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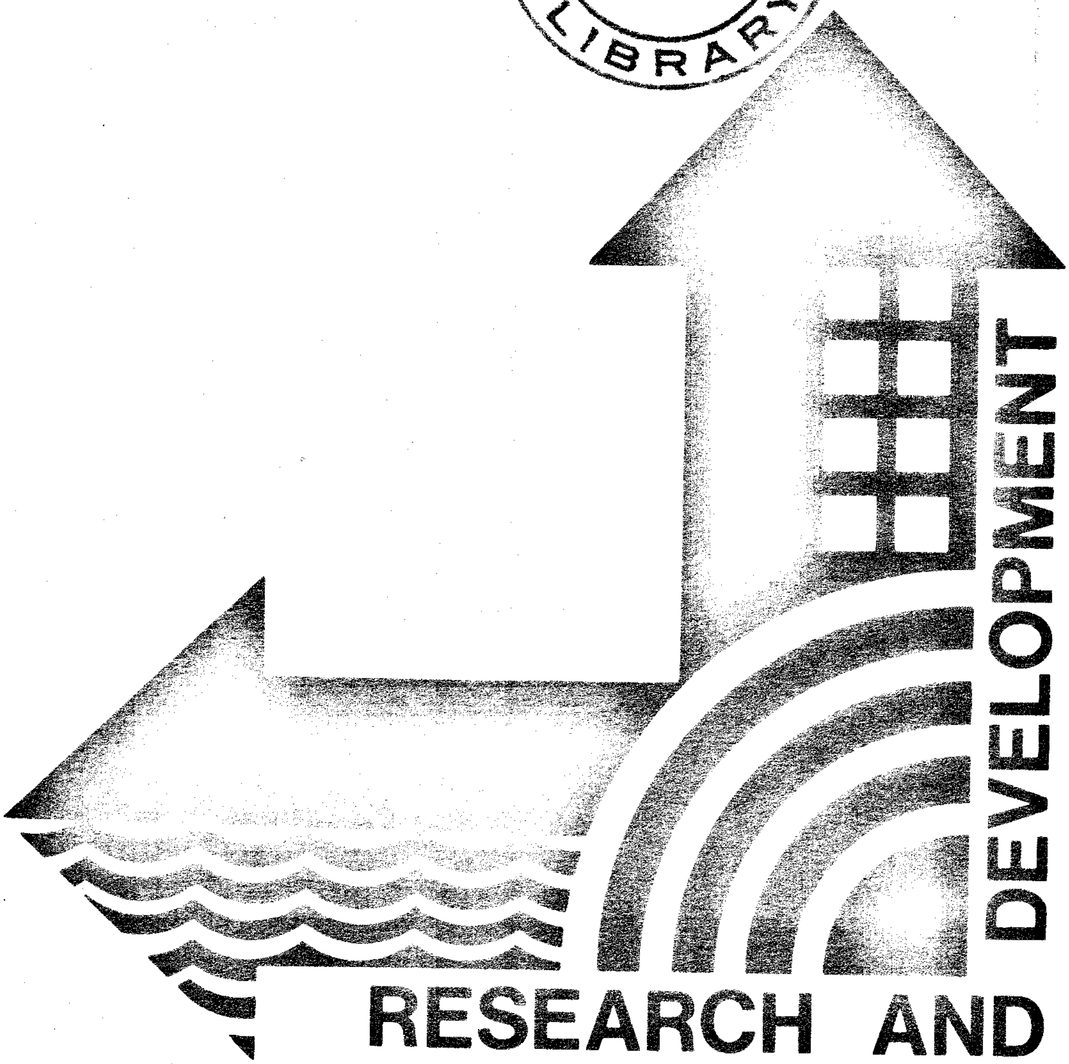
COASTAL RESPONSE AT POINT PELEE

LAKE ERIE

J. R. SHAW



OCEAN AND AQUATIC SCIENCES
CENTRAL REGION
CANADA CENTRE FOR INLAND WATERS
BURLINGTON, ONTARIO

COASTAL RESPONSE

AT

POINT PELEE - LAKE ERIE

by

J.R. SHAW

MANUSCRIPT REPORT SERIES NO. 4

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ABSTRACT

Concern for the effects of offshore dredging on the stability of the Point Pelee shoreline has led to this study. Its objective was to provide a quantitative assessment of the short-term changes in beach, nearshore, and offshore profiles of the Point. The study supplements the existing information base on the physical processes at Point Pelee with an objective account of annual erosion rates which will be useful in determining effective management strategies.

Nineteen profile sites were surveyed on a continuous basis during the spring through fall months of 1974-1975. Measurements of waves and bottom currents were also taken during select intervals of the survey period for further interpretation of the coastal processes.

It was found that, in quantitative terms, the east beach of Point Pelee is receding at five times the rate at which the west beach is advancing. Furthermore, the greatest amount of beach erosion occurred during the winter months. Despite the greater magnitudes and variability of beach response on the east side, the west beach evidenced the higher rates of erosion and deposition. The 1974-1975 annual sediment budget for Point Pelee showed a substantial net gain, largely in the offshore zone south of the Point.

It was concluded from profile, sediment, and current data analysis that surface sediments to the south of Point Pelee (in the area designated for dredging) may at certain times be a potential source of nearshore and beach replenishment.

ACKNOWLEDGMENTS

There have been a number of people who have contributed a great deal to the preparation of this report. For his encouragement, patience, and generous contributions of time and constructive criticism, I am indebted to Mr. W.S. Haras, Head, Shore Properties Studies, Ocean and Aquatic Sciences, Fisheries and Environment Canada. I would also like to thank Mr. N.G. Freeman, Chief, Research and Development Division, Ocean and Aquatic Sciences, Fisheries and Environment Canada, and Dr. S.B. McCann, Department of Geography, McMaster University, for their constructive criticism and guidance during the entirety of the report.

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The interest and support of Parks Canada in this study, particularly that of Mr. K. East, is gratefully acknowledged.

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CHAPTER 1

1.0 INTRODUCTION

Point Pelee, located as shown in Figure 1.1, is a partially inundated peninsula extending sixteen kilometres into the shallow waters of Lake Erie. With a wide range of transitional and successional environs and owing partly to the fact that it is the southernmost part of mainland Canada, Point Pelee is capable of satisfying habitat preferences for a vast number of floral and faunal communities not found elsewhere in Canada. Recent records published by Parks Canada indicate observations of more than 700 species of plants and 331 species of birds since Point Pelee was established as a National Park on June 5, 1918.

Concern of the biological sensitivity of this area is evidenced by the strict enforcement of Park policy concerning restrictions on camping, hunting, fishing, boating, and vehicular movement within its boundaries. The integrity of Point Pelee ecology, however, is now being threatened by accelerated rates of erosion to the protective beach ridge along the east shoreline. Again, the impact of man's intervention into the natural processes is under suspicion as, three kilometres to the south of Point Pelee, offshore sand and gravel deposits are being dredged at an average rate of 160,000 m^3/yr.

Records indicate that the subaqueous deposits have been tapped commercially in the vicinity of Point Pelee at least since 1914 (DPW Rpt. #2913, 1917) and more recently on a continual basis from 1943 (OMNR records). In geographical terms, the removal of material from the sediment budget constitutes an outflow, or what is commonly termed a 'sink'. If the sink created by the dredging process is substantial, it is conceivable that the effects would be reflected in alterations to the nature and magnitude of beach response. The east side of Point Pelee, in particular, appears to be most susceptible to large-scale changes in beach profile, as recent evidence of breaching now threatens the ecological balance of the low-lying marsh hinterland.

The question of the interrelationship of the dredging process and coastal dynamics at Point Pelee is complex and has been a source of unresolved dispute since the beginning of commercial aggregate production

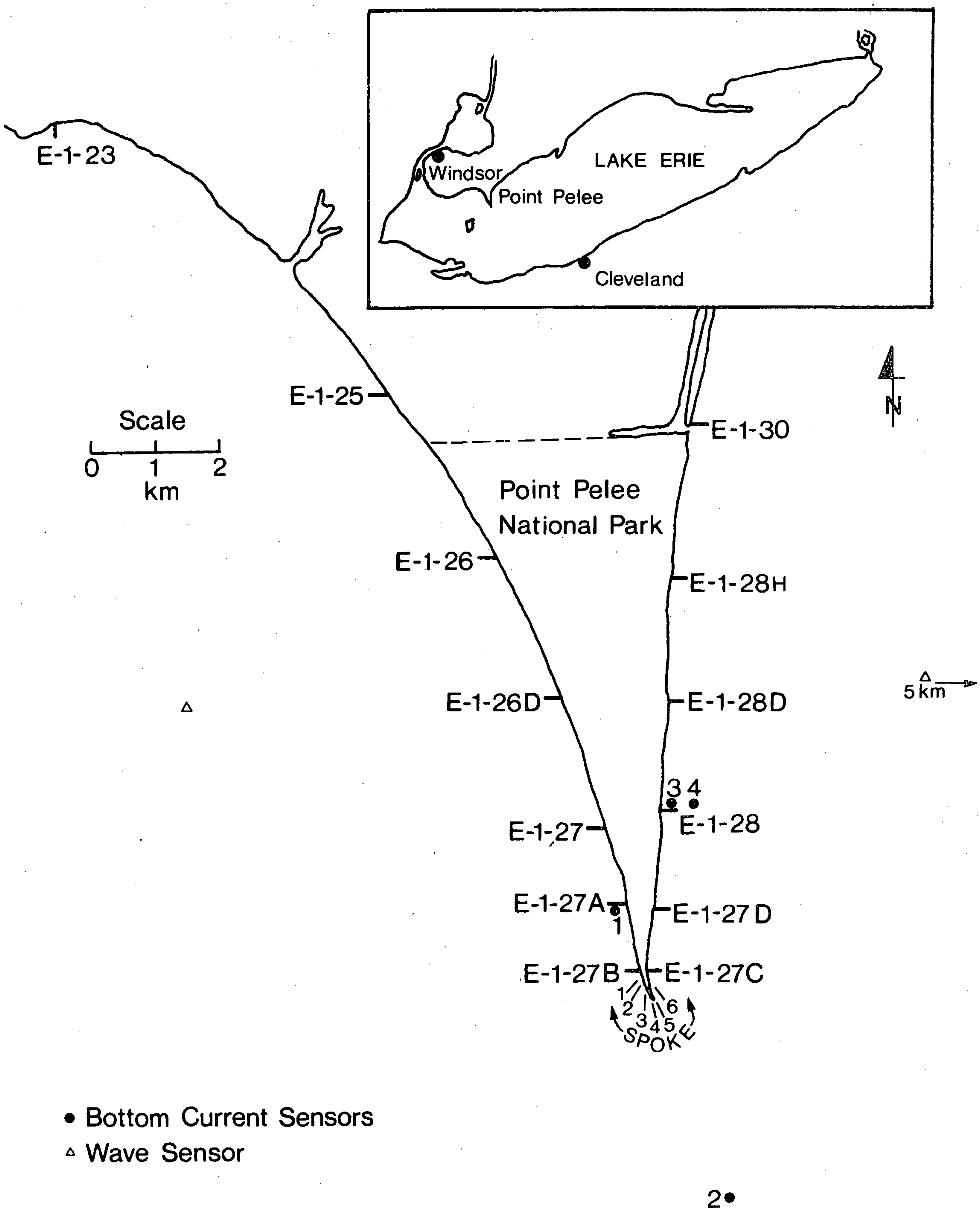


FIGURE 1.1 POINT PELEE STUDY AREA SHOWING NETWORK OF PROFILE-SITES AND LOCATION OF SENSOR INSTRUMENTATION

about sixty years ago. In response to a report of DPW (#2913), 1917, concerning high rates of erosion at Point Pelee, the Municipal Council of Mersea and the Town of Leamington agreed with the recommendations that annual surveys be undertaken while dredging continued, suggesting that a cause and effect relationship existed. However, a conflicting point of view was expressed by Kindle (1933), based on the fact that if dredging had caused erosion to the east beaches, why had there been no similar effect on west beaches. Furthermore, he points to the fact that beach ridge development on the west side of Point Pelee is in counter evidence to erosion on the east side which was active long before dredging operations ever began.

It is because of conflicting points of view such as this that Point Pelee continues to attract research scientists from a multitude of disciplines. For example, according to Coakley (1976), contrary to theories which invoke longshore drift and progressive accumulation of spits as a mode of formation, it is the author's contention that the Point Pelee foreland has undergone a progressive erosion in size by up to two-thirds its original area and has been retrograding at decreasing rates since its formation. In the application of digital ERTS-1 satellite data, using satellite, airborne, and ground-based observations, Bukata et al. (1974) present an interesting account of the Point Pelee sediment transport processes. They further developed the application of ERTS satellite data in deriving a conceptual mirror-image model defining the temporal evolution of Point Pelee and Rondeau landforms. Other studies related to coastal processes include that of Skafel (1975) whereby long-term longshore sediment transport rates were calculated as a function of hindcast wave conditions using Richards and Phillips (1970) wind climate for Lake Erie.

1.1 OBJECTIVE

In recognizing the need for a quantitative evaluation of the changes in profile to the beach, nearshore, and offshore zones of Point Pelee, this study was undertaken jointly by the Parks Branch of the Department of Indian and Northern Affairs and Ocean and Aquatic Sciences Branch of the Department of Fisheries and the Environment.

Shortly after the commencement of the study in the spring of 1974, the Ontario Mining Commission revoked dredging licences in the Pelee vicinity under the Beach Protection Act of Ontario. This provided the opportunity to record the nature and magnitude of short-term morphologic and volumetric changes to the coastal zone under natural conditions (assuming no 'lag' effect).

1.2 TERMINOLOGY

The author has adapted, in part, terminology after King (1972). The term "beach" includes the backshore and foreshore zones which are defined as the subaerial and swash zones, respectively. The term "nearshore" represents the subaqueous portion extending from the lower limits of the swash or Low Water Datum (International Great Lakes Datum, 1955) to the base of the Pelee rise where shore-parallel contours give way to irregular contours. If there is not a distinct change in slope, the eight-metre contour delimits the extent of the nearshore zone. Beyond this point is simply referred to as the "offshore" zone. Figure 1.2 diagrammatically expresses the terminology in the coastal zone.

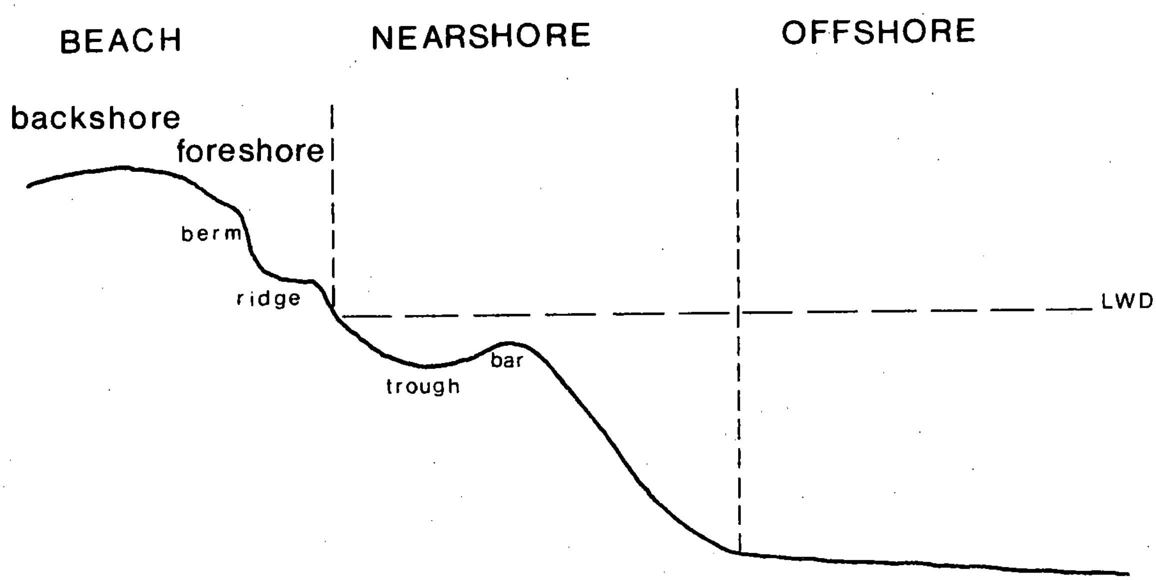


FIGURE 1.2 TERMINOLOGY OF THE COASTAL ZONE

1.3 METHOD OF DATA COLLECTION

Nineteen profile stations were established around the perimeter of Point Pelee. Six of these form a "spoke-like" network to monitor changes in the geometry of the subaqueous spit extending beyond the tip of the Point. The locations of the profile sites, indicated in Figure 1.1, were strategically selected so as to be representative of a homogeneous reach of shoreline. The survey frequency varied on a weekly basis in the spring and fall of 1974 to a monthly interval from May through to November, 1975. Conventional topographic survey methods were used to obtain a cross-section of the backshore and foreshore zones from an onshore control point to 1m depth. The nearshore and offshore zones were profiled using the Raytheon DE-719 echo sounder with depths being recorded on Fathometer chart paper. For horizontal control and positioning, a Tellurometer Hydrodist system was used in conjunction with a Wild T2 Transit and portable Motorola two-way radio transmitters. The survey vessel is shown on Plates 1.1 and 1.2.

