United States Department of the Interior
Geological Survey

Louisiana Barrier-Island Erosion Study:
Isles Dernieres Beach Profiles—August 1986 to September 1987

by
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ABSTRACT

As part of the Louisiana Barrier-Island Erosion Study, a section of one of the barrier islands in the Isles Dernieres chain has been selected for a detailed, multi-year study. The main objective of the study is to determine the nature of the local morphodynamic processes that have produced substantial erosion and landward migration of the islands during, at least, the last 100 years. One of the elements of the study is a beach-profiling program using a highly accurate electronic distance meter. Eleven shore-normal lines spaced along 400 m of the island were surveyed seven times during the period of August 1986 to September 1987 to determine the time and extent of beach change during a year. From that survey data, we have made quantitative estimates of erosion and deposition within the study area.

Between August 1986 and September 1987, the beach face migrated approximately 20 m landward along each of the eleven lines. As the amount of material deposited on the backshore (5,600 m^3) was less than the material lost from the beach face (19,200 m^3), there was a net loss of sediment from the surveyed area. Because the sand on the surface of the barrier island is only 1-to-2-m thick at the berm crest and the change in elevation between the berm crest and the first trough is almost 3 m, some erosion of the underlying muddy marsh deposits occurred (~8,000 m^3). Although the sand may have remained within the nearshore system, the mud likely dispersed offshore, which contributed significantly to the net loss observed.

INTRODUCTION

The Isles Dernieres, a barrier-island arc in the Gulf of Mexico, extends approximately 35 km along the central Louisiana coast (Fig. 1). The width of the islands ranges from a few tens of meters to approximately 2 km with most of the chain being approximately one-half to one-km wide. Typically, elevations on the islands are less than 1.5 m above Mean Sea Level (MSL).

The islands, which protect important lagoonal and marsh environments, are experiencing general attrition as evidenced by the disintegration of the chain into several smaller islands, by the long-term loss of land area, and by the landward migration of the gulf-side shoreline. Before 1887, the chain consisted of a single, long island (known as the Isle Derniere), but subsequent erosion and breaching has produced the present configuration (Kwon, 1969). Between 1887 and 1985, the Isles Dernieres arc lost 63 percent percent of its surface area (Penland and Boyd, 1981), and the front of the chain migrated approximately one kilometer landward (Sallenger and others, 1987; Penland and Suter, 1987).

Peyronnin (1962) reported that the Isles Dernieres arc predominately consists of a marsh deposit of organic clays 2-m to 3-m thick, underlain by delta-complex sands and clays, and covered by sandy beaches along the shoreline facing the Gulf of Mexico. Typically, the sandy beaches are about 100-m wide with the sand being almost 2-m thick at the berm crest and pinching out landward at the marsh and seaward in the nearshore at the first trough. Shells and mud are prevalent in the bar trough. Immediately seaward of the first trough are two sandy bars separated by another muddy trough. At the crest of the outer (second) bar, the water is approximately 2-m deep.

In the vicinity of the Isles Dernieres, the range between Mean High Water and Mean Lower Low Water is approximately 0.4 m (National Ocean Service, 1987), but the actual water level can be substantially higher under certain weather conditions. The climatic pattern for the area is to have relatively calm conditions from mid-spring to mid-autumn and stormy weather the rest of the year, as, typically, cold fronts pass through the area every 3-to-5 days from mid-autumn to mid-spring (Roberts and others, 1987). During calm conditions, waves generally are less than a meter high with periods of 6 to 8 s (Peyronnin, 1962), and winds are light. The cold fronts produce waves capable of eroding the beach face, storm tides that can cause overwash of the islands, and wind that can blow the sand. Hurricanes, which impact the area every four years on the average (Ritchie and Penland, *in press*), produce very strong surf, storm tides that can exceed 3 m, and very high winds. Based on their intensity and short recurrence interval, Roberts and others (1987) speculate that cold fronts are more important than hurricanes in barrier-island beach erosion.

According to Peyronnin (1962), there have been no external sources of sand for the Isles Dernieres region since at least 1904 when Bayou Lafourche, to the east, was dammed. He concluded that the only material available for deposition on the islands came from the erosion of the headland at the mouth of Bayou Lafourche, from reworking of the nearshore gulf bottom, and from the bay area behind the islands. Because littoral transport in the area is to the west and because the Isles Dernieres are separated from their easterly neighbors (the Timbalier Islands) by two relatively deep channels, the amount of sand reaching the Isles Dernieres is probably inconsequential.

Purpose of Present Study

A major objective of the present study is to determine when and how the Isles Dernieres erode. To accomplish that goal, a group of scientists from the U. S. Geological Survey are conducting various experiments on processes important to erosion of the barrier islands at a site near the western end of the largest of the islands in the chain (Sallenger and others, 1987). The experiments involve monitoring waves and currents flowing over the island during storms as well as monitoring morphologic changes. This report gives the results of seven detailed beach-profile surveys at the study site, taken over a period of 402 days; describes the changes observed; and presents preliminary conclusions about beach erosion and deposition in the area.

STUDY LOCATION AND METHODS

Study Site

The study site is located in the western half of the largest of the islands making up the Isles Dernieres (Fig. 1). As shown in Figure 2, the shoreline is straight in the vicinity of the site. On the north side of the study site, a small channel or bayou runs parallel to the beach. There are no permanent structures within the study area (we erected a meteorology/transmission tower in the north-central part of the area); however there are cabins along the bayous east of the study site, and occasionally a house boat will anchor at the entrance to the bayou behind the site.

Beach-profile surveys were made along eleven lines that extended from the bayou behind the beach to a depth of approximately 2 m in the Gulf of Mexico. One line, in the center of the study area, was marked by two reference stakes 50-m apart near the back of the beach and had pipes emplaced every 10 m for instrument mounting and other experimental purposes.

Each of the other lines, which were located 25, 50, 150, and 200 m on either side of the center line, has only two reference stakes marking its location. The lines are labeled from west to east as: W5, W4, W3, W2, W1, CL, E1, E2, E3, E4, and E5. The reference stakes were tied to Mean Sea Level through a U. S. Army, Corps of Engineers benchmark in the northeast sector of the study area. Figure 2, which was produced from detailed shore-normal and shore-parallel surveys made during the initial visit in August 1986, locates the eleven shore-normal lines and shows the topography within the study area.

Eastward of a point between W1 and W2 the backshore is smooth with small dunes on the landward margin of the beach. Westward of that point and immediately landward of the berm crest, small dunes (elevation < 1.5 m above MSL) alternate with non-duned areas. When the study started, the area shoreward of those dunes was essentially featureless, but at the time of the last survey, several small dunes had appeared on the backshore behind those beach-face dunes. Most of the new dunes have formed near W2 and W5, as a large washover area has existed in the vicinity of W3 and W4 throughout the study period.

Survey Procedures and Dates

All of the survey data presented herein were collected using an Electronic Distance Meter (EDM) capable of displaying distances and elevations to better than one millimeter. The EDM is a transit-like unit mounted on a tripod; a data storage device is connected to it by cable. A prism mounted on an approximately 2-m long surveyer's rod completes the equipment needed for a survey. Once leveled and aimed at the prism, the EDM measures its tilt from horizontal and the round-trip time for an infra-red beam to travel to the prism and back; it outputs azimuth, tilt angle, and distance. After the measurement cycle is complete, the three values are transferred electronically to the data storage device.

After establishing the location of the EDM relative to in the reference stake (the rear stake on the center line), the rod carrier starts at one end of a line and moves along the line, stopping either at notable changes in the profile or every 5 m (approximately). Offshore, the rod carrier continues along the line by wading or swimming until the prism goes underwater when the rod is placed on the bottom. Therefore, most of the surveys reached the vicinity of the outer bar, though the first two did not extend that far offshore. All eleven lines can be surveyed in a normal day, though some of the surveys actually took longer because of inclement weather.

The 11 profile lines were surveyed seven times over a period of 402 days between August 1986 and September 1987. Table 1 lists the survey dates and identifying numbers. Furthermore, additional surveys were taken along the Center Line on 23 June 1987 and along W4 on 24 June 1987 to evaluate the repeatability of the survey technique.

RESULTS AND DISCUSSION

The seven sets of eleven profiles are presented in Figures 3 through 6. For clarity, each figure takes up three pages and there are 3 or 4 lines per page: W5 through W2 on the first page (top to bottom); W1, CL, and E1 on the second; and E2 through E5 on the third. For clarity, S1 and S2 are shown together on Figure 3, S3 and S4 on Figure 4, S5 and S6 on Figure 5, and S1 and S7 on Figure 6. To facilitate comparisons between surveys, all of the center-line data are plotted on Figure 7. All the data are plotted with a vertical exaggeration

SURVEY DESIGNATOR	DATE
S1	14-15 August 1986
S2	20-21 November 1986
S3	22 March 1987
S4	24 March 1987
S5	1 April 1987
S6	24 June 1987
S7	19-20 September 1987.

Table 1. Dates for the seven surveys discussed herein. Some of the lines surveyed on 1 April 1987 did not extend offshore. The survey designators are used in the text to identify survey dates.

of 10 times.

The eleven profiles show similar changes from survey to survey with only minor variability between lines. Overall, there has been net erosion along all eleven profile lines with the beach face migrating landward. In all cases, the amount of material deposited on the backshore was significantly less than the amount lost from the beach face. Table 2 gives the net migration of the beach face for the eleven lines, and Figure 8 shows the amount of erosion between the first and last surveys as a function of distance along each profile.

LINE	W5	W4	W3	W2	W1	CL	E1	E2	E3	E4	E5	AVG
LANDWARD MIGRATION (m)	19	18	16	18	18	18	21	21	22	22	24	20

Table 2. landward migration of the beach face at Mean Sea Level along the eleven profiles across the study area.

The average landward migration of the beach face as measured at MSL was approximately 20 m with a standard deviation of 2.5 m. Essentially all of the offset along MSL occurred between the November 1986 survey and the first survey in March 1987, though minor changes in both the bars and berm occurred between each survey (Fig. 7). Because the profiles show that the beach face remained essentially stationary during the late spring and summer, we assume that there will not be significant beach-face progradation; instead, the next stormy season will produce more retrogradation. Many beaches around the world show large displacements of the beach face during any given year as they respond to changes in wave climate. However, when monitored over periods of several years, many of those beaches show little or no net migration of the beach face. On the Isles Dernieres, however, temporal measurements have shown that the beach face has migrated landward approximately 1 km in the last 100 years for an average rate of 10 m/yr.

To construct Figure 8, elevations along the selected profiles were linearly interpolated at 1-m intervals. The solid line on each graph of Figure 8 shows the change in elevation between August 1986 and September 1987; positive values mean net deposition, and negative ones erosion. The dashed line shows cumulative change starting at the back of the island and going seaward so that the value at any distance represents the net amount of erosion or deposition from the landward side of the barrier to that point. Moving along the cumulative curves from the start, negative (rising) slopes indicate deposition, and positive (falling) ones erosion. Anywhere the cumulative curve crosses zero, the amounts of material eroded and deposited are equal along the part of the profile landward of that point. If the cumulative curve returns to zero at the seaward end of the graph, then there has been no gain or loss of material from the surveyed part of the profile.

