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# Survey Data Report: Cape Canaveral, March-July, 1988

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November, 1988

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### **Abstract**

This report presents the results of a bathymetric surveying program carried out on the beach and nearshore region about  $1km$  to the north of the Port Canaveral inlet. The survey data covers a period between March 16 and July 21, 1988. The data was collected in support of a field study on directional wave measurement and Bragg reflection from artificial, shore-parallel bars, performed during June - July, 1988. The topography at the experiment site was generally monotonic in the on-offshore direction (except near the end of the experimental program) and uniform in the longshore direction.

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# 1 Introduction

This report presents the results of field surveying done in support of a field experiment conducted in June-July, 1988, at Cape Canaveral, Florida. The objectives of the surveying program were to determine the degree of longshore uniformity of the offshore bathymetry at the experiment site, to monitor changes in the offshore bathymetry, and to provide detailed beach profiling as needed. Data in this report was collected on a number of occasions, including:

1. A preliminary field survey in October, 1987.
2. A detailed survey of "box" and "cone" bathymetry regions and beach profiles in March, 1988.
3. A beach profiling survey in May, 1988.
4. A detailed "box" survey and reduced "fan" survey in June, 1988.
5. Beach profiling during the period of June 21 - July 19, 1988.
6. A final "box" survey on July 21, 1988.

Data presented in this report was collected mainly by the field crew of the Coastal and Oceanographic Engineering Laboratory (COEL), University of Florida, with assistance (and supervision) by personnel from the Naval Civil Engineering Laboratory (NCEL) during beach profiling. Also reported here are measurements of Bragg bar installation locations. Additional assistance was rendered in locating and surveying instrument arrays installed by the Scripps Institution of Oceanography (SIO) group; this data is not reported here.

This report is organized into the following sections:

1. A description of the local coordinate system established for the experiment site and its orientation with respect to compass and map coordinates, along with a description of vertical controls.
2. A description of the beach together with profile data obtained by wading in October, 1987, and March, May, June and July, 1988.
3. A description of methods and layout for "box" and "fan" surveys.
4. A description of results of the box and fan surveys.
5. A description of data related to the installation of the Bragg bar field.

## 2 The Coordinate System

A local coordinate system was established for the experiment. The local  $x$  axis consists of a baseline running approximately parallel to the beach in the study area, and located approximately 20m landward of the beach berm crest. Positive  $x$  is directed southward. In the following, southward will correspond to downcoast (to right looking seaward) and northward will correspond to upcoast (to left looking seaward). The baseline and reference survey markers are shown in Figure 1.

### 2.1 Horizontal Positioning

Horizontal position of the baseline was established by aligning as nearly parallel to the local October shoreline as possible. There is some indication that the beach is slightly curved, with the waterline located further from the baseline at the northern end of the box.

The orientation of the baseline is  $32^{\circ}58'14''$  with respect to true North, as judged from azimuth readings between survey markers and the Canaveral lighthouse. The longshore extent of the "box" surveying region falls in the region  $-100m \leq x \leq +250m$ . The box centerline is then located at  $x = +75m$ . The choice of coordinates used here makes  $y$  positive offshore from the baseline in a right-handed coordinate system. The geometry of the "box" and "fan" survey areas with respect to the local coordinate system is indicated in Figure 2. The location of the origin  $x = 0m$  was chosen based on a compromise between the request that the origin be located at the extension of South Patrol Road to the baseline and the fact that the beach access road actually curves around quite a bit.

The offshore extent of the box was taken to be 441m, which corresponds to an estimate of 41m from baseline to *MHW* based on October surveys, plus 400m. The fan then is in the offshore region  $441m \leq y \leq 1041m$ . The position of the box and fan with respect to the beach and other local features is indicated in Figure 3.

### 2.2 Vertical Positioning

The baseline is provided with three elevation markers at positions (x,y) equal to (200,0), (50,0) and (-100,0). These markers are tied back to the survey marker "Artesia", and have elevations of +2.87m, +2.81m and +2.71m NGVD respectively. These markers were used as reference to establish absolute elevation during beach profiling, since direct line of sight to the marker "Artesia" was obscured by vegetation and other beach features (and was quite distant from the immediate measurement region).

A second marker "Spoils" is present on the shoreward side of the dredge-spoil mount, close to the inlet. (See figure 3) This marker has been used to level tide gages and to check

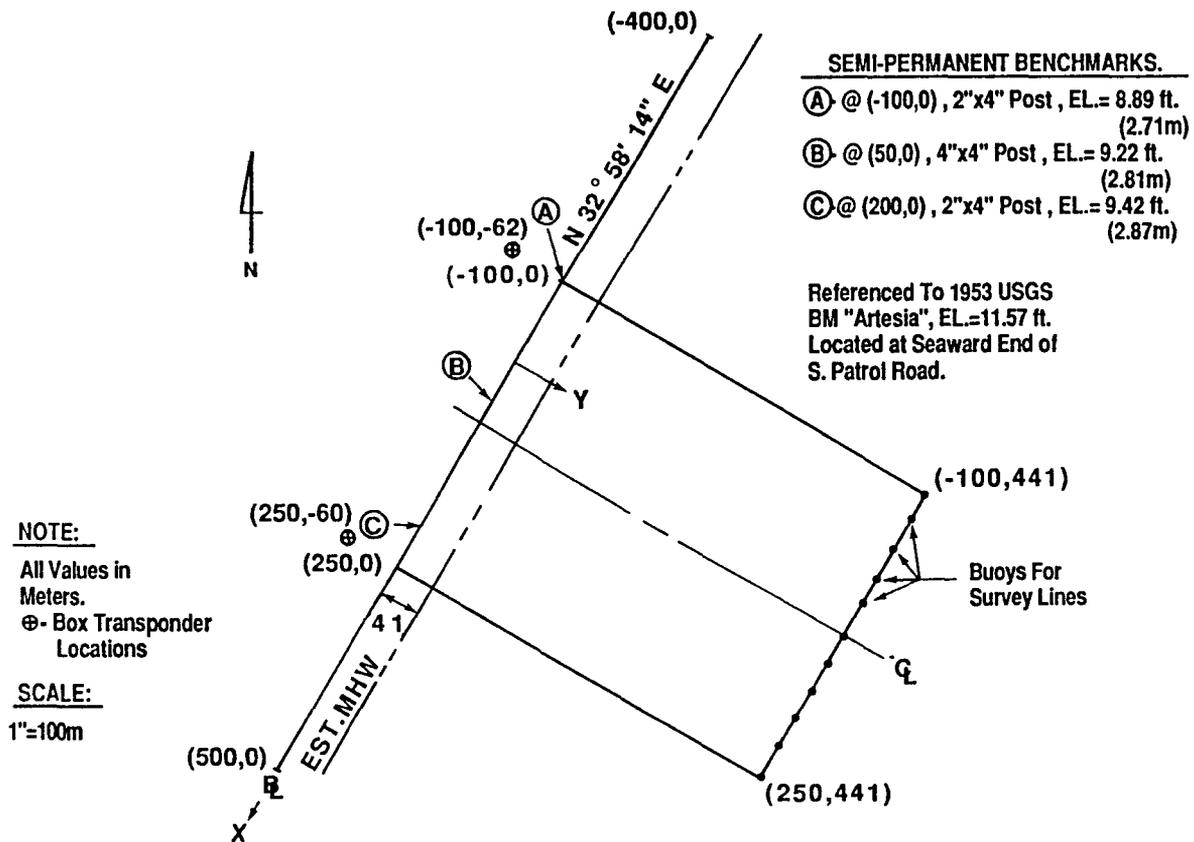


Figure 1: Baseline for local coordinate system

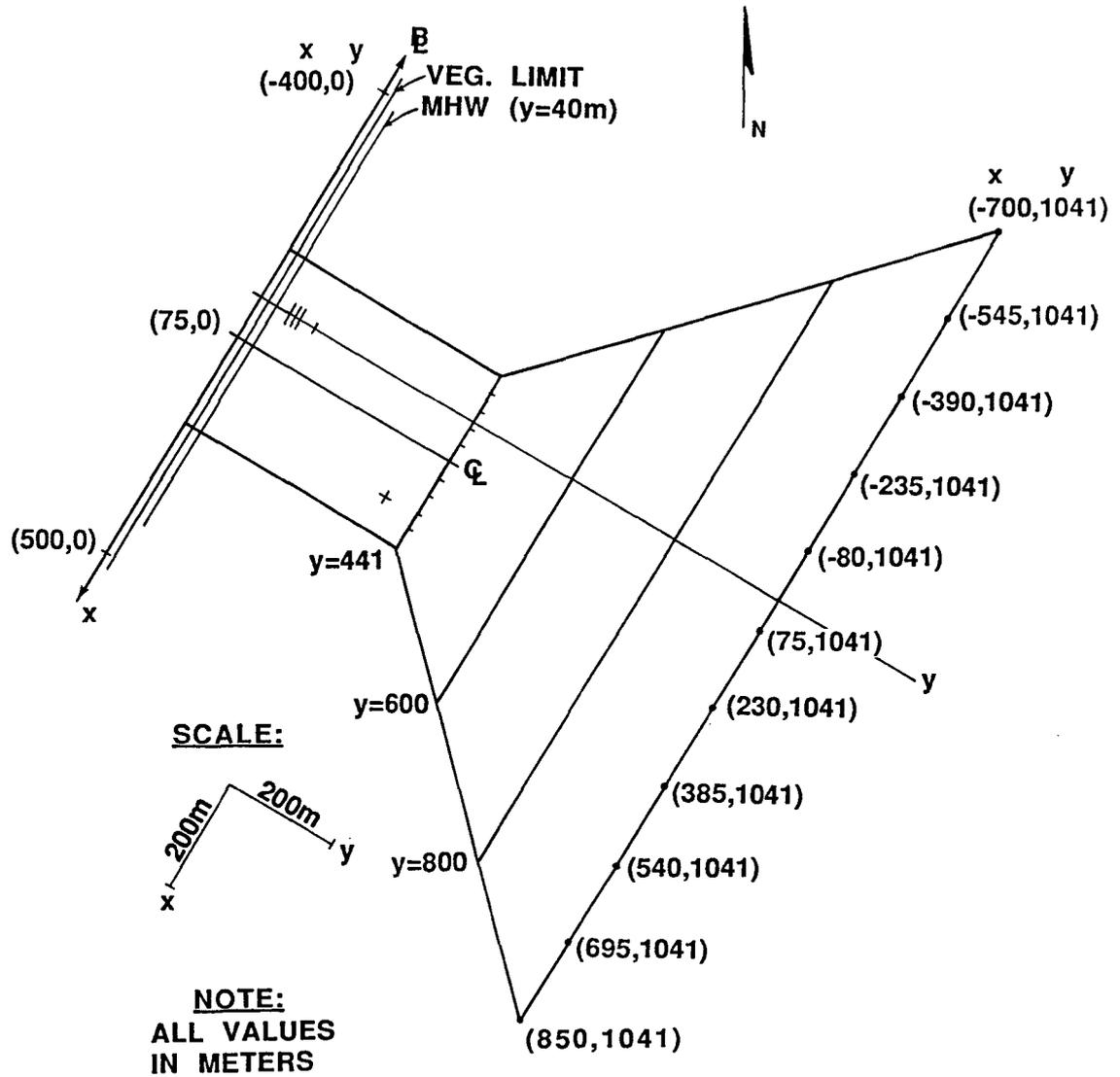


Figure 2: Geometry of box and fan survey areas



elevations at the southern end of the baseline. Positions of reference markers are indicated in Figure 1.

All elevation data provided in this report is with respect to NGVD as provided by NOS for the "Artesia" and "Spoils" markers. A correction to MLW is required to tie in with the NOAA Tide Tables 1988 (Reference 1). MLW for the Port Canaveral area is computed from a tide gage at Patrick Air Force Base. The correction is given by  $MLW = -0.44m$  NGVD. All data may be converted by adding  $0.44m$  from the given NGVD values to obtain MLW elevation values. Correspondence between local converted values of tidal minima and maxima and the values given by the NOAA tide tables was quite good under calm weather conditions. During the March survey, a strong offshore breeze set down the coastal water level, causing a marked discrepancy between measured and predicted tides. However, overlap between beach profiles and boat profiles was quite good during this period, indicating the accuracy of the tide gage levelling.

x(m)	March	May	June			July									
	16-17	16-17	21	25	27	7	9	10	12	13	14	15	16	17	19
-100	*	*		*	*										*
-82.5					*										
-65	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
-47.5					*			*	*	*					*
-30	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
-12.5					*			*	*	*					*
5	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22.5			*		*			*	*	*					
40	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
57.5			*		*										
75	*	*	*	*	*		*	*							
110		*	*	*	*										
145			*	*	*				*			*	*		
180		*	*	*	*	*	*	*	*	*	*	*	*	*	
215			*	*				*	*						
250	*	*		*								*	*		

Table 1: Available profile data for Cape Canaveral experiment, March - July, 1988

### 3 The Beach and Profile Data

The beach in the study area consists of a relatively flat intertidal zone backed by a steep foreshore. The beach shoreward of the berm is essentially flat but well vegetated, thus providing some obstacles in line of sight surveying. The vegetation line extends close to the berm in summer.

Beach profile data was collected using a number of techniques ranging from a standard level and tape operation to a total surveying station with mobile prism operation. No definitive intercomparison tests were made for the different techniques, but results were judged to be of sufficient accuracy due to the consistent repeatability in subaerial portions of the survey lines. A list of available profile data is indicated in Table 1. Plots of individual profiles and listings of the data sets are given in Appendix A. For the individual profile plots, data for each day is compared to data from the immediately previous survey, if available.

#### 3.1 March Surveys

At the time of the March surveys, it was visually apparent that the beach had suffered some active erosion during the winter. The activeness of the beach was evidenced by some apparent relic scarping which starts in the northern 50m of the box and extends to the north, as well as by the presence of a set of cusps in the southern half of the box and extending further south. At the time of the survey, the intertidal beach appeared to be relatively flat

and uniform, as has been noted before; however, surveys (see below) indicated the presence of a bar at the northern extreme of the box, extending to an unknown distance further north. Talks with several security guards indicated that winter damage had been extensive and that the beach had undergone fairly extensive recovery by the time of the surveys.

Due to the question of whether or not the beach had recovered a summer equilibrium, it was decided to conduct a somewhat reduced set of beach profiling. Profiles were conducted on  $x$ -coordinate stations  $-100m$ ,  $-65m$ ,  $-30m$ ,  $+5m$ ,  $+40m$  and  $+75m$ , which correspond to the box range lines for the northern half of the box, and at station  $+250m$ , which corresponds to the southern limit of the box. Profiling was done using a self-leveling transit to record elevations and an OMNI total station to determine offshore distance from the survey baseline. The wader used a standard fiberglass surveying pole with a three-prism element mounted on its top. The longshore position of the wader was controlled by line of site with a pair of range poles mounted on each longshore station. Elevations were tied to markers at coordinates  $(-100,0)$ ,  $(+50,0)$  and  $(+200,0)$ , which are in turn surveyed back to the survey marker "Artesia" in order to tie in with NGVD.

Profile lines are plotted in Figure 4, where distance  $y(m)$  corresponds to physical distance seaward of the baseline. The beach berm is generally located at  $y = +20m$ , but there is some general curvature of the beach which tends to place shore somewhat further from the baseline as  $x$  decreases (to the north). The profiles in Figure 4 are vertically scaled as indicated, with the  $x = -100m$  profile aligned with the scale and each subsequent profile shifted down by  $0.5in/35m$  increment in  $x$ . The vertical profile spacing thus corresponds to relative longshore spacing. The bottom of the figure is towards the south.

The profiles indicate the presence of a bar at the northern extreme of the profiling box. This feature also survives at the next station ( $x = -65m$ ) but is welded to the beach at this point. South of these two profiles, the beach is essentially uniform. The bar feature and the (otherwise) overall uniformity may be seen more clearly in Figure 5, where the profiles are overlaid.

Finally, the question of profile stability and of the present non-equilibrium state of the overall profile is addressed in Figure 6, where representative profiles from October and March are overlaid. The  $+600m$  October profile overlays the  $-100m$  March profile directly. The  $+450m$  October profile lies at  $+50m$  in the present local system and is shown in comparison to the  $+40m$  March profile. The  $+300m$  October profile lies at  $+200m$  in the local system and is shown in comparison to the  $+250m$  March profile. In all cases, a seaward movement of the berm is noted coupled with a general deepening of the nearshore profile. This somewhat odd coupling is deemed to be not-to-bizarre due to the fact that the beach is essentially a trapped feature maintained by the vicinity of the Port Canaveral

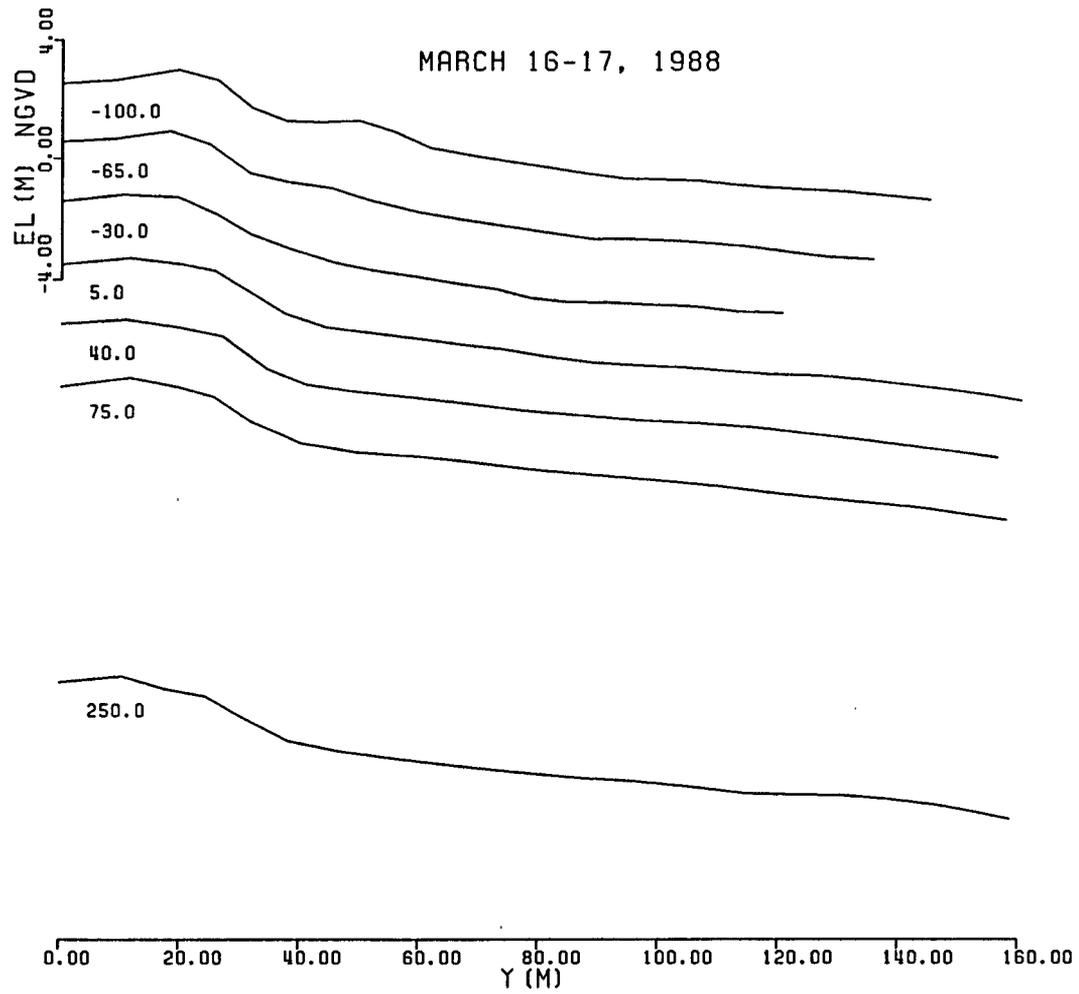


Figure 4: Wading profiles, March 16-17, 1988. Profiles at x stations -100, -65, -30, +5, +40, +75 and +250

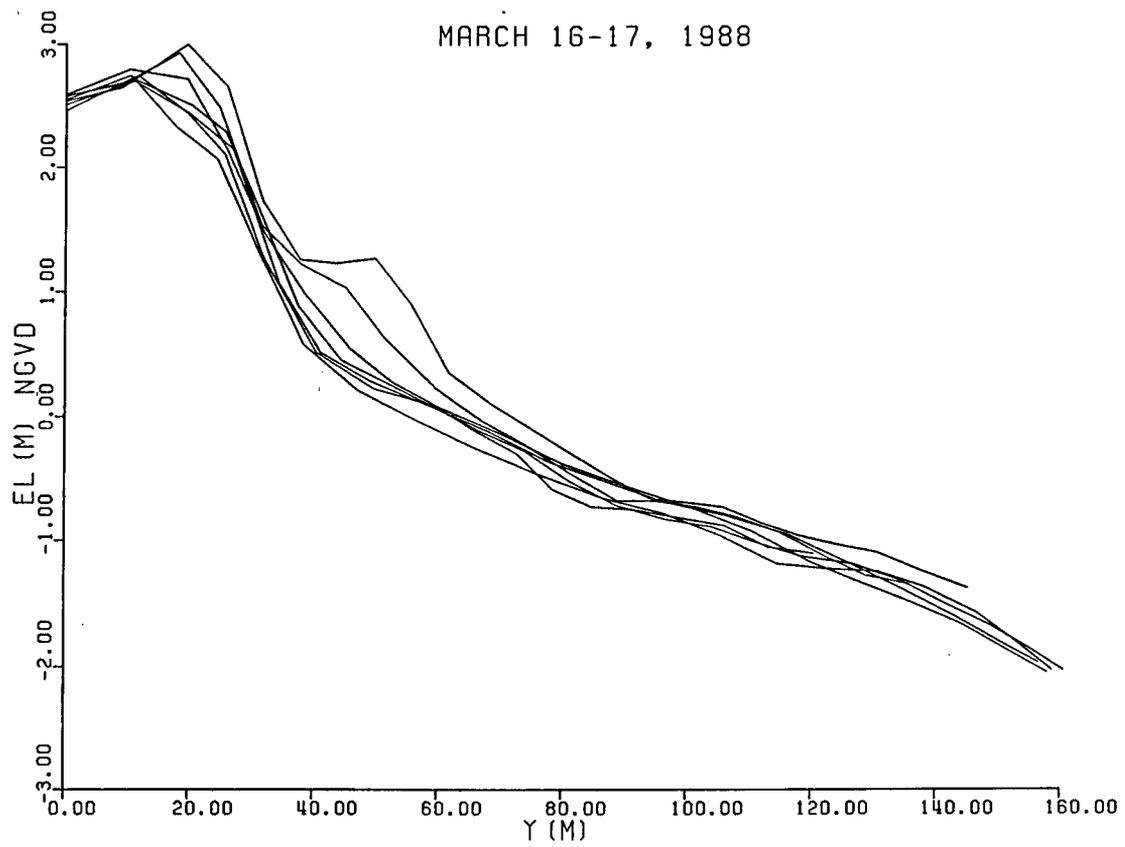


Figure 5: Overlay of March profiles. Note bar in profile at northern extreme of box, and the slight curvature of the beach.

north jetty.