Bottom currents were recorded by electromagnetic current meters moored at four locations around Point Pelee during August-October, 1975, (Figure 1.1), while currents at various depths were measured by tracking drogues in both the 1974 and 1975 field programs. Sediment samples were taken along each of the nineteen profiles to represent the nearshore and offshore zones using a Ponar Grab sampler, Sly (1969).

1.4 REPORT OUTLINE

The body of the report is organized into five main chapters. Chapter 2 provides a description of the physical setting of Point Pelee, as interpreted from a set of profiles taken in 1974, and the distribution of bottom sedimentary zones. Chapter 3 describes environmental factors or processes which are characteristic of the area based on previous records and observations taken during the study. Chapter 4 deals with short-term morphologic and volumetric changes to the subaerial and subaqueous profiles as a measure of the variability of coastal response. Quantitative analysis of shoreline change provides the means for estimating trends in the sediment budget of Point Pelee in Chapter 5. Conclusions are presented in Chapter 6.

PLATE 1.1 SURVEY LAUNCH 'CRESTLINER'

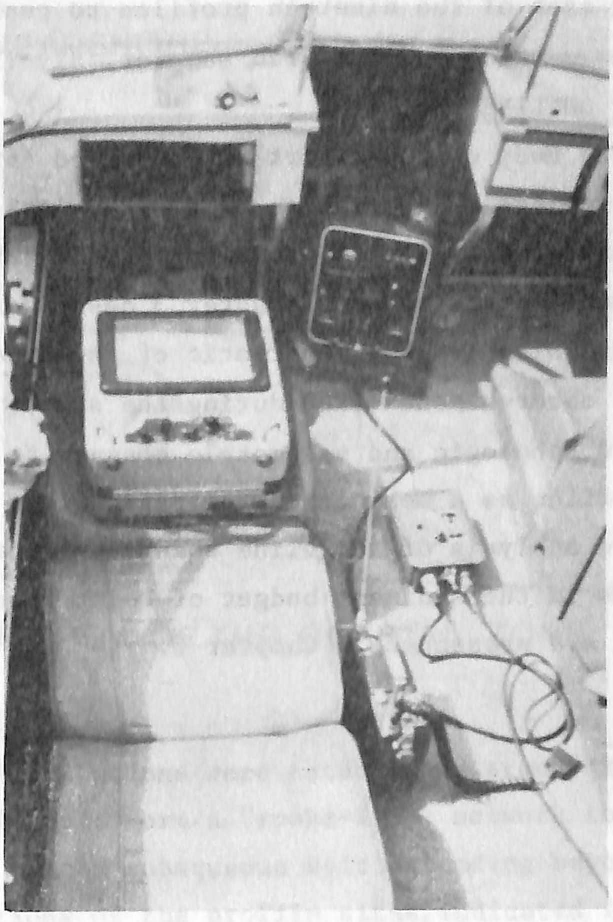


PLATE 1.2 SOUNDING AND POSITIONING EQUIPMENT ABOARD 'CRESTLINER' INCLUDES RAYTHEON SOUNDER, HYDRODIST, AND RADIO TELEPHONE

CHAPTER 2

2.0 POINT PELEE MORPHOLOGY

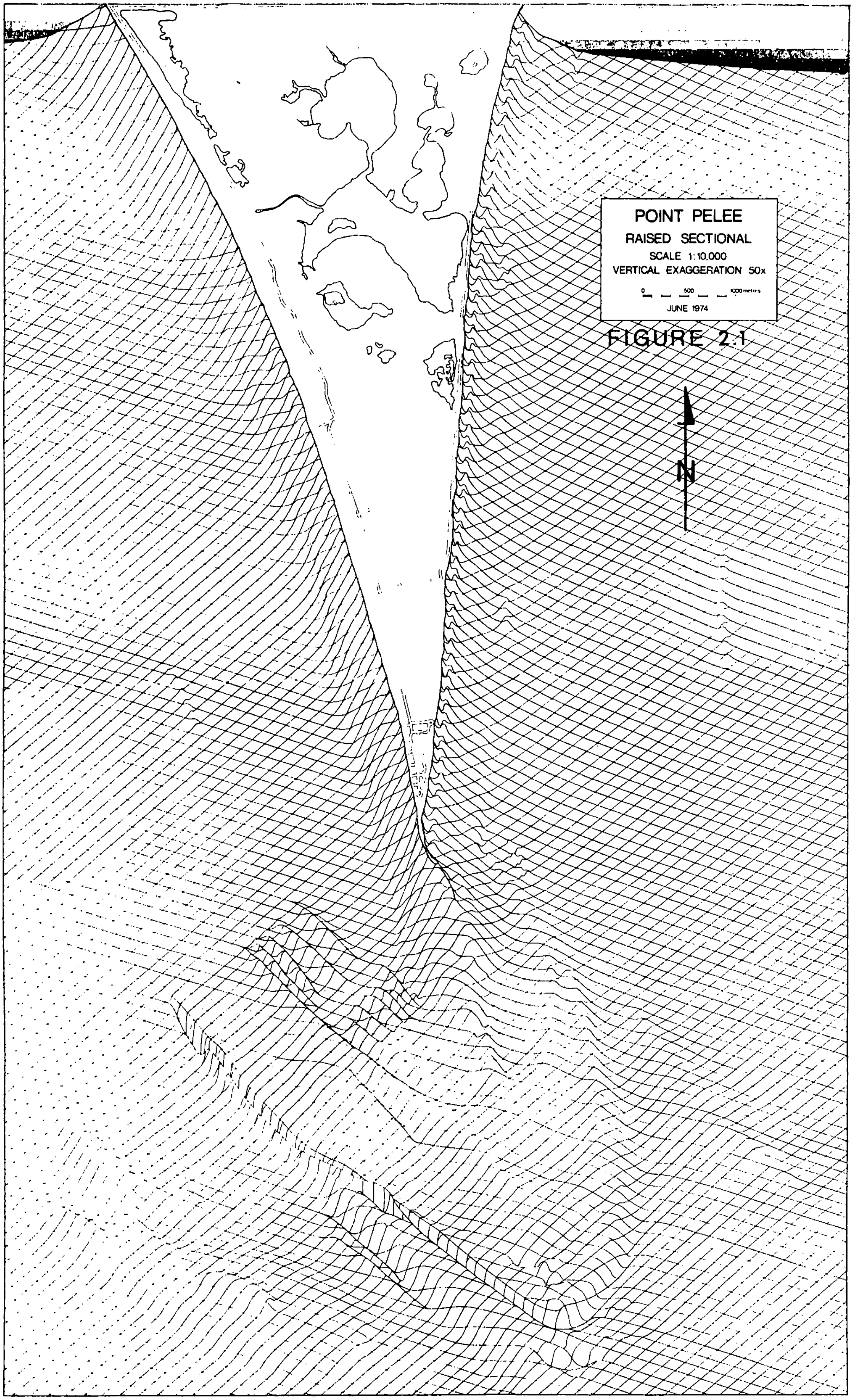
The morphology of the nearshore and offshore zones has been interpreted and mapped from profiles taken at each of the station sites in June, 1974. From contour interpolation, a raised sectional map was produced so as to provide a form of three-dimensional viewing, Figure 2.1. Vertical exaggeration on the order of 50x was introduced so as to accentuate minor morphologic features. Three distinct relief units emerge from the raised sectional map to the west, east, and south of Point Pelee.

2.1 BATHYMETRY

The west side of the Point is characterized by a pronounced featureless offshore zone with distinct change of slope where the nearshore and offshore zones intersect. Coakley (1972) referred to this feature as the "edge of the Pelee rise" and noted a pronounced eastward advance from 1964 to 1971. June profiles, Figure 2.2, show the smooth, uniform slope of the nearshore zone and the gradual taper in width from 0.7 km to 0.5 km from north to south with slopes of 1:63 and 1:47, respectively. Single, discontinuous bar and trough development does occur on the west nearshore zone, usually of small magnitude of less than 0.5 m.

On the east side of Point Pelee, development of inner submarine bars occurs at greater depths (2m) and are much larger than their western counterpart. June (1974) profiles also show evidence of a weak outer bar formation or terrace at stations E-1-30, E-1-28H, and E-1-28D at about 5m depth. Coakley (1976) has interpreted this feature as a possible wave cut abrasion ramp in the gently sloping till of the nearshore zone and as evidence of a general westward migration of Point Pelee. Slopes range from 1:55 above the 4m contour to 1:144 beyond this depth. Using the 8m contour as an approximation to the east edge of the Pelee rise, the width of the nearshore zone varies from 1 km at the north limits of the Park to .8 km at the tip.

A sharp contrast exists between the morphology to the south of Point Pelee and that of the west and east sides. It has an undulating hummocky surface consisting of a number of linear crests and troughs of


POINT PELEE
RAISED SECTIONAL
SCALE 1:10,000
VERTICAL EXAGGERATION 50x
0
500
1000 metres
JUNE 1974
N
FIGURE 2.1

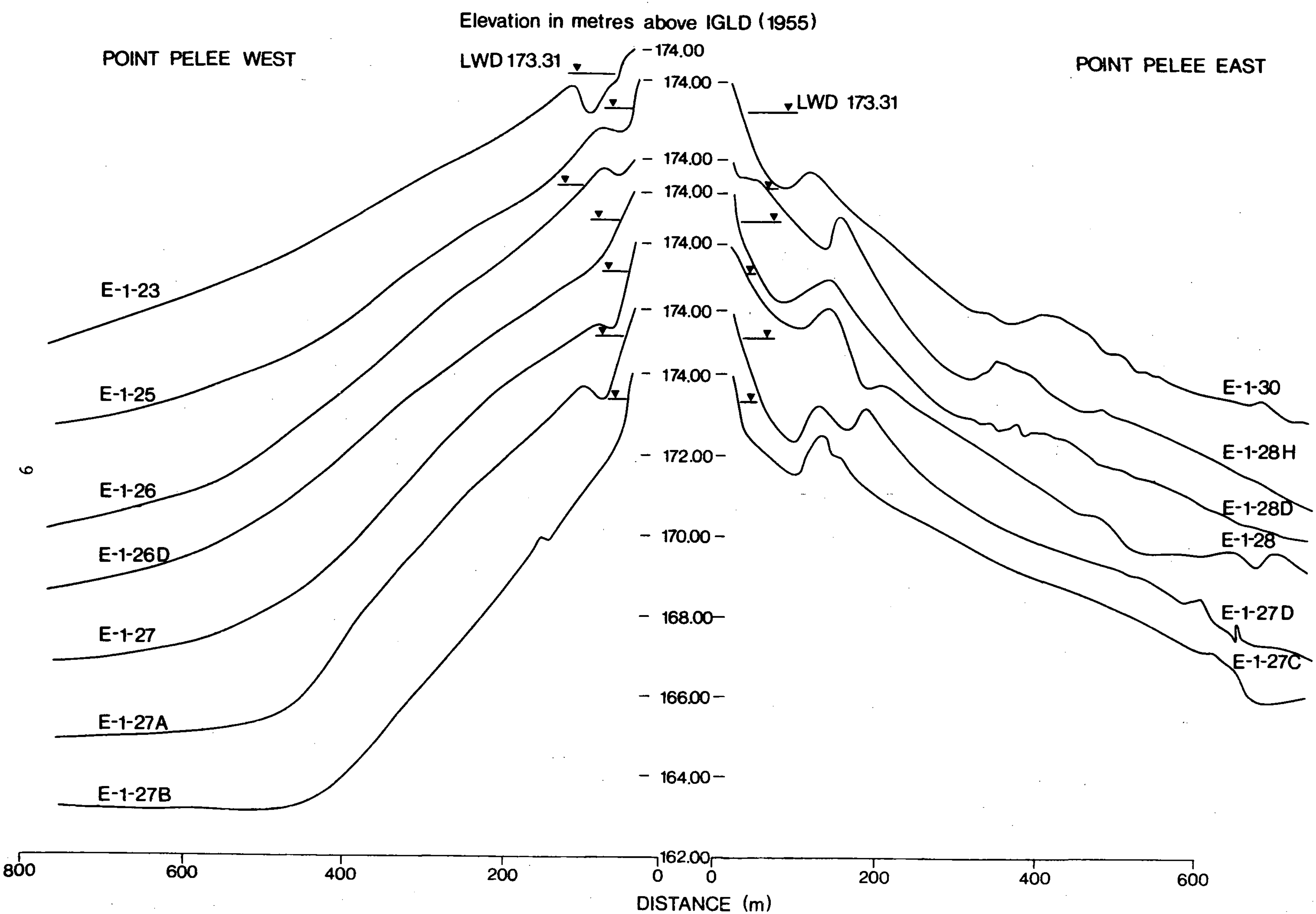


FIGURE 2.2 NEARSHORE PROFILES OF POINT PELEE

random orientation. The most outstanding relief feature is a 10m deep trench, 4 km in length. It is located approximately 3 km south of Point Pelee where it intersects spoke profiles 1, 2, and 3, Figure 2.6. Figure 2.3 shows a cross-section of the trench at two scales. The upper plot shows it with no vertical exaggeration, while the lower plot has a vertical exaggeration of 33x. Because of the physical dimensions of this feature and the possibility that it may be a result of the dredging activities, it may be part of the unnatural processes which are further augmenting erosion rates at Point Pelee in acting as a sediment sink.

2.2 SEDIMENTARY ENVIRONMENTS

Two previous studies show bottom sediment distributions for portions of the Lake Erie shoreline which include Point Pelee. Figure 2.4, St. Jacques et al.(1976), indicates textural classifications of bed material between Point Pelee and Port Burwell within the 20m contour. The most interesting aspect is the gradation of coarse sands and gravels to mud and clays from a west to east direction south of Point Pelee. This sequence suggests that easterly currents have played a major role in their distribution. The east side of the Point is shown as continuous glacial deposits which extend to about 15 km offshore.

On a larger scale, Figure 2.5 shows bottom sediments from Point Pelee to Detroit River, Coakley (1972). The extensive sand and gravel deposits to the south of Point Pelee are shown to extend west as well, forming a near symmetrical distribution on both sides of the subaqueous spit. Coakley has found, from the depth of trenches and excavations in the area, that the thickness of these deposits is in excess of 10m. In addition to the glacial deposits on the east side of Point Pelee, Coakley indicates a narrow band of sand in the immediate nearshore zone. This also extends up the west side of Point Pelee gradually changing to thin sands and mud in the offshore.

Further detail on the distribution of surficial sediments was provided by a survey undertaken during this study.

Bottom sample locations are indicated on Figure 2.6 with the corresponding sediment size analysis given in Table 2.1. Samples 27, 24, 22, 18, 14, 10 and 6 in the offshore zone on the west side of Point Pelee show a progressive south to north decrease in the percentage of coarser textured sediments. The respective values for percentage of sand in these samples are 91, 98, 78, 58, 24, 18, and 3. St. Jacques et al. (1976) suggest that a similar decrease in grain size south of Point Pelee (Figure 2.4) is the result of a redistribution of source sediments by lake processes. This would indicate that corresponding lake processes are influencing the distribution of sediments on the west side.

