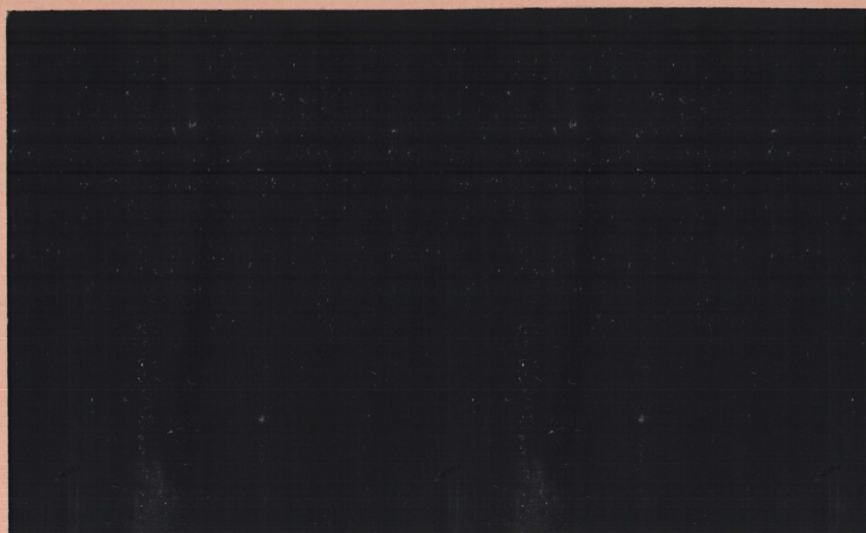
MARINE SCIENCES RESEARCH CENTER
STATE UNIVERSITY of NEW YORK
STONY BROOK, N.Y.

The Condition of New York's Ocean Shoreline: 1993

Henry Bokuniewicz

November 1994



MARINE SCIENCES RESEARCH CENTER

STATE UNIVERSITY OF NEW YORK

STONY BROOK, NEW YORK 11794-5000

The Condition of New York's Ocean Shoreline: 1993

Henry Bokuniewicz

November 1994

Approved for Distribution

J. K. Cochran

J. K. Cochran, Director

Working Paper #67
Reference #95-1

The Condition of New York's Ocean Shoreline: 1993

H. Bokuniewicz
Marine Sciences Research Center
State University of New York
Stony Brook, NY 11794-5000

Introduction

Technical specialists evaluating the risk of erosion at a particular location must use their best professional judgment to identify and rank the most relevant parameters from a wide range of possibilities. The complexity and variability of coastal processes make this evaluation procedure impossible to codify. It is very difficult even to quantify the risk at a specific site. Nonetheless, evaluations of the susceptibility of the shoreline to erosion must be done in order to manage the resource. Widely-accepted, generally applicable criteria are not available, but reasonable, site specific approaches may be developed to aid in this process.

It is my intention to explore ways to classify the coast, using only aerial photographs, in a way that will facilitate comparisons of different sites along NY's ocean shoreline with regards to the degree of protection provided by the beach and dune, or to their susceptibility to overwashing. These criteria are intended to provide a self-consistent way of comparing one area to another in relevant terms. In addition, an initial screening using only aerial photographs can be done relatively rapidly without time-consuming and expensive ground surveys. They are not the ideal parameters, however, since, for example, they cannot include the elevation of the dune or the volume of sand in the subaerial barrier.

This work was supported by the NY State Department of Environmental Conservation. The data was compiled and processed by Mr. Kenneth Sakson.

Approach

A series of aerial photographs were taken on 18 December, 1992 after the severe northeaster which occurred 12-14 December, 1992. The series was taken as stereo-pairs along the ocean shoreline of Long Island and Staten Island. These were examined in stereo at a scale of about 1:9500. The recent scarp in the seaward face of the dune caused by the storm could be distinguished easily.

A set of photographs taken in 1983 were also available for the shoreline outside of New York City. These had been used in a study of the distribution of natural, protective features and, where appropriate, the landward toe of the dune had been delineated at a scale of 1:2400. This set, therefore, provide a baseline against which the recent changes could be measured. There was nothing particularly special about 1983; it does not represent some ideal situation. But, the photographs are available, they had been used in the delineation of natural, protective features, and identifications had been checked in the field. As a result, they form a convenient base for much of the shoreline. The position of the scarp evident on the 1992 photographs was transferred into the 1983 series when possible. The transfer was done with respect to landmarks on each photograph. Landmarks were plentiful and easily identified, and it was estimated that the scarp line has been located with a precision of about 25 feet of its actual position.

Four parameters were measured from the aerial photographs every 200 feet along the shoreline. These were: post-storm dune width from the scarp to the landward toe; dune loss which was the difference between the position of the scarp in 1992 and the seaward edge of dune vegetation in 1983; island width from the storm scarp to the bay shoreline; and beach width. Along some stretches of shoreline not all measurements were possible or appropriate. On Staten Island and on sections of Long Beach, for example, only beach width could be measured.

Empirical parameters were then developed to reflect the relative condition of the shoreline in different areas. This was done by first locating problem areas based on my best professional judgment and knowledge of the area, and then exploring the conditions indicative of these areas. Those conditions were codified in a single parameter which was then applied to the entire stretch of beachfront. The approach was focused on the barrier island since that shoreline provided the richest array of parameters to be considered.

Results

Fire Island. For Fire Island, measurements were made of dune width (Figure 1), dune loss between 1983 and 1992 (Figure 2), island width from the scarp in 1992 to the bay shoreline (Figure 3) and the percentage of dune lost (Figure 4). By inspecting these numbers we find, for example, that (1) 38% of the island has a width under 1000 feet, (2) about 16% of the dune is less than

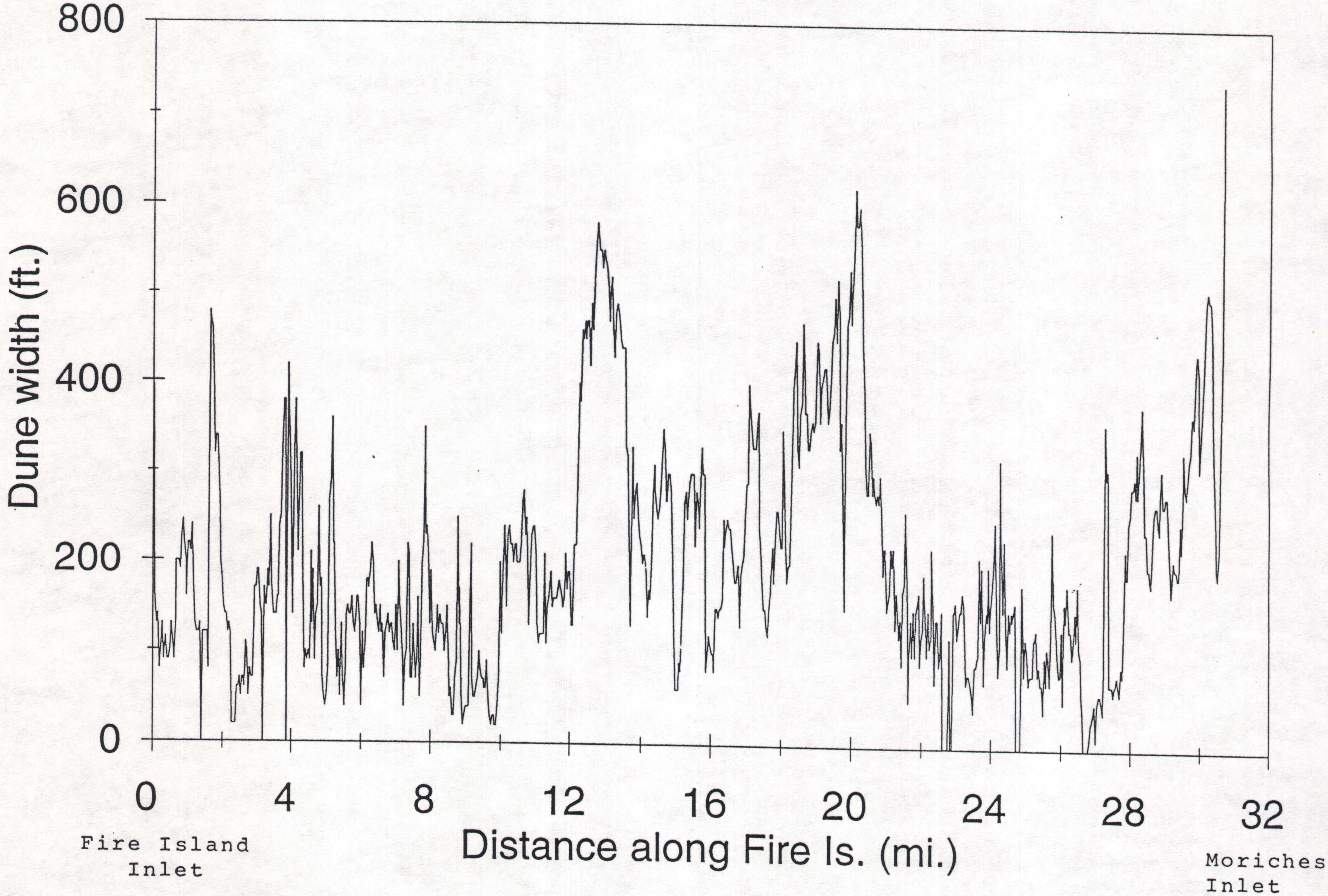

800
600
400
200
0
Dune width (ft.)
0
4
8
12
16
20
24
28
32
Fire Island Inlet
Distance along Fire Is. (mi.)
Moriches Inlet

Figure 1

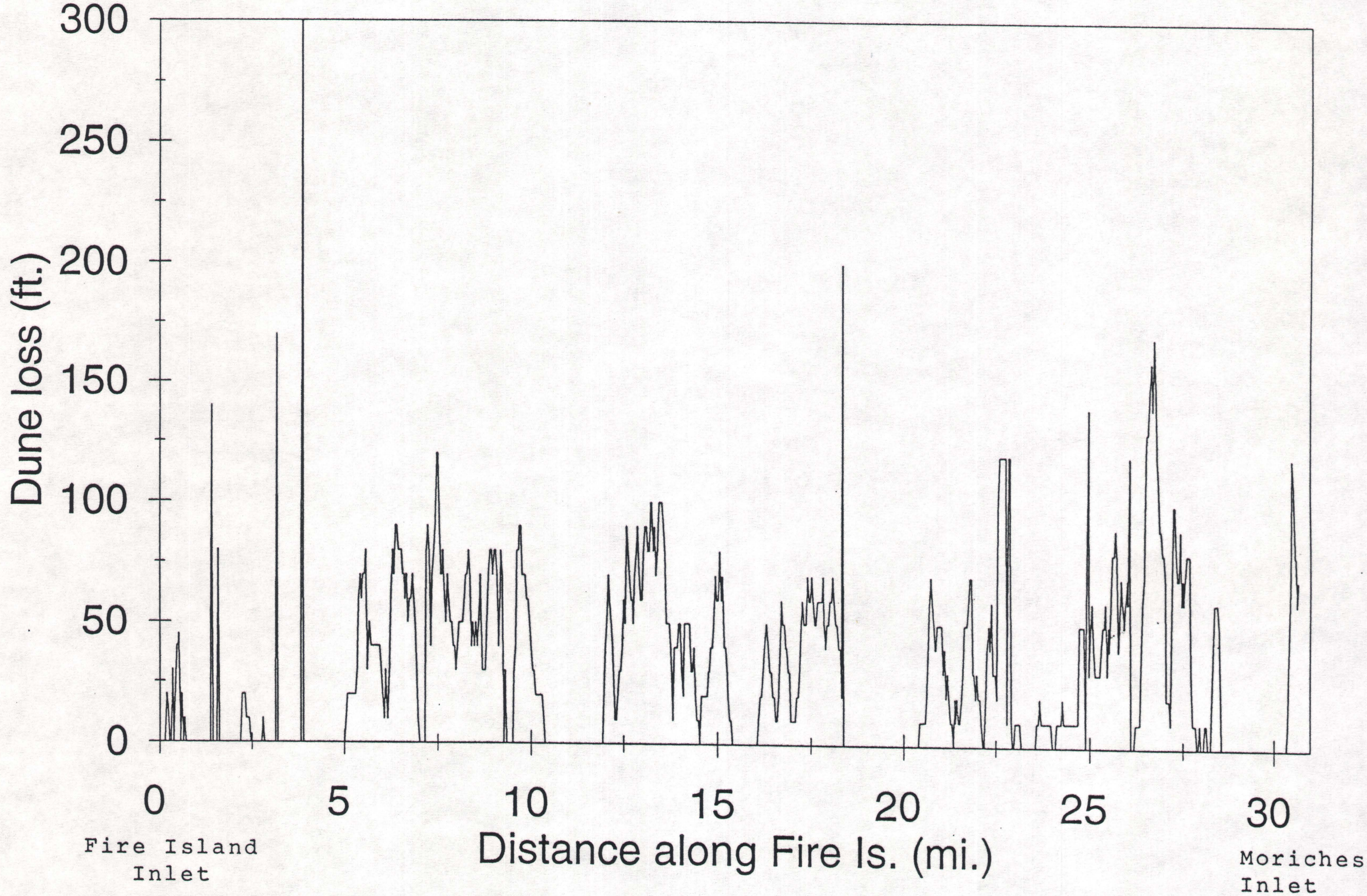

300
250
200
150
100
50
0
Dune loss (ft.)
0
5
10
15
20
25
30
Distance along Fire Is. (mi.)
Fire Island Inlet
Moriches Inlet