Along all eleven lines, there was a net loss of material between the August 1986 and September 1987 surveys. Table 3 lists the amount of material lost along each line; the values are given in m^2, which should be thought of as a volume per unit width in the alongshore direction. Table 3 also breaks down the net change into two categories: the inshore-foreshore and backshore. The former represents the erosional part of the profile from the final berm crest position to the offshore, and the latter represents the depositional part landward of the final berm crest.

All eleven lines showed a net loss of material with the two eastern most lines (E4 and E5) showing the least loss and W2 the most. Looking at column three, which gives the amount of erosion in the inshore-foreshore zone, the values are relatively uniform; the variation occurs in the column four, which represents the amount of deposition on the backshore.

LINE	NET CHANGE (m^2)	INSHORE-FORESHORE (m^2)	BACKSHORE (m^2)
W5	-31	-37	6
W4	-35	-48	13
W3	-38	-48	10
W2	-49	-56	7
W1	-41	-51	10
CL	-41	-53	12
E1	-40	-53	13
E2	-33	-49	16
E3	-34	-49	15
E4	-20	-41	21
E5	-16	-44	29
AVG	-34	-48	14

Table 3. Volumetric changes along the eleven profiles across the study area. The values represent change in volume per unit width. Negative values indicate erosion between the August 1986 and September 1987 surveys, and positive values deposition.

The most deposition occur at the eastern end of the study area, and the least on W2. Using the average net change of approximately 34 m^3 per meter of beach, calculation shows that approximately 19,200 m^3 of sand and finer grained material was eroded from the inshore-foreshore. Approximately 5,600 m^3 of sand was deposited on the backshore, and approximately 13,600 m^3 of sand and mud lost from the study site. Assuming that the first trough extends 1 m below the top of the marsh deposits, 20 m of beach-face retreat would yield about 8,000 m^3 of mud that would undoubtedly be transported out of the area.

Topographic variations probably account for the variability shown in Table 2. Line W2 goes through a dune that is located on the berm crest. When the beach eroded, more sand was lost from that area because the initial elevation was higher than elsewhere along the berm crest. Also, the dune blocked overwash so that less sand was carried to the more landward parts of W2. Probably, the only way overwashed sand could reach that area was to come around the ends of the dune. W5 goes through a small cut in the dunes so that it also would receive less overwash material than a duneless area.

Eastward of the study area a channel was cut during the winter. Because the longshore transport is from east to west, sand eroded from the channel could have been transported into the eastern end of the study area, causing increased deposition in that area. The western limit of that sand transport could have been between E4 and E3 because the amount of deposition along E3 is similar to that along the other lines with similar profiles.

CONCLUSIONS

Based on seven surveys taken over approximately one year between August 1986 and September 1987 along 11 shore-normal profiles, we have reached the following preliminary conclusions:

(1) Net beach erosion took place during the late fall and winter with little change during the spring, summer and early fall.

(2) The erosion produced a landward migration of the beach face (at MSL) of approximately 20 m.

(3) Net deposition occurred on the backshore, and net erosion occurred in the inshore-foreshore.

(4) Erosion exceeded deposition, and the beach lost material from within the study area. For the study area, the total sediment deficit was approximately 13,600 m^3 with 8,000 m^3 or less of that total being sediment that is finer grained than sand.

(5) Topographic control by small dunes along the berm crest resulted in less overwash along profiles through the dunes. A channel cut through the island east of the study site may have caused the high overwash values recorded at the eastern end of the study area.

ACKNOWLEDGEMENTS

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Sallenger, A. H., Jr., Penland, S., Williams, S.J., and Suter, J. R., 1987, Louisiana barrier island erosion study: Coastal Sediments '87, American Society of Civil Engineers, p. 1503-1516.

FIGURE CAPTIONS

(1) Location map of the study site on the Isles Dernieres, central coast of Louisiana.

(2) a) Contour map of the study area produced from shore-normal and shore-parallel surveys made in August 1986. Contour interval is 0.25 m, and axes scales are in meters. The locations of the east and west reference stakes and the Corps of Engineers benchmark posts are given. The symbols halfway between lines E1 and W1 mark the pipe locations along the Center Line. b) Mesh perspective view of the study area from the southeast. The survey area has been raised for visibility.

(3) Eleven profiles for the August and November 1986 surveys (S1 and S2). The profiles appear on three pages. Vertical exaggeration is 10 times.

(4) Eleven profiles for the two March 1987 surveys (S3 and S4). The profiles appear on three pages. Vertical exaggeration is 10 times.

(5) Eleven profiles for the April and June 1987 surveys (S5 and S6). The profiles appear on three pages. Vertical exaggeration is 10 times.

(6) Eleven profiles for the August 1986 and September 1987 surveys (S1 and S7). The profiles appear on three pages. Vertical exaggeration is 10 times.

(7) Center-Line profiles from the seven surveys. Vertical Exaggeration is 10 times.

(8) Profile changes between August 1986 and September 1987. The solid line is the difference between surveys (positive is accretion), and the dashed line is the cumulative change starting at the northernmost common point of the surveys. Note that the Cumulative Axis has a different scale than the Difference Axis.

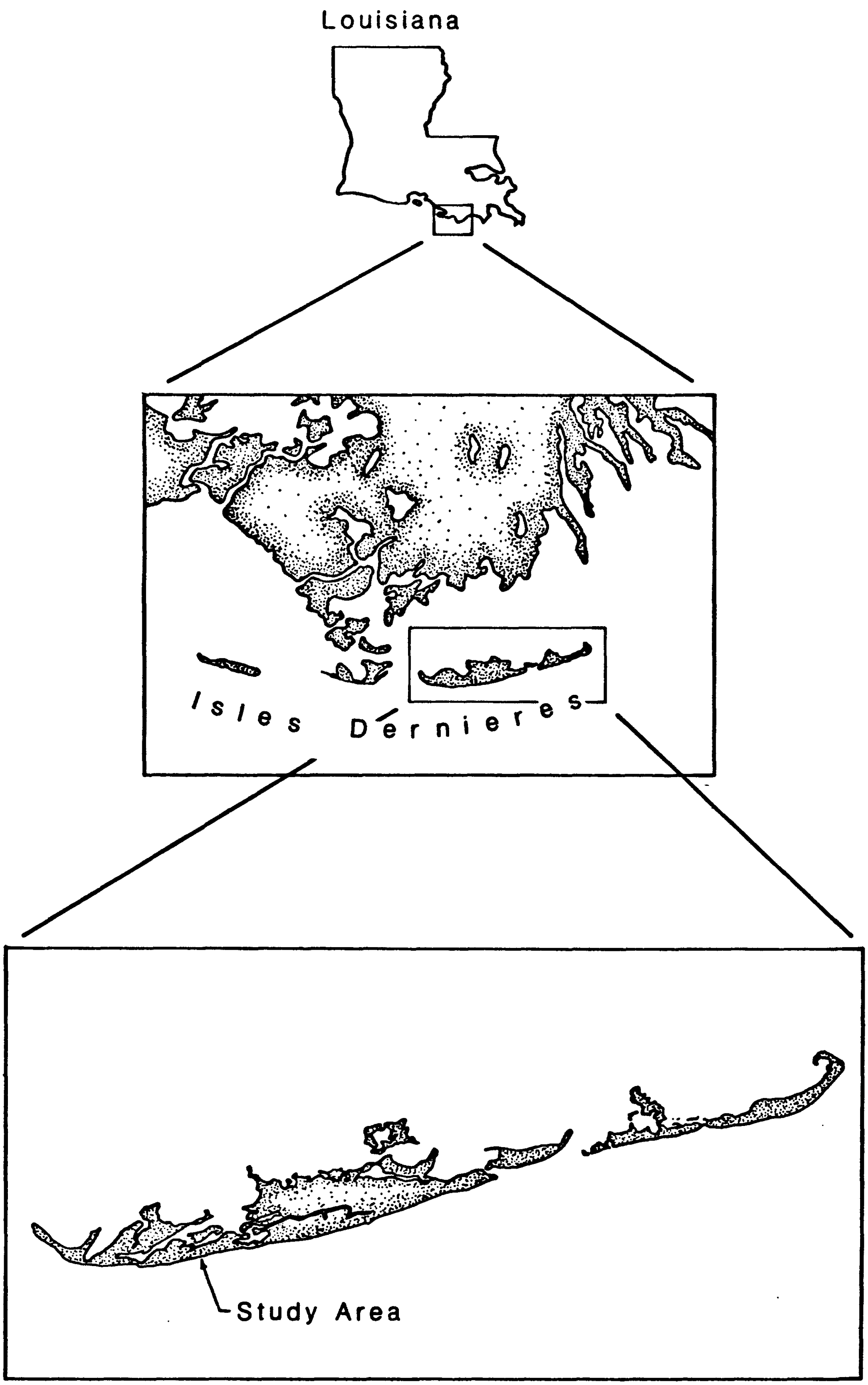
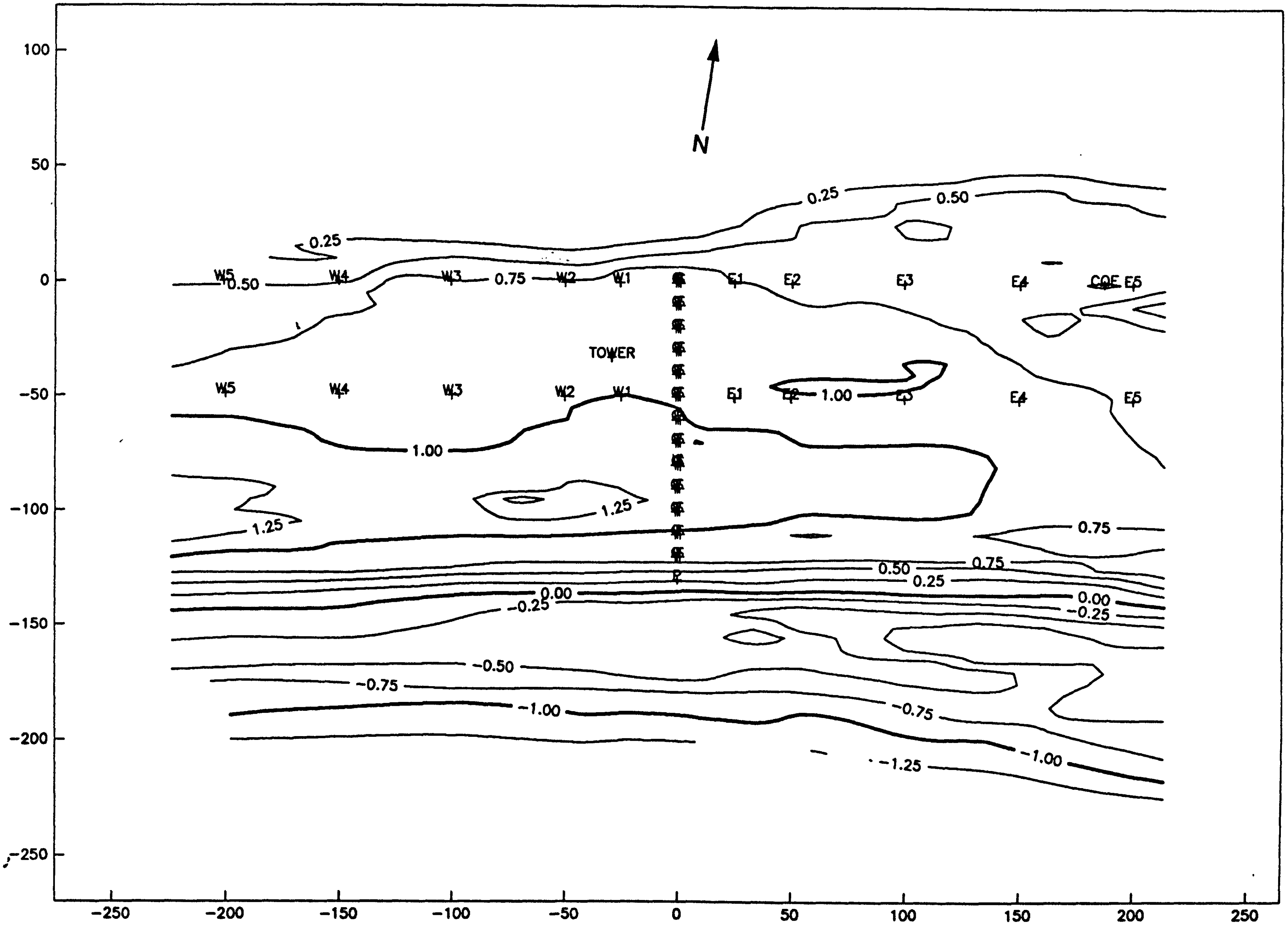