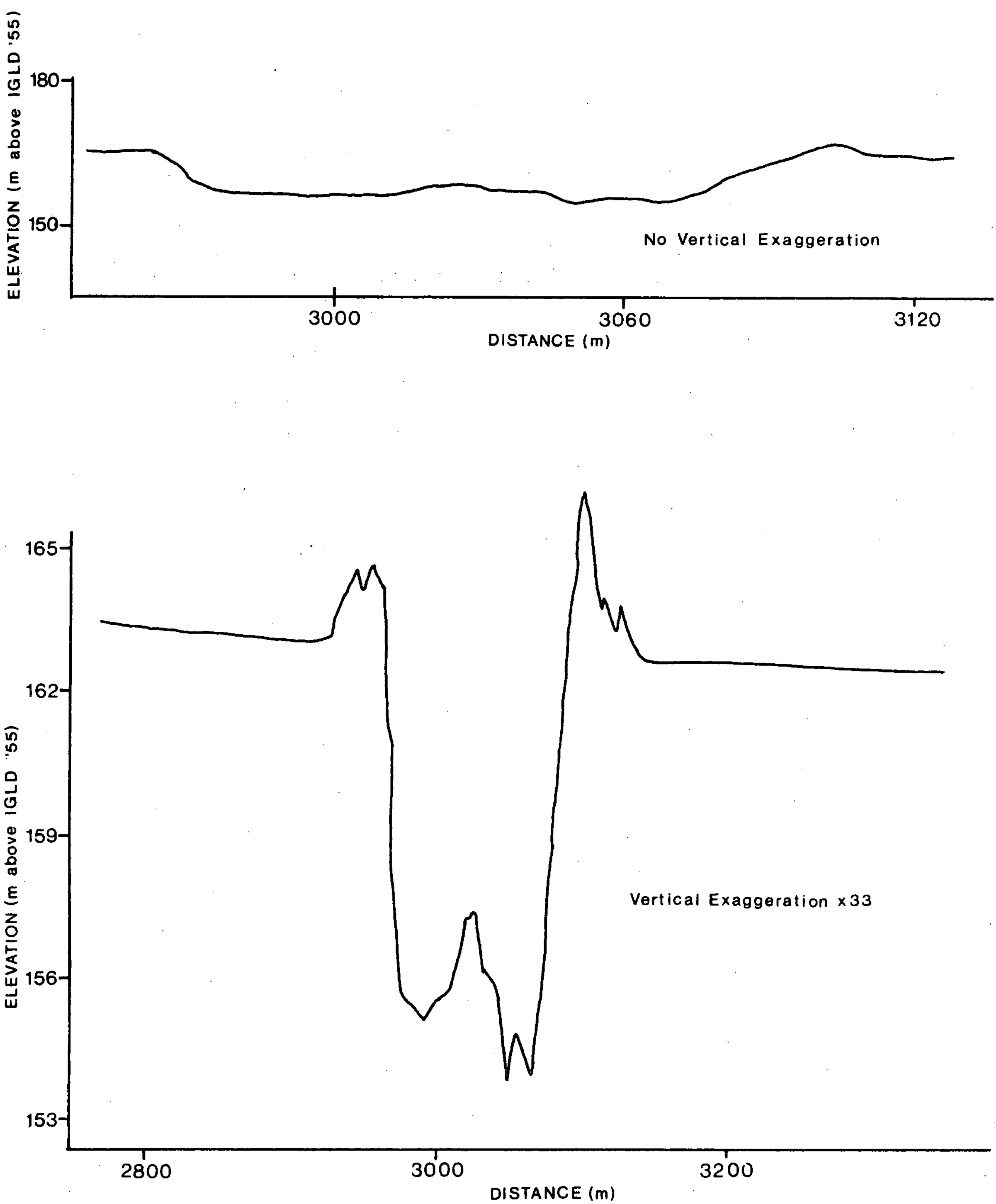


FIGURE 2.3 CROSS SECTION OF TRENCH IN LAKE BED SOUTH OF POINT PELEE (Spoke 1)

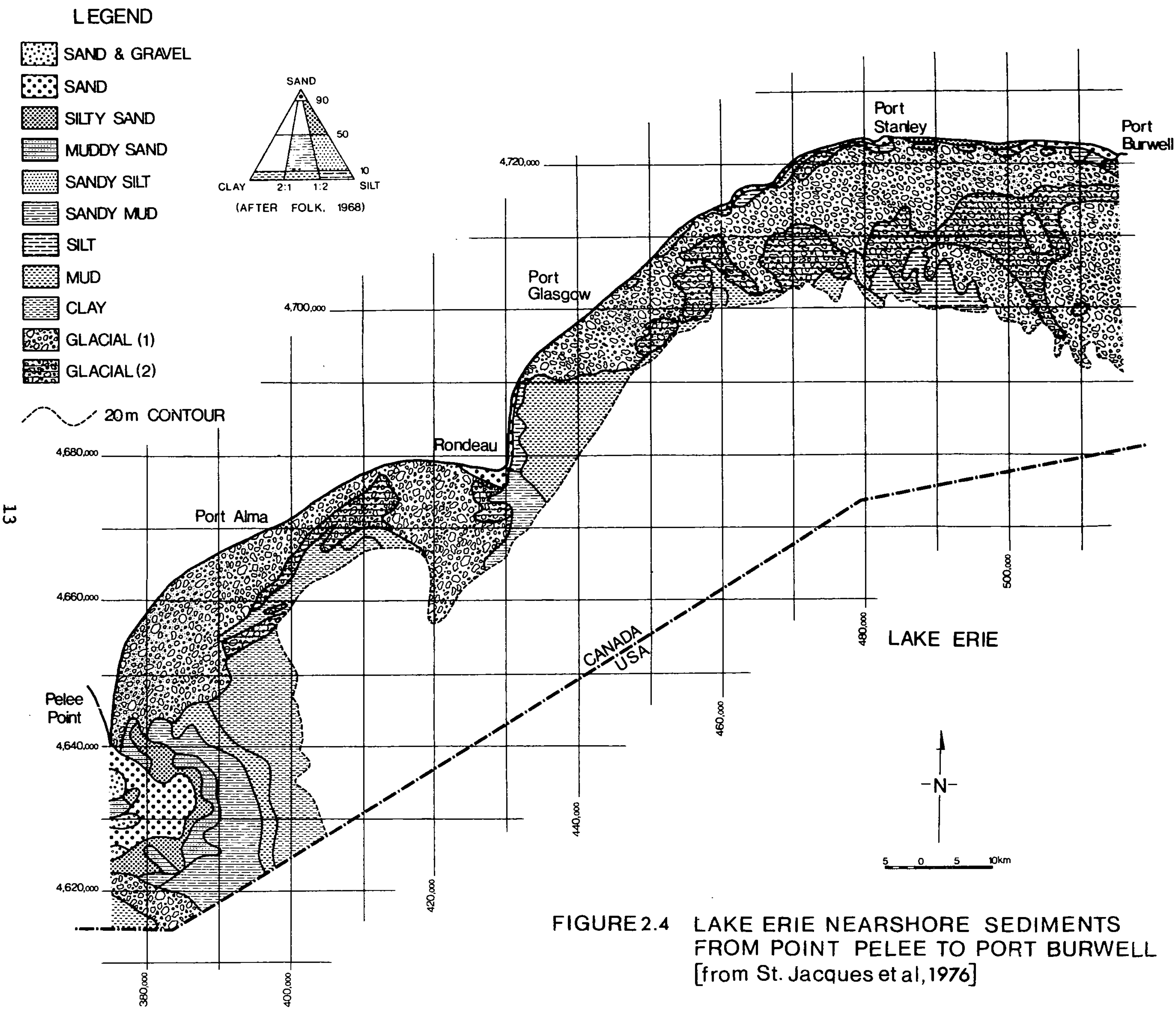


FIGURE 2.4 LAKE ERIE NEARSHORE SEDIMENTS FROM POINT PELEE TO PORT BURWELL [from St. Jacques et al, 1976]

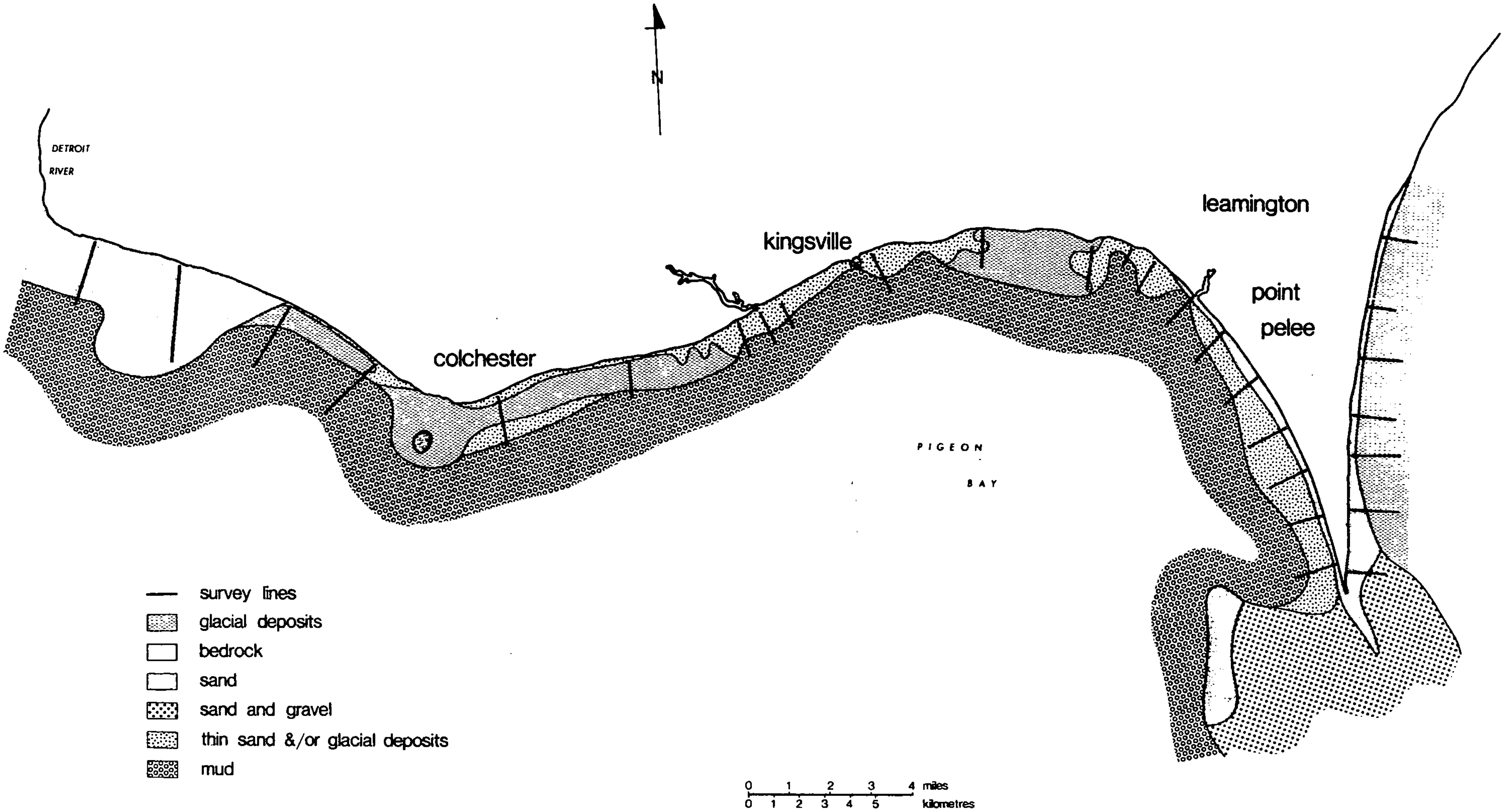


FIGURE 2.5 NEARSHORE BOTTOM SEDIMENTS, WESTERN LAKE ERIE
[from Coakley, 1972]

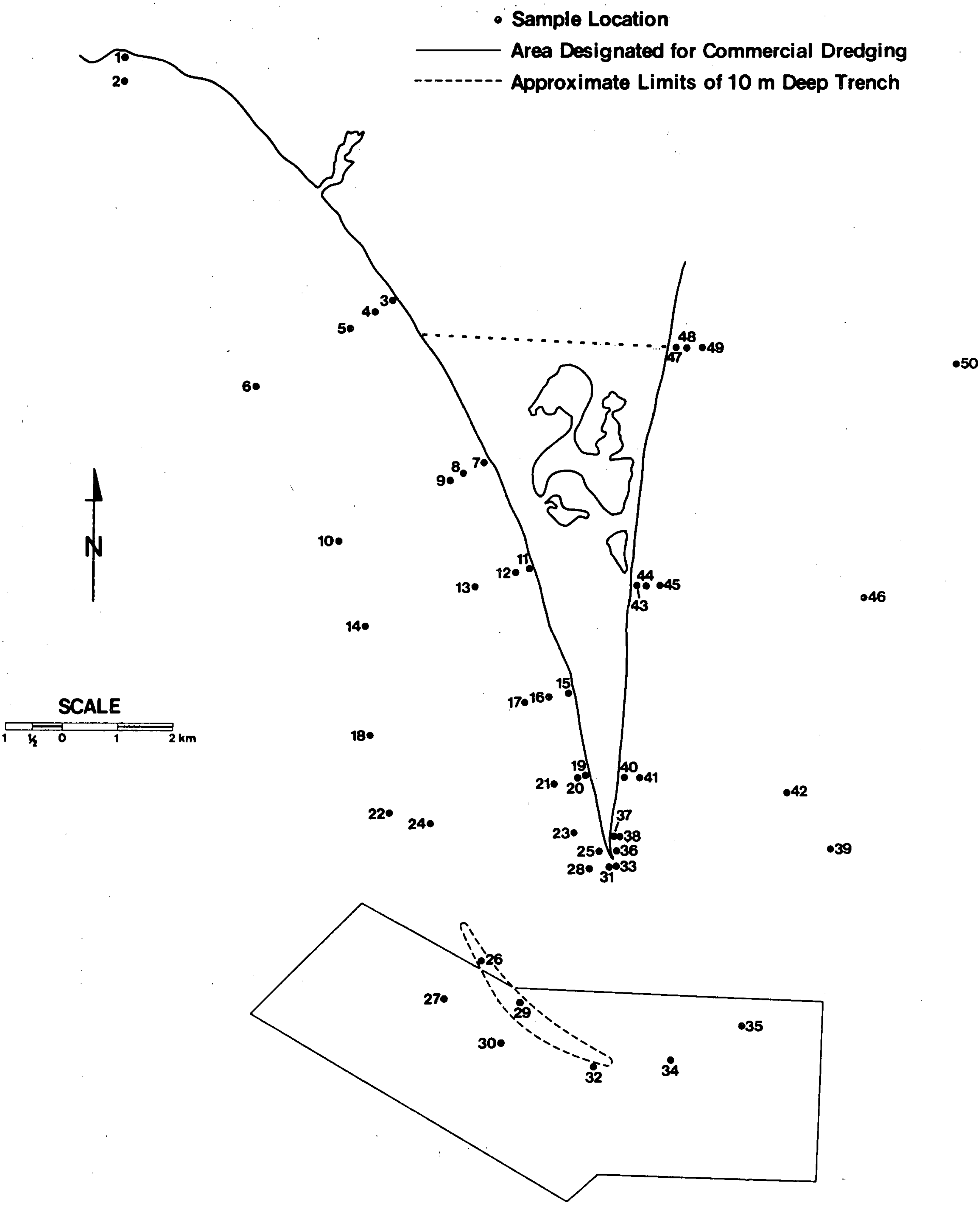


FIGURE 2.6 LOCATION OF BOTTOM SAMPLES AT POINT PELEE

PROFILE STATION		SAMPLE NUMBER	% COMPOSITION			
AREA	NUMBER		GRAVEL	SAND	SILT	CLAY
POINT PELEE WEST	E-1-23	1		94	4	2
		2		56	38	6
" " "	E-1-25	3		35	60	5
		4		5	72	23
		5				
		6		3	59	38
" " "	E-1-26	7		98	1	1
		8		26	66	8
		9		4	72	24
		10		18	47	35
" " "	E-1-26D	11		97	2	1
		12		94	4	2
		13		5	71	24
		14		24	48	28
" " "	E-1-27	15		97	2	1
		16		64	29	7
		17		10	62	27
		18		58	26	16
" " "	E-1-27A	19	90	10		
		20		97	2	1
		21		43	36	21
		22		78	13	9
" " "	E-1-27B	23		78	15	8
		24		98	1	1
POINT PELEE SOUTH	Spoke 1	25		98	1	1
		26		90	5	5
		27		91	5	4
" " "	Spoke 2	28		90	6	4
		29		40	37	23
		30		89	10	1
" " "	Spoke 3	31	80	20		
		32		97	2	1
" " "	Spoke 4	33	99	1		
		34		95	1	4
" " "	Spoke 5	35		97	1	2
" " "	Spoke 6	36		97	2	1
POINT PELEE EAST	E-1-27C	37		64	21	15
		38		98	1	1
		39		62	25	13
" " "	E-1-27D	40		98	1	1
		41		97	1	2
		42		42	38	20
" " "	E-1-28D	43	85	15		
		44		97	2	1
		45		18	30	52
		46		34	39	27
" " "	E-1-30	47		97	2	1
		48		97	2	1
		49		88	7	5
		50		64	19	17

TABLE 2.1: Sediment Size Analysis of Bottom Samples Taken At Point Pelee, August, 1975.

CHAPTER 3

3.0 COASTAL PROCESS ELEMENTS

The term 'coastal processes' is generally used as a blanket expression to cover all facets of coastal dynamics. It is appropriate in this report, however, that the processes be subdivided into two categories, these being process and response elements. Although in some cases variables may play a dual role (i.e. water levels respond to wind, yet they are also a process in effecting rates of erosion), for the purpose of this report the process elements consist of currents, lake levels, wind, waves, and ice; whereas morphologic and volumetric changes in beach profile primarily account for the response element. The following description of the process elements is based on previous research literature and field records of this survey for the general purpose of defining the Pelee coastal 'climate'.

3.1 LAKE CURRENTS

Descriptions of flow patterns around Point Pelee date back to early historical navigation records and observations by commercial fishermen. Kindle (1933) elaborates on several of these records and interpretations of Point Pelee flow dynamics. These records indicate, from drogue calculations under varying lake conditions (depth at which measurements were taken was not given), current speeds ranging from 43 cm/sec to 80 cm/sec on both sides of Point Pelee. Generally these currents were in a southward direction. However, anomalies such as flow oscillations, reversals and excessively strong flows around the Point of up to 134 cm/sec were also noted,emphasizing the complex hydraulics in the Pelee vicinity.