### **3.2 May Data**

A survey of the area in May, 1988 indicated that the beach had undergone a period of recovery since the March surveys. The shore-parallel bar evident in the northern portion of the range had been worked further shoreward. Figure 7 shows the profiles for the May survey, which are also shown overlayed in Figure 8 and give an indication of the longshore uniformity of the beach in the offshore region beyond the intertidal zone.

### **3.3 June-July Data**

The evolution of the beach profiles during the experimental period was quite complex due to a series of strong (and unexpected) weather events. First, a storm passed through the region about two weeks prior to the startup date of June 21. This storm left a pronounced bar and trough system parallel to the beach face. This feature advanced shoreward for several days, until the beach recovered a semblance of regularity on June 27. Then, an unseasonably strong storm from the North-East swept through the area and reestablished the bar-trough system (to an even greater degree). Beach profile recovery proceeded until about July 9 or 10, when it was felt that the artificial bar field could be installed.

Figures 9-21 provide plots of the surveyed beach at irregular intervals during the experimental period, and show the evolution of the bar-trough system. Plots for July 12, 13 and 14 also show the bar positions on the regularly surveyed profiles, while the set of profiles for July 15 show relict scouring due to the recently removed artificial bars. Overlays of profiles for each day are included in Appendix A, and give an idea of the relative degree of longshore variability occurring during the stormy conditions. Note that this variability was more extensive than during the pre-experiment surveys.

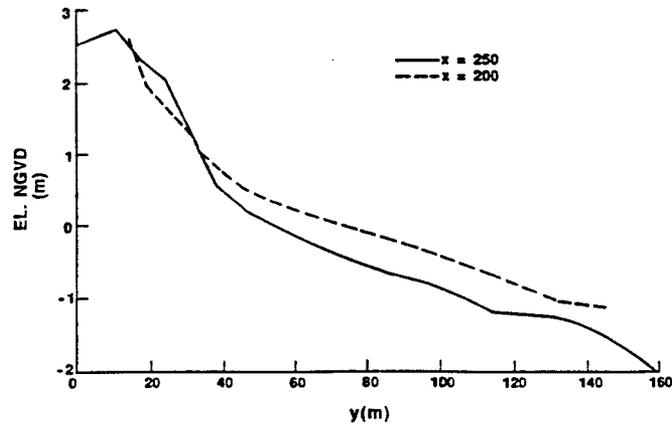
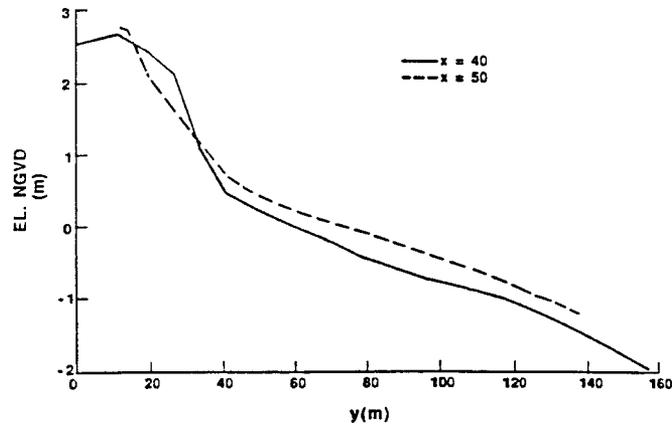
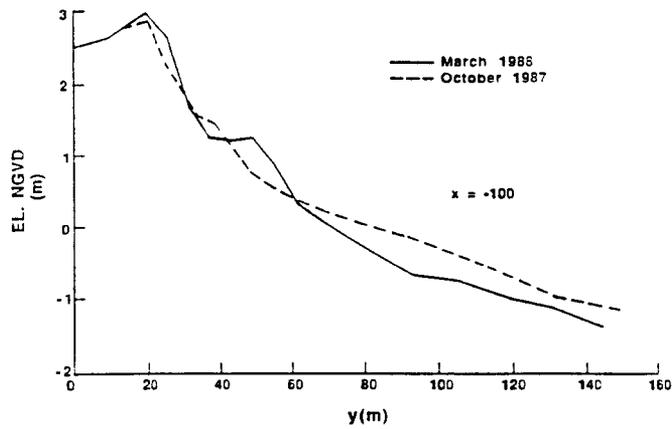


Figure 6: Comparison of March, 1988 and October, 1987 profiles. March profiles indicated by solid lines; October profiles by dashed lines.

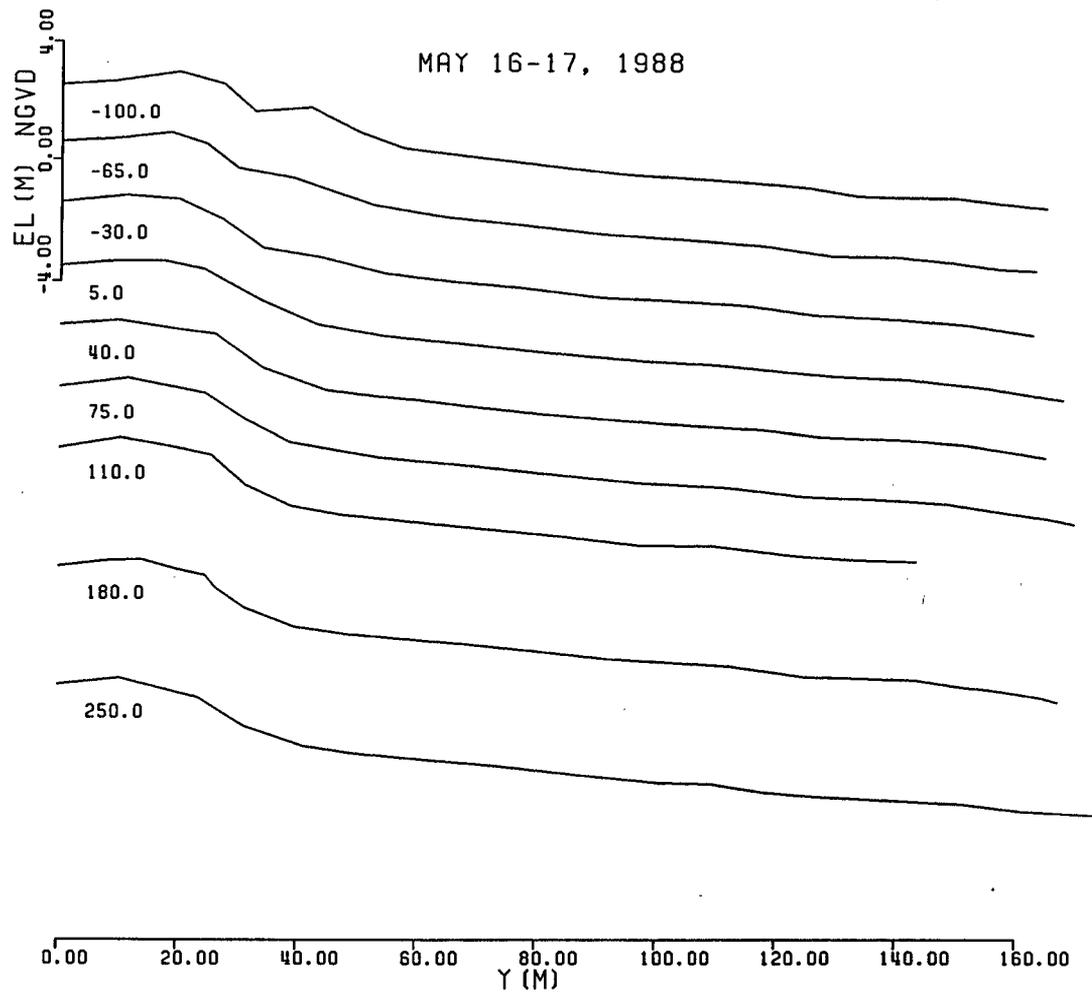


Figure 7: Wading profiles, May 16-17, 1988.

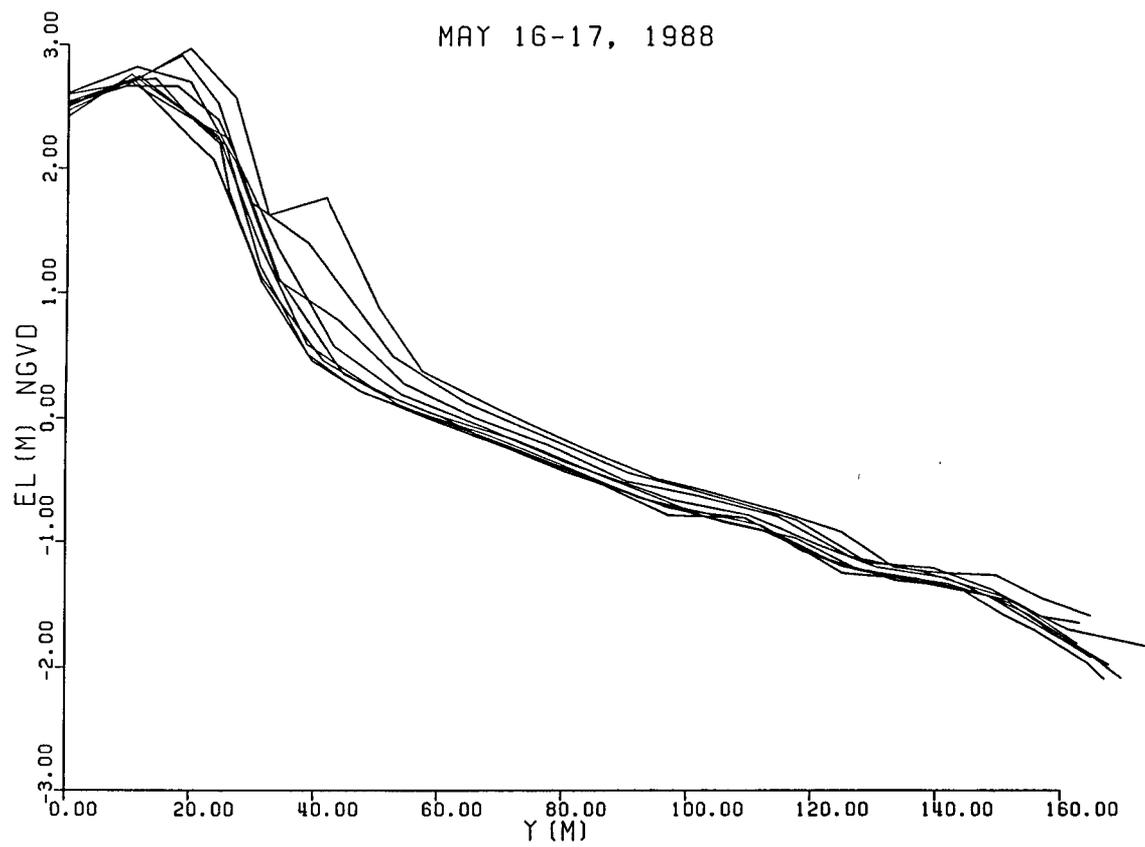


Figure 8: Overlay of May profiles.

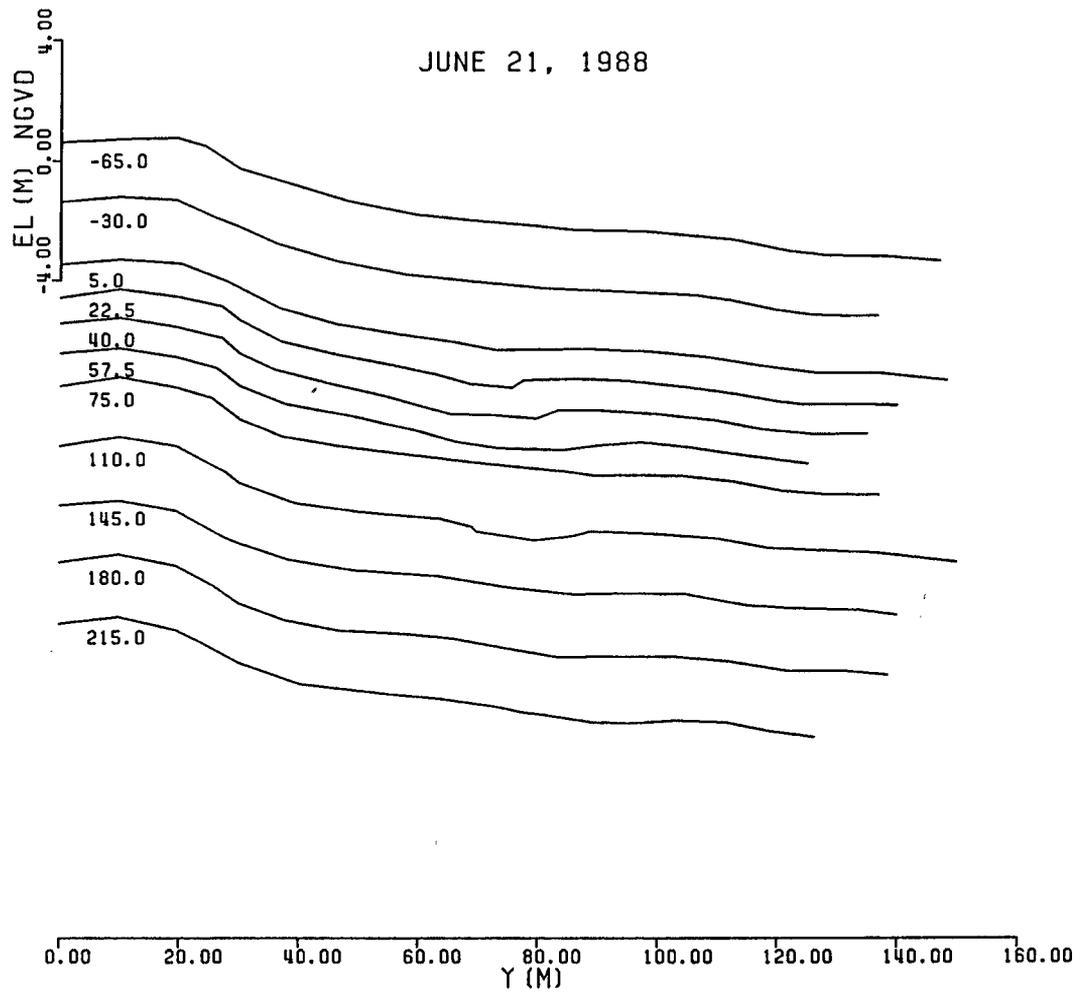


Figure 9: Wading profiles, June 21, 1988.

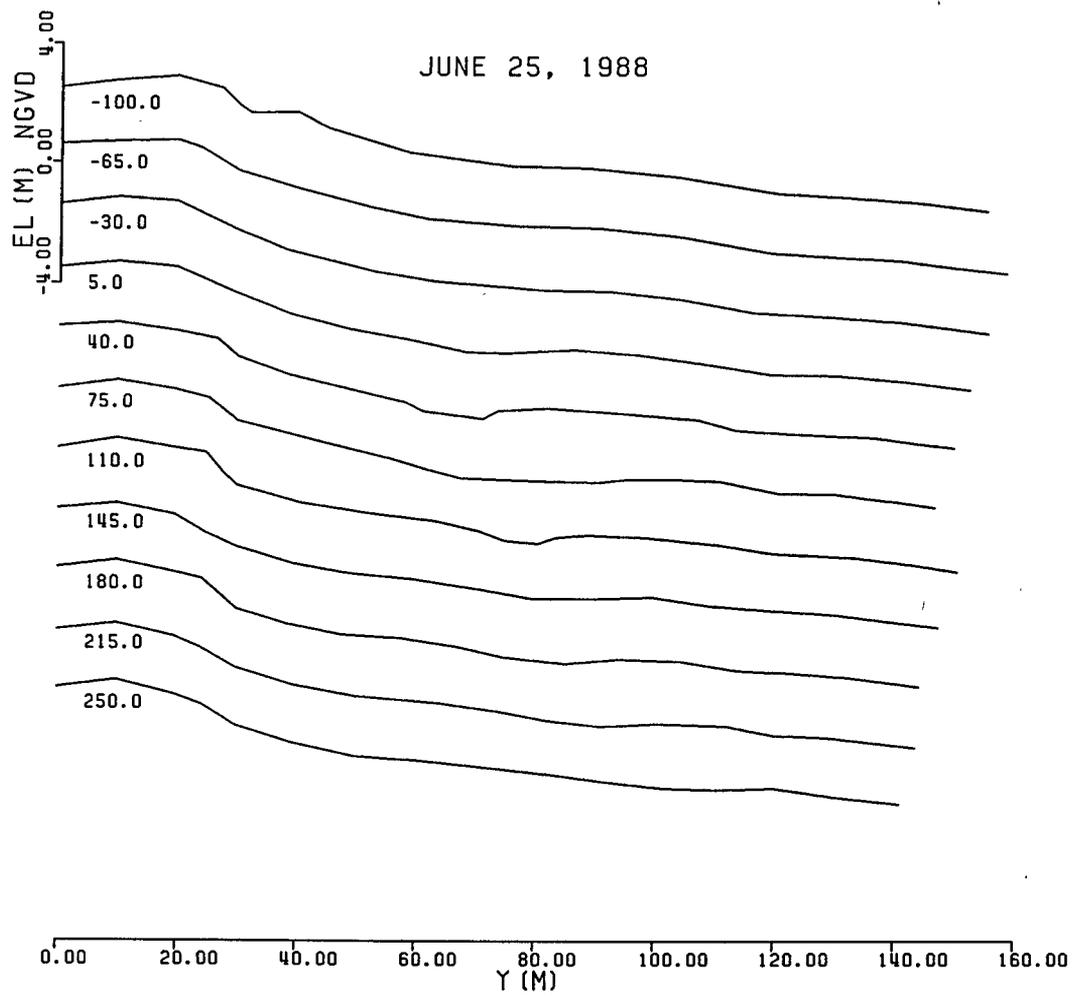


Figure 10: Wading profiles, June 25, 1988.