Figure 1


N
TOWER
W5
W4
W3
W2
W1
E1
E2
E3
E4
COE E5
E5
0.25
0.50
0.75
1.00
1.25
0.00
-0.25
-0.50
-0.75
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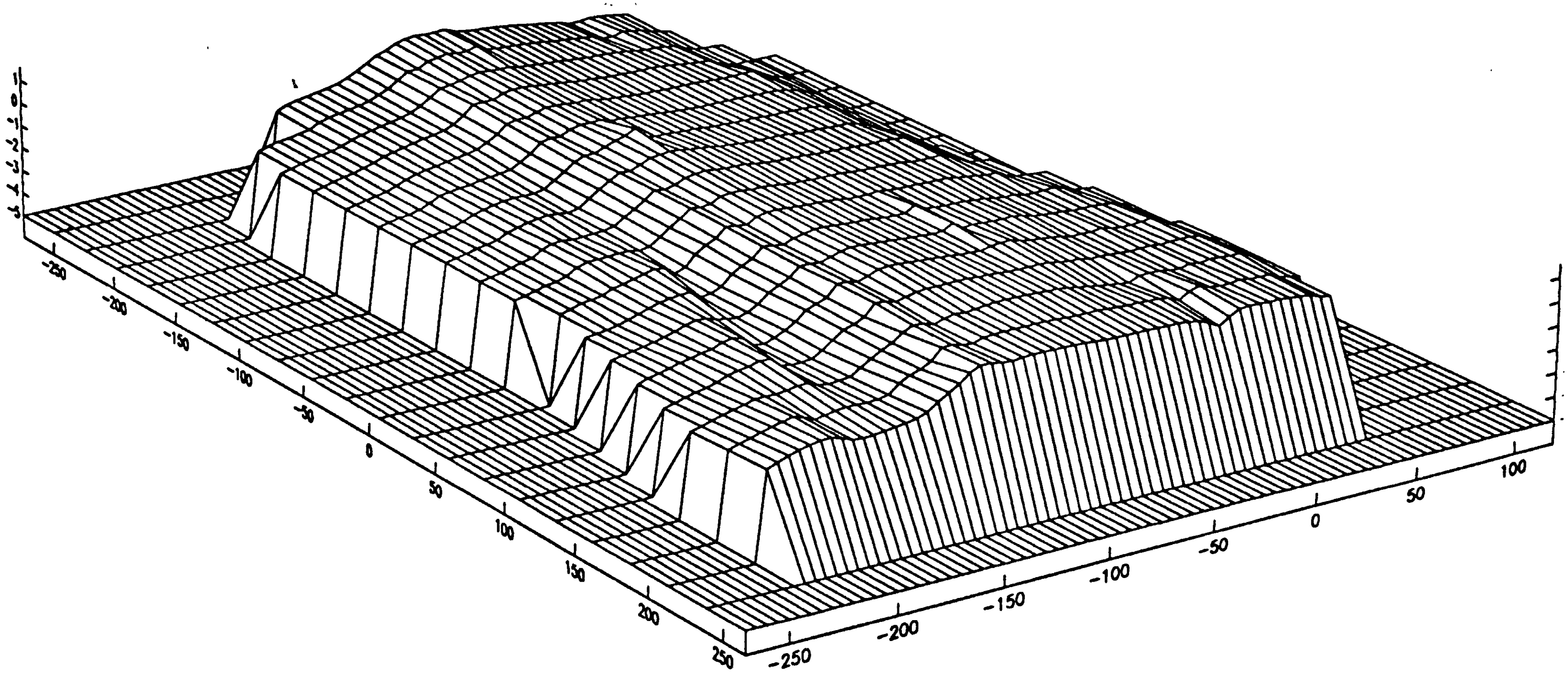
250
200
150

Figure 2 (a)


1
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-2
-3
-4
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-200
-150
-100
-50
0
50
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50
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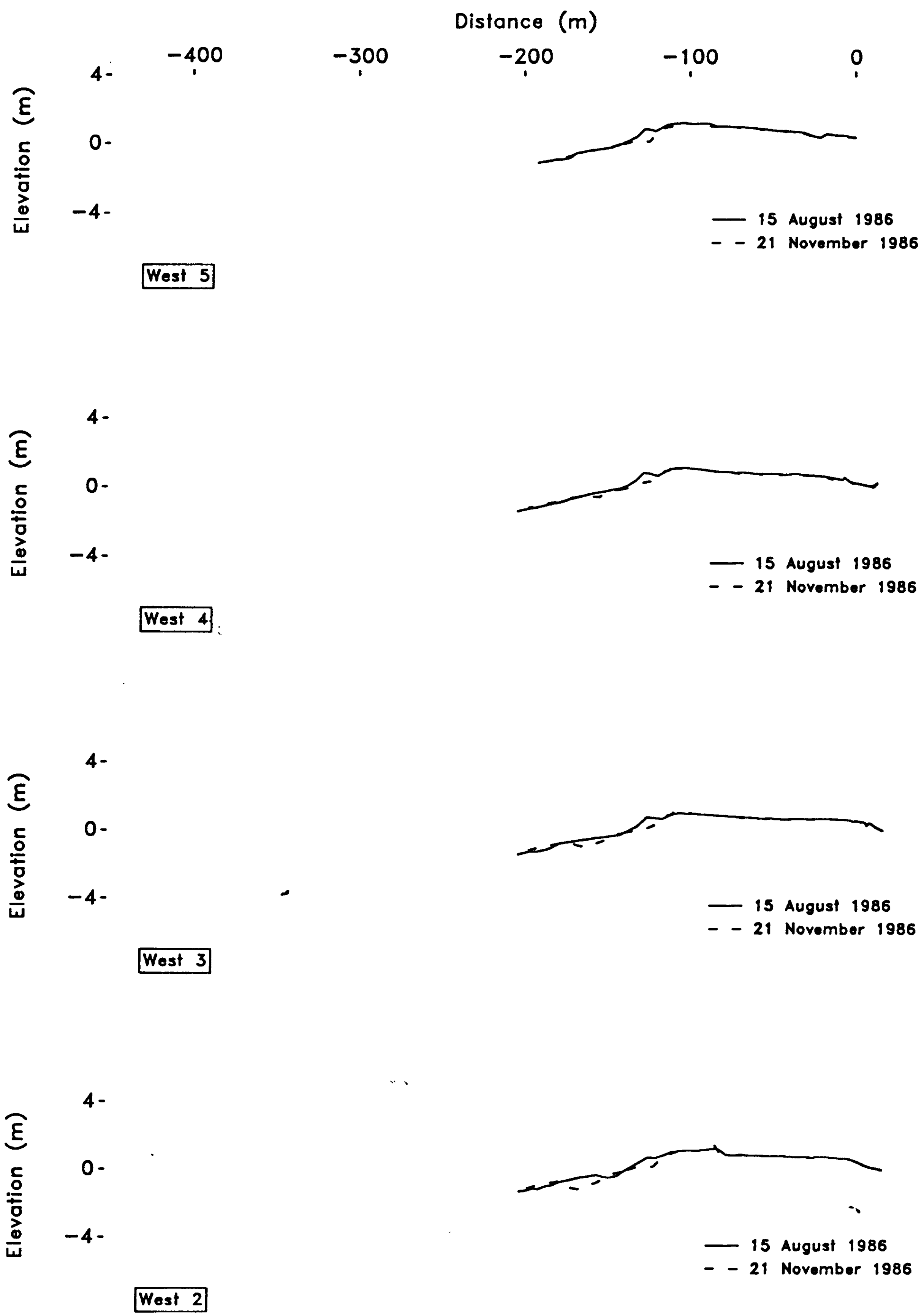
Figure 2 (b)

