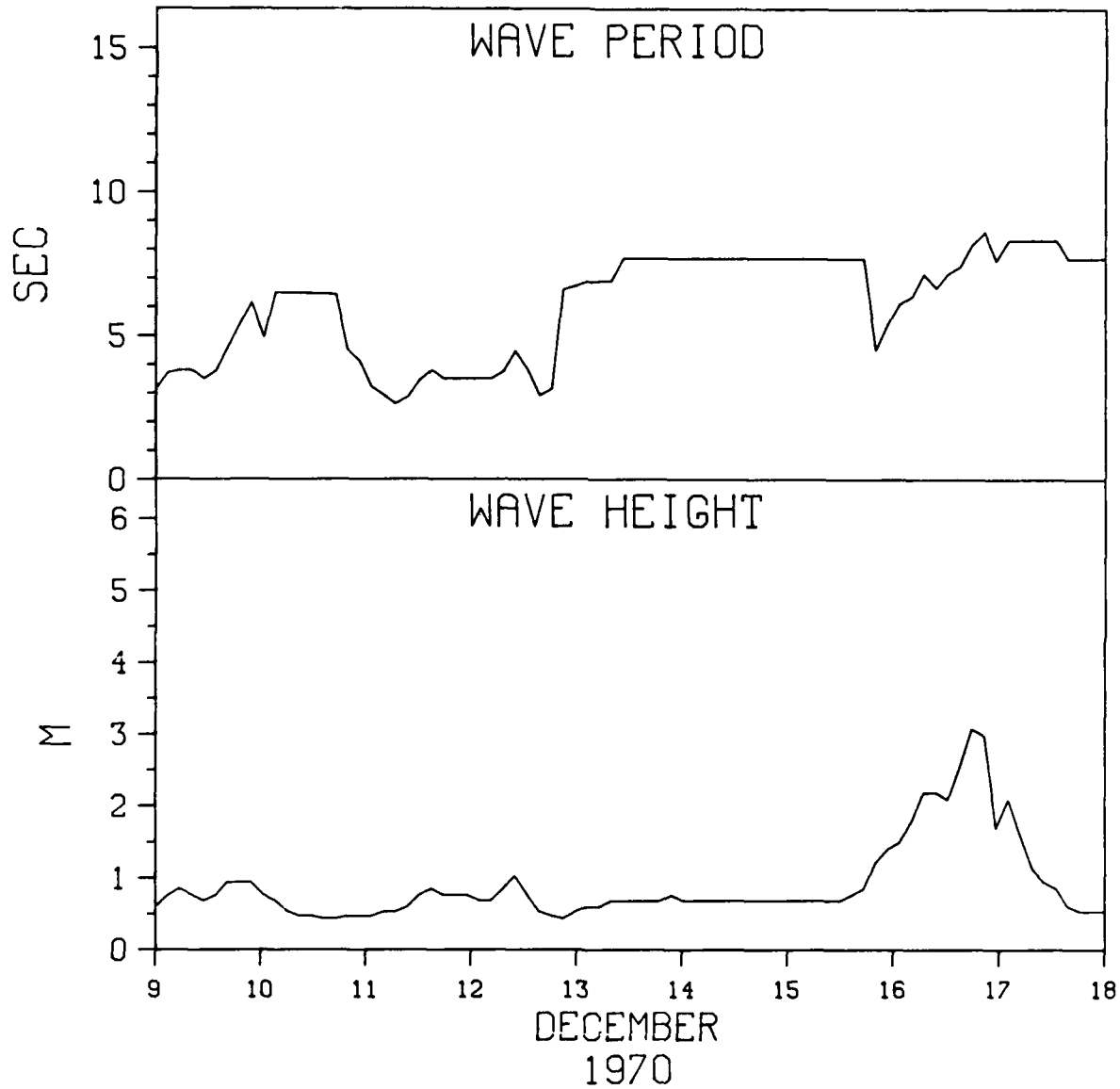



Figure H18. Hindcasted wave data for Atlantic City, N. J.

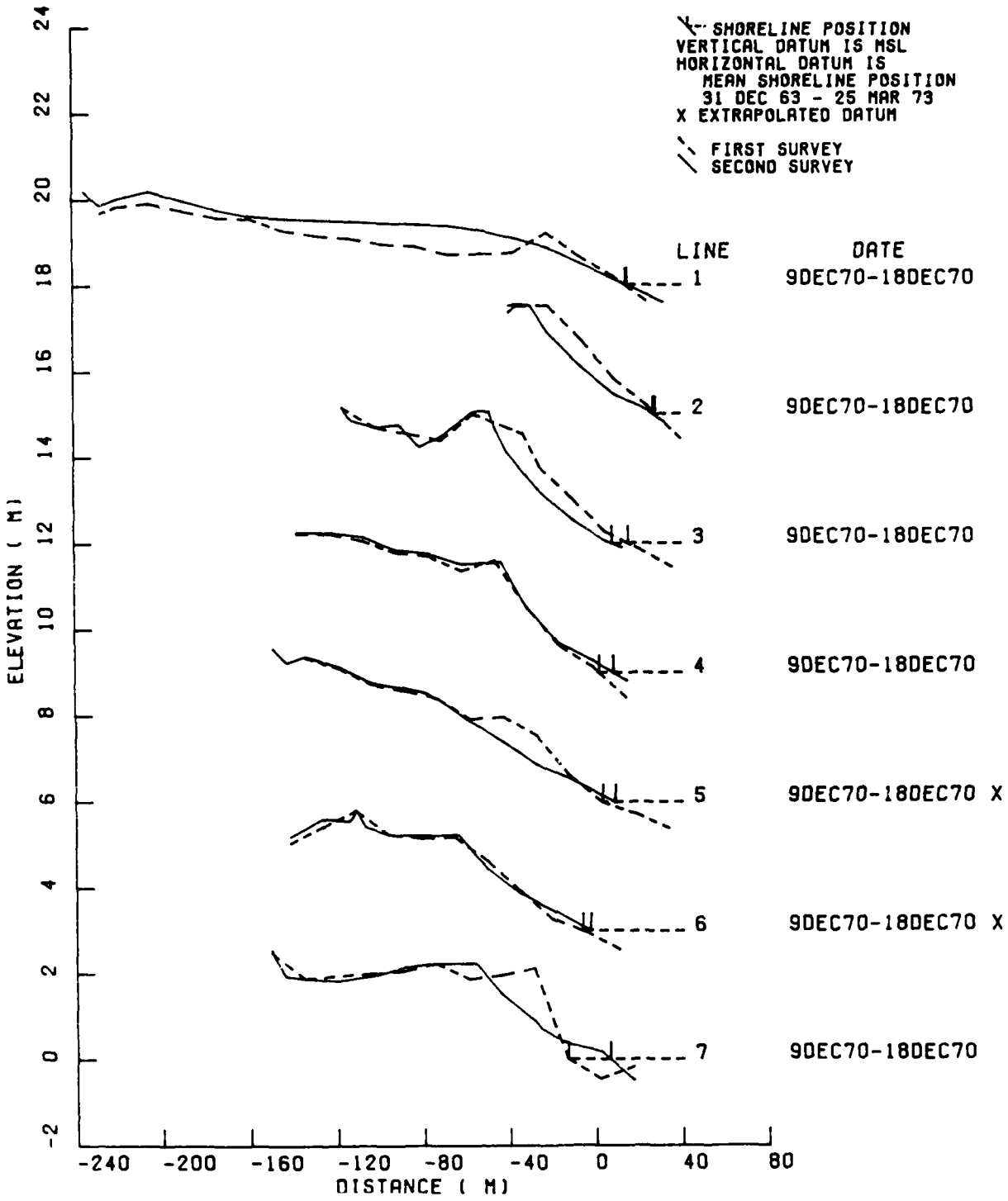



Figure H19. Profile comparisons for surveys at Atlantic City, N. J.

Table H11

Shoreline and Slope Changes at Atlantic City, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 9 Dec 70 | 18 Dec 70 | 0.74 | -0.038 | -0.024 | 0.014 |
| 2 | 9 Dec 70 | 18 Dec 70 | -1.12 | -0.050 | -0.036 | 0.014 |
| 3 | 9 Dec 70 | 18 Dec 70 | -7.50 | -0.026 | -0.020 | 0.006 |
| 4 | 9 Dec 70 | 18 Dec 70 | 6.49 | -0.046 | -0.030 | 0.016 |
| 5 | 9 Dec 70 | 18 Dec 70 X | 5.86 | -0.040 | -0.026 | 0.014 |
| 6 | 9 Dec 70 | 18 Dec 70 X | 3.70 | -0.020 | -0.028 | -0.008 |
| 7 | 9 Dec 70 | 18 Dec 70 | 19.40 | -0.140 | -0.044 | 0.096 |
| Median | | | 3.70 | -0.040 | -0.028 | 0.014 |
| Tri-Mean | | | 3.35 | -0.040 | -0.029 | 0.024 |
| High Hinge | | | 6.18 | -0.032 | -0.025 | 0.056 |
| Low Hinge | | | -0.19 | -0.048 | -0.033 | 0.010 |
| Mean | | | 3.94 | -0.051 | -0.030 | 0.033 |
| Standard Deviation | | | 8.33 | 0.040 | 0.008 | 0.044 |

Note: X = Extrapolated shoreline intercept.

Table H12

Unit Volume Changes ($m^3/m$) Between Contours
Atlantic City, N.J.
from 9 Dec 70 to 18 Dec 70

| Profile Line | Total Changes | | 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | Contours (m) above MSL 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 61.20 | | -1.26 | 8.46 | 38.11 | 12.96 | 2.93 | | | | | | | | | |
| 2 | -23.09 | | -2.48 | -4.47 | -5.51 | -6.04 | -4.82 | 0.23 | | | | | | | | |
| 3 | -27.38 | | -3.86 | -5.14 | -5.59 | -5.11 | -7.15 | -0.91 | 0.38 | | | | | | | |
| 4 | 9.76 | | 2.35 | 0.64 | -0.03 | 0.11 | 1.54 | 3.20 | 1.95 | | | | | | | |
| 5 | -16.87 | X | 1.25 | -3.39 | -7.83 | -9.00 | -0.13 | 1.62 | 0.62 | 0.00 | | | | | | |
| 6 | 3.54 | X | 2.94 | 0.44 | -1.49 | -0.97 | 3.32 | -0.70 | | | | | | | | |
| 7 | -15.60 | | 5.15 | -3.16 | -7.35 | -12.60 | 2.33 | 0.03 | | | | | | | | |
| Median | -15.60 | | 1.25 | -3.16 | -5.51 | -5.11 | 1.54 | 0.13 | 0.62 | 0.00 | | | | | | |
| Tri-mean | -11.13 | | 0.82 | -2.43 | -4.56 | -4.54 | 0.81 | 0.30 | 0.76 | 0.00 | | | | | | |
| High Hinge | 6.65 | | 2.64 | 0.54 | -0.76 | -0.43 | 2.63 | 1.62 | 1.29 | 0.00 | | | | | | |
| Low Hinge | -19.98 | | -1.87 | -3.93 | -6.47 | -7.52 | -2.48 | -0.70 | 0.50 | 0.00 | | | | | | |
| Mean | -1.21 | | 0.58 | -0.95 | 1.47 | -2.95 | -0.28 | 0.58 | 0.98 | 0.00 | | | | | | |
| Std Dev | 30.70 | | 3.23 | 4.72 | 16.41 | 8.27 | 4.11 | 1.56 | 0.85 | 0.00 | | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

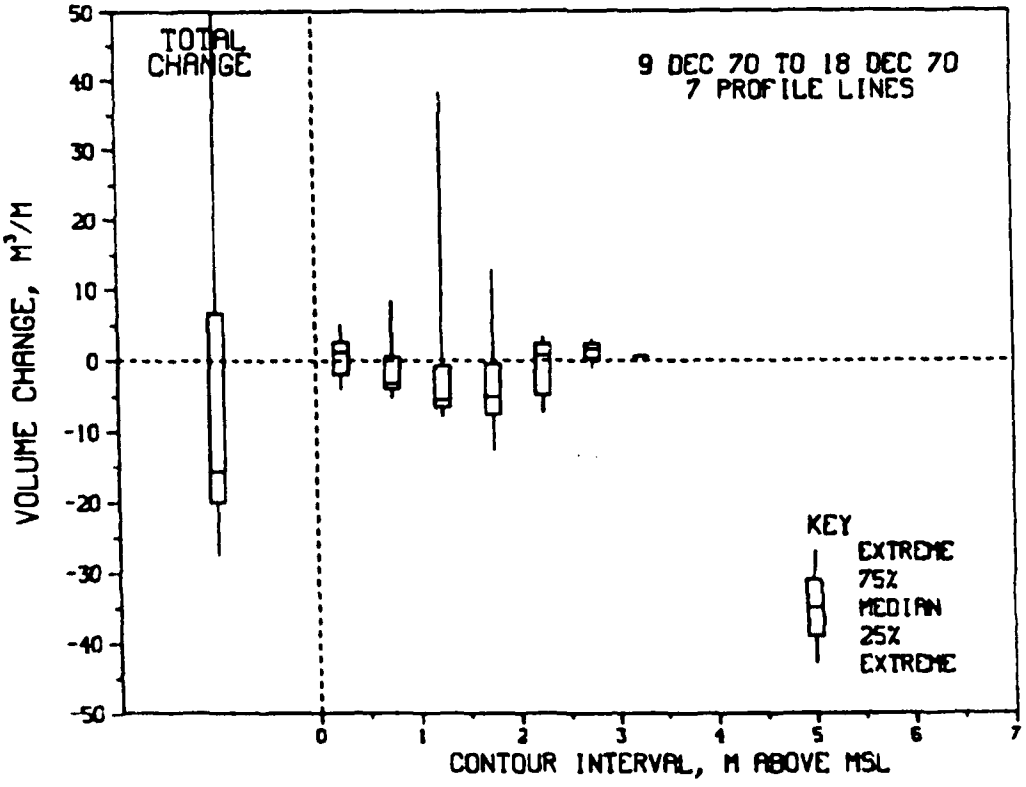



Figure H20. Distribution of volume changes by contour for Atlantic City, N. J.

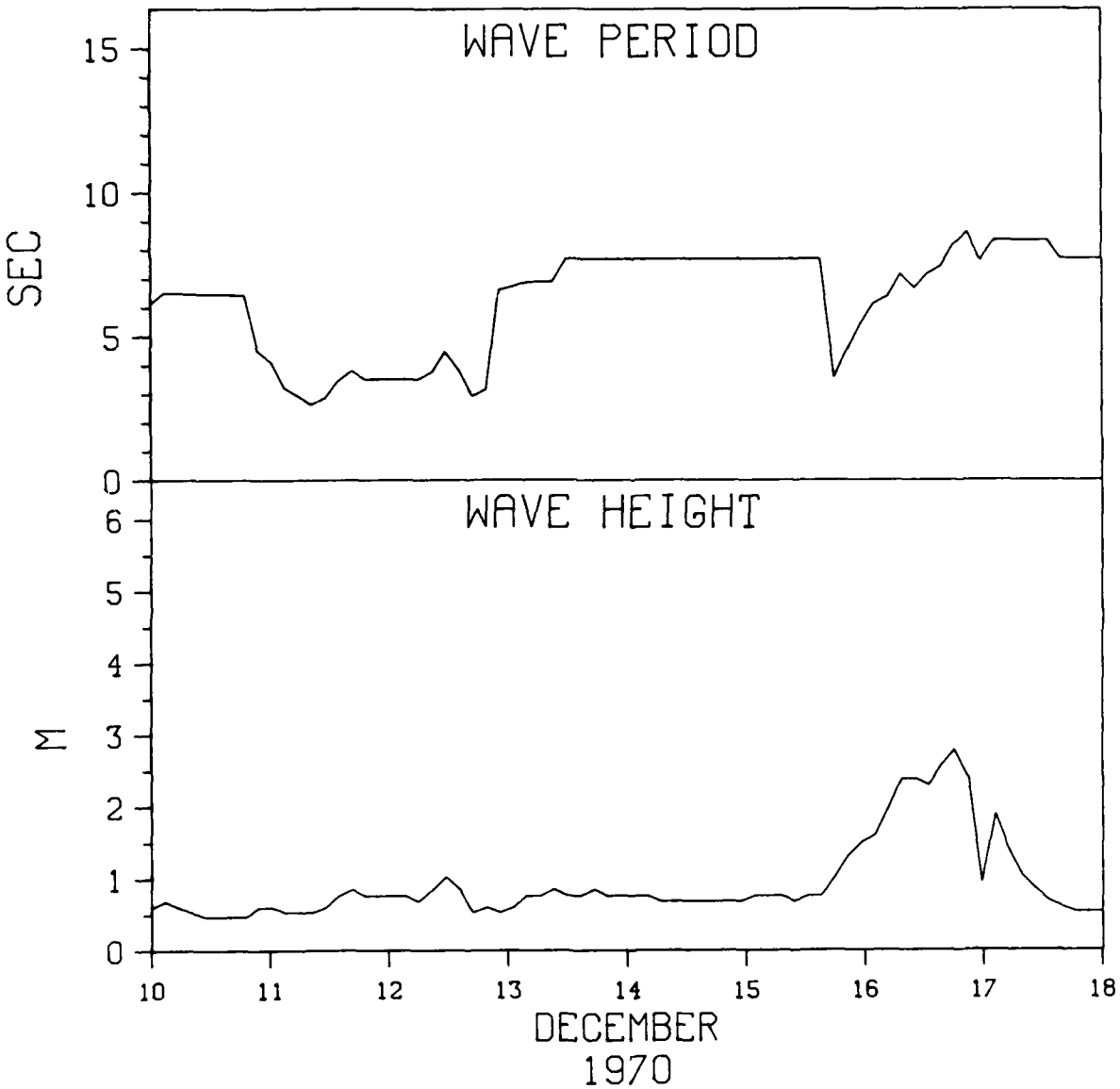
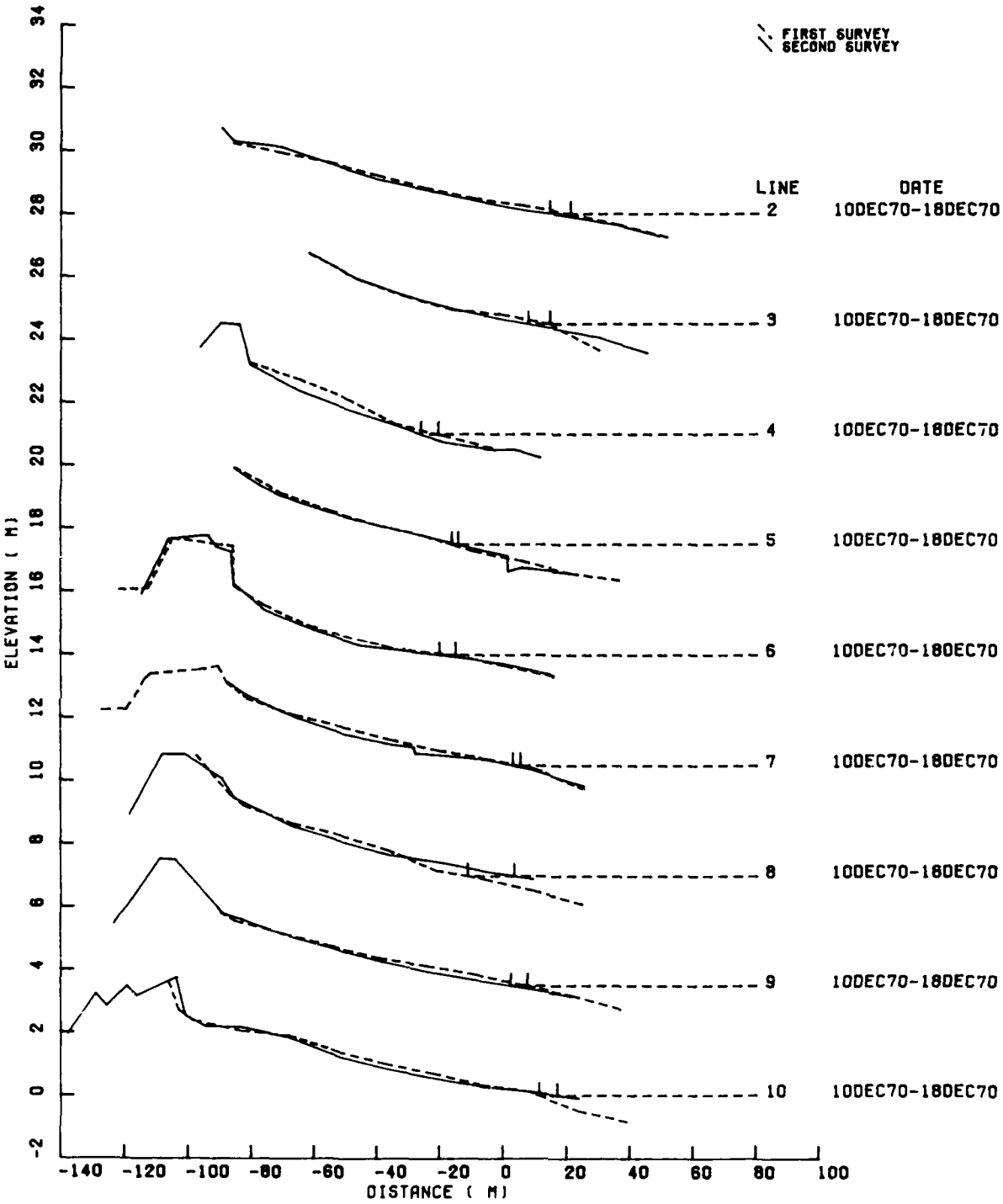
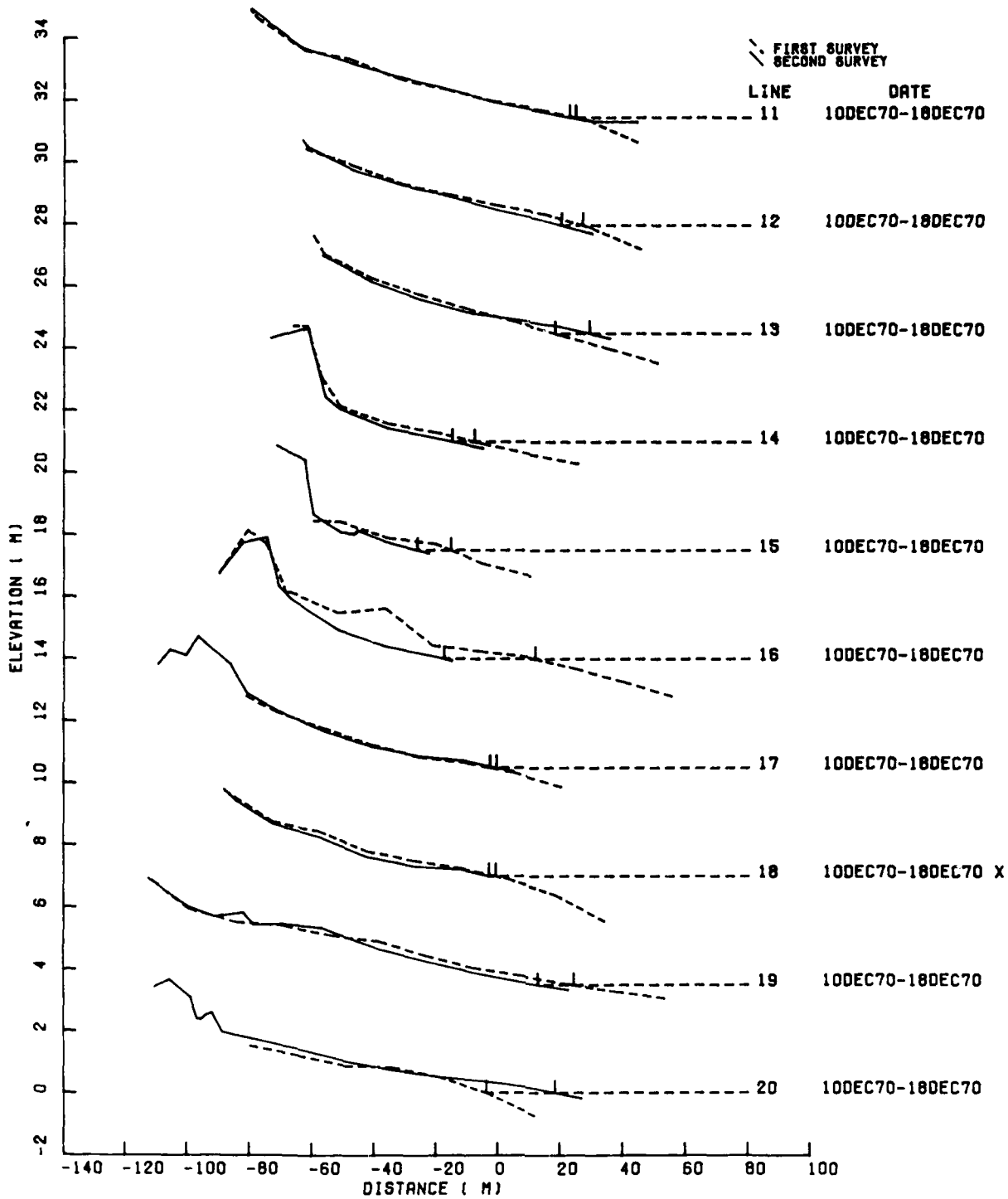



Figure H21. Hindcasted wave data for Ludlam Beach, N. J.




a. Profile lines 2-10

Figure H22. Profile comparisons for surveys at Ludlam Beach, N. J. (Continued)




b. Profile lines 11-20

Figure H22. (Concluded)

Table H13

Shoreline and Slope Changes at Ludlam Beach, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 2 | 10 Dec 70 | 18 Dec 70 | -6.53 | -0.018 | -0.014 | 0.004 |
| 3 | 10 Dec 70 | 18 Dec 70 | -6.77 | -0.020 | -0.018 | 0.002 |
| 4 | 10 Dec 70 | 18 Dec 70 | -5.50 | -0.024 | -0.036 | -0.012 |
| 5 | 10 Dec 70 | 18 Dec 70 | 1.98 | -0.032 | -0.026 | 0.006 |
| 6 | 10 Dec 70 | 18 Dec 70 | -5.08 | -0.010 | -0.012 | -0.002 |
| 7 | 10 Dec 70 | 18 Dec 70 | -2.36 | -0.020 | -0.022 | -0.002 |
| 8 | 10 Dec 70 | 18 Dec 70 | 14.61 | -0.018 | -0.016 | 0.002 |
| 9 | 10 Dec 70 | 18 Dec 70 | -5.20 | -0.022 | -0.016 | 0.006 |
| 10 | 10 Dec 70 | 18 Dec 70 | 5.66 | -0.040 | -0.014 | 0.026 |
| 11 | 10 Dec 70 | 18 Dec 70 | -1.94 | -0.022 | -0.020 | 0.002 |
| 12 | 10 Dec 70 | 18 Dec 70 | -6.75 | -0.030 | -0.028 | 0.002 |
| 13 | 10 Dec 70 | 18 Dec 70 | 10.92 | -0.030 | -0.024 | 0.006 |
| 14 | 10 Dec 70 | 18 Dec 70 | -7.16 | -0.024 | -0.022 | 0.002 |
| 15 | 10 Dec 70 | 18 Dec 70 | -10.79 | -0.042 | -0.026 | 0.016 |
| 16 | 10 Dec 70 | 18 Dec 70 | -29.36 | -0.024 | -0.025 | -0.001 |
| 17 | 10 Dec 70 | 18 Dec 70 | 2.08 | -0.020 | -0.022 | -0.002 |
| 18 | 10 Dec 70 | 18 Dec 70 X | -2.19 | -0.022 | -0.024 | -0.002 |
| 19 | 10 Dec 70 | 18 Dec 70 | -11.43 | -0.016 | -0.016 | 0.000 |
| 20 | 10 Dec 70 | 18 Dec 70 | 22.17 | -0.034 | -0.022 | 0.012 |
| Median | | | -5.08 | -0.022 | -0.020 | 0.006 |
| Tri-Mean | | | -3.72 | -0.023 | -0.020 | 0.010 |
| High Hinge | | | 2.03 | -0.017 | -0.014 | 0.026 |
| Low Hinge | | | -6.76 | -0.030 | -0.025 | 0.001 |
| Mean | | | -2.30 | -0.023 | -0.020 | 0.011 |
| Standard Deviation | | | 10.94 | 0.010 | 0.007 | 0.013 |

Note: X = Extrapolated shoreline intercept.

Table H14

Unit Volume Changes ($m^3/m$) Between Contours
Ludlam Beach, N.J.
from 10 Dec 70 to 18 Dec 70

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | -3.65 | -3.30 | -1.50 | -1.73 | 1.02 | 1.86 | 0.00 | | | | | | | | |
| 3 | -1.80 | -2.58 | 0.51 | 0.15 | 0.05 | 0.07 | | | | | | | | | |
| 4 | -12.56 | -1.39 | -2.86 | -4.38 | -3.26 | -0.66 | 0.00 | 0.00 | 0.00 | | | | | | |
| 5 | -2.86 | 0.27 | -0.39 | -1.06 | -1.13 | -0.55 | | | | | | | | | |
| 6 | -4.08 | -2.88 | -1.68 | -1.34 | -0.45 | 0.57 | 0.43 | -0.37 | 1.64 | | | | | | |
| 7 | -8.38 | -2.76 | -3.28 | -2.87 | -0.18 | 0.64 | 0.08 | 0.00 | | | | | | | |
| 8 | 1.56 | 5.57 | -1.62 | -2.84 | -0.71 | 0.51 | 0.60 | 0.36 | -0.31 | | | | | | |
| 9 | -7.77 | -4.28 | -3.14 | -1.14 | 0.19 | 0.61 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| 10 | -5.21 | -0.97 | -3.51 | -2.59 | -1.01 | 0.54 | 0.66 | 1.15 | 0.52 | | | | | | |
| 11 | -0.02 | -1.21 | 0.15 | 0.67 | -1.22 | 0.27 | 0.65 | 0.67 | | | | | | | |
| 12 | -8.78 | -4.06 | -2.31 | -0.89 | -1.57 | 0.02 | 0.03 | | | | | | | | |
| 13 | -2.67 | 3.58 | -1.83 | -2.20 | -1.38 | -0.79 | -0.06 | 0.00 | | | | | | | |
| 14 | -8.51 | -4.05 | -1.75 | -1.06 | -0.82 | -0.16 | -0.07 | 0.00 | -0.60 | | | | | | |
| 15 | -7.20 | -4.67 | -2.72 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | |
| 16 | -47.22 | -11.37 | -10.70 | -12.50 | -9.67 | -1.15 | -0.48 | -0.29 | -0.84 | -0.22 | | | | | |
| 17 | 0.38 | 1.22 | -0.94 | -0.93 | 0.44 | 0.60 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| 18 | -10.42 | X -2.98 | -3.14 | -2.49 | -1.14 | -0.58 | -0.09 | | | | | | | | |
| 19 | -7.43 | -5.26 | -3.44 | -3.44 | 2.31 | 2.20 | 0.23 | -0.03 | | | | | | | |
| 20 | 13.30 | 7.25 | 0.05 | 4.38 | 1.62 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | |
| Median | -5.21 | -2.76 | -1.83 | -1.34 | -0.71 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| Tri-mean | -5.28 | -2.48 | -2.01 | -1.58 | -0.62 | 0.09 | 0.06 | 0.00 | -0.08 | -0.03 | | | | | |
| High Hinge | -2.24 | -0.35 | -1.22 | -0.91 | 0.12 | 0.59 | 0.23 | 0.00 | 0.00 | 0.00 | | | | | |
| Low Hinge | -8.44 | -4.06 | -3.14 | -2.71 | -1.18 | -0.36 | 0.00 | 0.00 | -0.31 | -0.11 | | | | | |
| Mean | -6.49 | -1.78 | -2.32 | -1.90 | -0.89 | 0.21 | 0.12 | 0.11 | 0.05 | -0.07 | | | | | |
| Std Dev | 11.40 | 4.18 | 2.39 | 3.18 | 2.46 | 0.84 | 0.30 | 0.39 | 0.72 | 0.13 | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

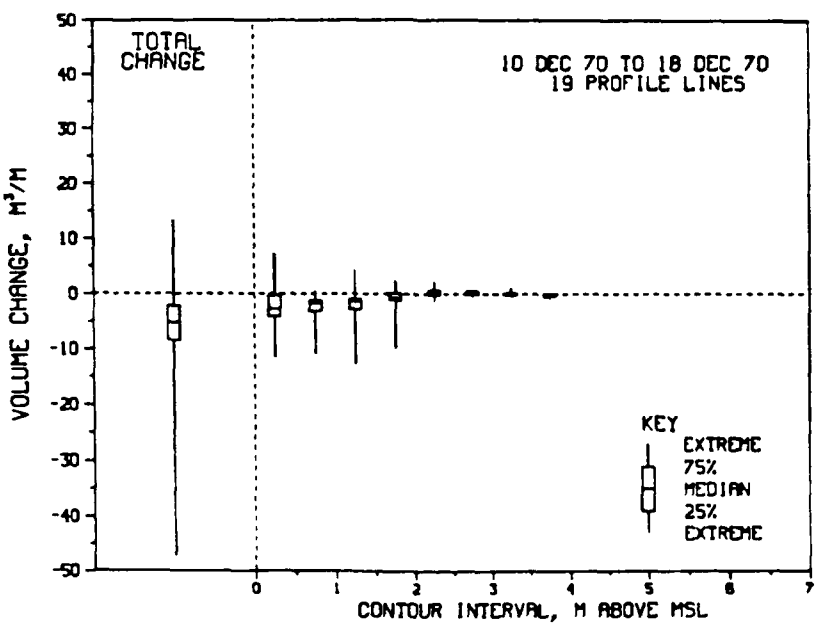


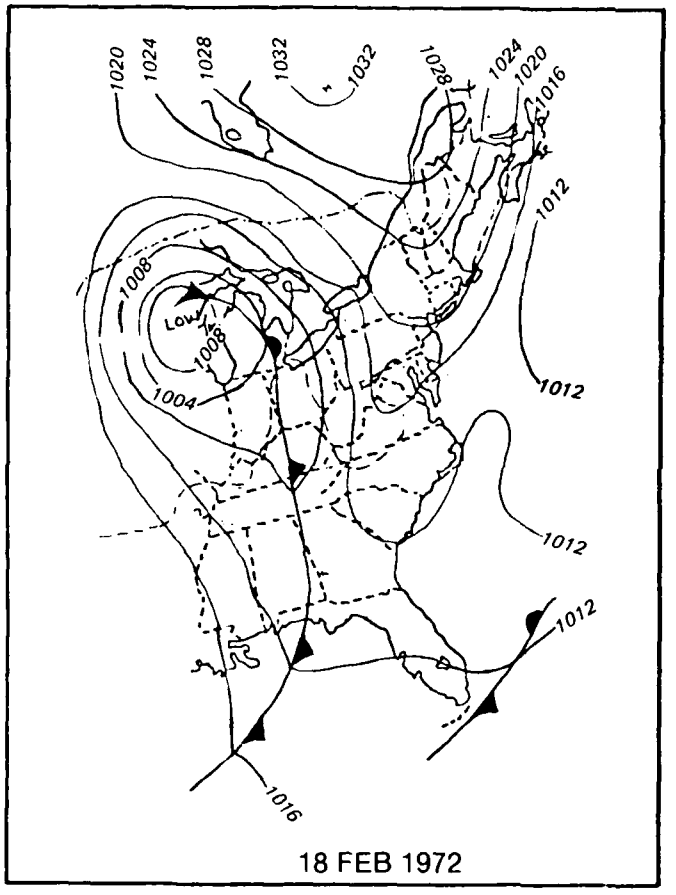

Figure H23. Distribution of volume changes by contour for Ludlam Beach, N. J.

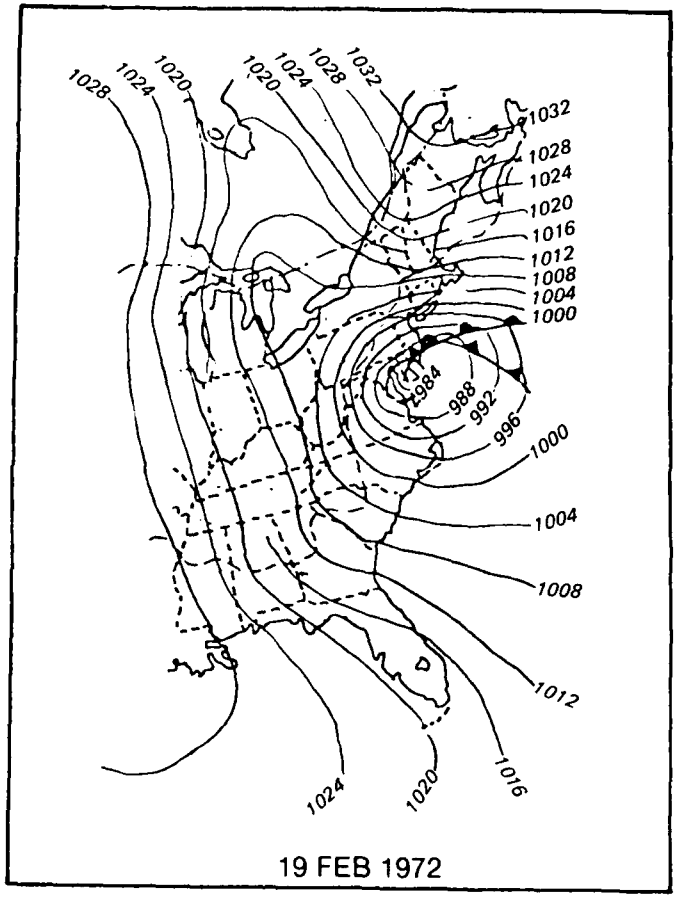
## APPENDIX I: DATA SUMMARY FOR THE STORM OF 19 FEBRUARY 1972

1. This storm was documented at all seven localities. The synoptic weather maps show that the low pressure cell developed over the Great Lakes region, quickly deepened, and migrated in an easterly direction to the coast. Maximum wave heights ranged from 4.3 to 5.1 m and were highest at the northern sites. Peak tide heights ranged from 1.8 m above msl at Atlantic City to 2 m above msl at Sandy Hook with computed storm surges of 1.3 and 1.4 m, respectively. The wave data indicate that a smaller storm on 13 February preceded this event. Poststorm surveys were all completed within 1 week after the storm.

2. This storm caused erosion at all localities, with Nauset Beach and Westhampton experiencing the greatest sediment loss, having median changes of -22.8 $m^3/m$. These were the only two sites which significantly flattened after the storm and which showed the greatest variation with hinge ranges greater than 20 $m^3/m$. The shoreline at Nauset Beach accreted the most with a change of 4.1 m, and Westhampton's shoreline receded -2.2 m. Long Beach Island lost the least amount of sediment with a median change of only -4.0 $m^3/m$. This site was the only one to experience a significant steepening of the foreshore at -0.025. All localities lost sediment high on the beach, up to at least the 3-m contour.

3. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.




a. 18 and 19 February 1972

Figure I1. Synoptic weather maps at 0700 for 18-19 February 1972

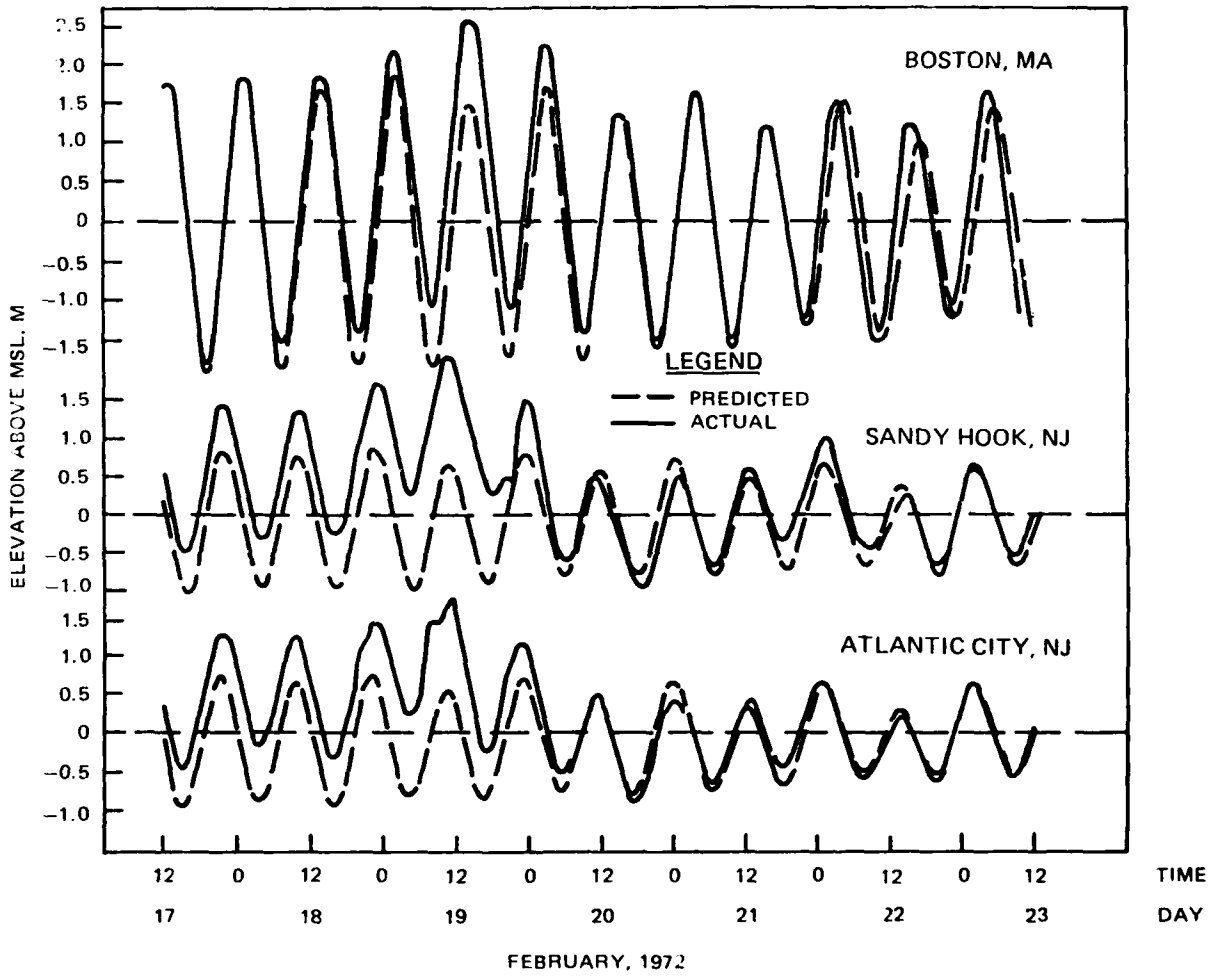



Figure I2. Predicted and actual water levels for 17-23 February 1972

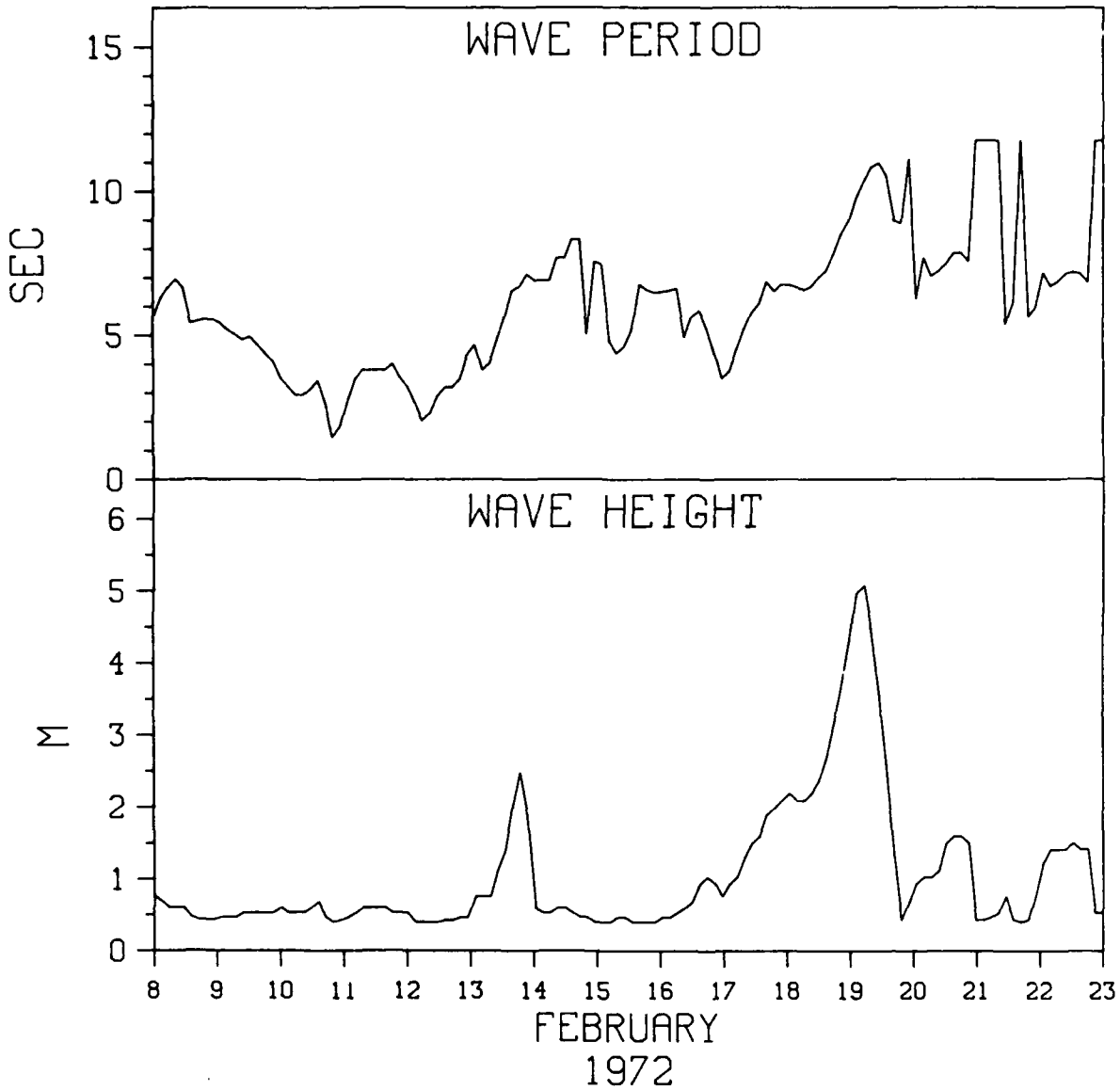



Figure I3. Hindcasted wave data for Nauset Beach, Mass.