Current measurements taken during the survey intervals of 1974-75 reinforce some of these earlier observations. For example, drogue movements at 1m and 5m depths, Figure 3.1, show evidence of:

1) June 27, 1974

   Nearshore current speed on the east side was twice that of the current measured further offshore at a 5m depth. Current direction in both cases was toward the south with winds of 19-32 km/sec from the northeast.

2) June 28, 1974

   Upwelling in the nearshore of the west side produced by consistent north-northeast winds.

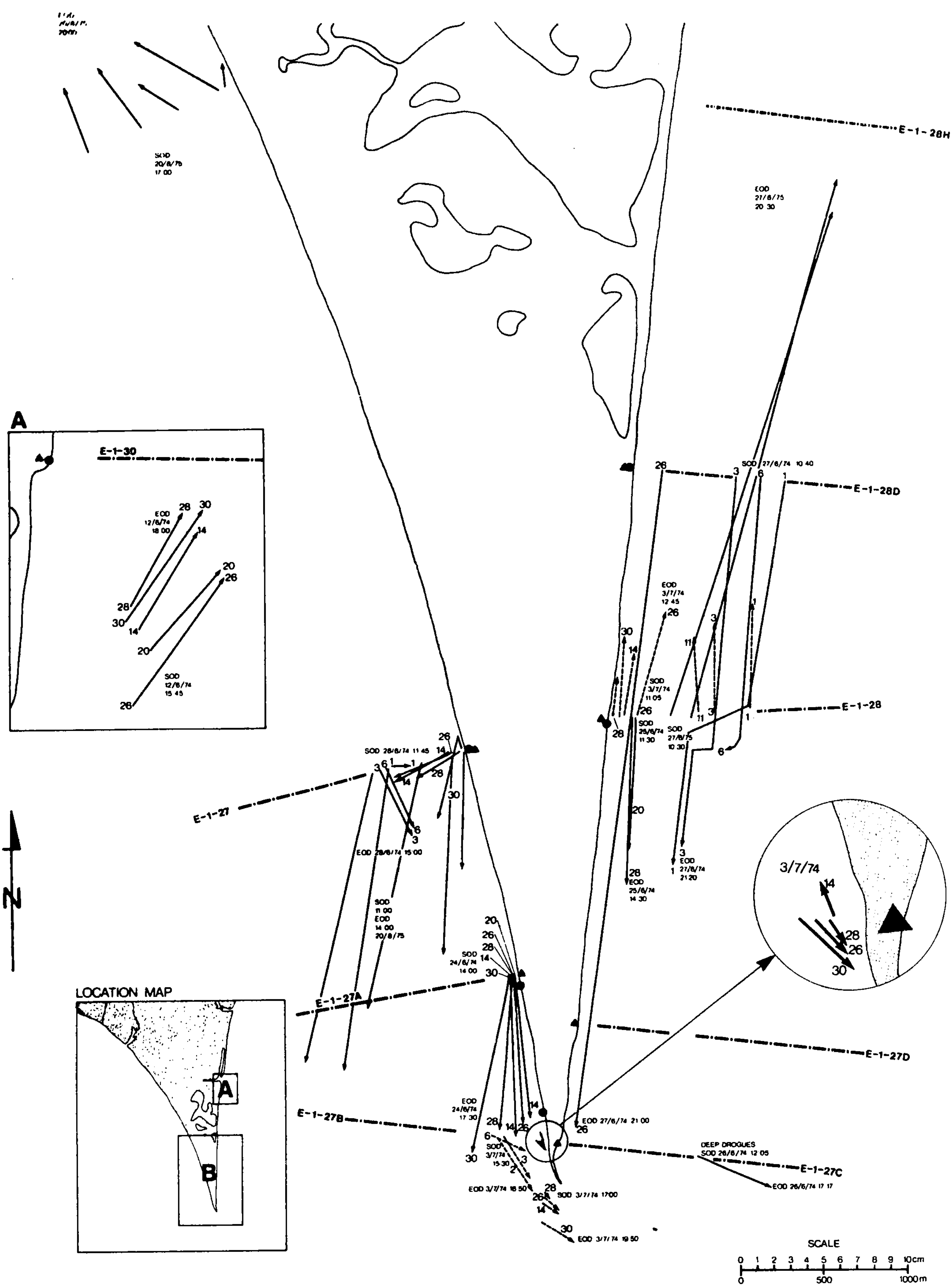


FIGURE 3.1 DROGUE MOVEMENTS AT POINT PELEE , 1974-75

3) <u>July 3, 1974</u>

Return flow in the west littoral zone during counterclockwise current around the tip of Point Pelee.

4) <u>August 20, 1975</u>

Either bifurcation or a short-term reversal in current direction was evidenced on the west side of the Point. Southerly flow at 12.9 cm/sec near profile station E-1-27 was in opposite direction to a current observed 2 hours hence at a location 5 km north. This current, however, was 4 cm/sec.

5) <u>August 20, 1975</u>

Maximum current recorded was 11 cm/sec in a southerly direction on the west side, while a minimum of 0.4 cm/sec occurred just to the south of the tip of Point Pelee.

The ability to evaluate actual current conditions, using the method of tracking drogues, is limited in that the vector plot merely represents a residual flow which has a tendency to mask any oscillations which may have occurred. Increasing the frequency of observations helps to overcome this problem to some degree. Furthermore, maximum currents recorded are generally not representative of the potential flows for the areas, as these would normally occur under adverse weather conditions when no survey operations on the water could take place.

Bottom currents were measured on a continuous basis during the latter part of the 1975 field season, using four self-recording electromagnetic current meters placed at 1m above lake bottom, Figure 1.1. Data acquired at these sites, numbered consecutively from west to east, are summarized on rose plots in the Appendix, in addition to figures referenced under this section.

Maximum mean and instantaneous current speeds were observed on the west side of Point Pelee at 15.3 cm/sec and 68 cm/sec, respectively. Mean speeds at the other three mooring positions varied between 4.5 cm/sec and 4.9 cm/sec. Generally, currents to the west and south of Point Pelee were more variable than those recorded on the east side of the Point.

The contrast is evident during a period of simultaneous record from August 26 to 30 when winds were light and variable, Figure 3.2. This short term record shows a weak oscillating current with a mean speed of 2.6 cm/sec for the inner nearshore on the east side, while speeds averaged 15 cm/sec and 25.2 cm/sec at the west and south moorings. In spite of the stronger currents evidenced to the west and south of Point Pelee, there was considerable variability in their strength with a standard deviation of 19.9 cm/sec and 20.5 cm/sec, respectively. The oscillating current on the east side had a standard deviation of 4.2 cm/sec.

The entire period of record from August 26 to September 23 continues to show bottom currents on the west side of Point Pelee as having higher speeds, with an average of 15.3 cm/sec and a maximum of 68.3 cm/sec. Flows were generally in a northerly orientation paralleling the shoreline. Compared to other mooring locations, these currents had a relatively high variability in strength, as evidenced in the standard deviation of 16.7 cm/sec. Currents at mooring 2, just east of the area designated for dredging south of Point Pelee, varied somewhat from the August record, in that the average speed from August 26 to October 22 was much less at 4.9 cm/sec. This area was characterized, however, by an oscillatory flow predominantly in a NNE-SSW orientation, with a standard deviation of 10 cm/sec. Maximum current speed occurred during August at 55 cm/sec. It is also noteworthy, in light of sediment transport processes, that the higher speeds tended toward northerly directions.

An oscillating current on the east side of Point Pelee at a 4m depth, mooring 3, predominated during latter August and September with a mean velocity of 4.5 cm/sec. As in the case of the south mooring location, maximum currents flowed toward the NE, at 39.7 cm/sec. Currents varied somewhat from these further offshore in 7m of water, Figure 3.3, in that oscillatory flow was rectilinear, and furthermore showed less variability with a standard deviation of 3 cm/sec as compared to 8.5 cm/sec at the 4m depth. This difference may be accounted for by the fact that the current record of the outer nearshore zone covers the more tranquil period of midsummer (June - July), while the inner nearshore record was taken during the month of September.

The current observations tend to substantiate the potential for sediment transport under prevailing conditions. Gradational distributions of bottom sediments described in the previous chapter tend to coincide with

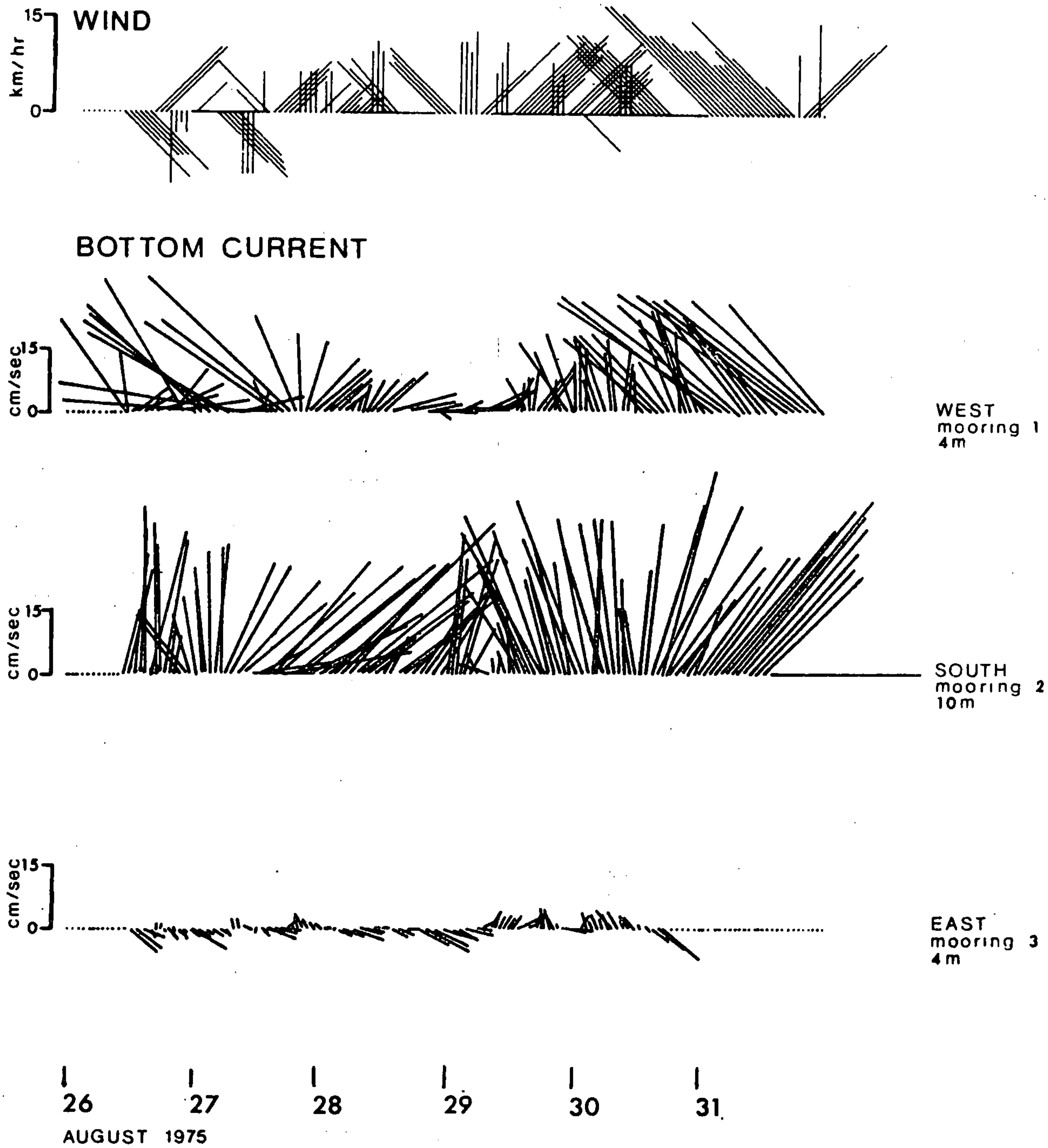


FIGURE 3.2 TIME-SERIES PLOT OF BOTTOM CURRENT AT MOORINGS 1,2 AND 3 [August 26-31 1975]

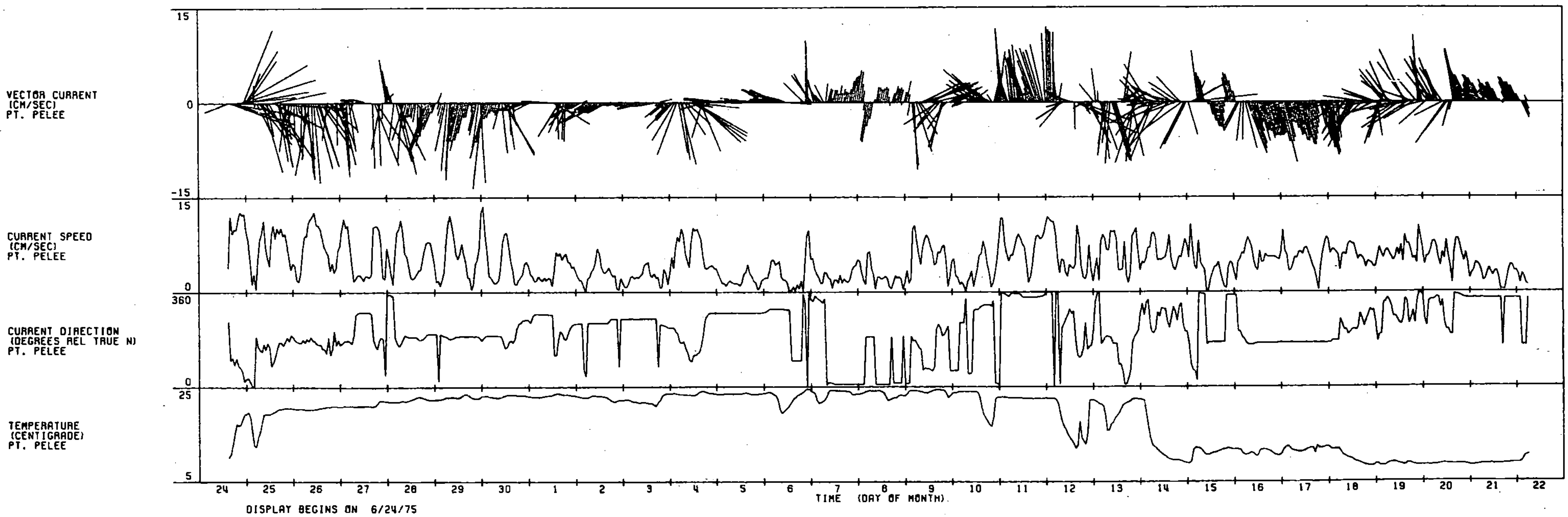


FIGURE 3.3 TIME-SERIES PLOT OF BOTTOM CURRENT AND TEMPERATURE AT POINT PELEE, MOORING 4 [JUNE/JULY 1975]

the predominant orientation of currents when they are at their maximum speeds.

Nevin (1946) calculated a minimum critical-traction speed required to transport sand and fine gravel-sized particles of 0.06 - 2.00 mm to be 35 cm/sec. If the assumption by Nevin that bottom currents 1m above lake bed approximate critical-traction speeds, then the possibility that sediments to the south of Point Pelee act as a source to the beach and nearshore zones is a real one. Currents exceeding 35 cm/sec accounted for 12.6% of the record at mooring 2 near the area designated for dredging. Seventy-one per cent of these were toward a northerly direction.

3.2 LAKE LEVELS

The surface of Lake Erie oscillates with a period of 14.2 hours, I.A. Hunt, Jr. (1959). This is particularly evident in the time-series plots of water levels for the two permanent gauges located at Point Pelee, Figures 3.4 and 3.5. Under wind set-up conditions, the morphology of the Point Pelee spit and shoal system is such that hydraulic flow between the west and central basins of the lake is restricted. This results in large short-term fluctuations in lake levels which may be further augmented if coincident with the 14-hour periodic surge in levels. This, of course, depends upon the duration and direction of the disturbance.

Figure 3.4 is an example of a wind set-up produced by strong NE winds at 32 - 43 km/hr. The resultant surge in water levels reached approximately 50 cm, however, the set-up diminished soon after winds had subsided. From the current record at mooring 2, south of Point Pelee, the effect on currents was limited to the actual set-up period with currents resuming predisturbed conditions upon the return to normal levels. This consisted of an oscillating current oriented in a N-S direction, with southerly flow approximating the 14-hour periodic rise in west levels. Because of turbulent flow conditions during the peak surge, no data was obtained for this period.

Figure 3.5 is an example of a wind set-up produced by NW and W winds at 24 - 32 km/hr. The effects on water levels and currents are quite different from the previous example, particularly in the development of a hydraulic gradient between the east and west sides. A 20 - 26 cm difference in levels between Pelee West and Pelee East developed with the onset of strong NW winds and was sustained over a four-day interval, despite a change to N winds on the third day. This may be accounted for by the fact that surface oscillations of the west and central basins were in phase at this time, and therefore strong NW and W winds simply augmented the oscillating motion.