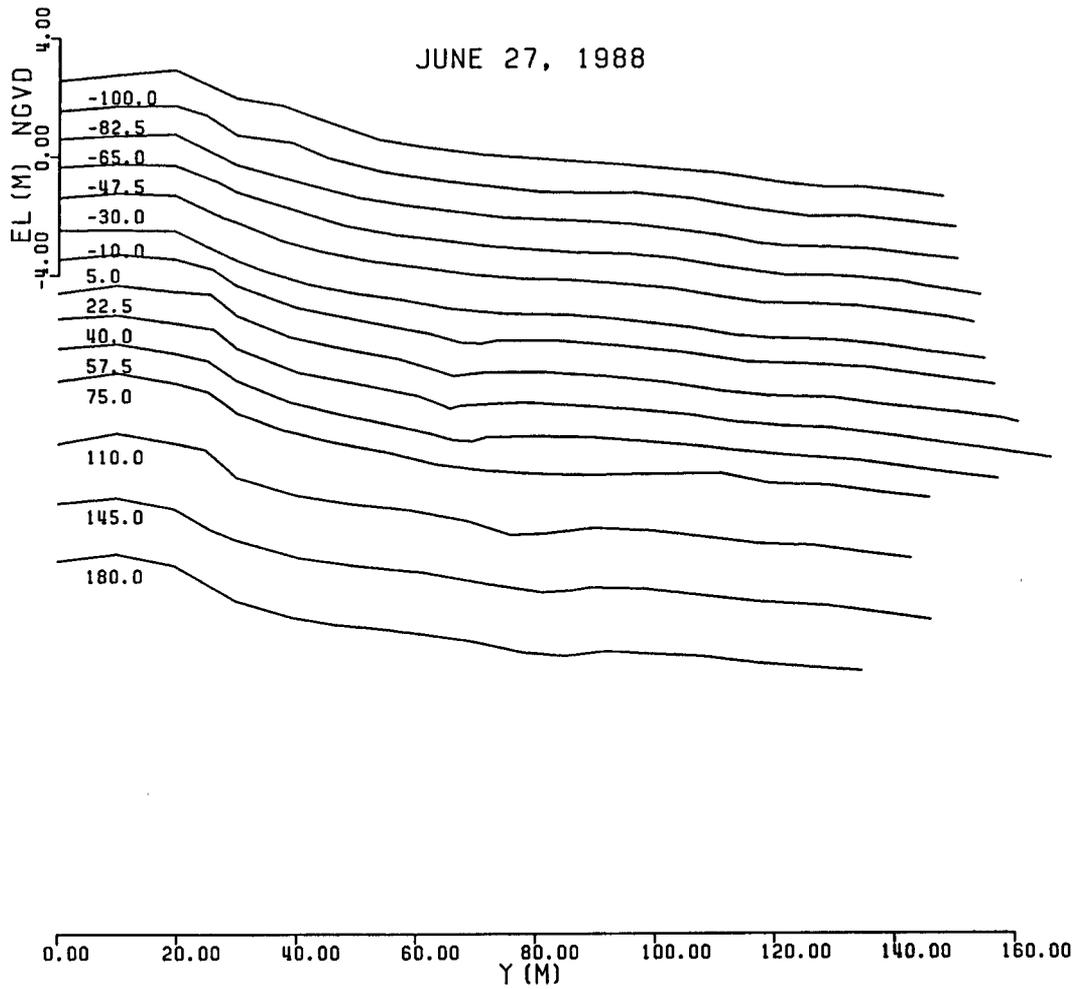


Figure 11: Wading profiles, June 27, 1988.

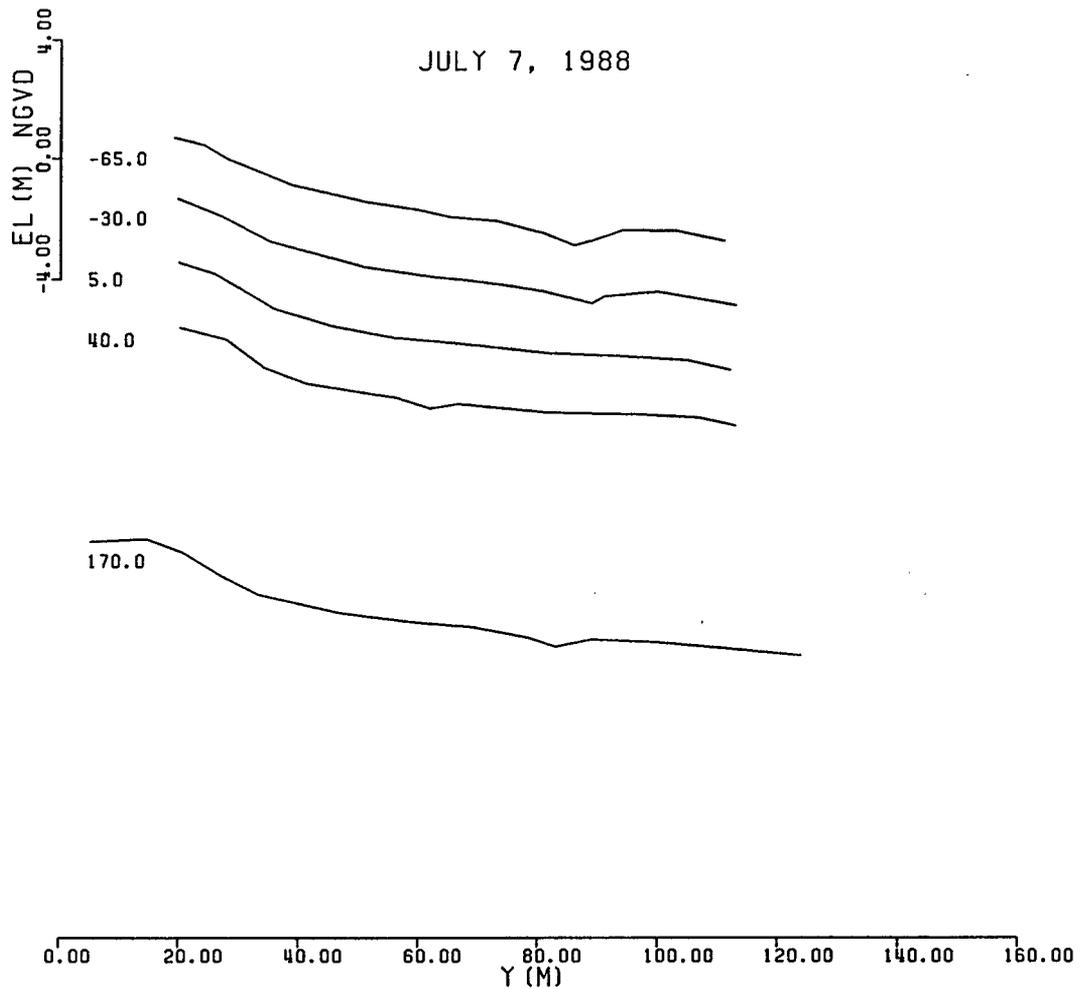


Figure 12: Wading profiles, July 7, 1988.

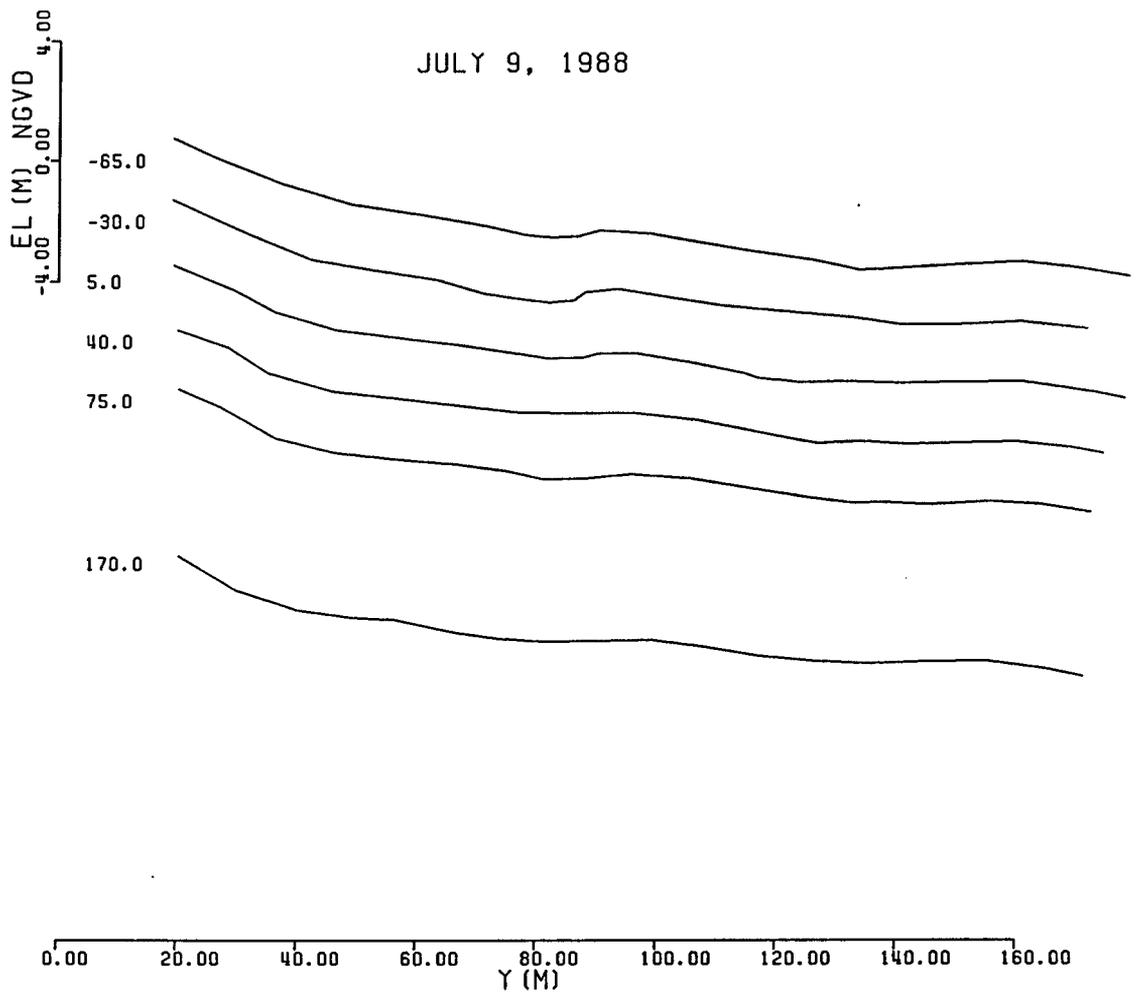


Figure 13: Wading profiles, July 9, 1988.

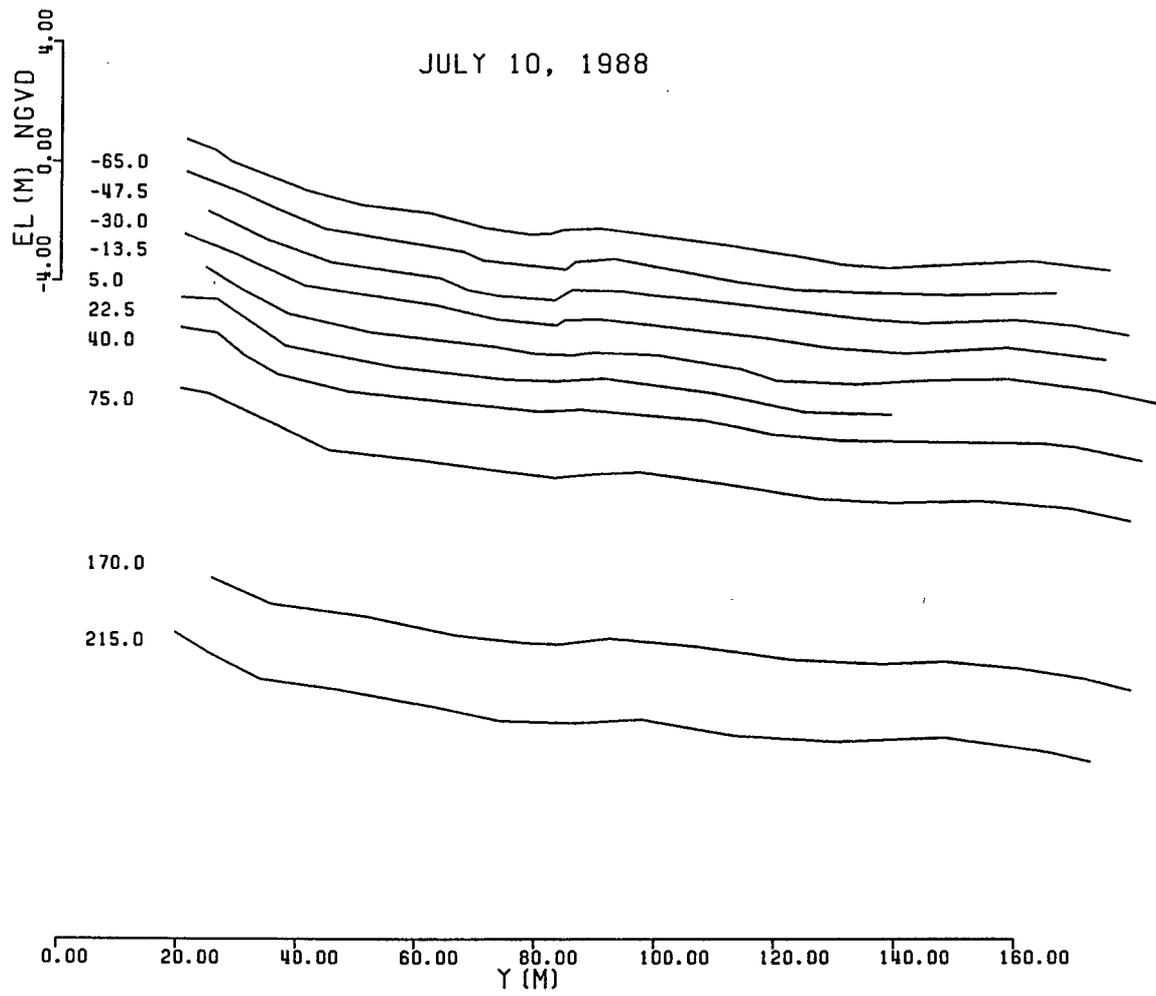


Figure 14: Wading profiles, July 10, 1988.

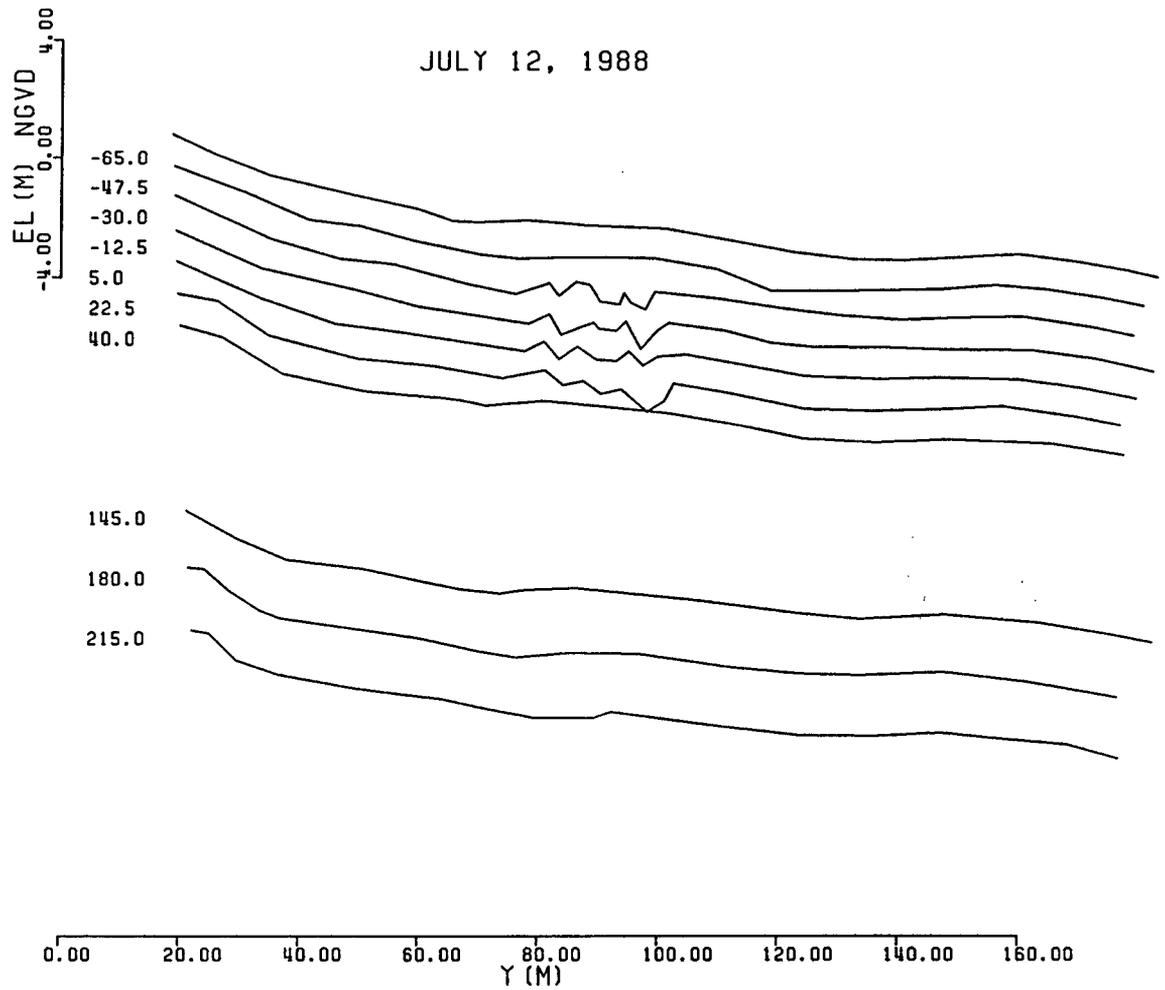


Figure 15: Wading profiles, July 12, 1988.

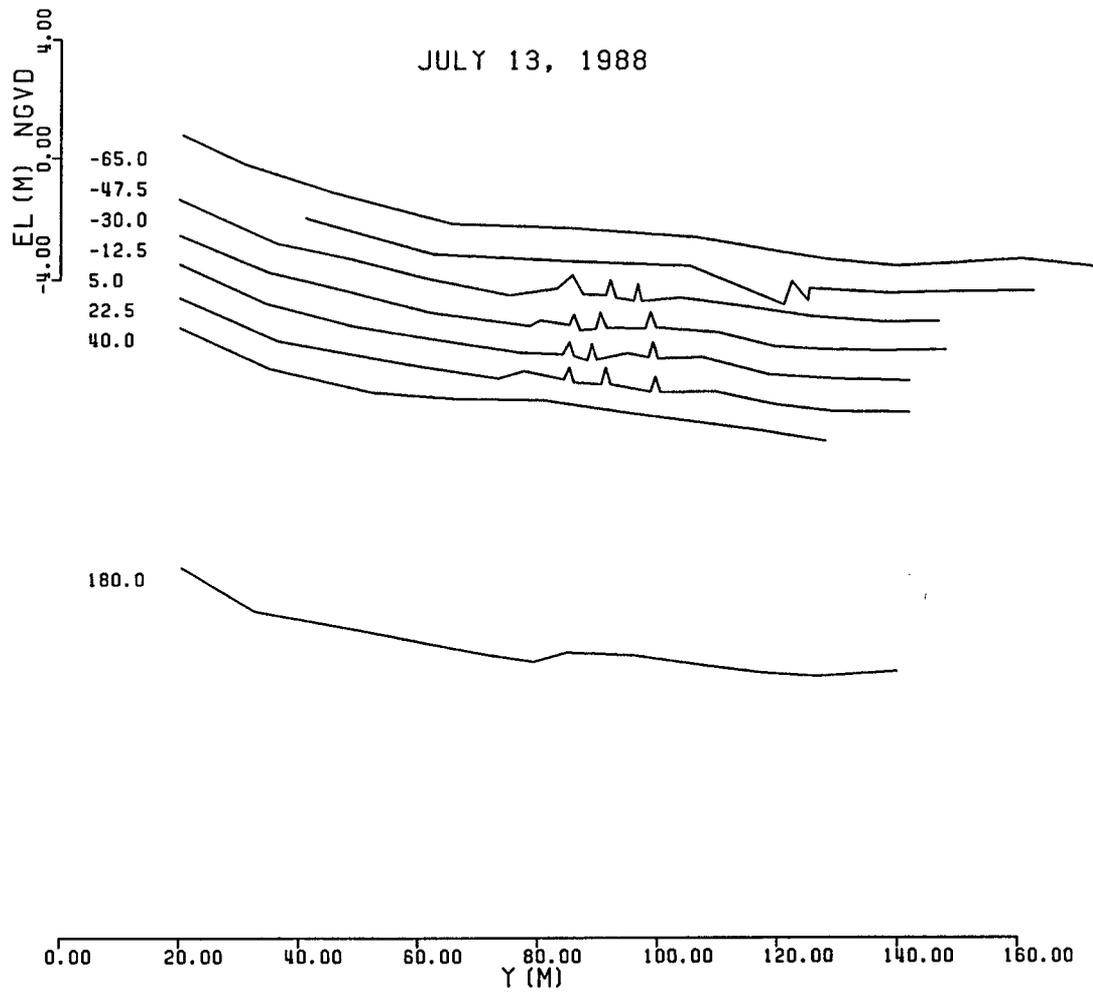


Figure 16: Wading profiles, July 13, 1988.