ISLES DERNIERES BEACH PROFILES



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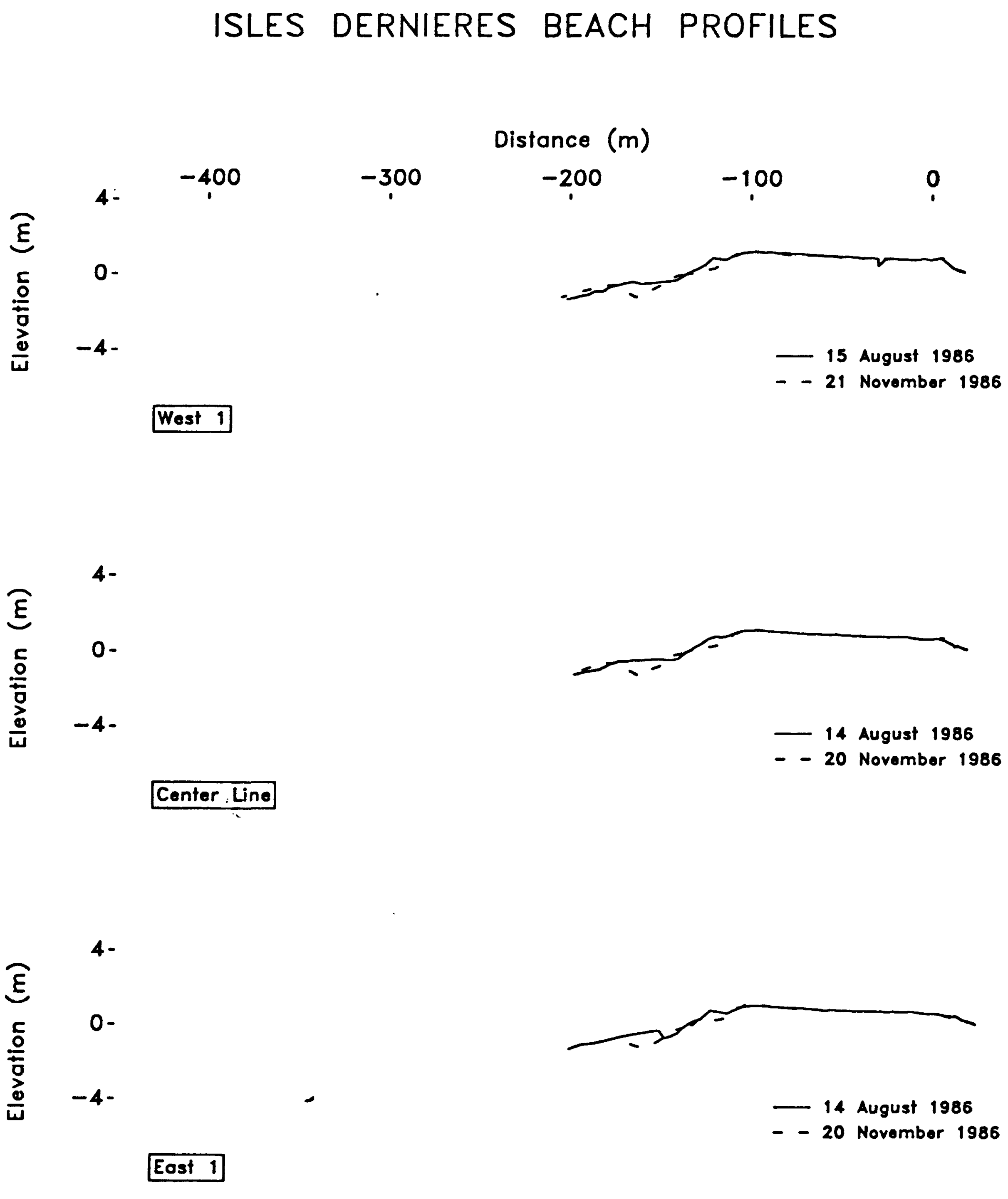
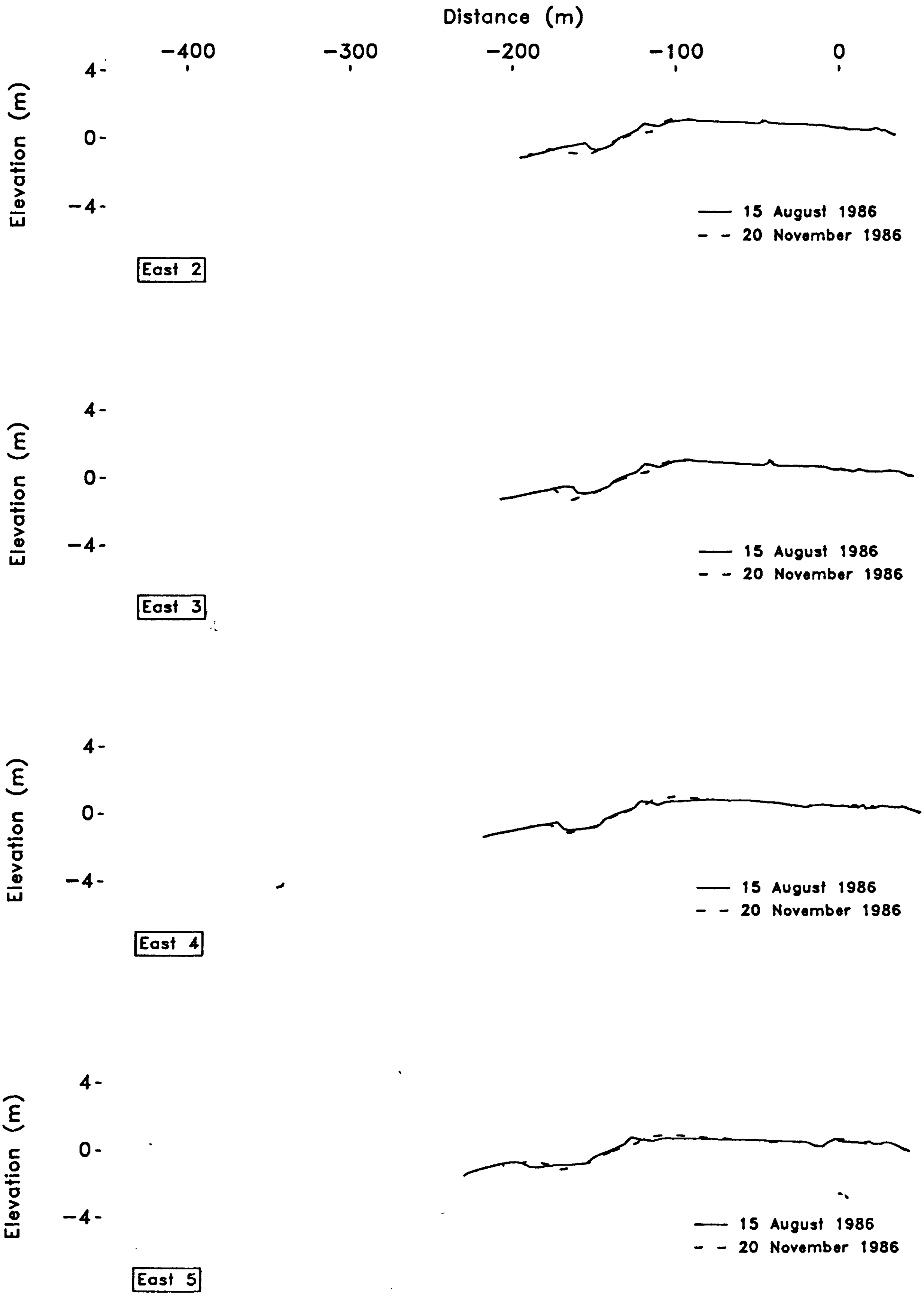


Figure 3 (2 of 3)

ISLES DERNIERES BEACH PROFILES



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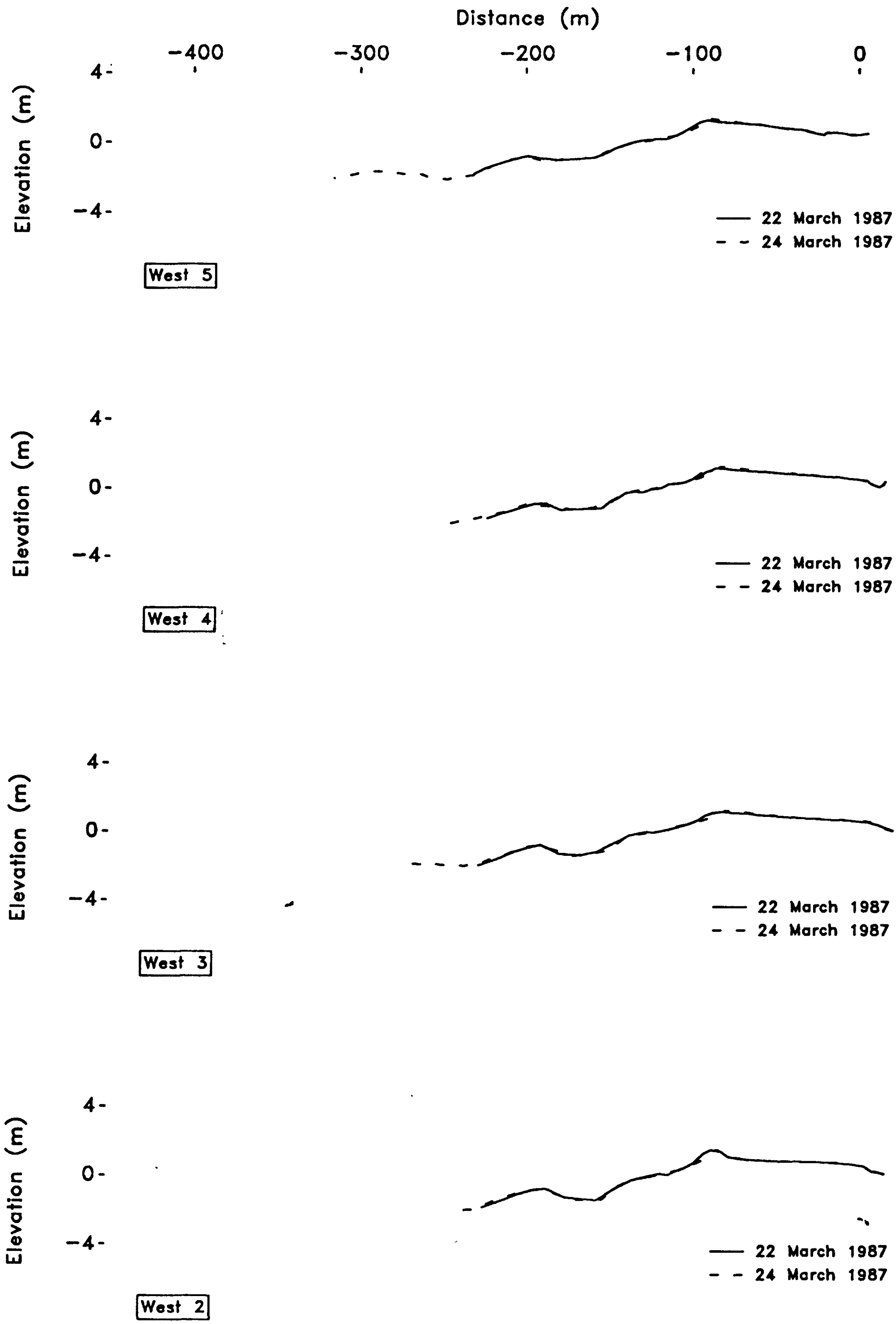
ISLES DERNIERES BEACH PROFILES