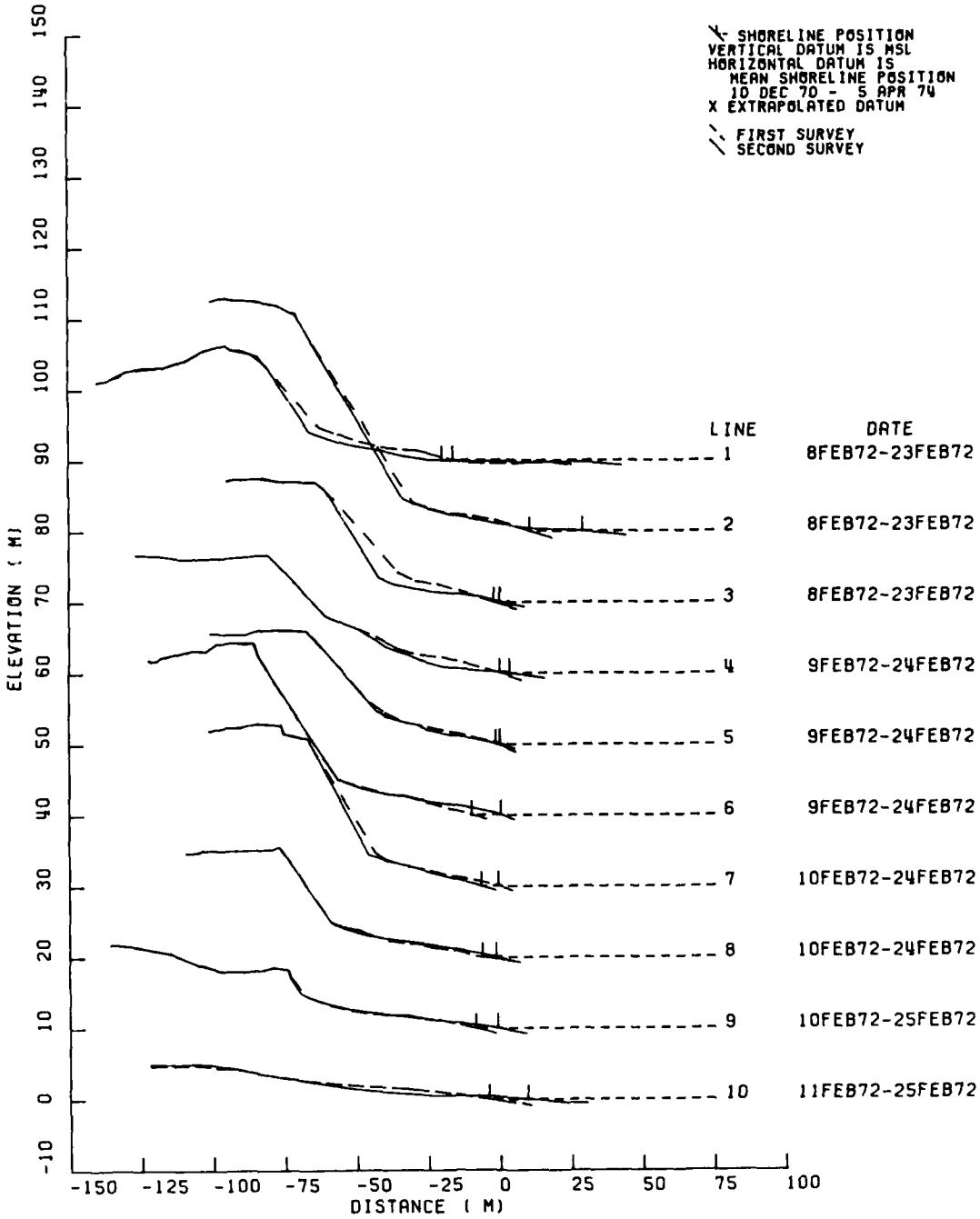



Figure I4. Profile comparisons for surveys for profile lines at Cape Cod, Mass.

Table I1

Shoreline and Slope Changes at Nauset Beach, Mass.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 8 Feb 72 | 23 Feb 72 | -3.78 | -0.130 | -0.016 | 0.114 |
| 2 | 8 Feb 72 | 23 Feb 72 | 18.47 | -0.132 | -0.036 | 0.096 |
| 3 | 8 Feb 72 | 23 Feb 72 | 2.14 | -0.132 | -0.112 | 0.020 |
| 4 | 9 Feb 72 | 24 Feb 72 | 3.48 | -0.116 | -0.052 | 0.064 |
| 5 | 9 Feb 72 | 24 Feb 72 | -1.45 | -0.120 | -0.156 | -0.036 |
| 6 | 9 Feb 72 | 24 Feb 72 | 10.14 | -0.119 | -0.132 | -0.013 |
| 7 | 10 Feb 72 | 24 Feb 72 | -5.92 | -0.120 | -0.124 | -0.004 |
| 8 | 10 Feb 72 | 24 Feb 72 | 4.75 | -0.056 | -0.088 | -0.032 |
| 9 | 10 Feb 72 | 25 Feb 72 | 7.66 | -0.088 | -0.064 | 0.024 |
| 10 | 11 Feb 72 | 25 Feb 72 | 13.59 | -0.060 | -0.032 | 0.028 |
| Median | | | 4.11 | -0.120 | -0.076 | 0.022 |
| Tri-Mean | | | 4.23 | -0.114 | -0.078 | 0.024 |
| High Hinge | | | 10.14 | -0.088 | -0.036 | 0.064 |
| Low Hinge | | | -1.45 | -0.130 | -0.124 | -0.013 |
| Mean | | | 4.91 | -0.107 | -0.081 | 0.026 |
| Standard Deviation | | | 7.73 | 0.029 | 0.048 | 0.051 |

Note: X = Extrapolated shoreline intercept.

Table I2

Unit Volume Changes ($m^3/m$) Between Contours
Nauset Beach, Mass.
from 8 Feb 72 to 23 Feb 72

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -57.87 | -4.69 | -6.06 | -6.22 | -4.05 | -4.00 | -4.22 | -4.05 | -3.88 | -3.26 | -2.27 | -2.00 | -1.87 | -11.28 | |
| 2 | -29.70 | 4.76 | -0.85 | -2.23 | -2.56 | -1.79 | -0.58 | -0.38 | -0.40 | -0.74 | -1.26 | -1.24 | -1.21 | -21.20 | |
| 3 | -80.25 | 0.90 | 0.14 | -3.33 | -6.21 | -7.31 | -6.40 | -5.25 | -4.69 | -3.96 | -3.75 | -3.58 | -3.41 | -33.40 | |
| 4 | -30.96 | -1.38 | -5.42 | -6.25 | -6.00 | -4.58 | -1.91 | -1.45 | -1.48 | -1.28 | -1.08 | -0.90 | -0.47 | 1.23 | |
| 5 | -11.51 | -0.75 | -0.93 | -2.31 | -2.41 | -1.70 | -0.12 | -0.25 | -0.97 | -1.05 | -0.95 | -0.62 | -0.28 | 0.85 | |
| 6 | 15.94 | 5.19 | 4.83 | 3.55 | 1.36 | 0.51 | 0.29 | -0.45 | -0.68 | -0.44 | -0.18 | 0.06 | 0.05 | 1.86 | |
| 7 | -32.21 | -2.79 | -2.55 | -1.76 | -1.37 | -0.73 | 0.31 | -0.26 | -0.71 | -1.33 | -1.38 | -1.32 | -1.27 | -17.04 | |
| 8 | 5.03 | 2.57 | 1.94 | 2.31 | 1.89 | 2.33 | 0.23 | -1.11 | -1.63 | -0.82 | -0.35 | -0.08 | -0.08 | -2.17 | |
| 9 | 3.04 | 3.25 | 1.29 | -0.98 | -0.69 | 1.46 | 0.78 | 0.54 | 0.29 | 0.13 | -0.43 | -0.55 | -0.47 | -1.59 | |
| 10 | -15.96 | 4.35 | -7.56 | -9.30 | -5.95 | -2.19 | -0.84 | -0.40 | 0.00 | 0.69 | 4.87 | 0.37 | | | |
| Median | -22.83 | 1.73 | -0.89 | -2.27 | -2.49 | -1.75 | -0.35 | -0.43 | -0.84 | -0.93 | -1.01 | -0.76 | -0.47 | -2.17 | |
| Tri-mean | -18.71 | 1.61 | -1.48 | -2.93 | -2.90 | -1.75 | -0.58 | -0.64 | -0.93 | -0.91 | -0.94 | -0.73 | -0.62 | -5.13 | |
| High Hinge | 3.04 | 4.35 | 1.29 | -0.98 | -0.69 | 0.51 | 0.29 | -0.28 | -0.40 | -0.44 | -0.35 | -0.08 | -0.28 | 0.85 | |
| Low Hinge | -32.21 | -1.38 | -5.42 | -6.22 | -5.95 | -4.00 | -1.91 | -1.45 | -1.63 | -1.33 | -1.38 | -1.32 | -1.27 | -17.04 | |
| Mean | -23.44 | 1.14 | -1.52 | -2.65 | -2.60 | -1.80 | -1.25 | -1.31 | -1.42 | -1.21 | -0.68 | -0.99 | -1.00 | -9.19 | |
| Std Dev | 29.53 | 3.43 | 3.90 | 3.91 | 2.96 | 2.93 | 2.33 | 1.86 | 1.63 | 1.4[illegible] | 2.22 | 1.16 | 1.10 | 12.42 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

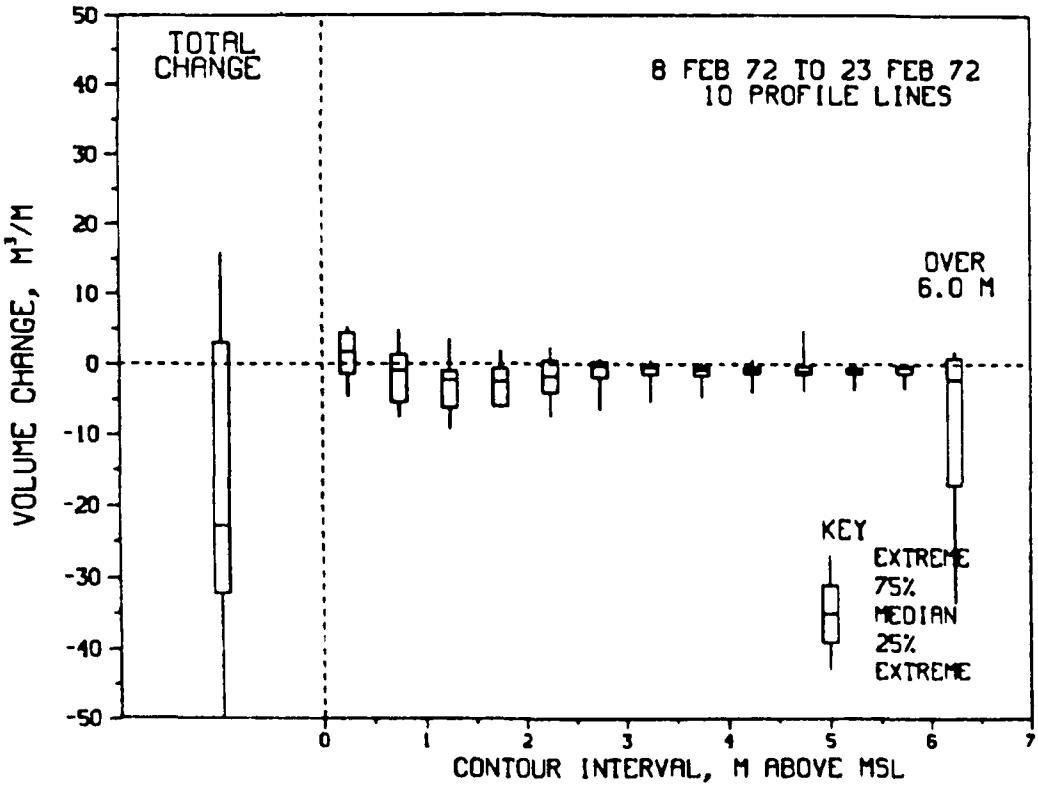



Figure I5. Distribution of volume changes by contour for Nauset Beach, Mass.

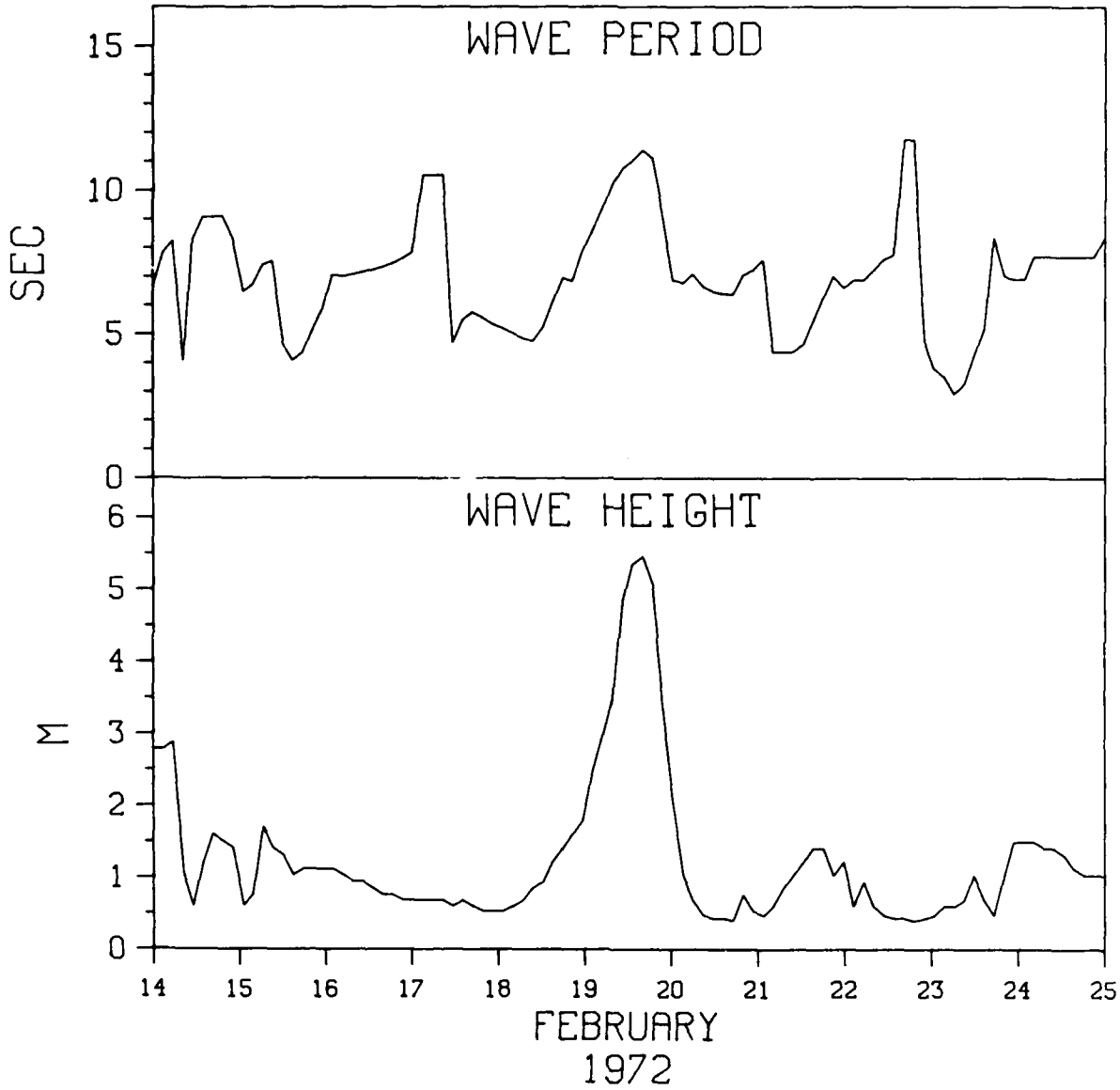



Figure I6. Hindcasted wave data for Misquamicut, R. I.

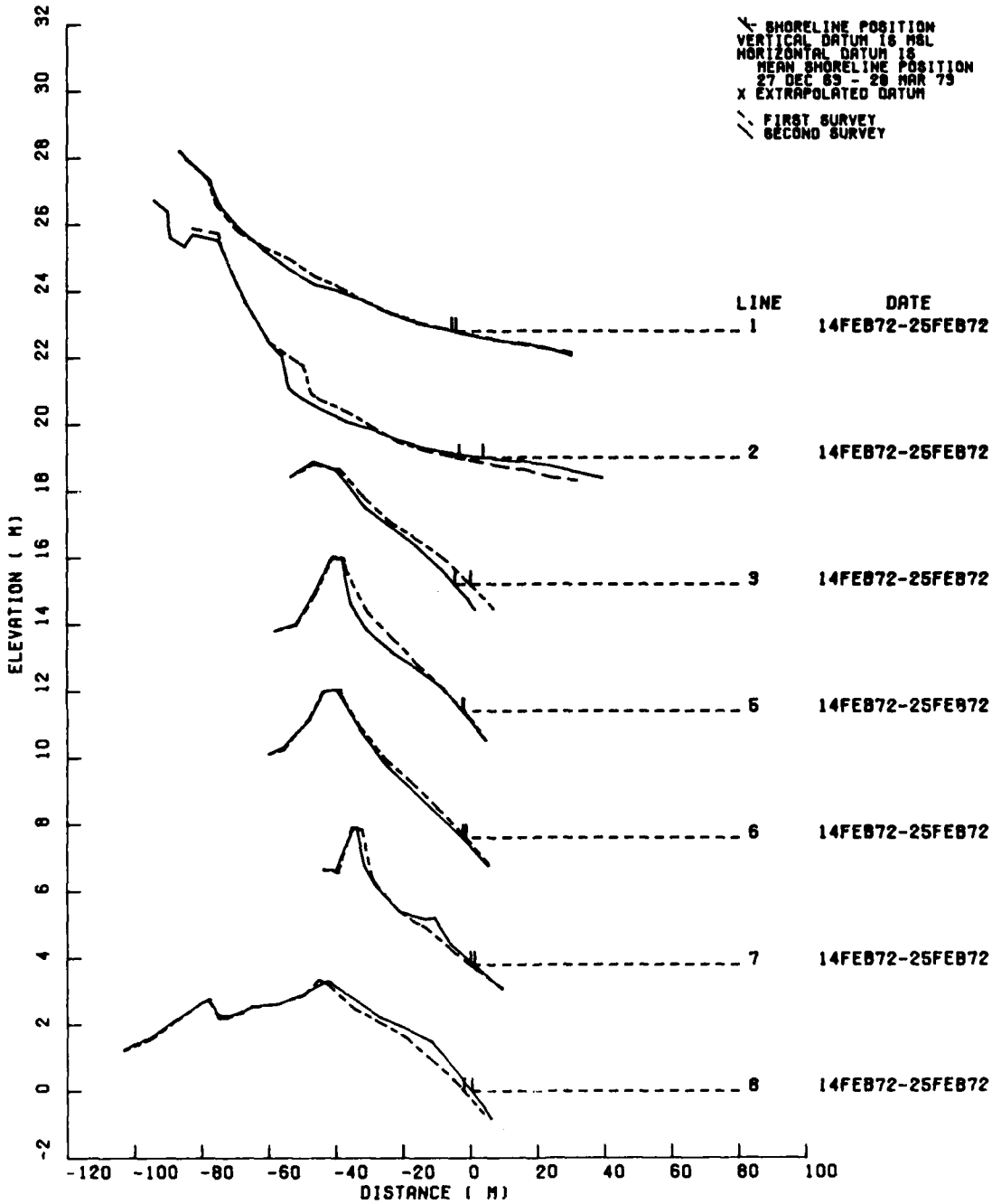



Figure I7. Profile comparisons for surveys at Misquamicut, R. I.

Table I3

Shoreline and Slope Changes at Misquamicut, R.I.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 14 Feb 72 | 25 Feb 72 | -1.27 | -0.024 | -0.024 | 0.000 |
| 2 | 14 Feb 72 | 25 Feb 72 | 7.11 | -0.020 | -0.012 | 0.008 |
| 3 | 14 Feb 72 | 25 Feb 72 | -4.66 | -0.108 | -0.112 | -0.004 |
| 5 | 14 Feb 72 | 25 Feb 72 | -0.34 | -0.108 | -0.120 | -0.012 |
| 6 | 14 Feb 72 | 25 Feb 72 | -1.02 | -0.120 | -0.096 | 0.024 |
| 7 | 14 Feb 72 | 25 Feb 72 | 1.21 | -0.080 | -0.088 | -0.008 |
| 8 | 14 Feb 72 | 25 Feb 72 | 2.36 | -0.120 | -0.132 | -0.012 |
| Median | | | -0.34 | -0.108 | -0.096 | -0.004 |
| Tri-Mean | | | -0.01 | -0.096 | -0.091 | -0.004 |
| High Hinge | | | 1.78 | -0.052 | -0.056 | 0.004 |
| Low Hinge | | | -1.14 | -0.114 | -0.116 | -0.010 |
| Mean | | | 0.49 | -0.083 | -0.083 | -0.001 |
| Standard Deviation | | | 3.66 | 0.044 | 0.047 | 0.013 |

Note: X = Extrapolated shoreline intercept.

Table I4

Unit Volume Changes ($m^3/m$) Between Contours
Misquamicut Beach, R.I.
from 14 Feb 72 to 25 Feb 72

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -4.54 | -0.53 | -0.19 | -1.65 | -2.18 | -1.59 | 0.06 | 0.51 | 0.45 | 0.34 | 0.16 | 0.08 | | | |
| 2 | -11.51 | 1.65 | -0.39 | -2.78 | -2.53 | -[illegible].00 | -2.54 | -0.55 | 0.02 | 0.05 | 0.07 | 0.05 | 0.03 | -1.59 | |
| 3 | -9.05 | -2.19 | -2.01 | -1.47 | -0.99 | -[illegible].24 | -0.91 | -0.55 | 0.31 | | | | | | |
| 5 | -9.81 | -0.05 | -0.04 | -0.81 | -1.92 | -2.43 | -1.92 | -1.48 | -0.84 | -0.16 | -0.16 | | | | |
| 6 | -5.64 | -0.68 | -0.89 | -1.02 | -1.06 | -0.74 | -0.25 | -0.39 | -0.33 | -0.28 | | | | | |
| 7 | 2.48 | 0.75 | 1.26 | 2.44 | 0.02 | -0.19 | -0.22 | -0.60 | -0.82 | -0.16 | | | | | |
| 8 | 13.55 | 1.36 | 2.04 | 3.00 | 2.88 | 2.20 | 2.02 | 0.05 | | | | | | | |
| Median | -5.64 | -0.05 | -0.19 | -1.02 | -1.06 | -1.24 | -0.25 | -0.55 | -0.16 | -0.16 | 0.07 | 0.06 | 0.03 | -1.59 | |
| Tri-mean | -5.43 | 0.09 | -0.10 | -0.70 | -1.16 | -1.24 | -0.50 | -0.46 | -0.20 | -0.11 | 0.05 | 0.06 | 0.03 | -1.59 | |
| High Hinge | -1.03 | 1.06 | 0.61 | 0.82 | -0.49 | -0.47 | -0.08 | -0.17 | 0.31 | 0.05 | 0.11 | 0.08 | 0.03 | -1.59 | |
| Low Hinge | -9.43 | -0.61 | -0.64 | -1.56 | -2.05 | -2.01 | -1.41 | -0.58 | -0.82 | -0.16 | -0.04 | 0.05 | 0.03 | -1.59 | |
| Mean | -3.50 | 0.04 | -0.03 | -0.33 | -0.83 | -1.00 | -0.54 | -0.43 | -0.20 | -0.04 | 0.02 | 0.06 | 0.03 | -1.59 | |
| Std Dev | 8.82 | 1.33 | 1.34 | 2.18 | 1.85 | 1.70 | 1.48 | 0.62 | 0.56 | 0.24 | 0.17 | 0.02 | 0.00 | 0.00 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

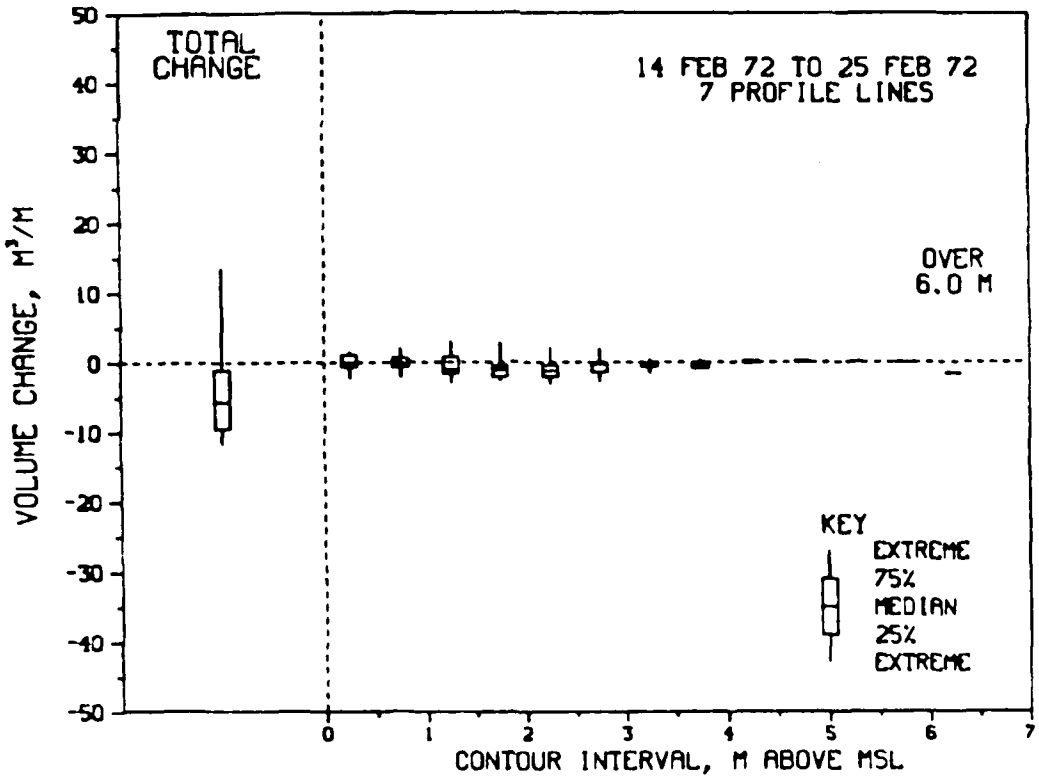



Figure I8. Distribution of volume changes by contour for Misquamicut, R. I.

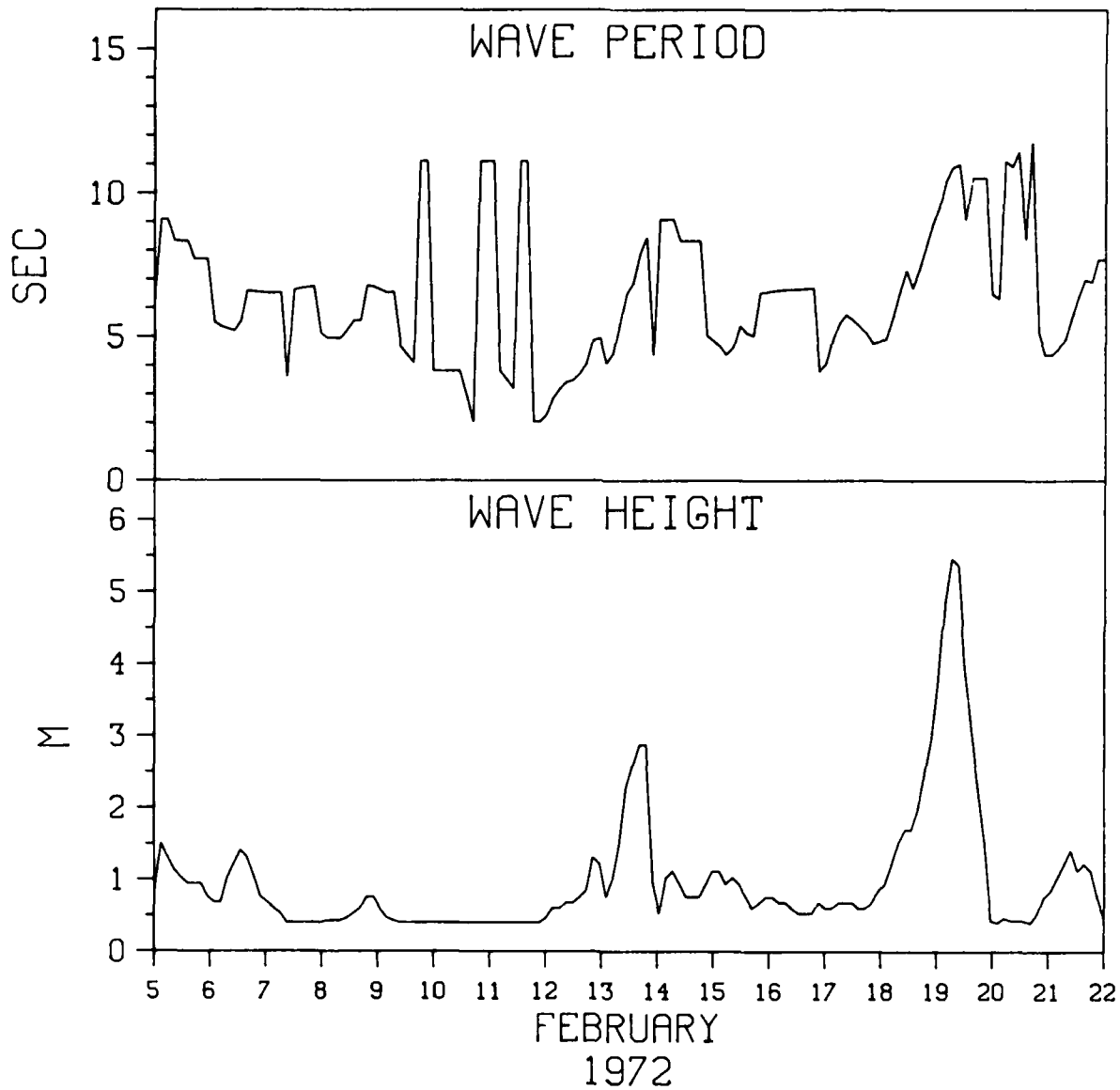



Figure I9. Hindcasted wave data for Westhampton, N. Y.

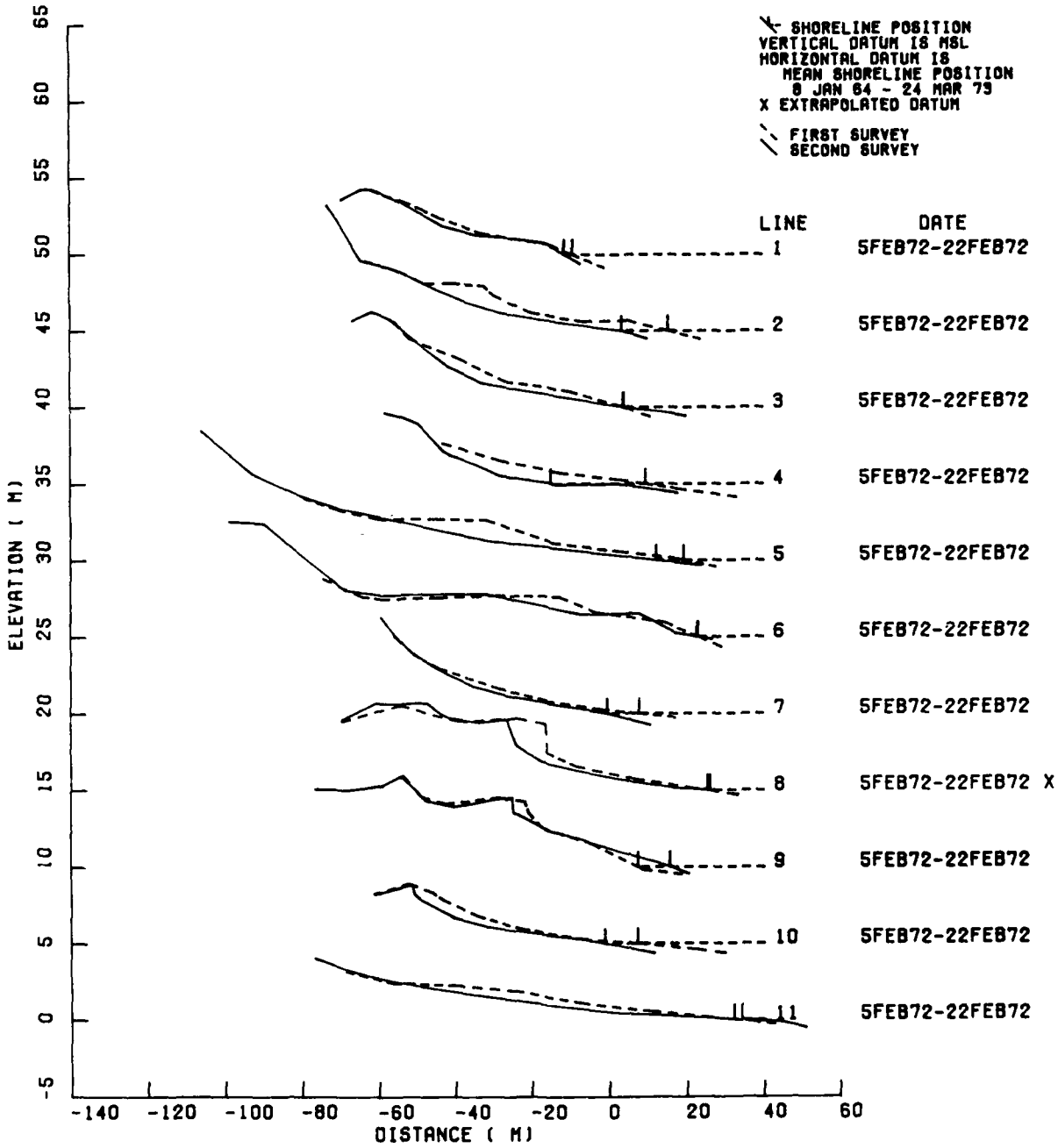



Figure I10. Profile comparisons for surveys at Westhampton, N. Y.

Table I5

Shoreline and Slope Changes at Westhampton, N.Y.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 5 Feb 72 | 22 Feb 72 | -2.18 | 0.104 | -0.143 | -0.039 |
| 2 | 5 Feb 72 | 22 Feb 72 | -11.92 | -0.065 | -0.033 | -0.032 |
| 3 | 5 Feb 72 | 22 Feb 72 | 0.09 | -0.092 | -0.038 | 0.054 |
| 4 | 5 Feb 72 | 22 Feb 72 | -24.38 | -0.040 | -0.040 | 0.000 |
| 5 | 5 Feb 72 | 22 Feb 72 | -7.20 | -0.055 | -0.029 | 0.026 |
| 6 | 5 Feb 72 | 22 Feb 72 | -0.30 | -0.108 | -0.045 | 0.063 |
| 7 | 5 Feb 72 | 22 Feb 72 | -8.08 | -0.029 | -0.041 | -0.013 |
| 8 | 5 Feb 72 | 22 Feb 72 X | -0.44 | -0.038 | -0.017 | 0.021 |
| 9 | 5 Feb 72 | 22 Feb 72 | 8.19 | -0.128 | -0.088 | 0.039 |
| 10 | 5 Feb 72 | 22 Feb 72 | -8.23 | -0.020 | -0.050 | -0.030 |
| 11 | 5 Feb 72 | 22 Feb 72 | 1.69 | -0.026 | -0.014 | -0.011 |
| Median | | | -2.18 | -0.055 | -0.040 | 0.021 |
| Tri-Mean | | | -3.06 | -0.060 | -0.040 | 0.018 |
| High Hinge | | | 0.26 | -0.034 | -0.031 | 0.036 |
| Low Hinge | | | -8.15 | -0.098 | -0.048 | -0.007 |
| Mean | | | -4.72 | -0.064 | -0.049 | -0.015 |
| Standard Deviation | | | 8.67 | 0.038 | 0.037 | 0.033 |

Note: X = Extrapolated shoreline intercept.

Table I6

Unit Volume Changes ($m^3/m$) Between Contours
Westhampton Beach, N.Y.
from 5 Feb 72 to 22 Feb 72

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -8.27 | -0.76 | 0.16 | -1.33 | -2.33 | -1.81 | -1.30 | -0.77 | -0.19 | 0.08 | | | | | |
| 2 | -37.67 | -7.86 | -6.06 | -4.33 | -5.36 | -5.90 | -6.78 | -1.04 | -0.18 | -0.13 | -0.01 | -0.02 | | | |
| 3 | -26.29 | -1.55 | -4.28 | -5.31 | -3.81 | -3.61 | -3.46 | -2.66 | -1.48 | -0.24 | 0.21 | -0.10 | | | |
| 4 | -33.85 | -11.98 | -8.83 | -5.90 | -4.39 | -2.60 | -0.16 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 5 | -40.04 | -4.48 | -5.25 | -7.33 | -9.68 | -11.29 | -3.30 | 0.84 | 0.40 | 0.05 | 0.00 | 0.00 | | | |
| 6 | -5.57 | -1.28 | -1.24 | 1.40 | -4.19 | -6.01 | 4.90 | 0.02 | 0.75 | 0.09 | 0.00 | 0.00 | | | |
| 7 | -13.25 | -2.93 | -2.12 | -2.65 | -2.50 | -1.87 | -0.87 | -0.26 | -0.12 | -0.06 | 0.09 | 0.04 | | | |
| 8 | -22.81 | X -2.13 | -2.62 | -2.67 | -2.89 | -2.82 | -3.47 | -4.15 | -4.46 | -4.51 | 1.35 | 5.56 | | | |
| 9 | -1.13 | 3.59 | 2.11 | 0.77 | 0.23 | -0.16 | -0.39 | -1.37 | -2.06 | -3.77 | 0.02 | -0.10 | | | |
| 10 | -21.11 | -1.66 | -2.17 | -3.65 | -3.64 | -3.24 | -2.96 | -2.74 | -1.05 | | | | | | |
| 11 | -27.59 | -3.29 | -6.36 | -6.78 | -8.30 | -3.88 | 0.68 | 0.35 | 0.00 | 0.00 | | | | | |
| Median | -22.81 | -2.13 | -2.62 | -3.65 | -3.81 | -3.24 | -1.30 | -0.77 | -0.18 | -0.03 | 0.01 | 0.00 | | | |
| Tri-mean | -21.77 | -2.39 | -3.14 | -3.72 | -3.80 | -3.40 | -1.56 | -0.89 | -0.41 | -0.06 | 0.04 | -0.01 | | | |
| High Hinge | -10.76 | -1.41 | -1.68 | -1.99 | -2.70 | -2.23 | -0.27 | 0.01 | 0.00 | 0.05 | 0.15 | 0.02 | | | |
| Low Hinge | -30.72 | -3.88 | -5.65 | -5.61 | -4.88 | -4.89 | -3.38 | -2.02 | -1.26 | -0.24 | 0.00 | -0.06 | | | |
| Mean | -21.60 | -3.12 | -3.33 | -3.43 | -4.26 | -3.93 | -1.56 | -1.07 | -0.76 | -0.85 | 0.21 | 0.77 | | | |
| Std Dev | 13.16 | 4.03 | 3.18 | 2.89 | 2.76 | 2.98 | 3.00 | 1.54 | 1.48 | 1.74 | 0.47 | 2.11 | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

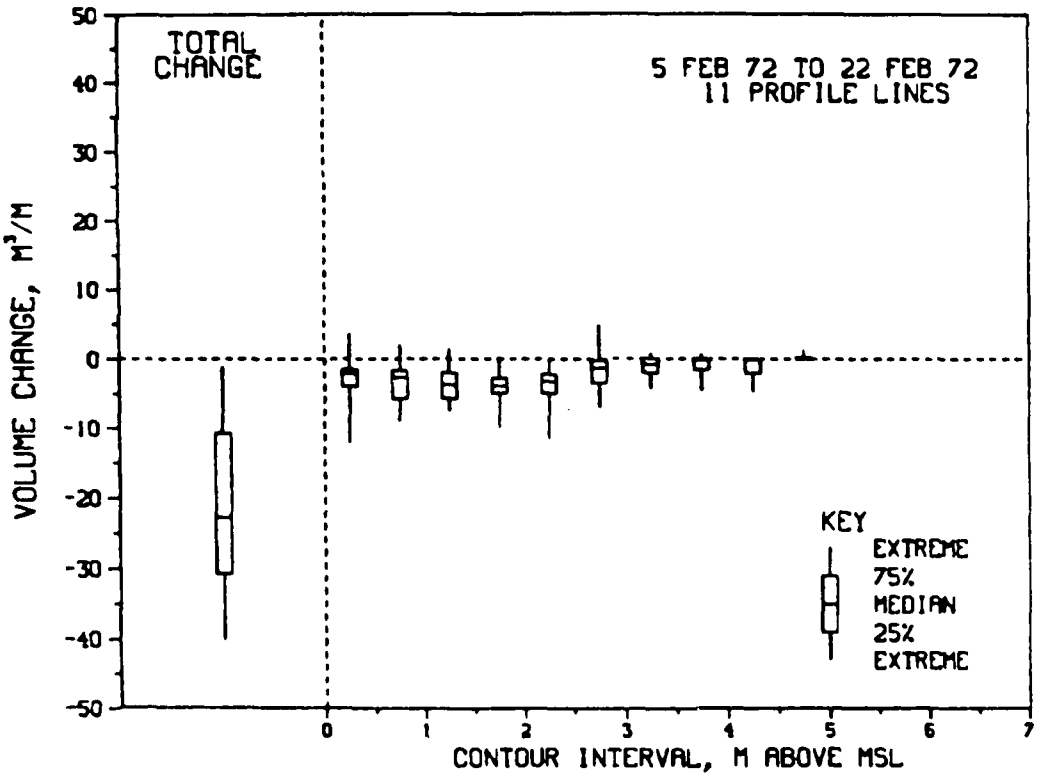



Figure I11. Distribution of volume changes by contour for Westhampton, N. Y.