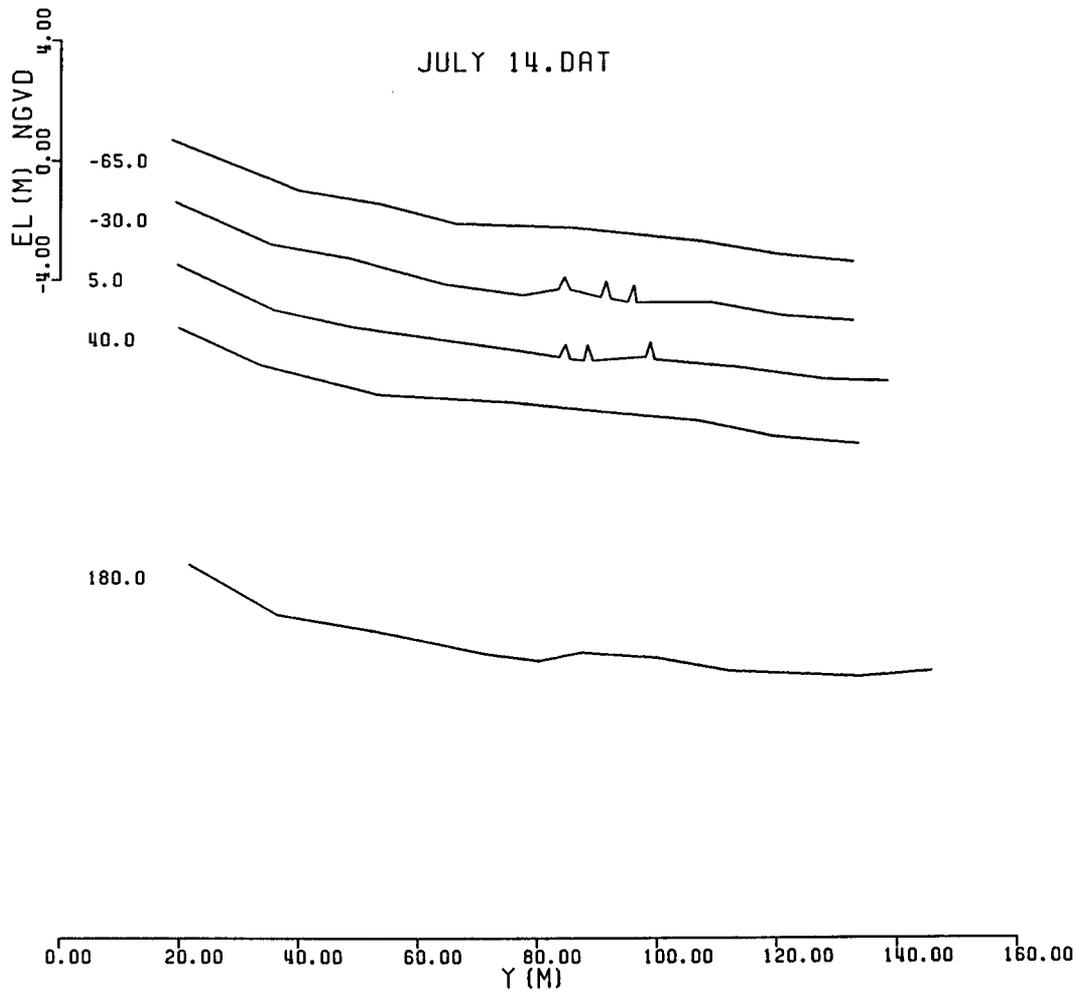


Figure 17: Wading profiles, July 14, 1988.

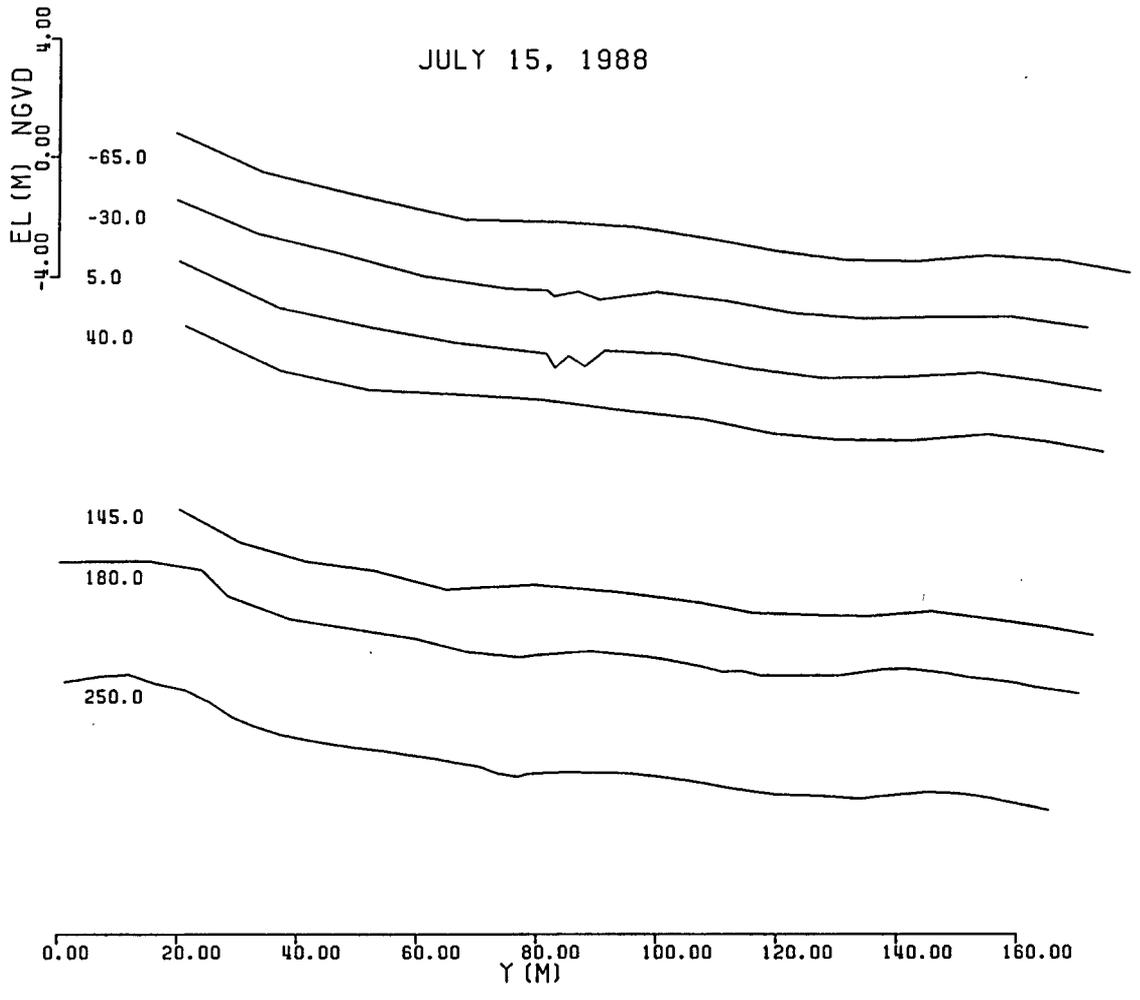


Figure 18: Wading profiles, July 15, 1988.

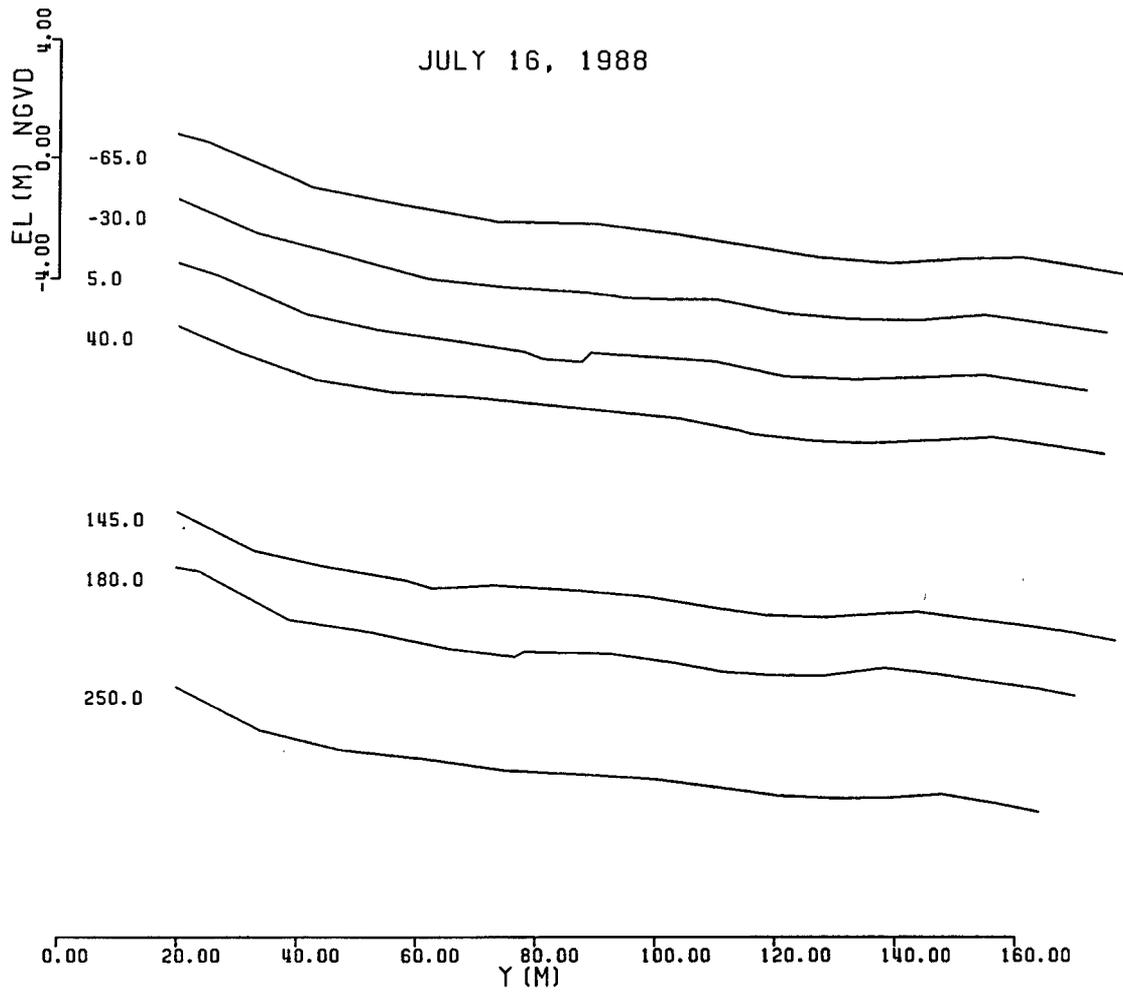


Figure 19: Wading profiles, July 16, 1988.

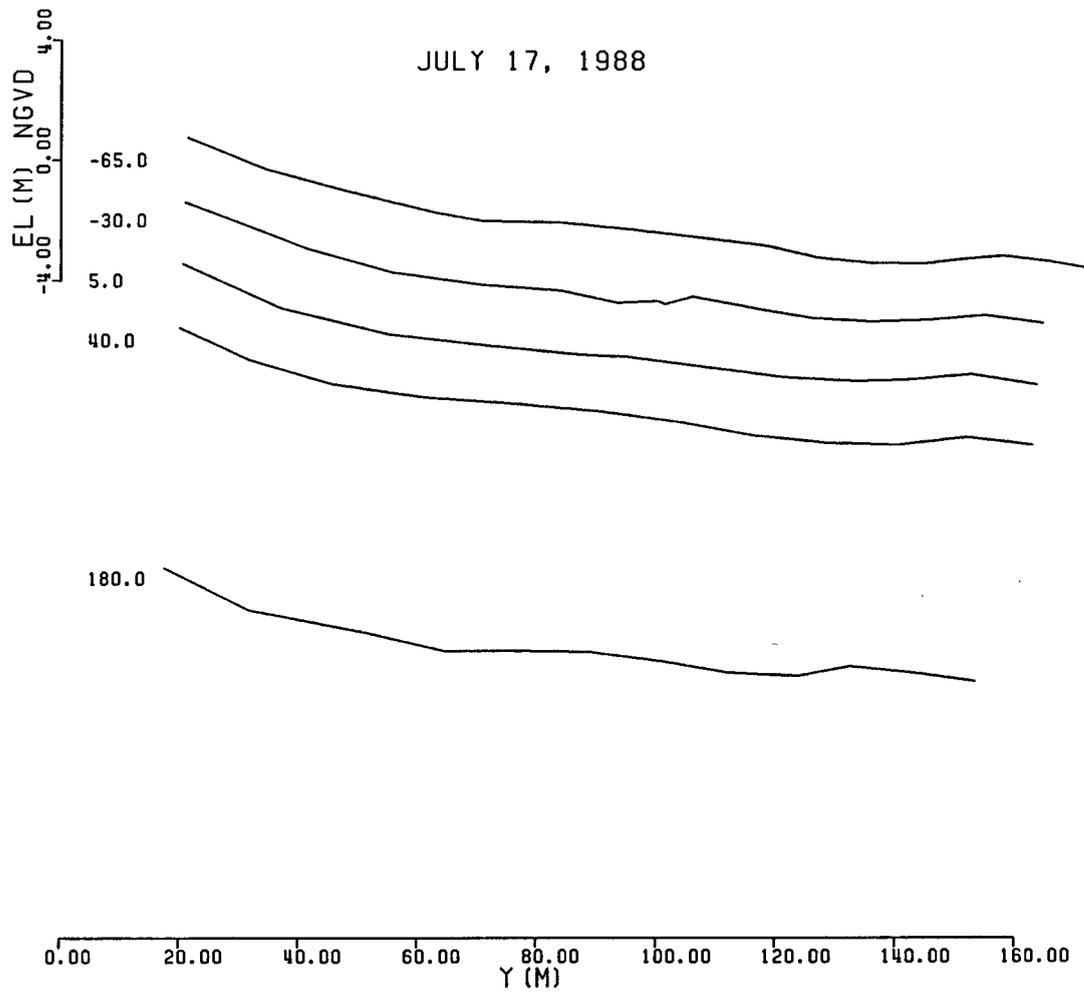


Figure 20: Wading profiles, July 17, 1988.

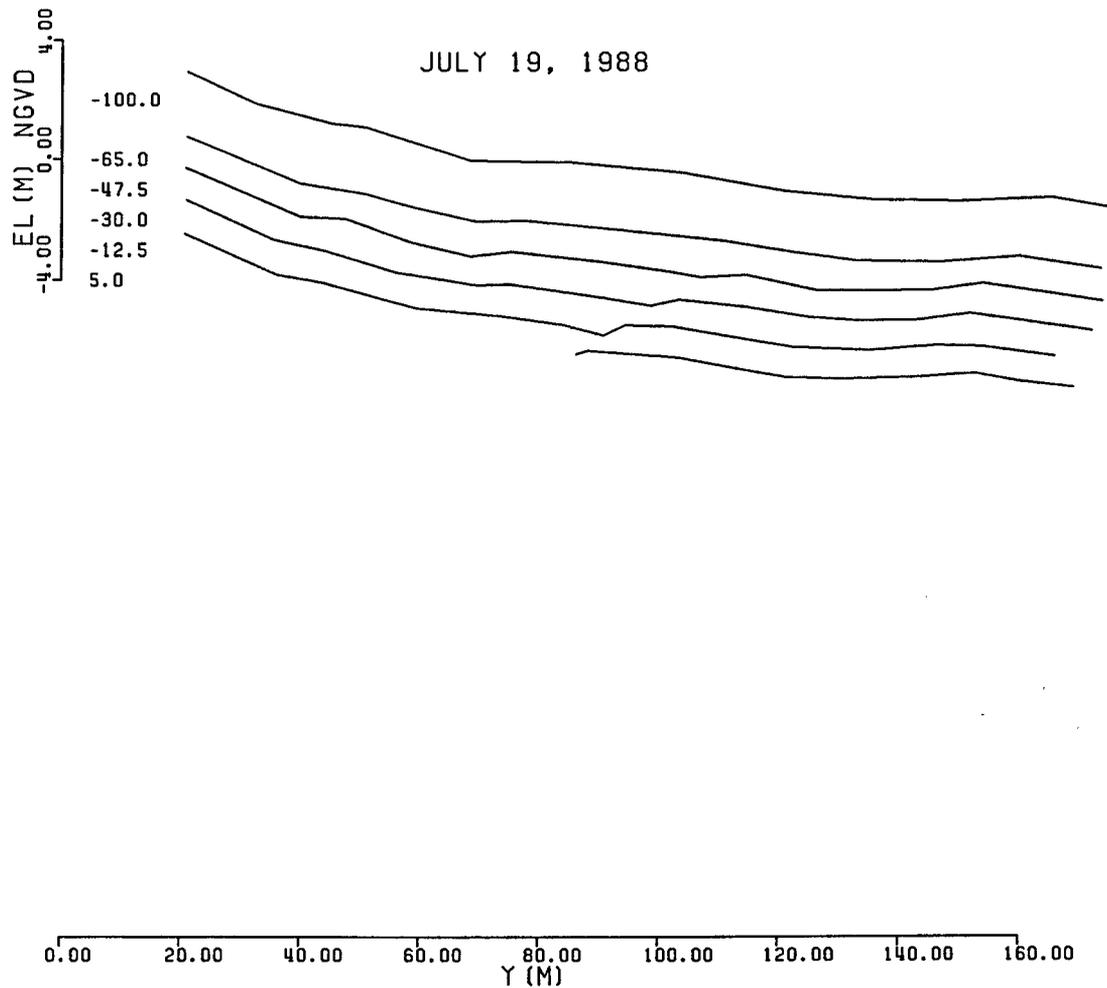


Figure 21: Wading profiles, July 19, 1988.

## 4 Box and Fan surveys: Methods and Layout

A view of the pre-chosen box and fan layout is indicated in Figure 2. This grid was layed out in the field by establishing a system of range poles along the lines  $y = 0m$  and  $y = 20m$  on the beach. The range pole pairs start at  $x = +250m$  and then proceed in 35m increments along the beach to  $x = -100m$ , providing a total of 11 reference pairs at the shore end. These range poles were left on the beach in order to aid in local positioning.

Boat position during buoy placement and surveying was measured using a Motorola Falcon III miniranger system. All surveying was done using a two-transponder system. Transponder sites were surveyed and marked permanently on the beach. For the fan survey and buoy placement, transponders were located at  $(+500,0)$  and  $(-400,0)$  with respect to the baseline. For the box surveys, transponder positions  $(+250,-60)$  and  $(-100,-62)$  were used.

Offshore control for the box was obtained by dropping buoys at the positions indicated in Figure 2. Based on October surveys, it was estimated that the offshore line of the box should be located at  $y = 441m$ . Due to boat drift during dropping and other factors, buoy position tends to be no more accurate than about 5m with respect to the originally specified position. During dropping, boat position was controlled by operating the miniranger system in  $x - y$  mode and thus searching for the actual position. Similarly, buoys for the offshore range of the fan were dropped along the desired line  $y = 1041m$ , with resulting typical errors.

After a great deal of experience was obtained with the Falcon III system in the first Canaveral survey as well as at surveys at other sites, it was found that adequate control of boat position could be maintained by steering according to the  $x - y$  position readout given by the Falcon III. This approach proved to be advantageous in comparison to steering between buoys, since the pilot did not need to maintain forward and backward line of site but could simply monitor a digital readout.

In order to obtain control on the vertical elevation of the surveying boat, a Stevens type F tide gage was mounted on the day buoy at the entrance to the Port Canaveral inlet, which is in clear line of sight of the work area (see Figure 3). The tide gage reference elevation was established with respect to the "Spoils" marker. The measured tide record was discretized into 1/2 hour increments, and then reference elevation for each measured sounding was corrected for tide by interpolation between the tabulated tide gage readings.

Depth soundings were obtained using an Innerspace model 412 fathometer. Depth soundings were calibrated in quite water in the Port Canaveral Harbor using a lead line, and the depth measurements were verified to be within their accuracy range ( $\pm 0.1ft$ ).

Additional calibration using submerged metal discs (trash can lids) was added in the June and July surveys.

The surveying system was operated by linking the miniranger and the fathometer to a MicroPDP-11. The PDP-11 then sampled the miniranger output and fathometer output at a 1Hz rate, and stored values of x,y and depth on floppy disk. Time was referenced to a header value placed in the raw data file at the start of each continuous surveying run. It is noted that the system experienced some difficulties during the March survey. These problems were later found to be a communication problem between the fathometer and PDP-11. The system error caused the computer to record short runs of data values which were typically lower than true, and which tended to hang on a particular constant value (although this value varied continuously with the true depth). No attempt has been made to smooth the March data, since the noise induced by the system error is strongly biased away from zero mean. For example, a running average then produces a profile which is too shallow at every point along the profile. Problems with system communication were corrected, and data from the June and July surveys are quite smooth with the exception of the up and down motion of the boat on the waves, which is easily removed with a running average.

During surveying, the boat operator tried to stay on the desired box profile lines while running inshore, using line-of-sight with respect to the range poles. Diagonal lines were then done while running offshore and tend to be more erratic. A plot of boat position during the March box survey is indicated in Figure 22 for example. Positions for all reported survey lines are indicated in figures in Appendices B and C.

The procedure for surveying fan lines was essentially similar, with line-of-sight positioning being somewhat more important. This is due to the fact that the desired lines were oriented at an angle in the  $x-y$  plane, and thus could not be run by staying on a prespecified  $x$  coordinate value. Plots of boat position for the entire survey run are not shown.