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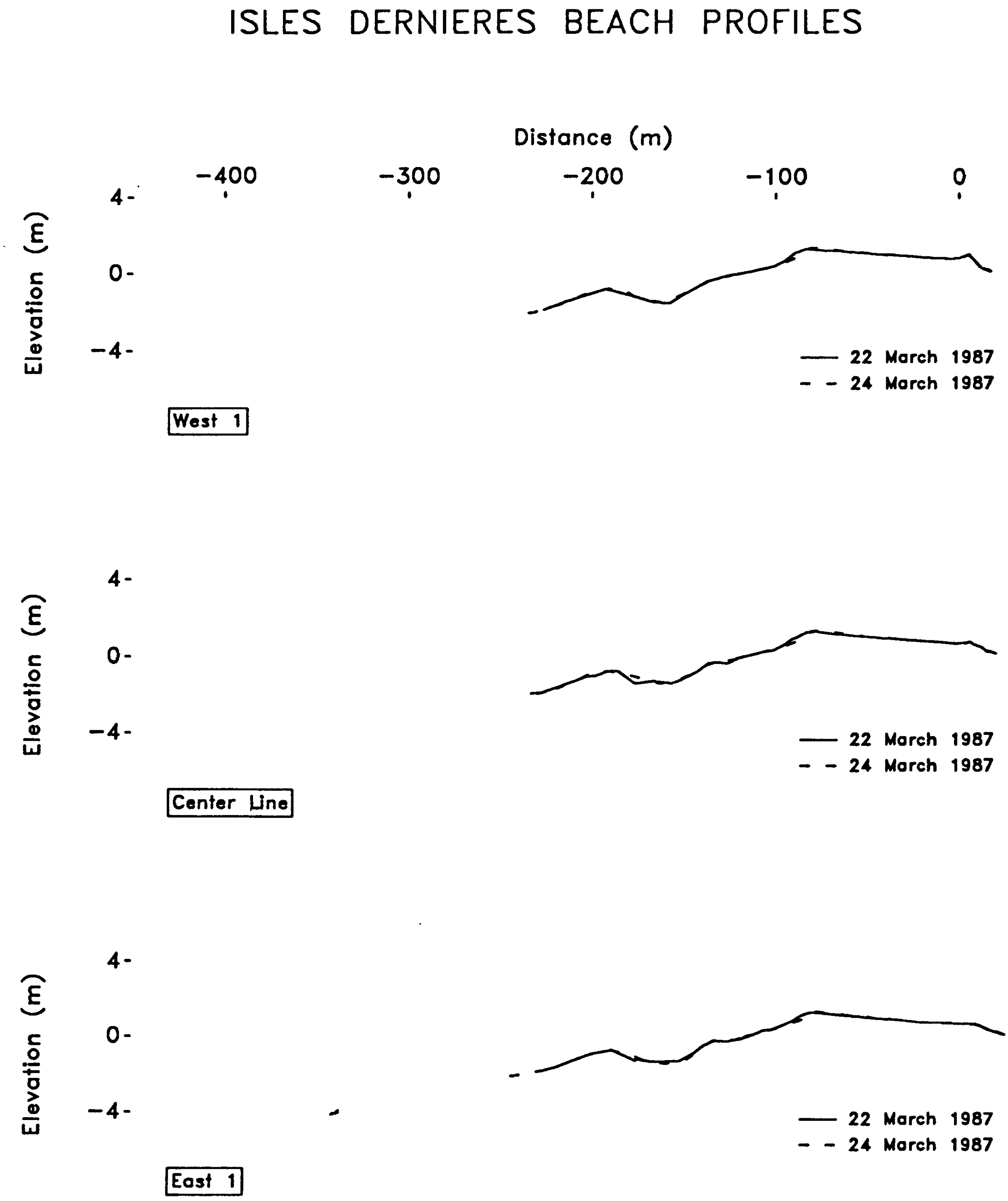

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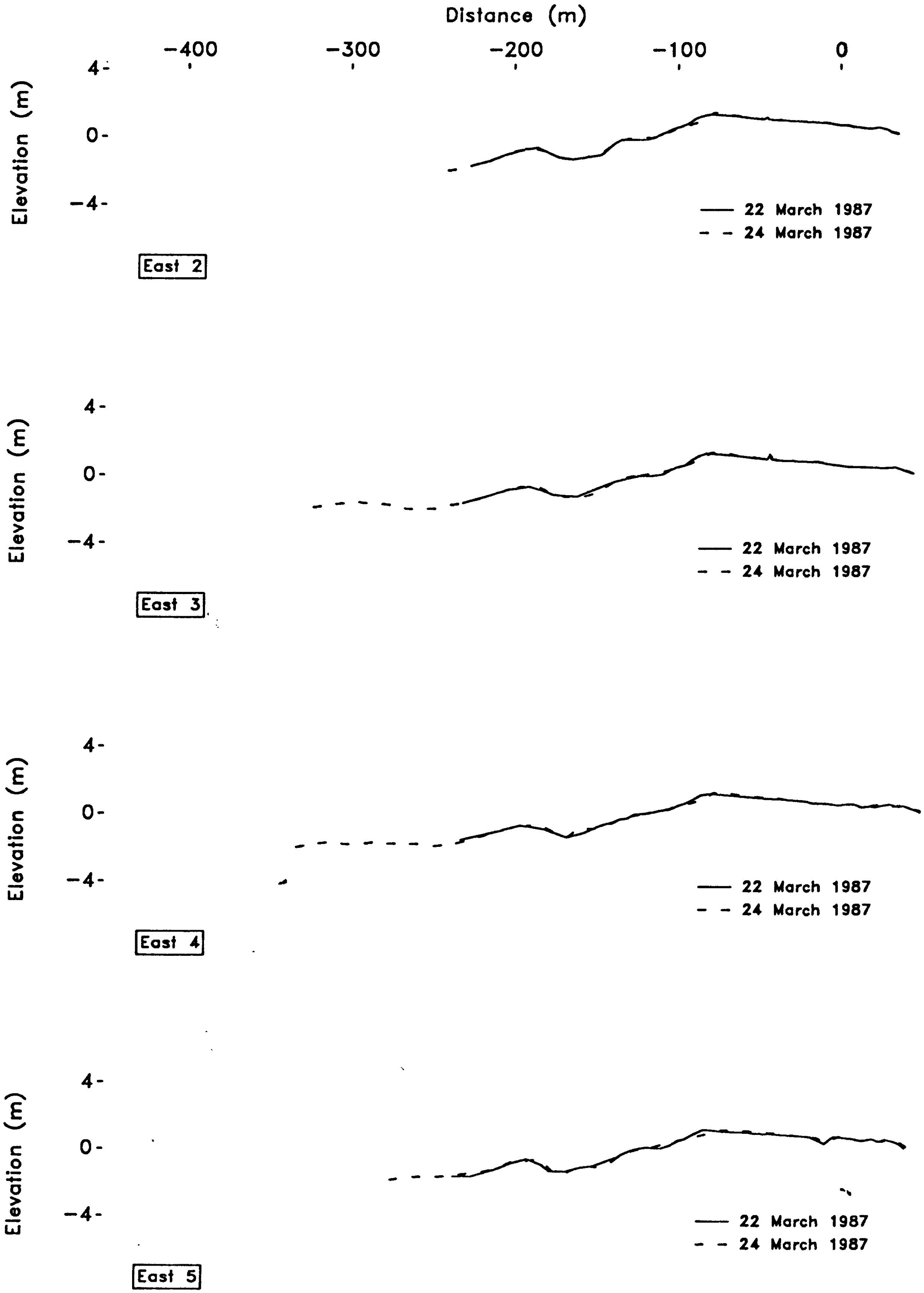
ISLES DERNIERES BEACH PROFILES



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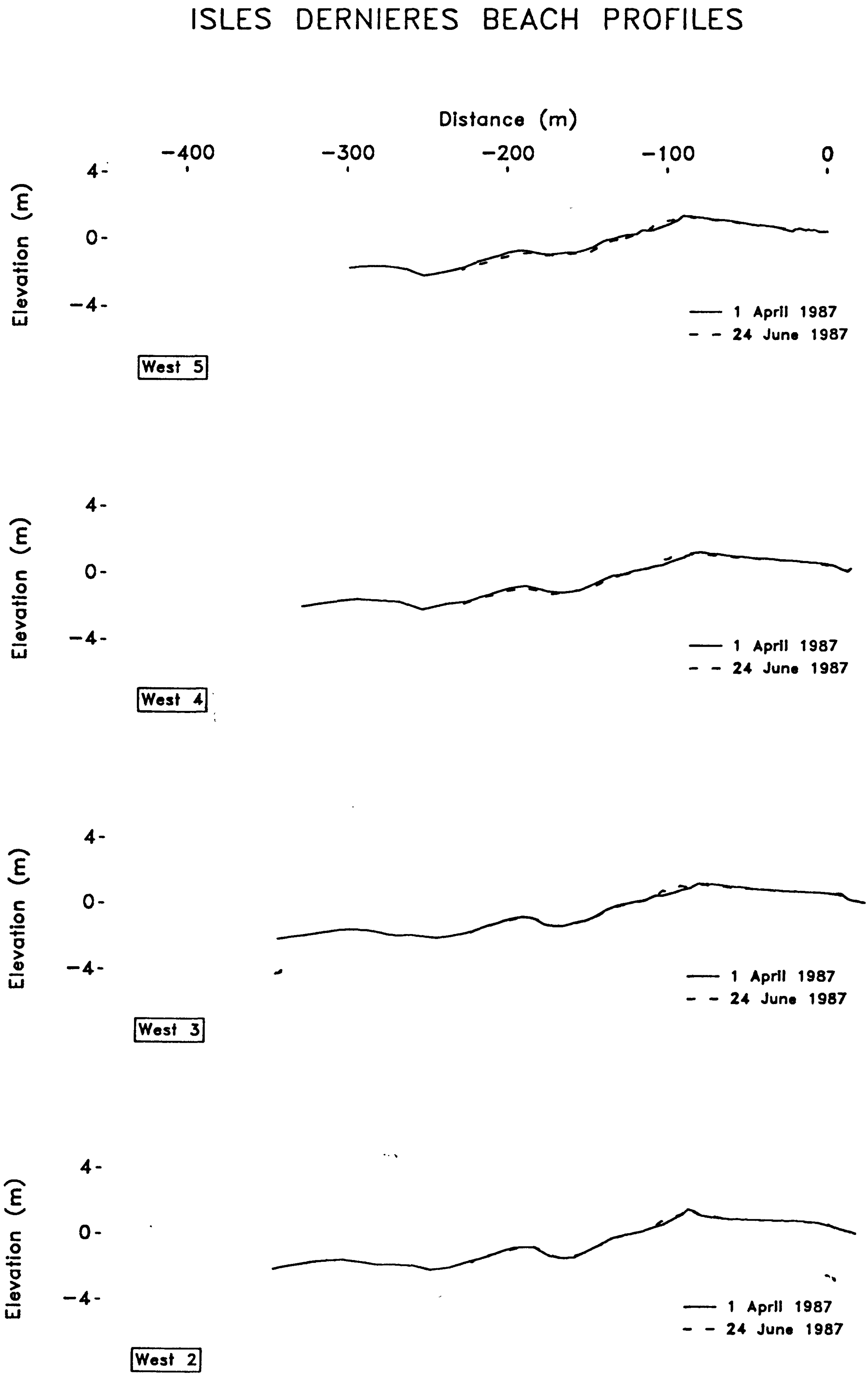