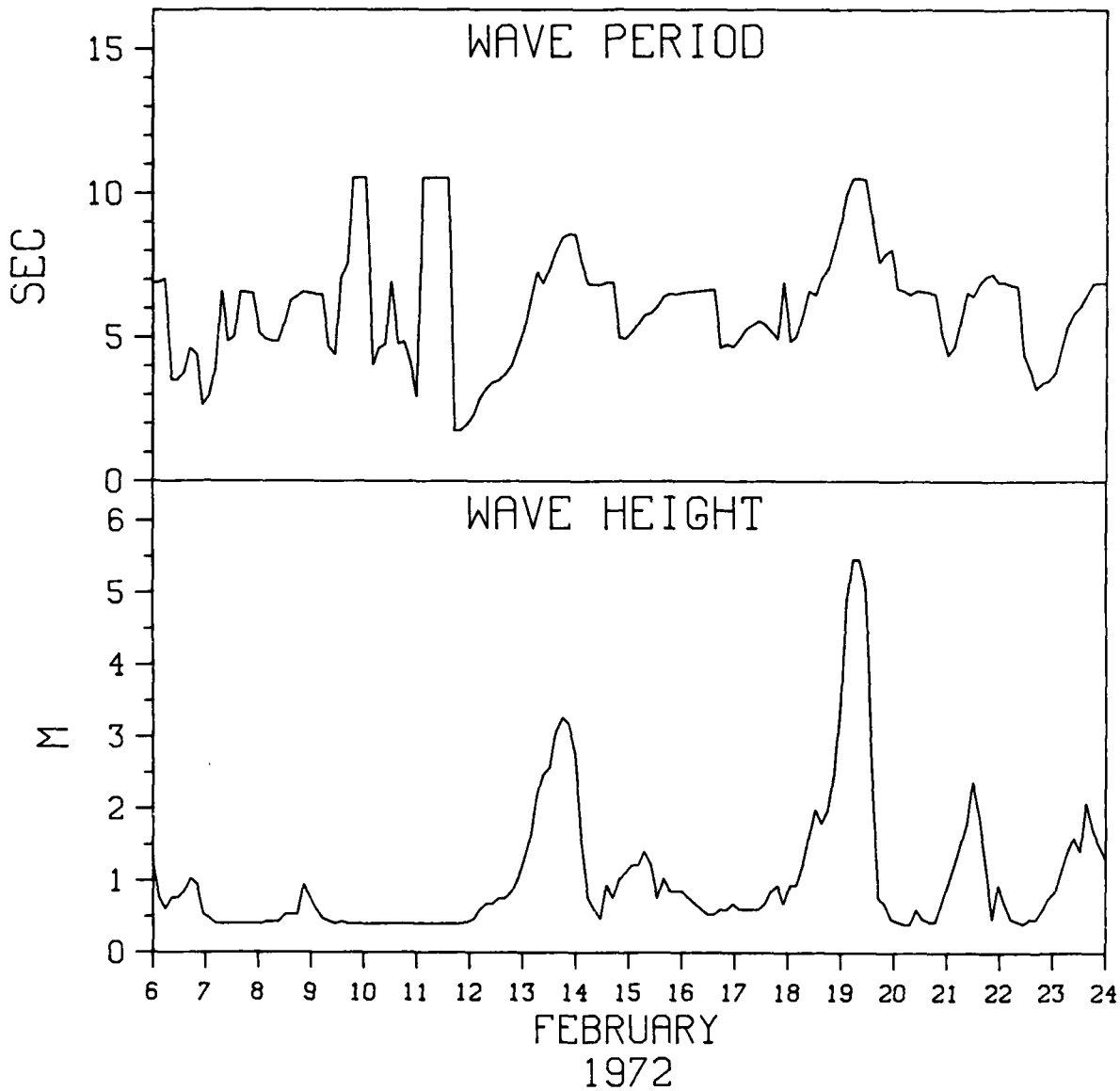



Figure I12. Hindcasted wave data for Jones Beach, N. Y.

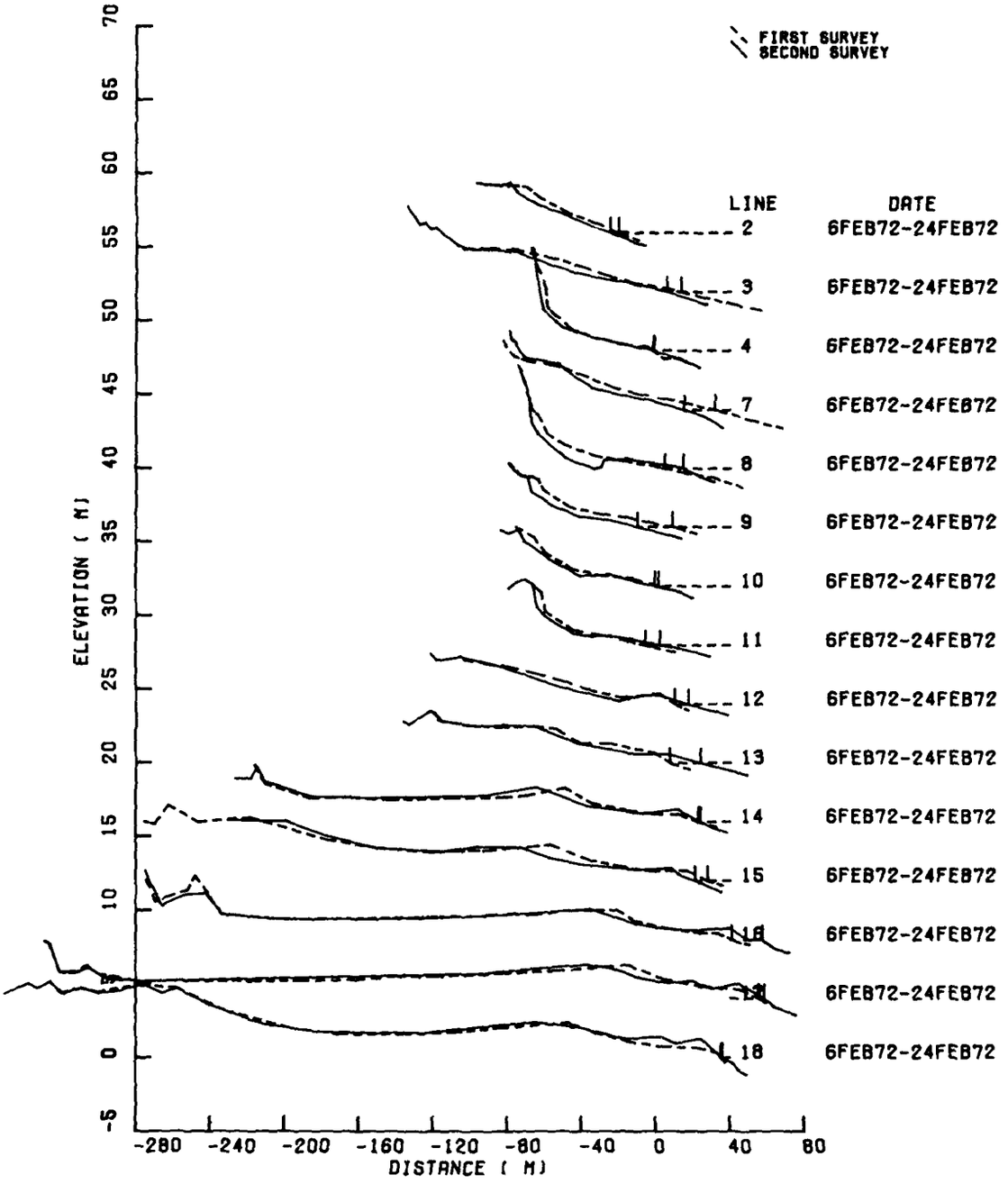



Figure I13. Profile comparisons for surveys at Jones Beach, N. Y.

Table I7

Shoreline and Slope Changes at Jones Beach, N.Y.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 2 | 6 Feb 72 | 24 Feb 72 | -4.59 | -0.054 | -0.047 | 0.007 |
| 3 | 6 Feb 72 | 24 Feb 72 | -7.59 | -0.030 | -0.037 | -0.007 |
| 4 | 6 Feb 72 | 24 Feb 72 | 0.32 | -0.090 | -0.040 | 0.050 |
| 7 | 6 Feb 72 | 24 Feb 72 | -16.57 | -0.030 | -0.034 | -0.004 |
| 8 | 6 Feb 72 | 24 Feb 72 | 10.16 | -0.028 | -0.062 | -0.034 |
| 9 | 6 Feb 72 | 24 Feb 72 | -18.73 | -0.026 | -0.033 | -0.007 |
| 10 | 6 Feb 72 | 24 Feb 72 | -2.05 | -0.038 | -0.030 | 0.008 |
| 11 | 6 Feb 72 | 24 Feb 72 | 7.72 | -0.030 | -0.027 | 0.003 |
| 12 | 6 Feb 72 | 24 Feb 72 | 7.13 | -0.087 | -0.038 | 0.049 |
| 13 | 6 Feb 72 | 24 Feb 72 | 16.46 | -0.083 | -0.035 | 0.048 |
| 14 | 6 Feb 72 | 24 Feb 72 | 1.30 | -0.048 | -0.069 | -0.020 |
| 15 | 6 Feb 72 | 24 Feb 72 | -6.83 | -0.063 | -0.046 | 0.017 |
| 16 | 6 Feb 72 | 24 Feb 72 | 16.72 | -0.060 | -0.092 | -0.032 |
| 17 | 6 Feb 72 | 24 Feb 72 | 3.23 | -0.068 | -0.110 | -0.043 |
| 18 | 6 Feb 72 | 24 Feb 72 | 0.67 | -0.154 | -0.074 | 0.080 |
| Median | | | 0.67 | -0.054 | -0.040 | 0.003 |
| Tri-Mean | | | 0.77 | -0.053 | -0.045 | 0.006 |
| High Hinge | | | 7.43 | -0.030 | -0.035 | 0.033 |
| Low Hinge | | | -5.71 | -0.076 | -0.066 | -0.014 |
| Mean | | | 0.49 | -0.059 | -0.052 | 0.008 |
| Standard Deviation | | | 10.45 | 0.035 | 0.025 | 0.036 |

Note: X=Extrapolated Shoreline Intercept.

Table I8

Unit Volume Changes ($m^3/m$) Between Contours
Jones Beach, N.Y.
from 6 Feb 72 to 24 Feb 72

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | -20.29 | -2.67 | -2.95 | -2.39 | -3.51 | -3.95 | -4.19 | -0.63 | | | | | | | |
| 3 | -27.73 | -2.97 | -3.28 | -5.77 | -6.52 | -5.14 | -4.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | |
| 4 | -14.07 | -0.93 | 0.02 | -0.95 | -1.91 | -1.75 | -1.63 | -1.25 | -1.51 | -1.64 | -1.37 | -1.00 | -0.51 | 0.35 | |
| 7 | -18.18 | -7.65 | -6.05 | -6.16 | -4.61 | -2.78 | 0.04 | 3.60 | 2.66 | 2.12 | 0.60 | 0.05 | | | |
| 8 | -28.10 | -0.15 | -9.05 | -6.09 | -3.54 | -2.77 | -2.59 | -2.52 | -1.48 | -0.36 | 0.01 | 0.15 | 0.26 | 0.06 | |
| 9 | -36.19 | -8.68 | -9.13 | -4.80 | -3.94 | -3.75 | -3.06 | -2.20 | -0.41 | -0.22 | | | | | |
| 10 | -16.21 | -1.83 | -2.46 | -1.80 | -1.81 | -1.46 | -2.46 | -3.15 | -1.24 | | | | | | |
| 11 | -9.96 | 3.48 | -3.00 | -1.84 | -1.96 | -1.48 | -2.02 | -1.93 | -1.16 | -0.05 | | | | | |
| 12 | -18.98 | -1.16 | -5.26 | -5.52 | -4.86 | -3.27 | 0.75 | 0.34 | | | | | | | |
| 13 | -8.69 | 6.01 | -5.67 | -5.57 | -2.35 | -1.20 | 0.08 | 0.02 | 0.00 | | | | | | |
| 14 | 14.5[illegible] | 1.62 | 0.78 | -3.78 | 11.36 | 3.47 | 0.80 | 0.38 | -0.10 | | | | | | |
| 15 | -11.35 | -4.04 | -1.58 | -8.31 | -8.76 | -0.03 | 3.47 | 4.05 | 5.57 | -1.72 | 0.00 | 0.00 | | | |
| 16 | -13.70 | 5.74 | 4.33 | -5.50 | -8.66 | -0.16 | -2.80 | -4.55 | -2.08 | -0.03 | 0.00 | | | | |
| 17 | 27.68 | 1.92 | 4.61 | 13.38 | 5.19 | 1.97 | 0.15 | 0.30 | 0.16 | | | | | | |
| 18 | 19.05 | 0.30 | 9.96 | 10.08 | 9.33 | 1.02 | -2.07 | -0.67 | -0.96 | -2.61 | -5.29 | -0.04 | | | |
| Median | -14.07 | -0.93 | -2.95 | -4.80 | -3.51 | -1.48 | -2.02 | -0.63 | -0.41 | -0.22 | 0.00 | 0.00 | 0.00 | 0.20 | |
| Tri-mean | -14.27 | -0.73 | -2.74 | -4.27 | -3.40 | -1.52 | -1.65 | -0.75 | -0.51 | -0.53 | -0.17 | 0.00 | -0.03 | 0.20 | |
| High Hinge | -9.32 | 1.77 | 0.40 | -1.82 | -1.86 | -0.09 | 0.12 | 0.32 | 0.00 | -0.03 | 0.00 | 0.05 | 0.13 | 0.35 | |
| Low Hinge | -19.64 | -2.82 | -5.47 | -5.67 | -4.74 | -3.03 | -2.69 | -2.07 | -1.24 | -1.64 | -0.69 | -0.04 | -0.25 | 0.06 | |
| Mean | -10.81 | -0.73 | -1.92 | -2.33 | -1.77 | -1.42 | -1.31 | -0.55 | -0.04 | -0.50 | -0.86 | -0.14 | -0.08 | 0.20 | |
| Std Dev | 17.95 | 4.24 | 5.23 | 6.09 | 5.93 | 2.36 | 2.12 | 2.29 | 2.06 | 1.36 | 2.04 | 0.43 | 0.39 | 0.21 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

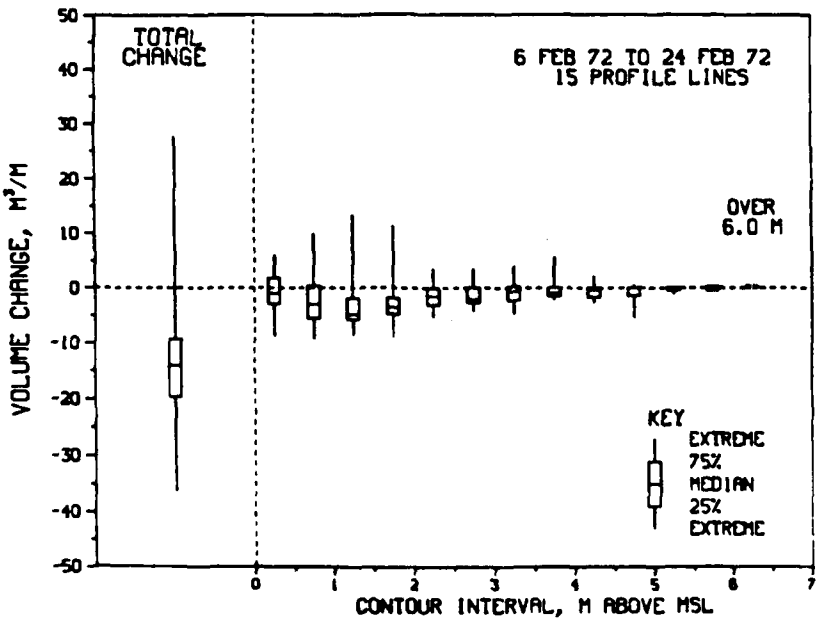



Figure I14. Distribution of volume changes by contour for Jones Beach, N. Y.

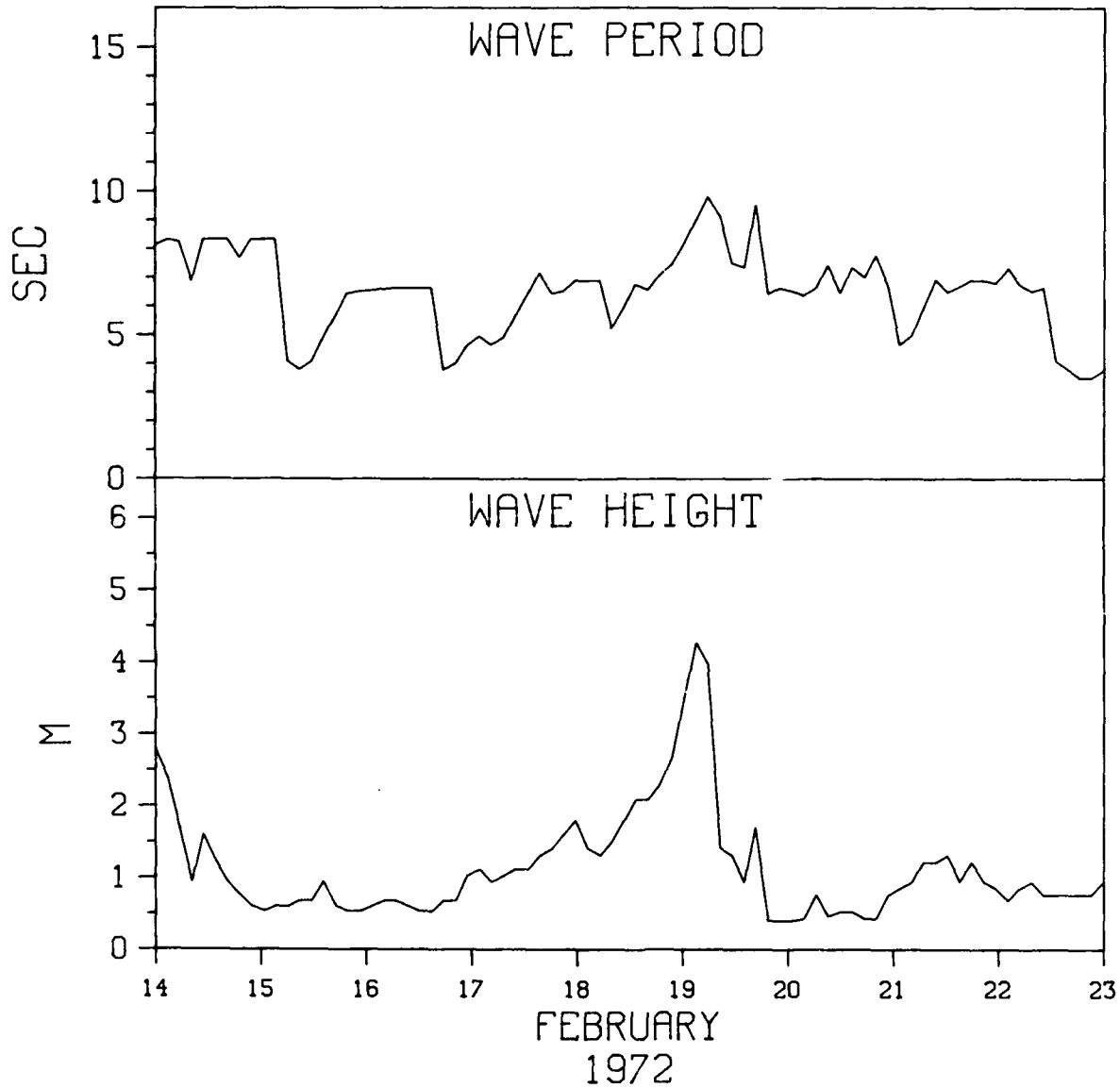
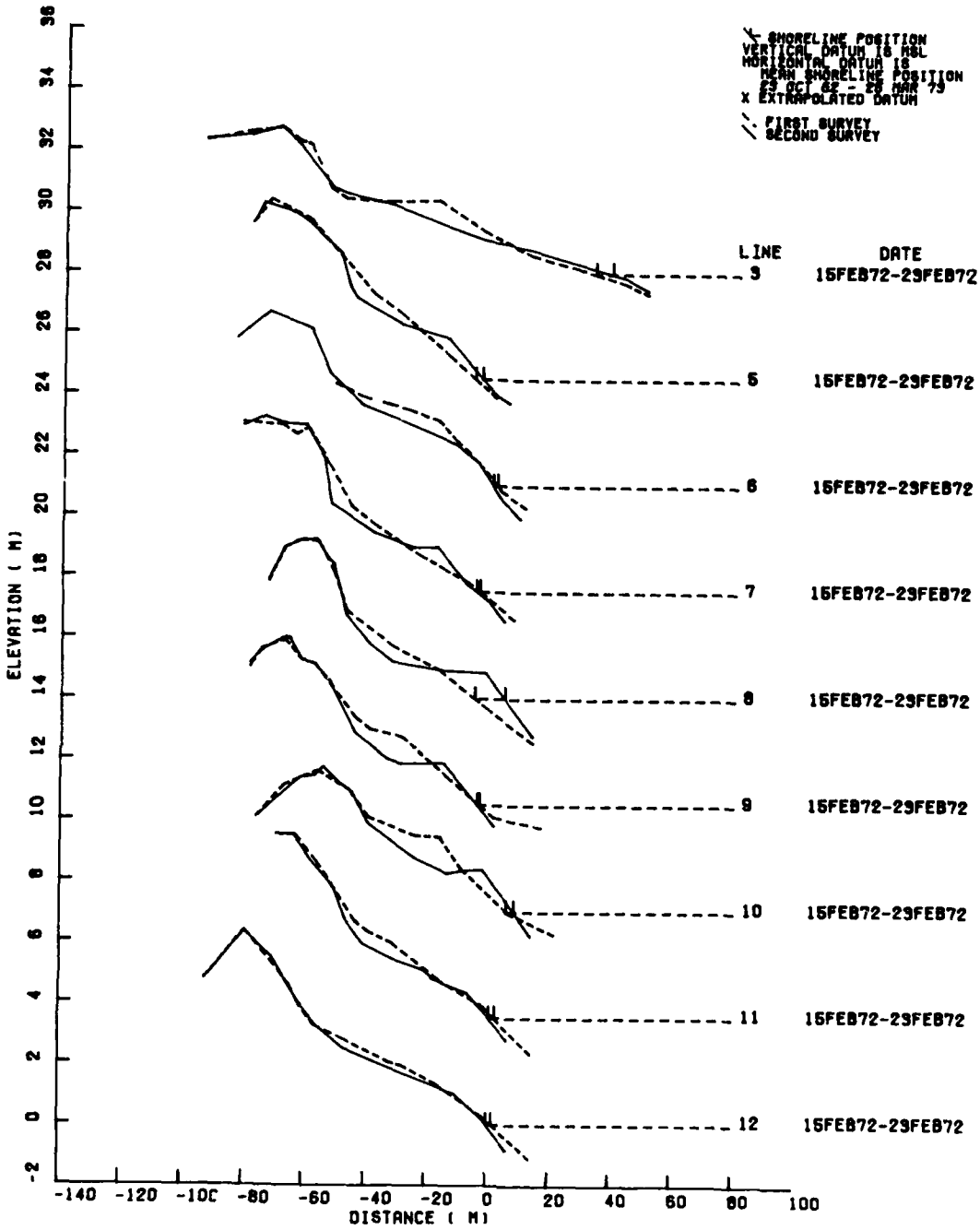
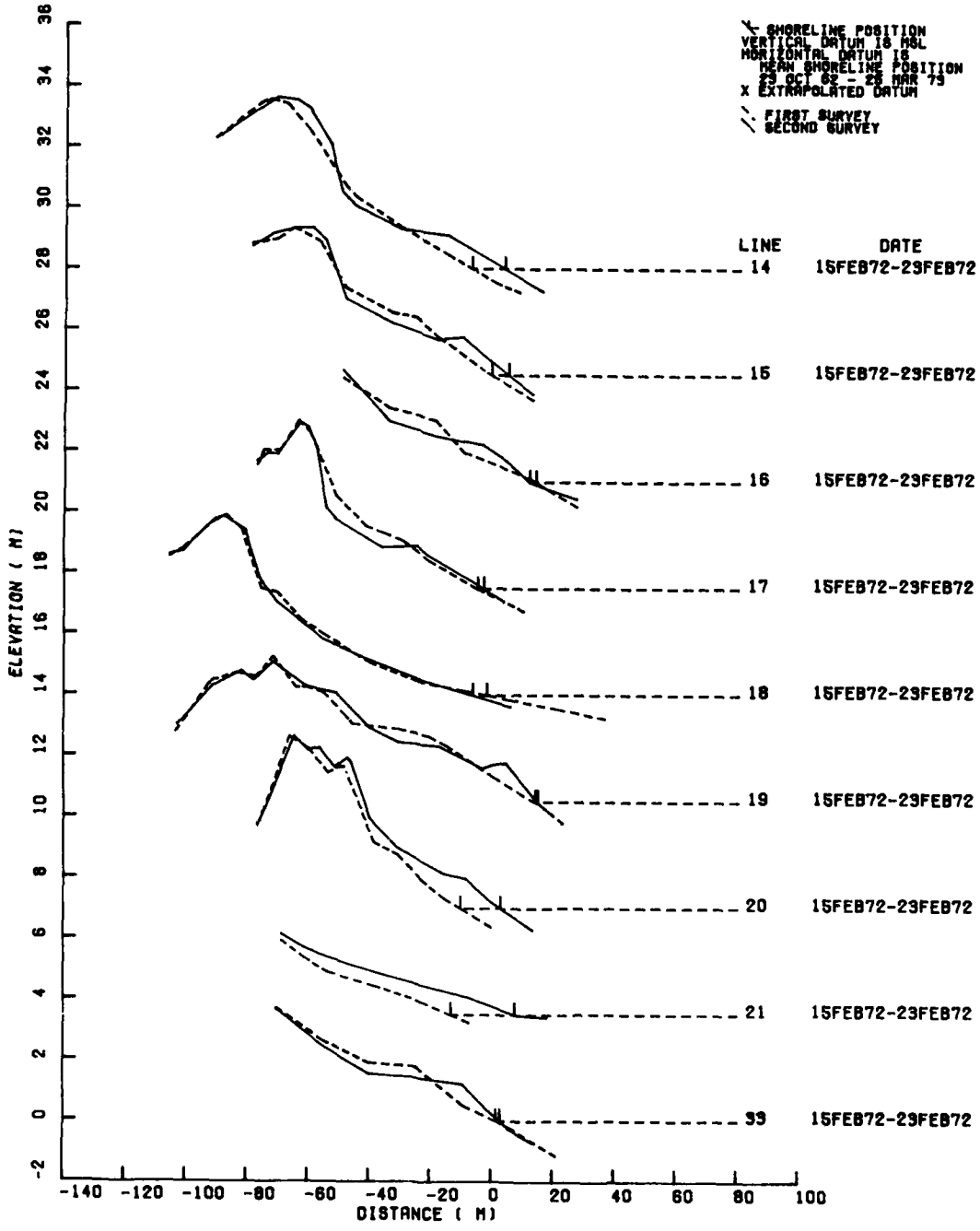



Figure I15. Hindcasted wave data for Long Beach Island, N. J.




a. Profile lines 3-12

Figure I16. Profile comparisons for surveys at Long Beach Island, N. J. (Continued)




b. Profile lines 14-33

Figure I16. (Concluded)

Table I9

Shoreline and Slope Changes at Long Beach Island, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 3 | 15 Feb 72 | 23 Feb 72 | 5.46 | -0.032 | -0.030 | 0.002 |
| 5 | 15 Feb 72 | 23 Feb 72 | 2.37 | -0.090 | -0.120 | -0.030 |
| 6 | 15 Feb 72 | 23 Feb 72 | -1.38 | -0.124 | -0.160 | -0.036 |
| 7 | 15 Feb 72 | 23 Feb 72 | -1.14 | -0.080 | -0.080 | 0.000 |
| 8 | 15 Feb 72 | 23 Feb 72 | 9.89 | -0.080 | -0.132 | -0.052 |
| 9 | 15 Feb 72 | 23 Feb 72 | -0.74 | -0.088 | -0.128 | -0.040 |
| 10 | 15 Feb 72 | 23 Feb 72 | 2.44 | -0.094 | -0.144 | -0.050 |
| 11 | 15 Feb 72 | 23 Feb 72 | -1.88 | -0.100 | -0.120 | -0.020 |
| 12 | 15 Feb 72 | 23 Feb 72 | -1.66 | -0.090 | -0.132 | -0.042 |
| 14 | 15 Feb 72 | 23 Feb 72 | 10.67 | -0.060 | -0.060 | 0.000 |
| 15 | 15 Feb 72 | 23 Feb 72 | 5.59 | -0.060 | -0.080 | -0.020 |
| 16 | 15 Feb 72 | 23 Feb 72 | -2.03 | -0.060 | -0.092 | -0.032 |
| 17 | 15 Feb 72 | 23 Feb 72 | 2.04 | -0.050 | -0.069 | -0.019 |
| 18 | 15 Feb 72 | 23 Feb 72 | -4.57 | -0.020 | -0.030 | -0.010 |
| 19 | 15 Feb 72 | 23 Feb 72 | 0.79 | -0.060 | -0.125 | -0.065 |
| 20 | 15 Feb 72 | 23 Feb 72 | 13.03 | -0.062 | -0.067 | -0.005 |
| 21 | 15 Feb 72 | 23 Feb 72 | 20.78 | -0.044 | -0.038 | 0.006 |
| 33 | 15 Feb 72 | 23 Feb 72 | 1.33 | -0.048 | -0.088 | -0.040 |
| Median | | | 1.69 | -0.061 | -0.090 | -0.025 |
| Tri-Mean | | | 1.89 | -0.064 | -0.094 | -0.024 |
| High Hinge | | | 5.59 | -0.044 | -0.067 | -0.005 |
| Low Hinge | | | -1.38 | -0.090 | -0.128 | -0.040 |
| Mean | | | 3.39 | -0.065 | -0.094 | -0.025 |
| Standard Deviation | | | 6.51 | 0.031 | 0.040 | 0.021 |

Note: X = Extrapolated shoreline intercept.

Table I10

Unit Volume Changes ($m^3/m$) Between Contours
Long Beach Island, N.J.
from 15 Feb 72 to 23 Feb 72

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | -13.20 | 2.69 | 1.66 | -3.27 | -6.02 | -5.37 | 0.94 | -0.32 | -1.11 | -1.44 | -0.96 | | | | |
| 5 | -5.72 | 1.53 | 2.23 | 2.66 | -1.05 | -3.05 | -3.41 | -2.40 | -0.90 | 0.13 | -0.21 | -0.50 | -0.75 | | |
| 6 | -13.81 | -0.46 | -0.13 | -0.69 | -3.28 | -5.77 | -3.52 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | |
| 7 | -2.33 | -0.35 | 1.68 | 3.68 | -0.85 | -2.14 | -2.68 | -2.42 | -1.47 | -0.51 | -0.13 | 1.47 | 1.39 | | |
| 8 | 1.32 | 5.56 | 5.26 | -3.84 | -3.34 | -2.19 | -0.85 | -0.05 | 0.16 | 0.46 | 0.13 | 0.02 | | | |
| 9 | -13.19 | 0.07 | 0.92 | -0.20 | -6.52 | -5.85 | -1.84 | -0.80 | -0.13 | 0.18 | 0.24 | 0.72 | 0.02 | | |
| 10 | -13.92 | 1.67 | 2.43 | 0.62 | -6.07 | -7.77 | -3.46 | -0.68 | -0.69 | -0.29 | 0.32 | | | | |
| 11 | -13.36 | -0.70 | 0.54 | -0.40 | -1.82 | -4.28 | -3.05 | -1.42 | -0.68 | -0.09 | -0.41 | -0.73 | -0.40 | 0.08 | |
| 12 | -7.06 | -0.49 | 0.25 | -0.60 | -2.43 | -2.59 | -1.97 | -0.01 | 0.25 | 0.00 | -0.12 | 0.36 | 0.35 | -0.06 | |
| 14 | 15.75 | 5.33 | 5.33 | 1.80 | -1.53 | -1.81 | -0.91 | 0.19 | 1.24 | 1.96 | 1.83 | 1.76 | 0.56 | | |
| 15 | 0.93 | 3.06 | 3.34 | 0.51 | -4.69 | -3.38 | -1.78 | -0.19 | 0.34 | 1.16 | 2.56 | | | | |
| 16 | -3.33 | 0.30 | 3.60 | 2.61 | -4.78 | -4.72 | -1.00 | 0.50 | 0.16 | | | | | | |
| 17 | -12.95 | 1.23 | 1.26 | -0.25 | -4.44 | -3.54 | -3.10 | -1.71 | -1.07 | -0.90 | -0.29 | -0.15 | 0.00 | | |
| 18 | -1.11 | -0.23 | 1.15 | 0.44 | -1.06 | -0.73 | -0.88 | -1.07 | 0.54 | 0.41 | 0.22 | 0.35 | -0.25 | | |
| 19 | 2.93 | 1.48 | 3.62 | 1.82 | -2.27 | -5.15 | 2.20 | 1.72 | 0.43 | -0.48 | -0.44 | | | | |
| 20 | 29.64 | 6.78 | 7.30 | 4.36 | 2.25 | 2.52 | 1.33 | 0.74 | 0.80 | 0.88 | 2.51 | 0.21 | -0.04 | | |
| 21 | 34.28 | 9.98 | 9.06 | 7.74 | 5.09 | 2.24 | 0.19 | | | | | | | | |
| 33 | -4.58 | 1.86 | 3.55 | 1.64 | -7.41 | -2.36 | -1.13 | -0.61 | -0.12 | | | | | | |
| Median | -3.95 | 1.50 | 2.33 | 0.56 | -2.86 | -3.22 | -1.45 | -0.32 | 0.00 | 0.00 | 0.00 | 0.21 | 0.00 | 0.01 | |
| Tri-mean | -4.94 | 1.46 | 2.36 | 0.83 | -2.89 | -3.43 | -1.70 | -0.42 | -0.09 | 0.01 | 0.01 | 0.22 | 0.02 | 0.01 | |
| High Hinge | 1.32 | 3.06 | 3.62 | 2.61 | -1.06 | -2.14 | -0.85 | 0.05 | 0.34 | 0.44 | 0.28 | 0.54 | 0.35 | 0.08 | |
| Low Hinge | -13.19 | -0.23 | 1.15 | -0.40 | -4.78 | -5.15 | -3.05 | -1.07 | -0.69 | -0.38 | -0.25 | -0.08 | -0.25 | -0.06 | |
| Mean | -1.10 | 2.18 | 2.95 | 1.04 | -2.79 | -3.11 | -1.38 | -0.50 | -0.13 | 0.10 | 0.35 | 0.32 | 0.09 | 0.01 | |
| Std Dev | 14.33 | 2.96 | 2.49 | 2.70 | 3.14 | 2.66 | 1.72 | 1.09 | 0.75 | 0.83 | 1.07 | 0.76 | 0.58 | 0.10 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

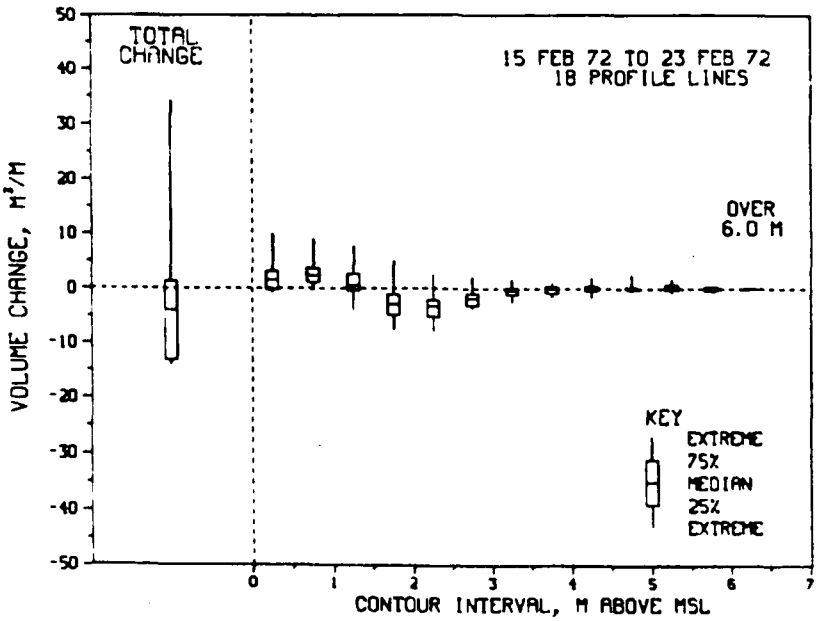



Figure I17. Distribution of volume changes by contour for Long Beach Island, N. J.

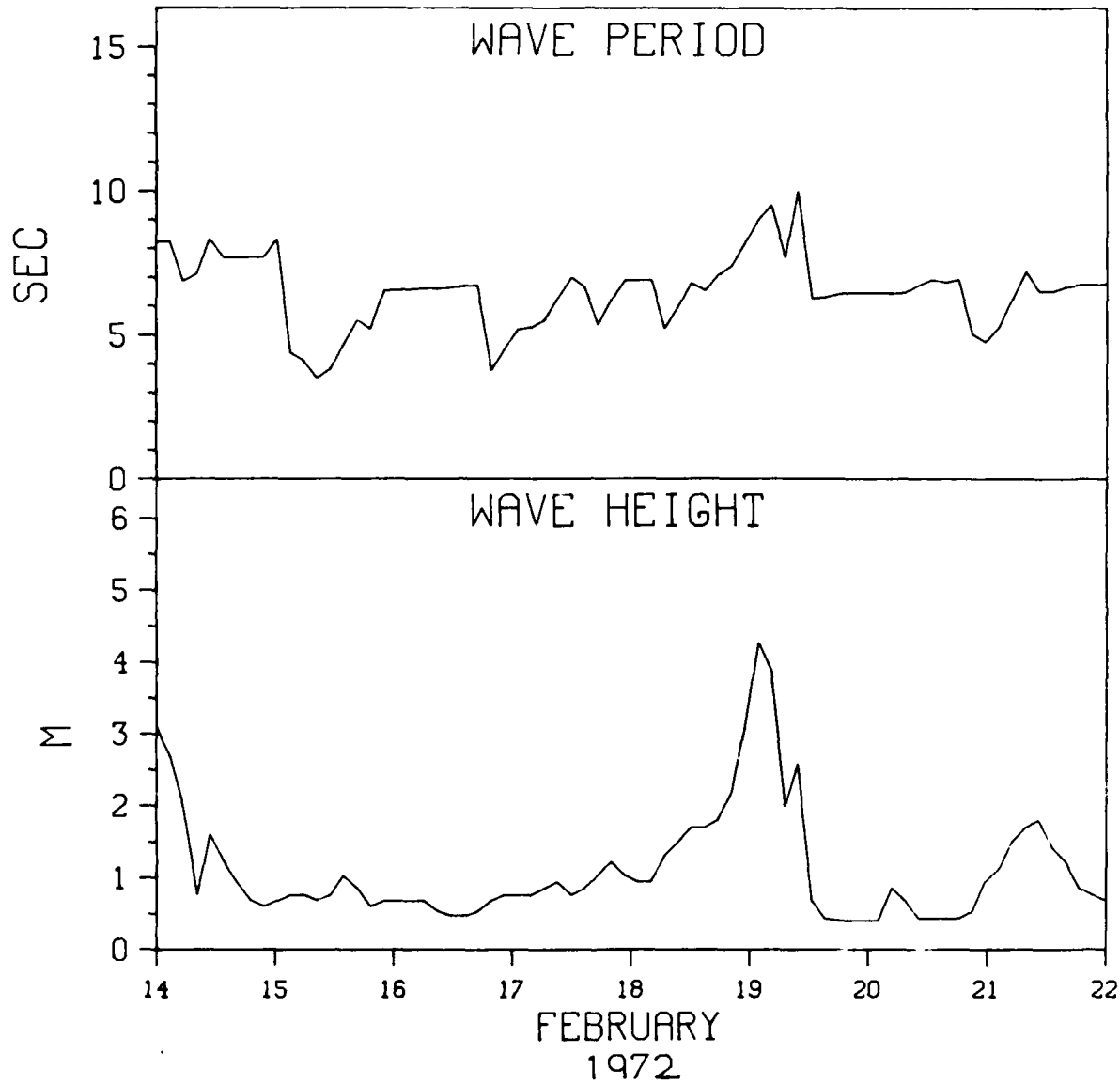



Figure I18. Hindcasted wave data for Atlantic City, N. J.