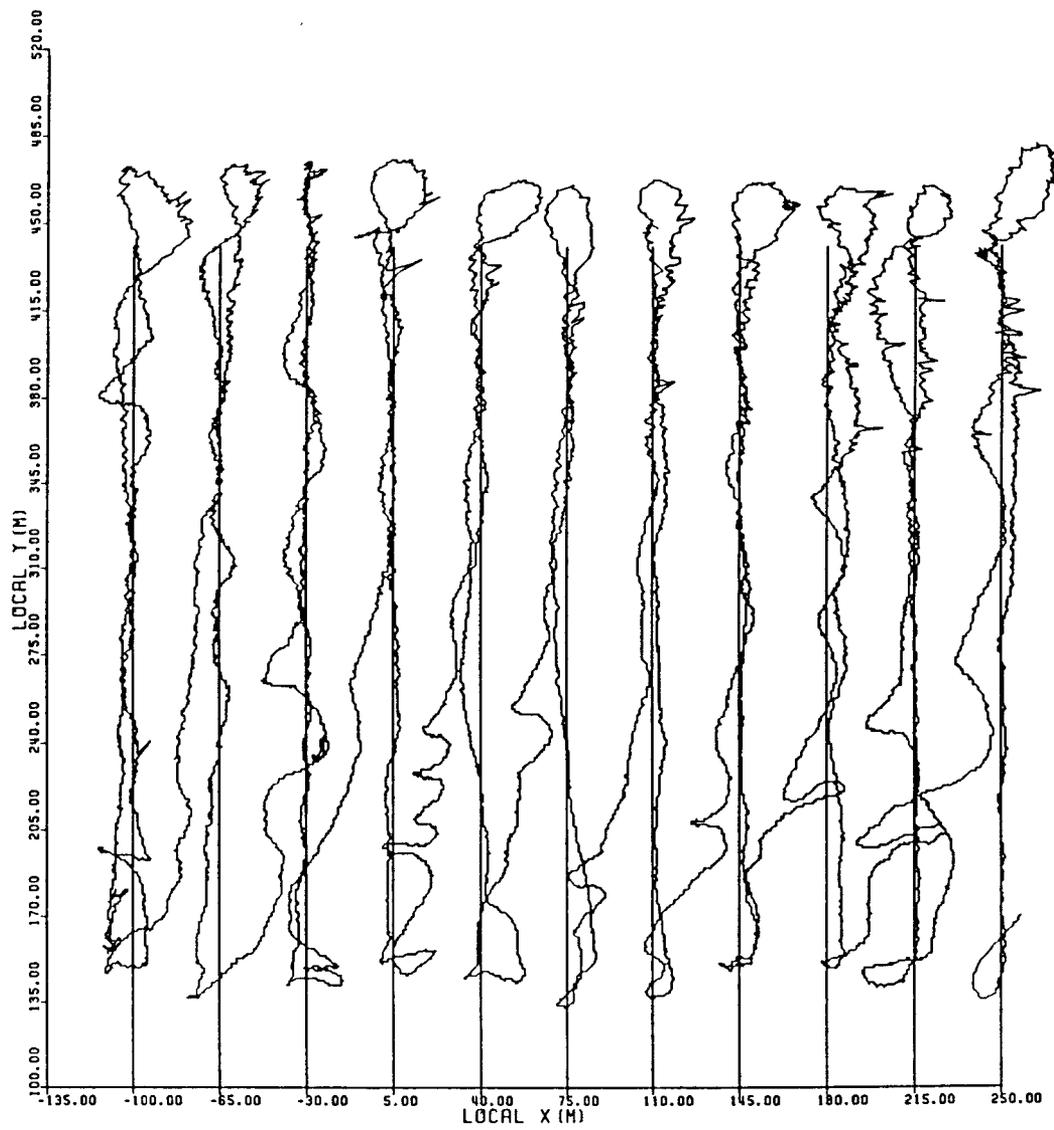


Figure 22: Boat position during March box line survey

## 5 Results of Box and Fan Surveys

### 5.1 March, 1988

The data collected during the March box and fan surveys was found to contain various spikes as well as a relatively more frequent noise component represented by data shifts to several constant values representing depths generally less than the true local value.

Survey data was prepared for reduction as follows.

1. Segments of data corresponding to a particular line, diagonal or transect were isolated and split into separate files. Each file was provided with a header indicating time of run start, which allows for computation of tidal effects.
2. Each separate file was then screened for bad points and, to the degree possible, for the background noise. Bad points are replaced in the record by the arithmetic mean of the two adjacent data points in the record.

Following this initial screening, each record was adjusted for tidal effects and the elevations referenced to NGVD. Appendix B contains plots of the boat track and tidally-corrected data for each separate line and transect in the box section. Data may be obtained on unlabelled, 1600 BPI, ASCII tapes. Beach profiles are included where available (Lines 1,2,3,4,5,6,11 corresponding to  $x = -100, -65, -30, 5, 40, 75, 250$ ). Overlap of beach and box profiles are seen to be excellent except on line 1 (and, to a lesser degree, on line 2).

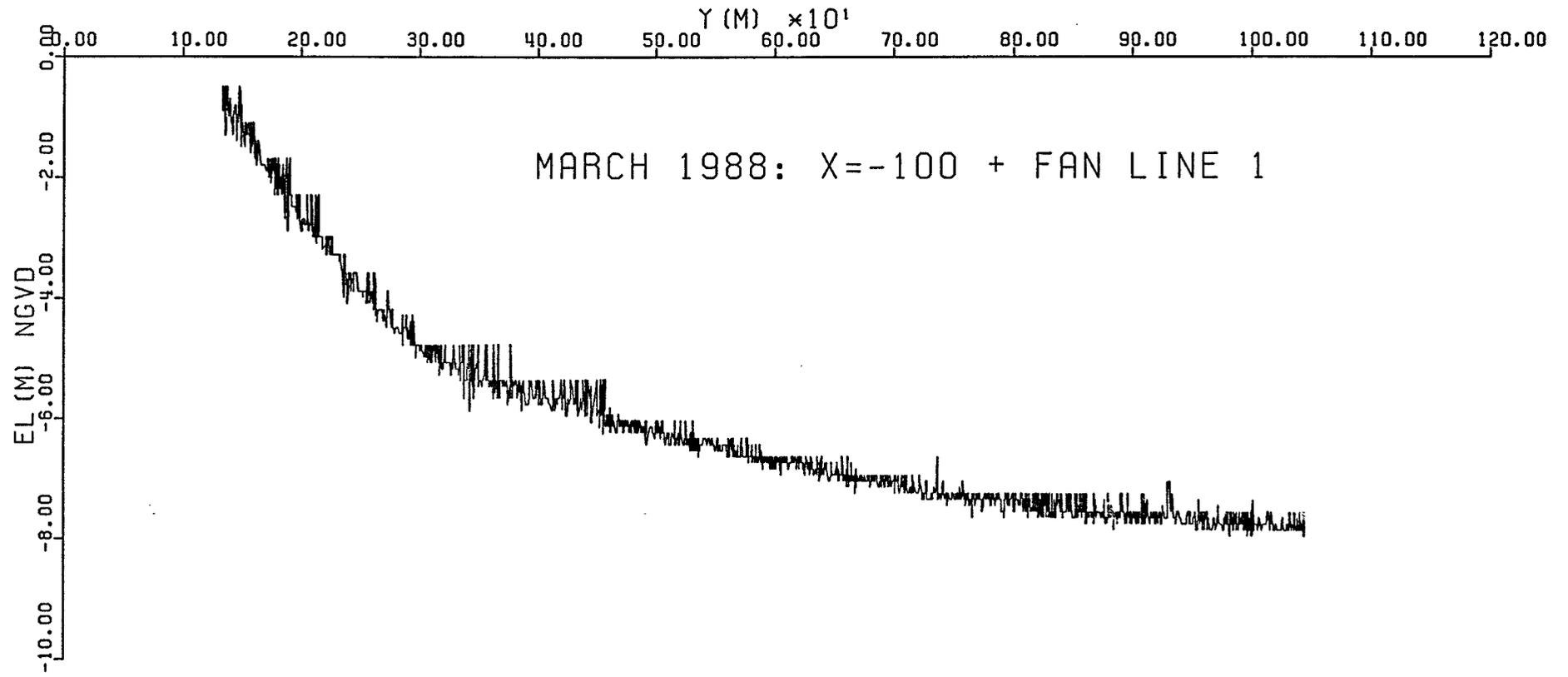
Appendix C contains boat tracks and tidally-corrected data for each line and transect in the fan survey.

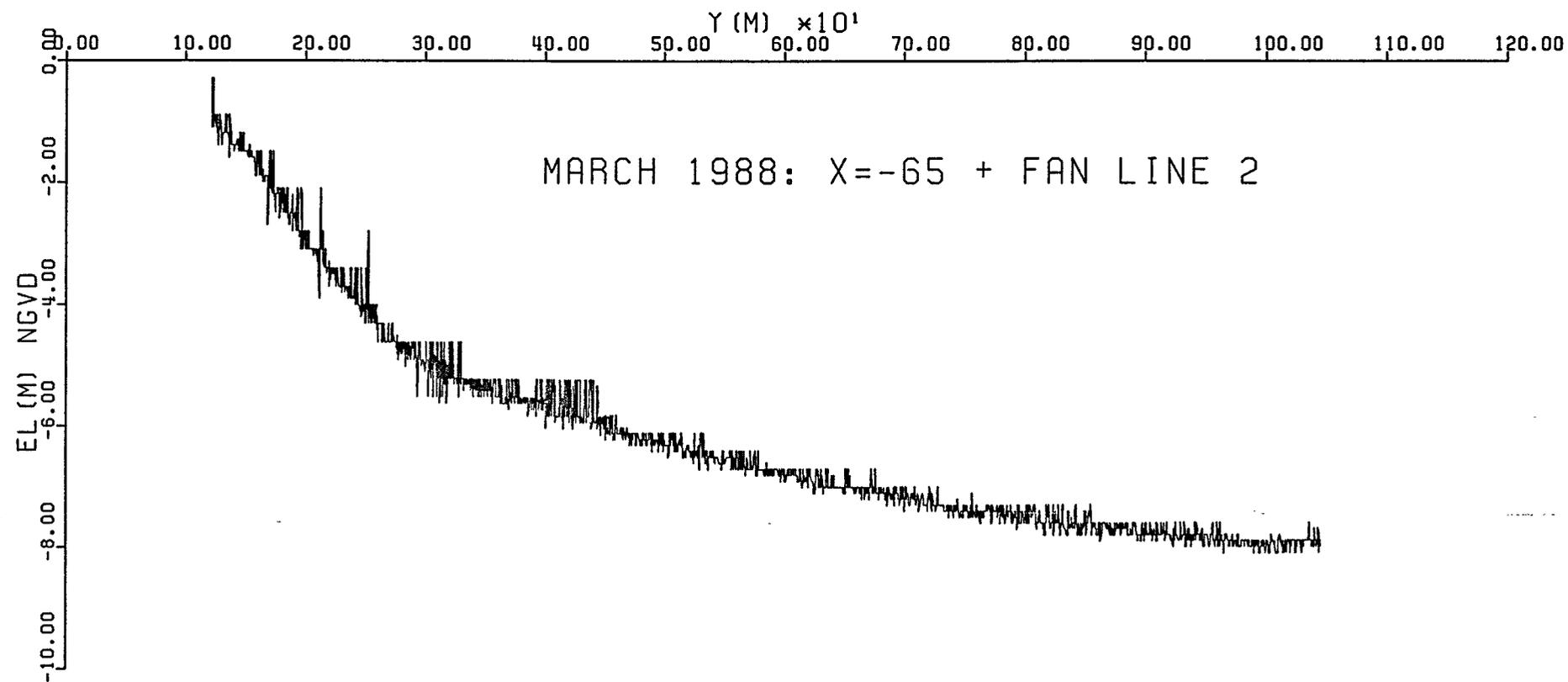
Due to prevailing weather conditions and a miniranger breakdown, it was necessary to perform the box and fan surveys 5 days apart. Figure 23 shows the overlap of tidally-corrected data along each line. Recall that a box and fan line join at the outer edge of the box, but a "line" does not represent a straight-offshore section beyond the junction point. Overlap of box and fan data was again excellent except on lines 9, 10 and 11, where a vertical offset on the order of 30 - 40cm is apparent. This effect is not understood at present, but appears to be associated with the box profiles being too "flat" in their offshore extremes.

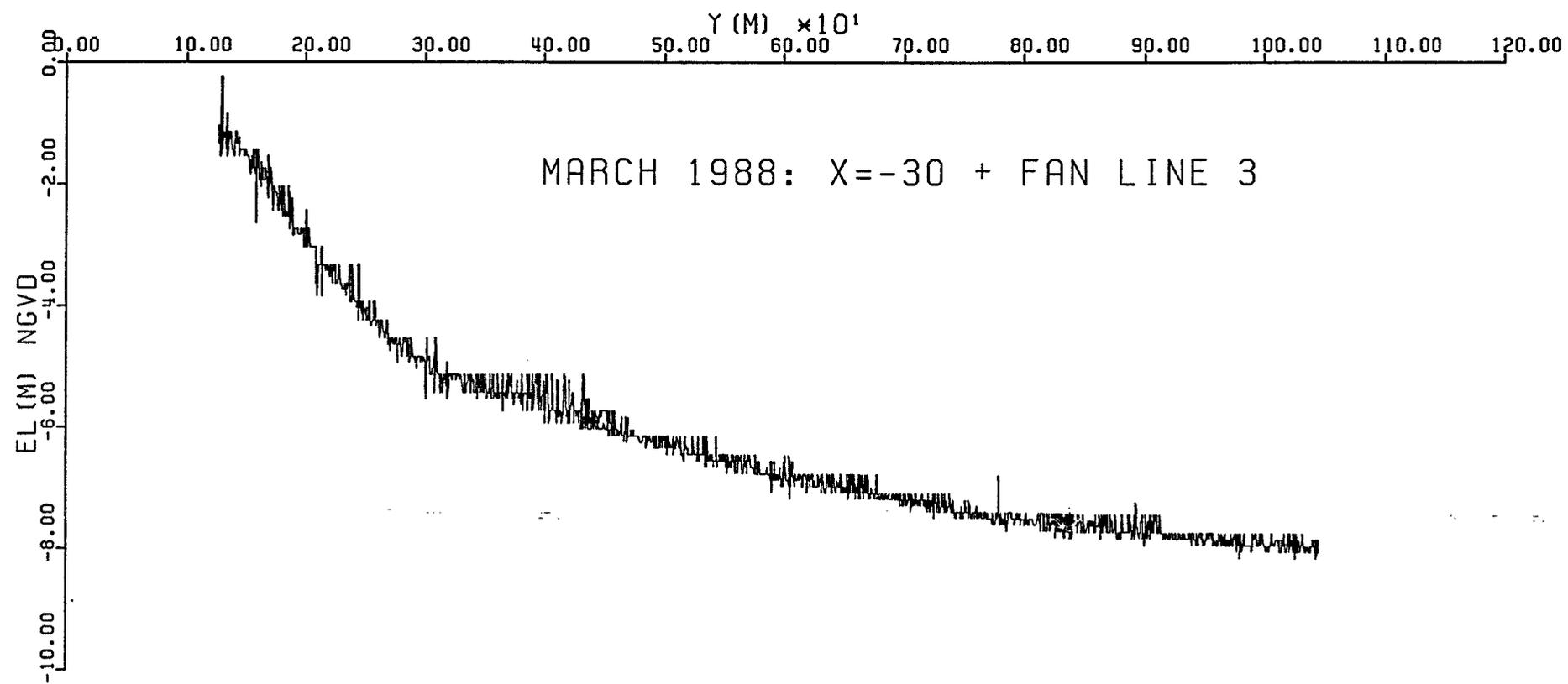
Based on a subjective interpretation of the box and fan data, smooth profiles were constructed and are shown in Figure 24 (with longshore distance in the fan lines again collapsed onto apparent offshore distance alone). The profiles are offset down the page to indicate relative longshore spacing in the box region. There is some indication that the offshore profiles are slightly deeper in the middle of the range, but are relatively closer to each other at the extremes of the range. There is thus no indication of an overall offshore

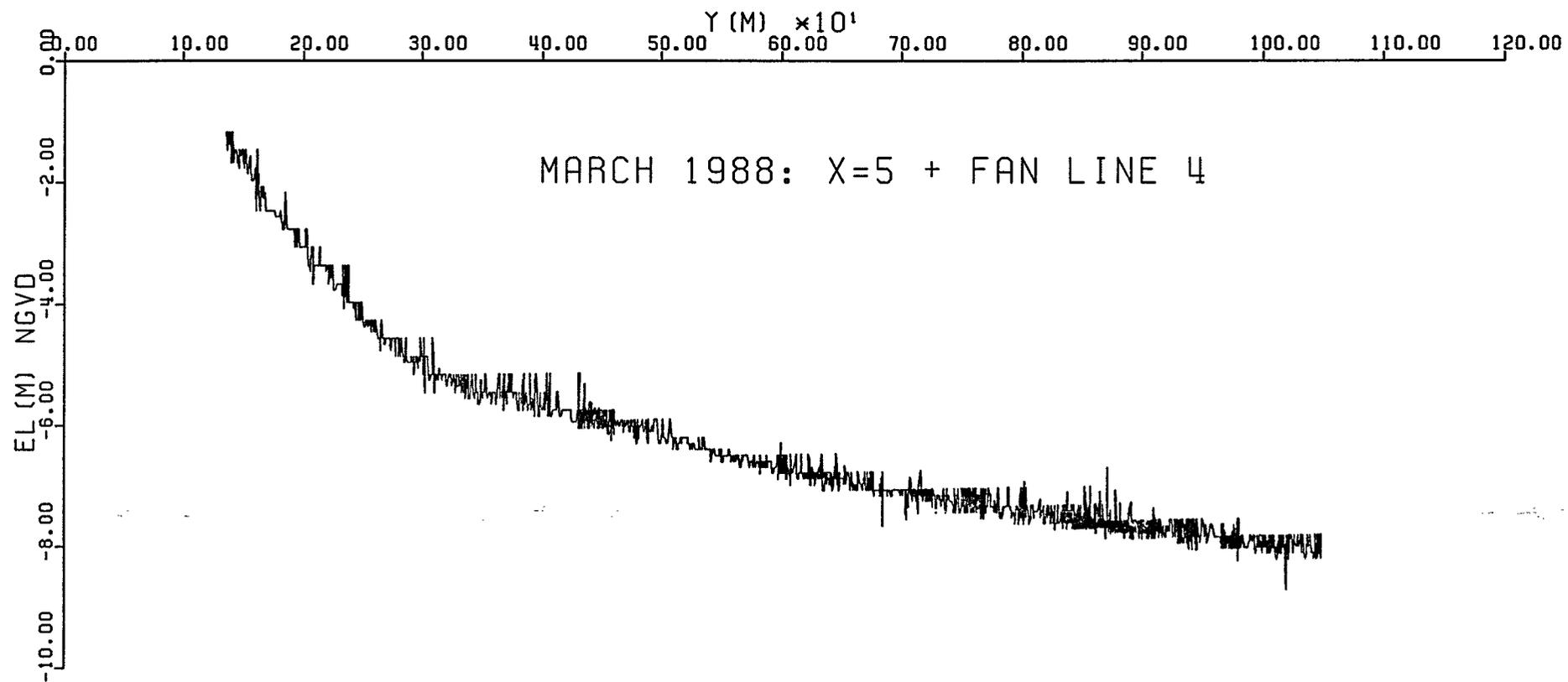
(Profiles on following pages)

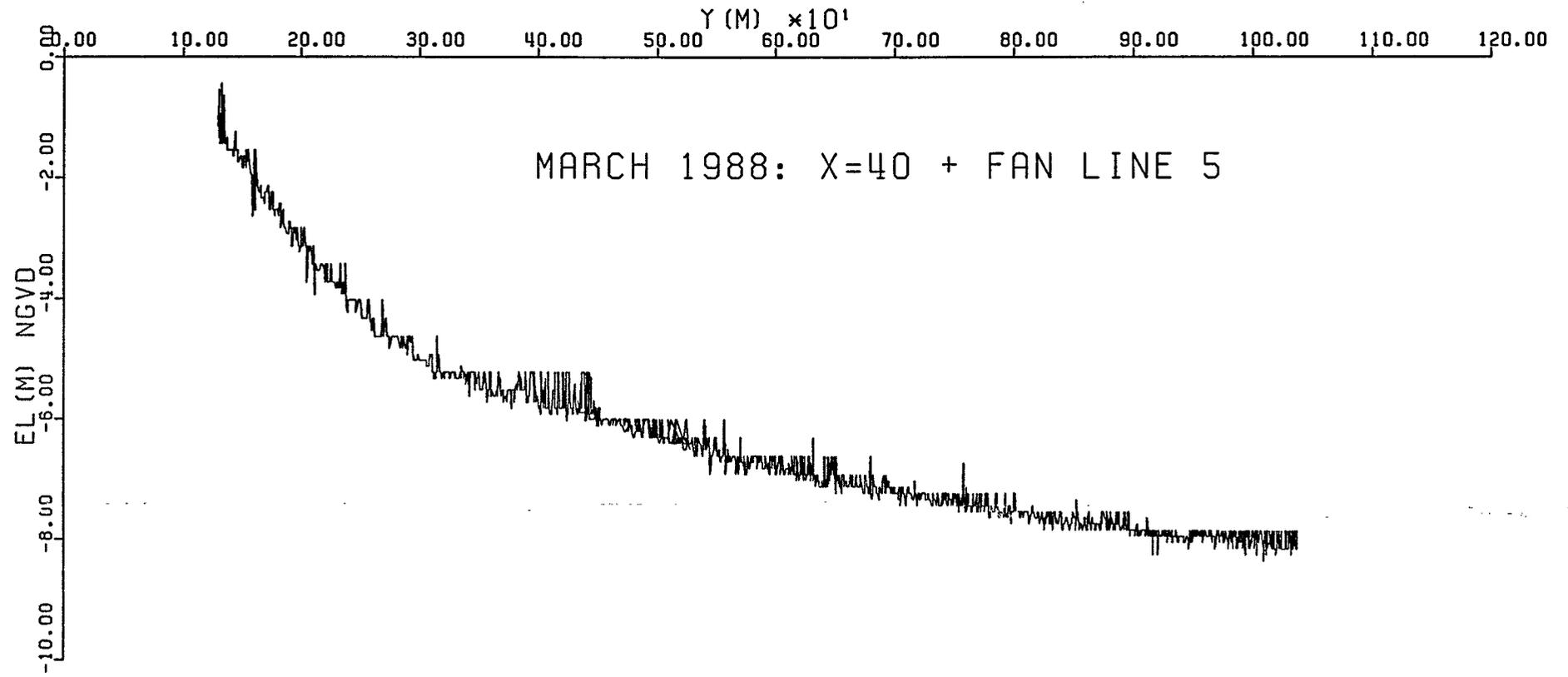
Figure 23: Box and Fan Lines for March Survey