Current response on the west side of Point Pelee was largely evident in a distinct shift in direction toward the NW, opposite to the wind direction, and a periodic increase in speeds of up to 10 cm/sec, coinciding with the 14-hour oscillating lake surface. To the south of Point Pelee, currents showed an increase of 30 - 32 cm/sec at the initial

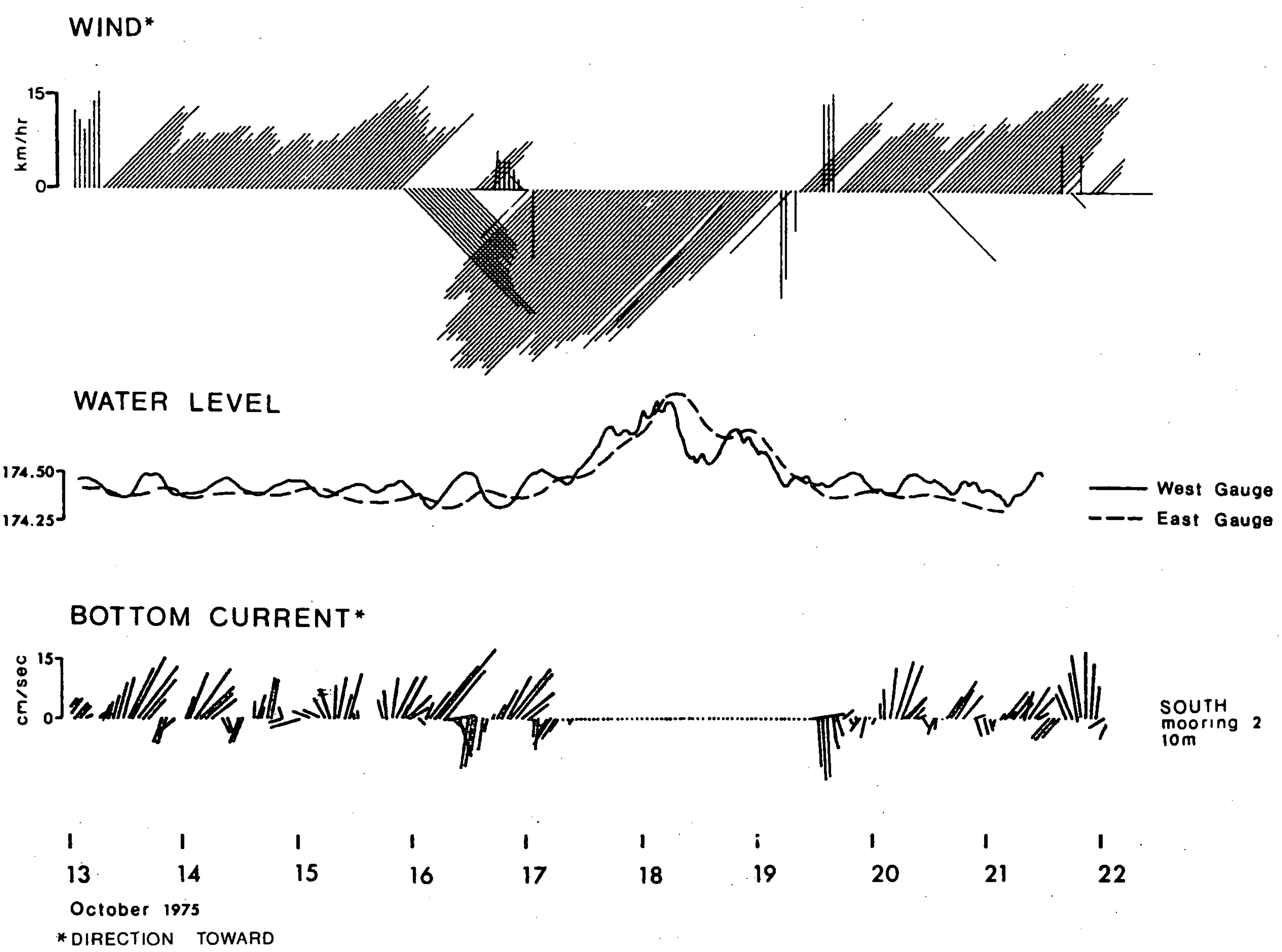


FIGURE 3.4 TIME-SERIES PLOT OF WIND, WATER LEVEL AND BOTTOM CURRENT AT POINT PELEE [October 1975]

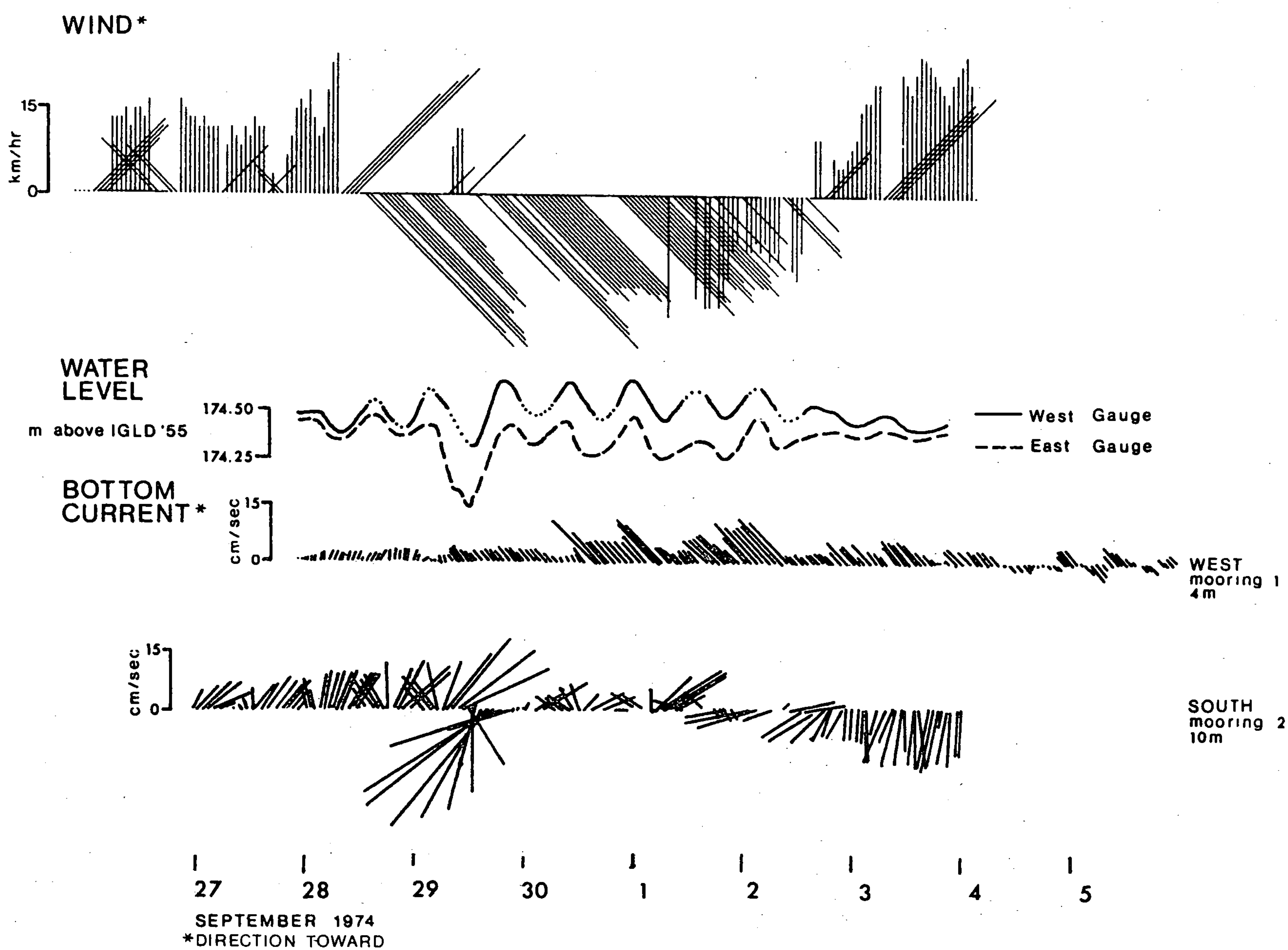


FIGURE 3.5 TIME-SERIES PLOT OF WIND, WATER LEVEL AND BOTTOM CURRENT AT POINT PELEE [September/October 1974]

drop of water levels, which was on the order of 50 cm on the east side. For the duration of the NW winds, currents were unstable both in direction and speed. With a change in winds to the south, reducing the difference in water levels between the west and east sides, currents settled to a southerly flow at about 15 cm/sec.

A summary of the differences in water levels between the west and east sides of Point Pelee during the 1974-75 survey periods is given in the Appendix. Because of prevailing westerly winds, all but one observation showed higher levels on the west side, with a maximum variation of 63 cm. It has been shown that the difference in levels under wind set-up conditions and an oscillating lake surface may produce distinct responses in the flow characteristics around Point Pelee. The effect on beach dynamics may also be significant as the west side of Point Pelee is characterized by a series of cumulative beach ridges which are the basis for the argument of a westerly migration during its evolution. The author contends that the disparity in water levels between the west and east sides of Point Pelee is a significant factor in the progressive accumulation of beach material on the west side.

3.3 WIND CLIMATE

Richards & Phillips (1970) present a synthesized wind climate for Lake Erie based on a conversion of wind data collected at London, Ontario, to over-lake conditions for the period 1957 to 1966.

It is evident from these data that early spring months are characterized by stormy conditions with winds in excess of 29 km/hr (16 knots) 58% and 54% of the time during the months of March and April respectively. These winds are predominantly from the east and west, on a 50/50 basis, and therefore are particularly significant as the longitudinal axis of Lake Erie approximates an east-west orientation. Late spring and early summer months of May, June and July are, in contrast, largely quiescent with calm conditions reaching annual maximums of 10% to 13%. Winds in excess of 29 km/hr are rare, occurring less than 15% in June and August and 1% in July.

September is a transitional period whereby the summer calms are replaced by the stormy conditions encountered during the fall and winter months. Frequency of winds greater than 29 km/hr increase to a maximum of 66% for the months of November and December. Not only is the frequency of high winds greater during the fall months as opposed to the stormy spring period, but the direction is predominantly from the west.

January and February are usually considered to be on average periods of ice cover. However, from the viewpoint of coastal processes, the work of Dickie et al.(1974) and Rondy (1971) on ice characteristics at Point Pelee and Lake Erie show that these months may be particularly significant with respect to wind-generated shoreline processes. The east shoreline of Point Pelee has open water conditions during mild and normal winters, and only under severe cases does the central basin of Lake Erie experience complete ice cover. The maximum loss of beach material during the Pelee survey occurred between the fall profiles of November, 1974, and spring resurvey of April, 1975. Characteristically, winds greater than 29 km/hr from the NE,E and SE account for 14% of January and 16% of February.

Garriott (1903) has documented the frequency of severe storms on the Great Lakes by month from 1876-1900 (Table 3.1).

Table 3.1

Frequency of Severe Storms on the Great Lakes from 1876-1900

SPRING		SUMMER		FALL		WINTER	
Month	Freq.	Month	Freq.	Month	Freq.	Month	Freq.
April	16	July	6	Oct.	29	Jan.	16
May	15	Aug.	8	Nov.	45	Feb.	14
June	9	Sept.	23	Dec.	35	Mar.	22

In spite of the fact the record represents a period prior to 1900, the frequency of high winds tends to correspond well with that of Richards and Phillips wind data of 1966, with fall months superseding any other time of the year for stormy conditions.

3.4 WAVE CLIMATE

Using wind data recorded at Point Pelee, a hindcast wave climate was calculated for the 1974-75 survey intervals following the relations from the U.S. Army Corps of Engineers, Shore Protection Manual (1973):

$$\frac{gH_s}{U^2} = 0.283 \tanh\left[0.578\left(\frac{gd}{U^2}\right)^{0.75}\right] \tanh\left\{\frac{0.0125\left(\frac{gF}{U^2}\right)^{0.42}}{\tanh\left[0.578\left(\frac{gd}{U^2}\right)^{0.75}\right]}\right\} \quad (1)$$

$$\frac{gT_s}{2\pi U} = 1.20 \tanh \left[0.520 \left(\frac{gd}{U^2}\right)^{0.375}\right] \tanh \left\{ \frac{0.077 \left(\frac{gF}{U^2}\right)^{0.25}}{\tanh \left[0.520 \left(\frac{gd}{U^2}\right)^{0.375}\right]} \right\} \quad (2)$$

where g is the acceleration of gravity; H_s is the significant wave height; U is the wind speed; d is the water depth; F is the fetch length; and T_s is the significant wave period.

Effective fetch lengths and mean water depths calculated by Skafel (1975), Table 3.2, were used as input to the formulae.

Table 3.2

Effective Fetch Lengths & Mean Water Depths for Seven Wind Directions at Point Pelee.

Direction	Effective Fetch Length (km)	Mean Water Depth (m)	Duration in hours required for Fully-Developed Wave with Winds of 19 km/hr
NE	74	16	8
E	138	22	14
SE	72	19	8
S	47	12	6
SW	50	10	6
W	47	9	6
NW	14	8	3

The minimum duration required for a fully-developed wave based on a 19 km/hr wind has been added, as there were 13.25% of the cases in which the duration would limit wave development. No compensation was made, however, as hindcast values tend to be conservative estimates when compared to measured wave data at Point Pelee. Wave observations on the west and east sides of Point Pelee (Figure 1.1), for the duration of the 1974 field season, are included with hindcast estimates in the Appendix.

With the exception of 5 cases, predicted wave heights were underestimates of those recorded. The weighted percentage difference varied from 21.5% for NE and E fetches to 33.7% for W,SW and S fetches and 42% for NW fetch. The SE fetch had the greatest variation with hindcast significant wave heights 50% less than the observed. However, winds from the SE occurred only twice during the 'observation' period.

In distinguishing between constructive and destructive waves, King (1972) comments on studies which show that relatively long and short, low waves are associated with the building up of a beach; whereas high, steep storm waves erode it. Furthermore, critical steepness values, at which waves change from constructive to destructive in character, have also been estimated at 0.11 and 0.17 for sand and shingle beaches in south Wales.

From the hindcast wave data presented in the Appendix, wave dimensions were calculated for the 1974 and 1975 survey periods (Table 3.3) in order to detect any of the above relations when compared to beach response at Point Pelee.

Table 3.3

Average Dimensions of the Hindcast Wave Climate at Point Pelee during the 1974-75 Survey Periods.

Fetch	Frequency	Significant Wave Height (H_s) in m	Significant Period (T_s)	Wave Length (L) m	Wave Steepness (H_s/L)
NW	13	.41	2.19	7.5	.055
W	6	.66	2.62	10.8	.061
SW	55	.59	2.96	10.0	.058
S	18	.55	2.52	10.0	.055
SE	12	.64	2.80	12.4	.051
E	7	.80	3.11	15.2	.052
NE	15	.70	2.85	12.8	.055

On a relative basis, it appears that the west side of Point Pelee was characterized by low, short waves with a weighted average of .56 m in height and 9.63 m in length. The east side, on the other hand, had higher significant wave heights averaging .70 m and wave lengths of 13.15 m. Wave steepness tended to be all destructive relative to the values from King (1972), with the steeper waves in the westerly fetches. This was also found by Gillis (1975).

Variation in the average wave lengths between the west and east sides suggests that this may be the more significant wave parameter in distinguishing between constructive versus destructive waves at Point Pelee.

The longer waves reaching the east shoreline of Point Pelee would permit a more effective backwash when compared to the more swash-effective action of the low, shorter waves on the west shore.

3.5 ICE

Ice serves as a temporary form of natural beach protection in two ways. Firstly, ice accumulation along the shoreline forms a mantle or barrier upon which wave energy may dissipate and secondly, extensive ice cover over the lake surface reduces the effective fetch, thereby limiting the development of wind-generated waves. Reference to ice charts of Lake Erie, Rondy (1971), shows maximum ice cover for mild and severe winters and the characteristic pattern and extent of ice cover during winters classified as normal, Figure 3.6.

It is evident from these charts that the east shorelines of Point Pelee are characterized by open water conditions for most of the winter months in mild and normal winters; whereas the west shoreline, in contrast, shows ice formation under a mild winter classification and for a three-month duration during normal winters. The western and central basins of Lake Erie also vary in the rate and extent of ice cover, with the western basin being the most thermally unstable. Ice cover exists under all winter classifications and is of greater duration when compared to the central basin which is characterized by partial ice cover except in severe cases and at maximum stages under normal winters (≃2 weeks).