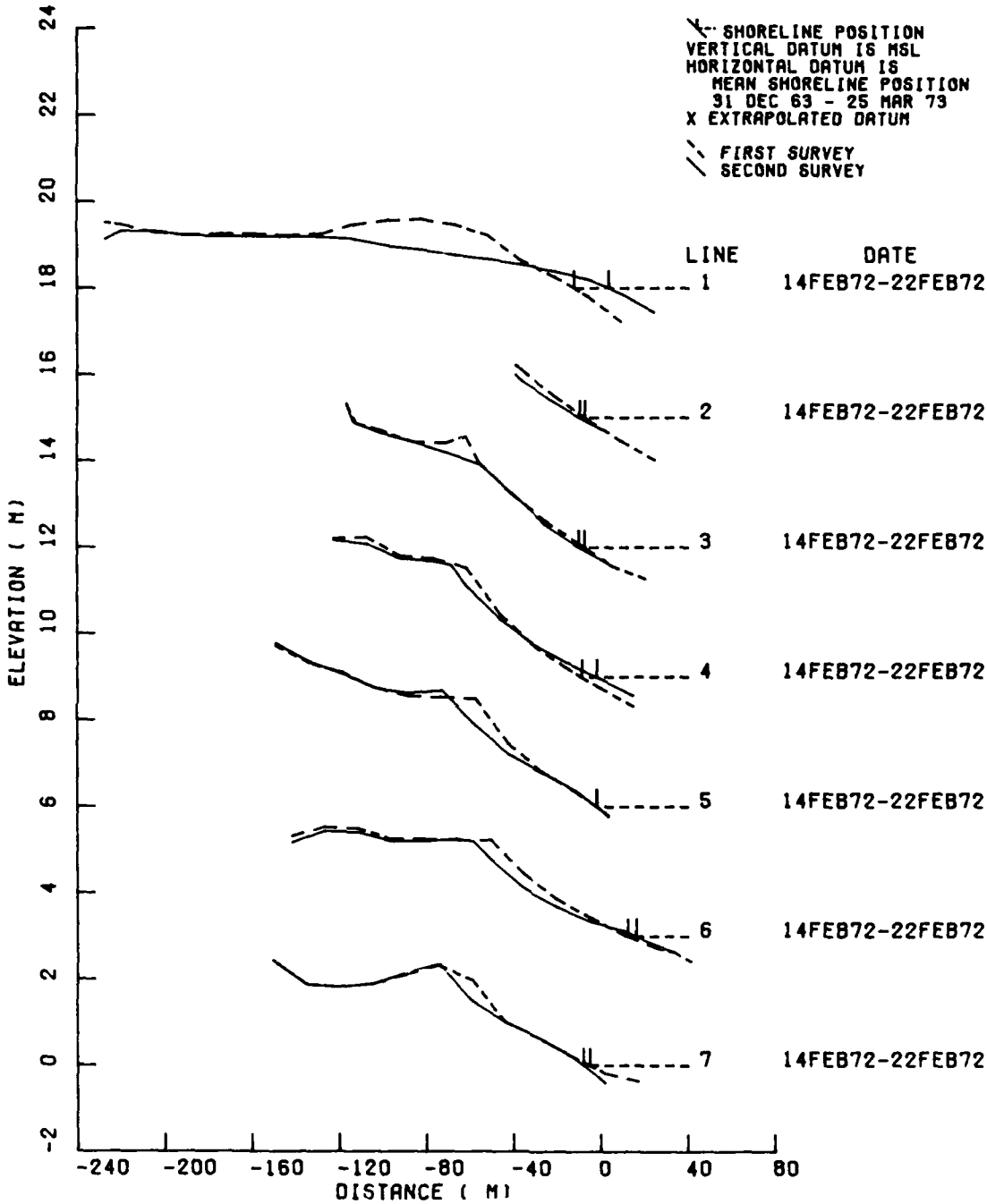



Figure I19. Profile comparisons for surveys at Atlantic City, N. J.

Table I11

Shoreline and Slope Changes at Atlantic City, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 14 Feb 72 | 22 Feb 72 | 15.79 | -0.030 | -0.022 | 0.008 |
| 2 | 14 Feb 72 | 22 Feb 72 | -2.37 | -0.036 | -0.030 | 0.006 |
| 3 | 14 Feb 72 | 22 Feb 72 | -2.69 | -0.034 | -0.034 | 0.000 |
| 4 | 14 Feb 72 | 22 Feb 72 | 6.86 | -0.030 | -0.024 | 0.006 |
| 5 | 14 Feb 72 | 22 Feb 72 | -0.25 | -0.036 | -0.040 | -0.004 |
| 6 | 14 Feb 72 | 22 Feb 72 | 4.02 | -0.020 | -0.022 | -0.002 |
| 7 | 14 Feb 72 | 22 Feb 72 | -2.87 | -0.026 | -0.040 | -0.014 |
| Median | | | -0.25 | -0.030 | -0.030 | 0.000 |
| Tri-Mean | | | 0.60 | -0.031 | -0.030 | 0.001 |
| High Hinge | | | 5.44 | -0.028 | -0.023 | 0.006 |
| Low Hinge | | | -2.53 | -0.035 | -0.037 | -0.003 |
| Mean | | | 2.64 | -0.030 | -0.030 | 0.000 |
| Standard Deviation | | | 6.89 | 0.006 | 0.008 | 0.008 |

Note: X = Extrapolated shoreline intercept.

Table I12

Unit Volume Changes ($m^3/m$) Between Contours
Atlantic City, N.J.
from 14 Feb 72 to 22 Feb 72

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -45.74 | 4.95 | -12.66 | -36.23 | -1.80 | | | | | | | | | | |
| 2 | -5.15 | -1.83 | -2.72 | -0.60 | | | | | | | | | | | |
| 3 | -9.72 | -1.34 | -0.69 | 0.16 | -0.27 | -6.47 | -1.01 | -0.10 | | | | | | | |
| 4 | -8.11 | 2.31 | 0.44 | -0.94 | -2.04 | -3.02 | -2.65 | -2.21 | | | | | | | |
| 5 | -9.42 | 0.20 | -0.49 | -2.58 | -3.90 | -5.30 | 2.06 | 0.11 | 0.48 | | | | | | |
| 6 | -19.34 | -0.21 | -3.22 | -4.09 | -4.27 | -7.29 | -0.26 | | | | | | | | |
| 7 | -6.35 | -0.31 | 0.00 | -1.91 | -3.99 | -0.14 | | | | | | | | | |
| Median | -9.42 | -0.21 | -0.69 | -1.91 | -2.97 | -5.30 | -0.63 | -0.10 | 0.48 | | | | | | |
| Tri-mean | -10.15 | 0.00 | -1.15 | -1.98 | -2.93 | -5.02 | -0.55 | -0.34 | 0.48 | | | | | | |
| High Hinge | -7.23 | 1.25 | -0.25 | -0.77 | -1.80 | -3.02 | 0.90 | 0.00 | 0.48 | | | | | | |
| Low Hinge | -14.53 | -0.83 | -2.97 | -3.34 | -3.99 | -6.47 | -1.83 | -1.15 | 0.48 | | | | | | |
| Mean | -14.83 | 0.54 | -2.76 | -6.60 | -2.71 | -4.44 | -0.47 | -0.73 | 0.48 | | | | | | |
| Std Dev | 14.39 | 2.35 | 4.57 | 13.14 | 1.59 | 2.89 | 1.96 | 1.28 | 0.00 | | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

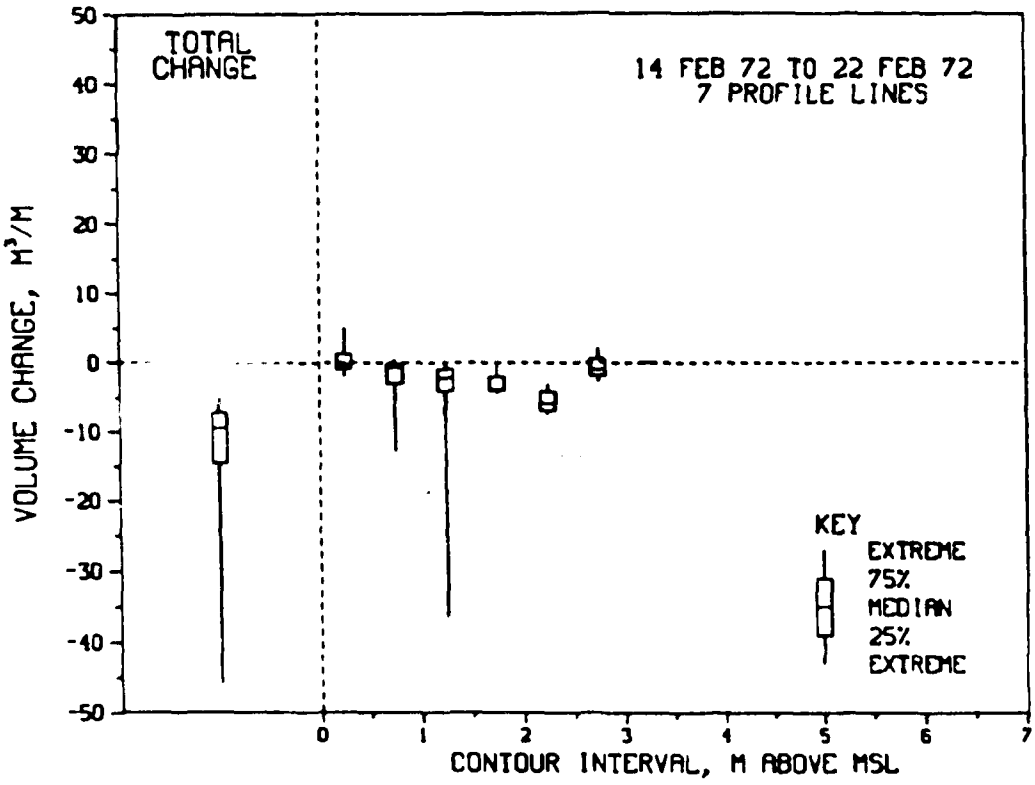



Figure I20. Distribution of volume changes by contour for Atlantic City, N. J.

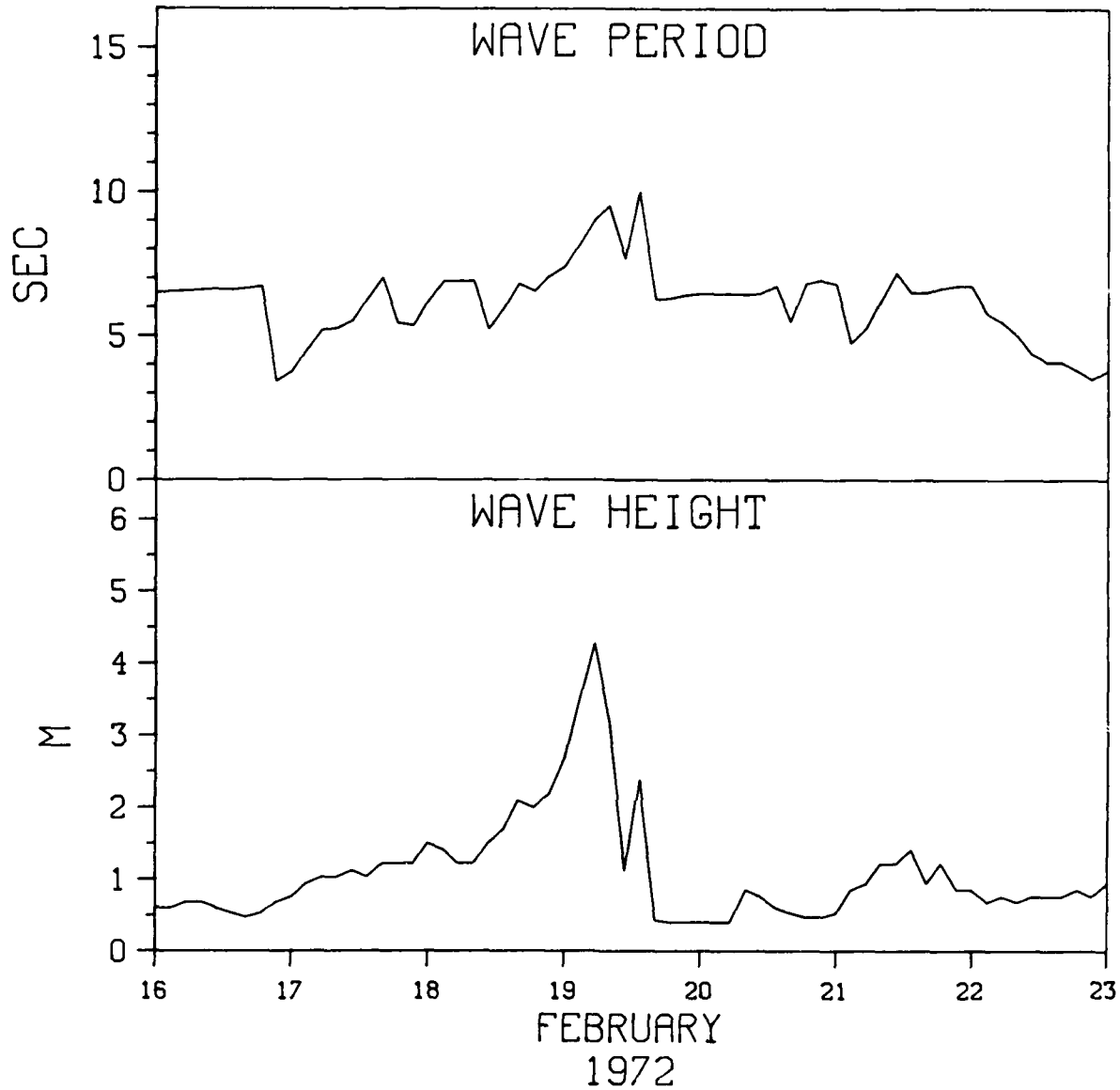
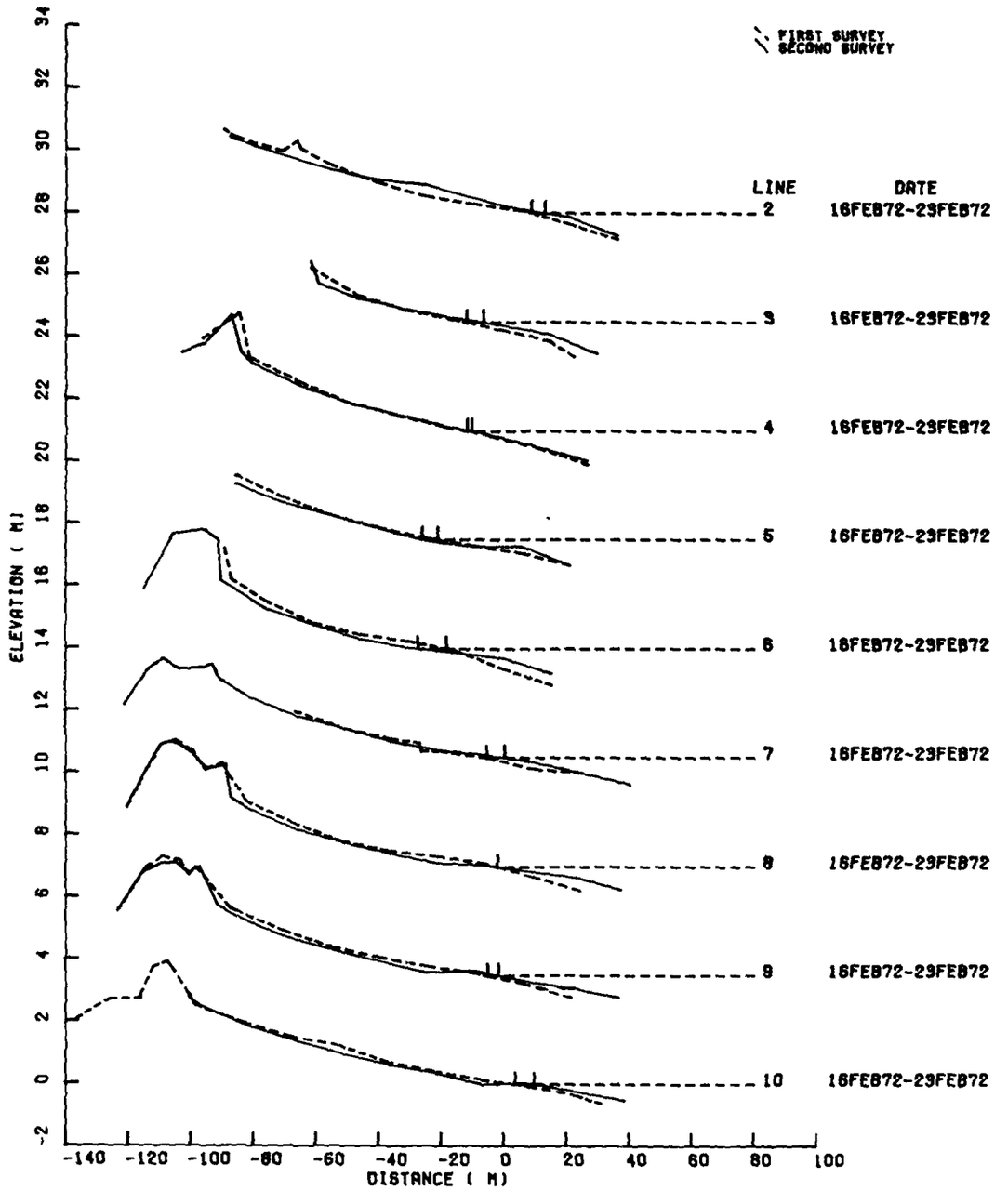
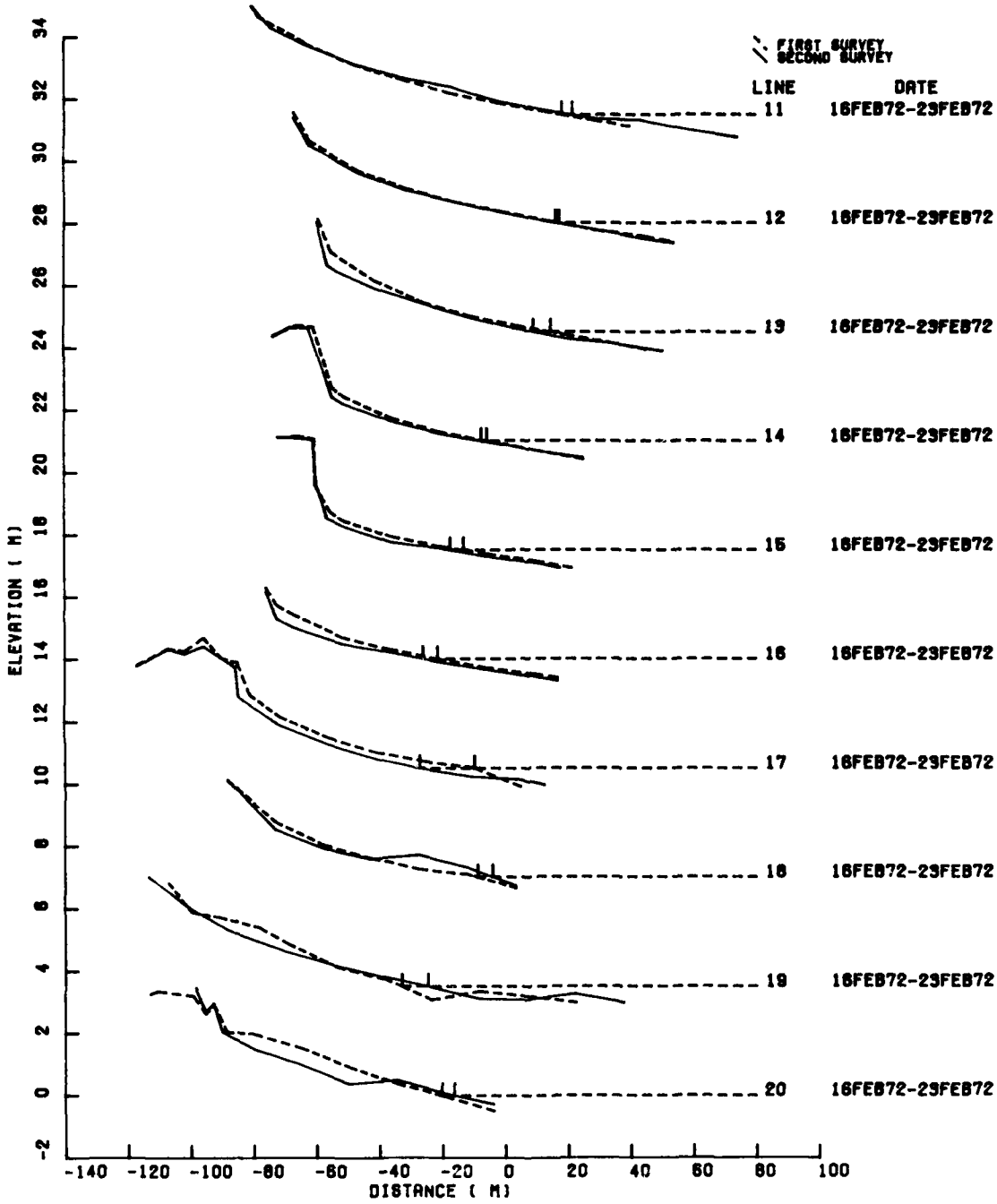



Figure I21. Hindcasted wave data for Ludlam Beach, N. J.




a. Profile lines 2-10

Figure I22. Profile comparisons for surveys at Ludlam Beach, N. J. (Continued)




b. Profile lines 11-20

Figure I22. (Concluded)

Table I13

Shoreline and Slope Changes at Ludlam Beach, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 2 | 16 Feb 72 | 23 Feb 72 | 4.35 | -0.028 | -0.016 | 0.012 |
| 3 | 16 Feb 72 | 23 Feb 72 | 5.37 | -0.022 | -0.016 | 0.006 |
| 4 | 16 Feb 72 | 23 Feb 72 | 1.52 | -0.020 | -0.020 | 0.000 |
| 5 | 16 Feb 72 | 23 Feb 72 | -4.98 | -0.016 | -0.026 | -0.010 |
| 6 | 16 Feb 72 | 23 Feb 72 | -9.14 | -0.020 | -0.010 | 0.010 |
| 7 | 16 Feb 72 | 23 Feb 72 | 5.72 | -0.014 | -0.016 | -0.002 |
| 8 | 16 Feb 72 | 23 Feb 72 | 0.00 | -0.028 | -0.014 | 0.014 |
| 9 | 16 Feb 72 | 23 Feb 72 | 3.46 | -0.022 | -0.020 | 0.002 |
| 10 | 16 Feb 72 | 23 Feb 72 | 6.05 | -0.014 | -0.018 | -0.004 |
| 11 | 16 Feb 72 | 23 Feb 72 | 3.39 | -0.018 | -0.018 | 0.000 |
| 12 | 16 Feb 72 | 23 Feb 72 | -1.14 | -0.020 | -0.016 | 0.004 |
| 13 | 16 Feb 72 | 23 Feb 72 | -5.59 | -0.018 | -0.020 | -0.002 |
| 14 | 16 Feb 72 | 23 Feb 72 | -1.69 | -0.020 | -0.018 | 0.002 |
| 15 | 16 Feb 72 | 23 Feb 72 | -4.23 | -0.016 | -0.018 | -0.002 |
| 16 | 16 Feb 72 | 23 Feb 72 | -4.57 | -0.020 | -0.020 | 0.000 |
| 17 | 16 Feb 72 | 23 Feb 72 | -17.39 | -0.040 | -0.022 | 0.018 |
| 18 | 16 Feb 72 | 23 Feb 72 | 4.76 | -0.028 | -0.038 | -0.010 |
| 19 | 16 Feb 72 | 23 Feb 72 | 8.31 | -0.044 | -0.022 | 0.022 |
| 20 | 16 Feb 72 | 23 Feb 72 | 3.94 | -0.026 | -0.022 | 0.004 |
| Median | | | 1.52 | -0.018 | -0.016 | 0.004 |
| Tri-Mean | | | 0.80 | -0.019 | -0.016 | 0.005 |
| High Hinge | | | 4.55 | -0.014 | -0.010 | 0.013 |
| Low Hinge | | | -4.40 | -0.024 | -0.020 | -0.001 |
| Mean | | | -0.10 | -0.021 | -0.016 | 0.006 |
| Standard Deviation | | | 6.39 | 0.009 | 0.007 | 0.010 |

Note: X = Extrapolated shoreline intercept.

Table I14

Unit Volume Changes ($m^3/m$) Between Contours
Ludlam Beach, N.J.
from Feb 72 to 23 Feb 72

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2.69 | 3.13 | 6.26 | -0.37 | -3.94 | -2.37 | -0.02 | | | | | | | | |
| 3 | -2.25 | 1.29 | -1.11 | -2.32 | -0.11 | | | | | | | | | | |
| 4 | -6.02 | 0.68 | 0.25 | -0.92 | -1.36 | -1.10 | -1.54 | -1.66 | -0.37 | | | | | | |
| 5 | -6.14 | -1.14 | -0.38 | -2.16 | -2.39 | -0.07 | | | | | | | | | |
| 6 | -12.30 | -4.82 | -1.52 | -2.20 | -1.91 | -1.28 | -0.51 | -0.06 | 0.00 | | | | | | |
| 7 | -1.22 | 1.08 | -1.15 | -1.15 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | |
| 8 | -12.94 | -4.64 | -1.19 | -2.06 | -2.18 | -1.67 | -0.73 | -0.01 | -0.41 | -0.05 | | | | | |
| 9 | -13.70 | -3.19 | -2.21 | -2.33 | -2.13 | -1.36 | -0.64 | -0.26 | -1.58 | | | | | | |
| 10 | -9.61 | -2.56 | -2.43 | -3.53 | -1.17 | -0.01 | 0.10 | 0.00 | 0.00 | | | | | | |
| 11 | 5.14 | 1.67 | 3.16 | 1.25 | 0.26 | -0.44 | -0.92 | 0.16 | | | | | | | |
| 12 | -4.65 | -0.68 | -0.34 | -0.84 | -0.71 | -1.01 | -0.58 | -0.47 | -0.02 | | | | | | |
| 13 | -12.27 | -1.90 | -0.76 | -1.88 | -3.10 | -3.02 | -1.00 | -0.58 | -0.03 | | | | | | |
| 14 | -8.37 | -1.25 | -1.60 | -2.27 | -0.73 | -0.59 | -0.67 | -0.79 | -0.47 | | | | | | |
| 15 | -7.04 | -3.11 | -2.48 | -1.00 | -0.17 | 0.14 | 0.02 | -0.09 | -0.35 | | | | | | |
| 16 | -11.60 | -2.73 | -3.70 | -3.86 | -1.10 | -0.21 | | | | | | | | | |
| 17 | -21.02 | -5.96 | -3.33 | -2.89 | -2.14 | -2.04 | -1.28 | -1.00 | -2.02 | -0.36 | | | | | |
| 18 | 3.63 | 6.77 | 1.43 | -1.98 | -1.52 | -0.75 | -0.31 | 0.00 | | | | | | | |
| 19 | -9.48 | 1.90 | -0.36 | -3.38 | -5.23 | -1.60 | -0.40 | -0.41 | 0.00 | | | | | | |
| 20 | -20.23 | 0.60 | -7.10 | -7.46 | -6.18 | -0.70 | 0.18 | 0.43 | | | | | | | |
| Median | -8.37 | -1.14 | -1.15 | -2.16 | -1.52 | -0.88 | -0.54 | -0.09 | -0.35 | -0.21 | | | | | |
| Tri-mean | -8.12 | -1.00 | -1.24 | -2.00 | -1.51 | -0.89 | -0.48 | -0.18 | -0.29 | -0.21 | | | | | |
| High Hinge | -3.45 | 1.18 | -0.35 | -1.08 | -0.72 | -0.21 | -0.01 | 0.00 | -0.01 | -0.05 | | | | | |
| Low Hinge | -12.28 | -2.92 | -2.32 | -2.61 | -2.29 | -1.60 | -0.83 | -0.52 | -0.44 | -0.36 | | | | | |
| Mean | -7.76 | -0.78 | -0.98 | -2.18 | -1.88 | -1.00 | -0.52 | -0.32 | -0.48 | -0.21 | | | | | |
| Std Dev | 7.27 | 3.12 | 2.74 | 1.76 | 1.74 | 0.89 | 0.51 | 0.53 | 0.69 | 0.22 | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

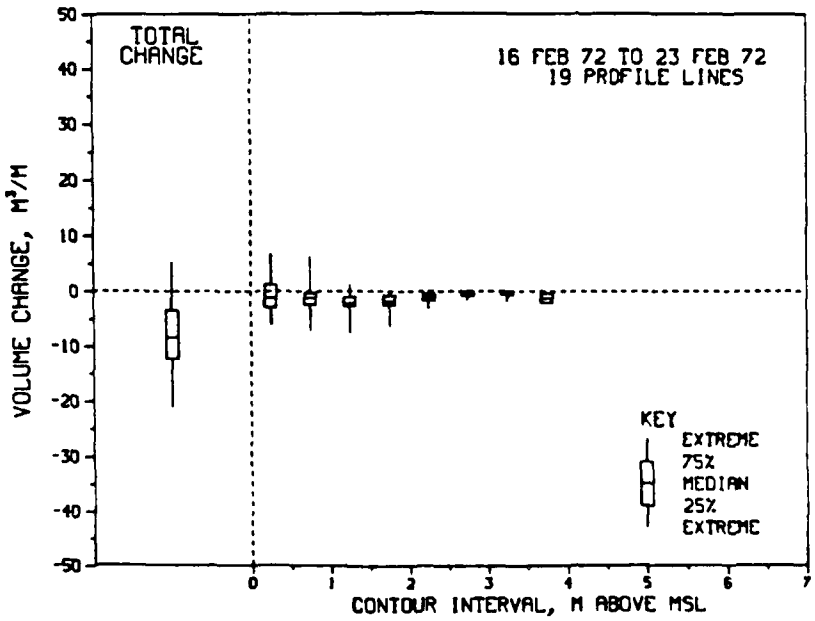



Figure I23. Distribution of volume changes by contour for Ludlam Beach, N. J.

## APPENDIX J: DATA SUMMARY FOR THE STORM OF 17-22 MARCH 1973

1. Two storms occurred during the 5-day period from 17 to 22 March 1973 with each storm affecting different localities. The synoptic surface weather maps show the development of both storm systems. Surveys covering this period were collected at Nauset Beach, Westhampton, Jones Beach, Long Beach Island, and Atlantic City. All surveying was conducted within 5 days of the first storm on 17 March, and within 3 days after the second storm on 22 March.

2. From the tide record, it appears that both storms produced significant tides and surges. Peak tides reached 1.4 m above msl for both storms at the Sandy Hook gage but the surges differed, 0.6 m during the peak tide of the first storm and 0.9 m for the second. The wave data indicate that waves were higher during the first storm along the New Jersey and New York coasts and during the second storm at Nauset Beach. The second storm does not appear in the wave records for the Long Beach Island sites. The storm passed this area because the waves were hindcasted to be moving offshore.

3. The measured beach changes do indicate that shoreline orientation and wave sheltering may have been important. Though each locality had individual profile lines with significant erosion, median changes were low, under -6.5 $m^3/m$, except at Westhampton which experienced its largest losses with a median loss of -31.4 $m^3/m$. The associated median shoreline change was also significant, equaling -20.2 m. Apparently one of the storms, possibly the second, produced significant waves from the southwest quadrant that were sheltered at all sites except Westhampton.

4. Changes did occur at the other sites though with less magnitude and with greater variation. All of the sites had median erosion with most of the profiles eroding. At Long Beach Island, 13 of the profiles eroded with most losing between 3 and 10 $m^3/m$.

5. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.

Figure J1. Synoptic weather maps at 0700 for 17 and 22-23 March 1973

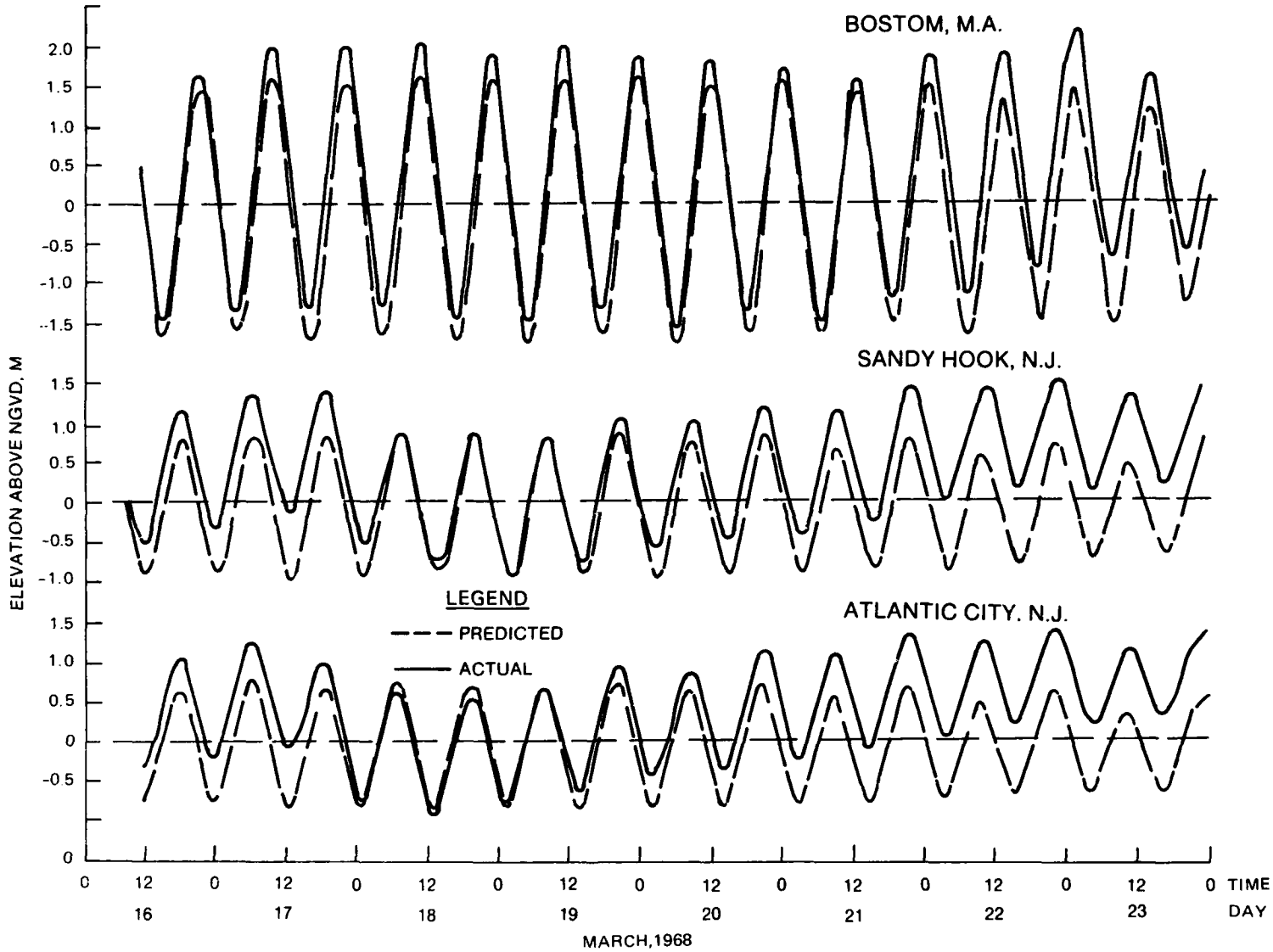



Figure J2. Predicted and actual water levels for 16-23 March 1973

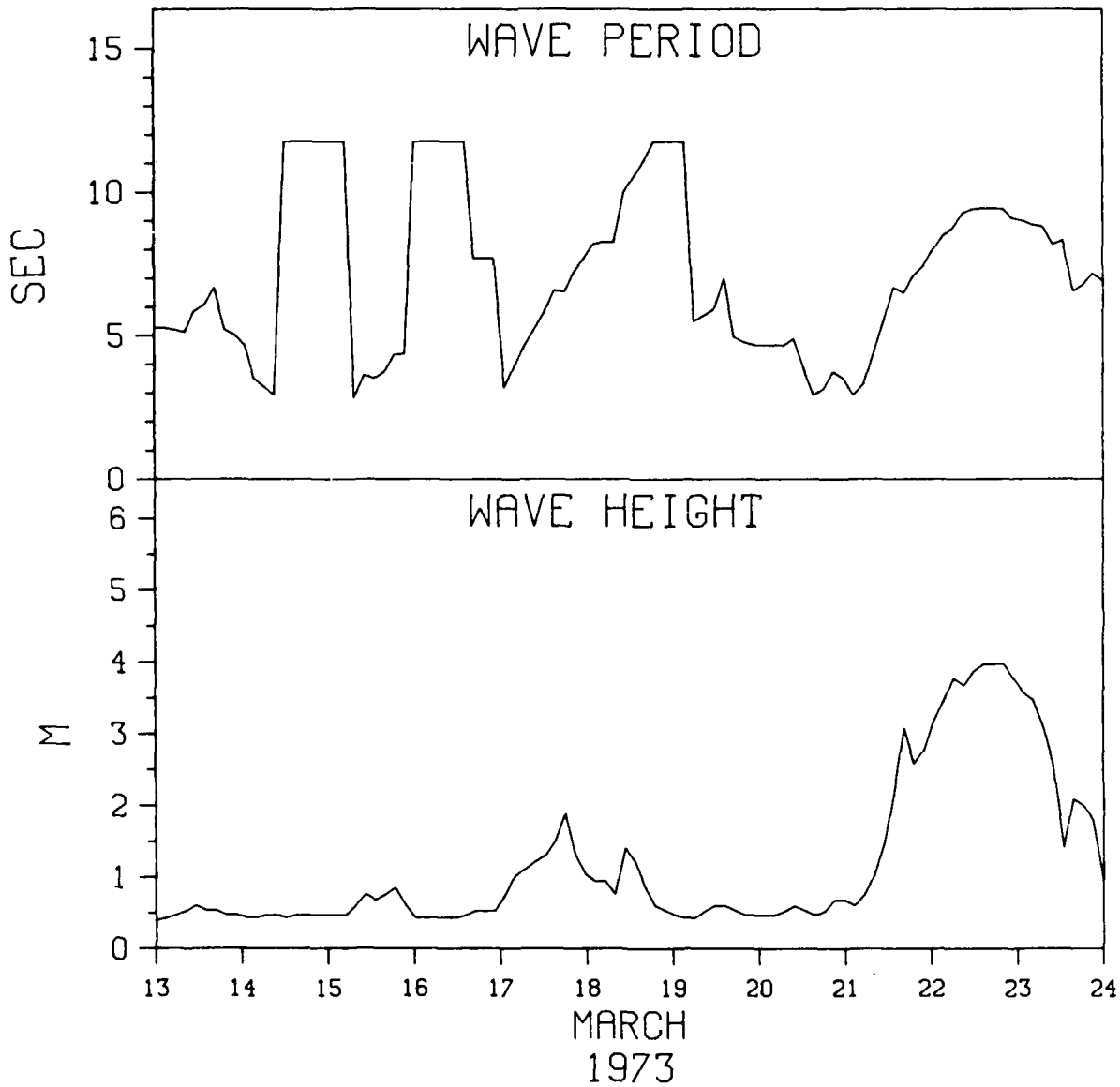



Figure J3. Hindcasted wave data for Nauset Beach, Mass.

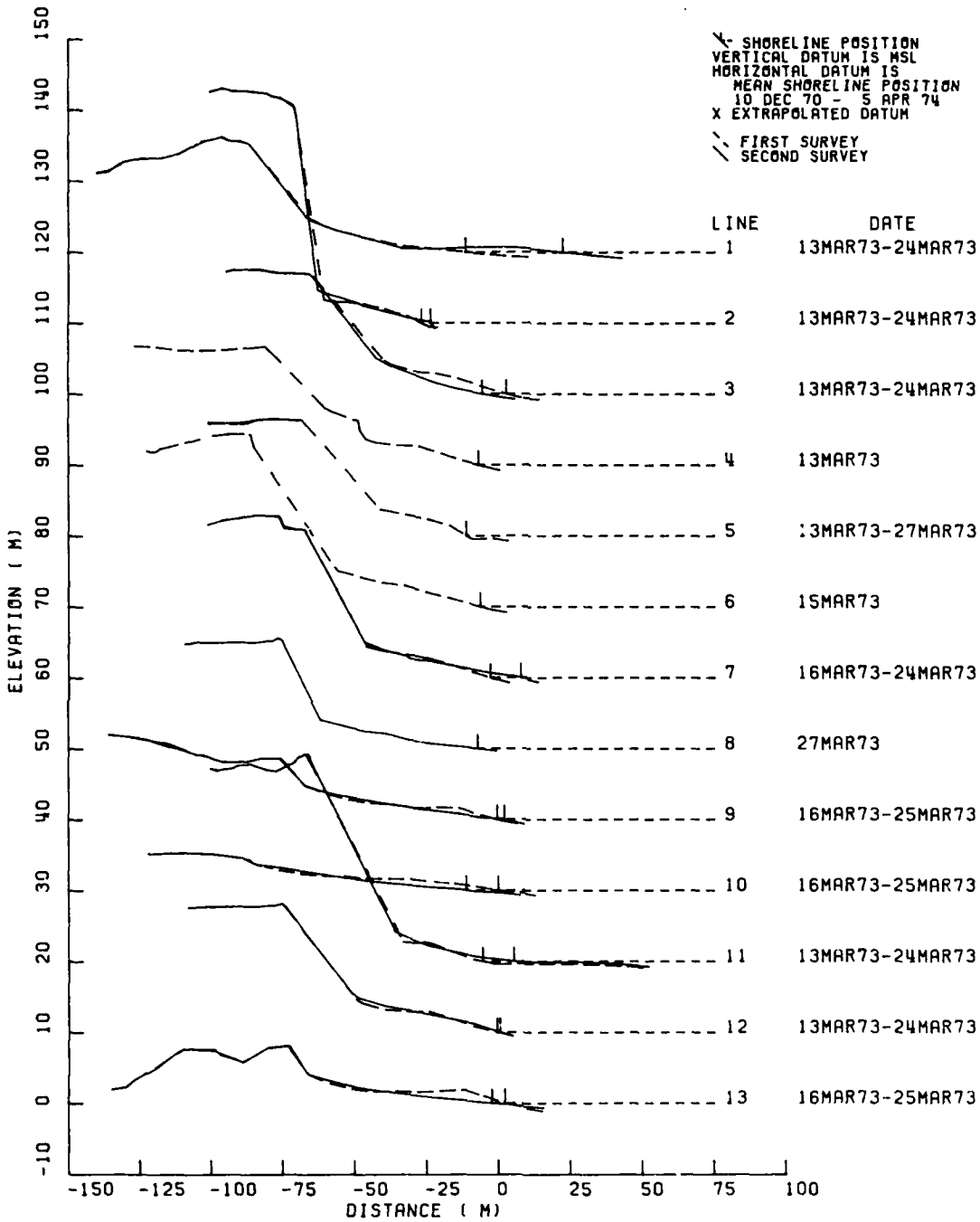



Figure J4. Profile comparisons for surveys of 13 profile lines at Cape Cod, Mass.

Table J1

Shoreline and Slope Changes at Nauset Beach, Mass.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 13 Mar 73 | 24 Mar 73 | 33.83 | -0.048 | -0.044 | 0.004 |
| 2 | 13 Mar 73 | 24 Mar 73 | 3.13 | -0.196 | -0.443 | -0.247 |
| 3 | 13 Mar 73 | 24 Mar 73 | -8.30 | -0.100 | -0.072 | 0.028 |
| 7 | 16 Mar 73 | 24 Mar 73 | 10.53 | -0.132 | -0.100 | 0.032 |
| 9 | 16 Mar 73 | 25 Mar 73 | 2.59 | -0.108 | -0.100 | 0.008 |
| 10 | 16 Mar 73 | 25 Mar 73 | -11.08 | -0.068 | -0.044 | 0.024 |
| 11 | 13 Mar 73 | 24 Mar 73 | 10.85 | -0.088 | -0.048 | 0.040 |
| 12 | 13 Mar 73 | 24 Mar 73 | 1.01 | -0.096 | -0.130 | -0.034 |
| 13 | 16 Mar 73 | 25 Mar 73 | -4.54 | -0.136 | -0.032 | 0.104 |
| Median | | | 2.59 | -0.100 | -0.072 | 0.024 |
| Tri-Mean | | | 2.79 | -0.105 | -0.072 | 0.021 |
| High Hinge | | | 10.53 | -0.088 | -0.044 | 0.032 |
| Low Hinge | | | -4.54 | -0.132 | -0.100 | 0.004 |
| Mean | | | 4.22 | -0.108 | -0.113 | -0.005 |
| Standard Deviation | | | 13.43 | 0.043 | 0.128 | 0.098 |

Note: X = Extrapolated shoreline intercept.