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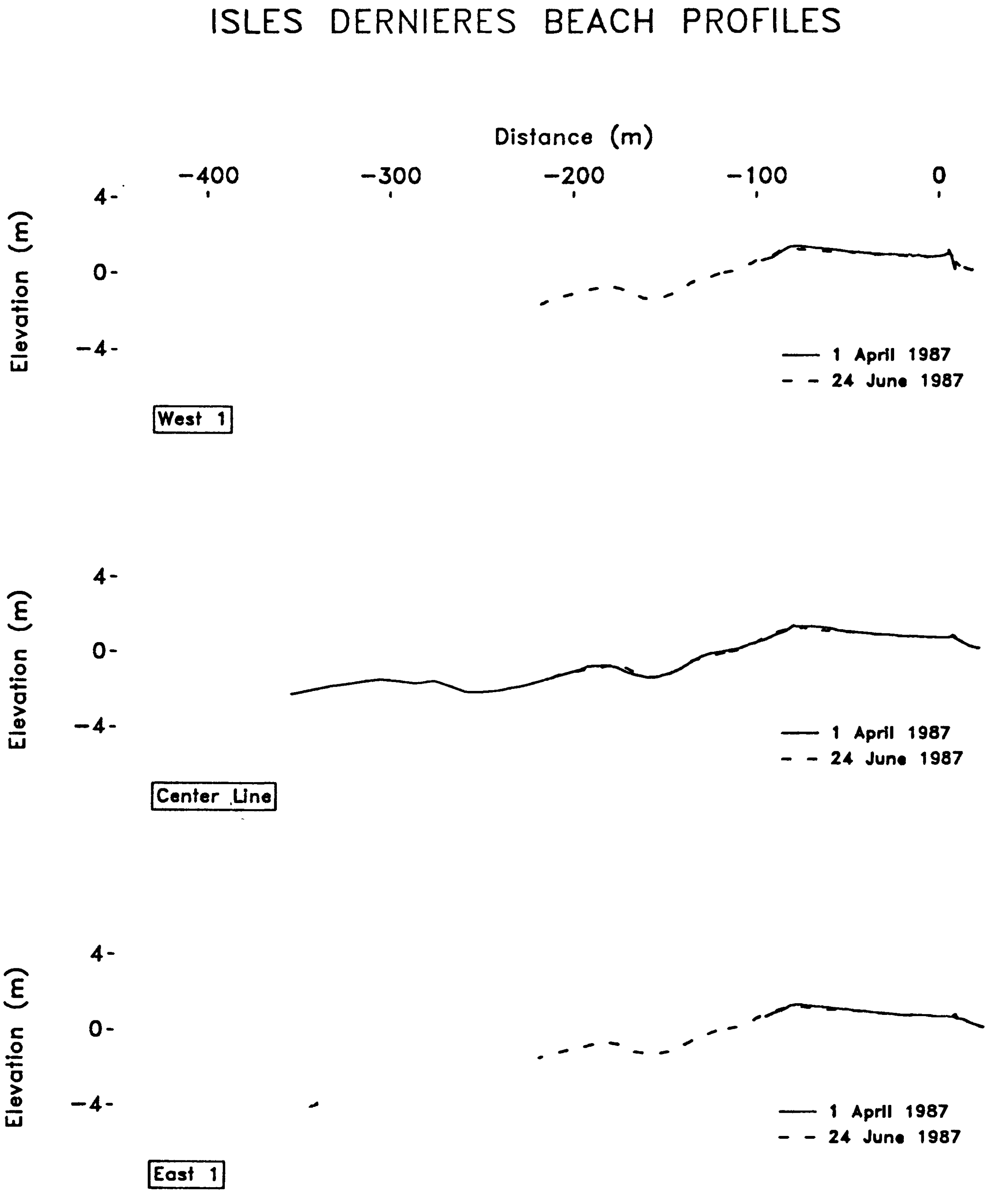

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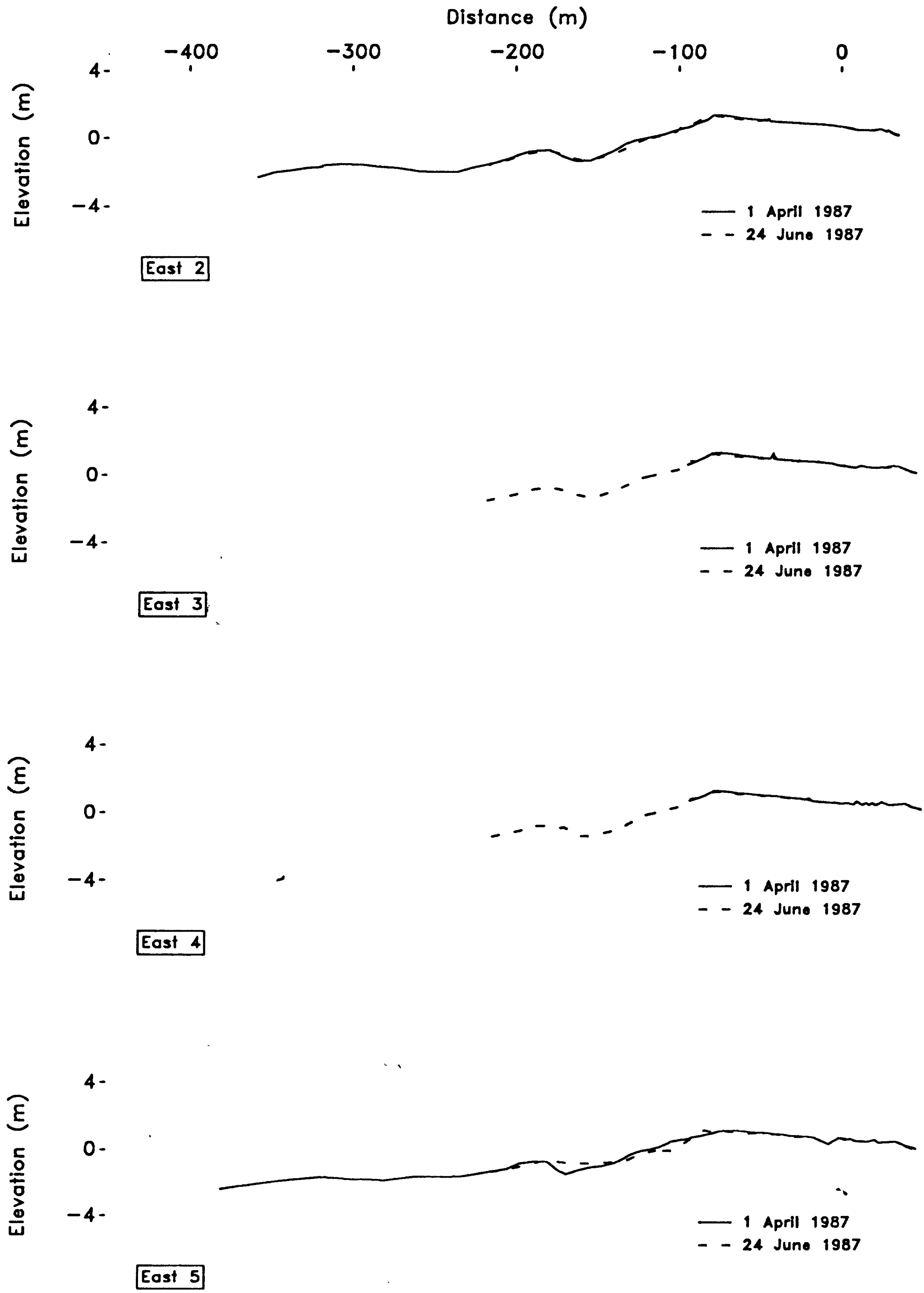

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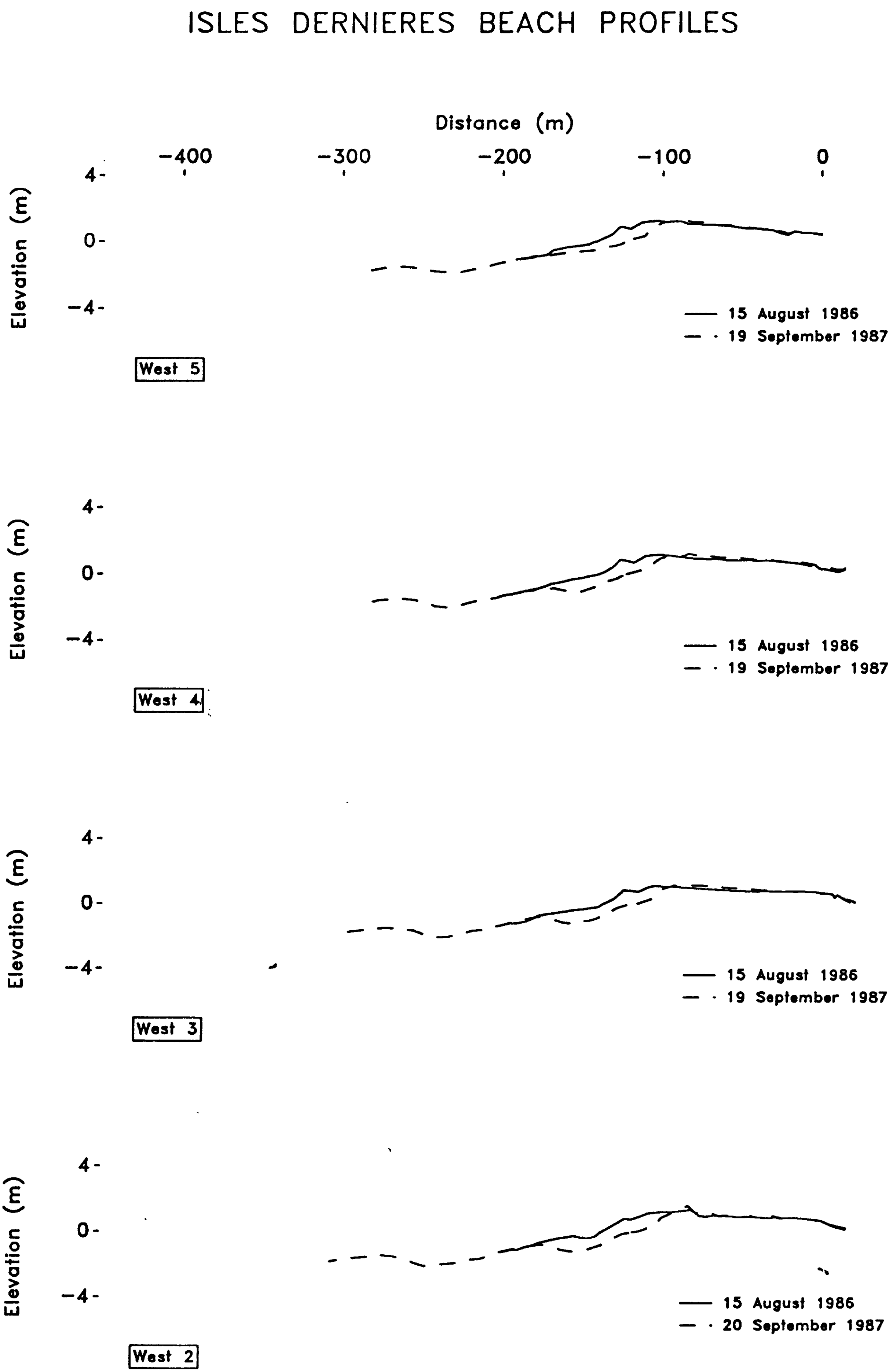