Figure 2

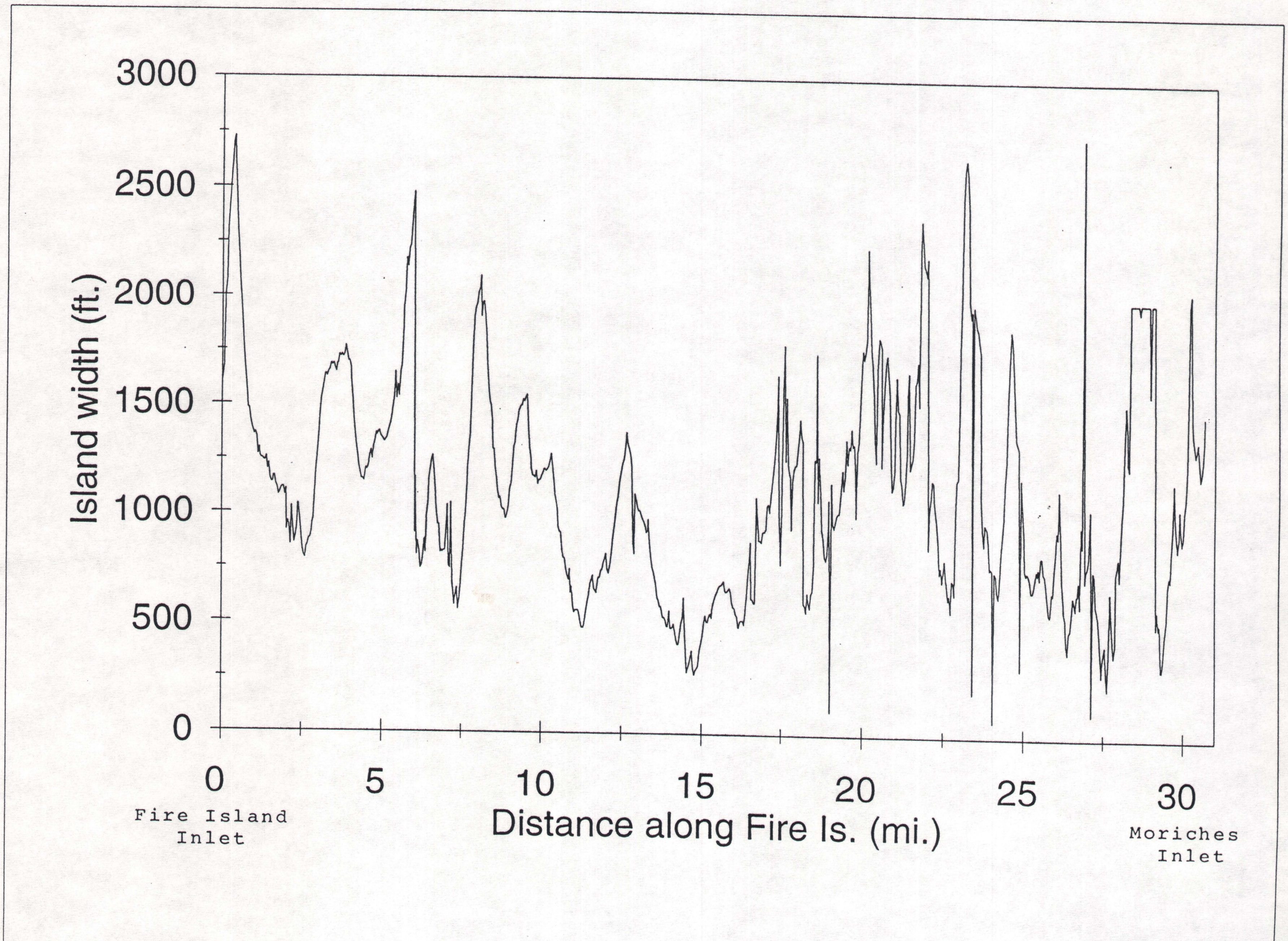

3000
2500
2000
1500
1000
500
0
Island width (ft.)
0
5
10
15
20
25
30
Fire Island
Inlet
Distance along Fire Is. (mi.)
Moriches
Inlet

Figure 3

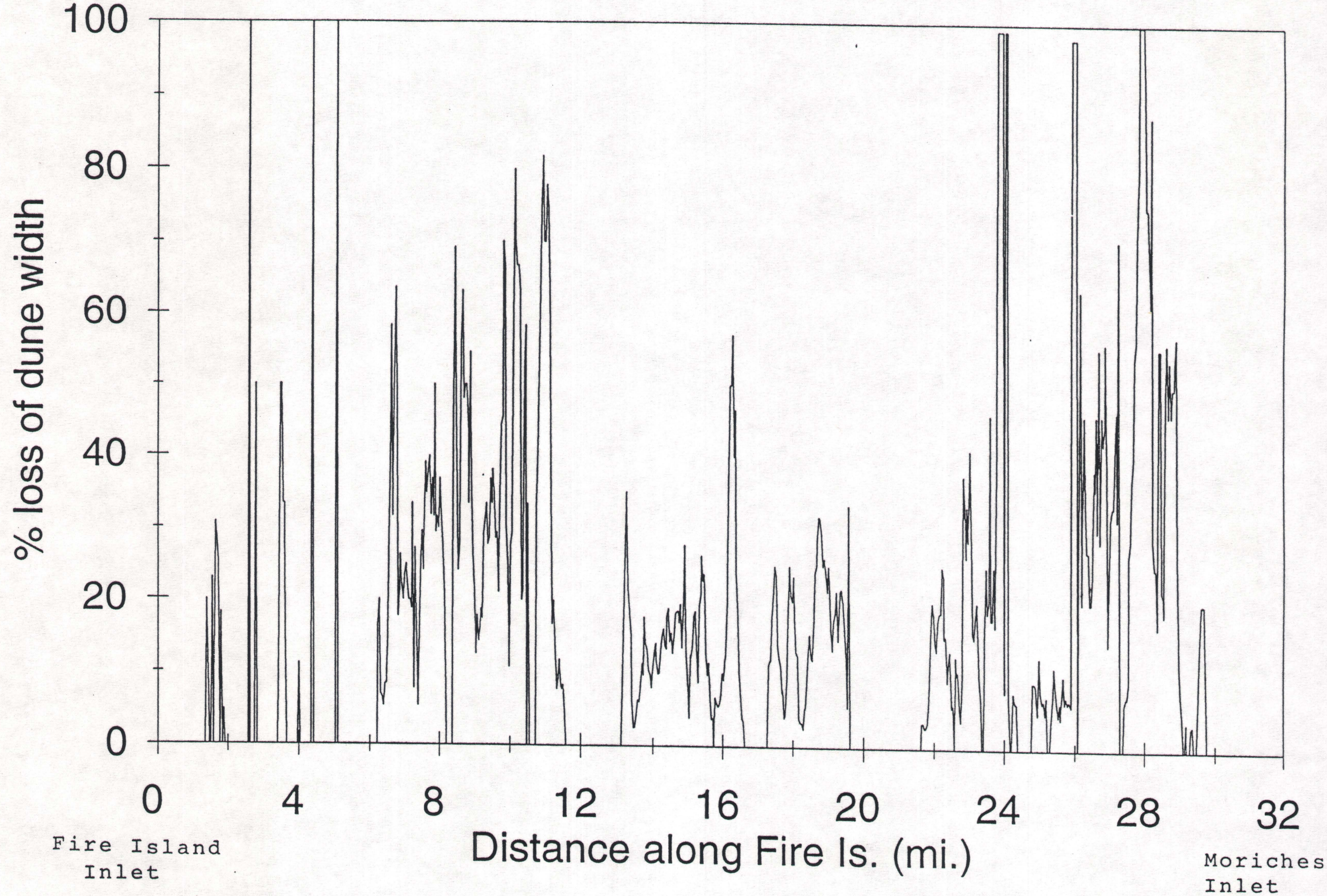

100
80
60
40
20
0
% loss of dune width
0
4
8
12
16
20
24
28
32
Distance along Fire Is. (mi.)
Fire Island Inlet
Moriches Inlet

Figure 4

50 feet wide, and (3) 60% suffered measurable loss of the dune relative to the 1983 vegetation line. Twenty-seven percent of the shoreline meets two or more of these conditions simultaneously.

Two basic parameters were formulated from these measurements. One, which I will refer to as the "loss index", was based on the ratio of the percentage of dune width lost to the island width. Large values of this parameter indicate places where the island is narrow and a substantial fraction of the dune has already been lost. Such locations may indicate where the recent erosion has substantially enhanced the danger of overwashing (i.e., movement of sand from the ocean to the bay). The loss index was calculated as L = percent dune lost/ island width/maximum width of the island. Its distribution along the length of Fire Island is shown in Figure 5a. Locations of overwashes in Smith Point County Park (distance interval above 649 on Figure 5a or beyond 24.5 miles east of Fire Island Inlet) and at Old Inlet (distance interval 598-606 on Figure 5a or between mile points 22.6 and 22.9) have the highest indices of dune loss. Other locations of overwash, such as in Atlantique, appear with index values over seven. However, the area in Fair Harbor where a row of houses was left stranded on the beach has lower values of the index; even though the retreat of the dune exposed oceanfront houses, the threat of overwashing was less here than at other locations.

The other parameter, which I will refer to as the "dune index", was essentially the pre-storm dune thinness (relative to the widest dune found on the island) divided by the island width.

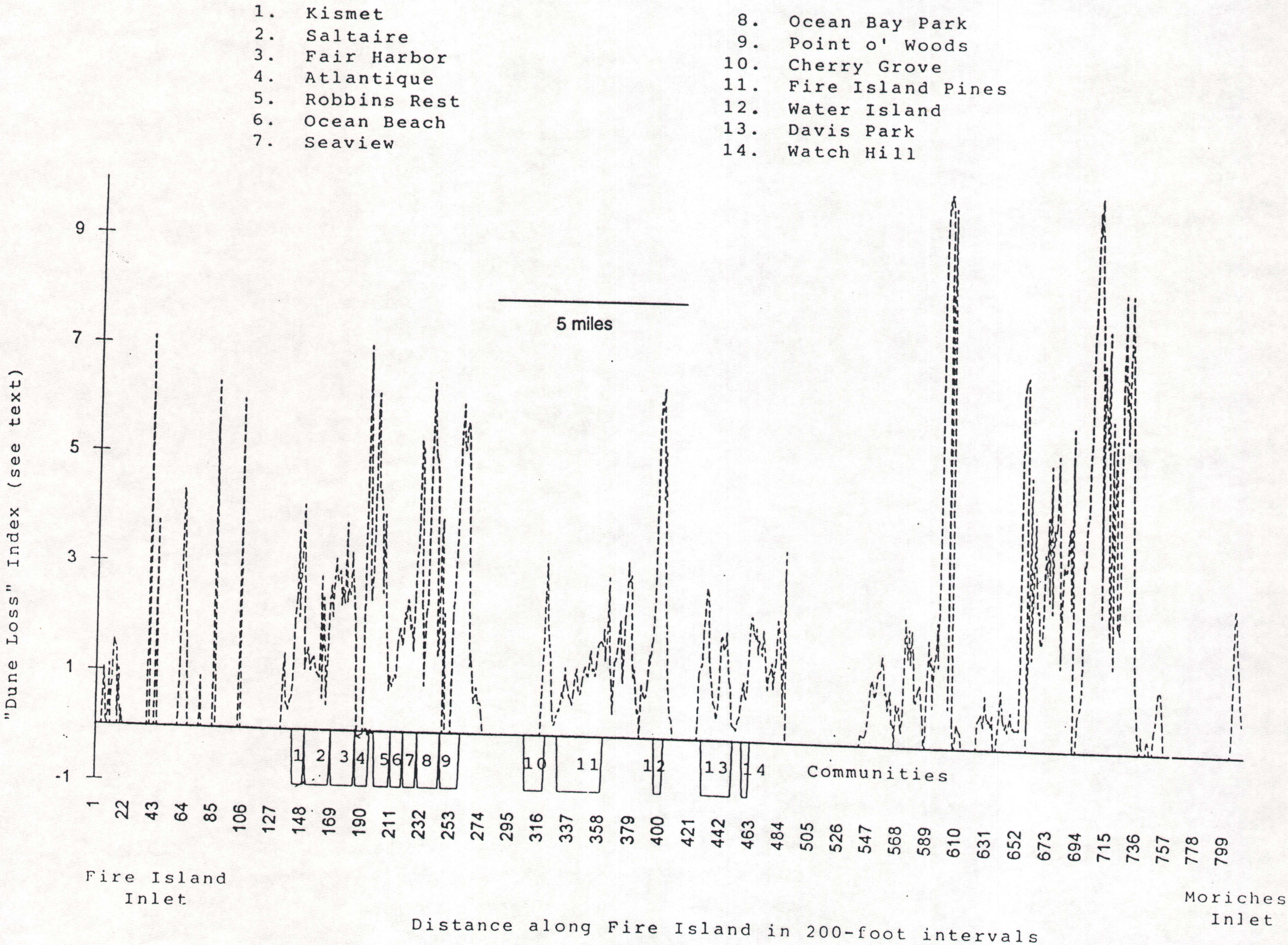

1. Kismet
2. Saltaire
3. Fair Harbor
4. Atlantique
5. Robbins Rest
6. Ocean Beach
7. Seaview
8. Ocean Bay Park
9. Point o' Woods
10. Cherry Grove
11. Fire Island Pines
12. Water Island
13. Davis Park
14. Watch Hill
5 miles
"Dune Loss" Index (see text)
9
7
5
3
1
-1
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Communities
1 22 43 64 85 106 127 148 169 190 211 232 253 274 295 316 337 358 379 400 421 442 463 484 505 526 547 568 589 610 631 652 673 694 715 736 757 778 799
Fire Island Inlet
Moriches Inlet
Distance along Fire Island in 200-foot intervals

Figure 5a

High values of this parameter indicate where both the island and the dune are thinner presumably providing less resistance to overwash. The dune index was calculated as D = (1 - the dune width in 1983/maximum dune width) / island width/maximum width of the island. Both indices were normalized so that their values fell between zero and 10.

Several cautionary remarks are in order before we proceed.

1. The distribution of the loss index seems reasonable. Areas that we know to be problems appear with high index values. Nevertheless, the index remains an empirical one. It may not have captured all the areas at risk or, conversely, all areas with high index values may not be at comparable risk due to other factors, such as low elevation of the beach and dune.

2. The values of the indices do not necessarily have a linear relationship to the actual risk. That is, an area with an index value of 10 is not necessarily twice as susceptible to erosion as an area with a value of 5. The exact relationship between the value of the index and the actual risk is unknown; the index is for comparative purposes only.

3. The indices are normalized to conditions on Fire Island as they existed after the storm in December, 1992. The relative level of risk is different for different locations, but the absolute value is not discriminated. All values may correspond to high, or low, actual risks.