Table J2

Unit Volume Changes ($m^3/m$) Between Contours
Nauset Beach, Mass.
from 13 Mar 73 to 24 Mar 73

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13.56 | 16.70 | 2.29 | -0.86 | -0.39 | -0.03 | 0.00 | 0.00 | 0.07 | 0.38 | -0.24 | -0.44 | -0.41 | -3.50 | |
| 2 | -12.55 | 1.44 | -0.30 | -1.00 | -1.40 | -1.38 | 0.19 | 3.67 | 2.13 | 0.20 | -0.79 | -0.79 | -0.78 | -13.74 | |
| 3 | -49.05 | -4.59 | -5.51 | -5.91 | -6.02 | -5.61 | -4.60 | -1.70 | -0.90 | -0.48 | -0.69 | -0.97 | -0.94 | -11.13 | |
| 7 | 3.38 | 4.49 | 2.36 | 0.86 | -0.36 | -1.53 | -2.93 | -0.91 | 0.62 | 1.29 | 0.49 | -0.04 | -0.04 | -0.91 | |
| 9 | -5.05 | -0.74 | -3.06 | -5.71 | -2.96 | 0.95 | 2.42 | 1.55 | 0.68 | 0.27 | 0.03 | -0.04 | -0.07 | 1.65 | |
| 10 | -22.01 | -6.96 | -9.56 | -9.97 | -3.18 | 2.43 | 2.81 | 1.64 | 0.12 | -0.27 | 0.08 | 0.85 | 0.00 | | |
| 11 | -0.99 | 4.19 | 1.72 | 0.44 | -0.59 | -1.38 | 1.16 | 1.37 | 0.34 | -0.43 | -0.46 | -0.45 | -0.44 | -6.45 | |
| 12 | 11.29 | 0.78 | 1.31 | 1.25 | 0.09 | -0.93 | -1.13 | 2.78 | 2.29 | 1.98 | 0.91 | 0.25 | 0.02 | 1.68 | |
| 13 | -27.64 | -4.56 | -9.01 | -12.56 | -4.45 | 1.93 | 1.76 | 1.05 | 0.20 | -0.25 | -0.41 | -0.38 | -0.51 | -0.44 | |
| Median | -5.05 | 0.78 | -0.30 | -1.00 | -1.40 | -0.93 | 0.19 | 1.37 | 0.34 | 0.20 | -0.24 | -0.38 | -0.41 | -2.20 | |
| Tri-mean | -7.18 | 0.30 | -1.10 | -1.87 | -1.59 | -0.57 | 0.25 | 1.10 | 0.37 | 0.13 | -0.22 | -0.31 | -0.34 | -3.15 | |
| High Hinge | 3.38 | 4.19 | 1.72 | 0.44 | -0.39 | 0.95 | 1.76 | 1.64 | 0.68 | 0.38 | 0.08 | -0.04 | -0.04 | 0.61 | |
| Low Hinge | -22.01 | -4.56 | -5.51 | -5.91 | -3.18 | -1.38 | -1.13 | 0.00 | 0.12 | -0.27 | -0.46 | -0.45 | -0.51 | -8.79 | |
| Mean | -9.90 | 1.19 | -2.20 | -3.72 | -2.14 | -0.62 | -0.04 | 1.05 | 0.62 | 0.30 | -0.12 | -0.22 | -0.35 | -4.10 | |
| Std Dev | 20.25 | 7.05 | 4.80 | 5.06 | 2.13 | 2.39 | 2.48 | 1.70 | 1.01 | 0.84 | 0.56 | 0.55 | 0.35 | 5.83 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

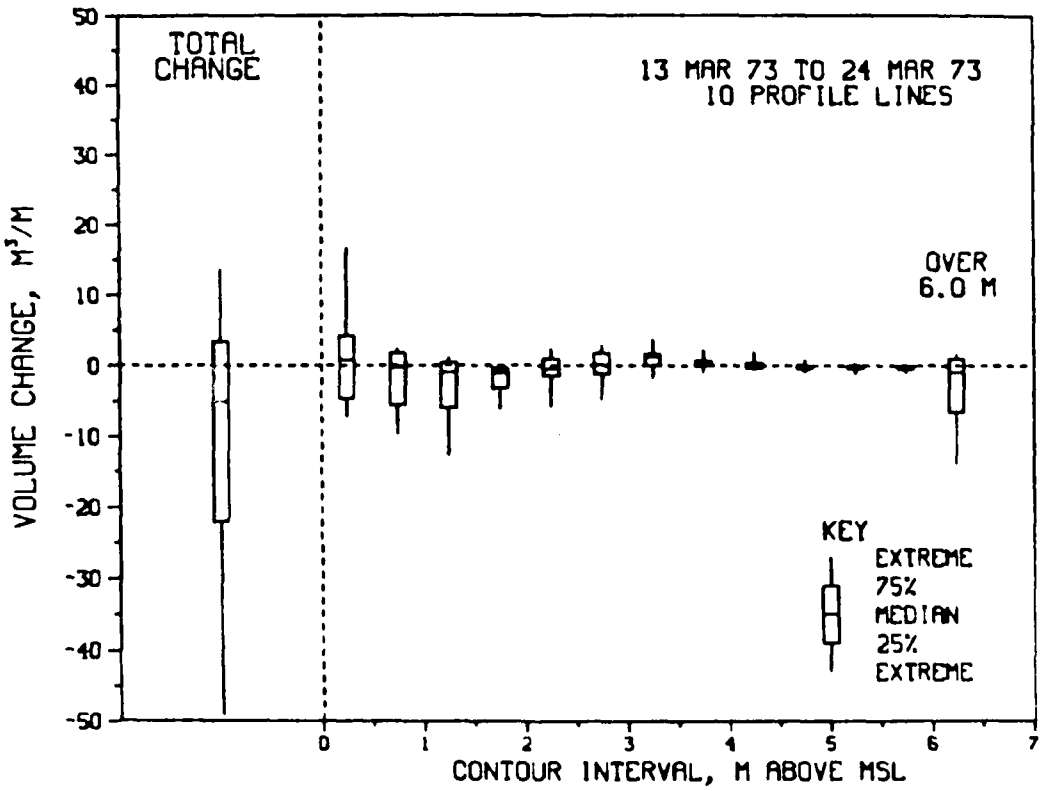



Figure J5. Distribution of volume changes by contour for Nauset Beach, Mass.

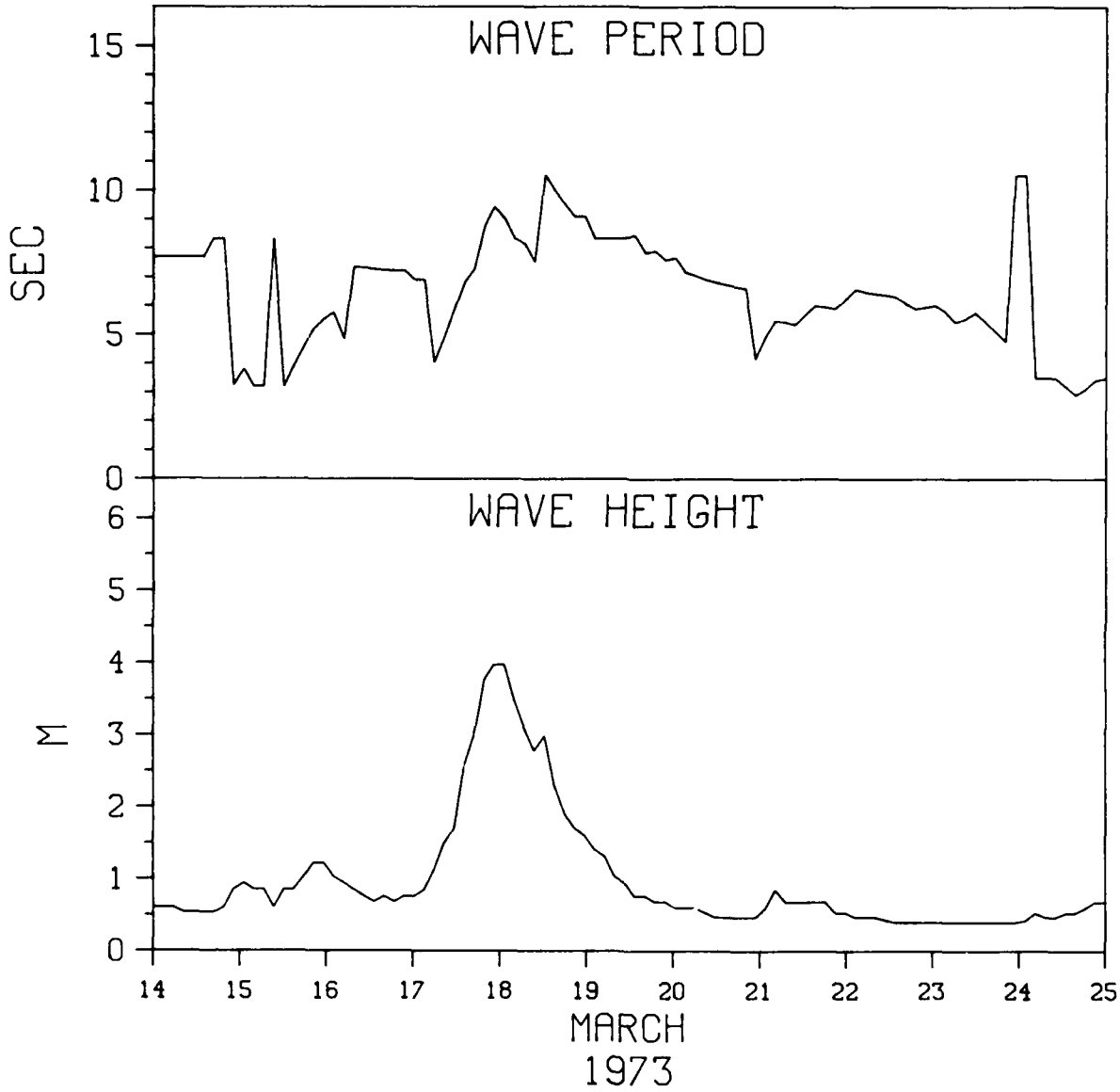



Figure J6. Hindcasted wave data for Westhampton, N. Y.

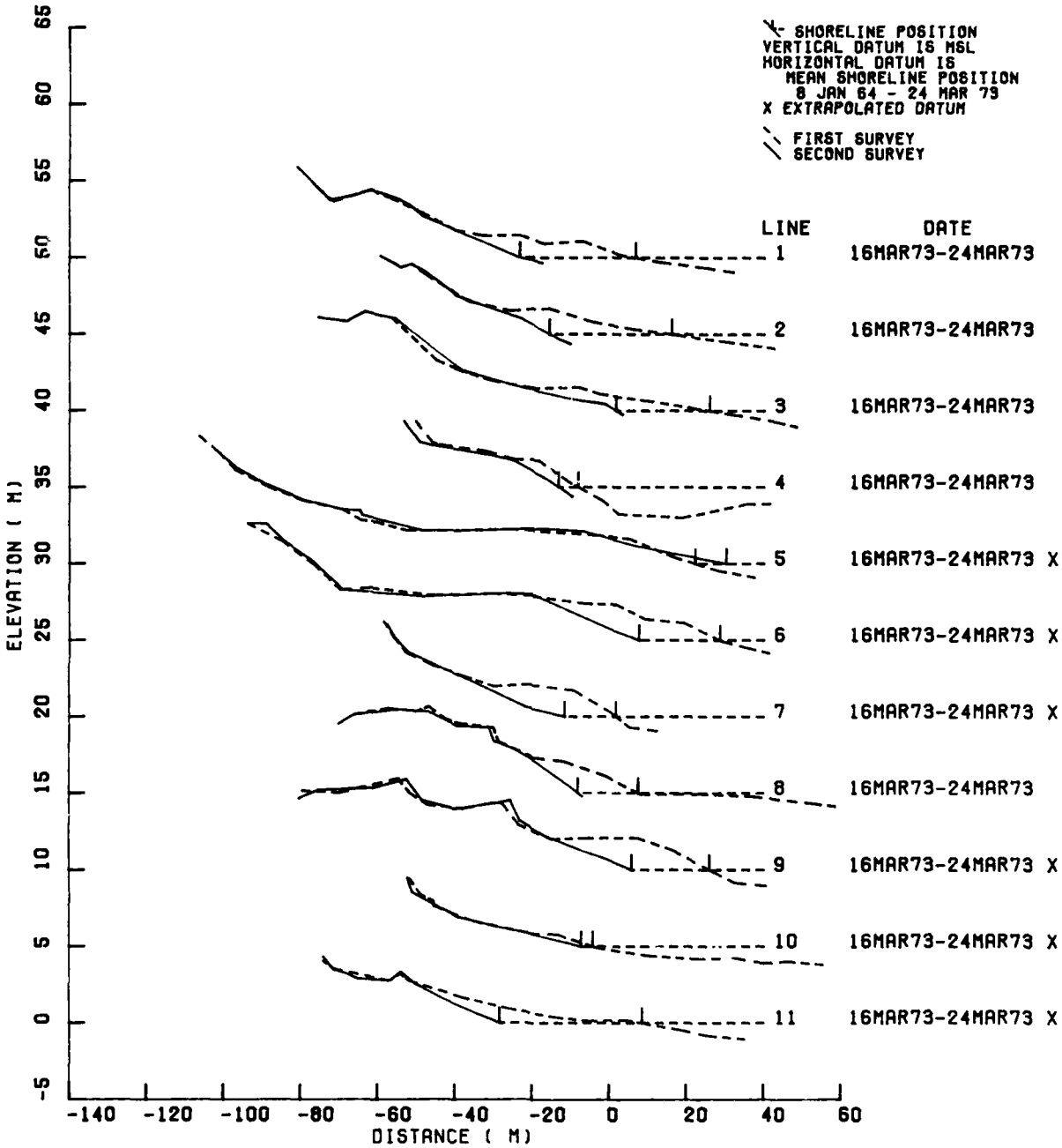



Figure J7. Profile comparisons for surveys at Westhampton, N. Y.

Table J3

Shoreline and Slope Changes at Westhampton, N.Y.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 16 Mar 73 | 24 Mar 73 | -29.99 | -0.046 | -0.057 | -0.011 |
| 2 | 16 Mar 73 | 24 Mar 73 | -31.44 | -0.034 | -0.138 | -0.103 |
| 3 | 16 Mar 73 | 24 Mar 73 | -24.01 | -0.041 | -0.147 | -0.106 |
| 4 | 16 Mar 73 | 24 Mar 73 | -5.07 | -0.141 | -0.175 | -0.034 |
| 5 | 16 Mar 73 | 24 Mar 73 X | 7.98 | -0.076 | -0.048 | 0.029 |
| 6 | 16 Mar 73 | 24 Mar 73 X | -21.03 | -0.121 | -0.094 | 0.027 |
| 7 | 16 Mar 73 | 24 Mar 73 X | -13.38 | -0.200 | -0.063 | 0.138 |
| 8 | 16 Mar 73 | 24 Mar 73 | -15.62 | -0.133 | -0.200 | -0.067 |
| 9 | 16 Mar 73 | 24 Mar 73 X | -20.21 | -0.134 | -0.105 | 0.030 |
| 10 | 16 Mar 73 | 24 Mar 73 X | -3.07 | -0.085 | -0.063 | 0.022 |
| 11 | 16 Mar 73 | 24 Mar 73 X | -36.84 | -0.047 | -0.100 | -0.053 |
| Median | | | -20.21 | -0.085 | -0.100 | -0.011 |
| Tri-Mean | | | -19.16 | -0.088 | -0.101 | -0.014 |
| High Hinge | | | -9.22 | -0.047 | -0.063 | 0.028 |
| Low Hinge | | | -27.00 | -0.134 | -0.143 | -0.060 |
| Mean | | | -17.52 | -0.096 | -0.108 | -0.012 |
| Standard Deviation | | | 13.49 | 0.053 | 0.051 | 0.071 |

Note: X = Extrapolated shoreline intercept.

Table J4

Unit Volume Changes ($m^3/m$) Between Contours
Westhampton Beach, N.Y.
from 16 Mar 73 to 24 Mar 73

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -33.87 | -14.09 | -13.23 | -6.40 | -0.53 | -0.40 | -0.58 | 0.18 | 0.92 | 0.27 | 0.00 | 0.00 | | | |
| 2 | -31.37 | -13.06 | -9.06 | -7.83 | -1.86 | 0.07 | -0.24 | 0.10 | 0.36 | 0.15 | 0.00 | 0.00 | | | |
| 3 | -18.01 | -9.81 | -7.98 | -6.73 | -0.01 | 0.54 | 0.56 | 1.37 | 1.32 | 1.12 | 0.91 | 0.70 | | | |
| 4 | -16.02 | -2.37 | -2.52 | -2.94 | -2.18 | -2.01 | -1.47 | -1.51 | -0.87 | -0.15 | | | | | |
| 5 | 9.88 | X 2.99 | 0.51 | -1.67 | -0.65 | 4.09 | 2.09 | 1.56 | 0.13 | 0.21 | 0.33 | 0.29 | | | |
| 6 | -48.88 | X -10.82 | -11.34 | -9.50 | -7.71 | -6.63 | -1.53 | -2.76 | 0.35 | 0.34 | 0.33 | 0.39 | | | |
| 7 | -38.24 | X -8.00 | -9.90 | -10.39 | -9.63 | -1.26 | -0.34 | 0.25 | 0.40 | 0.30 | 0.19 | 0.14 | | | |
| 8 | -32.28 | -7.50 | -6.95 | -6.18 | -4.75 | -1.88 | -0.28 | -0.42 | -0.60 | -1.25 | -0.62 | -1.85 | | | |
| 9 | -40.21 | X -10.37 | -10.98 | -11.84 | -11.58 | -0.73 | 0.81 | 0.68 | 0.84 | 1.59 | 0.18 | 1.19 | | | |
| 10 | -6.41 | X -2.06 | -1.84 | -0.31 | -0.21 | -0.14 | -0.17 | -0.73 | -0.72 | -0.23 | | | | | |
| 11 | -28.98 | X -12.29 | -6.75 | -4.42 | -2.69 | -1.27 | -0.84 | -1.01 | 0.12 | 0.17 | | | | | |
| Median | -31.37 | -9.81 | -7.98 | -6.40 | -2.18 | -0.73 | -0.28 | 0.10 | 0.35 | 0.21 | 0.19 | 0.22 | | | |
| Tri-mean | -28.95 | -9.03 | -7.76 | -6.29 | -2.80 | -0.77 | -0.27 | -0.05 | 0.27 | 0.19 | 0.18 | 0.24 | | | |
| High Hinge | -17.01 | -4.93 | -4.64 | -3.68 | -0.59 | -0.04 | 0.19 | 0.47 | 0.62 | 0.32 | 0.33 | 0.54 | | | |
| Low Hinge | -36.06 | -11.56 | -10.44 | -8.66 | -6.23 | -1.58 | -0.71 | -0.87 | -0.24 | 0.00 | 0.00 | 0.00 | | | |
| Mean | -25.85 | -7.94 | -7.28 | -6.20 | -3.80 | -0.87 | -0.18 | -0.21 | 0.20 | 0.23 | 0.17 | 0.11 | | | |
| Std Dev | 16.88 | 5.35 | 4.35 | 3.64 | 4.08 | 2.53 | 1.04 | 1.27 | 0.70 | 0.72 | 0.43 | 0.89 | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

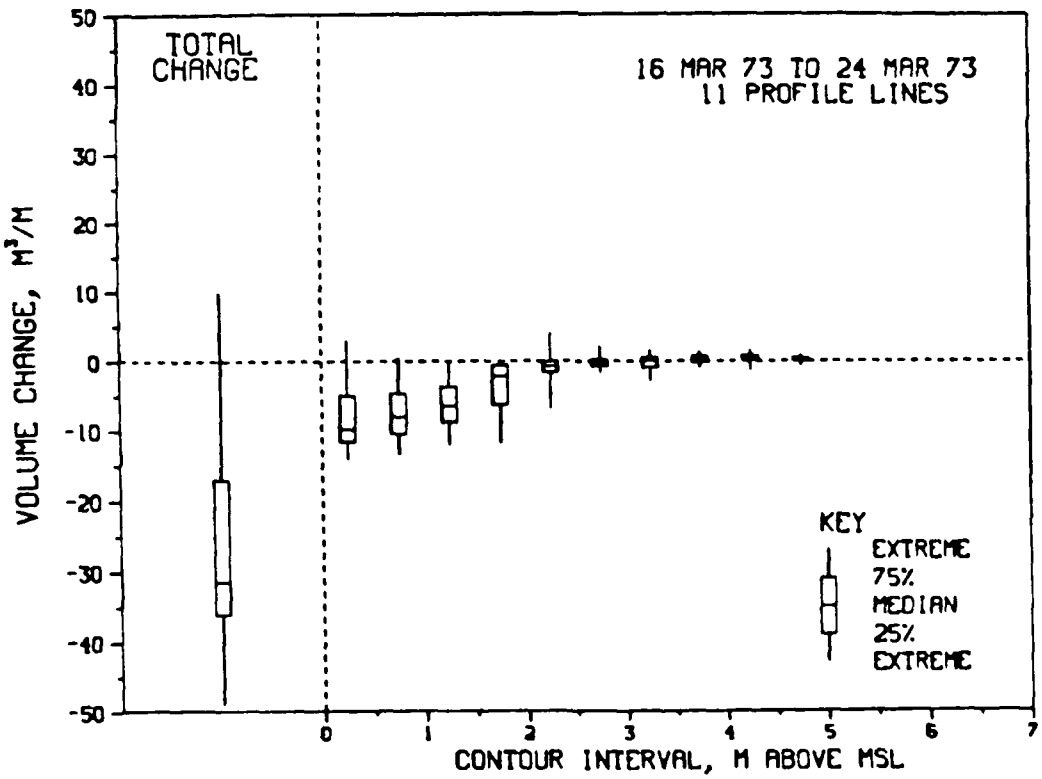



Figure J8. Distribution of volume changes by contour for Westhampton, N. Y.

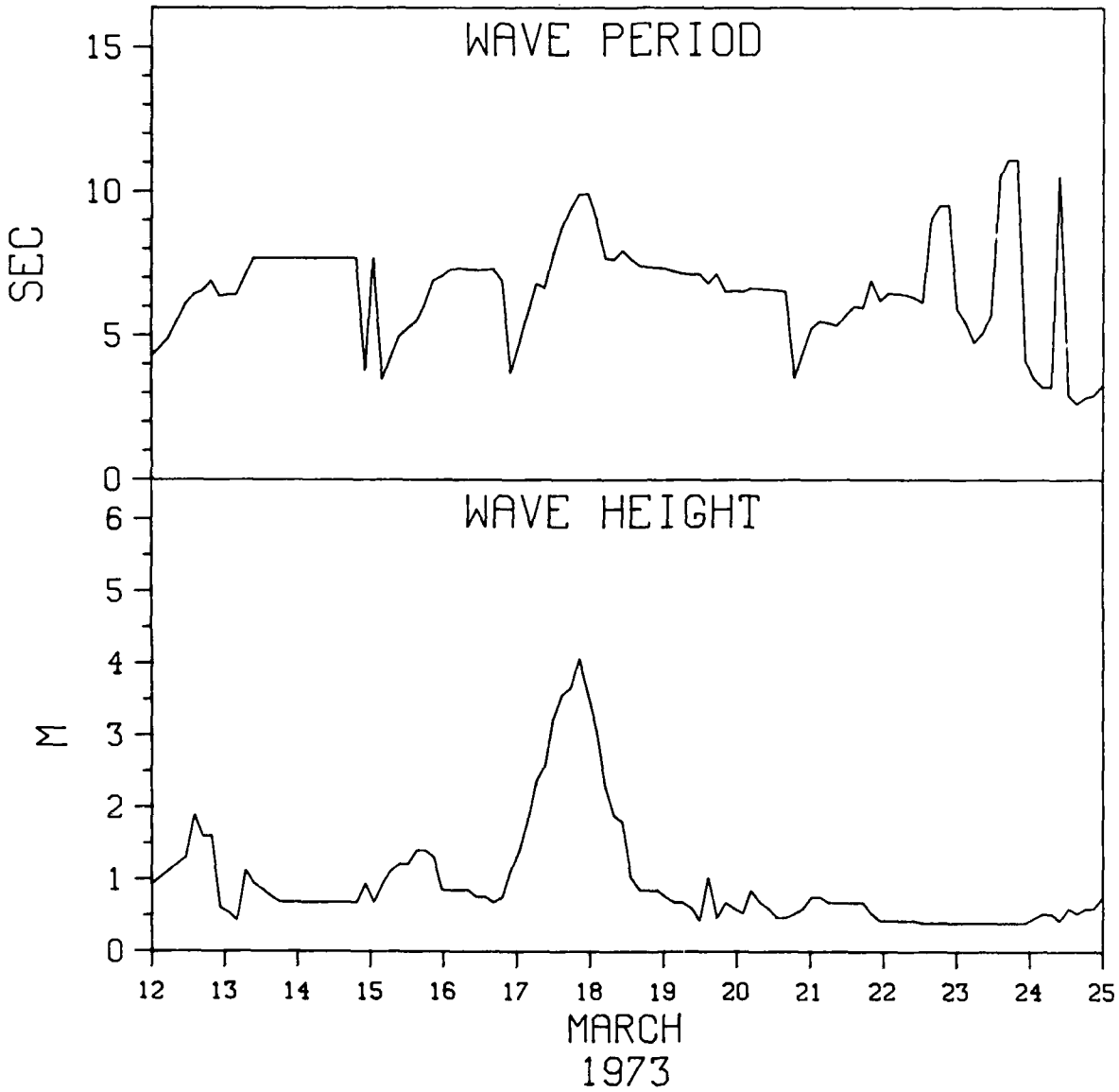



Figure J9. Hindcasted wave data for Jones Beach, N. Y.

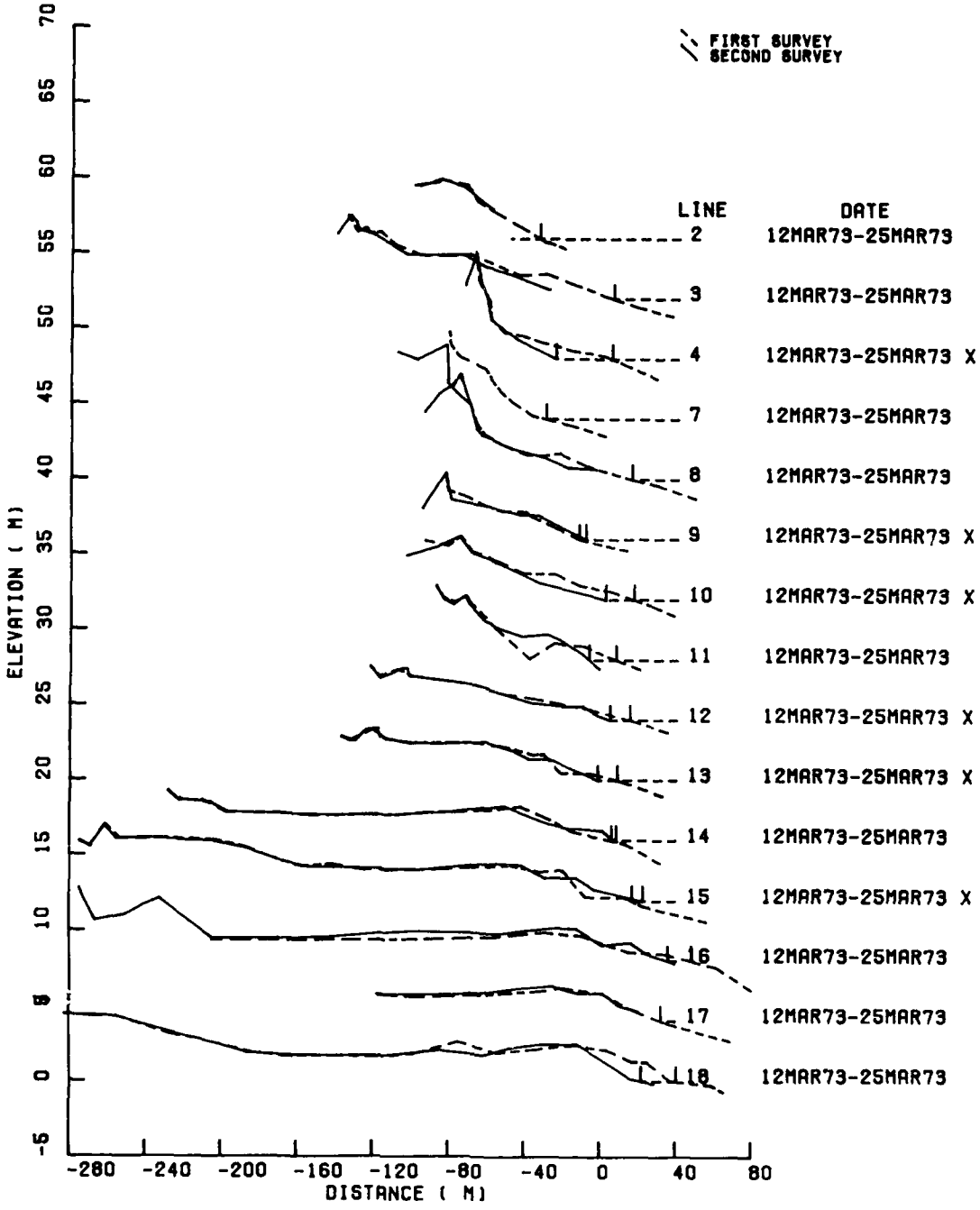



Figure J10. Profile comparisons for surveys at Jones Beach, N. Y.

Table J5

Shoreline and Slope Changes at Jones Beach, N.Y.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 4 | 12 Mar 73 | 25 Mar 73 X | -29.56 | -0.054 | -0.063 | -0.009 |
| 9 | 12 Mar 73 | 25 Mar 73 X | 3.53 | -0.062 | -0.063 | 0.000 |
| 10 | 12 Mar 73 | 25 Mar 73 X | -15.07 | -0.044 | -0.032 | 0.012 |
| 11 | 12 Mar 73 | 25 Mar 73 | -14.08 | -0.049 | -0.111 | -0.062 |
| 12 | 12 Mar 73 | 25 Mar 73 X | -10.45 | -0.033 | -0.052 | -0.019 |
| 13 | 12 Mar 73 | 25 Mar 73 X | -10.20 | -0.034 | -0.055 | -0.021 |
| 14 | 12 Mar 73 | 25 Mar 73 | 2.59 | -0.029 | -0.073 | -0.044 |
| 15 | 12 Mar 73 | 25 Mar 73 X | 5.57 | -0.063 | -0.030 | 0.033 |
| 16 | 12 Mar 73 | 25 Mar 73 | -12.33 | -0.032 | -0.042 | -0.010 |
| 18 | 12 Mar 73 | 25 Mar 73 | -18.17 | -0.013 | -0.028 | -0.015 |
| Median | | | -11.39 | -0.039 | -0.054 | -0.013 |
| Tri-Mean | | | -8.81 | -0.041 | -0.051 | -0.012 |
| High Hinge | | | 2.59 | -0.032 | -0.032 | 0.000 |
| Low Hinge | | | -15.07 | -0.054 | -0.063 | -0.021 |
| Mean | | | -9.82 | -0.041 | -0.055 | -0.014 |
| Standard Deviation | | | 10.96 | 0.016 | 0.025 | 0.027 |

Note: X=Extrapolated Shoreline Intercept.

Unit Volume Changes ($m^3/m$) Between Contours
Jones Beach, N.Y.
from 12 Mar 73 to 25 Mar 73

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | | 0.00 | 0.00 | 0.98 | 0.45 | -0.82 | | | | | | | |
| 3 | | | | -10.09 | -4.34 | -3.47 | -1.27 | -2.10 | -1.56 | -1.77 | 0.67 | | | | |
| 4 | -24.33 | X -13.16 | -7.48 | -4.29 | -0.12 | 0.14 | -0.16 | -0.32 | -0.46 | -0.04 | 0.29 | 0.46 | 0.38 | 0.43 | |
| 7 | | | | -12.04 | -11.94 | -11.91 | -10.90 | -9.44 | -5.78 | -2.43 | -0.93 | -0.27 | | | |
| 8 | | | | -6.16 | -0.66 | 0.03 | -0.74 | -0.86 | -0.39 | -0.22 | -0.07 | 0.02 | 0.09 | 0.16 | |
| 9 | -1.10 | X 1.78 | 1.83 | 2.09 | -1.12 | -1.59 | -4.20 | -0.22 | 0.22 | 0.11 | | | | | |
| 10 | -36.45 | X -8.63 | -8.73 | -9.02 | -4.40 | -1.10 | -1.47 | -1.81 | -1.26 | -0.03 | | | | | |
| 11 | 14.11 | -3.77 | 3.71 | 13.23 | 4.66 | -0.15 | -1.18 | -0.88 | -1.37 | -0.15 | 0.00 | | | | |
| 12 | -10.84 | X -3.84 | -0.93 | -5.08 | -0.66 | 0.04 | -0.71 | 0.34 | 0.00 | | | | | | |
| 13 | -3.88 | X -3.03 | 3.96 | -0.12 | -3.82 | -1.68 | -0.38 | 1.19 | | | | | | | |
| 14 | 2.41 | 4.12 | 3.56 | -2.94 | -2.37 | 1.40 | -1.29 | -0.07 | | | | | | | |
| 15 | 9.43 | X 5.96 | 4.97 | 2.77 | -6.07 | 6.86 | -0.24 | -0.52 | -2.37 | -1.36 | -0.57 | | | | |
| 16 | 57.35 | -5.15 | 4.69 | 19.21 | 35.70 | 2.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| 17 | | | | -0.80 | 4.53 | 3.74 | 0.00 | 0.00 | | | | | | | |
| 18 | -37.08 | -9.87 | -10.49 | -9.18 | -7.11 | -3.86 | 0.26 | 1.76 | 0.74 | 0.67 | | | | | |
| Median | -2.49 | -3.80 | 2.69 | -2.94 | -1.12 | 0.03 | -0.71 | -0.32 | -0.46 | -0.09 | 0.00 | 0.02 | 0.23 | 0.30 | |
| Tri-mean | -4.97 | -3.62 | 0.47 | -3.11 | -1.67 | -0.10 | -0.69 | -0.38 | -0.60 | -0.39 | -0.04 | 0.04 | 0.23 | 0.30 | |
| High Hinge | 9.43 | 1.78 | 3.96 | 1.04 | -0.06 | 1.19 | -0.08 | 0.00 | 0.00 | 0.00 | 0.14 | 0.24 | 0.38 | 0.43 | |
| Low Hinge | -24.33 | -8.63 | -7.48 | -7.59 | -4.37 | -1.63 | -1.28 | -0.87 | -1.46 | -1.36 | -0.32 | -0.13 | 0.09 | 0.16 | |
| Mean | -3.04 | -3.56 | -0.49 | -1.49 | 0.15 | -0.51 | -1.46 | -0.92 | -1.11 | -0.52 | -0.09 | 0.07 | 0.23 | 0.30 | |
| Std Dev | 27.73 | 6.13 | 6.08 | 8.56 | 10.71 | 4.17 | 2.84 | 2.56 | 1.80 | 0.98 | 0.53 | 0.37 | 0.21 | 0.19 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

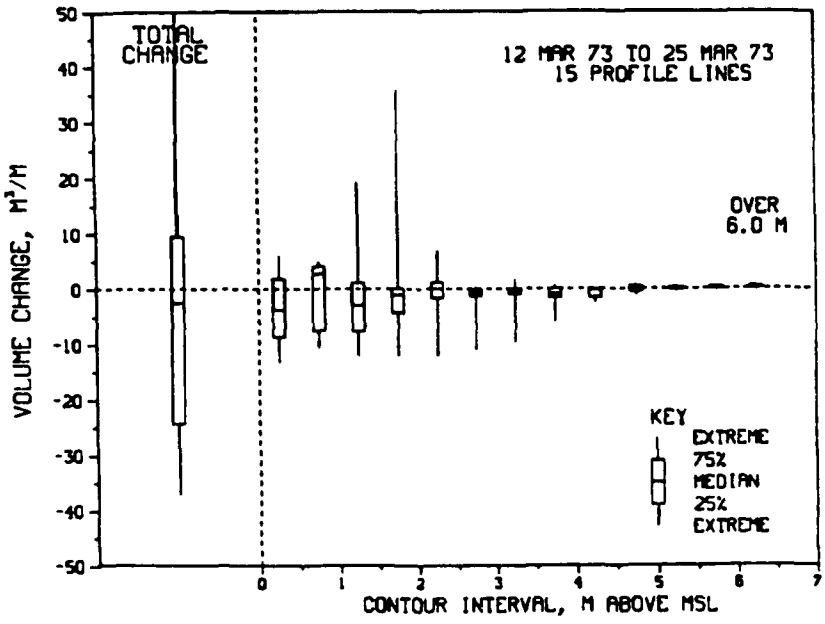



Figure J11. Distribution of volume changes by contour for Jones Beach, N. Y.

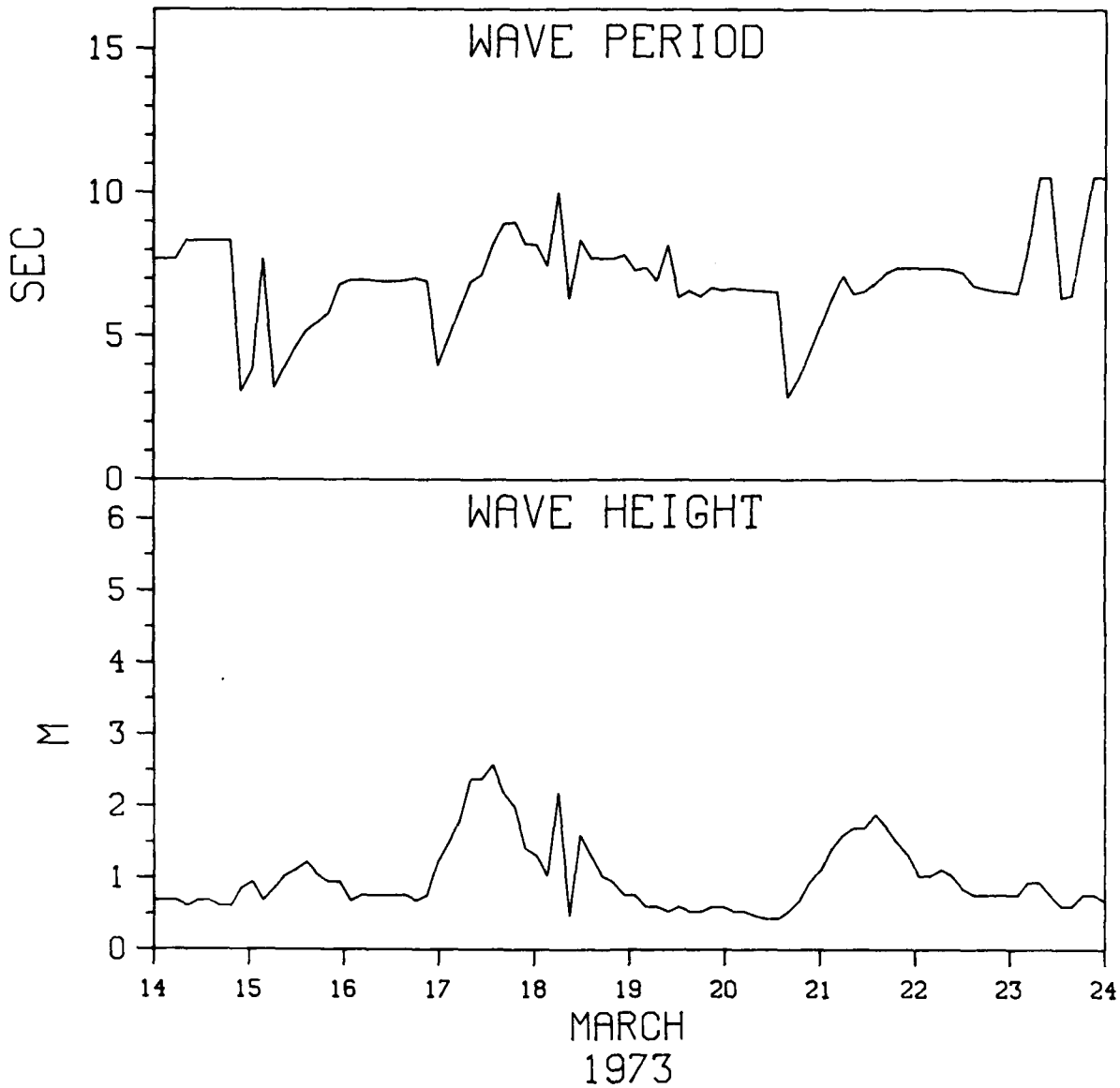
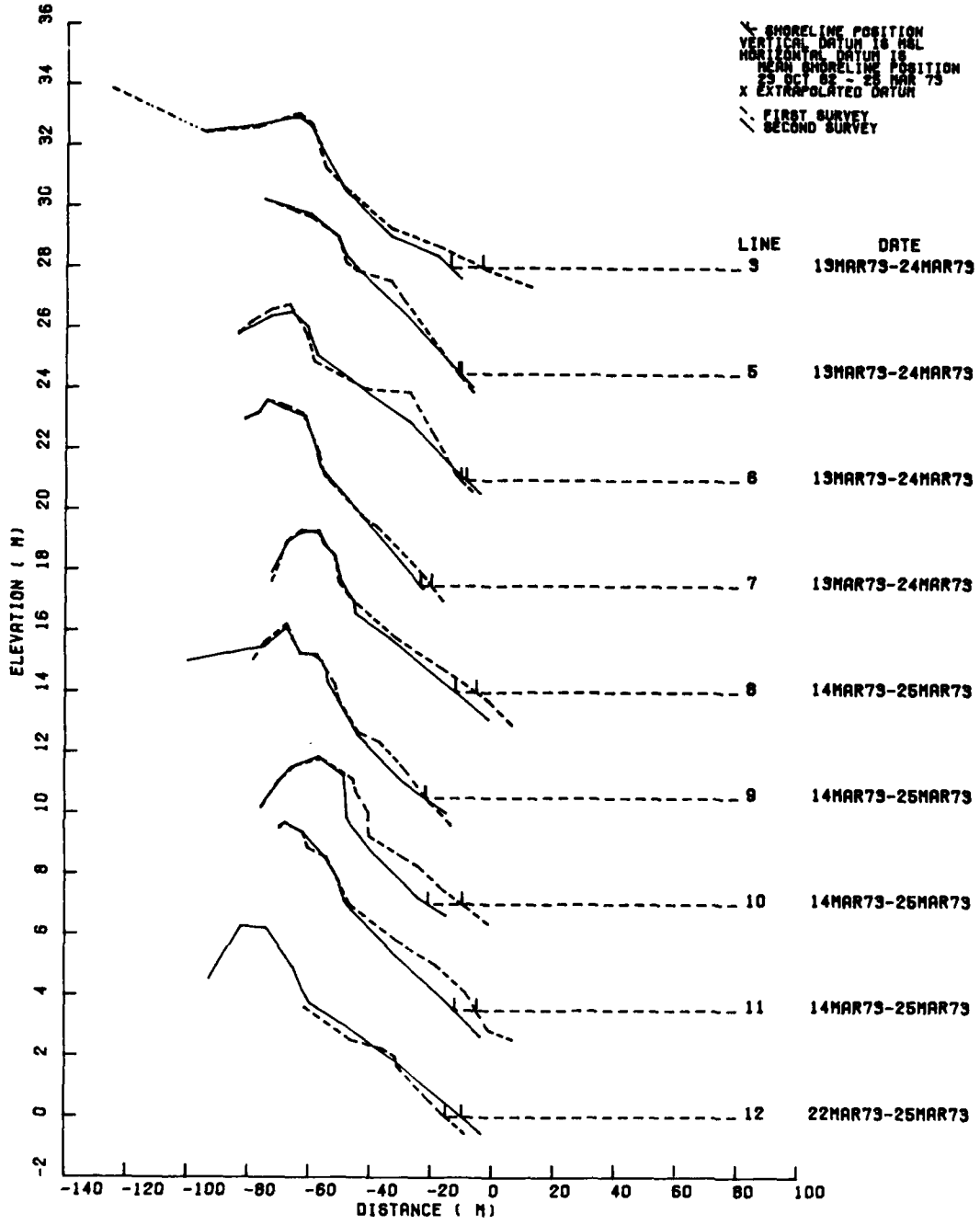
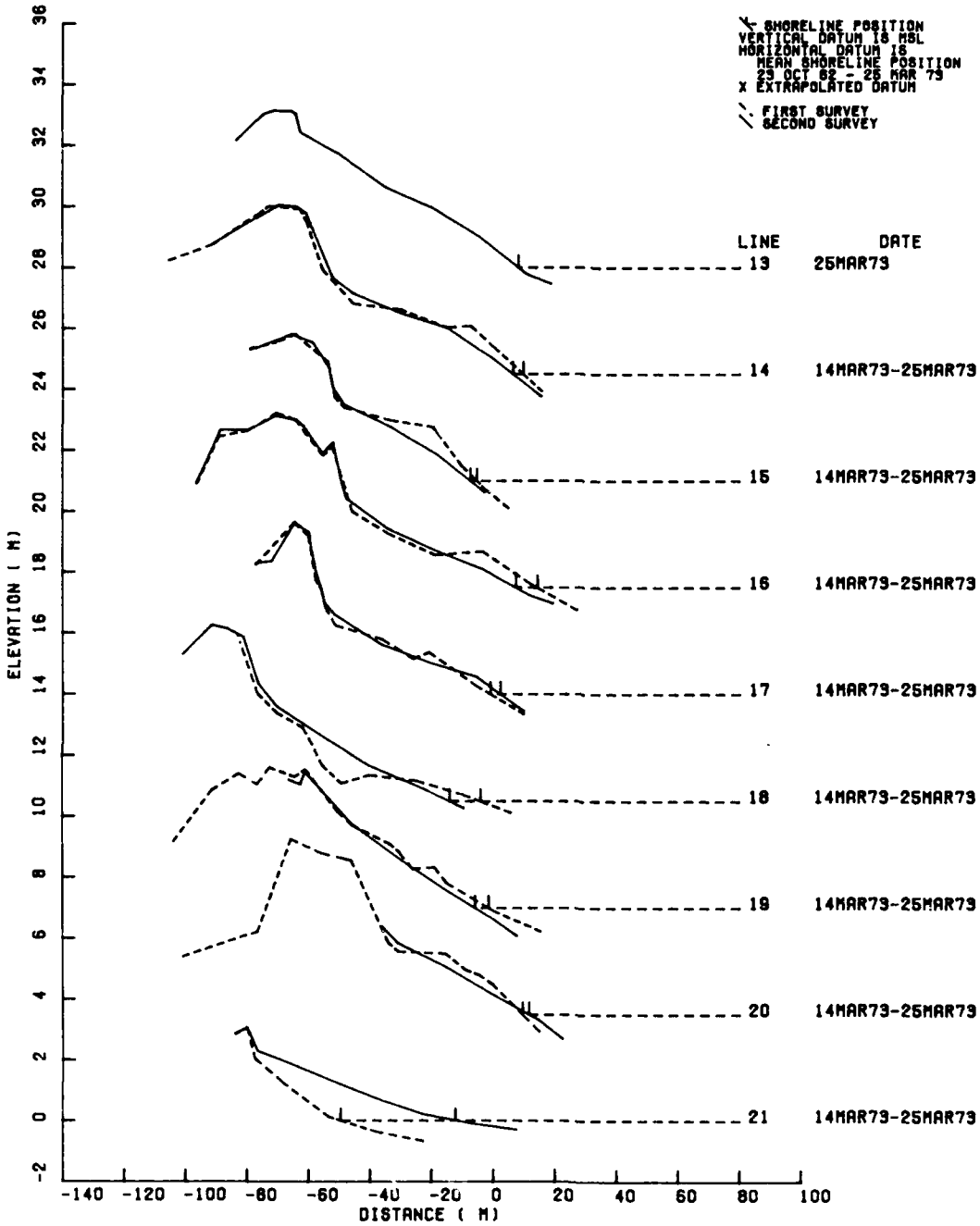