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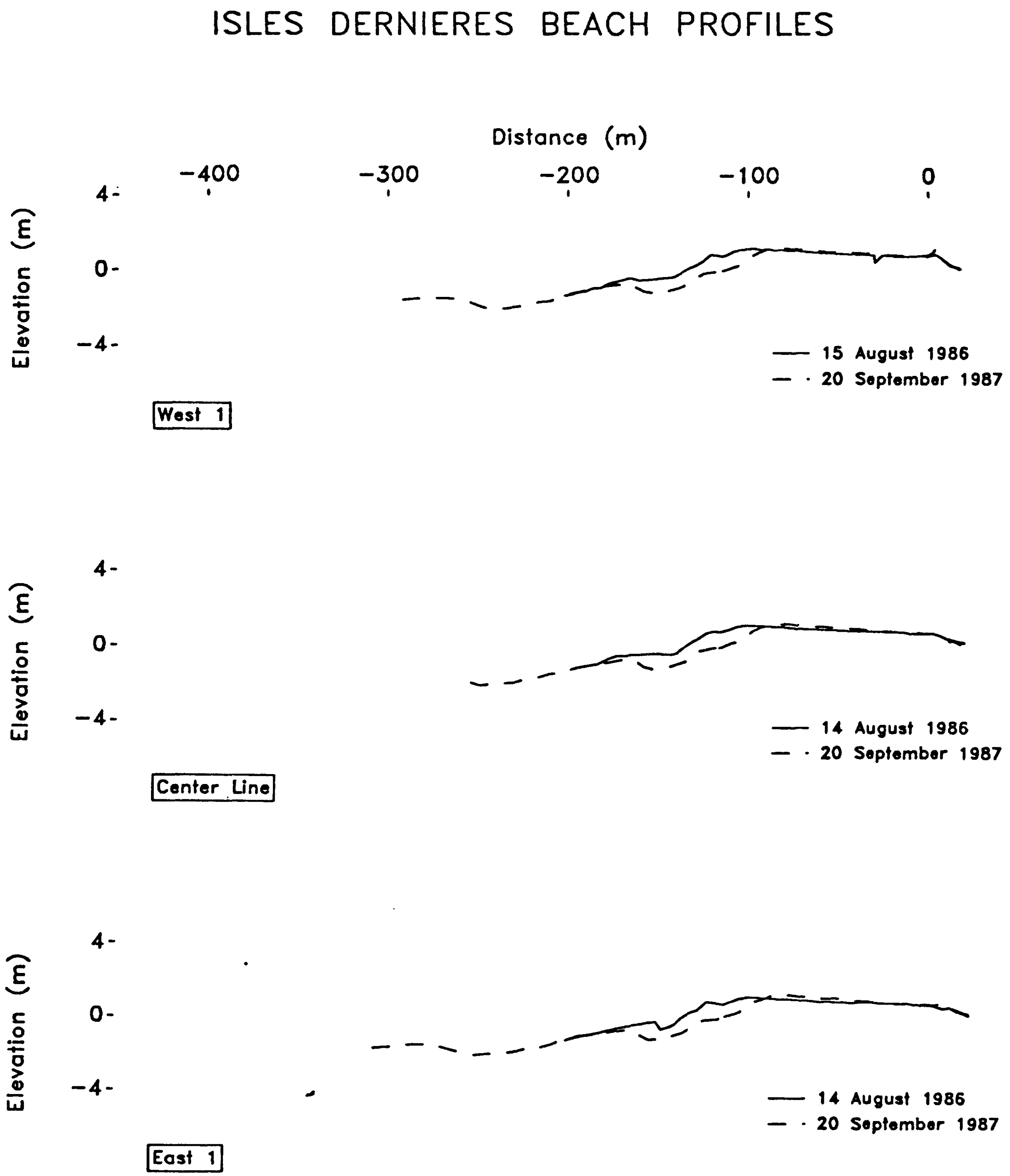

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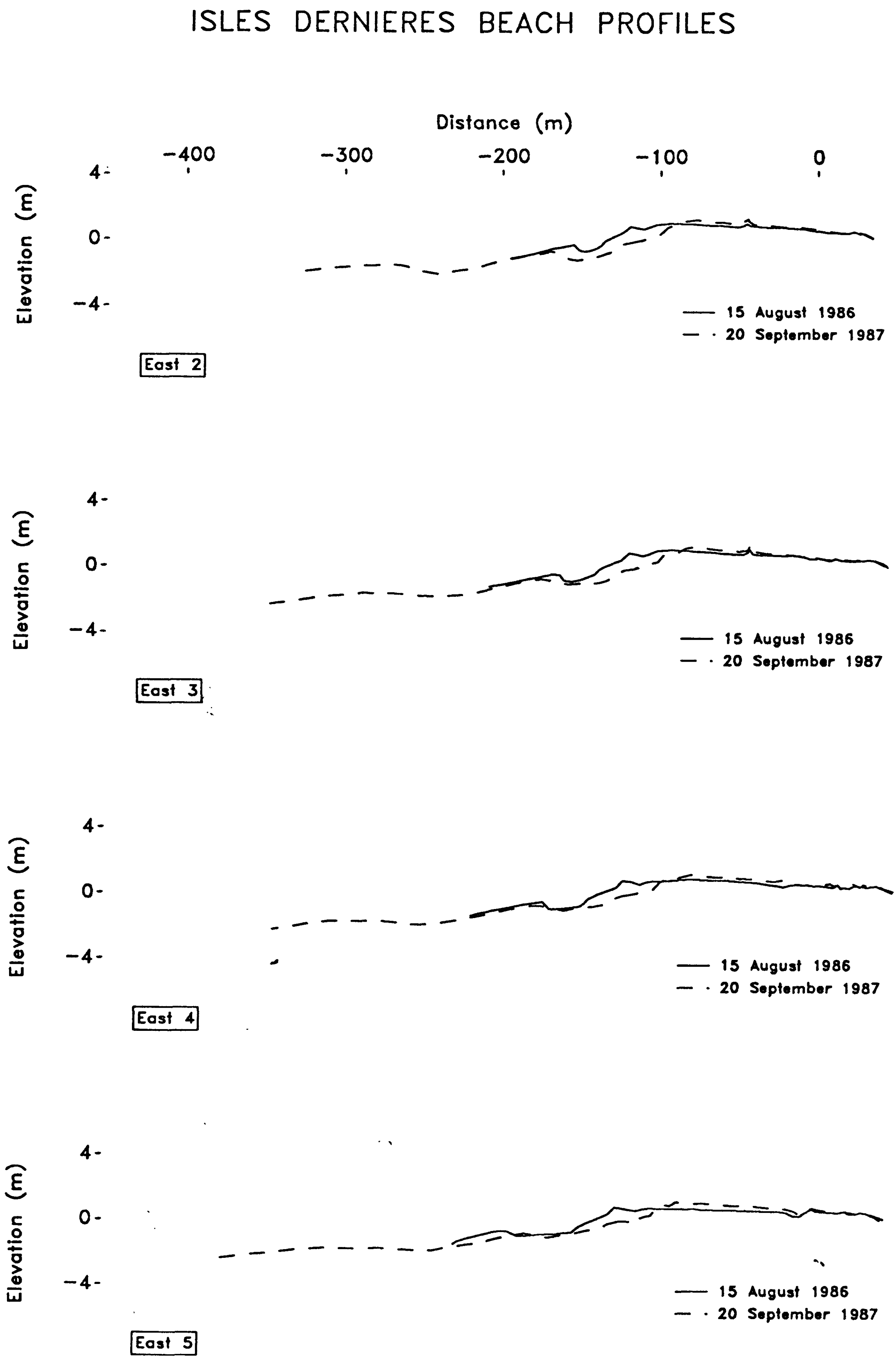

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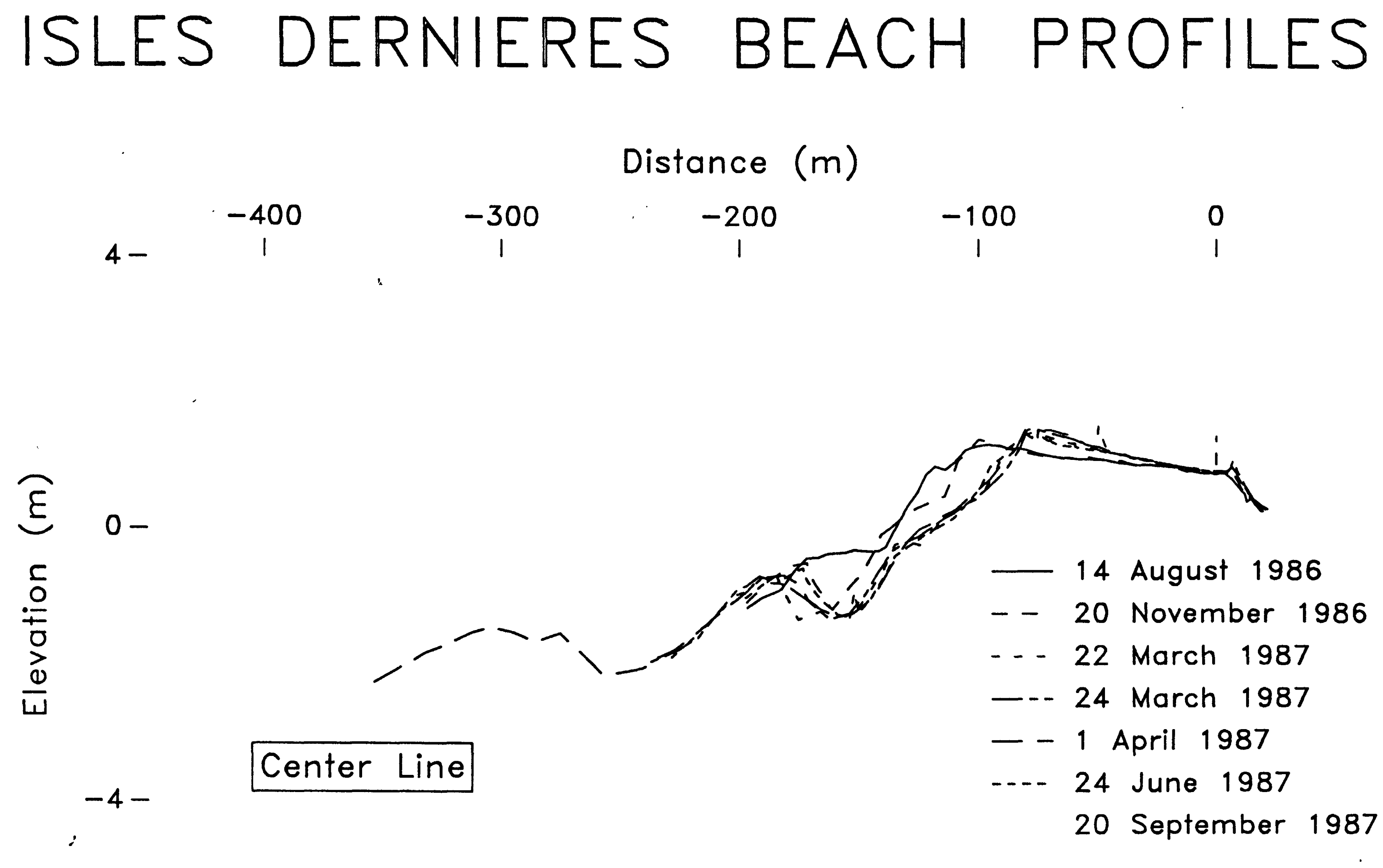

ISLES DERNIERES BEACH PROFILES
Distance (m)
-400
-300
-200
-100
0
Elevation (m)
4
0
-4
Center Line
14 August 1986
20 November 1986
22 March 1987
24 March 1987
1 April 1987
24 June 1987
20 September 1987