Composite parameters were also prepared by weighting each parameter, adding them, and normalizing each combination to a range between zero and ten. Figures 5b-f show the

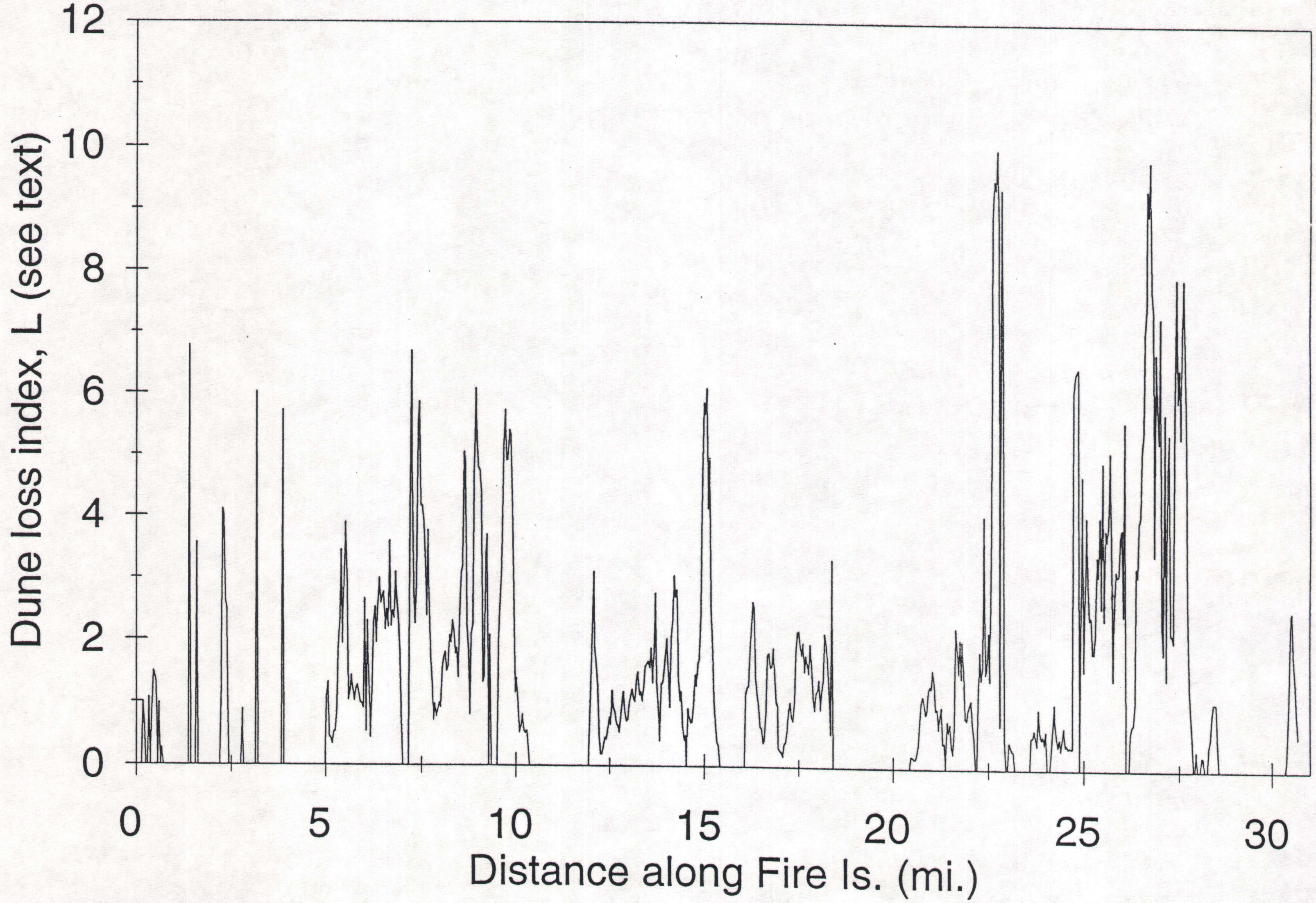

Dune loss index, L (see text)
Distance along Fire Is. (mi.)
0
2
4
6
8
10
12
0
5
10
15
20
25
30

Figure 5b

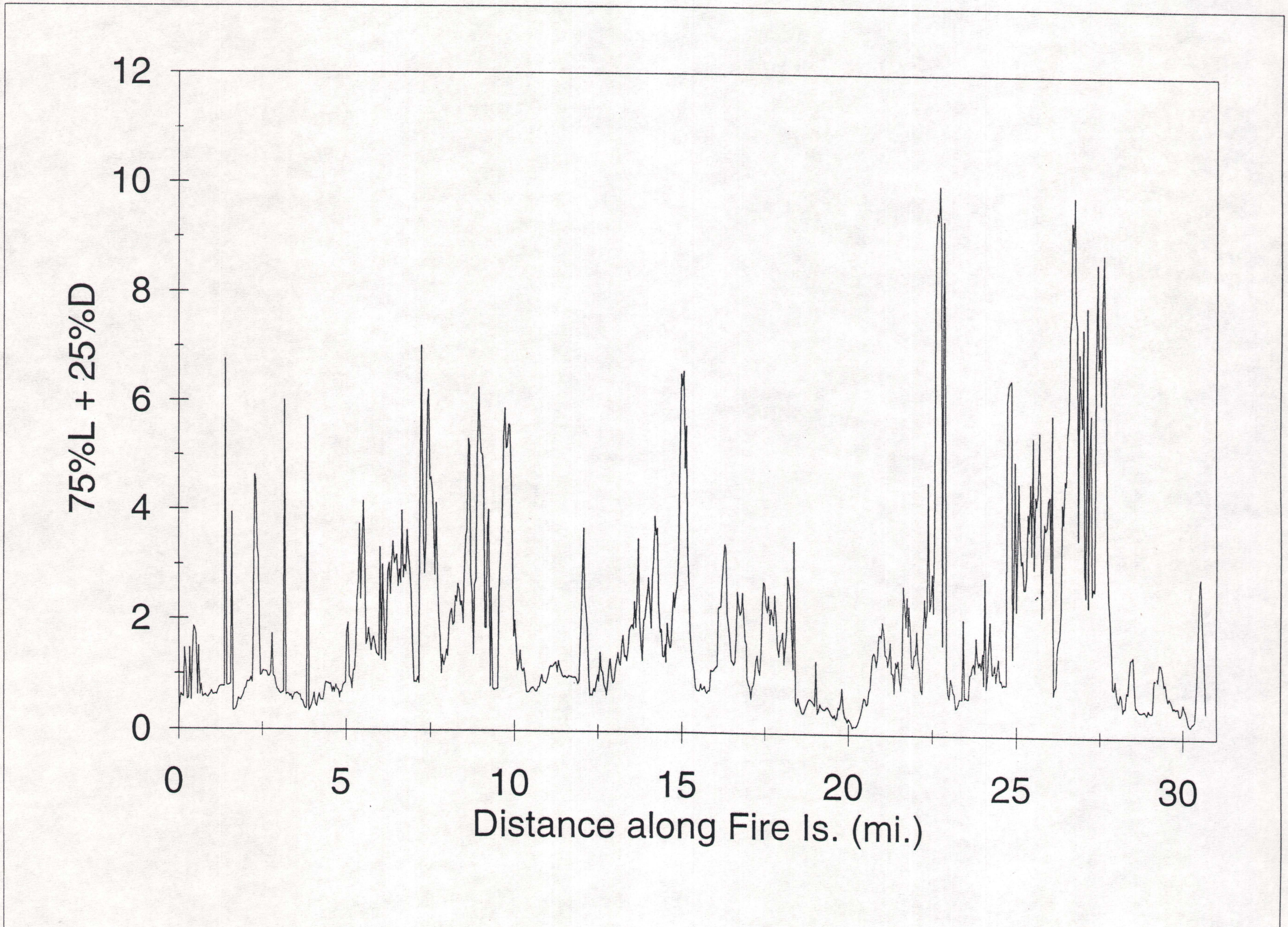


Figure 5c

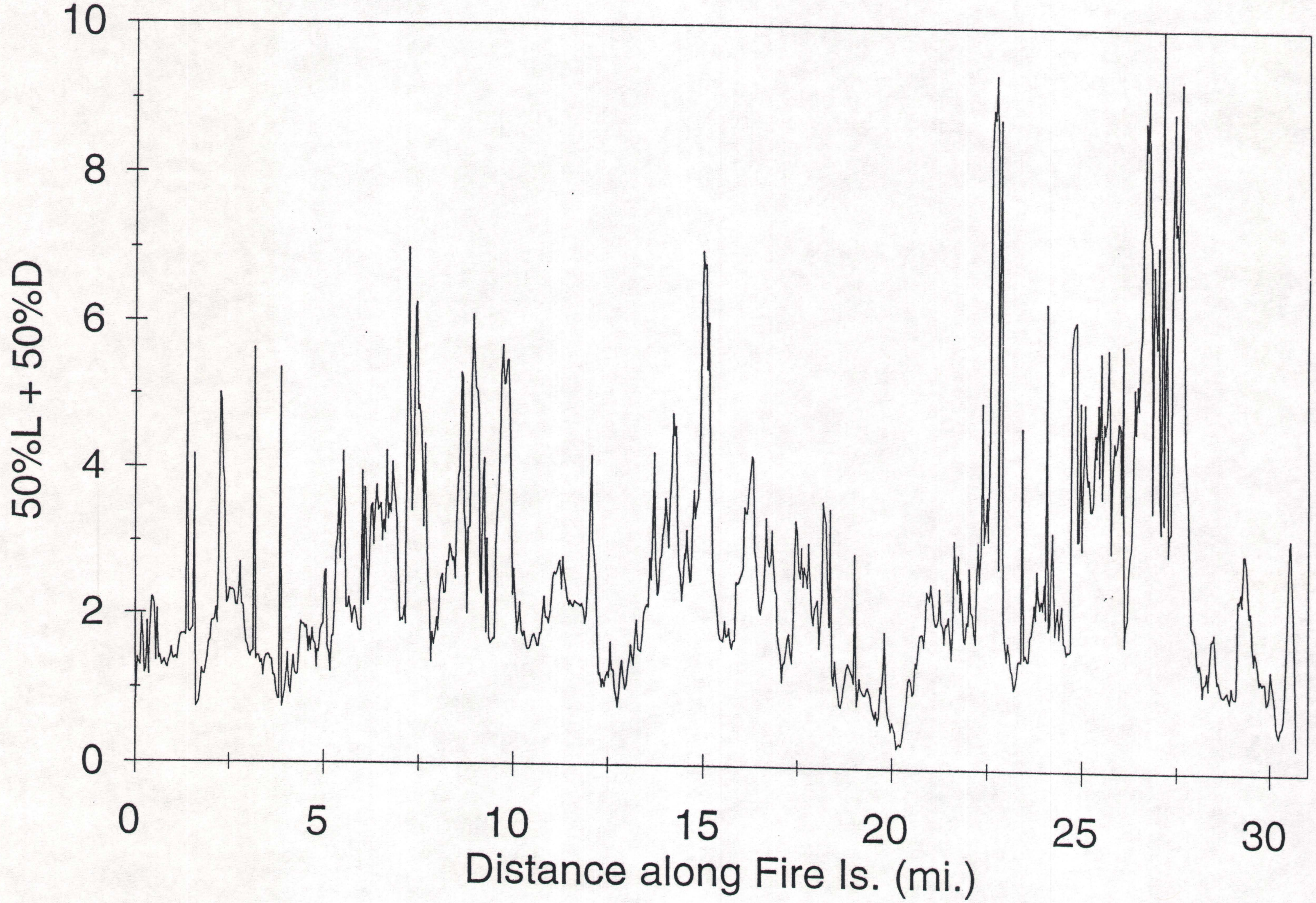


Figure 5d

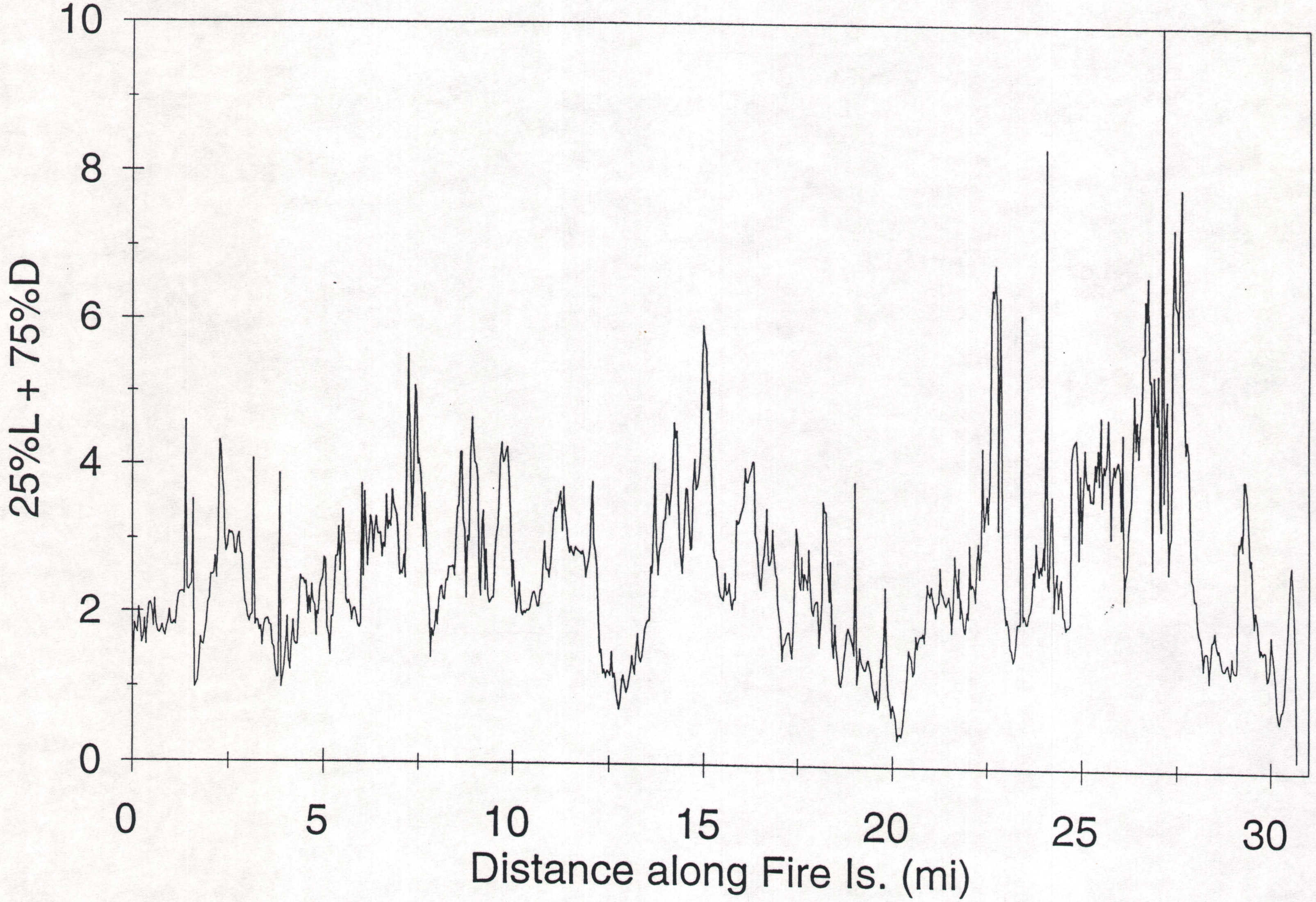
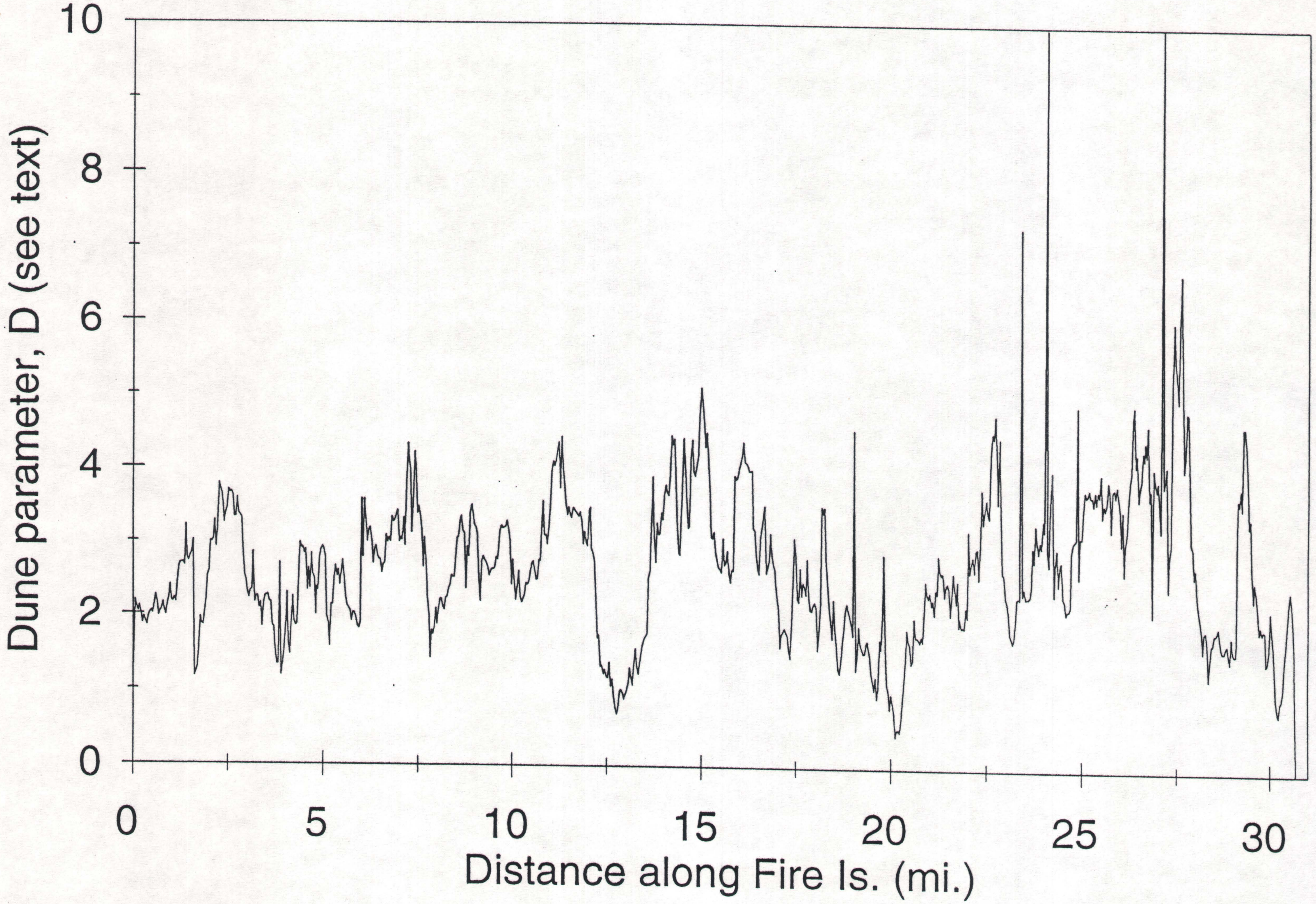


Figure 5e



10
8
6
4
2
0
Dune parameter, D (see text)
0
5
10
15
20
25
30
Distance along Fire Is. (mi.)