Therefore, the west shoreline of Point Pelee is relatively protected at a crucial time of the year either by an ice barrier along the beach or by an ice cover over the west basin for a three-month period during a normal winter. The east shore, on the other hand, may be exposed to open water conditions for a greater length of time. Dickie et al. (1974) have found that ice ridge development along the east beach of Point Pelee, which is generally of greater magnitude as opposed to the west side, results in an overall steepening of the beach face and, consequently, is more vulnerable to erosion. Furthermore, where ice ridges did not form, there was evidence of severe wave action which resulted in breaks to the sand bar at the south tip. Therefore, winter conditions on the east side tend to have considerable impact despite ice formation and may, in fact, augment the erosive

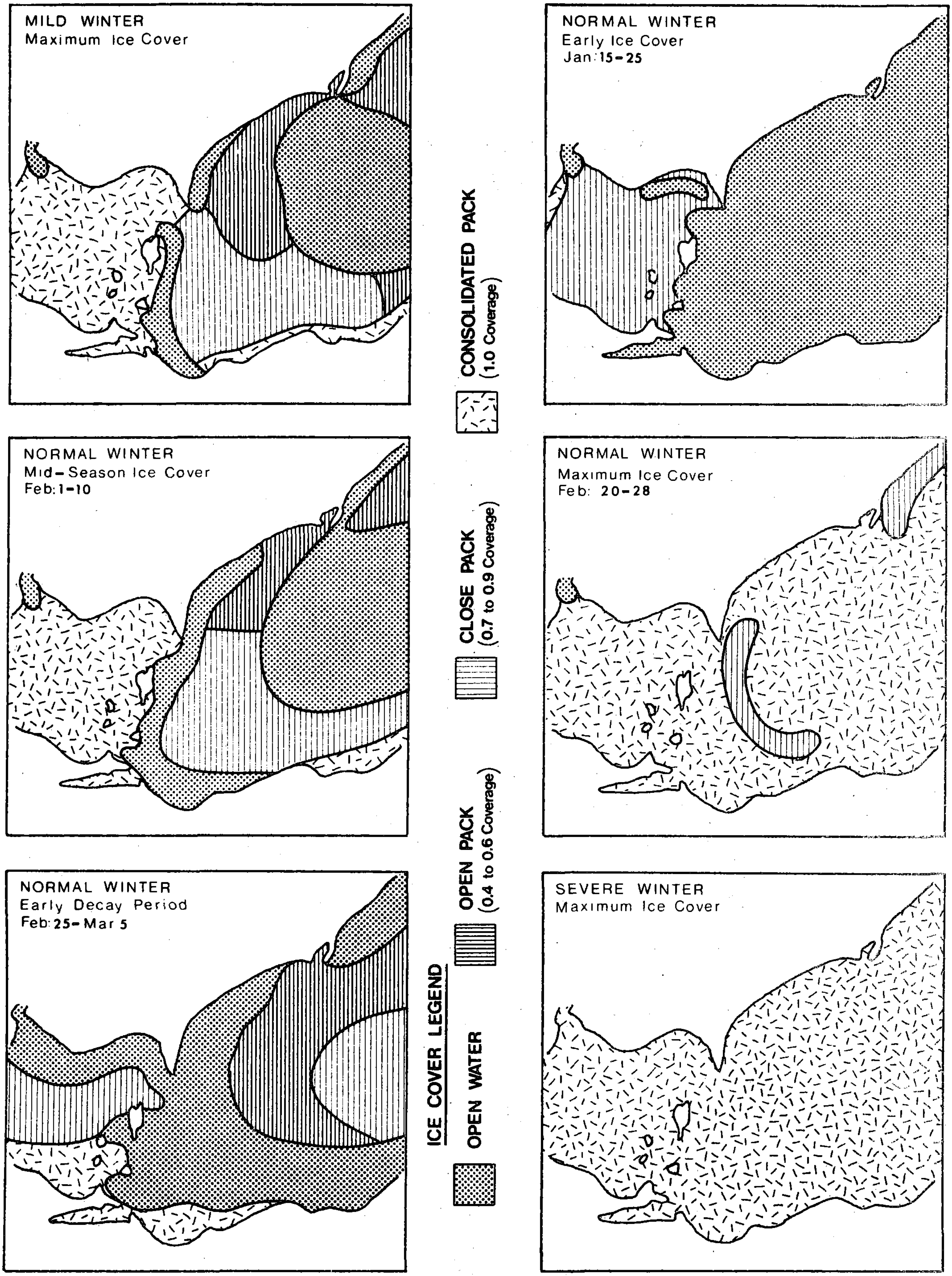


FIGURE 3.6 EXTENT OF ICE COVER ON LAKE ERIE DURING MILD, NORMAL AND SEVERE WINTERS [from Rondy, 1971]

process, which is in contrast to the minimal effect of ice and winter processes on the west side. This is substantiated in view of the relative degree of beach response.

During the period from November through to March, profile changes on the east beach showed an average loss of 18.2 m^2 while the west beach evidenced an average gain of 4.2 m^2. Stations E-1-27B and E-1-27C were not included in the averaged values as changes in profile are largely influenced by the continuous shifting action of the tip of the sand spit.

CHAPTER 4

4.0 COASTAL RESPONSE

As a direct measure of the magnitude of response to the process elements, a series of profiles at selected sites surrounding Point Pelee (Figure 1.1) were surveyed on a weekly to monthly basis using conventional topographic and hydrographic techniques. Accuracies for the subaerial portion of the beach profile (topographic methods) are within 0.03 m vertical and 0.05 m horizontal. The extension of the beach profile into the nearshore and offshore zones was obtained through hydrographic survey methods. Variability of the sounding process was determined by a repeatability test measuring a single line five times. As a measure of depth variation, one standard deviation was .09 m, while the total area deviation under a common specified datum varied a maximum of 1.2% from the mean. Quantitative changes to the subaerial/subaqueous profiles were derived from integral analysis for each segment of the profile as indicated in the beach nomenclature of Figure 1.2; the beach consisting of the backshore and foreshore representing changes in above datum, Table 4.1; the nearshore extending from the foreshore (≃1m depth) to the base of the slope or edge of the Pelee rise, Table 4.3; and the offshore extending 1 km beyond the base of the nearshore slope, Table 4.5. This data is presented as cross-sectional units (m^2) in this chapter to quantify the morphologic change in profile, and in m^3 in Chapter 5 for a volumetric description of the sediment budget.

4.1 BEACH ZONE

The degree of response of the exposed or subaerial portion of the beach profile is of particular significance in this study as the low-lying, ecologically-sensitive hinterland is directly dependent on the natural barrier protection of the raised beach rim. In the preceding chapters, it has been emphasized that the west and east shores of Point Pelee are subject to process elements which vary in magnitude and character. The effects of such variability become evident in comparing the morphological changes to sweep zones for the west and east beaches. Sweep zones represent the physical limits or envelope within which beach changes occur during a specified survey period. The lower limit, therefore, represents periods of maximum erosion and the upper limit periods of marked accumulation. Figure 4.1 shows very little change for the west beach of Point Pelee between the 1974 and 1975 surveys as sweep zones for the two periods approximate each other. Minor variances, however, occur as 1975 profiles indicate an accumulation zone near water's edge resulting in a slight concavity to the sweep zone profiles at stations centrally located along the west shore (E-1-26, 26D), as opposed to the predominant convex slopes of the other beach profiles. Beaches to the south, and near the tip of the Point, evidenced less sediment removal during the 1975 period as lower limits of the sweep zone were 0.7 m above that of 1974 (E-1-27), while upper limits did not change. Greatest accumulation occurred 1 km north of the tip (E-1-27A), where beach elevations were consistently higher in 1975 with a maximum range of deposition between successive sweep zones of 1.5 m, representing a cross-sectional area 17.9 m^2 (Table 4.1). No consistent trend of seasonal erosion or deposition was evidenced with lower limits in most cases defined by June profiles in 1974 and April, August, and November in 1975. Periods of maximum accumulation also varied between years with upper limits defined by September/October profiles in 1974 and April, August, October, and November profiles in 1975.

In contrast to the regular, smooth profiles of the west beach where annual net changes were either insignificant or in the form of narrower, raised sweep zones, the east beach evidenced severe erosion, as indicated by the magnitude of downward displacement of the 1975 sweep zones in Figure 4.2. Lower limits of the set of profiles show the removal of 1-2m of beach material relative to the storm profiles of 1974. From Table 4.1, this represents an average cross-sectional loss as of April, 1975, of 18.2 m^2 from the east beach of Point Pelee, (station E-1-27C excluded), with a maximum loss of 30.8 m^2 at station E-1-30. By the end of the 1975 survey period, the maximum sediment restored to the beach profile did not exceed 4.5 m^2. Again, a moderate response was evidenced for the central reach of the shoreline (E-1-28D) relative to survey sites to the north and south. Here the sweep zones were much

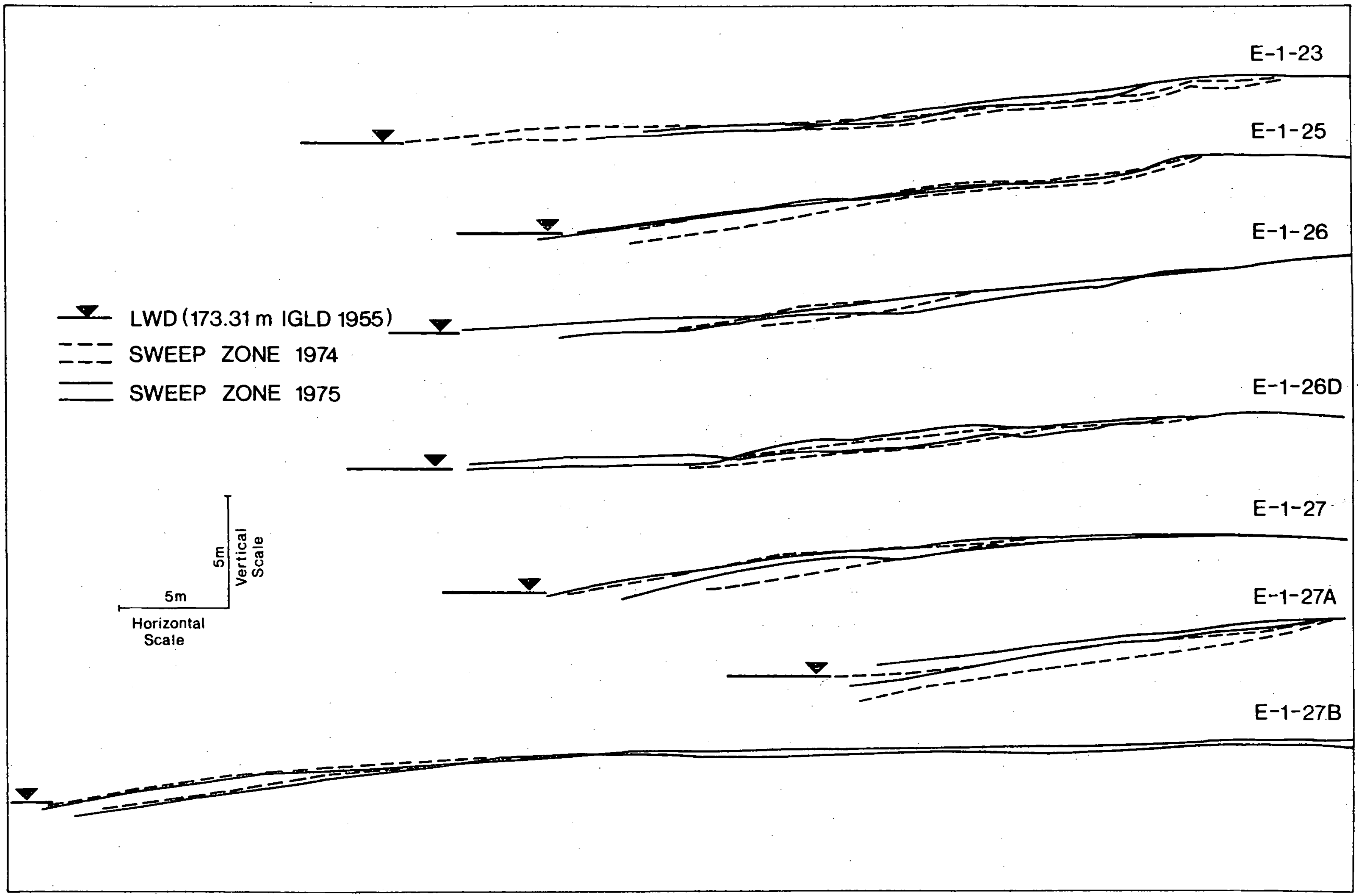


Figure 4.1 Sweep zones of beach profiles for the west shore of Point Pelee.

EROSION STATION	1974 APR.	1974 MAY	1974 JUNE	1974 JULY	1974 AUG.	1974 SEP.	1974 OCT.	1974 NOV.	1975 APR.	1975 MAY	1975 JUNE	1975 JULY	1975 AUG.	1975 SEP.	1975 OCT.	1975 NOV.
E-1-23			- 0.71			- 7.78			0.00		- 1.89		- 4.63			
E-1-25	- 5.73		- 1.99			0.95	- 5.51		0.00		1.86		2.04			
E-1-26			- 2.12			- 0.80	1.63		0.00		- 0.09		- 0.14		2.03	
E-1-26D		-4.31	- 2.07			1.01	- 3.74		0.00		2.47		3.64		-0.32	- 5.74
E-1-27		-0.60	2.37			6.32	- 5.18		0.00		2.84		7.30		3.91	2.40
E-1-27A			-17.92			-12.45	- 8.37		0.00		- 5.86		- 7.48		6.56	3.86
E-1-27B			2.90			4.44	7.80		0.00		0.62		- 4.44		-5.99	- 2.56
SPOKE 1				4.87		7.54		5.54	0.00		- 6.97		- 8.81		6.76	1.99
2				-13.06		-12.20		-19.03	0.00		-43.04		-44.82		15.50	- 6.21
3				- 9.97		34.68		26.93	0.00		-55.67		-33.30			-80.90
4				4.59		21.86		23.79	0.00		28.12		42.11			
5				4.18		15.36		14.80	0.00		14.87		22.72			
6				3.79		12.97	2.25	13.24	0.00		9.38		17.41			- 8.19
E-1-27C			- 7.36			-13.21	-10.50		0.00		2.85		0.73			- 3.85
E-1-27D			26.69			11.62	19.02		0.00		- 0.63		3.72			4.46
E-1-28	22.80		17.44	16.49		15.87	14.43		0.00		- 0.54		3.44			- 3.60
E-1-28D			10.43			10.87	12.52		0.00		- 0.94		0.05			
E-1-28H			16.22			15.19	14.24		0.00							
E-1-30			31.14	29.30			30.80		0.00			-5.60	- 5.51		-15.22	-18.16

Note:

Negatives denote the amount of material required to replenish beach to April 1975 level shown as 0.00.

TABLE 4.1: Cross-Sectional Changes (m^2) to the Beach Zone of Point Pelee relative to April, 1975.

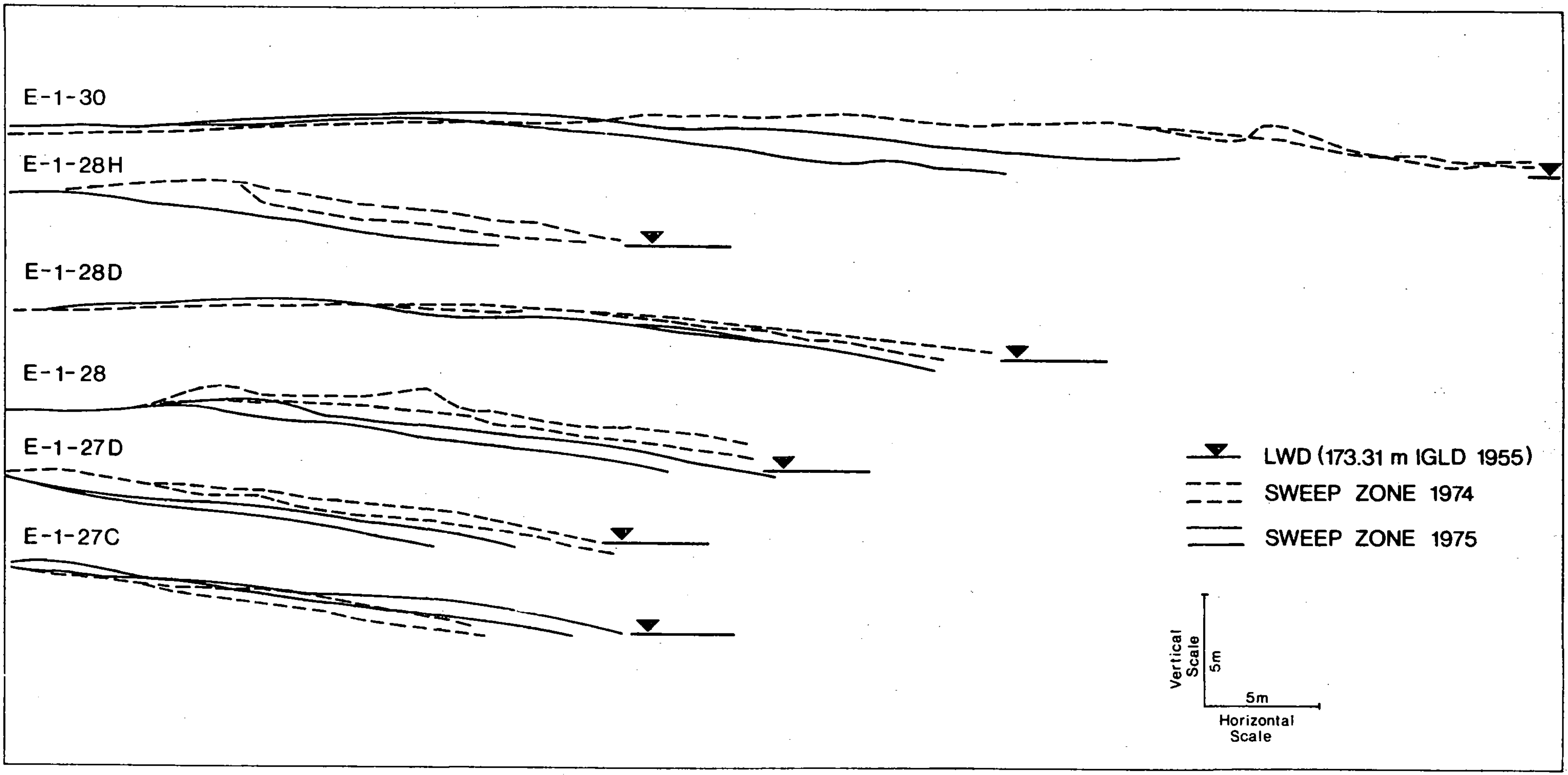


Figure 4.2 Sweep zones of beach profiles for the east shore of Point Pelee.

narrower with a slight drop in 1975. Erosion limits for 1974-1975 were attained on the east shoreline in September and November, respectively, while maximum deposition was attained during April/June/October, 1974, and May/June/August, 1975.