Figure 7

ISLES DERNIERES BEACH–PROFILE COMPARISONS

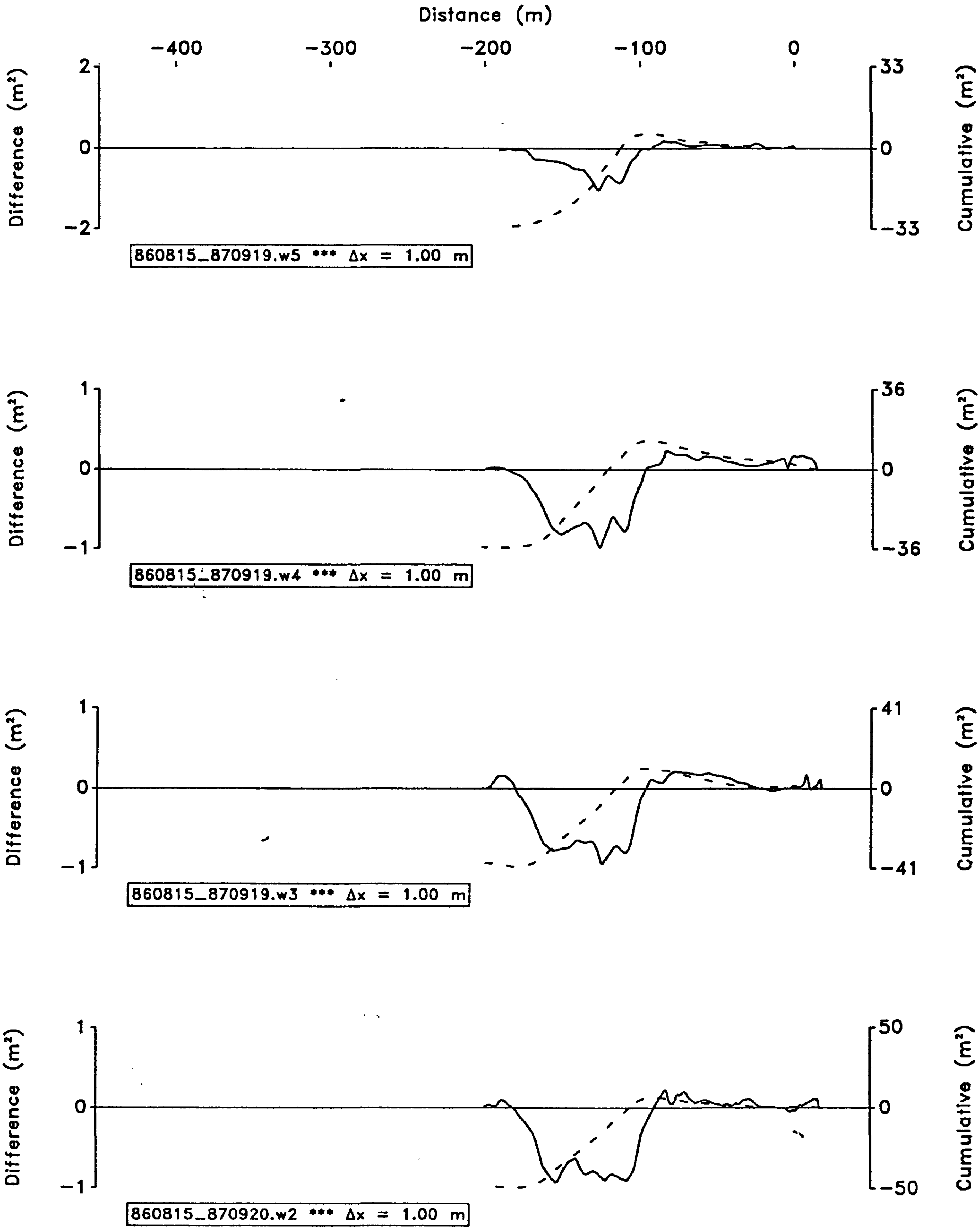
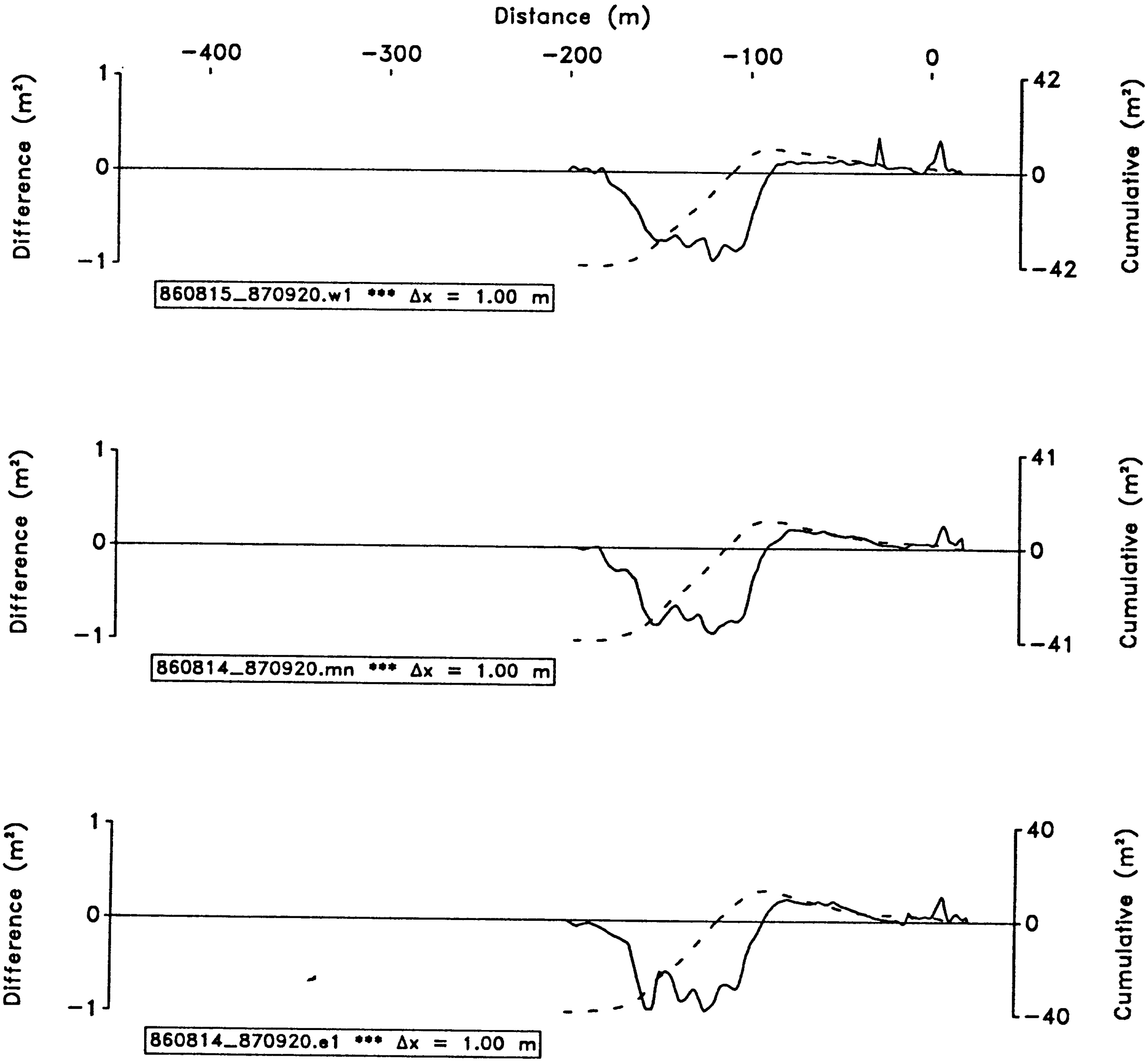


Figure 8 (1 of 3)

ISLES DERNIERES BEACH-PROFILE COMPARISONS



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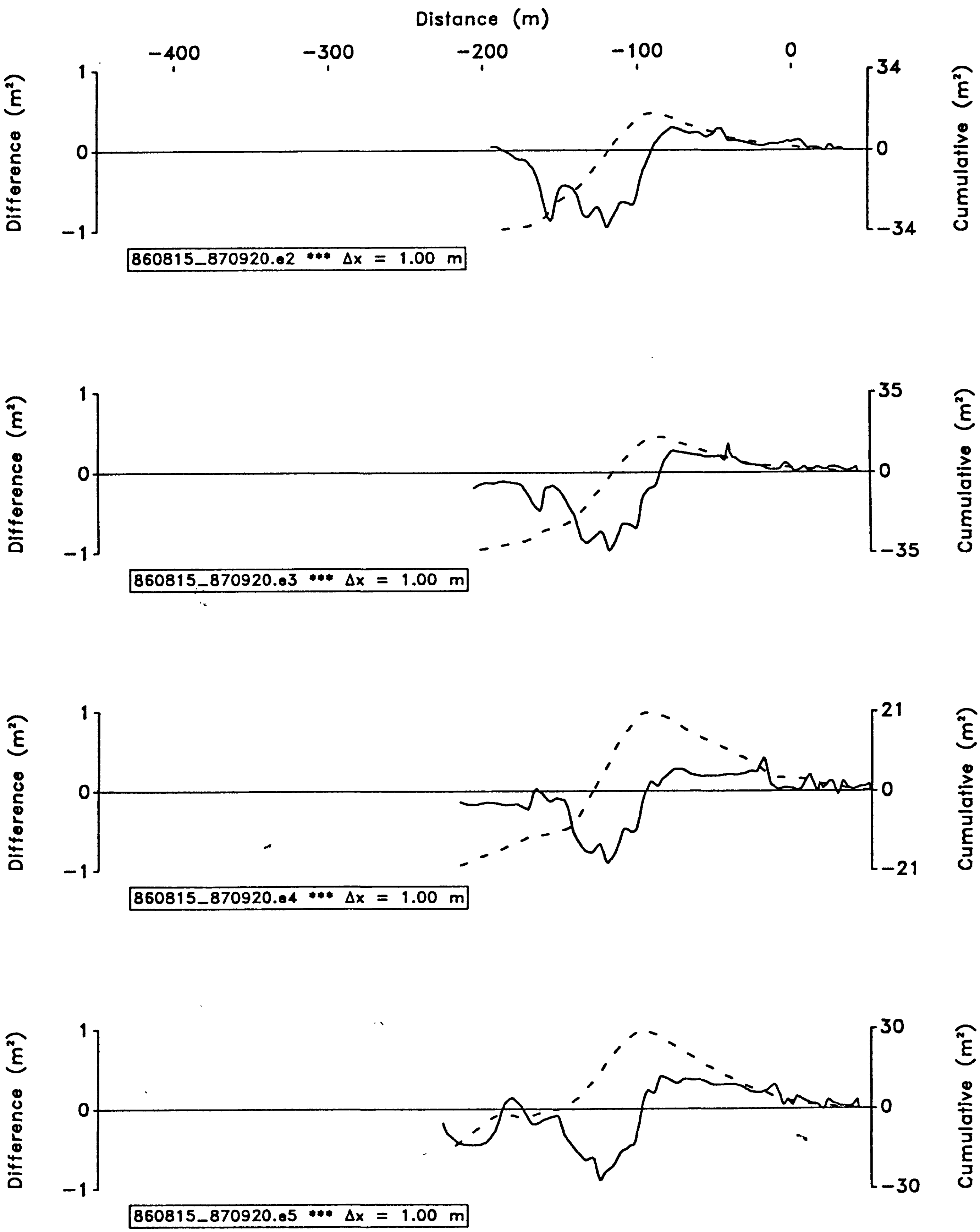

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