Figure J12. Hindcasted wave data for Long Beach Island, N. J.




a. Profile lines 3-12

Figure J13. Profile comparisons for surveys at Long Beach Island, N. J. (Continued)




b. Profile lines 13-21

Figure J13. (Concluded)

Table J7

Shoreline and Slope Changes at Long Beach Island, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 3 | 13 Mar 73 | 24 Mar 73 | -10.50 | -0.050 | -0.096 | -0.046 |
| 5 | 13 Mar 73 | 24 Mar 73 | 0.71 | -0.128 | -0.112 | 0.016 |
| 6 | 13 Mar 73 | 24 Mar 73 | 1.74 | -0.106 | -0.096 | 0.010 |
| 7 | 13 Mar 73 | 24 Mar 73 | -3.49 | -0.133 | -0.122 | 0.011 |
| 8 | 14 Mar 73 | 25 Mar 73 | -6.86 | -0.070 | -0.082 | -0.012 |
| 9 | 14 Mar 73 | 25 Mar 73 | -0.26 | -0.140 | -0.073 | 0.067 |
| 10 | 14 Mar 73 | 25 Mar 73 | -11.18 | -0.076 | -0.066 | 0.010 |
| 11 | 14 Mar 73 | 25 Mar 73 | -7.17 | -0.164 | -0.102 | 0.062 |
| 12 | 22 Mar 73 | 25 Mar 73 | 5.35 | -0.088 | -0.086 | 0.002 |
| 14 | 14 Mar 73 | 25 Mar 73 | -3.31 | -0.094 | -0.080 | 0.014 |
| 15 | 14 Mar 73 | 25 Mar 73 | -2.13 | -0.100 | -0.080 | 0.020 |
| 16 | 14 Mar 73 | 25 Mar 73 | -6.98 | -0.058 | -0.056 | 0.002 |
| 17 | 14 Mar 73 | 25 Mar 73 | 3.25 | -0.060 | -0.074 | -0.014 |
| 18 | 14 Mar 73 | 25 Mar 73 | -10.06 | -0.038 | -0.048 | -0.010 |
| 19 | 14 Mar 73 | 25 Mar 73 | -4.38 | -0.060 | -0.062 | -0.002 |
| 20 | 14 Mar 73 | 25 Mar 73 | 2.11 | -0.102 | -0.056 | 0.046 |
| 21 | 14 Mar 73 | 25 Mar 73 | 37.34 | -0.032 | -0.020 | 0.012 |
| Median | | | -3.31 | -0.088 | -0.080 | 0.010 |
| Tri-Mean | | | -2.96 | -0.086 | -0.080 | 0.009 |
| High Hinge | | | 1.74 | -0.060 | -0.062 | 0.016 |
| Low Hinge | | | -6.98 | -0.106 | -0.096 | -0.002 |
| Mean | | | -0.93 | -0.088 | -0.077 | 0.011 |
| Standard Deviation | | | 11.06 | 0.038 | 0.025 | 0.028 |

Note: X = Extrapolated shoreline intercept.

Table J8

Unit Volume Changes ($m^3/m$) Between Contours
Long Beach Island, N.J.
from 13 Mar 73 to 24 Mar 73

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | -10.30 | -4.13 | -3.80 | -2.14 | -1.09 | -0.73 | 0.01 | 0.94 | 0.67 | 0.23 | -0.09 | -0.17 | 0.00 | | |
| 5 | -6.04 | 0.21 | -0.22 | -0.74 | -1.26 | -1.89 | -2.77 | -1.41 | 0.75 | 0.16 | 0.17 | 0.78 | 0.18 | | |
| 6 | -13.21 | 0.53 | -0.44 | -1.41 | -2.39 | -4.15 | -5.68 | 0.33 | 1.46 | 0.81 | 0.47 | -1.33 | -1.41 | | |
| 7 | -6.48 | -1.82 | -1.64 | -1.33 | -1.03 | -0.19 | 0.16 | 0.34 | 0.15 | -0.27 | -0.11 | 0.11 | -0.74 | -0.13 | |
| 8 | -10.33 | -3.17 | -2.57 | -1.80 | -1.19 | -1.62 | -1.18 | 0.23 | 0.62 | 0.49 | 0.02 | -0.16 | | | |
| 9 | -10.25 | -0.96 | -2.07 | -2.39 | -2.33 | -0.47 | -0.19 | -0.21 | -0.78 | -0.11 | 0.49 | -0.91 | -0.32 | | |
| 10 | -30.02 | -5.64 | -5.29 | -4.98 | -3.49 | -2.02 | -3.19 | -2.96 | -1.92 | -0.80 | 0.27 | | | | |
| 11 | -22.58 | -4.05 | -4.79 | -4.87 | -4.24 | -2.68 | -1.74 | -0.96 | -0.38 | 0.02 | -0.06 | 0.69 | 0.42 | 0.06 | |
| 12 | 11.47 | 2.50 | 1.93 | 1.30 | 0.16 | -0.17 | 2.43 | 2.18 | 1.12 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 14 | -3.71 | -1.89 | -2.64 | -3.62 | -1.16 | 1.28 | 1.42 | 0.77 | 1.01 | 0.88 | 0.34 | -0.22 | 0.12 | | |
| 15 | -12.15 | -1.38 | -2.36 | -4.42 | -5.35 | -0.34 | 0.52 | 0.01 | -0.14 | 0.52 | 0.79 | | | | |
| 16 | -3.40 | -3.72 | -5.02 | -0.43 | 1.53 | 1.57 | 0.69 | -0.25 | -0.02 | 0.40 | 0.89 | 1.41 | -0.55 | | |
| 17 | 0.51 | 1.95 | 0.39 | -1.63 | -1.00 | 1.74 | 0.68 | 0.06 | 0.35 | -0.37 | -1.29 | -0.37 | 0.00 | | |
| 18 | 19.23 | -4.06 | 3.91 | 7.16 | 4.44 | 1.87 | 1.40 | 1.26 | 0.99 | 0.76 | 0.81 | 0.70 | 0.00 | | |
| 19 | -9.18 | -2.12 | -2.00 | -1.88 | -1.16 | -1.25 | 0.09 | 0.43 | 0.14 | -1.41 | -0.02 | | | | |
| 20 | -6.03 | 0.05 | -1.90 | -2.88 | -3.26 | 1.41 | 0.55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | |
| 21 | 43.55 | 15.88 | 11.64 | 8.54 | 5.48 | 1.66 | 0.35 | 0.00 | | | | | | | |
| Median | -6.48 | -1.82 | -2.00 | -1.80 | -1.16 | -0.34 | 0.16 | 0.06 | 0.25 | 0.09 | 0.09 | 0.00 | 0.00 | 0.00 | |
| Tri-mean | -6.67 | -1.79 | -1.72 | -1.81 | -1.43 | -0.22 | -0.04 | 0.09 | 0.32 | 0.12 | 0.16 | 0.12 | -0.09 | -0.01 | |
| High Hinge | -3.40 | 0.21 | -0.22 | -0.74 | -1.00 | 1.41 | 0.68 | 0.43 | 0.87 | 0.50 | 0.48 | 0.69 | 0.06 | 0.03 | |
| Low Hinge | -10.33 | -3.72 | -2.64 | -2.88 | -2.39 | -1.62 | -1.18 | -0.21 | -0.08 | -0.19 | -0.04 | -0.22 | -0.44 | -0.06 | |
| Mean | -4.05 | -0.70 | -0.99 | -1.03 | -1.02 | -0.35 | -0.38 | 0.04 | 0.25 | 0.08 | 0.17 | 0.04 | -0.19 | -0.02 | |
| Std Dev | 16.57 | 4.84 | 4.05 | 3.72 | 2.78 | 1.78 | 1.99 | 1.12 | 0.83 | 0.61 | 0.52 | 0.73 | 0.50 | 0.10 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

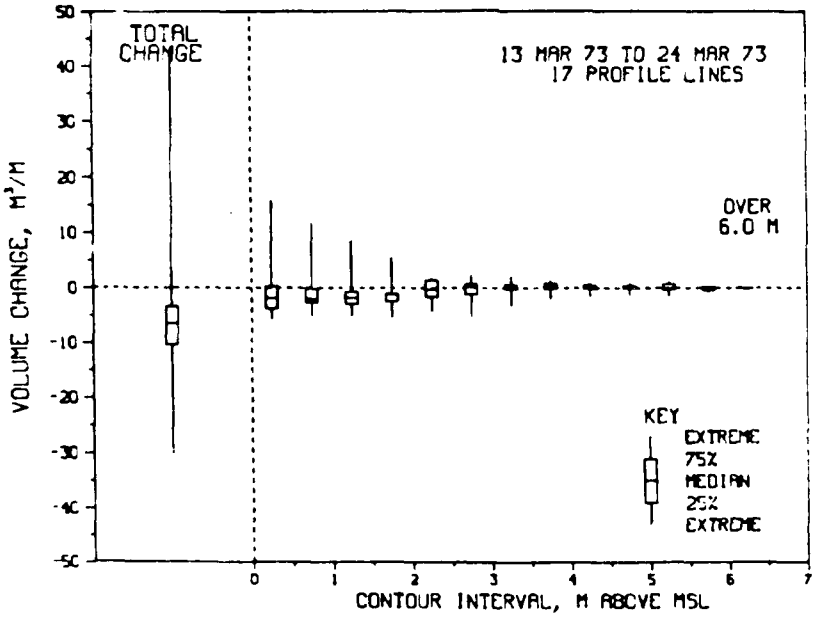



Figure J14. Distribution of volume changes by contour for Long Beach Island, N. J.

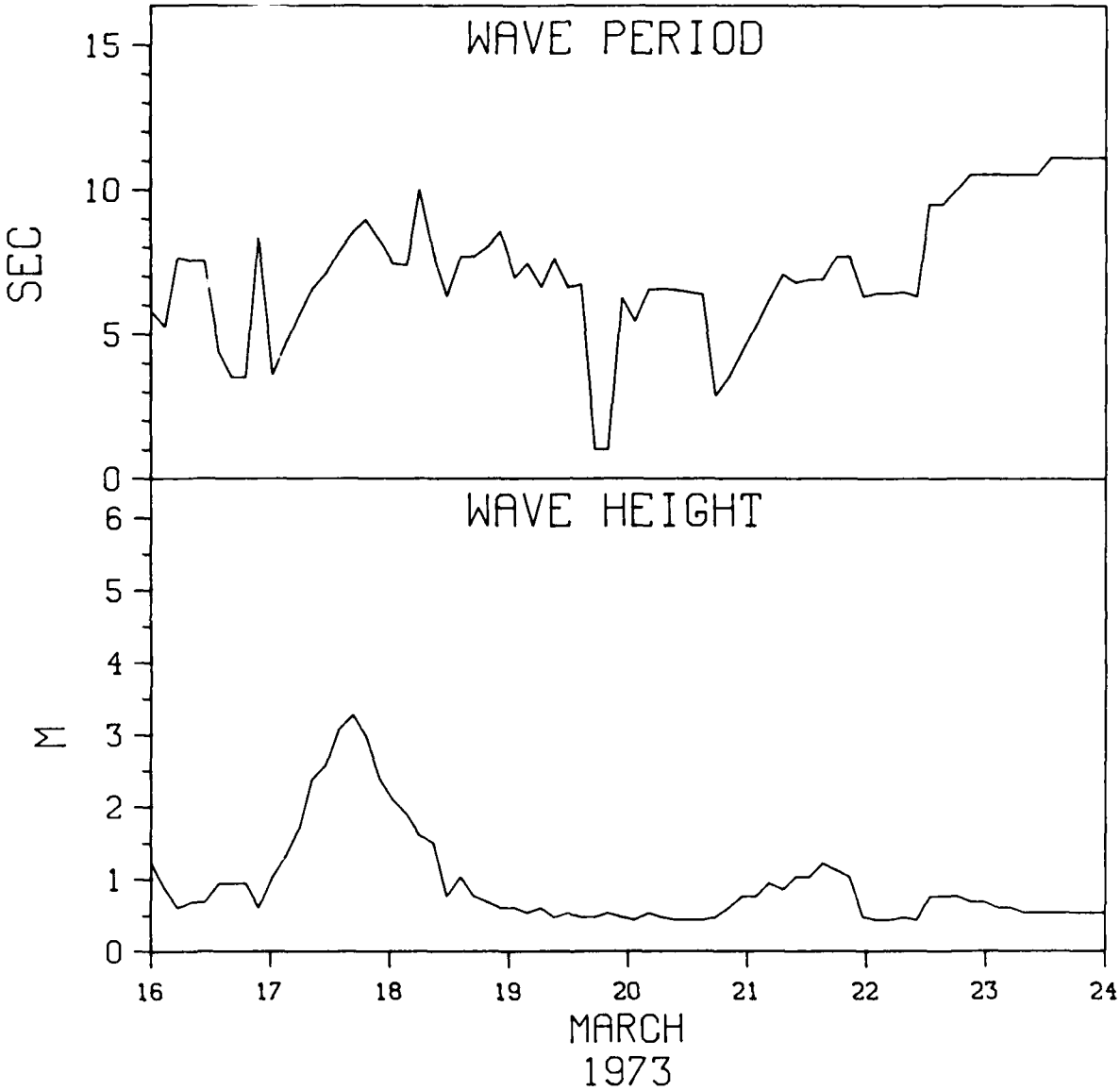



Figure J15. Hindcasted wave data for Atlantic City, N. J.

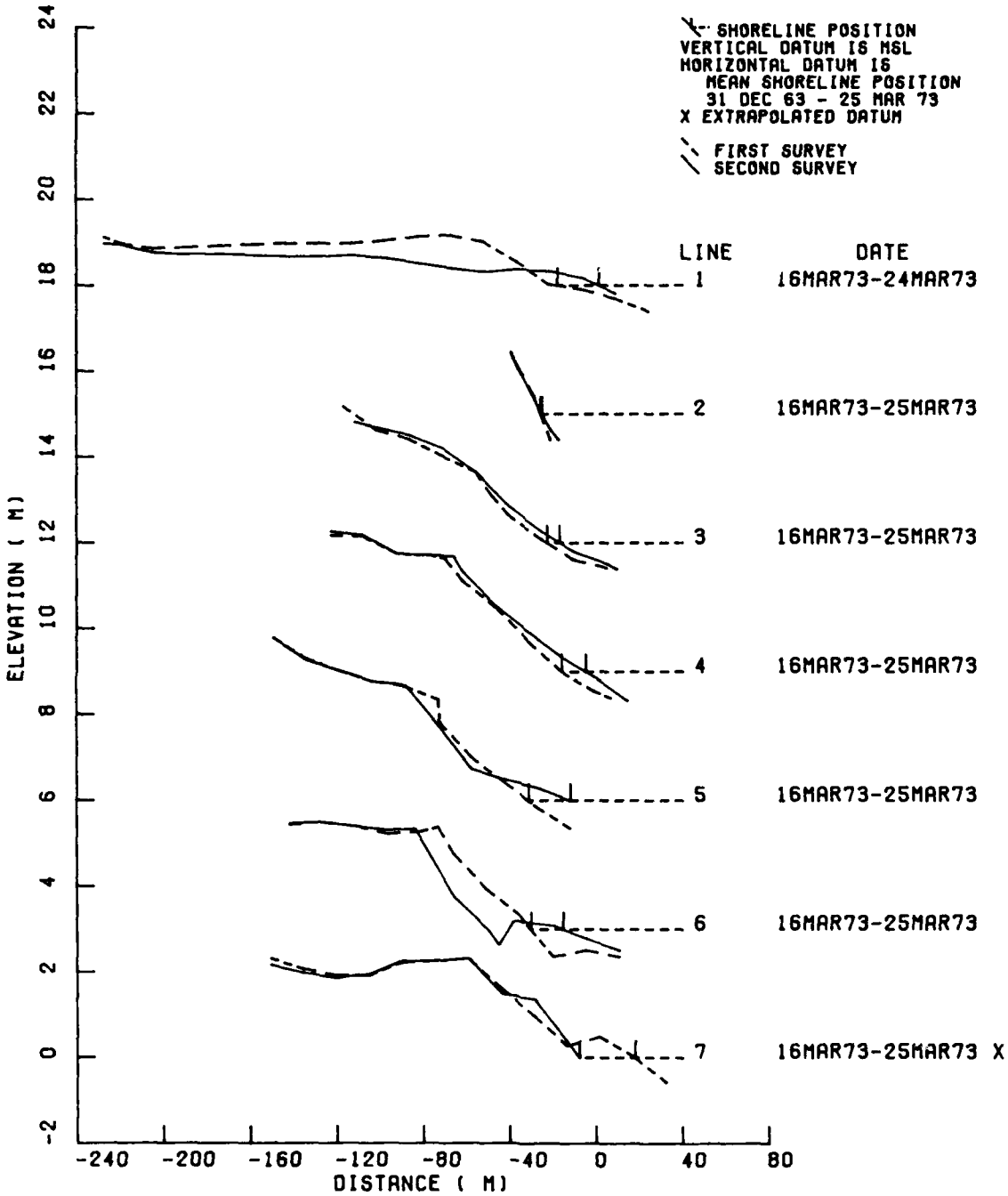



Figure J16. Profile comparisons for surveys at Atlantic City, N. J.

Table J9

Shoreline and Slope Changes at Atlantic City, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 1 | 16 Mar 73 | 24 Mar 73 | 19.05 | -0.008 | -0.024 | -0.016 |
| 2 | 16 Mar 73 | 25 Mar 73 | 0.67 | -0.136 | -0.096 | 0.040 |
| 3 | 16 Mar 73 | 25 Mar 73 | 5.72 | -0.032 | -0.032 | 0.000 |
| 4 | 16 Mar 73 | 25 Mar 73 | 11.18 | -0.046 | -0.030 | 0.016 |
| 5 | 16 Mar 73 | 25 Mar 73 | 19.25 | -0.038 | -0.020 | 0.018 |
| 6 | 16 Mar 73 | 25 Mar 73 | 14.90 | -0.062 | -0.020 | 0.042 |
| 7 | 16 Mar 73 | 25 Mar 73 X | -25.70 | -0.040 | -0.066 | -0.026 |
| Median | | | 11.18 | -0.040 | -0.030 | 0.016 |
| Tri-Mean | | | 10.63 | -0.042 | -0.033 | 0.013 |
| High Hinge | | | 16.97 | -0.035 | -0.022 | 0.029 |
| Low Hinge | | | 3.19 | -0.054 | -0.049 | -0.008 |
| Mean | | | 6.44 | -0.052 | -0.041 | 0.011 |
| Standard Deviation | | | 15.73 | 0.041 | 0.029 | 0.026 |

Note: X = Extrapolated shoreline intercept.

Table J10

Unit Volume Changes ($m^3/m$) Between Contours
Atlantic City, N.J.
from 16 Mar 73 to 24 Mar 73

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -58.12 | 0.09 | -52.96 | -5.25 | | | | | | | | | | | |
| 2 | -0.48 | -0.04 | -0.33 | -0.11 | | | | | | | | | | | |
| 3 | 10.09 | 2.69 | 2.24 | 1.04 | 0.93 | 2.92 | 0.26 | 0.00 | | | | | | | |
| 4 | 12.97 | 4.23 | 2.59 | 1.08 | 1.03 | 1.84 | 1.12 | 1.08 | | | | | | | |
| 5 | -3.50 | 6.03 | -2.24 | -1.76 | -1.38 | -3.62 | -0.08 | -0.39 | -0.06 | | | | | | |
| 6 | -31.91 | -7.43 | -9.55 | -7.45 | -5.88 | -1.60 | | | | | | | | | |
| 7 | -6.43 | X -8.34 | 2.26 | 3.29 | -1.97 | -1.67 | | | | | | | | | |
| Median | -3.50 | 0.09 | -0.33 | -0.11 | -1.38 | -1.60 | 0.26 | 0.00 | -0.06 | | | | | | |
| Tri-mean | -5.34 | -0.02 | -1.08 | -0.67 | -0.95 | -0.76 | 0.32 | 0.09 | -0.06 | | | | | | |
| High Hinge | 4.81 | 3.46 | 2.25 | 1.06 | 0.93 | 1.84 | 0.69 | 0.54 | -0.06 | | | | | | |
| Low Hinge | -19.17 | -3.73 | -5.89 | -3.51 | -1.97 | -1.67 | 0.09 | -0.19 | -0.06 | | | | | | |
| Mean | -11.05 | -0.40 | -8.28 | -1.31 | -1.45 | -0.43 | 0.43 | 0.23 | -0.06 | | | | | | |
| Std Dev | 25.38 | 5.56 | 20.16 | 3.81 | 2.82 | 2.71 | 0.62 | 0.76 | 0.00 | | | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

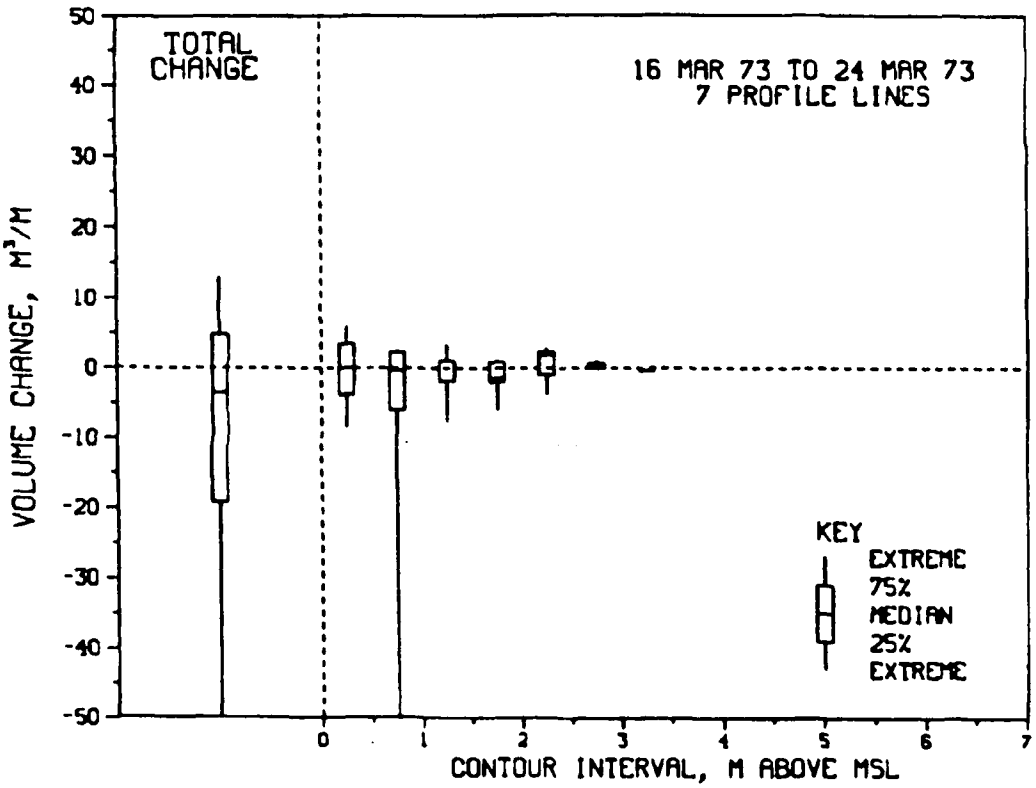



Figure J17. Distribution of volume changes by contour for Atlantic City, N. J.

## APPENDIX K: DATA SUMMARY FOR THE STORM OF 14 OCTOBER 1977

1. The storm of 14 October 1977, although short in duration, caused significant erosion along the east coast. Though this storm was a typical "northeaster" moving northward close along the coast, it was complicated by the development and passage of Hurricane Evelyn. Figure K1 illustrates the tracks of the two storms.

2. This event was monitored by a two-man crew at Long Beach Island and Ludlam Beach. Hindcasted waves for this storm were not available; however, visual observations taken during the storm recorded breaking wave heights of 1.8 m with periods of 6 to 7.5 sec at both localities. Peak tide measured at the Atlantic City gage was 1.8 m above msl with an associated surge of approximately 0.9 m. Survey crews were in New Jersey when the storm developed, and profiling was completed immediately before and after the storm. Even so, there is some evidence of recovery on the Long Beach profile lines near the msl intercept.

3. This storm produced significant but varied changes on the two beaches. All profile lines eroded with most erosion occurring between the 1- and 2-m contours at Ludlam Beach and between the 1.5- and 2.5-m contours at Long Beach Island. Further evidence of recovery at Long Beach Island is the 5 m of shoreline accretion. Long Beach Island experienced consistent erosion with a median volume change of -26.2 $m^3/m$ and a hinge range of only 11.8 $m^3/m$. The dunes on most of the lines also eroded.

4. At Ludlam Beach, the storm caused a -4.7 m shoreline movement and a slight steepening of the foreshore. The median change was -14.8 $m^3/m$ with a hinge range of 13.4 $m^3/m$. The changes were lowest within the Sea Isle City groin field (profile lines 11 to 16) and highest between profile lines 4 and 10. The storm caused the dune both north and south of the groin field to erode and to breach between profile lines 7 and 8.

5. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.

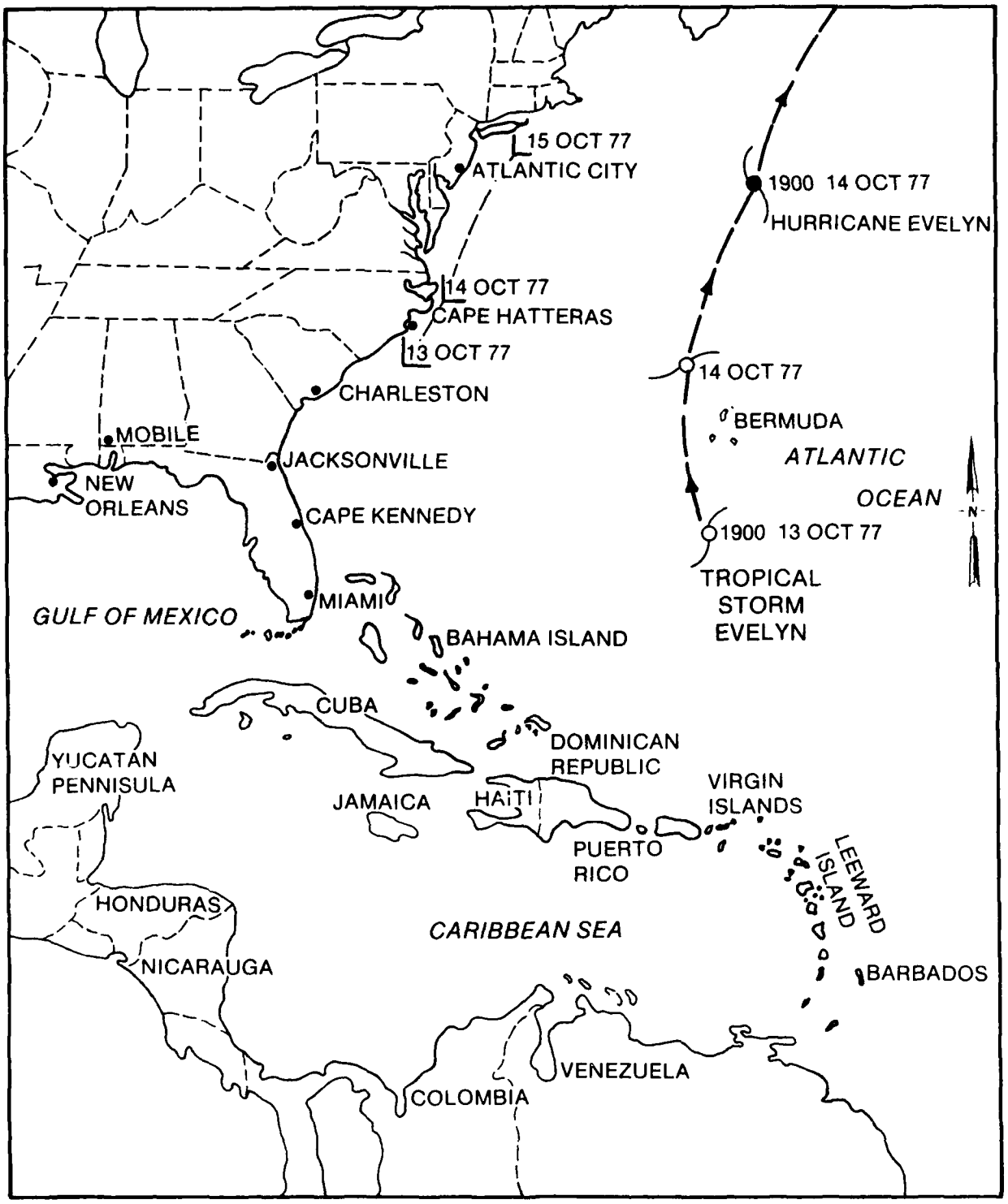



Figure K1. Paths of low and Hurricane Evelyn from 13-15 October 1977

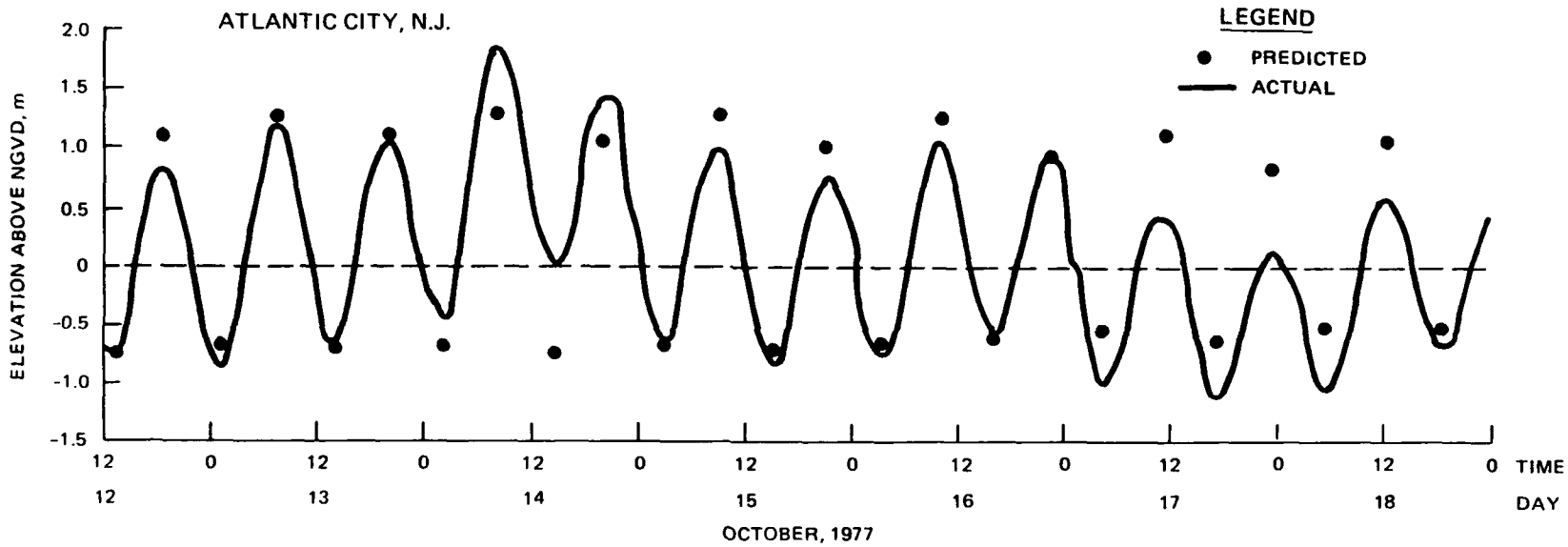



Figure K2. Actual and predicted water level data for 12-18 October 1977

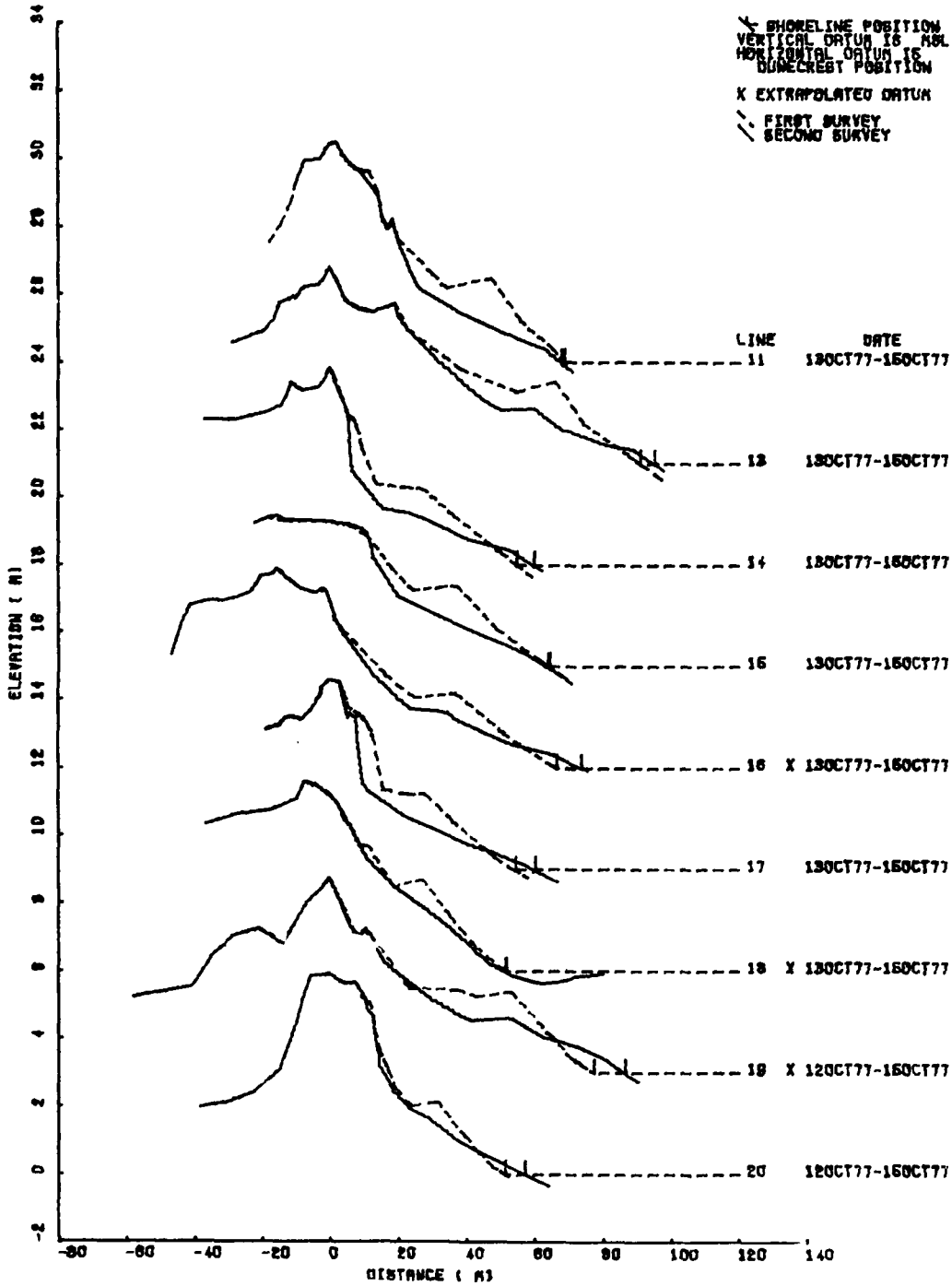



Figure K3. Profile comparisons for surveys at Long Beach Island, N. J.

Table K1

Shoreline and Slope Changes at Long Beach Island, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 11 | 13 Oct 77 | 15 Oct 77 | -0.84 | -0.125 | -0.087 | 0.038 |
| 13 | 13 Oct 77 | 15 Oct 77 | 4.08 | -0.074 | -0.068 | 0.006 |
| 14 | 13 Oct 77 | 15 Oct 77 | 4.96 | -0.076 | -0.061 | 0.015 |
| 15 | 13 Oct 77 | 15 Oct 77 | -0.51 | -0.073 | -0.063 | 0.010 |
| 16 | 13 Oct 77 X | 15 Oct 77 | 7.13 | -0.065 | -0.050 | 0.015 |
| 17 | 13 Oct 77 | 15 Oct 77 | 5.87 | -0.059 | -0.054 | 0.006 |
| 18 | 13 Oct 77 X | 15 Oct 77 | 0.12 | -0.085 | -0.054 | 0.031 |
| 19 | 12 Oct 77 X | 15 Oct 77 | 9.11 | -0.067 | -0.069 | -0.002 |
| 20 | 12 Oct 77 | 15 Oct 77 | 5.62 | -0.067 | -0.049 | 0.018 |
| Median | | | 4.96 | -0.073 | -0.061 | 0.015 |
| Tri-Mean | | | 3.98 | -0.072 | -0.061 | 0.014 |
| High Hinge | | | 5.87 | -0.067 | -0.054 | 0.018 |
| Low Hinge | | | 0.12 | -0.076 | -0.068 | 0.006 |
| Mean | | | 3.95 | -0.077 | -0.062 | 0.015 |
| Standard Deviation | | | 3.57 | 0.020 | 0.012 | 0.013 |

Note: X = Extrapolated shoreline intercept.