Sweep zones for the spoke network, Figure 4.3, represent changes in profile to the treeless spit 0.5 km in length at the tip of Point Pelee. This area is also highly responsive to the process elements as vertical dimensions of sweep zones were 1.5-1.8 m which is comparable to the eroding east shoreline. The dimensions of the sweep zones of the spoke network, however, simply show the transfer of material as the spit shifts in position as opposed to large volumes of net erosion. A good example of this type of shift occurred within a 57-day interval between April 30 and June 27, 1975. The west shore of the sand spit lost an average cross-sectional area of 26.27 m^2, while the east beach of the spit was in response to an episodic event, as in a storm surge. Beach changes averaged 0.24 m^2 deposition and 0.70 m^2 erosion on the west and east sides of Point Pelee, respectively, during the corresponding period. Neither was there significant berm development on either shoreline which would have resulted from surge conditions. Furthermore, simultaneous water level records for the west and east gauges near the tip of the Point show no evidence of a storm surge with a maximum variation of 4 cm. Hydraulic gradient-induced currents would not, therefore, also have played a major role in the realignment of the spit.

As a matter of deduction then, the shift occurring between May and June was gradual and in response to the prevailing nearshore currents.

It is evident, from the relative dimensions of the sweep zones, that the degree of response for the various beach reaches varies considerably. As a measure of the variability of response (or index to the impact of the process elements), the standard deviation (σ) was calculated for changes in cross-sectional area for each survey interval and listed in Table 4.2. Stations are from N to S for Pelee west and east beaches.

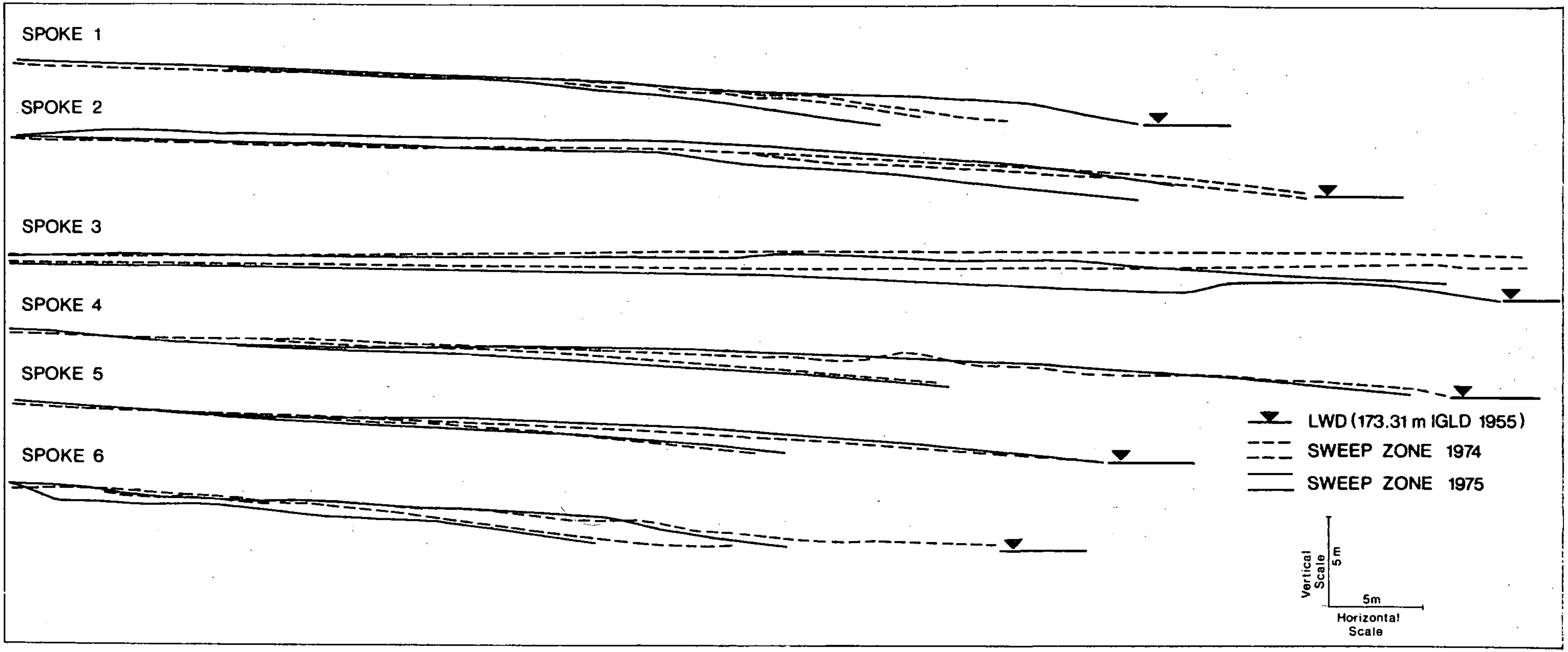


Figure 4.3 Sweep zones of beach profiles for the treeless tip of Point Pelee.

TABLE 4.2

Variability of Beach Response at Point Pelee

PELEE WEST (Station)	(σ)	SUBAERIAL SAND SPIT (Station)	(σ)	PELEE EAST (Station)	(σ)
E-1-25	3.06	E-1-27B	4.11	E-1-30	22.69
E-1-26	2.38	Spoke 1	9.11	E-1-28H	-
E-1-26D	3.31	" 2	16.20	E-1-28D	6.47
E-1-27	4.27	" 3	45.72	E-1-28	9.68
E-1-27A	5.06	" 4	13.47	E-1-27D	10.41
		" 5	6.61		
		" 6	8.68		
		E-1-27C	6.30		

The tip of the Point Pelee sand spit is the most variable with standard deviations of 6.61 to 45.72. This is a reflection on the continuous adjustment of beach material as the spit shifts position in response to lake processes. Both the east and west beaches of Point Pelee show an increase in variability in a southerly progression, with the east beach being generally the more variable of the two. The high variability of Station E-1-30 is believed to be the influence of timber crib groynes which, by 1974, had shoreward ends 10m offshore.

In spite of the fact that the east beach has been shown to have a more variable cross-sectional response, the west beach indicates a greater rate of response. Changes in beach profile (m^2) at each survey station were divided by the number of days between surveys. In aggregating those showing positive and negative changes in profile, average and maximum rates of beach accumulation and erosion were calculated for the west, east and spoke profiles.

Beach accumulation on the west beach was twice that of the east beach with an average of .34 m^2 /day and maximum rate of 1.03 m^2 /day. Corresponding values for east Pelee were .15 m^2 /day and .46 m^2 /day respectively. The maximum rate on the west beach occurred during a five-day survey interval in June, 1974. Winds were light and variable for the first three days, while the following two days preceding the resurvey of the beach were characterized by NE and NNE winds of 16 to 35 km/hr (Windsor data as no record for Pelee exists), and are thus believed to be of most consequence.

Observed significant wave heights for Pelee west and east under these conditions were 0.6m and 1.4m with peak periods of 3.1 and 6.5 seconds, respectively. On a relative basis, the observed waves characterizing the west shoreline during a period of a maximum rate of beach accumulation were short and low, which King (1972) associated with the building up of a beach. Maximum rate of accumulation for the east beach occurred over a 16-day interval in September, 1974, and did not appear to be related to any episodic wind conditions.

Rates of beach erosion did not vary significantly between west and east beaches with an average rate of .32 m^2 /day and .38 m^2 /day, respectively. The west side again experienced the maximum recorded rate of change with a net loss of .81 m^2 /day when compared to .73 m^2 /day for the east beach. The excessive rate of loss on the west beach was preceded by a four-day interval of prevailing NW winds having an average velocity of 26 km/hr, resulting in observed significant wave heights of up to 1.34 m with a peak wave period of 5.06 seconds. The only distinct wind condition which may be related to the maximum rate of loss measured on the east shore was a consistent north wind of strengths not exceeding 21 km/hr during the last three days of the survey interval, with a maximum significant wave height recorded of .55 m. This may be important since northerly fetches are generally excluded at Point Pelee in wave energy calculations, Skafel (1975) and Gillis (1975). Wave heights measured on the west side of Point Pelee during a 24-hour north wind of 32-40 km/hr in December, 1974, reached .98 m. Corresponding values on the east side measured 2.4 m. However, as the wave gauge is approximately 9 km offshore, nearshore conditions are not known.

Rates of beach response are, of course, a function of time and therefore dependent on the duration of the survey interval. Consequently, the maximum rates of recovery and erosion expressed above may, in fact, be an underestimate of potential rates which can only be determined by increasing the number of observations.

4.2 NEARSHORE ZONE

Morphologic changes to the nearshore zone of Point Pelee were expressed in shifts and redistribution of the submarine bar. The east shore had the most pronounced alterations to its profile between the fall of 1974 and spring of 1975, respectively, as evidenced at Stations E-1-27D and E-1-28D, Figure 4.4. At the northerly station (28D), the single-crested bar characteristic of the 1974 profiles had transformed into a double-crested bar by May of 1975, which was maintained throughout the remainder of the 1975 survey period. Reference to the summary of quantitative changes in cross-sectional area, Table 4.3, shows the alteration of the nearshore profile extending 800 m offshore involved a total accumulation of 32 m^2 in cross-sectional area.

In contrast to the bar reformation of E-1-28D, at a location 3.2 km to the south (27D), the submarine bar was transformed from a double-crested bar to a single crest, 0.9 m above the former and 30 m landward. Evidence of outer bar formation occurred at 200 m, with a weaker crest at 300 m offshore. Cross-sectional area showed a gain of material of 141 m^2 (Table 4.3).

The transformation of the nearshore morphology reflects on an abundance of material available for such bar development during the 1974-1975 survey interim, and, secondly, on a wave climate which was significantly variable from one year to the next to maintain the morphologic changes which had occurred. The relationship between the breakpoint and position of the submarine bar, established by Otto (1912), Evan (1940), and Keulegan (1945), was taken out of King (1972, p. 336). There is evidence to substantiate that the supply of material to the submarine bar development of 1975 originated from excessive erosion to the east beaches during the corresponding period (fall 1974 - spring 1975) where average erosion measured 18.2 m^3/m (Table 4.1). Furthermore, wind data at Point Pelee (Appendix) shows that the prevailing direction during the survey periods switched from a NS axis in 1974 to one from the SW in 1975. The consequence to respective wave climates, however, is thought to be of minor significance as sweep zone limits did not vary substantially for the corresponding periods.

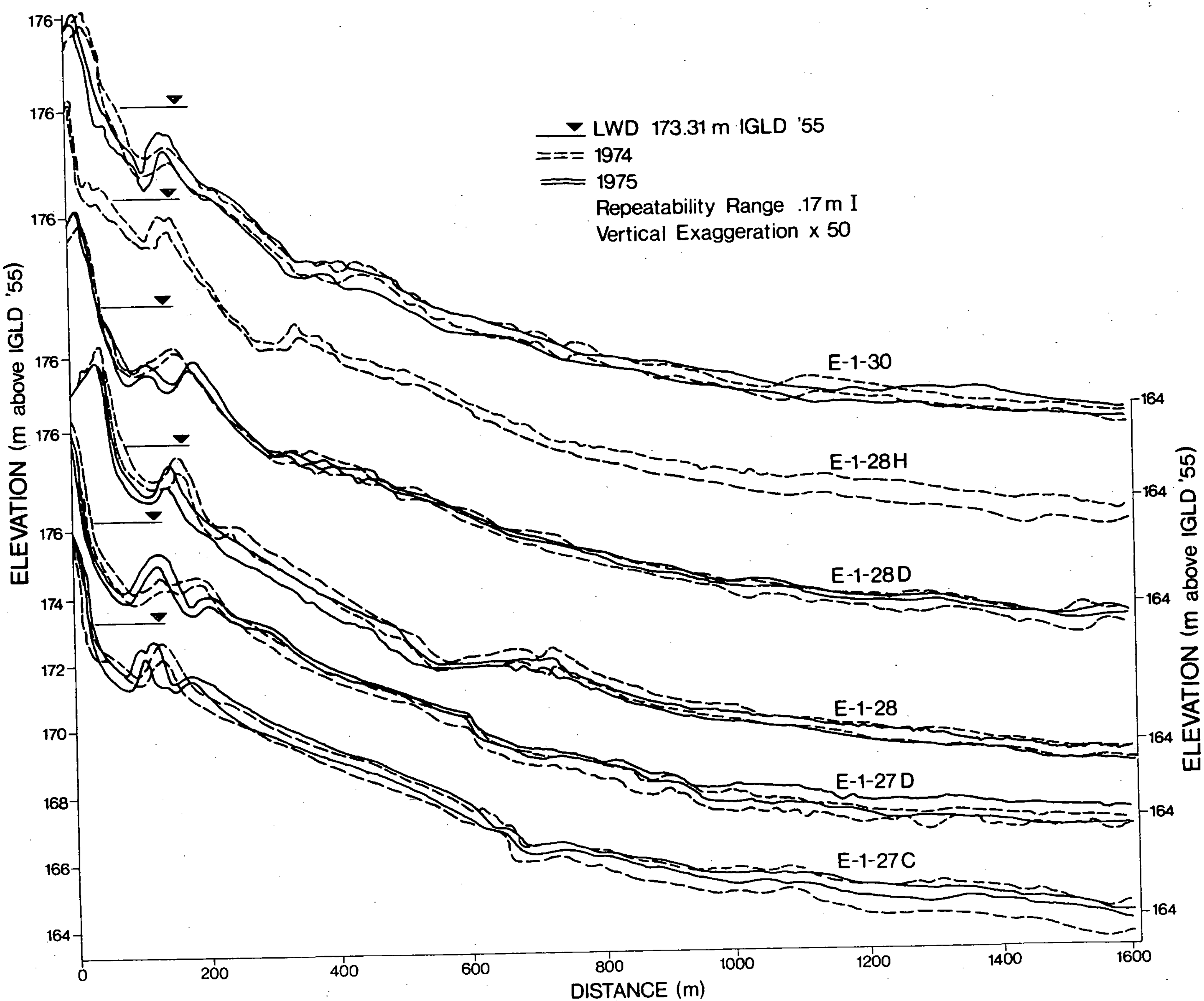


FIGURE 4.4 SWEEP ZONES OF THE 1974-75 NEARSHORE-OFFSHORE PROFILES OF POINT PELEE EAST

EROSION STATION	BREADTH OF NEARSHORE ZONE (m)	1974								1975							
		APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.
E-1-23	900			.10			.11			0.00		-.01		-.06			
E-1-25	700			-.08			.16	.13		0.00		.14		-.10		-.02	
E-1-26	700			.20			.09	.26		0.00		-.06		-.09		-.00	-.06
E-1-26D	700		-.26	.06			-.02	-.04		0.00		.01		-.20		-.22	
E-1-27	600		-.14	-.03			.08	.08		0.00		-.10		-.16		.13	-.17
E-1-27A	500			.28			-.05	.25		0.00		.10		-.25		-.03	
E-1-27B	500		-.33	.04			-.08	.03		0.00		-.09		-.16		-.09	.27
Spoke 1	500				-.40		-.26		-.37	0.00		-.41		-.34		-.41	
2	700				-.68		-.21		-.25	0.00		-.30		-.35			
3	800				-.76		-.48		-.35	0.00		-.32		-.41			
4	800				-.51		-.16			0.00		-.26		-.26			
5	800						-.52		-.46	0.00		-.02		.05			
6	800				-.36		-.06	-.09	-.11	0.00		-.09		-.15			
E-1-27C	800			-.07			-.04	-.13		0.00		-.25		-.27			-.27
E-1-27D	800			-.38			-.09	-.18		0.00		-.21		-.22			
E-1-28	800			-.03			-.03	-.06		0.00		-.25		-.31			
E-1-28D	800			.10			-.01	-.04		0.00		.00		-.15			
E-1-28H	800			0.00			.08	-.10									
E-1-30	800			-.25	-.05			.02		0.00			-.09	-.19		-.27	-.16

Note:

Negatives denote the amount of material required to replenish beach to April 1975 level shown as 0.00.