Figure 5f

distribution of the following weighted combinations:

b. 100% L

c. 75% L + 25% D

d. 50% L + 50% D

e. 25% L + 75% D

f. 100% D

The dune parameter reaches its highest values east of Old Inlet in Smith Point County Park. The loss index was also highest in this region but not at exactly the same points. An area of the National Seashore east of Watch Hill (between mile points 18.4 and 20.5) has low values both of the loss index and of the dune parameter while the vicinity of Water Island mile point 15.0 and the vicinity of Atlantique and Robbins Rest (between mile points 7.3 and 7.5) both have relatively high values of each number Sailors Haven and the western part of Cherry Grove (between mile points 10.4 and 12.0) did not appear to have undergone substantial dune erosion during the recent storms but have a relatively high rank in terms of the dune parameter. There is a general, positive correlation between the loss index and the dune parameter (Figure 5g), although a few areas where the dune was not scarped during the northeaster of 1992 have high values of the dune parameter (notably the isolated point in the lower right corner of Figure 5g which is east of Old Inlet).

Jones Island. The distribution of dune loss at 200-foot intervals between Jones Inlet and Fire island Inlet is shown in Figure 6. The dune width and dune loss index are shown on Figures 7 and 8 respectively. Damage had been concentrated in

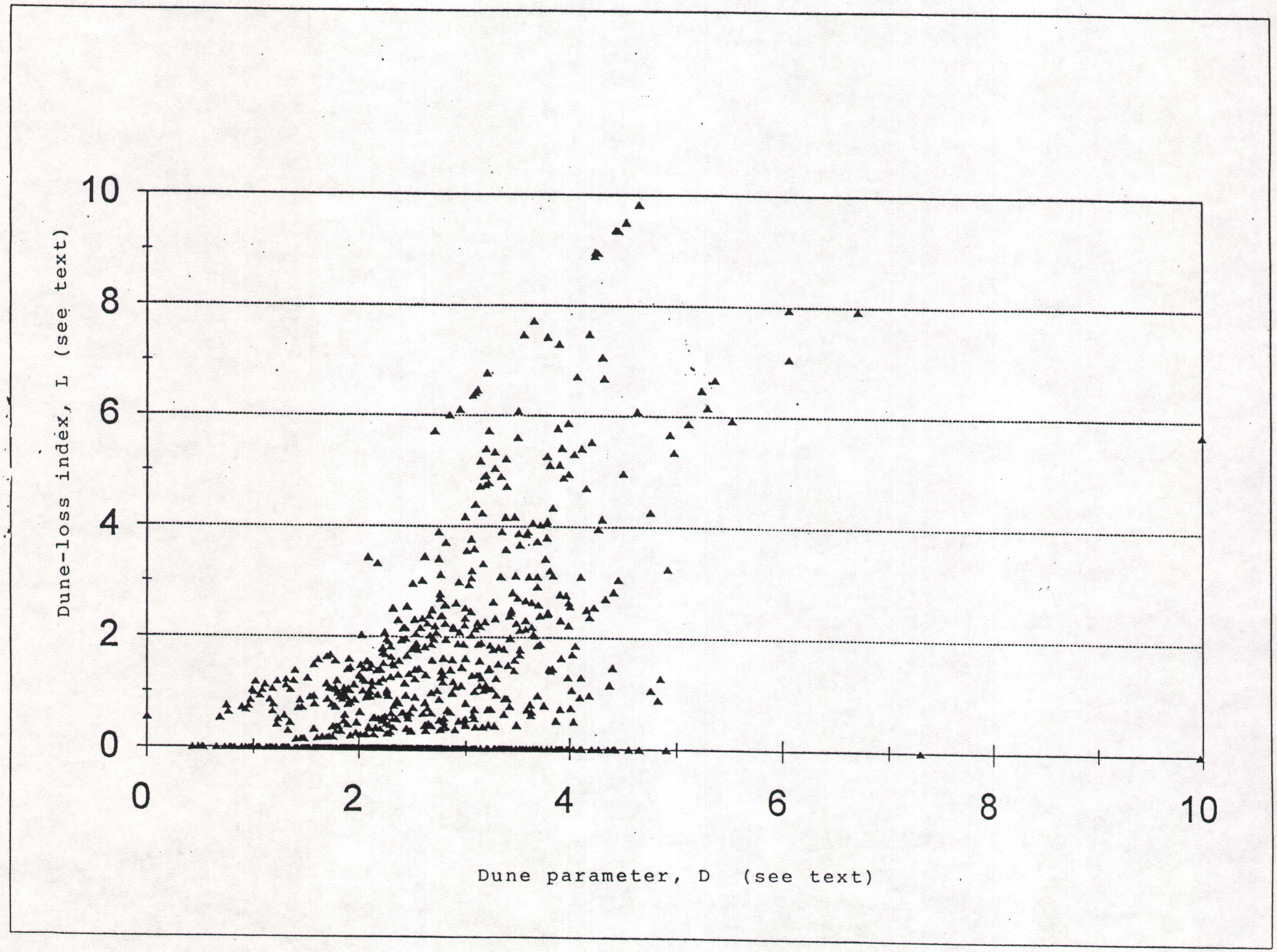
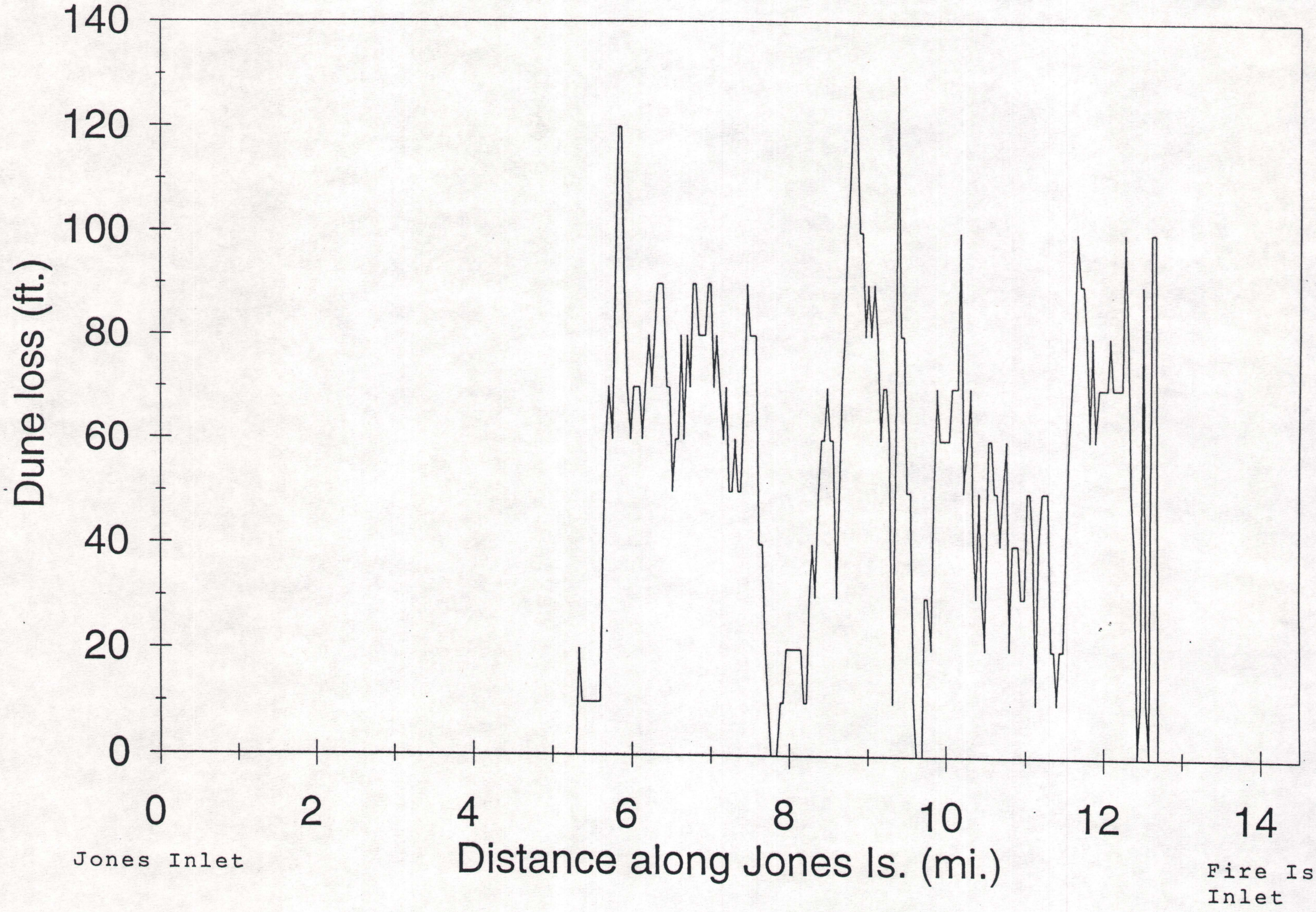

10
8
6
4
2
0
Dune-loss index, L (see text)
0
2
4
6
8
10
Dune parameter, D (see text)

Figure 5g



140
120
100
80
60
40
20
0
Dune loss (ft.)
0
2
4
6
8
10
12
14
Jones Inlet
Distance along Jones Is. (mi.)
Fire Is.
Inlet

Figure 6

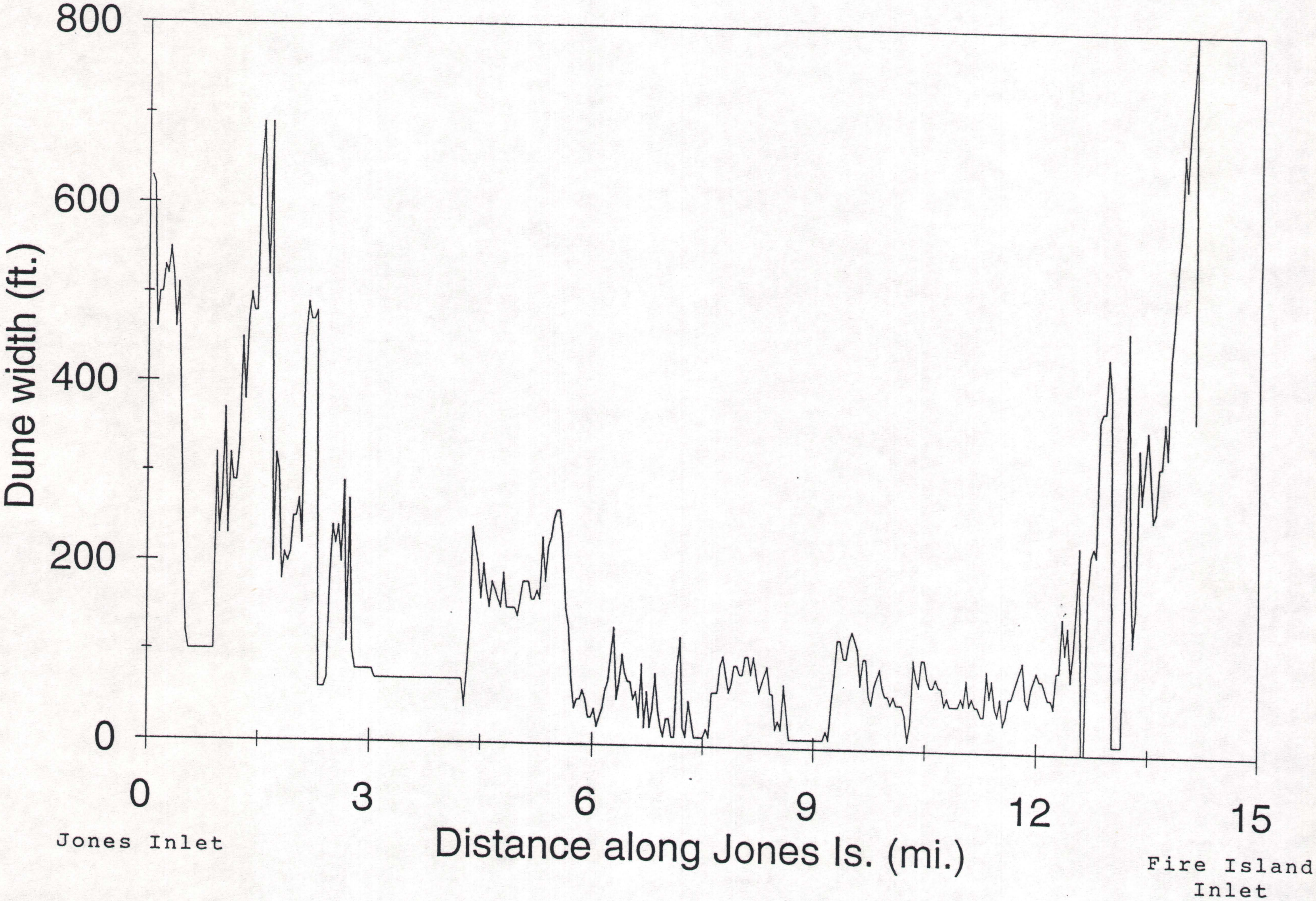
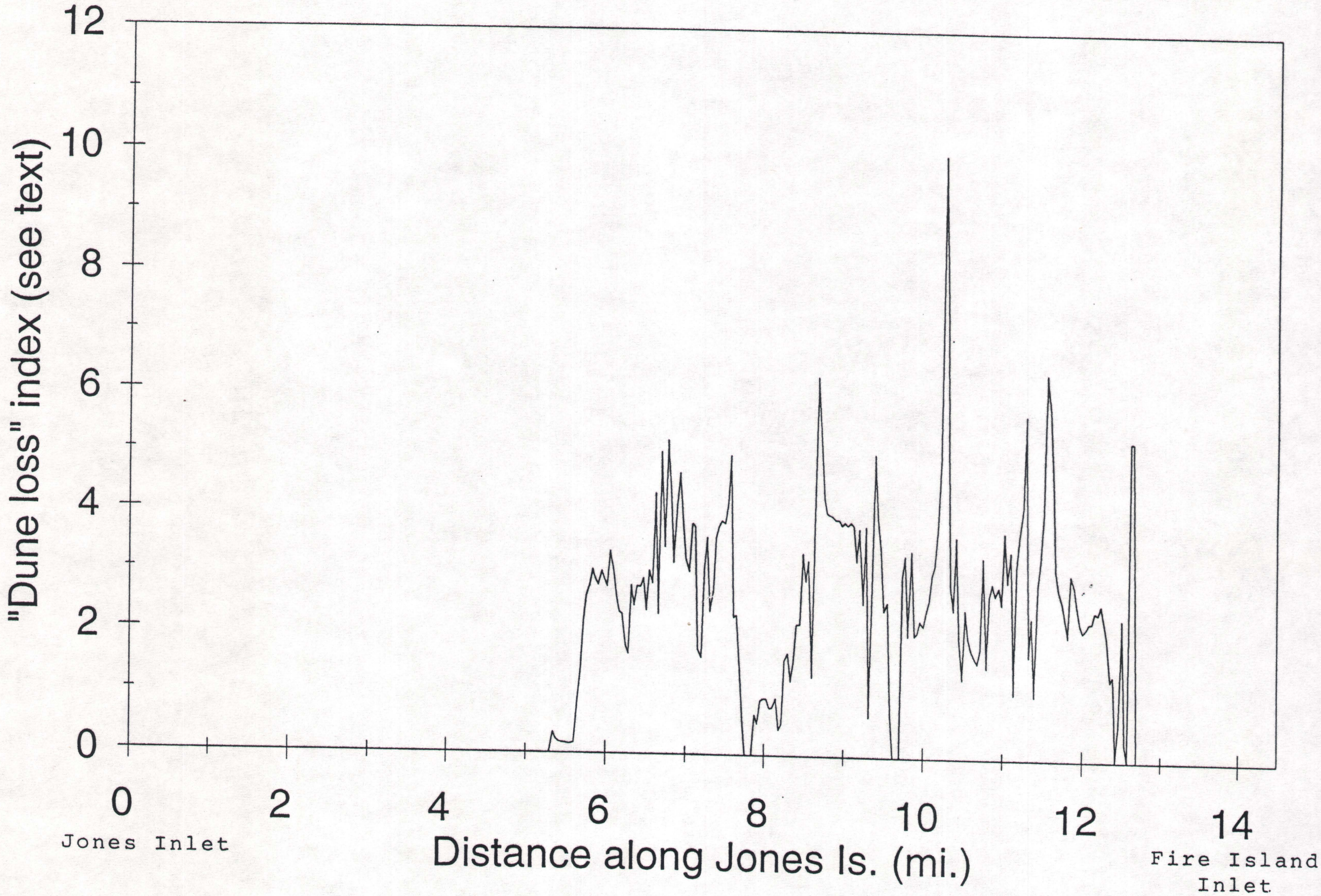