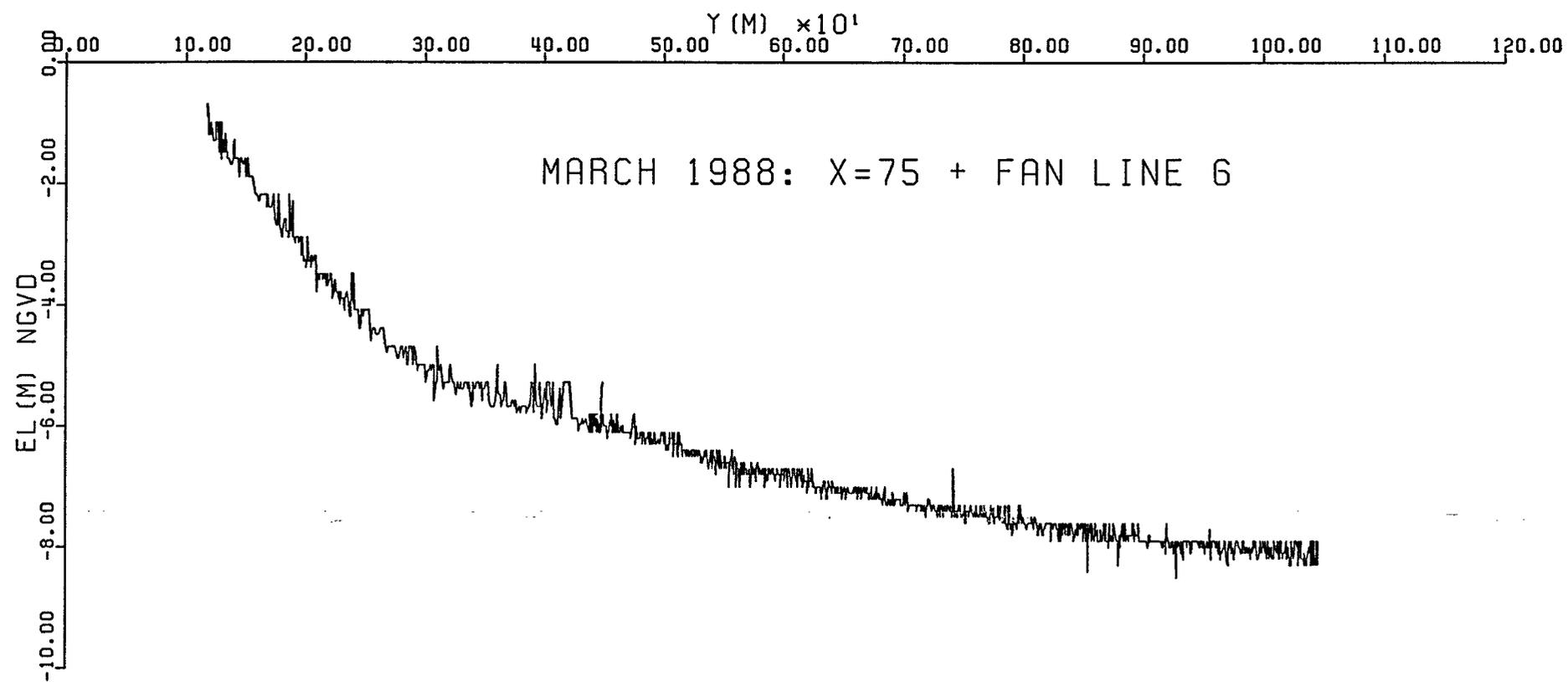


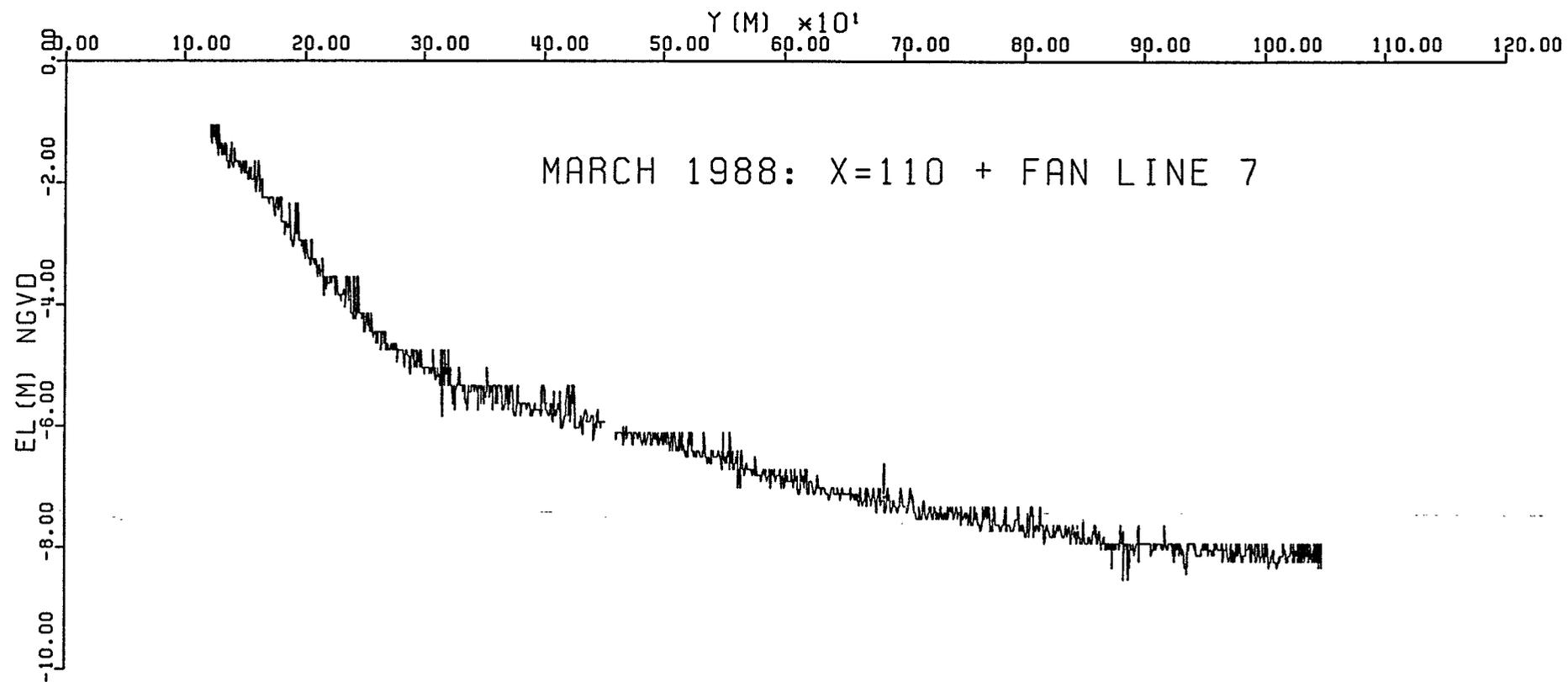


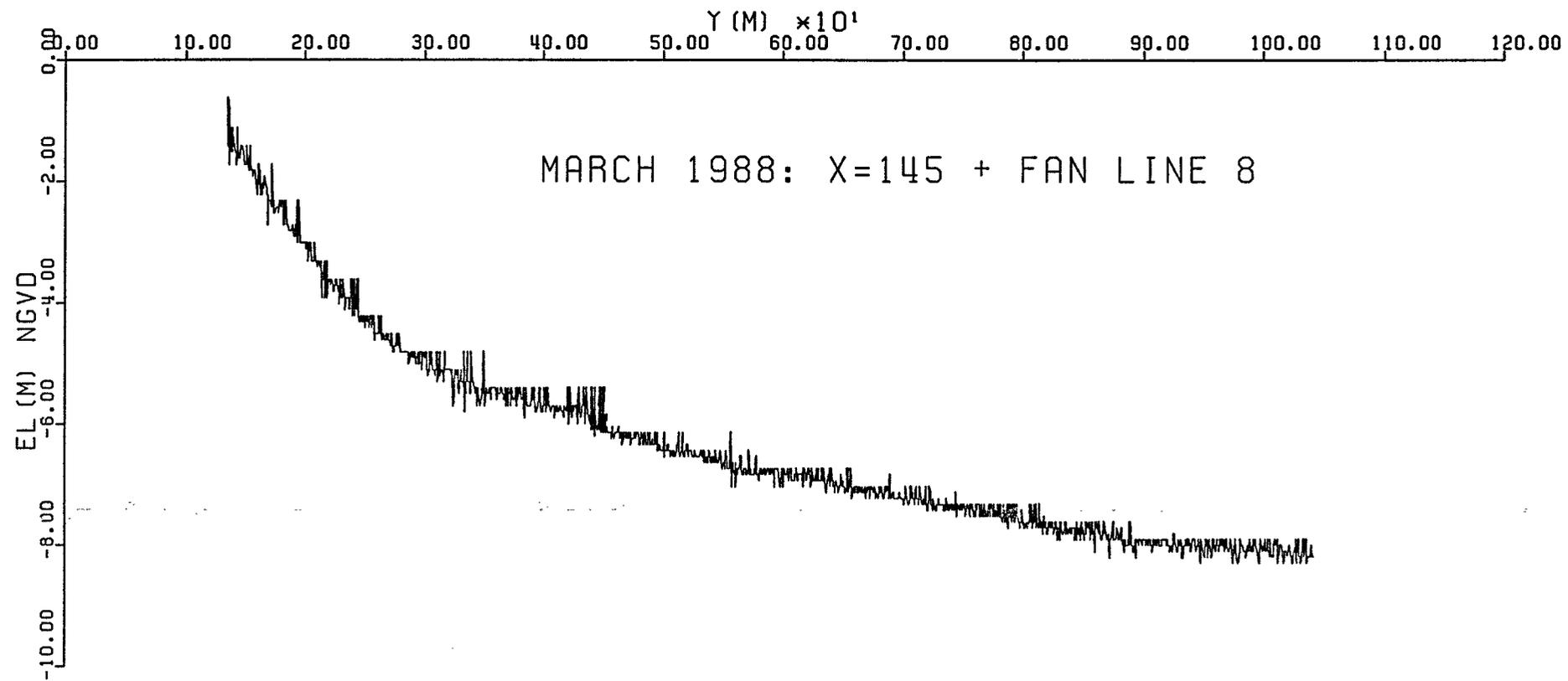


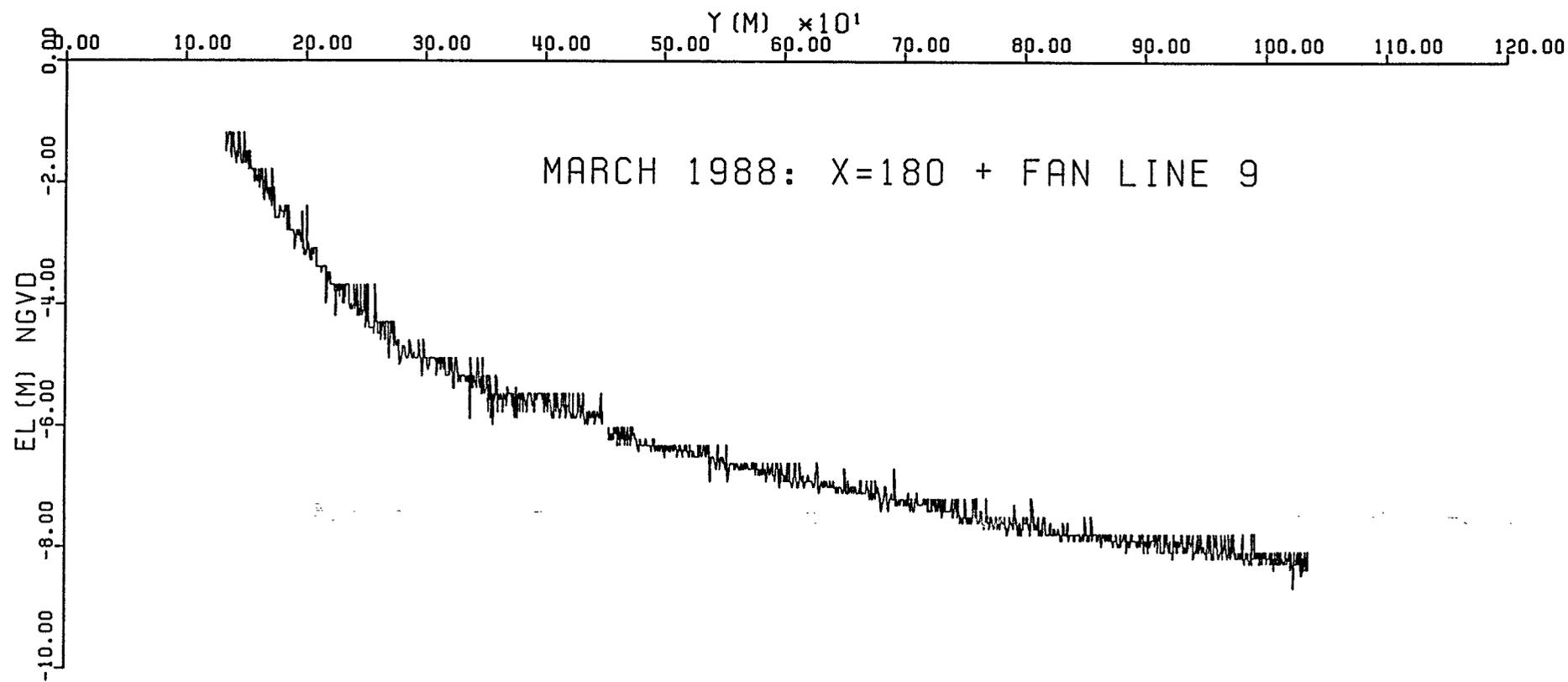


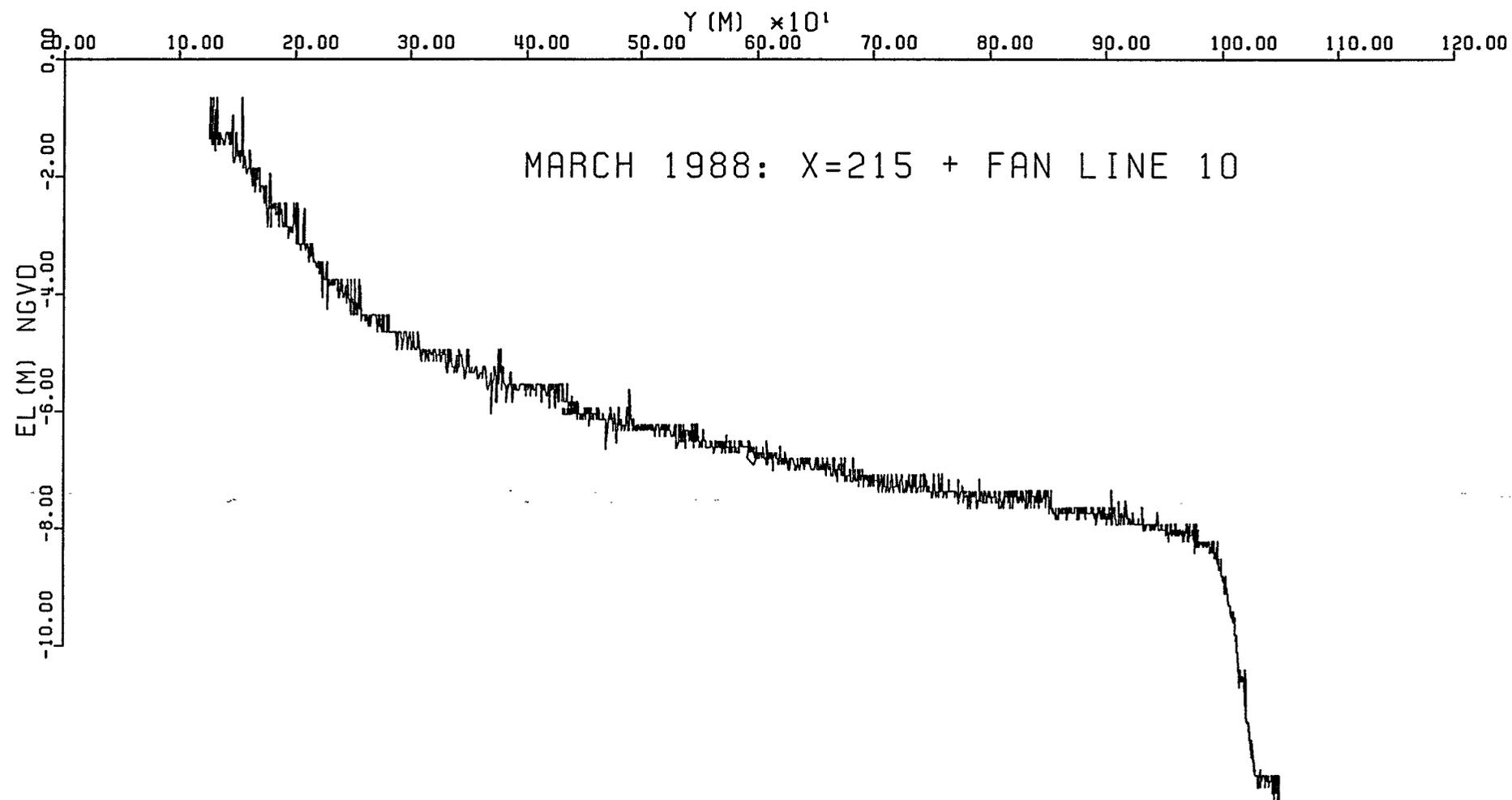


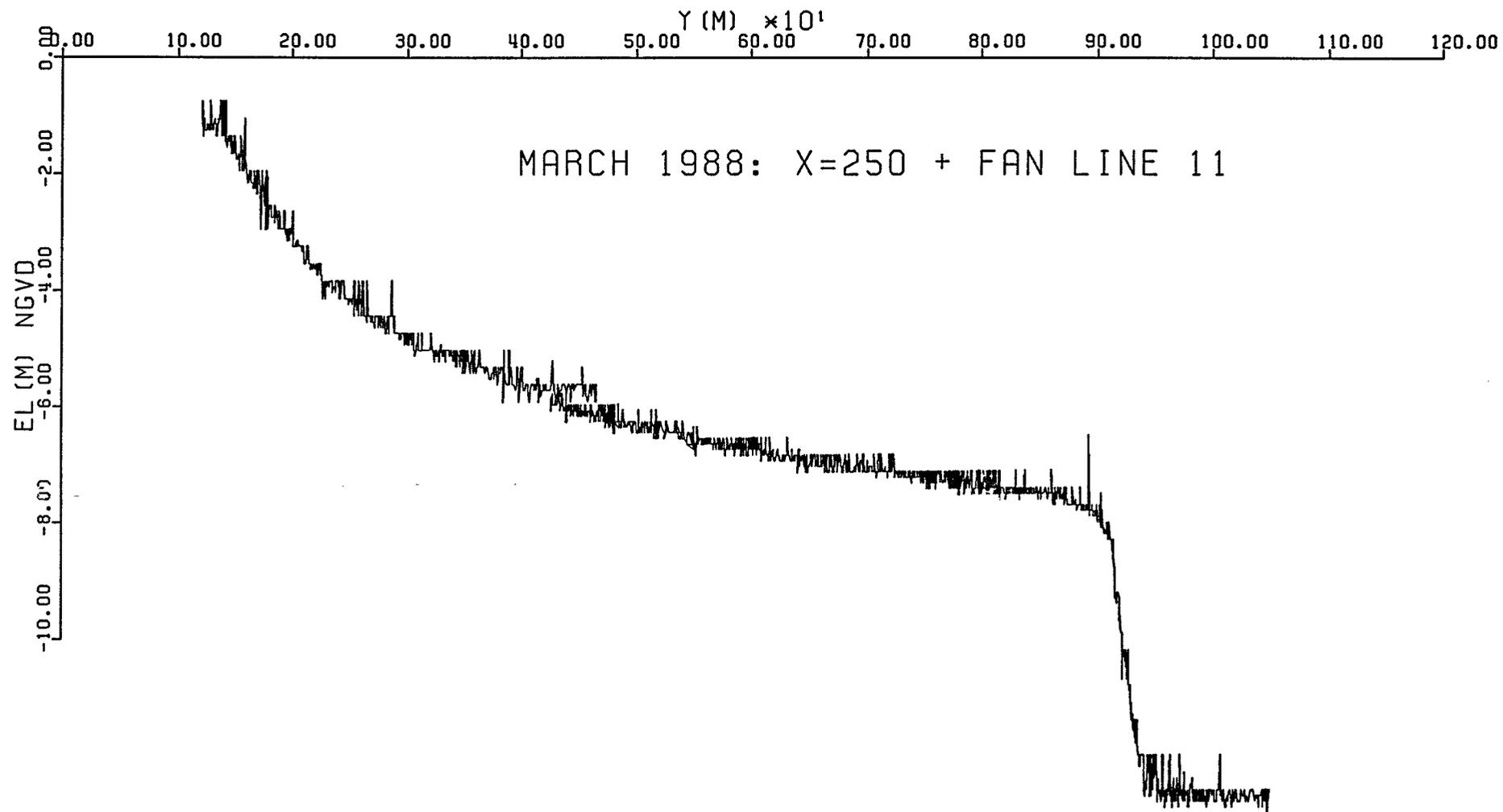












tilt to the bottom. (This type of result may have been expected due to the presence of the Cape feature to the north. The Cape does not seem to influence the offshore profiles in the region of the survey.)