Table K2

Unit Volume Changes ($m^3/m$) Between Contours
Long Beach Island, N.J.
from 13 Oct 77 to 15 Oct 77

| Profile Line | Total Changes | | 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Contours (m) above MSL | | | | | | | | | | | | | |
| 11 | -34.56 | | -1.03 | -3.98 | -6.75 | -9.27 | -8.25 | -2.57 | -1.22 | -0.16 | 0.00 | -0.12 | -0.82 | -0.38 | 0.00 | |
| 13 | -29.81 | | 1.69 | -2.75 | -4.75 | -10.56 | -8.82 | -2.35 | -1.36 | -0.45 | -0.34 | -0.12 | -0.01 | 0.00 | | |
| 14 | -26.43 | | 1.88 | -2.08 | -4.55 | -8.49 | -6.10 | -2.66 | -2.13 | -1.52 | -0.77 | 0.03 | -0.05 | 0.00 | | |
| 15 | -26.90 | | -0.64 | -2.80 | -5.27 | -8.22 | -7.30 | -2.03 | -1.39 | -0.07 | 0.82 | | | | | |
| 16 | -17.88 | X | 2.87 | -1.33 | -3.86 | -7.76 | -4.09 | -1.73 | -1.27 | -0.74 | 0.07 | 0.05 | -0.10 | 0.00 | | |
| 17 | -26.20 | | 1.92 | -1.80 | -4.72 | -6.63 | -4.81 | -2.79 | -2.58 | -2.36 | -1.55 | -0.68 | -0.20 | 0.00 | | |
| 18 | -12.35 | X | -0.64 | -0.87 | -1.46 | -2.54 | -3.93 | -1.17 | -1.08 | -0.62 | -0.04 | 0.04 | -0.03 | 0.00 | | |
| 19 | -15.08 | X | 4.56 | 2.28 | -1.98 | -9.66 | -9.53 | 0.58 | -0.58 | -0.37 | -0.17 | -0.13 | -0.07 | 0.00 | | |
| 20 | -7.92 | | 1.97 | -0.47 | -2.19 | -3.72 | -1.20 | -0.67 | -0.82 | -0.33 | -0.20 | -0.34 | 0.03 | 0.02 | | |
| Median | -26.20 | | 1.88 | -1.80 | -4.55 | -8.22 | -6.10 | -2.03 | -1.27 | -0.45 | -0.17 | -0.12 | -0.06 | 0.00 | 0.00 | |
| Tri-mean | -23.60 | | 1.27 | -1.80 | -4.01 | -8.09 | -6.14 | -1.95 | -1.25 | -0.49 | -0.17 | -0.11 | -0.07 | 0.00 | 0.00 | |
| High Hinge | -15.08 | | 1.97 | -0.87 | -2.19 | -6.63 | -4.09 | -1.17 | -1.08 | -0.33 | 0.00 | 0.04 | -0.02 | 0.00 | 0.00 | |
| Low Hinge | -26.90 | | -0.64 | -2.75 | -4.75 | -9.27 | -8.25 | -2.57 | -1.39 | -0.74 | -0.34 | -0.23 | -0.15 | 0.00 | 0.00 | |
| Mean | -21.90 | | 1.40 | -1.53 | -3.95 | -7.43 | -6.00 | -1.71 | -1.38 | -0.74 | -0.24 | -0.16 | -0.16 | -0.04 | 0.00 | |
| Std Dev | 8.92 | | 1.65 | 1.79 | 1.75 | 2.70 | 2.73 | 1.11 | 0.62 | 0.74 | 0.65 | 0.25 | 0.28 | 0.14 | 0.00 | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

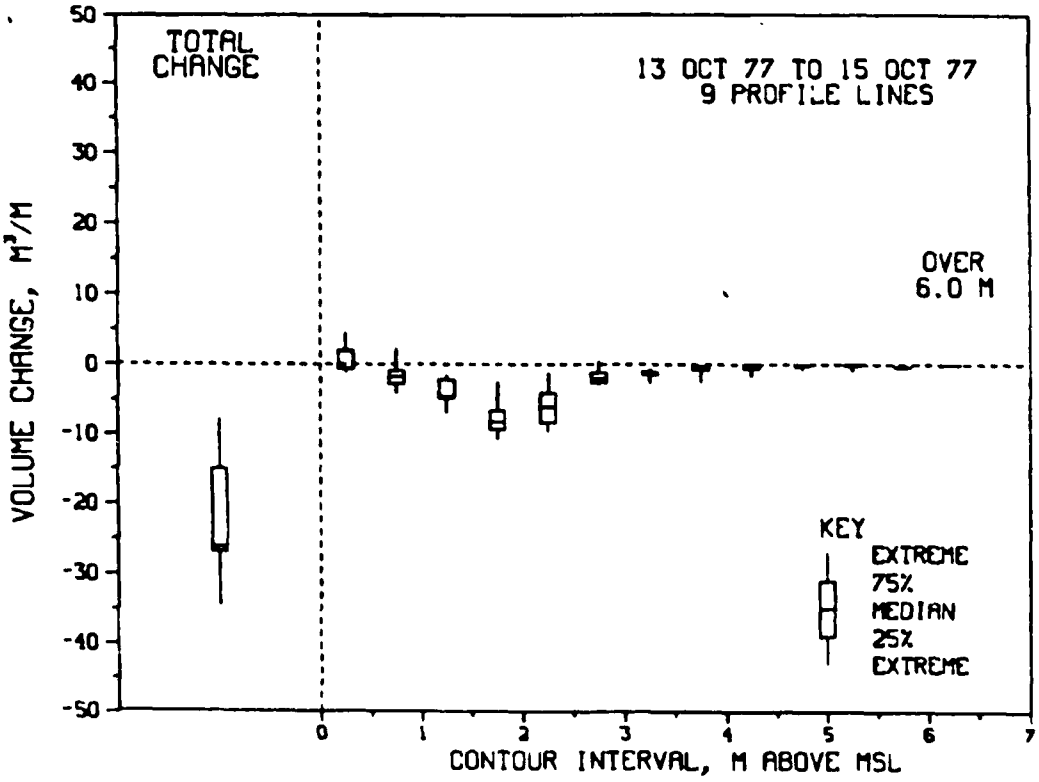



Figure K4. Distribution of volume changes by contour for Long Beach Island, N. J.

a. 13 October 1977

b. 15 October 1977

Figure K5. Photographs of Long Beach Island, Profile 17, looking north

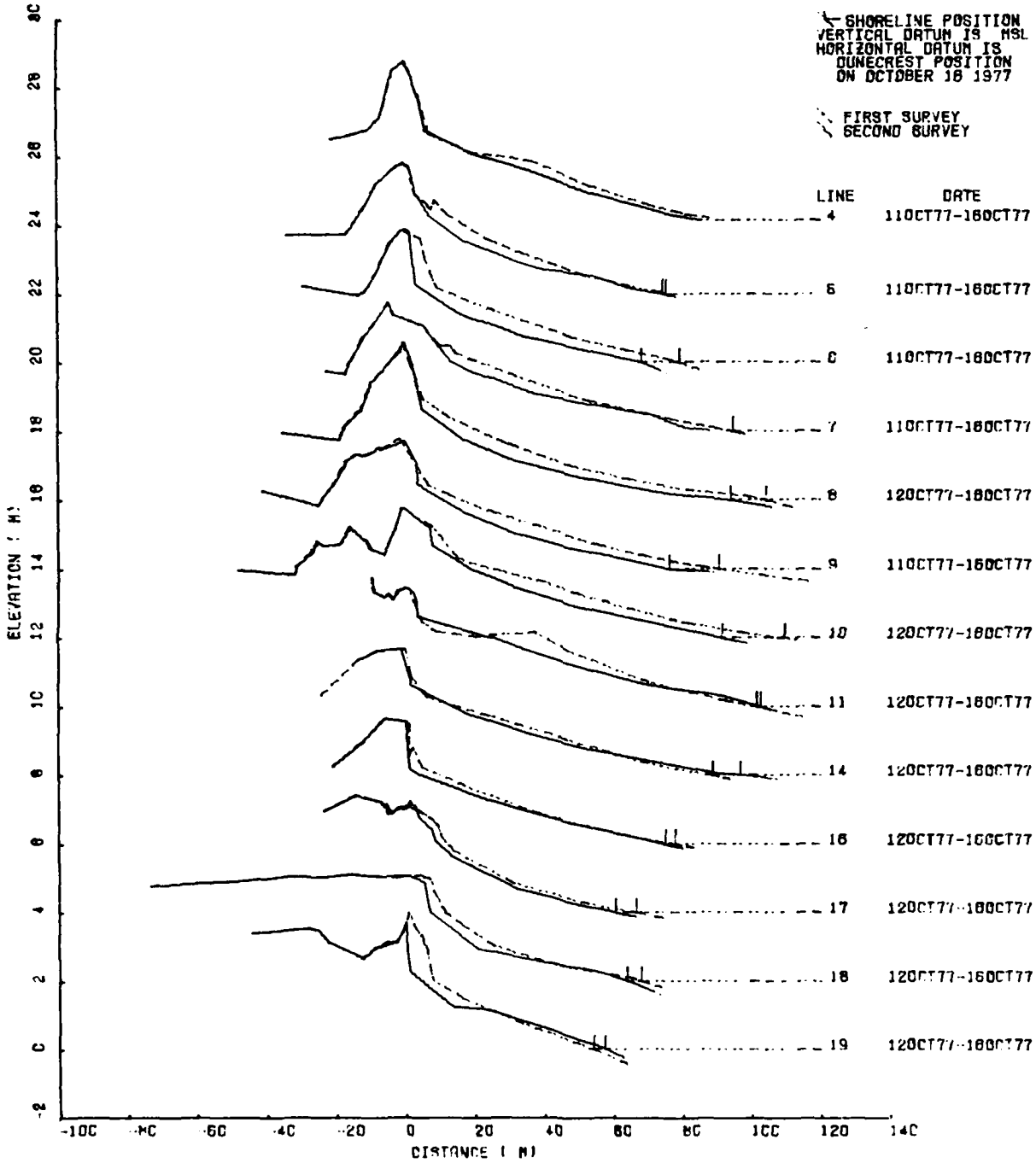



Figure K6. Profile comparisons for surveys at Ludlam Beach, N. J.

Table K3

Shoreline and Slope Changes at Ludlam Beach, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 4 | 11 Oct 77 X | 16 Oct 77 X | -17.88 | -0.011 | -0.021 | -0.010 |
| 5 | 11 Oct 77 | 16 Oct 77 | -0.91 | -0.025 | -0.017 | 0.008 |
| 6 | 11 Oct 77 | 16 Oct 77 | -11.14 | -0.033 | -0.041 | -0.007 |
| 7 | 11 Oct 77 | 16 Oct 77 X | -4.74 | -0.019 | -0.013 | 0.005 |
| 8 | 12 Oct 77 | 16 Oct 77 | -10.67 | -0.025 | -0.015 | 0.010 |
| 9 | 11 Oct 77 | 16 Oct 77 | -14.33 | -0.013 | -0.023 | -0.009 |
| 10 | 12 Oct 77 | 16 Oct 77 | -17.96 | -0.013 | -0.021 | -0.008 |
| 11 | 12 Oct 77 | 16 Oct 77 | 1.30 | -0.021 | -0.027 | -0.006 |
| 14 | 12 Oct 77 | 16 Oct 77 | 8.11 | -0.019 | -0.009 | 0.010 |
| 16 | 12 Oct 77 | 16 Oct 77 | -3.14 | -0.018 | -0.023 | -0.006 |
| 17 | 12 Oct 77 | 16 Oct 77 | -5.98 | -0.019 | -0.022 | -0.002 |
| 18 | 12 Oct 77 | 16 Oct 77 | -4.17 | -0.032 | -0.041 | -0.009 |
| 19 | 12 Oct 77 | 16 Oct 77 | 3.22 | -0.042 | -0.041 | 0.002 |
| Median | | | -4.74 | -0.019 | -0.021 | -0.006 |
| Tri-Mean | | | -5.38 | -0.019 | -0.020 | -0.004 |
| High Hinge | | | -0.91 | -0.013 | -0.015 | 0.005 |
| Low Hinge | | | -11.14 | -0.025 | -0.023 | -0.008 |
| Mean | | | -6.02 | -0.022 | -0.022 | -0.002 |
| Standard Deviation | | | 8.05 | 0.009 | 0.010 | 0.008 |

Note: X = Extrapolated shoreline intercept.

Table K4

Unit Volume Changes ($m^3/m$) Between Contours
Ludlam Beach, N.J.
from 11 Oct 77 to 16 Oct 77

| Profile Line | Total Changes | | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | -15.47 | X | -4.46 | -2.68 | -2.99 | -4.18 | -0.69 | -0.16 | -0.17 | -0.08 | 0.04 | -0.10 | | | | |
| 5 | -14.85 | | -0.77 | -2.98 | -4.02 | -3.67 | -2.90 | -0.78 | 0.14 | 0.13 | | | | | | |
| 6 | -31.23 | | -6.11 | -6.71 | -6.41 | -4.40 | -2.75 | -2.32 | -1.74 | -0.79 | | | | | | |
| 7 | -16.65 | X | -2.54 | -2.00 | -4.77 | -4.62 | -2.47 | -0.24 | -0.01 | 0.00 | | | | | | |
| 8 | -27.30 | | -6.35 | -5.54 | -5.84 | -4.86 | -3.12 | -1.69 | -0.38 | 0.05 | 0.41 | 0.02 | | | | |
| 9 | -23.69 | | -5.67 | -6.05 | -6.10 | -3.77 | -1.65 | -0.67 | 0.38 | -0.16 | | | | | | |
| 10 | -27.71 | | -6.31 | -6.10 | -6.59 | -5.15 | -1.39 | -1.62 | -0.54 | 0.00 | | | | | | |
| 11 | -10.37 | | 1.31 | -1.93 | -4.74 | -6.37 | 1.19 | -0.04 | 0.20 | 0.00 | | | | | | |
| 14 | -5.13 | | 1.95 | -1.35 | -2.82 | -2.14 | 0.31 | -0.49 | -0.42 | -0.17 | | | | | | |
| 16 | -7.71 | | -0.26 | -0.45 | -1.64 | -2.33 | -2.05 | -0.61 | -0.35 | -0.02 | | | | | | |
| 17 | -9.48 | | -2.43 | -1.82 | -1.34 | -1.39 | -1.28 | -1.29 | 0.07 | | | | | | | |
| 18 | -10.24 | | -0.28 | -2.10 | -2.56 | -2.18 | -1.83 | -1.27 | -0.02 | | | | | | | |
| 19 | -10.63 | | 1.51 | 1.14 | -2.06 | -2.45 | -2.65 | -2.92 | -2.40 | -0.80 | | | | | | |
| Median | -14.85 | | -2.43 | -2.10 | -4.02 | -3.77 | -1.83 | -0.78 | -0.17 | -0.02 | 0.22 | -0.04 | | | | |
| Tri-mean | -15.91 | | -2.70 | -2.89 | -4.11 | -3.62 | -1.90 | -0.92 | -0.17 | -0.05 | 0.22 | -0.04 | | | | |
| High Hinge | -10.24 | | -0.26 | -1.82 | -2.56 | -2.33 | -1.28 | -0.49 | 0.07 | 0.00 | 0.41 | 0.02 | | | | |
| Low Hinge | -23.69 | | -5.67 | -5.54 | -5.84 | -4.62 | -2.65 | -1.62 | -0.42 | -0.16 | 0.04 | -0.10 | | | | |
| Mean | -16.19 | | -2.34 | -2.97 | -3.99 | -3.65 | -1.64 | -1.08 | -0.40 | -0.17 | 0.22 | -0.04 | | | | |
| Std Dev | 8.57 | | 3.15 | 2.41 | 1.88 | 1.46 | 1.29 | 0.87 | 0.80 | 0.32 | 0.26 | 0.08 | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

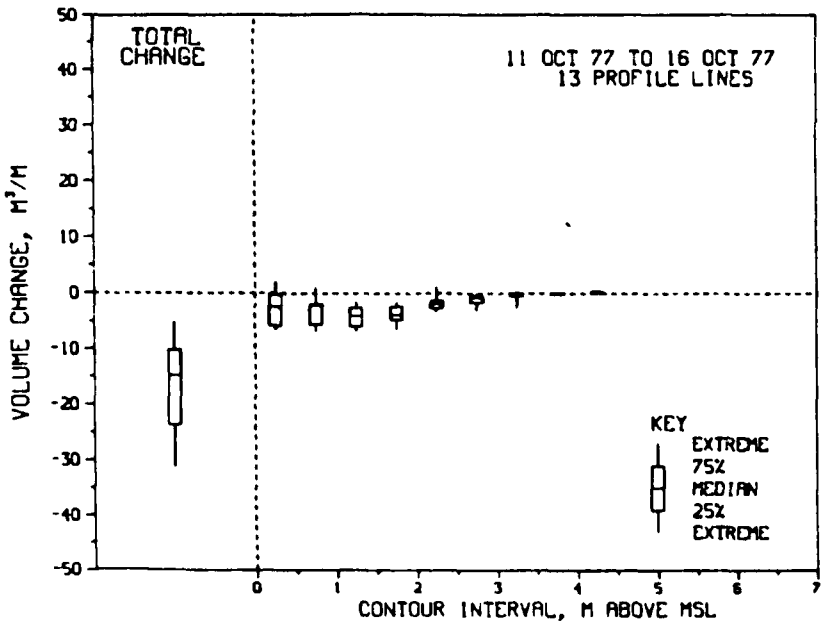



Figure K7. Distribution of volume changes by contour for Ludlam Beach, N. J.

## APPENDIX L: DATA SUMMARY FOR THE STORM OF 19 DECEMBER 1977

1. The 19 December 1977 storm was a major event causing significant and consistent erosion at Long Beach Island and Ludlam Beach. Since surveys were conducted during the waning stages of the storm, a good record of the storm's impact was obtained. Birkemeier (1979) reported on the beach changes caused by this storm and included additional data taken 2 days later and data from a beach in North Carolina.

2. As can be seen on the synoptic weather map, this storm developed off the southeastern United States moving first northward and then almost due east, forced out to sea by a blocking high-pressure system. Peak high tide at Atlantic City was 1.4 m above msl with an associated 1.0-m surge. Visual observations during the storm recorded maximum breaking wave heights ranging from 3 m at Long Beach Island to 2.3 m at Ludlam Beach. As shown in Figure L3, incident waves measured in 11 m of water reached nearly 3 m in height at Ludlam Beach.

3. Erosion was consistent along both islands with almost all profile lines eroding. The pattern of erosion differed between the two localities. Long Beach Island eroded the most by losing -21.1 $m^3/m$, the foreshore flattened and the shoreline actually accreted on one-half of the lines for a median change of 1.6 m. Apparently, the material simply shifted or "rotaced" from the foreshore "across" the shoreline to the offshore. Considerable dune erosion occurred as shown in Figure L6. Recovery was fast. Birkemeier (1979) showed some 51 percent of the material had returned to the foreshore by 22 December.

4. The volume changes at Ludlam Beach were similar with a median erosion of -17.6 $m^3/m$; however, unlike at Long Beach Island, the foreshore slope remained the same and the shoreline retreated -8.8 m. Basically the beach face lowered and retreated. The lowering is obvious in the before and after photos shown in Figure L9. Surveys a day later showed no significant recovery.

5. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.

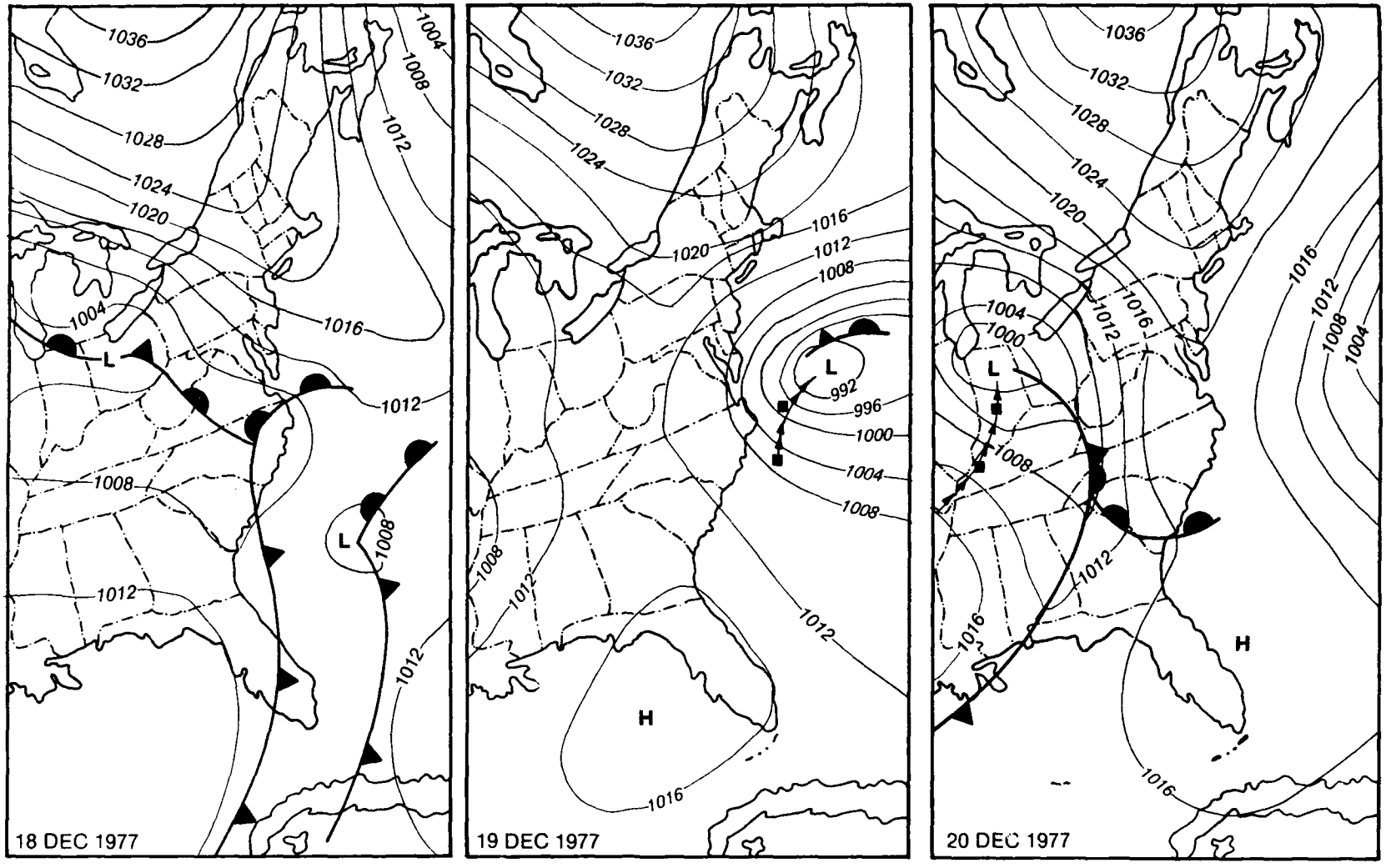



Figure L1. Synoptic weather maps at 0700 EST for 18-20 December 1977 (NOAA 1977)

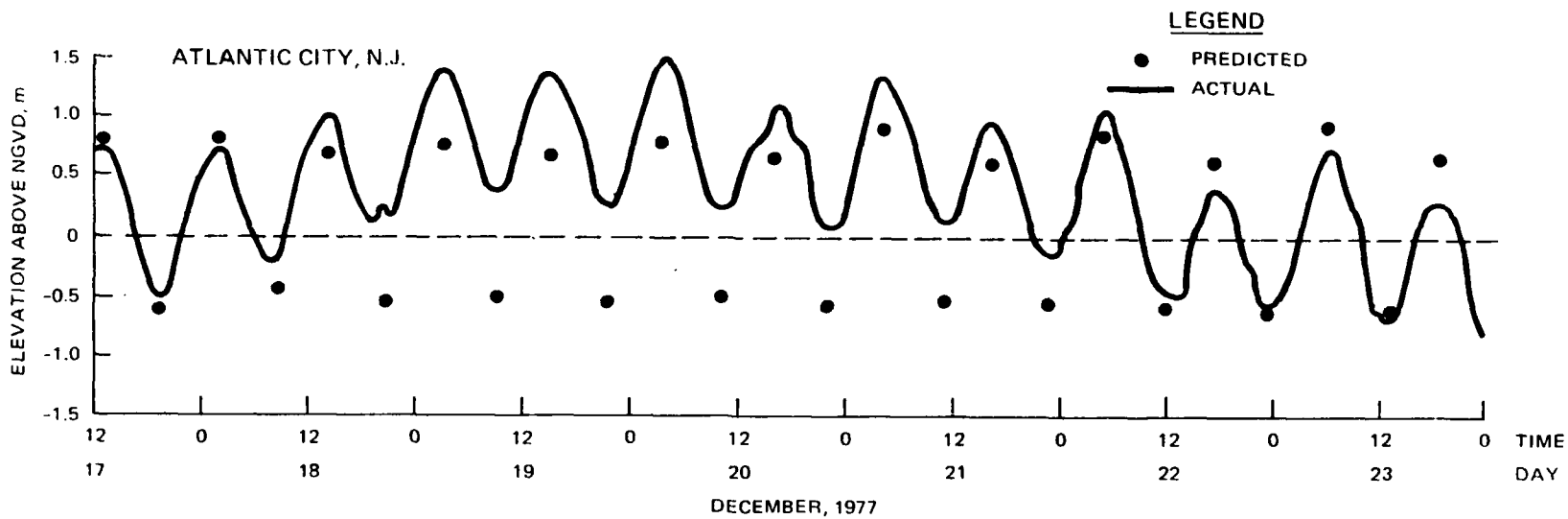



Figure L2. Actual and predicted water level data for 17-23 December 1977

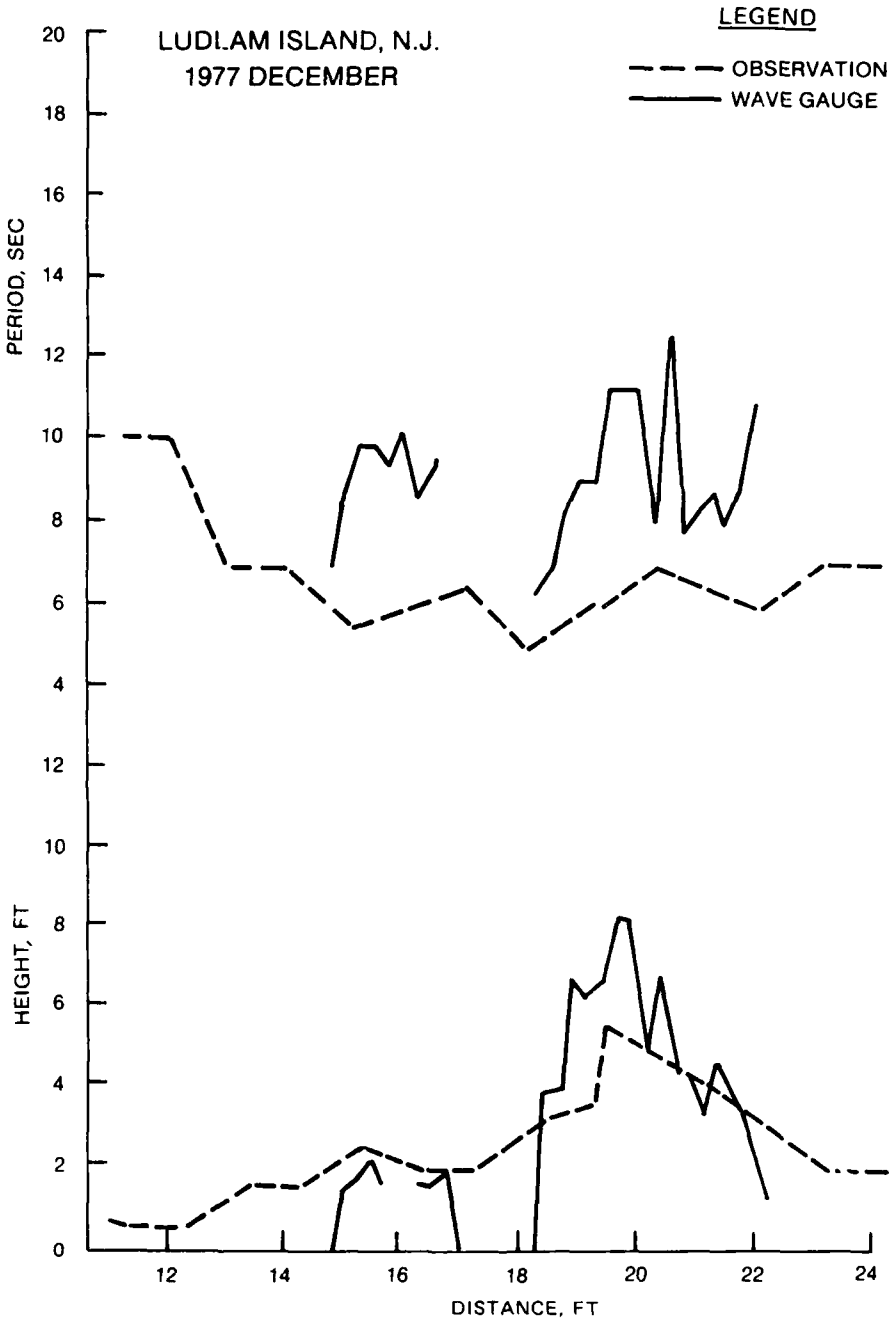



Figure L3. Significant wave heights for 17-22 December 1977 at Ludlam Beach, N. J.

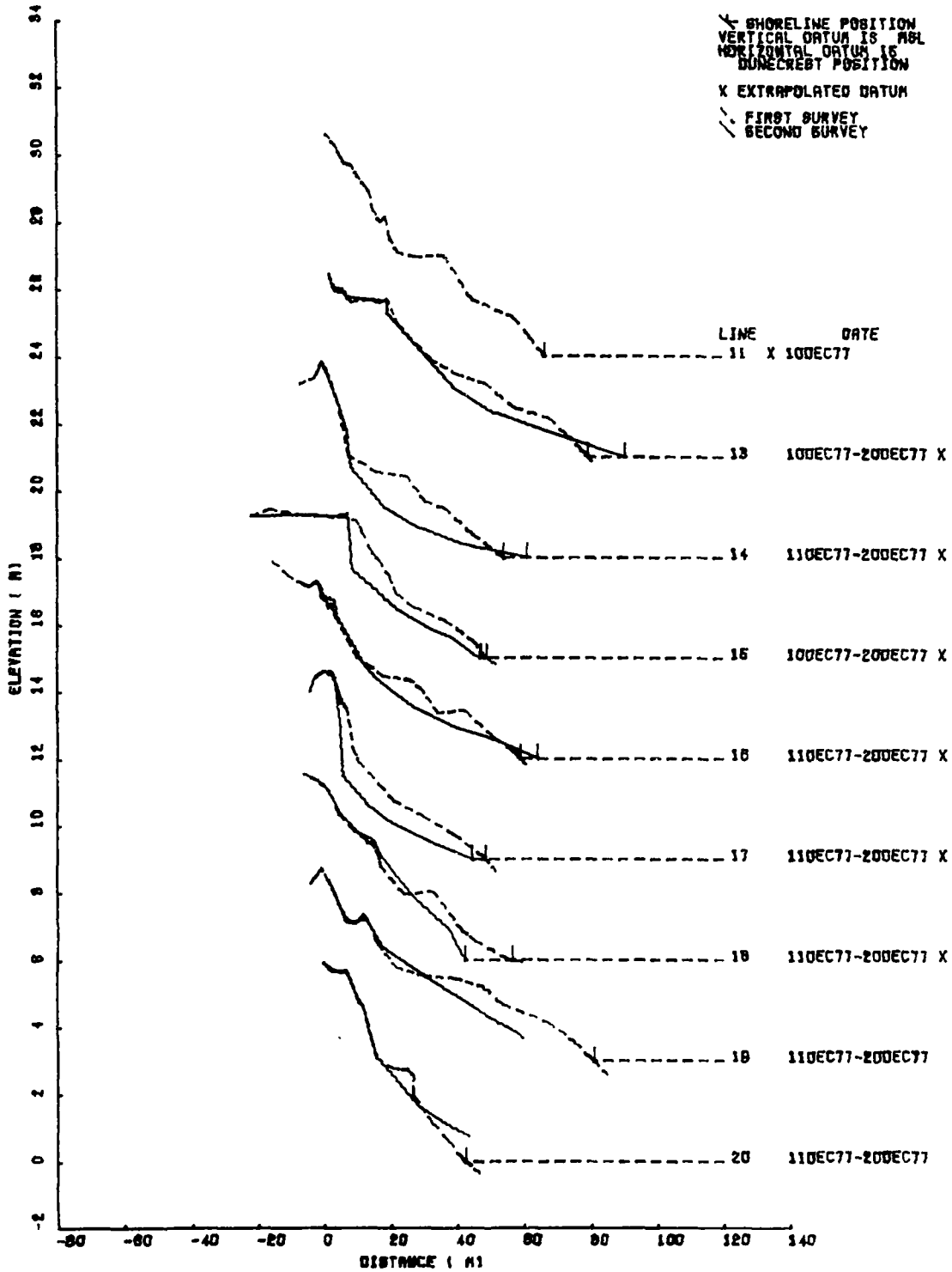



Figure L4. Profile comparisons for surveys at Long Beach Island, N. J.

Table L1

Shoreline and Slope Changes at Long Beach Island, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 13 | 10 Dec 77 | 20 Dec 77 X | 10.86 | -0.110 | -0.033 | 0.077 |
| 14 | 11 Dec 77 | 20 Dec 77 X | 6.90 | -0.077 | -0.021 | 0.056 |
| 15 | 10 Dec 77 | 20 Dec 77 X | -1.73 | -0.064 | -0.069 | -0.006 |
| 16 | 11 Dec 77 | 20 Dec 77 X | 4.84 | -0.108 | -0.043 | 0.065 |
| 17 | 11 Dec 77 | 20 Dec 77 X | -4.24 | -0.117 | -0.042 | 0.075 |
| 18 | 11 Dec 77 | 20 Dec 77 X | -14.22 | -0.021 | -0.200 | -0.179 |
| Median | | | 1.55 | -0.093 | -0.043 | 0.061 |
| Tri-Mean | | | 1.44 | -0.090 | -0.047 | 0.048 |
| High Hinge | | | 6.90 | -0.064 | -0.033 | 0.075 |
| Low Hinge | | | -4.24 | -0.110 | -0.069 | -0.006 |
| Mean | | | 0.40 | -0.083 | -0.068 | 0.015 |
| Standard Deviation | | | 9.07 | 0.037 | 0.067 | 0.100 |

Note: X = Extrapolated shoreline intercept.

Table L2

Unit Volume Changes ($m^3/m$) Between Contours
Long Beach Island, N.J.
from 10 Dec 77 to 20 Dec 77

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | -15.73 | X | 2.85 | -2.13 | -5.48 | -4.99 | -4.29 | -1.26 | -0.34 | -0.22 | -0.65 | 0.69 | 0.09 | | |
| 14 | -30.60 | X | -0.72 | -6.00 | -7.99 | -7.20 | -7.08 | -2.36 | 0.14 | 0.40 | 0.23 | 0.02 | -0.06 | 0.02 | |
| 15 | -26.47 | X | -1.70 | -3.47 | -3.74 | -2.69 | -3.64 | -4.52 | -3.06 | -2.04 | -1.61 | | | | |
| 16 | -13.79 | X | 0.86 | -2.22 | -4.95 | -3.71 | -4.25 | -0.65 | 0.34 | 0.25 | 0.24 | 0.47 | -0.16 | 0.00 | |
| 17 | -34.46 | X | -3.66 | -5.91 | -6.04 | -4.74 | -4.40 | -3.34 | -2.01 | -1.72 | -1.51 | -0.71 | -0.22 | -0.20 | |
| 18 | -9.80 | X | -5.09 | -2.47 | -2.42 | -3.17 | 1.00 | 1.10 | 0.47 | 0.53 | 0.28 | -0.03 | 0.00 | 0.00 | |
| 19 | | | | | -6.59 | -5.14 | -5.09 | 1.64 | 1.01 | 0.14 | 0.22 | 0.09 | 0.06 | | |
| 20 | | | | | 1.50 | -0.32 | -1.76 | -1.90 | 0.13 | 0.05 | 0.04 | 0.06 | -0.02 | | |
| Median | -21.10 | | -1.21 | -2.97 | -5.22 | -4.22 | -4.27 | -1.58 | 0.13 | 0.09 | 0.13 | 0.06 | -0.02 | 0.00 | 0.00 |
| Tri-mean | -21.65 | | -1.31 | -3.52 | -4.96 | -4.11 | -4.00 | -1.45 | -0.12 | -0.11 | -0.15 | 0.10 | -0.03 | -0.02 | 0.00 |
| High Hinge | -13.79 | | 0.86 | -2.22 | -3.08 | -2.93 | -2.70 | 0.23 | 0.41 | 0.32 | 0.23 | 0.28 | 0.03 | 0.01 | 0.00 |
| Low Hinge | -30.60 | | -3.66 | -5.91 | -6.32 | -5.06 | -4.74 | -2.85 | -1.17 | -0.97 | -1.08 | 0.00 | -0.11 | -0.10 | 0.00 |
| Mean | -21.81 | | -1.24 | -3.70 | -4.46 | -3.99 | -3.69 | -1.41 | -0.41 | -0.33 | -0.34 | 0.08 | -0.04 | -0.05 | 0.00 |
| Std Dev | 10.05 | | 2.91 | 1.81 | 2.95 | 2.04 | 2.40 | 2.10 | 1.39 | 0.99 | 0.81 | 0.44 | 0.11 | 0.10 | 0.00 |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

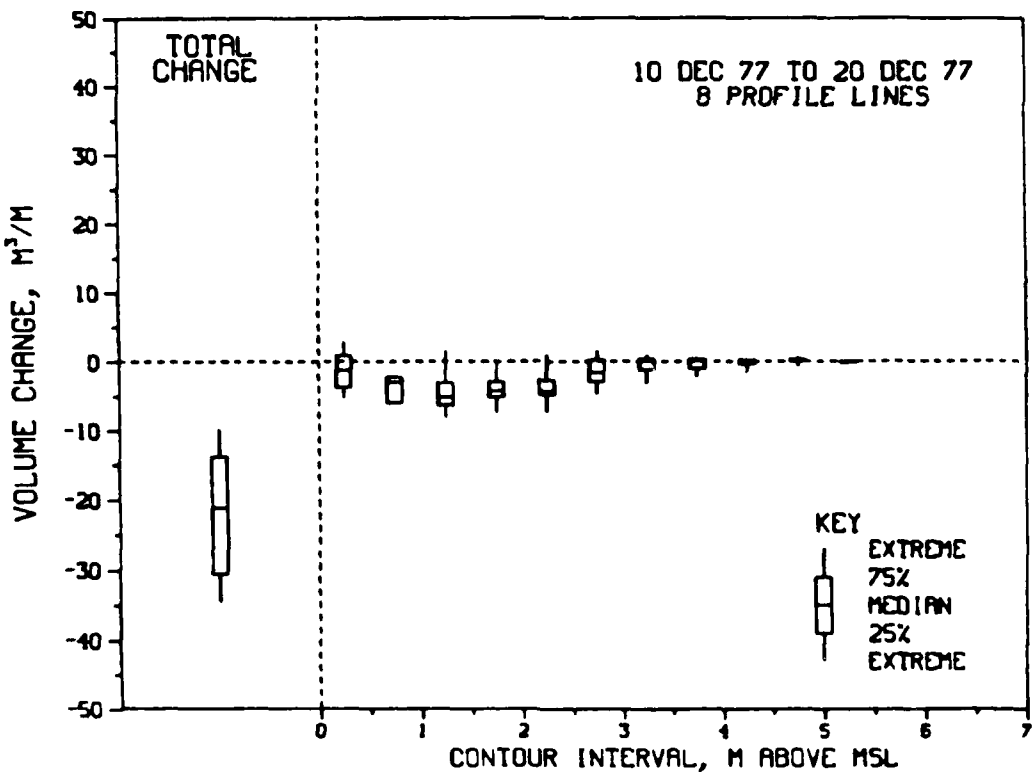



Figure L5. Distribution of volume changes by contour for Long Beach Island, N. J.

a. 26 November 1977

b. 20 December 1977

Figure L6. Pre- and post-storm photographs of profile 15, Long Beach Island

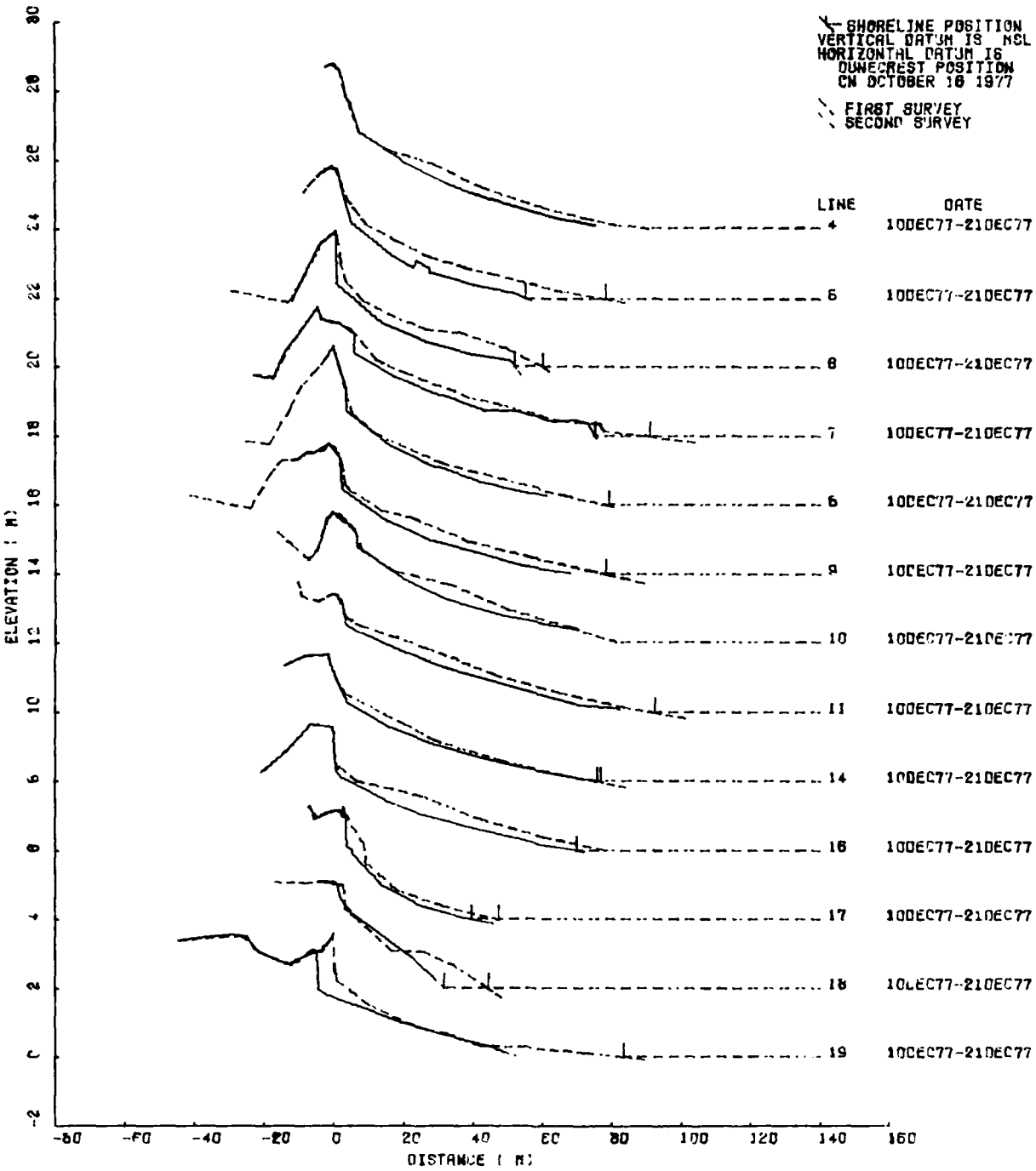



Figure L7. Profile comparisons for surveys at Ludlam Beach, N. J.

Table L3

Shoreline and Slope Changes at Ludlam Beach, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 4 | 10 Dec 77 X | 21 Dec 77 X | -15.95 | -0.009 | -0.020 | -0.011 |
| 5 | 10 Dec 77 | 21 Dec 77 | -23.03 | -0.017 | -0.044 | -0.027 |
| 6 | 10 Dec 77 | 21 Dec 77 | -8.27 | -0.053 | -0.144 | -0.092 |
| 7 | 10 Dec 77 | 21 Dec 77 | -16.04 | -0.012 | -0.188 | -0.175 |
| 8 | 10 Dec 77 | 21 Dec 77 X | -0.58 | -0.022 | -0.015 | 0.006 |
| 9 | 10 Dec 77 | 21 Dec 77 X | -8.65 | -0.022 | -0.017 | 0.006 |
| 10 | 10 Dec 77 X | 21 Dec 77 X | 2.72 | -0.033 | -0.025 | 0.008 |
| 11 | 10 Dec 77 | 21 Dec 77 X | -3.81 | -0.018 | -0.014 | 0.003 |
| 14 | 10 Dec 77 | 21 Dec 77 | 1.00 | -0.018 | -0.016 | 0.002 |
| 16 | 10 Dec 77 X | 21 Dec 77 | -9.17 | -0.021 | -0.016 | 0.005 |
| 17 | 10 Dec 77 | 21 Dec 77 | -7.72 | -0.025 | -0.021 | 0.004 |
| 18 | 10 Dec 77 | 21 Dec 77 | -12.84 | -0.067 | -0.100 | -0.033 |
| 19 | 10 Dec 77 | 21 Dec 77 | -30.54 | -0.011 | -0.036 | -0.025 |
| Median | | | -8.65 | -0.021 | -0.021 | 0.002 |
| Tri-Mean | | | -9.26 | -0.021 | -0.026 | -0.005 |
| High Hinge | | | -3.81 | -0.017 | -0.016 | 0.005 |
| Low Hinge | | | -15.95 | -0.025 | -0.044 | -0.027 |
| Mean | | | -10.22 | -0.025 | -0.050 | -0.025 |
| Standard Deviation | | | 9.54 | 0.017 | 0.057 | 0.053 |

Note: X = Extrapolated shoreline intercept.