800
600
400
200
0
Dune width (ft.)
0
3
6
9
12
15
Jones Inlet
Distance along Jones Is. (mi.)
Fire Island Inlet

Figure 7



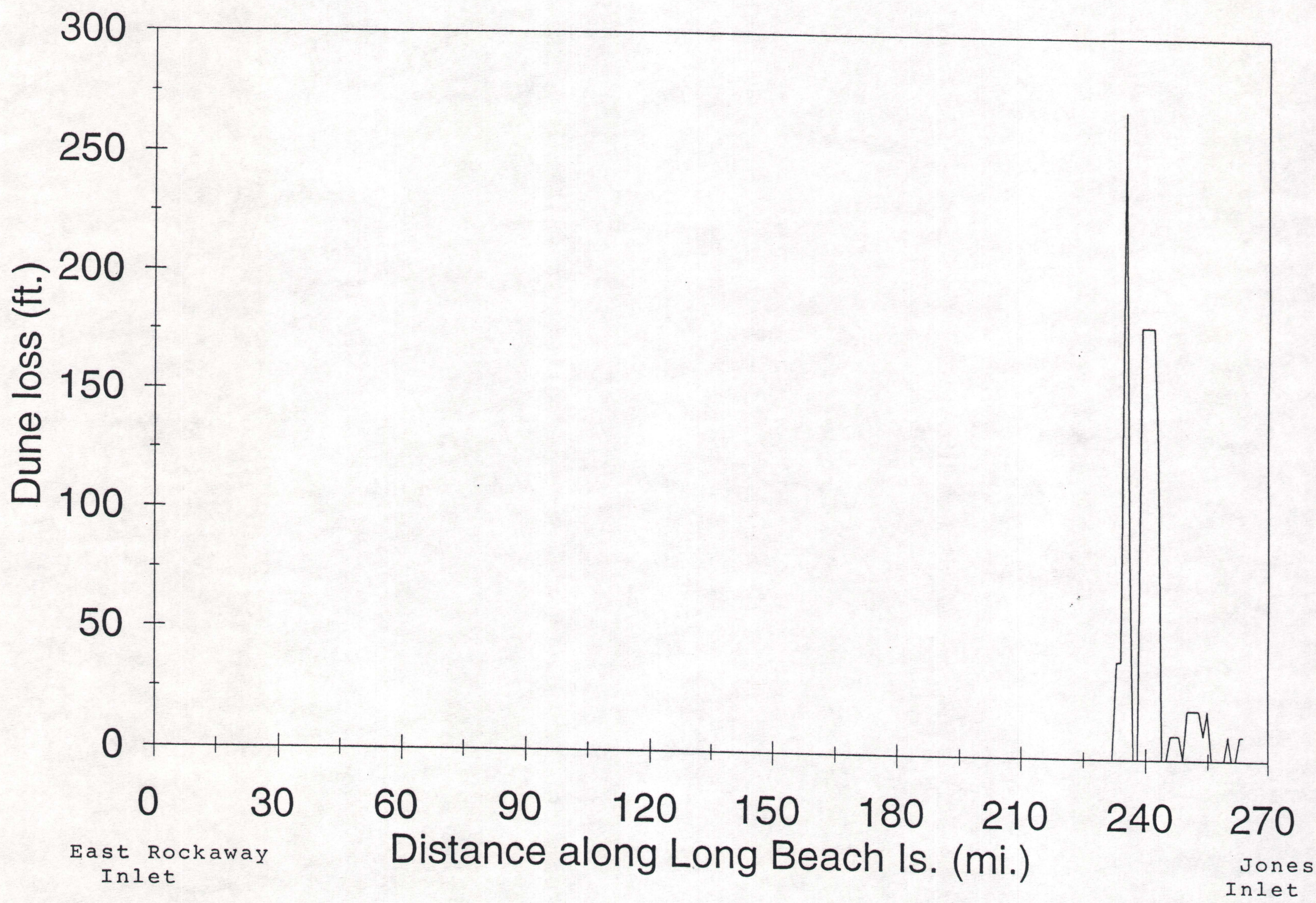
"Dune loss" index (see text)
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
Jones Inlet
Distance along Jones Is. (mi.)
Fire Island Inlet

Figure 8

the eastern half of the island beginning east of the beach at Zacks Bay (mile point 5.3 from Jones Inlet) with the most susceptible areas being located on the strand in front of the bay along Gilgo Beach. Cedar Beach is the easternmost peak on the distribution of the loss parameter (mile point 12.7).

Long Beach. Much of the length of Long Beach is stabilized with a bulkhead covered by a boardwalk so that no losses could be measured from the aerial photographs. Some dune loss could be identified in the extreme eastern stretch of the beach near Point Lookout (Figure 9). Most of the island exceeded 2000 feet in width except in the western third (Figure 10). The dune width (as best as could be determined in the presence of structures) is shown in Figure 11. The index based on dune loss identifies areas in the eastern end only (Figure 12), as susceptible to breaching at the dune line. These parameters, however, cannot identify the occurrence of low dune elevations; without information on dune heights and volume of the subaerial barrier, a complete assessment of susceptibility cannot be done.

Staten Island. The system developed for Fire Island and Jones Island could not be applied to headlands or developed stretches of the coast. Areas that had sustained damage due to erosion could be identified along the Staten Island shore, and beach width provides one indicator for some of these areas. The beach width along the Staten Island coast is shown in Figure 13 and damaged areas were identified as follows:



300
250
200
150
100
50
0
Dune loss (ft.)
0
30
60
90
120
150
180
210
240
270
Distance along Long Beach Is. (mi.)
East Rockaway
Inlet
Jones
Inlet

Figure 9

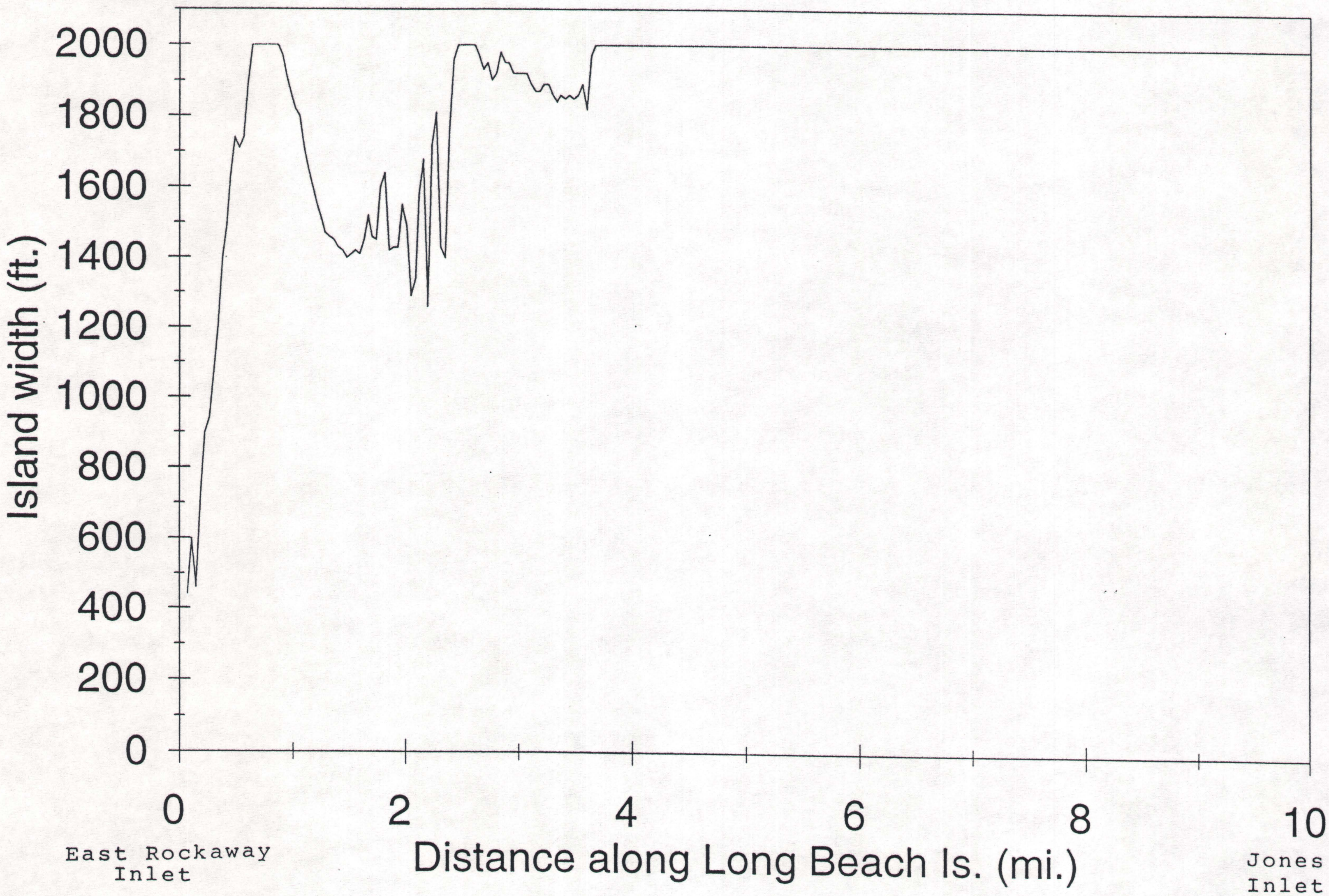
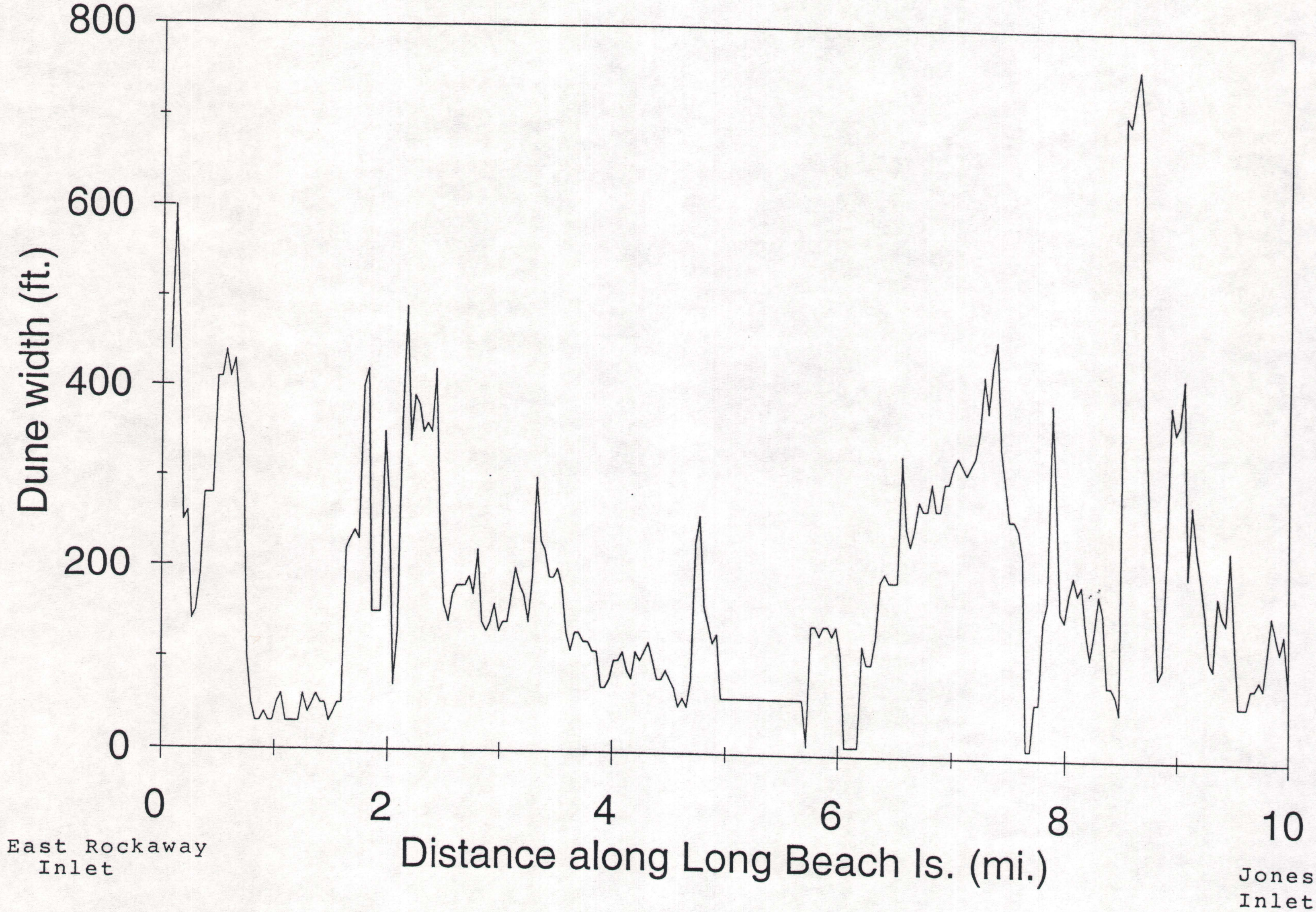