Several smoothed profile lines (1,6,10 and 11) are shown overlain in Figure 25. This plot shows the relatively greater depth in the center of the range offshore, as well as the curvature of the shoreline as manifested by profile 1 being further seaward of the other profiles in the box region ( $y \leq 450m$ ) The offshore region is relatively uniform (except for the presence of the Port Canaveral Channel in the southern profiles).

Figure 26 shows plots of longshore transect data at nominal stations  $y = 600m$  and  $y = 800m$ . These transects again show that the on-offshore profiles are somewhat deeper in the middle of the range, and also show that the relatively shallow regions to the south are associated with a broad feature on the shallower transect. A feature is also apparent on the deeper transect but is confined to the region south of line 10. This narrow feature is close to the channel edge and is possibly associated with dredging spoils or local sedimentation patterns. Note that the vertical relief of the broad feature along  $y = 600m$  is on the order of  $20cm$  in a depth of  $6.8m$ . Likewise, the somewhat sharper feature near the channel edge, apparent on transect  $y = 800m$ , has a vertical relief of about  $40cm$  in a depth of  $7.5m$ .

## 5.2 June, 1988 survey

A box survey and a reduced fan survey were conducted in the period of June 21-22, 1988. Plots of boat position and profile data are shown in Appendices B and C for box and fan data, respectively. An overlay of the box lines indicates that there is very little longshore variability in the offshore profiles, as was found in March. The profile data in appendix B is shown in unsmoothed form (after tide correction), and after smoothing by a moving 9 point, unweighted averaging window in order to filter wave motion. The smoothed profiles are plotted together with corresponding beach profiles from June 21, where available.

Figures 27 - 29 show plots of the overlap between several box and fan lines for the June survey. In Figure 27, box line  $x = 5$  and fan line  $x = -10$  are shown, and the observed overlap is good as expected. The overlap in Figure 28 is between box line  $x = -100$  and fan line  $x = -500$ . This figure shows the tendency for the entire profile to curve towards the east as the cape is approached from the south, and is consistent with the overall layout of the bathymetry. Finally, Figure 29 shows a comparison between the box line  $x = 250$  and fan line  $x = 500$ , indicating that the on-offshore profile in the region to the south of the surveyed box is basically uninterrupted, the only major feature being the presence of the shipping channel. The channel shows up quite clearly in the fan region transects, shown in Appendix C.

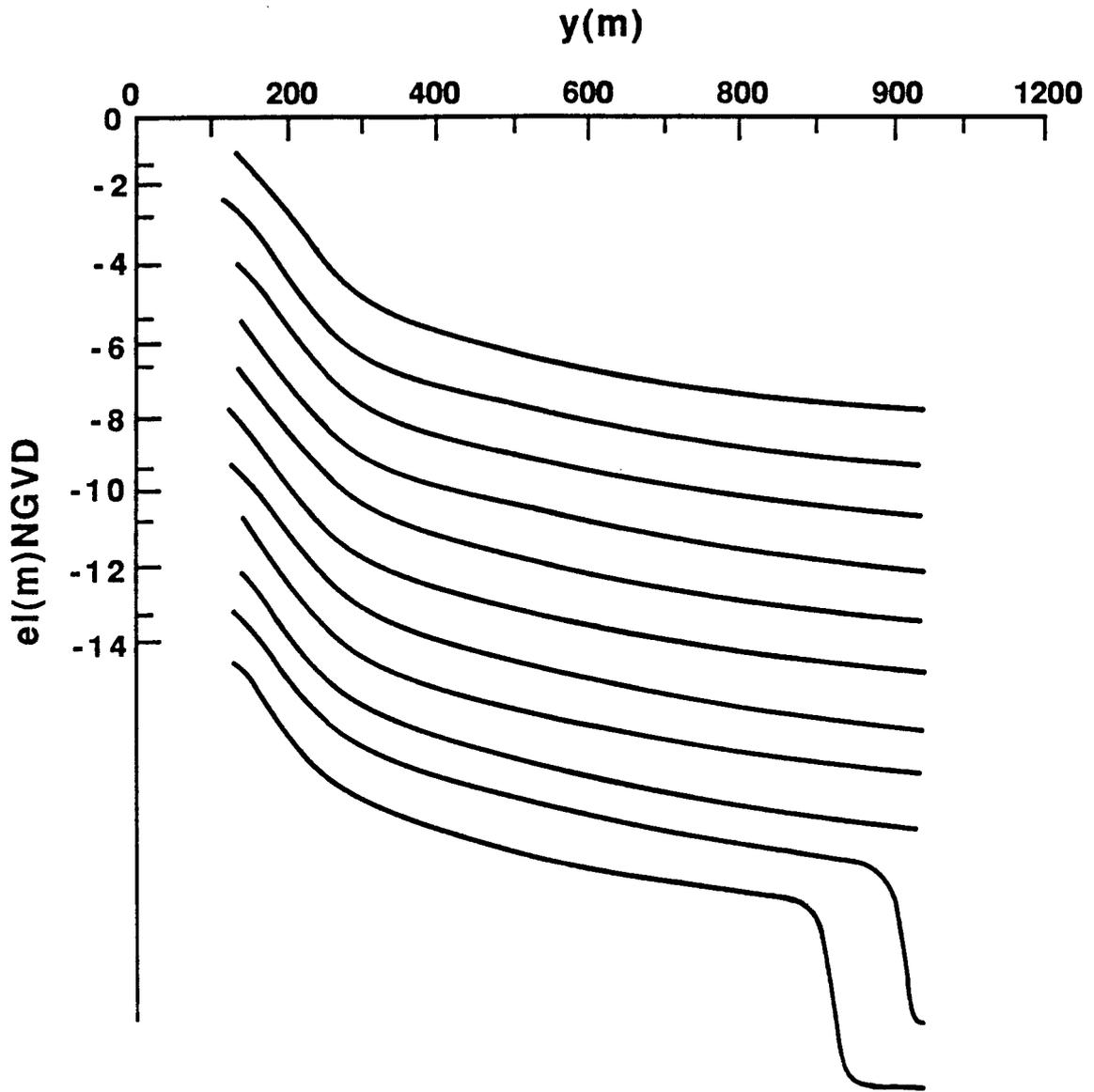


Figure 24: Smoothed Box and Fan Survey Lines, March survey

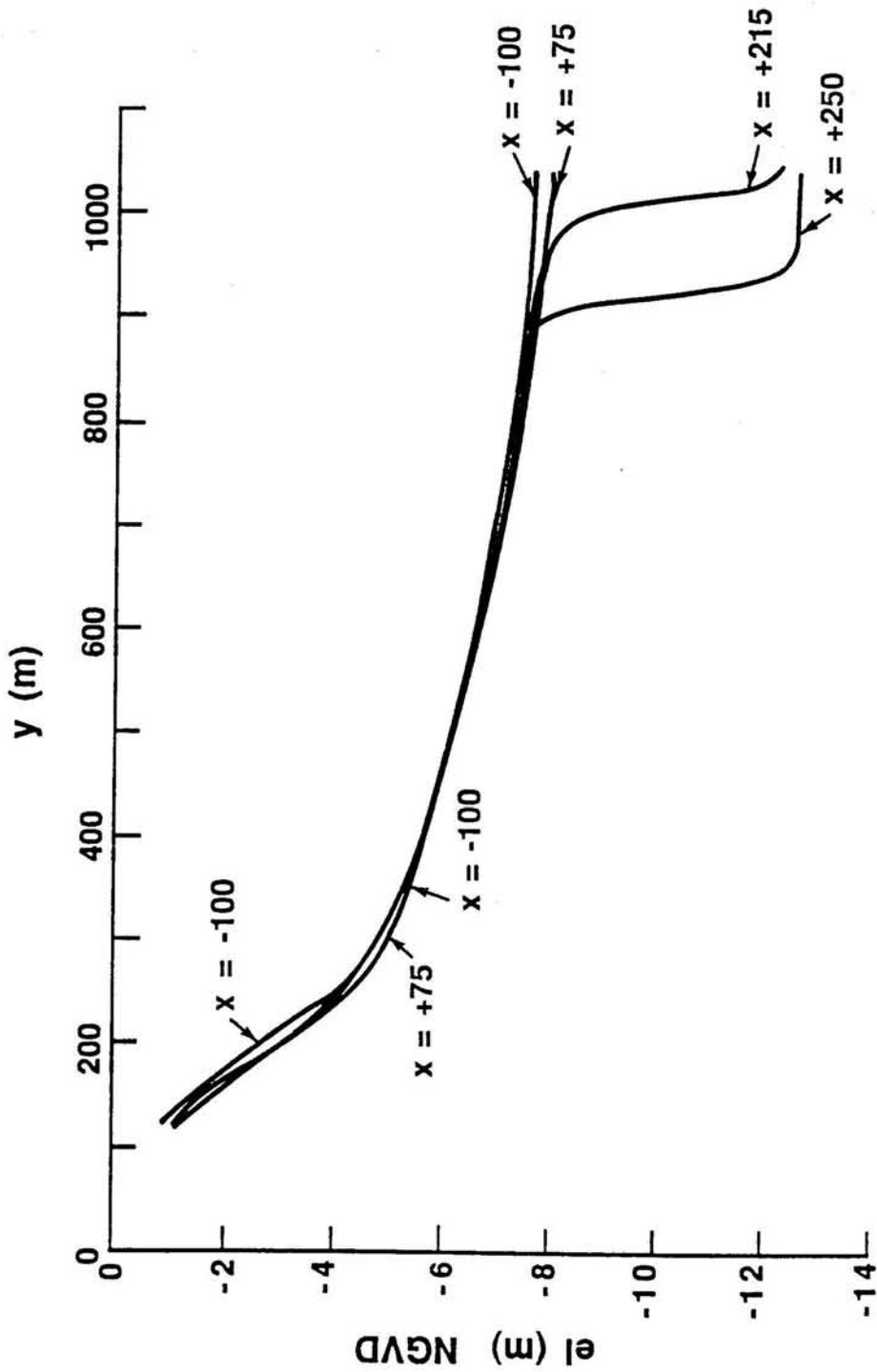


Figure 25: Superimposed survey lines, March survey

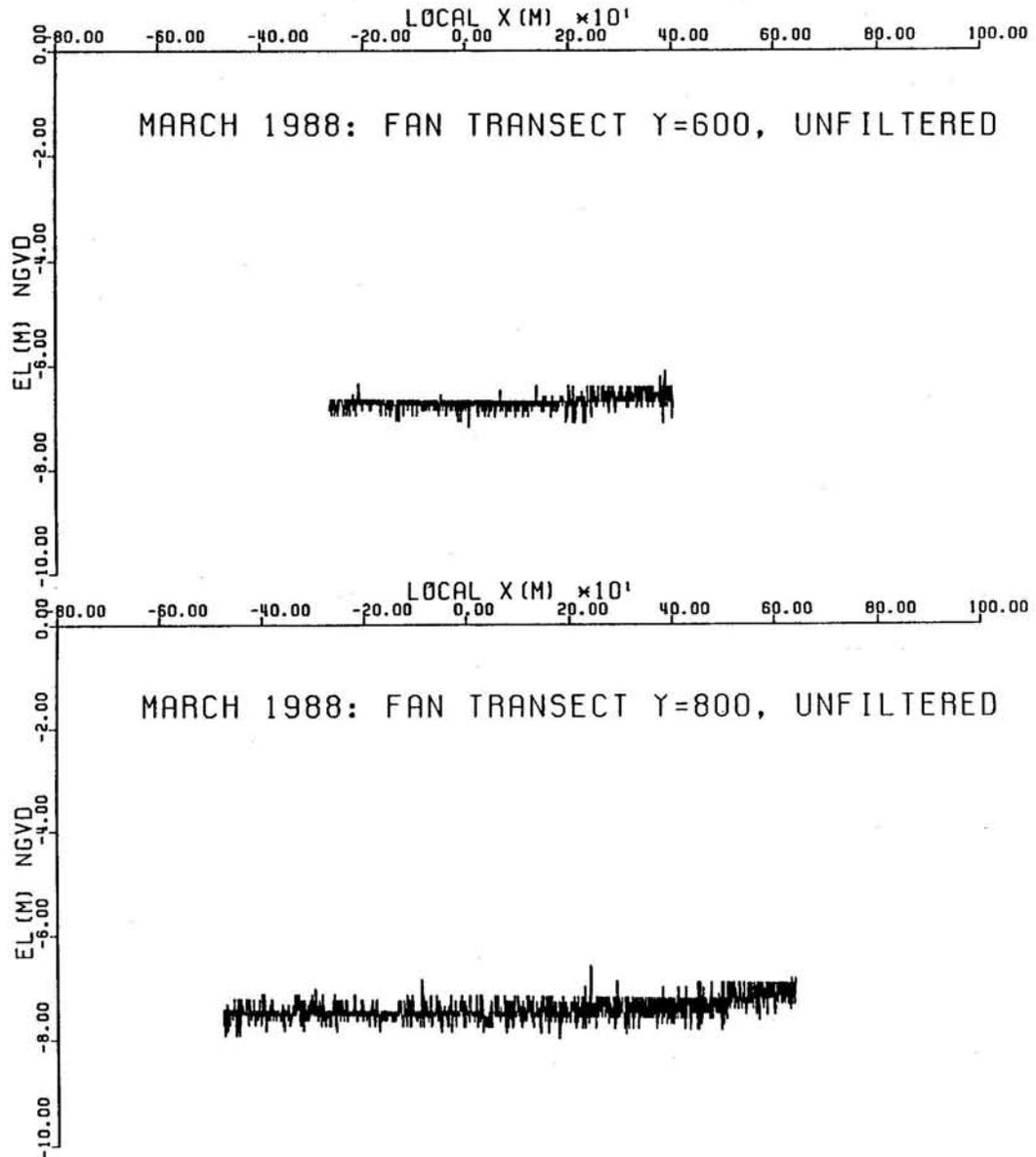


Figure 26: Longshore transects at  $y = 600m$  and  $800m$ , March survey.