Table L4

Unit Volume Changes ($m^3/m$) Between Contours
Ludlam Beach, N.J.
from 10 Dec 77 to 21 Dec 77

| Profile Line | Total Changes | | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | -17.58 | X | -4.89 | -3.83 | -3.77 | -3.76 | -1.24 | -0.21 | 0.11 | 0.00 | 0.06 | -0.05 | | | | |
| 5 | -26.49 | | -9.05 | -7.19 | -4.94 | -3.03 | -1.61 | -0.58 | -0.15 | 0.06 | | | | | | |
| 6 | -22.65 | | -5.03 | -8.55 | -4.18 | -1.74 | -1.64 | -0.98 | -0.39 | -0.14 | | | | | | |
| 7 | -14.07 | | -2.28 | -3.03 | -3.57 | -2.73 | -1.42 | -0.93 | -0.14 | 0.03 | | | | | | |
| 8 | -11.57 | X | -2.65 | -4.55 | -2.43 | -1.32 | -0.18 | -0.50 | -0.08 | 0.10 | 0.05 | 0.00 | | | | |
| 9 | -20.79 | X | -5.84 | -5.20 | -5.01 | -2.90 | -1.10 | -0.50 | 0.21 | -0.45 | | | | | | |
| 10 | -13.12 | X | -0.14 | -3.68 | -5.08 | -4.16 | -0.52 | -0.29 | 0.15 | 0.60 | | | | | | |
| 11 | -20.64 | X | -3.99 | -4.02 | -4.40 | -4.74 | -3.03 | -0.56 | 0.09 | 0.00 | | | | | | |
| 14 | -8.89 | | -0.46 | -1.54 | -2.07 | -2.74 | -1.90 | -0.19 | 0.00 | 0.00 | | | | | | |
| 16 | -23.02 | X | -5.19 | -5.71 | -6.68 | -4.39 | -1.04 | -0.01 | 0.00 | 0.00 | | | | | | |
| 17 | -10.61 | | -3.61 | -1.51 | -1.17 | -1.23 | -2.08 | -0.82 | -0.19 | | | | | | | |
| 18 | -9.65 | | -5.84 | -4.32 | 0.59 | 0.71 | 0.13 | -0.73 | -0.19 | | | | | | | |
| 19 | -17.73 | X | -6.19 | -0.61 | -1.49 | -3.54 | -3.01 | -2.34 | -0.78 | 0.23 | | | | | | |
| Median | -17.58 | | -4.89 | -4.02 | -3.77 | -2.90 | -1.42 | -0.56 | -0.08 | 0.00 | 0.05 | -0.03 | | | | |
| Tri-mean | -16.88 | | -4.57 | -4.07 | -3.64 | -2.83 | -1.44 | -0.56 | -0.06 | 0.02 | 0.05 | -0.03 | | | | |
| High Hinge | -11.57 | | -2.65 | -3.03 | -2.07 | -1.74 | -1.04 | -0.29 | 0.09 | 0.08 | 0.06 | 0.00 | | | | |
| Low Hinge | -20.79 | | -5.84 | -5.20 | -4.94 | -3.76 | -1.90 | -0.82 | -0.19 | 0.00 | 0.05 | -0.05 | | | | |
| Mean | -16.68 | | -4.24 | -4.13 | -3.40 | -2.74 | -1.43 | -0.66 | -0.10 | 0.04 | 0.05 | -0.03 | | | | |
| Std Dev | 5.77 | | 2.45 | 2.24 | 1.99 | 1.52 | 0.95 | 0.58 | 0.26 | 0.25 | 0.01 | 0.04 | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

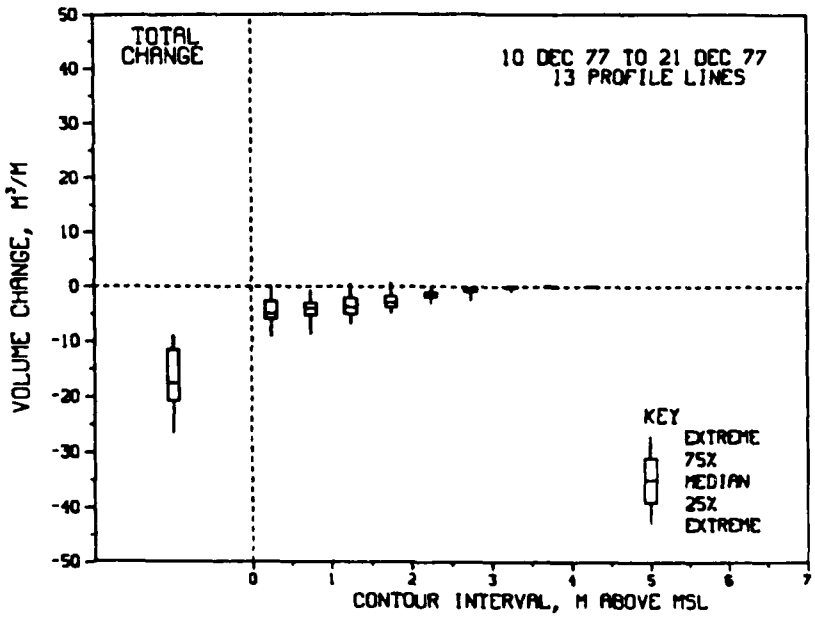



Figure L8. Distribution of volume changes by contour for Ludlam Beach, N. J.

a. 10 December 1977

b. 21 December 1977

Figure L9. Pre- and post-storm photographs of profile 5, Ludlam Beach, N.J.

## APPENDIX M: DATA SUMMARY FOR THE STORM OF 6 FEBRUARY 1978

1. The storm of 6 February 1978 was an intense "northeaster" which became known as the "Blizzard of '78." In addition to high waves and tides, the storm produced heavy snowfalls which paralyzed many mid-Atlantic and New England states. Newspapers reported erosion from Maryland to Maine with the beaches of Massachusetts being the hardest hit. Damage estimates reached $400 million and included the destruction of 2,000 coastal homes in Massachusetts alone (Jones 1978). The development of the storm is shown in the synoptic weather map.

2. Though its effects were much less severe in New Jersey, both Long Beach Island and Ludlam Beach eroded. A peak tide of 1.7 m above msl was measured at the Atlantic City tide gage with a surge of 1.0 m. Based on the surge, the storm had a recurrence interval of once every 3 years. Visual estimates of breaking wave heights taken at Ludlam Beach during the storm reached 4.5 m at the outer edge of the wide surf zone and 1.2 m nearshore.

3. Surveys at both Long Beach Island and Ludlam Beach were conducted immediately after the storm; however, the prestorm survey was done in December following the 19 December 1977 storm. Although the 6 February storm was the next biggest event, measured beach changes cannot be attributed solely to one storm.

4. Although both sites are close in proximity, they both responded very differently to this storm. Shoreline movement at Long Beach Island was -1.4 m, whereas the shoreline accreted 2.4 m at Ludlam Beach. Slope changes at both sites showed a flattening of the foreshore. Erosion was most significant and nearly universal at Long Beach Island with all but profile line 20 eroding (profile line 20 is just north of a groin). The median erosion was -22.29 $m^3/m$. Most interesting is profile line 14 which lost 34 $m^3/m$ of material, all from the dune, whereas during the 19 December 1977 storm (Appendix L) it suffered only berm erosion. Dune scarping occurred at all lines except profile line 20.

5. The median change at Ludlam Beach was considerably less, only -3.5 $m^3/m$ with 70 percent of the profiles eroding. There was also considerable variation between the lines with profile lines 4, 8, and 11 changing little, and profile line 18 downdrift of the Sea Isle City groins losing -34.1 $m^3/m$.

6. Tables and figures are arranged according to predicted and actual water levels, hindcasted wave data, profile comparisons, shoreline and slope changes, unit volume changes, and distribution of unit volume changes.

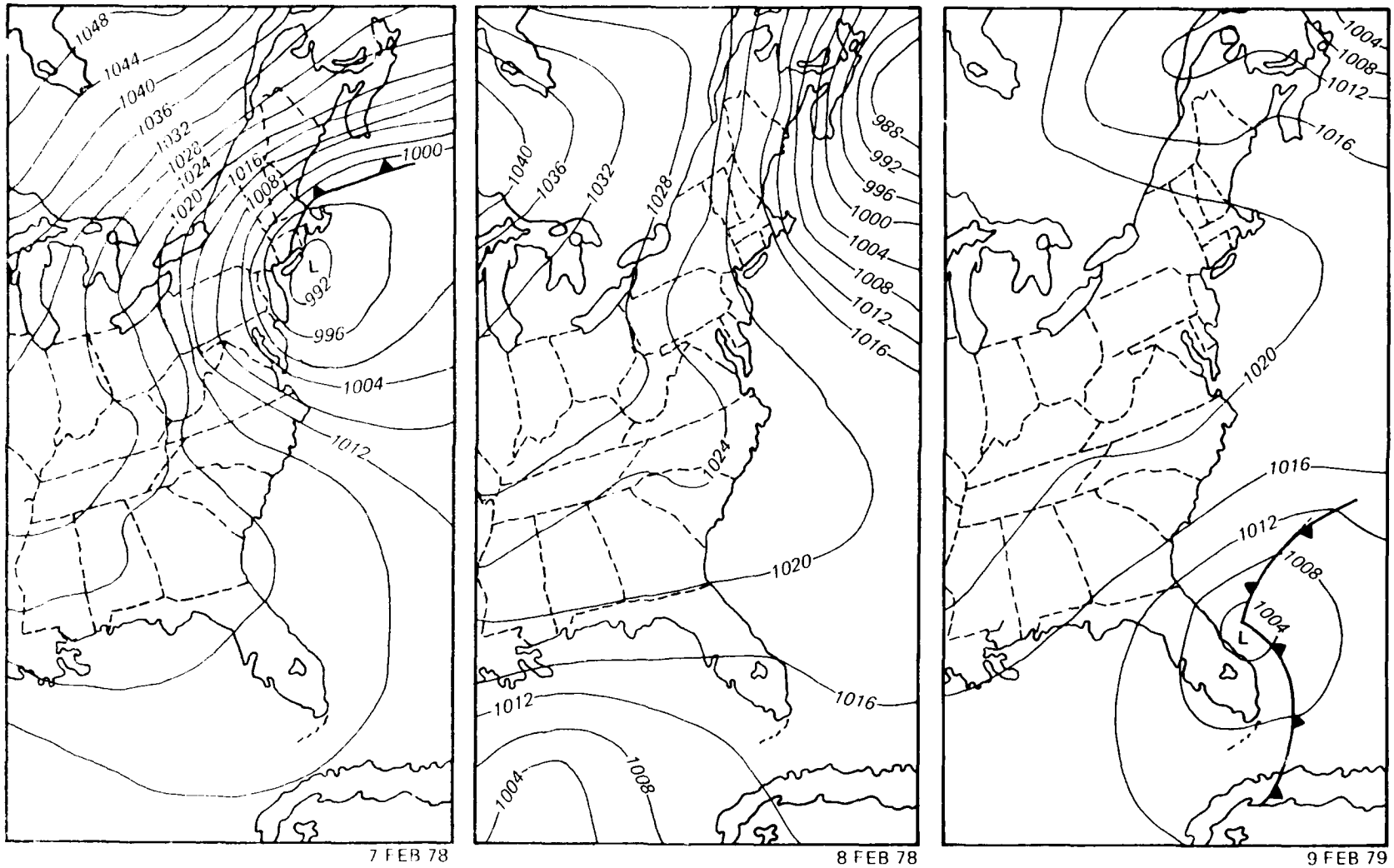



Figure M1. Synoptic weather maps at 0700 for 7 to 9 February 1978

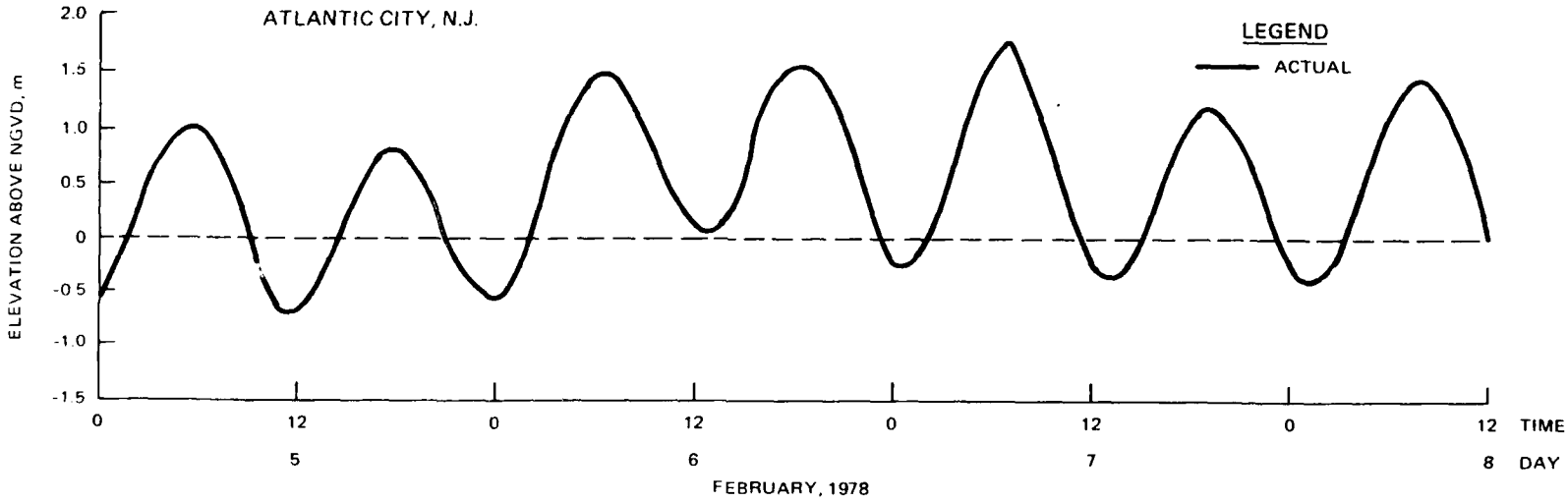



Figure M2. Actual water level data for 5-8 February 1978

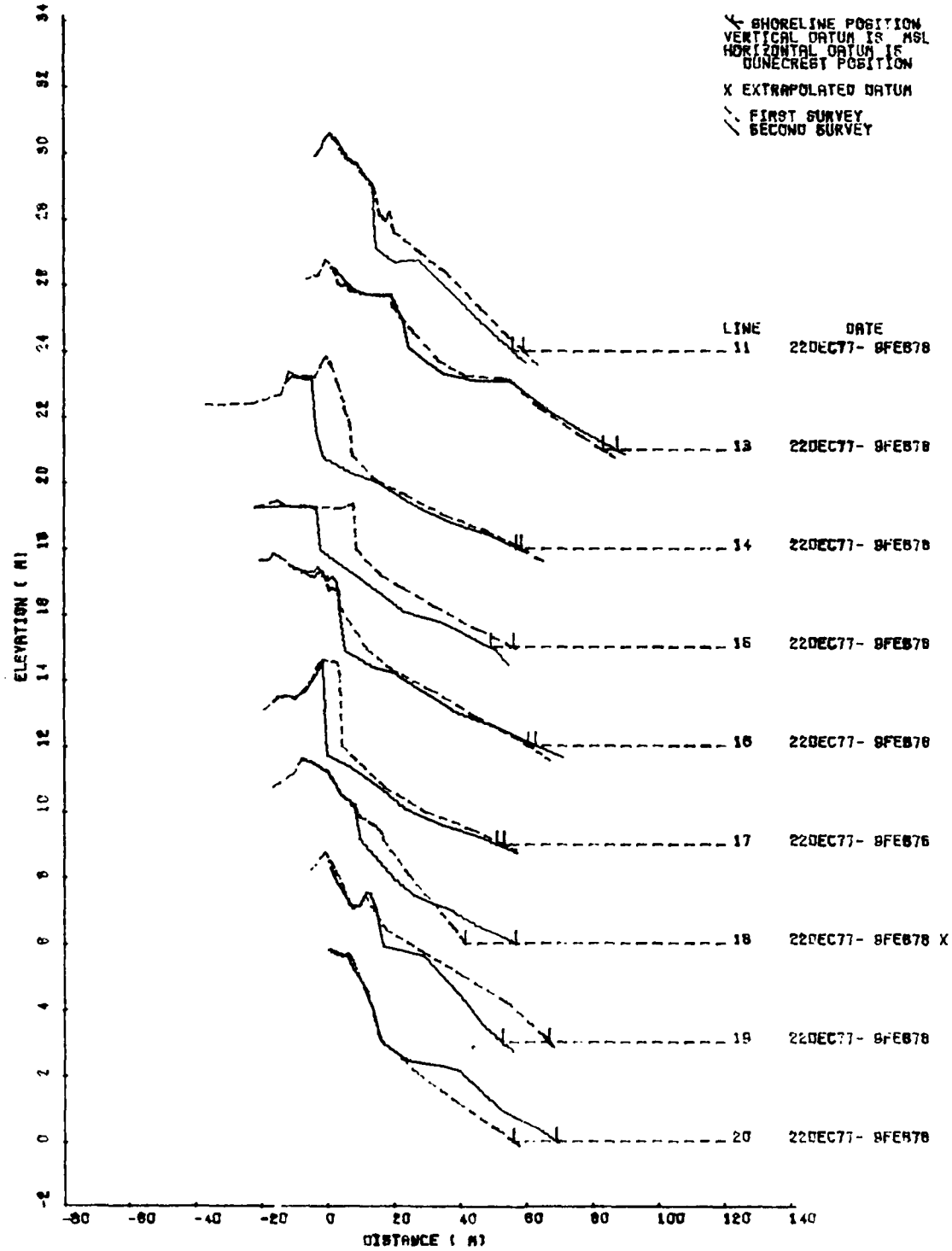



Figure M3. Profile comparisons for surveys at Long Beach Island, N. J.

Table M1

Shoreline and Slope Changes at Long Beach Island, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 11 | 22 Dec 77 | 9 Feb 78 | -3.37 | -0.097 | -0.081 | 0.015 |
| 13 | 22 Dec 77 | 9 Feb 78 | 4.29 | -0.066 | -0.056 | 0.010 |
| 14 | 22 Dec 77 | 9 Feb 78 | -1.40 | -0.059 | -0.048 | 0.012 |
| 15 | 22 Dec 77 | 9 Feb 78 | -6.93 | -0.049 | -0.053 | -0.004 |
| 16 | 22 Dec 77 | 9 Feb 78 | 2.02 | -0.069 | -0.044 | 0.025 |
| 17 | 22 Dec 77 | 9 Feb 78 | -2.14 | -0.048 | -0.046 | 0.002 |
| 18 | 22 Dec 77 | 9 Feb 78 X | 14.99 | -0.100 | -0.046 | 0.054 |
| 19 | 22 Dec 77 | 9 Feb 78 | -13.98 | -0.122 | -0.089 | 0.033 |
| 20 | 22 Dec 77 | 9 Feb 78 | 12.73 | -0.076 | -0.080 | -0.004 |
| Median | | | -1.40 | -0.069 | -0.053 | 0.012 |
| Tri-Mean | | | -0.47 | -0.074 | -0.058 | 0.013 |
| High Hinge | | | 4.29 | -0.059 | -0.046 | 0.025 |
| Low Hinge | | | -3.37 | -0.097 | -0.080 | 0.002 |
| Mean | | | 0.69 | -0.076 | -0.060 | 0.016 |
| Standard Deviation | | | 9.12 | 0.025 | 0.018 | 0.019 |

Note: X = Extrapolated shoreline intercept.

Table M2

Unit Volume Changes (m3/m) Between Contours
Long Beach Island, N.J.
from 22 Dec 77 to 9 Feb 78

| Profile Line | Total Changes | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | -22.29 | -1.74 | -1.83 | -1.98 | -2.10 | -2.21 | -4.15 | -4.99 | -2.84 | -1.01 | -0.28 | 0.27 | 0.33 | | 0.24 |
| 13 | -2.32 | 1.82 | 1.23 | 0.85 | 0.35 | -2.84 | -2.24 | -2.24 | -0.62 | 0.40 | 0.13 | 0.84 | 0.00 | | |
| 14 | -34.01 | -0.99 | -1.78 | -1.66 | -0.83 | -2.07 | -4.19 | -4.82 | -5.06 | -4.60 | -4.15 | -3.20 | -0.66 | | |
| 15 | -41.38 | -3.32 | -4.04 | -5.65 | -4.60 | -3.99 | -4.99 | -5.50 | -5.52 | -3.77 | | | | | |
| 16 | -10.22 | 0.33 | -1.07 | -1.79 | -1.29 | -1.31 | -3.04 | -2.51 | -1.17 | -0.06 | 0.69 | 1.00 | 0.00 | | |
| 17 | -24.15 | -1.50 | -2.48 | -1.99 | -0.93 | -1.74 | -3.06 | -2.33 | -2.34 | -2.34 | -2.61 | -2.47 | -0.36 | | |
| 18 | -4.27 | X 5.78 | 3.06 | -0.33 | -2.29 | -2.79 | -3.12 | -3.32 | -1.35 | 0.28 | -0.13 | -0.02 | -0.04 | | |
| 19 | -31.99 | -7.23 | -6.95 | -5.99 | -4.25 | -2.39 | -2.63 | -2.16 | -0.15 | 0.49 | -0.42 | -0.33 | 0.02 | | |
| 20 | 27.61 | 6.32 | 5.36 | 5.38 | 6.20 | 4.53 | 0.23 | 0.11 | 0.15 | -0.06 | -0.15 | -0.40 | -0.06 | | |
| Median | -22.29 | -0.99 | -1.78 | -1.79 | -1.29 | -2.21 | -3.06 | -2.51 | -1.35 | -0.06 | -0.22 | -0.18 | -0.02 | | 0.24 |
| Tri-mean | -20.21 | -0.47 | -1.20 | -1.48 | -1.42 | -2.24 | -3.22 | -3.02 | -1.54 | -0.54 | -0.49 | -0.31 | -0.06 | | 0.24 |
| High Hinge | -4.27 | 1.82 | 1.23 | -0.33 | -0.83 | -1.74 | -2.63 | -2.24 | -0.62 | 0.28 | 0.00 | 0.56 | 0.01 | | 0.24 |
| Low Hinge | -31.99 | -1.74 | -2.48 | -1.99 | -2.29 | -2.79 | -4.15 | -4.82 | -2.84 | -2.34 | -1.51 | -1.44 | -0.21 | | 0.24 |
| Mean | -15.89 | -0.06 | -0.94 | -1.46 | -1.08 | -1.65 | -3.02 | -3.08 | -2.10 | -1.19 | -0.87 | -0.54 | -0.10 | | 0.24 |
| Std Dev | 21.18 | 4.28 | 3.71 | 3.39 | 3.16 | 2.44 | 1.49 | 1.78 | 2.05 | 1.93 | 1.64 | 1.52 | 0.29 | | 0.00 |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

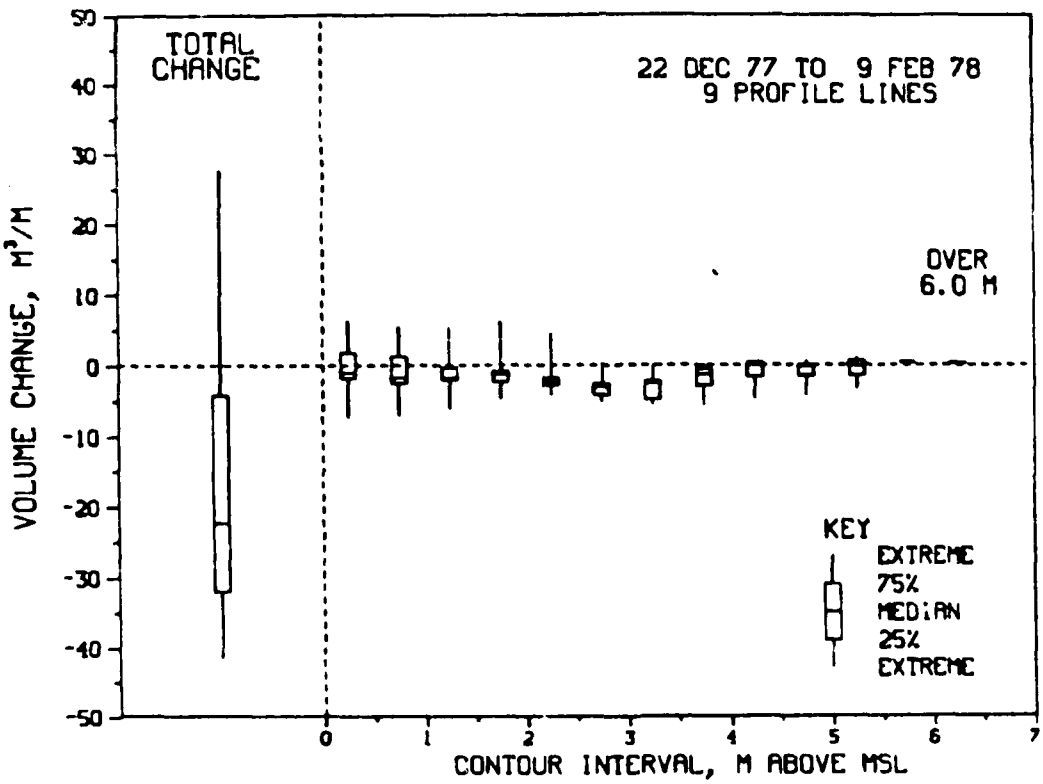



Figure M4. Distribution of volume changes by contour for Long Beach Island, N. J.

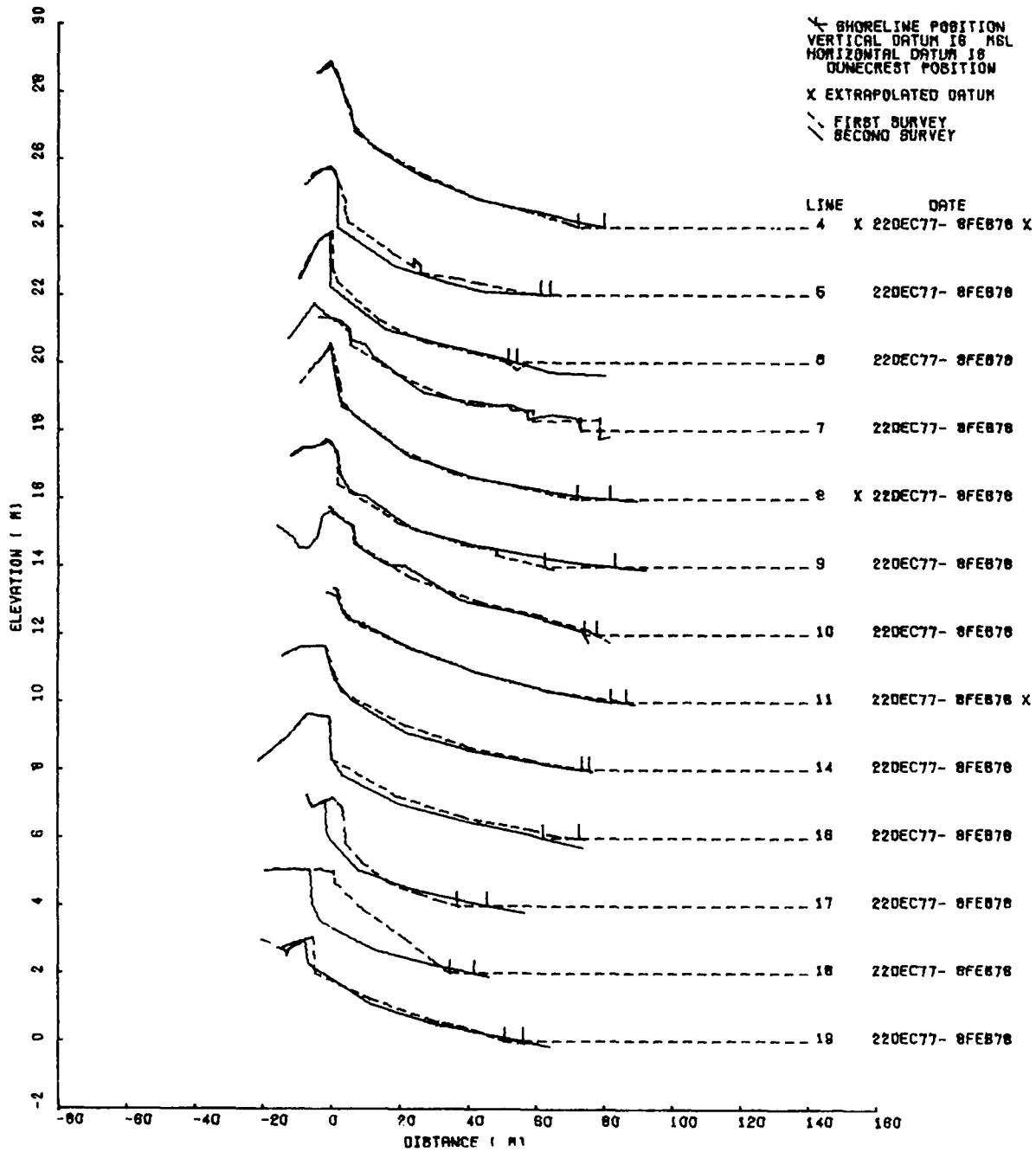



Figure M5. Profile comparisons for surveys at Ludlam Beach, N. J.

Table M3

Shoreline and Slope Changes at Ludlam Beach, N.J.

| Profile Line | Survey Dates From | Survey Dates To | Shoreline Change (m) | Foreshore Slope First Survey | Foreshore Slope Second Survey | Foreshore Slope Change |
|---|---|---|---|---|---|---|
| 4 | 22 Dec 77 X | 8 Feb 78 X | 7.62 | -0.040 | -0.022 | 0.018 |
| 5 | 22 Dec 77 | 8 Feb 78 | -2.74 | -0.005 | -0.006 | -0.001 |
| 6 | 22 Dec 77 | 8 Feb 78 | 2.42 | -0.080 | -0.028 | 0.052 |
| 7 | 22 Dec 77 | 8 Feb 78 | -5.79 | -0.188 | -0.600 | -0.413 |
| 8 | 22 Dec 77 X | 8 Feb 78 | 9.55 | -0.020 | -0.008 | 0.013 |
| 9 | 22 Dec 77 | 8 Feb 78 | 20.67 | -0.024 | -0.010 | 0.014 |
| 10 | 22 Dec 77 | 8 Feb 78 | -3.59 | -0.055 | -0.200 | -0.145 |
| 11 | 22 Dec 77 | 8 Feb 78 X | -4.51 | -0.025 | -0.019 | 0.006 |
| 14 | 22 Dec 77 | 8 Feb 78 | -2.13 | -0.025 | -0.016 | 0.009 |
| 16 | 22 Dec 77 | 8 Feb 78 | -10.60 | -0.013 | -0.023 | -0.011 |
| 17 | 22 Dec 77 | 8 Feb 78 | 8.83 | -0.028 | -0.020 | 0.008 |
| 18 | 22 Dec 77 | 8 Feb 78 | 7.01 | -0.079 | -0.021 | 0.057 |
| 19 | 22 Dec 77 | 8 Feb 78 | 5.51 | -0.038 | -0.019 | 0.019 |
| Median | | | 2.42 | -0.028 | -0.020 | 0.009 |
| Tri-Mean | | | 2.22 | -0.034 | -0.020 | 0.009 |
| High Hinge | | | 7.62 | -0.024 | -0.016 | 0.018 |
| Low Hinge | | | -3.59 | -0.055 | -0.023 | -0.001 |
| Mean | | | 2.48 | -0.048 | -0.076 | -0.029 |
| Standard Deviation | | | 8.42 | 0.048 | 0.165 | 0.125 |

Note: X = Extrapolated shoreline intercept.

Table M4

Unit Volume Changes ($m^3/m$) Between Contours
Ludlam Beach, N.J.
22 Dec 77 to 8 Feb 78

| Profile Line | Total Changes | | Contours (m) above MSL 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | over 6.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0.56 | X | 2.08 | -0.01 | -0.58 | -0.53 | -0.31 | 0.24 | 0.14 | 0.09 | -0.12 | -0.44 | | | | |
| 5 | -14.53 | | -4.01 | -2.54 | -2.54 | -2.55 | -1.56 | -1.00 | -0.28 | -0.05 | | | | | | |
| 6 | -4.50 | | 0.85 | -0.22 | -1.12 | -1.27 | -1.40 | -0.65 | -0.47 | -0.22 | | | | | | |
| 7 | 0.86 | | -0.60 | 0.37 | -1.22 | 0.13 | 0.97 | 0.50 | 0.64 | 0.07 | | | | | | |
| 8 | 1.07 | X | 1.48 | 0.56 | -0.44 | -0.07 | -0.06 | 0.20 | -0.34 | -0.27 | -0.01 | 0.02 | | | | |
| 9 | 9.23 | | 5.46 | 0.60 | 0.54 | 1.17 | 0.70 | 0.40 | 0.30 | 0.06 | | | | | | |
| 10 | -1.60 | | -1.32 | -1.26 | -0.43 | 1.79 | -0.29 | 0.03 | 0.05 | -0.17 | | | | | | |
| 11 | -0.56 | X | -0.91 | -0.08 | -0.07 | 0.24 | 0.48 | 0.08 | -0.30 | | | | | | | |
| 14 | -6.89 | | -1.31 | -2.11 | -2.05 | -1.04 | -0.07 | -0.19 | -0.11 | 0.00 | | | | | | |
| 16 | -11.57 | | -3.55 | -2.67 | -2.34 | -2.44 | -0.56 | 0.00 | 0.00 | 0.00 | | | | | | |
| 17 | -6.85 | | 2.59 | -0.26 | -1.83 | -1.84 | -2.58 | -2.45 | -0.48 | | | | | | | |
| 18 | -32.14 | | -0.55 | -6.36 | -7.97 | -7.67 | -5.64 | -3.69 | -0.26 | | | | | | | |
| 19 | -3.44 | | -0.09 | -1.73 | -1.29 | 0.41 | -0.27 | -0.41 | -0.06 | | | | | | | |
| Median | -3.44 | | -0.55 | -0.26 | -1.22 | -0.53 | -0.29 | 0.00 | -0.11 | 0.00 | -0.06 | -0.21 | | | | |
| Tri-mean | -3.30 | | -0.23 | -0.66 | -1.23 | -0.67 | -0.51 | -0.11 | -0.12 | -0.03 | -0.06 | -0.21 | | | | |
| High Hinge | 0.56 | | 1.48 | -0.01 | -0.44 | 0.24 | -0.06 | 0.20 | 0.05 | 0.06 | -0.01 | 0.02 | | | | |
| Low Hinge | -6.89 | | -1.31 | -2.11 | -2.05 | -1.84 | -1.40 | -0.65 | -0.30 | -0.17 | -0.12 | -0.44 | | | | |
| Mean | -5.41 | | 0.01 | -1.21 | -1.64 | -1.05 | -0.81 | -0.53 | -0.09 | -0.05 | -0.06 | -0.21 | | | | |
| Std Dev | 10.06 | | 2.54 | 1.94 | 2.11 | 2.38 | 1.74 | 1.23 | 0.32 | 0.13 | 0.08 | 0.33 | | | | |

Note: Data not reaching MSL are not included in column or row statistics.
X = Extrapolated shoreline intercept.

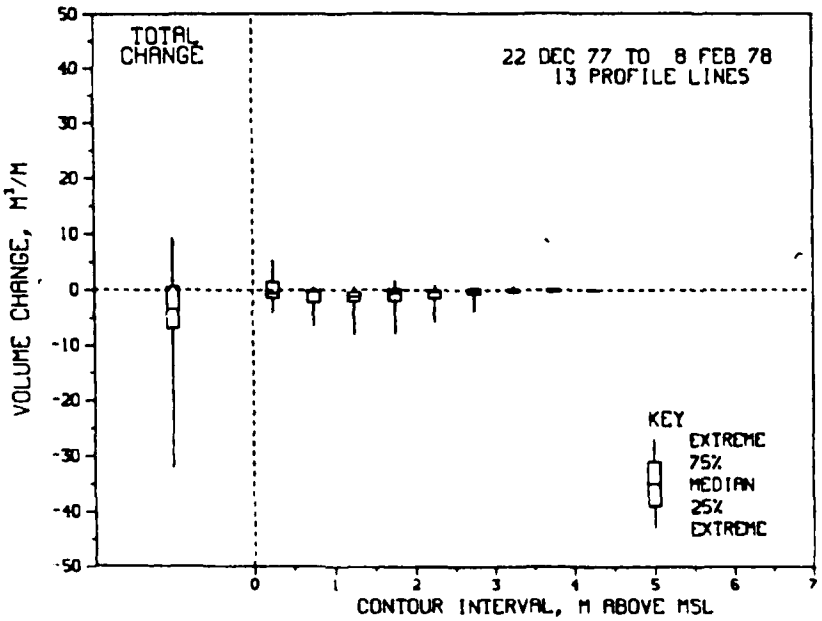



Figure M6. Distribution of volume changes by contour for Ludlam Beach, N. J.

## APPENDIX N: DESCRIPTION OF DATA TAPE FORMAT

1. In order to facilitate use of the data described in this report, a magnetic tape has been prepared which contains all the profile and hindcast wave data. The tape does not include the tide data which were compiled from paper tables. Copies of the tape can be arranged through the Information and Analysis Center of CERC. Specific details of the tape and the format of the 9 data files are described in Table N1.

Table N1
Description of Magnetic Tape Files

| File Number | Description | Survey Locality | Phase III Hindcast Grid | Shoreline Angle* |
|---|---|---|---|---|
| 1 | Message File | | | |
| 2 | Nauset Beach, Mass. | 14 | 29 | 105 |
| 3 | Misquamicut Beach, R.I. | 6 | 41 | 14 |
| 4 | Westhampton Beach, N.Y. | 7 | 46 | 22 |
| 5 | Jones Beach, N.Y. | 8 | 50 | 23 |
| 6 | Long Beach Island,N.J. | 9 | 58 | 65 |
| 7 | Atlantic City, N.J. | 10 | 61 | 38 |
| 8 | Ludlam Beach, N.J. | 11 | 62 | 60 |
| 9 | WIS wave hindcast data | | | |

* Counterclockwise from due east.

Survey locality codes and Phase III hindcast grid codes are used to identify the data from each locality. The shoreline angles are used in the interpretation of the wave direction data. The specific details of the tape format are: ASCII, 8 bit word size, 80 characters per record, 10 records per block, 9 track, 1,600 bits per inch. This format should make it easily readable on most computer systems.

2. The survey data follow the BPAS "EDIT2" card image format (Fleming and DeWall 1982). The data are in customary units (feet) with elevations relative to NGVD. The information along with other useful parameters are specified in a "Header Record," which is the first line on each survey data file. The format of the Header Record is given in Table N2.

3. The data for each survey of a profile line are stored in a number of 80 column lines which follow the header record. The format of the data is given in Table N3. The first line contains the date and the number of survey points. The data within each file are sorted by profile number and then by survey number (see Part 1, Table 1). If there are exactly four coordinate pairs (only the first line is needed), then it is followed by a blank line.

4. All of the Wave Information Studies (Jensen 1983) hindcast data are

Table N2

Format of the Header Record

| Character Position | Entry Description | Entry Format |
|---|---|---|
| 1-2 | 00 | 2X |
| 3-5 | Lowest profile number in the data file | I3 |
| 6-9 | Lowest survey number in the data file | I4 |
| 10-12 | Highest profile number in the data file | I3 |
| 13-16 | Highest survey number in the data file | I4 |
| 17-19 | Maximum number of coordinate pairs required to define any one survey | I3 |
| 20 | Number of decimal places for distances | I1 |
| 21 | Number of decimal places for elevation | I1 |
| 22-23 | Units of measurement | A2 |
| 24-27 | Four character datum label | A4 |
| 28-49 | Range of dates and times covered by the data | 2(3I2,I5) |
| 50-80 | Description of the data | 31A1 |

Sample Header Record

```
0000100020070117 2501FT MSL631231 1200730325 0800ATLANTIC CITY, NJ
```

Table N3

Survey Data Format

| Character Position | Entry Description | Format |
|---|---|---|
| | *First card in each record* | |
| 1-2 | Survey code | A2 |
| 3-5 | Profile line number | I3 |
| 6-9 | Survey identification number | I4 |
| 10 | Card number (always 1 for first card) | A1 |
| 11-16 | Date of survey (YRMODA) | I6 |
| 17-21 | Time of survey | I5 |
| 22-24 | Number of coordinate pairs for survey | I3 |
| 25-29 | Minimum elevation for survey | F5.2 |
| 30-40 | Blank | 11X |
| 41-80 | First four distance-elevation pairs | 4(F5.0,F5.1) |
| | Continuation Cards | |
| 1-9 | Same as for first card | |
| 10 | Card number (2-9, then A-Z) | A1 |
| 11-80 | Seven distance-elevation pairs | 7(F5.0,F5.1) |

Sample Survey Data

```
10  1   21621101 1200 16  -21              20   50   48   47   79   38  120   39
10  1   22  170   39  221   39  271   37  321   36  370   36  421   38  520   54
10  1   23  559   63  610   18  648  -11  697  -14  723  -21
10  1   31621109 1200 11   -6              29   42  120   40  224   39  273   38
10  1   32  321   37  420   37  521   36  570   29  634   12  683    5  736   -6
```

combined into a single file with the format given in Table N4. Wave direction is relative to a shorenormal direction of 90 deg with 0 deg to the right.

Table N4

Format of the Wave Hindcast Data

| Character Position | Entry Description | Format |
|---|---|---|
| 1-2 | Storm number (not used in report) | I2 |
| 3-6 | Survey locality code number | I4 |
| 7-10 | Hindcast code | I4 |
| 11-12 | Blank | 2X |
| 13-18 | Date (YRMODA) | I6 |
| 19-20 | Hour | I2 |
| 21-30 | Decimal day since prestorm survey | F10.2 |
| 31-40 | Wave height (m) | F10.2 |
| 41-50 | Wave period (sec) | F10.2 |
| 51-60 | Direction | F10.2 |

Sample Wave Hindcast Data

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 35 | 14 | 29 | 70121000 | 0.00 | .53 | 5.55 | 35.00 |
| 35 | 14 | 29 | 70121003 | .13 | .43 | 4.67 | 15.00 |
| 35 | 14 | 29 | 70121006 | .25 | .40 | 6.38 | 145.00 |
| 35 | 14 | 29 | 70121009 | .38 | .40 | 6.37 | 145.00 |
| 35 | 14 | 29 | 70121012 | .50 | .43 | 4.79 | 165.00 |
| 35 | 14 | 29 | 70121015 | .63 | .47 | 5.26 | 145.00 |