Island width (ft.)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
2
4
6
8
10
East Rockaway Inlet
Distance along Long Beach Is. (mi.)
Jones Inlet

Figure 10



800
600
400
200
0
Dune width (ft.)
0
2
4
6
8
10
East Rockaway
Inlet
Distance along Long Beach Is. (mi.)
Jones
Inlet

Figure 11

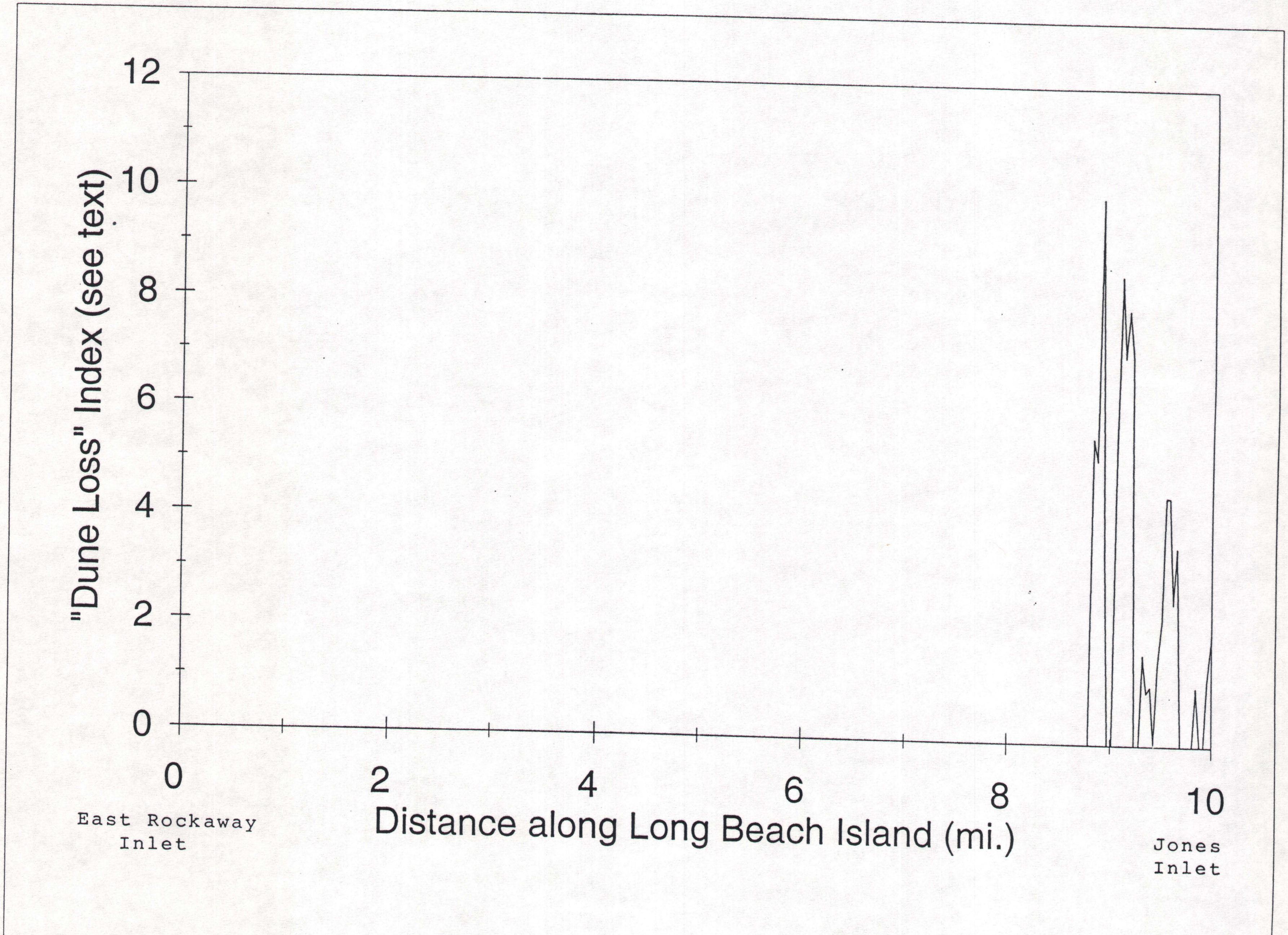

"Dune Loss" Index (see text)
12
10
8
6
4
2
0
0
2
4
6
8
10
East Rockaway Inlet
Distance along Long Beach Island (mi.)
Jones Inlet

Figure 12

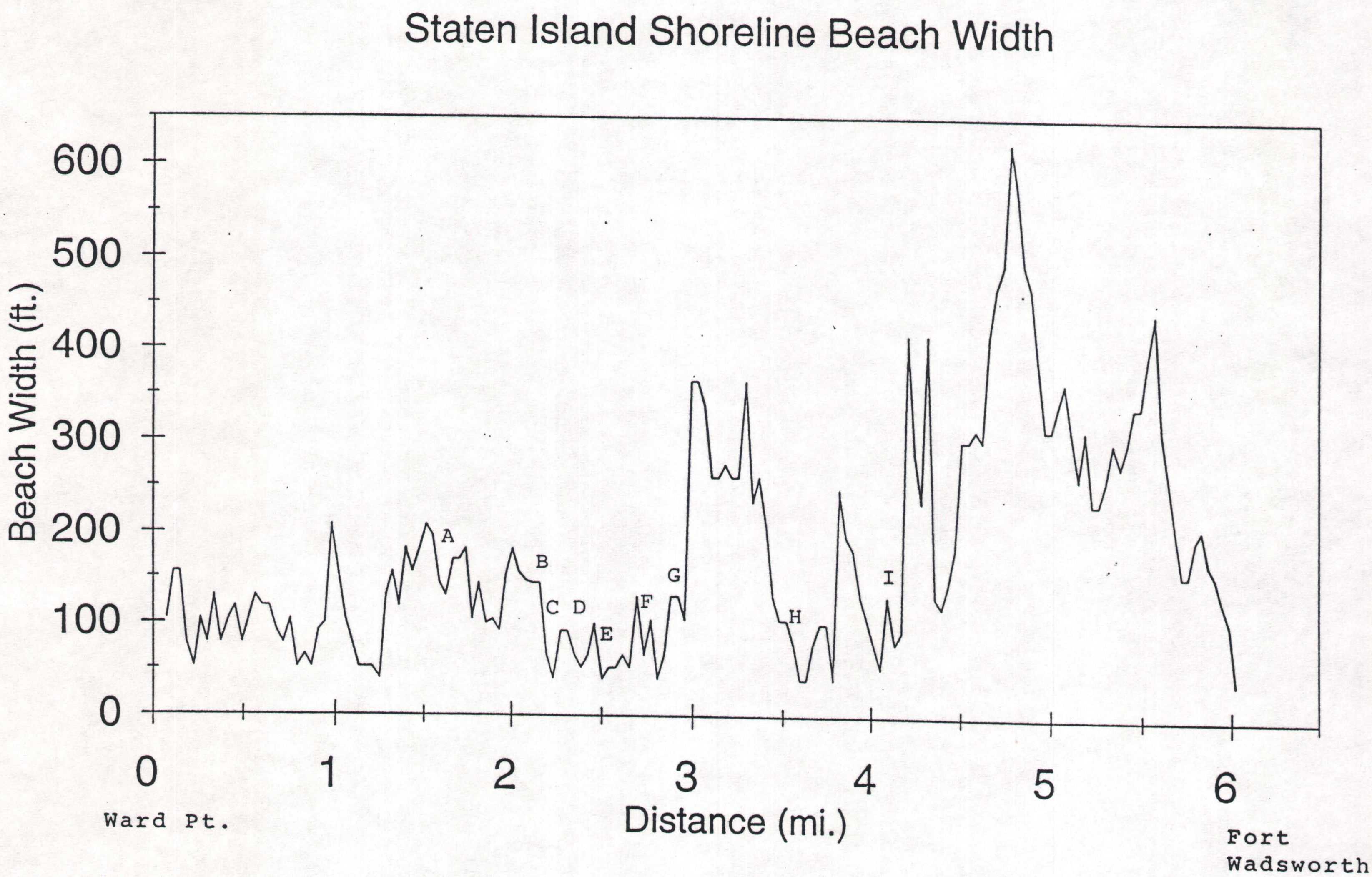

Staten Island Shoreline Beach Width
Beach Width (ft.)
600
500
400
300
200
100
0
A
B
C
D
E
F
G
H
I
0
1
2
3
4
5
6
Ward Pt.
Distance (mi.)
Fort Wadsworth

Figure 13

Letter Indicated on Figure 13	Description
A	Possible breach, lake threatened (Wolf's Pond)
B	Structures threatened (Arbutus Lake)
C	Structures threatened along with adjacent lake threatened by possible breach (Paillor Ave.)
D	Narrow beach, shoreline structures threatened (Barclay Ave.)
E	Narrow beach, infrastructure threatened (Wakefield Ave.)
F	Narrow beach, shoreline structures threatened (Arden Ave.)
G	Point of land susceptible to undercutting by storm seas, shoreline structures threatened (Richmond Ave)
H	Beach undercut, large buildings possibly threatened (Great Kills Recreational Area Parking Field)
I	Narrow beach, shorefront structures threatened Cedar Grove Beach)

These are not relative rankings but subjective choices.

Westhampton. Between Shinnecock and Moriches Inlet, the dune width reflects the general pattern of erosion susceptibility. The dune has been washed out between Pikes Beach (mile point 5.5 from Moriches Inlet or distance interval 145) and the former Little Pikes Inlet (mile point 3.2 or distance interval 85) just west of the westernmost groin. The dune widths are relatively large within the groin field and decrease fairly steadily to the east (Figure 14). The losses in the western half of this stretch are confined to the area both east and west of the groin field (Figure 15) and the dune-loss index identifies the obvious problems west of the groin field and near Shinnecock Inlet with

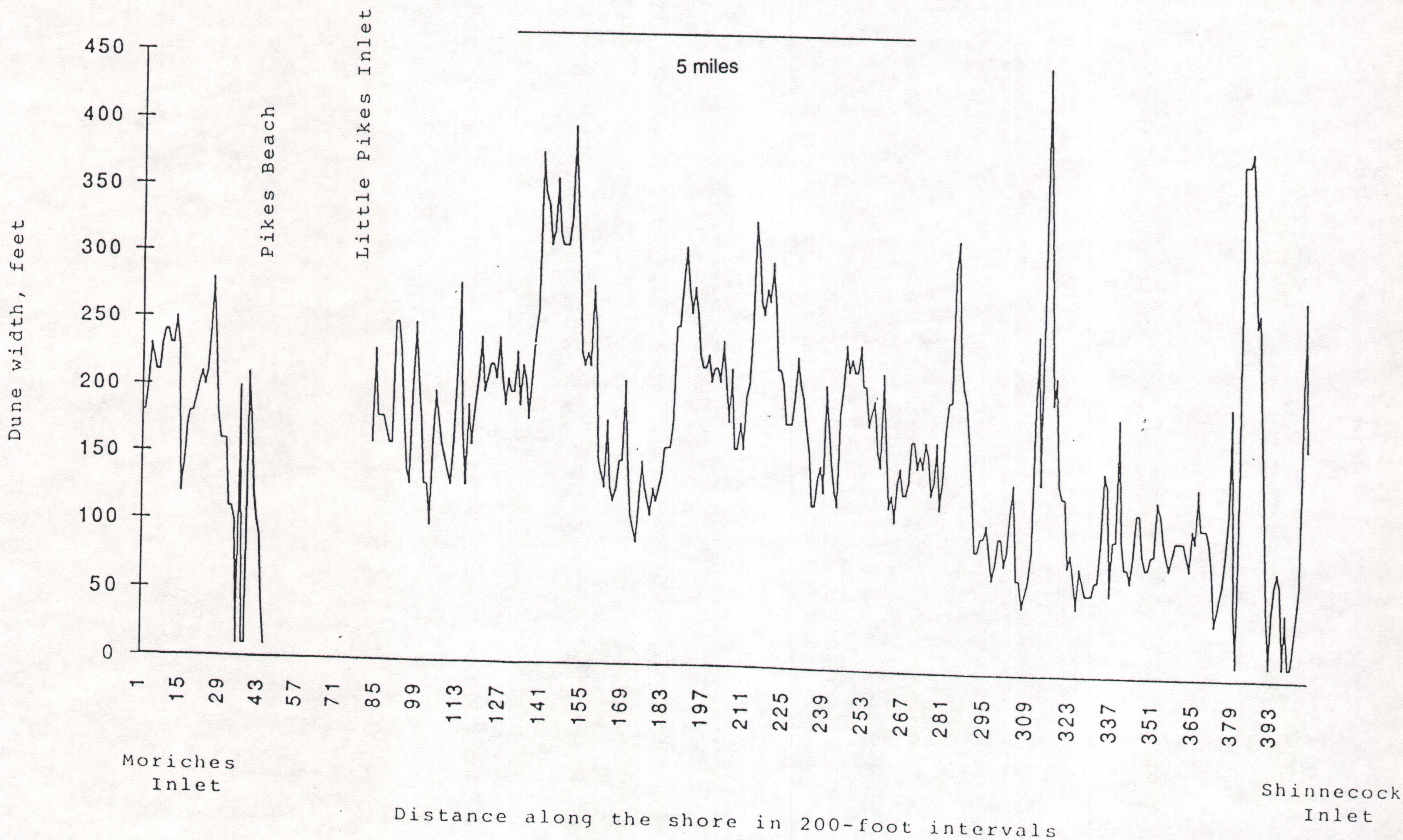

Dune width, feet
450
400
350
300
250
200
150
100
50
0
Pikes Beach
Little Pikes Inlet
5 miles
1
15
29
43
57
71
85
99
113
127
141
155
169
183
197
211
225
239
253
267
281
295
309
323
337
351
365
379
393
Moriches Inlet
Shinnecock Inlet
Distance along the shore in 200-foot intervals