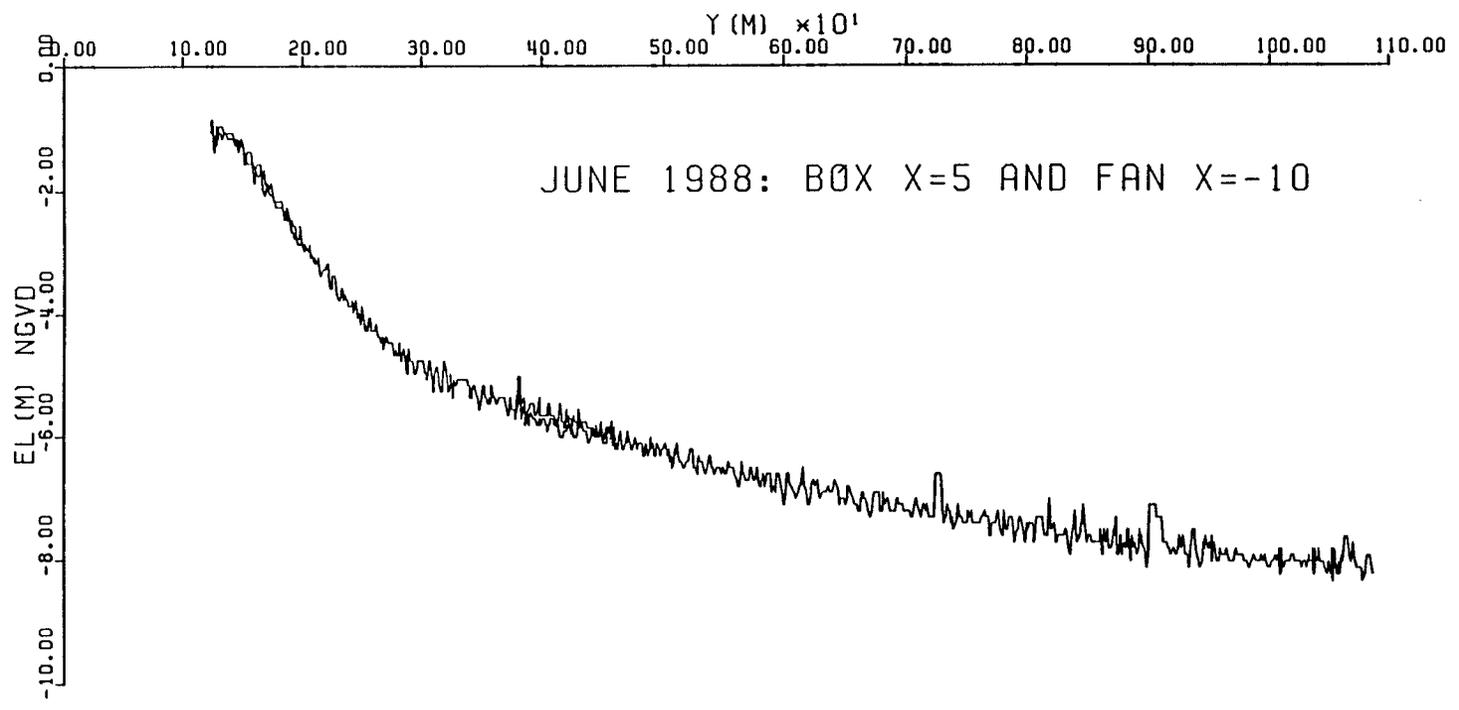


Figure 27: Box and fan profile overlaps, June 1988

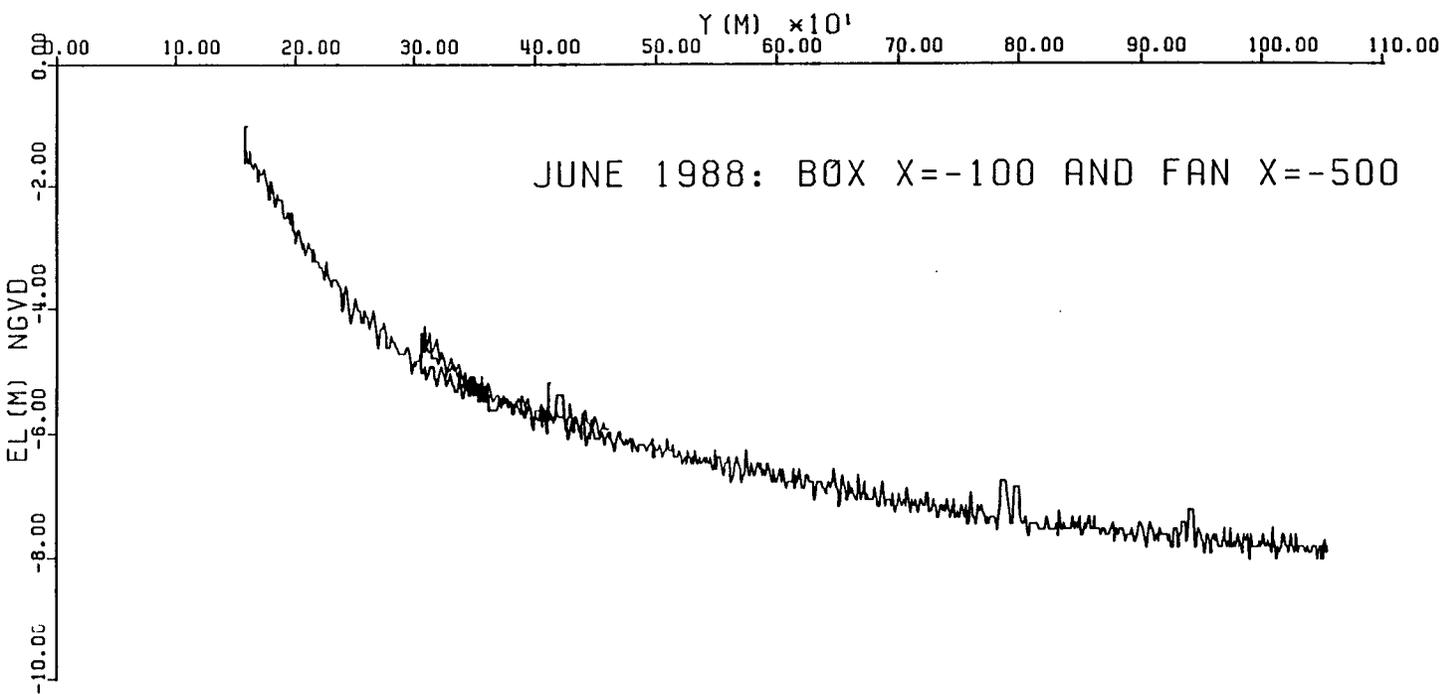


Figure 28: Box and fan profile overlaps, June 1988

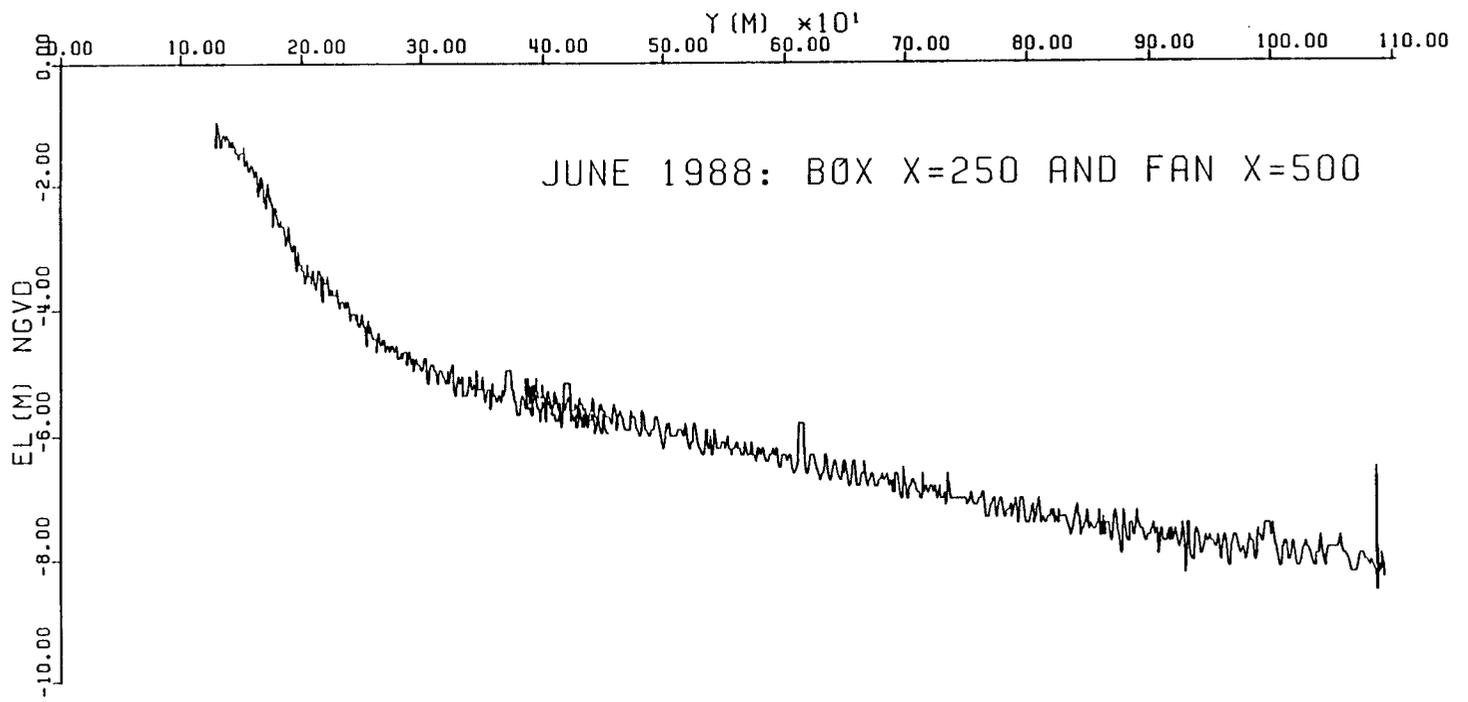


Figure 29: Box and fan profile overlaps, June 1988

### 5.3 July, 1988 survey

A final box survey was conducted on July 21, 1988, after the end of the beach surveying program. Plots of boat position and profile data are shown in Appendix B. It is apparent in the nearshore portion of the box profiles that the storm activity during the month from June 21 to July 21 build a major bar feature at around  $y = 150m$  offshore. This bar is apparent along the entire beach and is also relatively uniform in the longshore direction, as is apparent from an overlay of the profiles. The offshore portion of the profiles (beyond  $y = 200m$  or so) are essentially unaltered over the entire measurement program. The box profile data is presented in unsmoothed and smoothed form, and the smoothed data is compared to beach profiles where available.

		July 11	July 12	July 13
Bar 1	$\bar{y}$	99.36	98.48	98.86
	$\sigma_y$	0.252	1.092	1.047
	$\bar{z}$	0.208	-0.076	-0.133
	$\sigma_z$	0.068	0.060	0.058
Bar 2	$\bar{y}$	92.64	91.88	91.45
	$\sigma_y$	0.246	0.397	1.299
	$\bar{z}$	0.374	0.183	-0.031
	$\sigma_z$	0.050	0.046	0.120
Bar 3	$\bar{y}$	85.88	85.52	85.70
	$\sigma_y$	0.266	0.462	0.904
	$\bar{z}$	0.319	0.236	0.007
	$\sigma_z$	0.075	0.087	0.148

Table 2: Statistics of bar positions, July 11-13, 1988

## 6 Artificial Bragg Bar Installation

During installation of the artificial Bragg bar sections, surveying measurements were made which located the horizontal and vertical position of the end of each bar section. These measurements were repeated each day until the bars were removed. The complete set of surveying data is included in Appendix D.

Table 2 gives values for the mean offshore position  $\bar{y}$  and mean elevation  $\bar{z}$  for each set of ten artificial bar sections. Means were calculated according to

$$\bar{y} = \frac{1}{20} \sum_{i=1}^{20} y_i \quad (1)$$

$$\bar{z} = \frac{1}{20} \sum_{i=1}^{20} z_i \quad (2)$$

where  $i$  ranges over the number of bar ends in each set of ten bars. Values of standard deviation  $\sigma_y$  and  $\sigma_z$  of the data values about the means are also given. These quantities were calculated according to

$$\sigma_y = \left( \frac{1}{20} \sum_{i=1}^{20} (y_i - \bar{y})^2 \right)^{1/2} \quad (3)$$

$$\sigma_z = \left( \frac{1}{20} \sum_{i=1}^{20} (z_i - \bar{z})^2 \right)^{1/2} \quad (4)$$

Plots of the surveyed horizontal bar positions are given in Figures 30, 31 and 32 for July 11, 12 and 13, respectively. Figures 33 and 34 indicate the relative change of bar positions for each day.

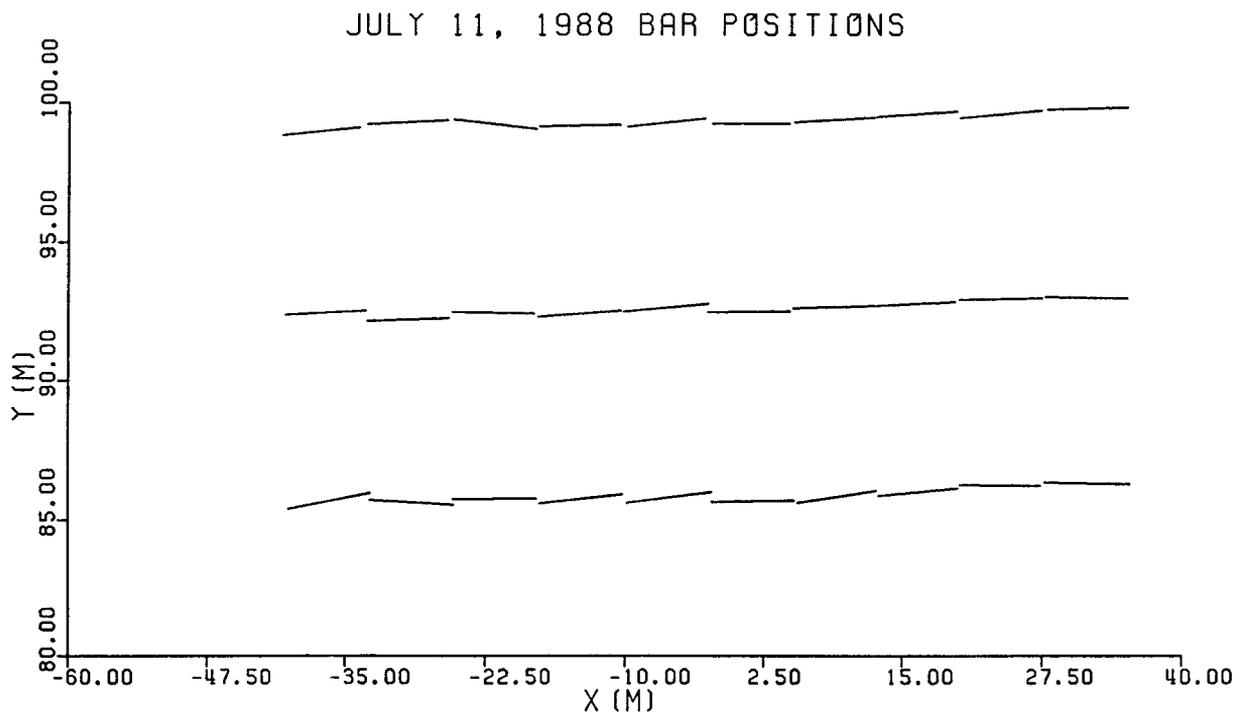


Figure 30: Artificial bar positions, July 11, 1988

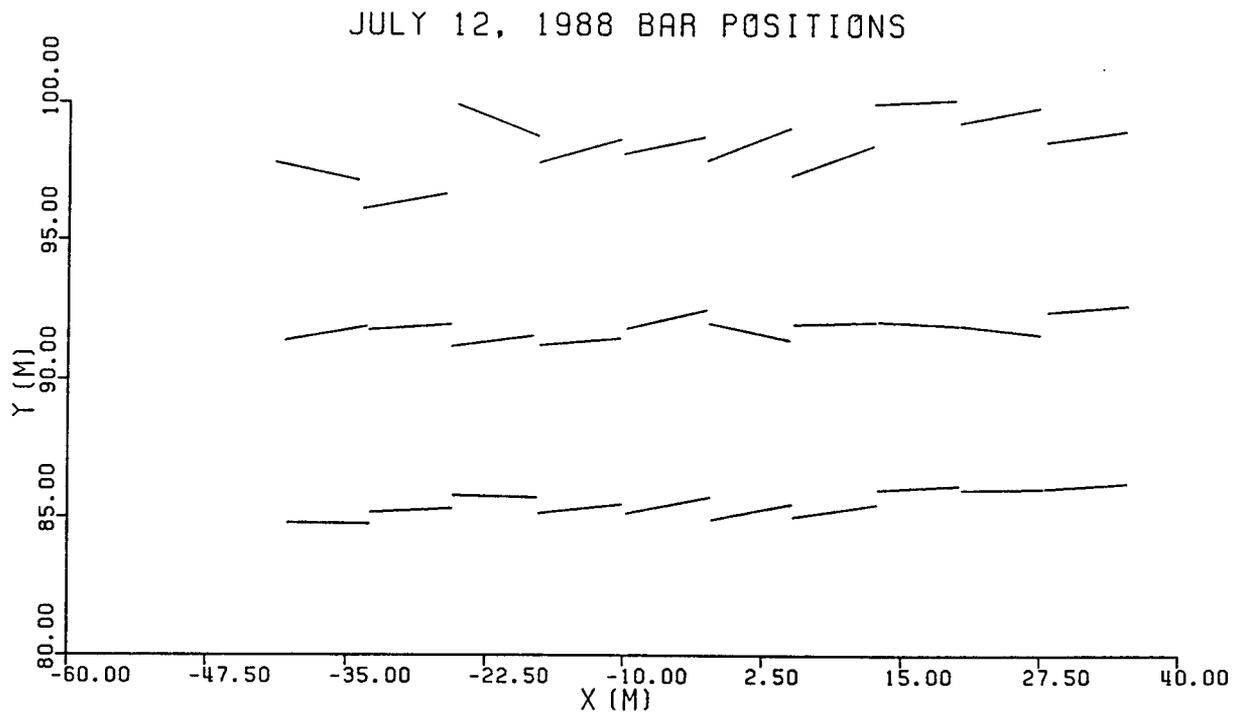


Figure 31: Artificial bar positions, July 12, 1988

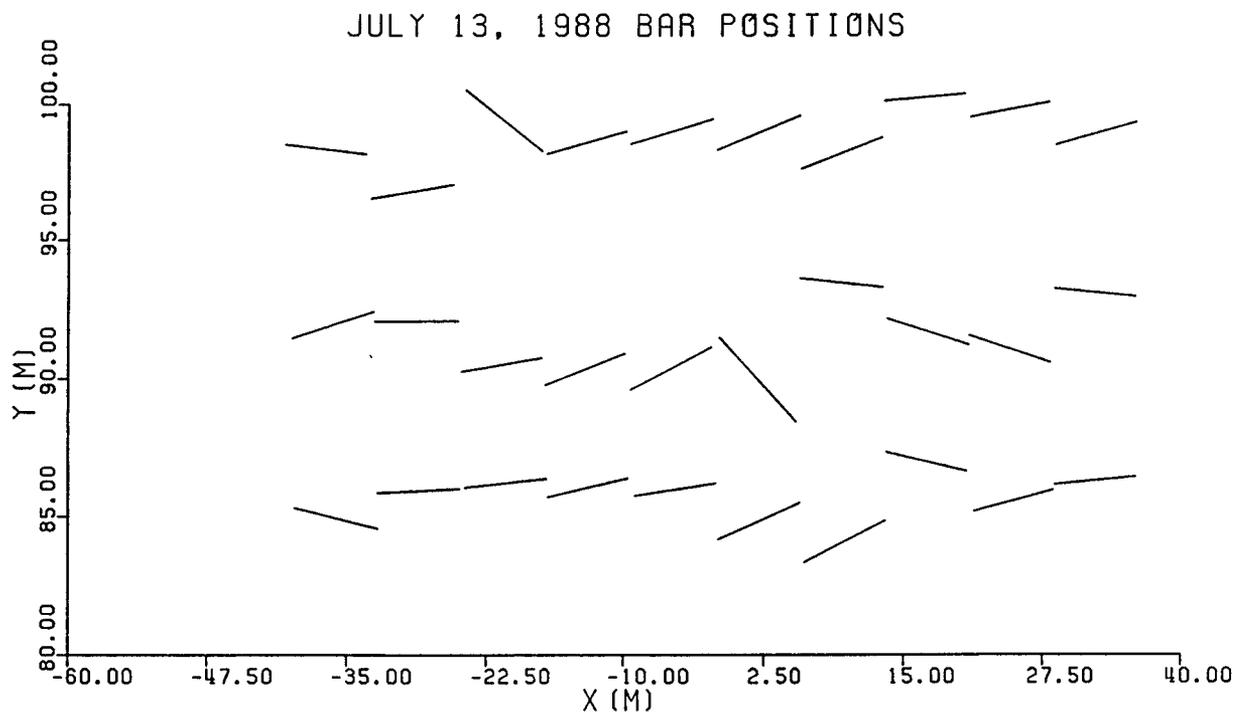


Figure 32: Artificial bar positions, July 13, 1988

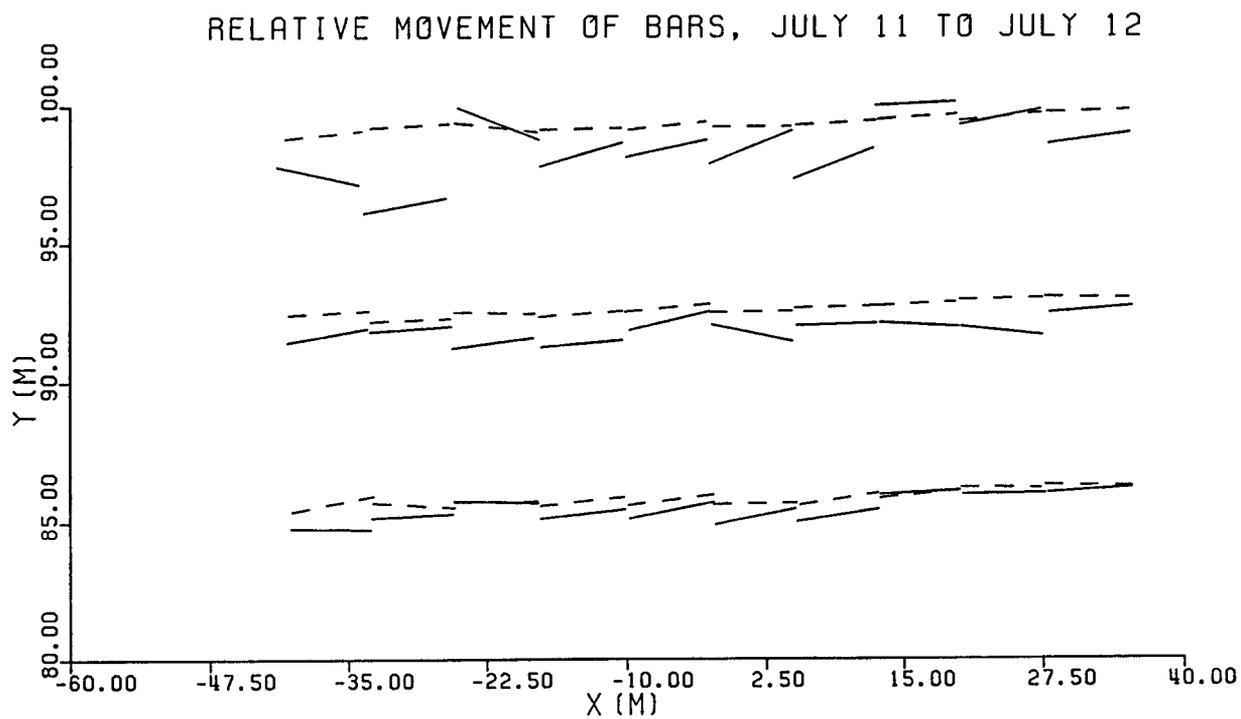


Figure 33: Change in artificial bar positions, July 11 - 12, 1988

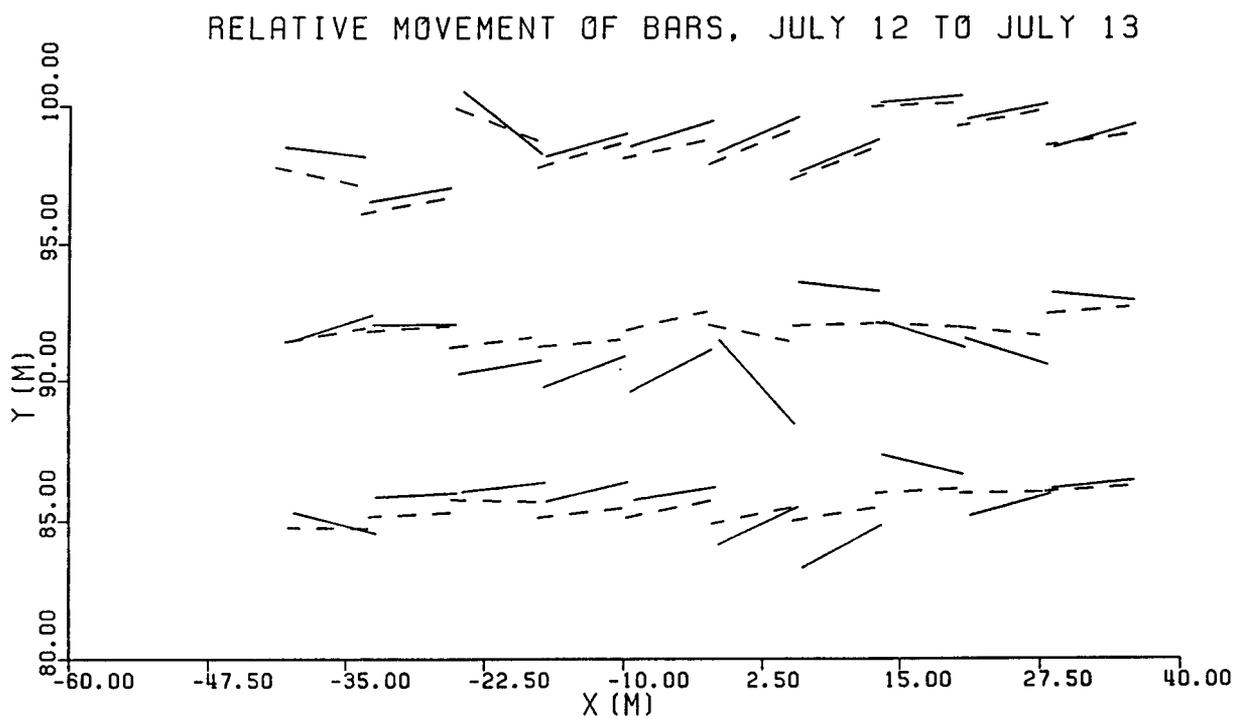


Figure 34: Change in artificial bar positions, July 12 - 13, 1988

## References

1. "Tide Tables 1988: East Coast of North and South America, including Greenland.", U. S. Department of Commerce, National Oceanic and Atmospheric Administration, 1987.

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