Figure 14

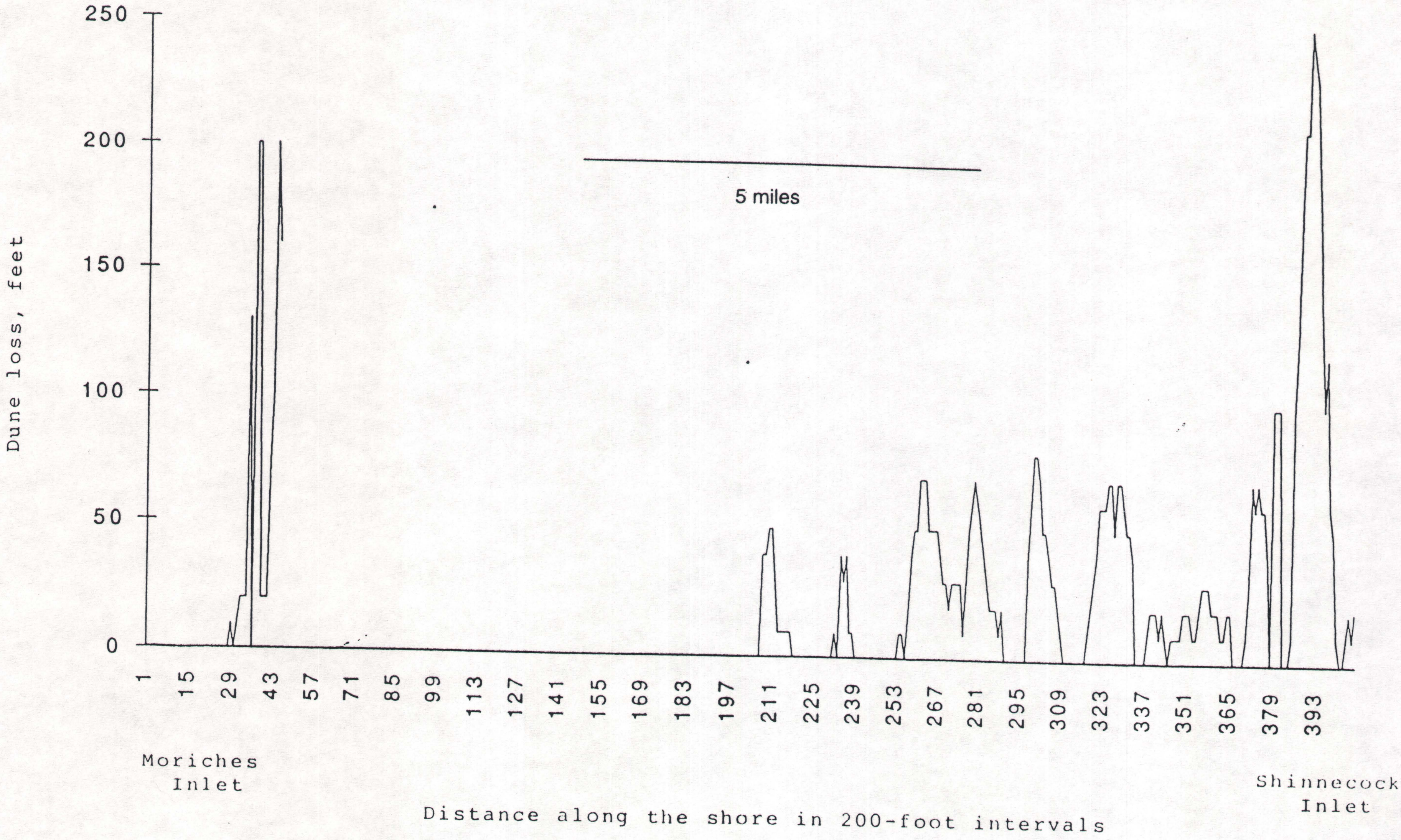

250
200
150
100
50
0
Dune loss, feet
5 miles
1
15
29
43
57
71
85
99
113
127
141
155
169
183
197
211
225
239
253
267
281
295
309
323
337
351
365
379
393
Moriches Inlet
Shinnecock Inlet
Distance along the shore in 200-foot intervals

Figure 15

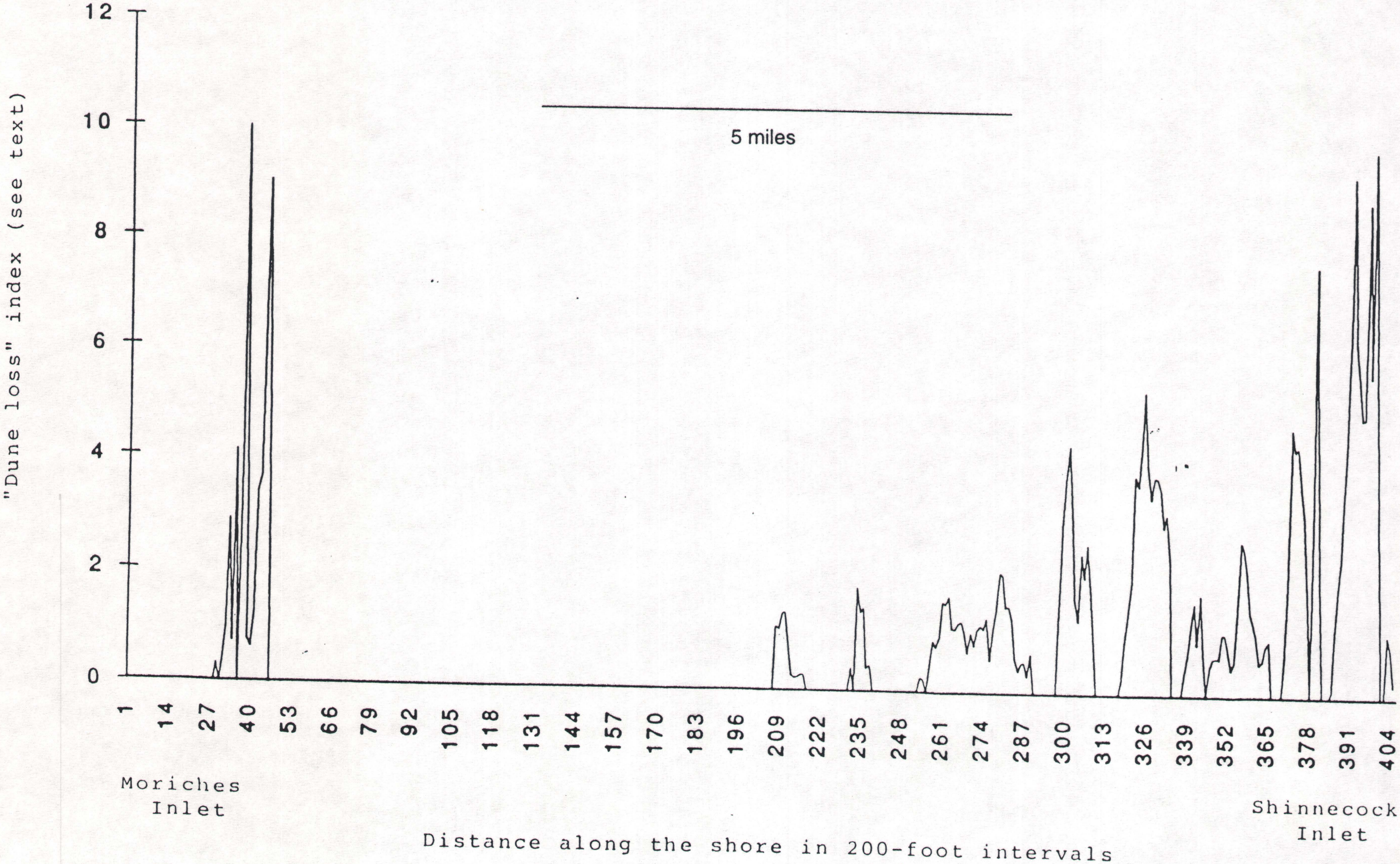
an irregular and decreasing risk from Shinnecock Inlet to the eastern edge of the groin field (Figure 16).

The Headland Beaches. East of Shinnecock Inlet, the barrier island joins the mainland. In this section, the loss index was calculated to a maximum island width of 2000 feet after which, or along the headland, the denominator was set to unity.

The dune width decreases fairly steadily from Shinnecock Inlet about 4 miles eastwardly (Figure 17). The width begins to widen again in the Town of East Hampton, reaching a local maximum east of Amagansett (Figure 18). The losses along this stretch of shoreline was distributed in spot erosion (Figures 19 and 20) with the most serious losses being found in Southampton (mile point 7.8 from the western boundary of the Town of East Hampton) and in East Hampton immediately to the west of Indian Well Rd. Since the width of the island ceases to be a relevant parameter in along the headland coast, the dune-loss index reduces to the percentage of dune width reduction. From the Town of East Hampton eastwardly, the loss index is high in isolated areas west of Georgica Pond and the losses generally lessen further to the east (Figure 21).

Discussion

The parameters explored here are promising as a screening tool for the barrier island section of New York's ocean coast. They could be updated fairly rapidly from aerial photographs and refined empirically as more cases are examined. To extend this system, however, evaluations of the subaerial beach would be



"Dune loss" index (see text)
12
10
8
6
4
2
0
5 miles
1
14
27
40
53
66
79
92
105
118
131
144
157
170
183
196
209
222
235
248
261
274
287
300
313
326
339
352
365
378
391
404
Moriches Inlet
Shinnecock Inlet
Distance along the shore in 200-foot intervals

Figure 16

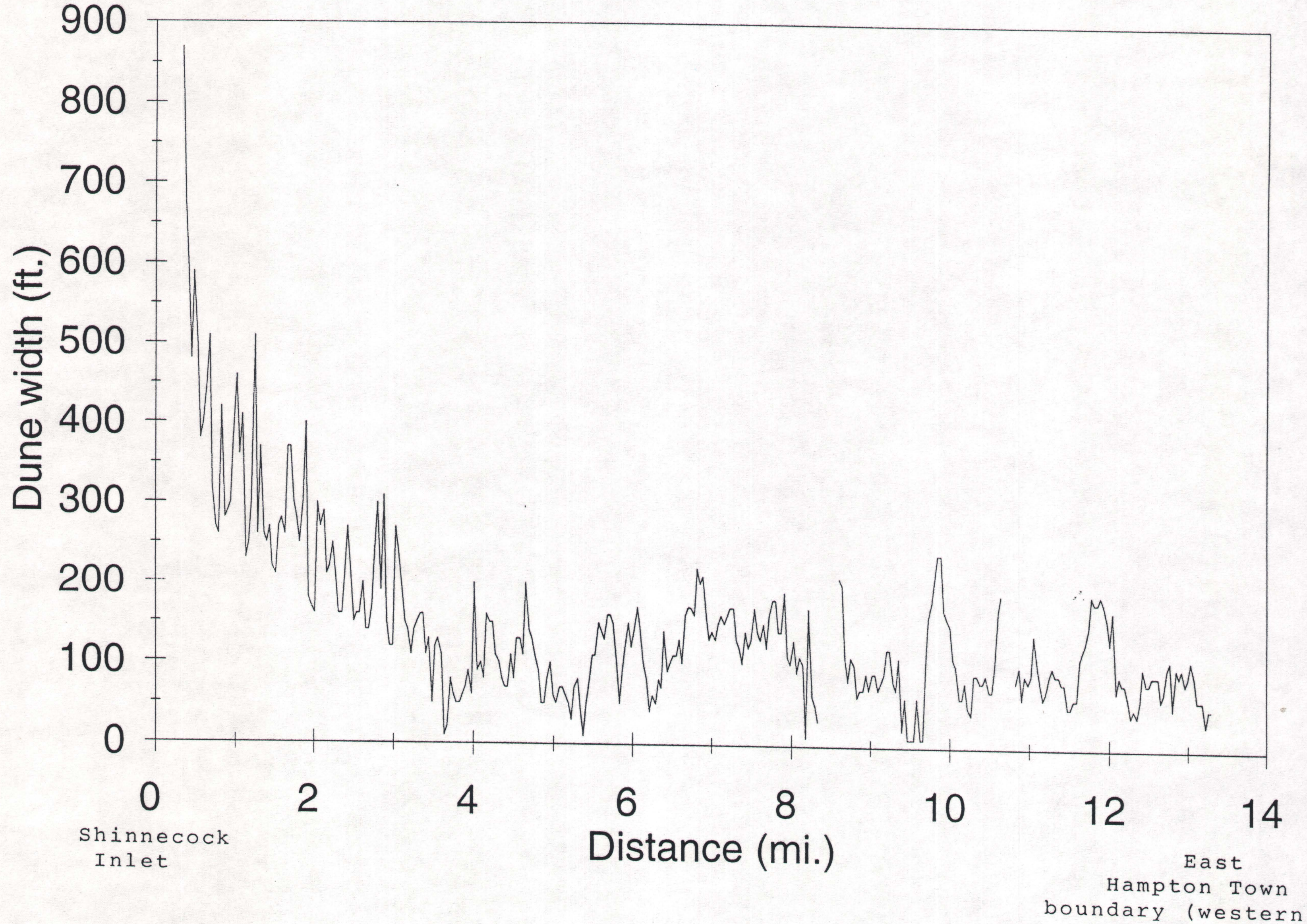

900
800
700
600
500
400
300
200
100
0
Dune width (ft.)
0
2
4
6
8
10
12
14
Distance (mi.)
Shinnecock
Inlet
East
Hampton Town
boundary (western)

Figure 17

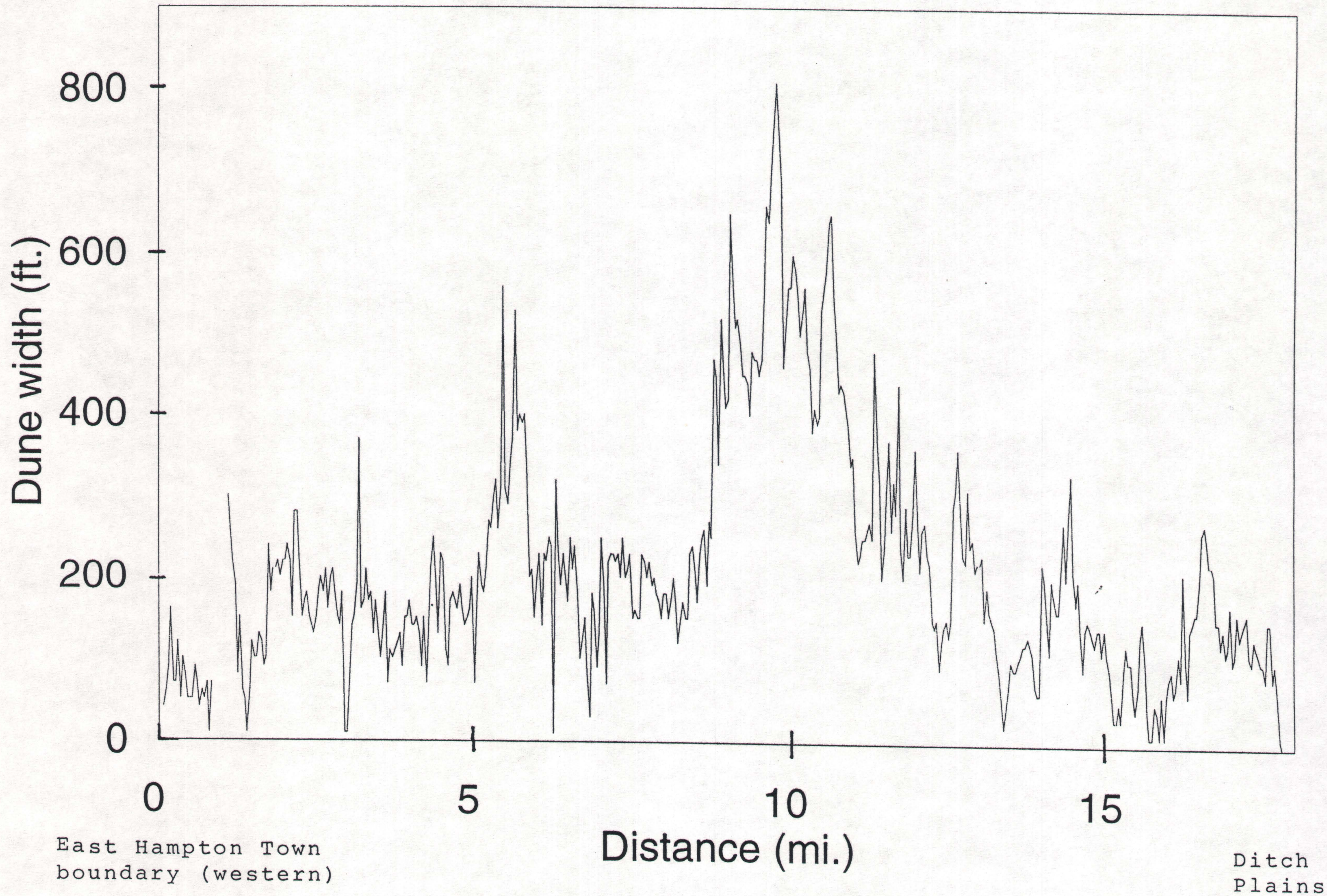
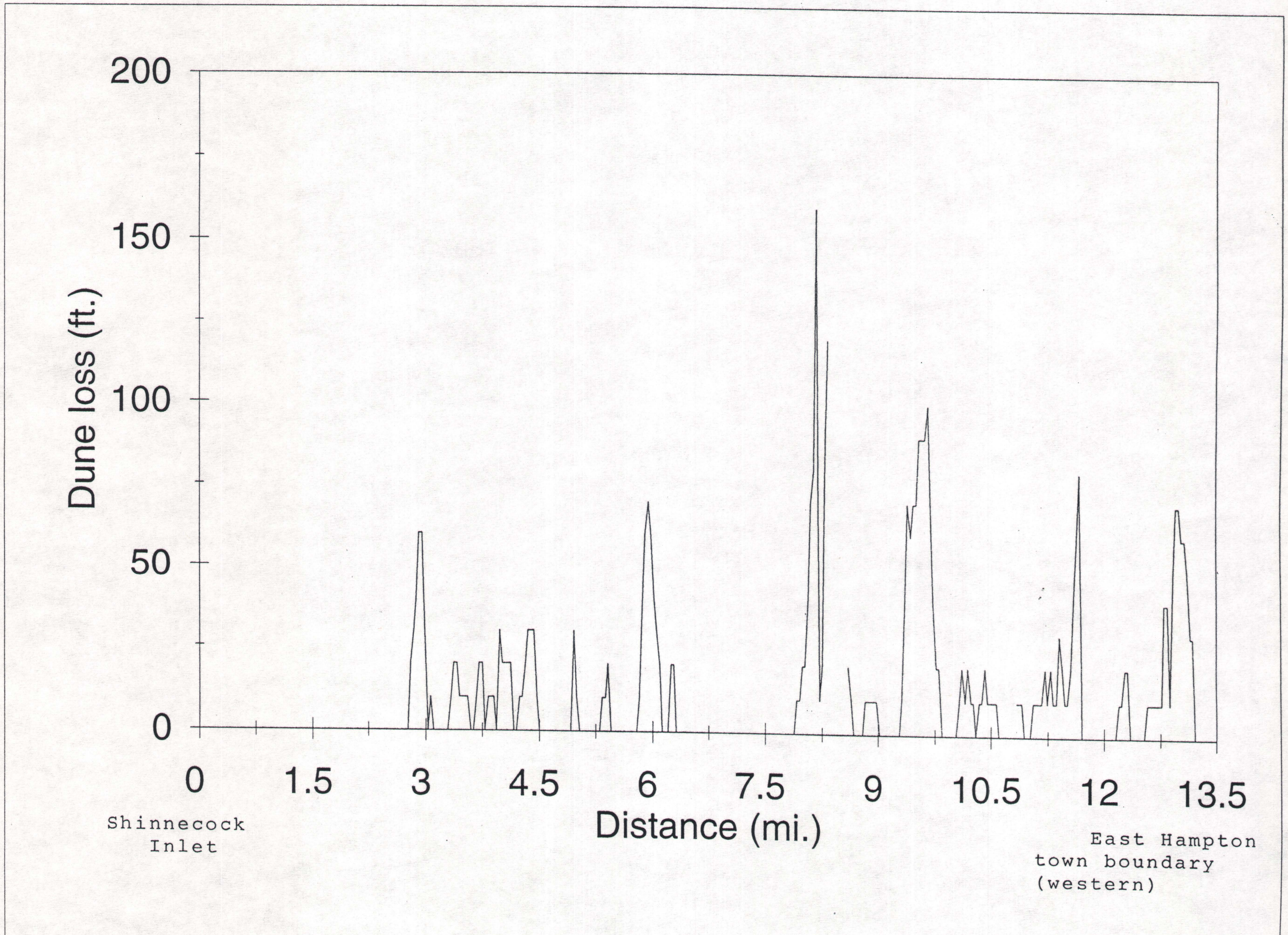
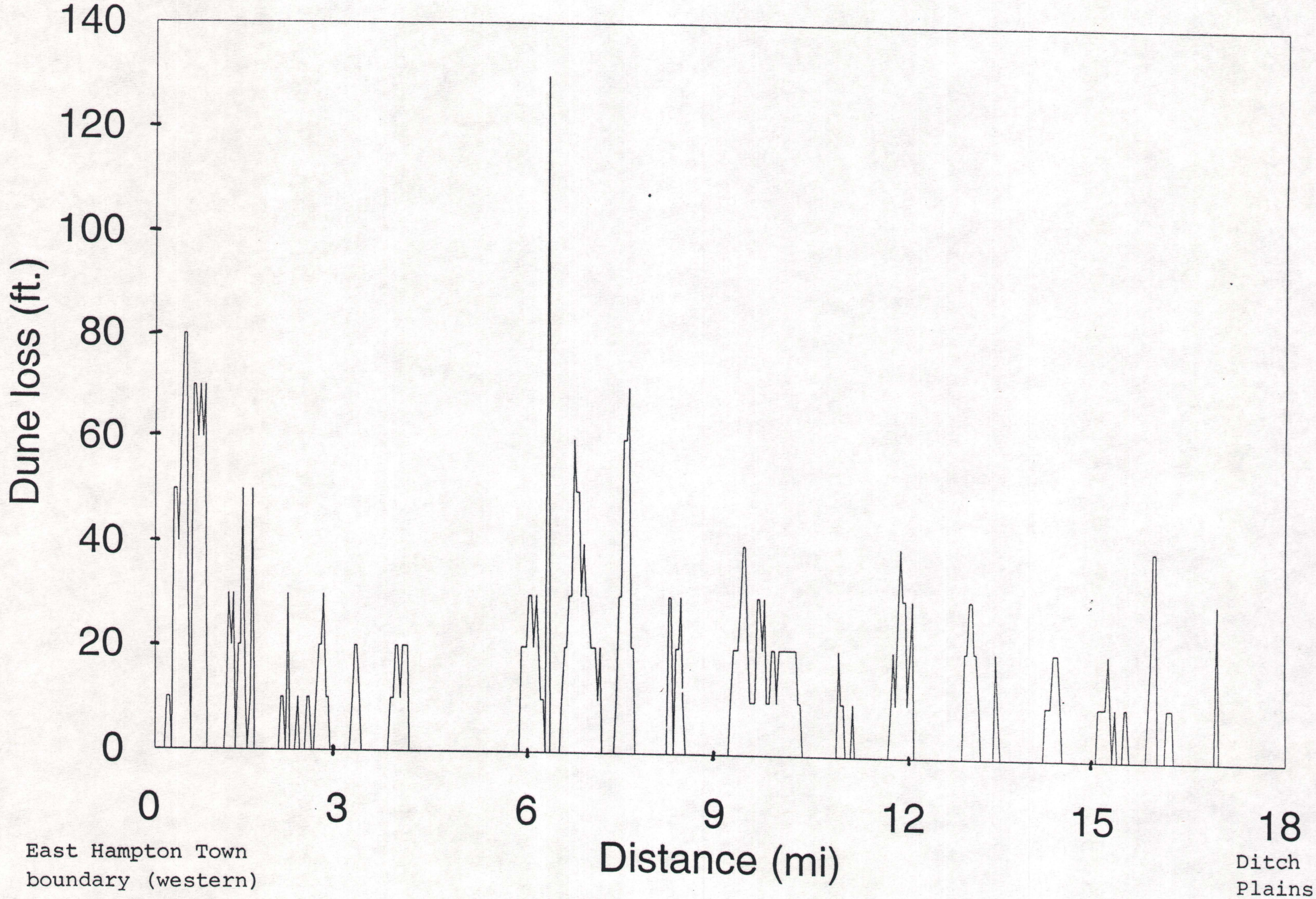

800
600
400
200
0
Dune width (ft.)
0
5
10
15
Distance (mi.)
East Hampton Town
boundary (western)
Ditch
Plains

Figure 18



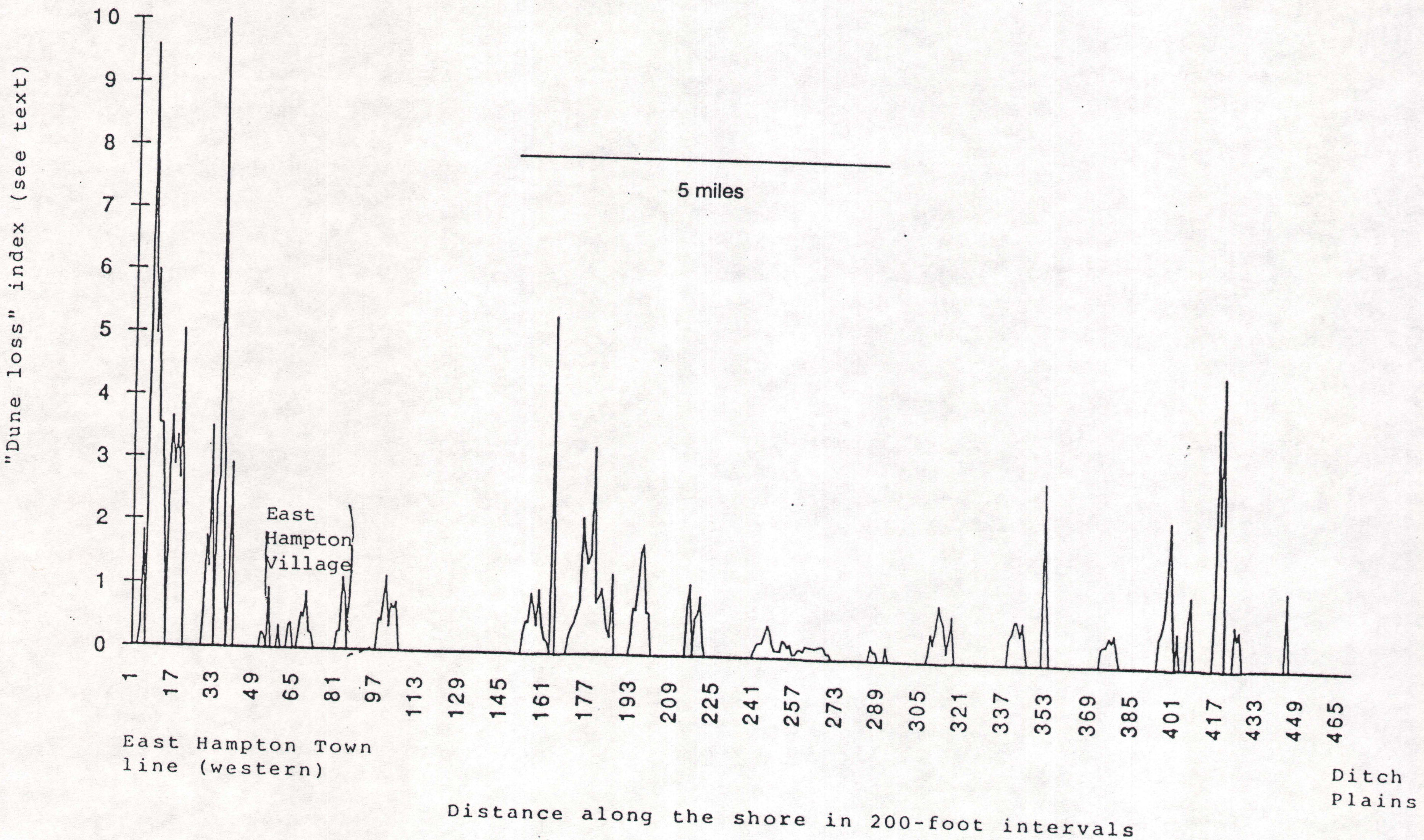
Dune loss (ft.)
200
150
100
50
0
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
Distance (mi.)
Shinnecock Inlet
East Hampton town boundary (western)

Figure 19



140
120
100
80
60
40
20
0
Dune loss (ft.)
0
3
6
9
12
15
18
Distance (mi)
East Hampton Town
boundary (western)
Ditch
Plains

Figure 20



10
9
8
7
6
5
4
3
2
1
0
"Dune loss" index (see text)
5 miles
East
Hampton
Village
1
17
33
49
65
81
97
113
129
145
161
177
193
209
225
241
257
273
289
305
321
337
353
369
385
401
417
433
449
465
East Hampton Town
line (western)
Ditch
Plains
Distance along the shore in 200-foot intervals

Figure 21

needed. In principle, these could be determined from stereo pairs of aerial photographs using a parallax bar but preliminary trials did not give sufficient resolution to be encouraging. Cross-sections produced by ground surveys would seem to be most useful.

To calculate the volume of sand needed to restore erosional losses, for example, the dune loss for each 200-foot interval would need to be multiplied by an estimate of the thickness of the sand layer represented by the loss. From experience, a value of 5-feet would seem to be a reasonable one but true values can only be determined by measurements of elevations.

Another parameter that could be incorporated into an assessment of risk is the volume of sand present in any cross-section of the island. The total, subaerial, cross-sectional volume per unit length of shoreline could be normalized to one-half of the product of maximum dune height and the island width at the section. If the normalized volume is less than one, the island profile is deflated and more susceptible to breaching than an area with the same dune height and island width but with a greater volume of sand in its cross-section.