TABLE 4.3: Cross-Sectional Changes (m^2/m) to the Nearshore Zone of Point Pelee relative to April, 1975.

The west beach of Point Pelee did not show significant change to the nearshore profile with the exception of small shifts to the submarine bar, and a much narrower sweep zone in 1975 at E-1-27B, Figure 4.5. Variations in submarine bar development were minimal and occurred generally throughout the entire reach length in response to small fluctuations in water levels and wave climate. However, the reduction in the size of the sweep zone from approximately 1m to .25m for 1974 and 1975, respectively, is a substantial change. Because changes of this magnitude were limited to the most southerly station E-1-27B, on the otherwise relatively stable west shore, it is felt that such variation in annual sweep zones is due to the station's location, .5 km north of the tip, where it is influenced by the shifting tip of the sand spit.

Figure 4.6 shows dramatic changes in bottom profiles to the nearshore (and offshore) of the submerged spit extension. The impact of movements in spit position on bottom profiles is quite evident, particularly in reference to the centrally located Spokes 3, 4 and 5. Within the nearshore zone (800 m), the upper nearshore slope of Spoke 3 shows an annual net recession of 80 m, while Spokes 4 and 5 during the corresponding period evidenced significant accumulations. This would indicate a net shift of spit material from west to east. The large volumes of accumulation, especially along Spoke 5, could have been the result of the high erosion losses from the east beach averaged at 18.2 m^2 (Table 4.1).

Seventy-eight per cent of the recorded changes in profile to the west nearshore zone were within repeatability error limits established at 2σ (.17m) for a 95% confidence interval. Northerly stations E-1-23/25/26 had no significant changes, while at the more southerly reaches profiles of May, 1974, and August, 1975, show an average depletion relative to April, 1975, on the order of 0.24 m^2/m and 0.19 m^2/m, respectively (Table 4.3).

Approximately half of the nearshore morphologic changes to the east side of Point Pelee involved volumetric displacements greater than 2σ, most of which are subsequent to the May 1975 profile. The magnitude of change was relatively evenly distributed along the east shore (unlike

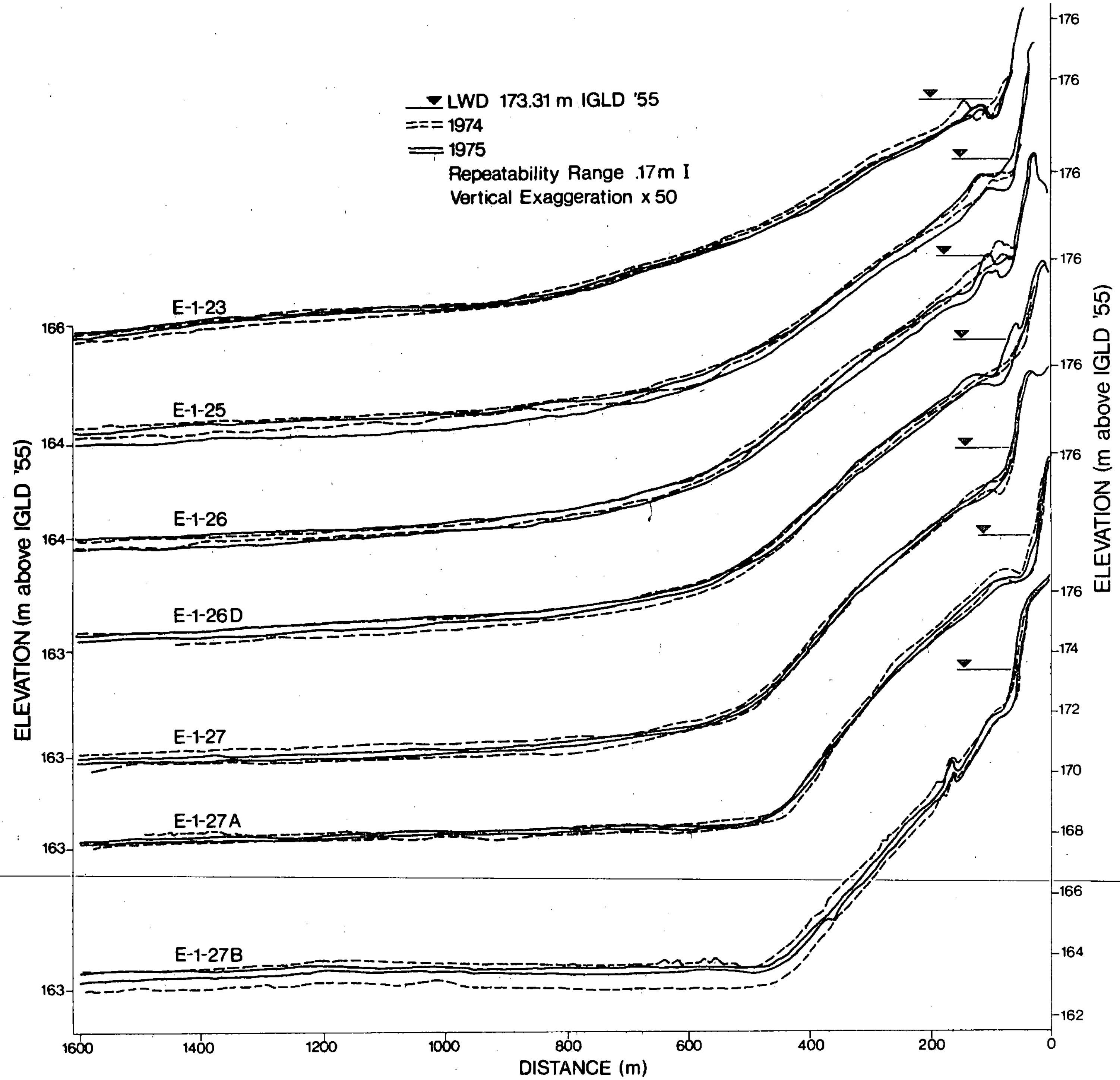


FIGURE 4.5 SWEEP ZONES OF THE 1974-75 NEARSHORE-OFFSHORE PROFILES OF POINT PELEE WEST

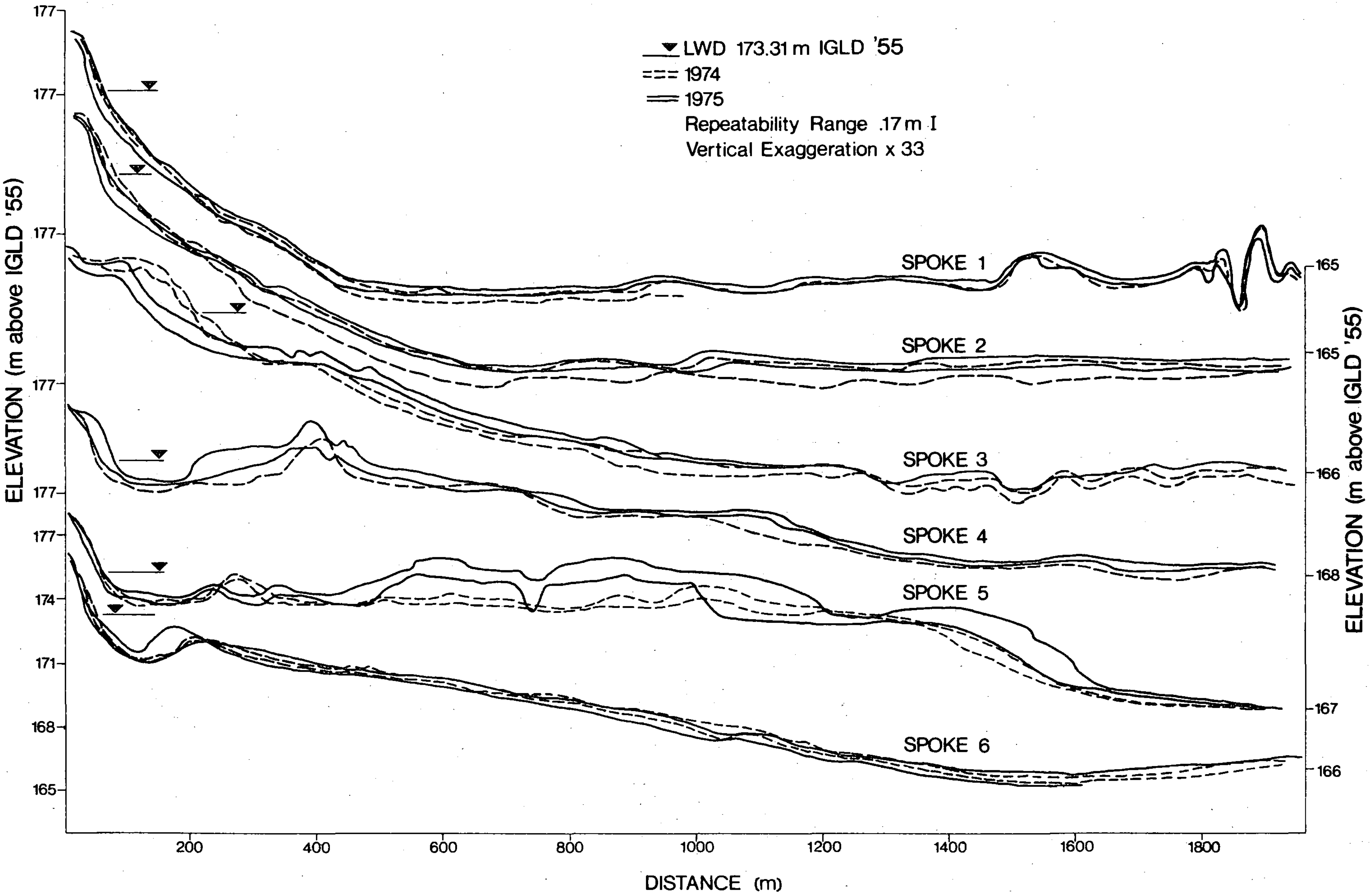


FIGURE 4.6 SWEEP ZONES OF THE 1974-75 NEARSHORE-OFFSHORE PROFILES OF POINT PELEE SOUTH

beach response) and, furthermore, volumetric calculations indicate that the spring profile of 1975 was one of marked accumulation, as subsequent profiles of June and August averaged 0.23 m^2/m less.

The configuration of the subaqueous spit, as measured by the April 1975 profiles of Spokes 1-6, Figure 4.6, conforms to 1975 spring accumulations with profiles exceeding those of 1974 by an average of .32 m^2/m and those subsequent to April by 0.26 m^2/m. (73% of the spit profiles evidenced a measurable change of greater than 2σ.)

It is conceivable, therefore, that the erosion to the east beaches of Point Pelee during the 1974-1975 survey interim is related to the marked spring accumulations along the east nearshore zone and April buildup of the subaqueous spit.

The variation of response is not as distinct as was the case for beach volumetric changes. However, in comparing the standard deviation (σ) of the nearshore profile changes (m^2/m) relative to April of 1975, Table 4.4, the west nearshore zone shows slightly higher dispersion relative to that of the east stations. Stations are listed from north to south for Pelee west and east reaches.

Table 4.4

Variability of Nearshore Response at Point Pelee

PELEE WEST		SAND SPIT		PELEE EAST	
(Station)	(σ)	(Station)	(σ)	(Station)	(σ)
E-1-23	0.08	Spoke 1	0.06	E-1-30	0.11
E-1-25	0.12	" 2	0.19	E-1-28H	-
E-1-26	0.14	" 3	0.05	E-1-28D	0.10
E-1-26D	0.13	" 4	0.15	E-1-28	0.17
E-1-27	0.12	" 5	0.29	E-1-27D	0.11
E-1-27A	0.20	" 6	0.11	E-1-27C	0.10
E-1-27B	0.13				

4.3 OFFSHORE ZONE

Changes to the offshore profile at depths greater than 8 m were limited to fluctuations in bed elevations as opposed to actual changes in morphology as was evidenced in the nearshore zone. On a relative basis, the magnitude of change varied considerably and in some respects substantiates anomalies in beach response discussed earlier.

Generally the magnitude of response as measured by sweep zone limits, Figures 4.4 to 4.6, was within 0.5m, with the exception of stations at the tip of Point Pelee, where sweep zone dimensions reach 0.7m to 0.9m. A moderation in response is evident at mid-reaches of Point Pelee, also noted in beach response, where maximum variation in profiles did not exceed 0.3m to 0.4m.

Spoke profiles indicate substantial changes to the offshore zone at Spoke 5 (Figure 4.6), which aligns with a southeasterly-oriented subaqueous spit. The spring transposition of the spit toward the east resulted in profound changes to the topography of the offshore zone, with accumulations of 1.5m up to distances of 1,600 m offshore.

Table 4.5 summarizes in quantitative terms volumes of displaced bottom material expressed relative to the spring profiles of 1975. Offshore response of the east side of Point Pelee is similar to that of the nearshore zone, showing spring to be a period of marked sediment accumulation. Cross-sectional areas of spring 1975 profiles averaged 0.04 m^2/m greater than fall 1974 profiles and 0.19 m^2/m greater than subsequent June 1975 profiles. Spring accumulations did not occur on the west side of Point Pelee, however, as profiles generally show a period of sediment loss averaging 0.19 m^2/m when compared to fall 1974 profiles, and 0.23 m^2/m relative to June 1975 profiles.

Approximately half of the quantitative changes are within the 2 σ envelope of error for east and west profiles, while only 31% of the spoke network is within these limits. As a measure of variability of response in the offshore zone, the standard deviation (σ) in m^2/m is indicated in a north to south listing (see Table 4.6).

EROSION STATION	1974 APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	1975 APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.
E-1-23			.01			.05			0.00		.01		.09			
E-1-25			.03			.53	.27		0.00		.40		.76		.31	
E-1-26			.22			.29	.24		0.00		.33		.31		.17	.15
E-1-26D			-.48			.20	.18		0.00		.14		.23		.15	
E-1-27		-.10	-.01			.25	.16		0.00		.08		.17		.25	.15
E-1-27A			-.47			.03	.12		0.00		.06		.17		.13	
E-1-27B		-.47	.13			.13	.17		0.00		.19		.23		.04	.03
Spoke 1						-.29		-.42	0.00		-.33		.01		-.26	
Spoke 2				-.73		-.25		-.29	0.00		-.15		.01			
Spoke 3				0.00		.37		.46	0.00		.45		.55			
Spoke 4				-.28		.39			0.00		.02		-.08			
Spoke 5						.26		.55	0.00		1.15		1.00			
Spoke 6				-.42		-.09	.01	-.01	0.00		.13		.03			
E-1-27C			-.22			.11	-.18		0.00		-.19		-.08			
E-1-27D			-.41			.11	-.13		0.00		-.23		.15			
E-1-28			-.30			.08	.12		0.00		-.13		.18			-.26
E-1-28D			-.12			-.05	-.01		0.00		-.22		.02			
E-1-28H			0.00			.48	.19		0.00							
E-1-30			-.70	-.05			-.02		0.00			.07	-.03		-.16	-.18

Note:

Negatives denote amount of material required to replenish profile to April 1975 level shown as 0.00.

TABLE 4.5: Cross-Sectional Changes (m^2/m) to the Offshore Zone within 1,000 metres of the Edge of the Pelee Rise, relative to April, 1975.

Table 4.6

Variability of Offshore Response at Point Pelee

PELEE WEST (Station)	(σ)	SAND SPIT (Station)	(σ)	PELEE EAST (Station)	(σ)
E-1-23	0.04	Spoke 1	0.16	E-1-30	0.26
E-1-25	0.25	" 2	0.13	E-1-28H	0.10
E-1-26	0.07	" 3	0.07	E-1-28D	0.15
E-1-26D	0.27	" 4	0.25	E-1-28	0.21
E-1-27	0.12	" 5	0.41	E-1-27D	0.23
E-1-27A	0.23	" 6	0.08	E-1-27C	0.14
E-1-27B	0.22				

Beyond the limits of the offshore zone, changes in the lake bed are recorded along spoke profiles 1 and 2. At a distance of 3,000 m, these profiles intersect a 10 m deep trench illustrated in the raised sectional of Figure 2.1 and Figure 2.3. Figure 4.7 shows changes in the depth of the trench at profile intersections recorded during the 1974-1975 sounding surveys.

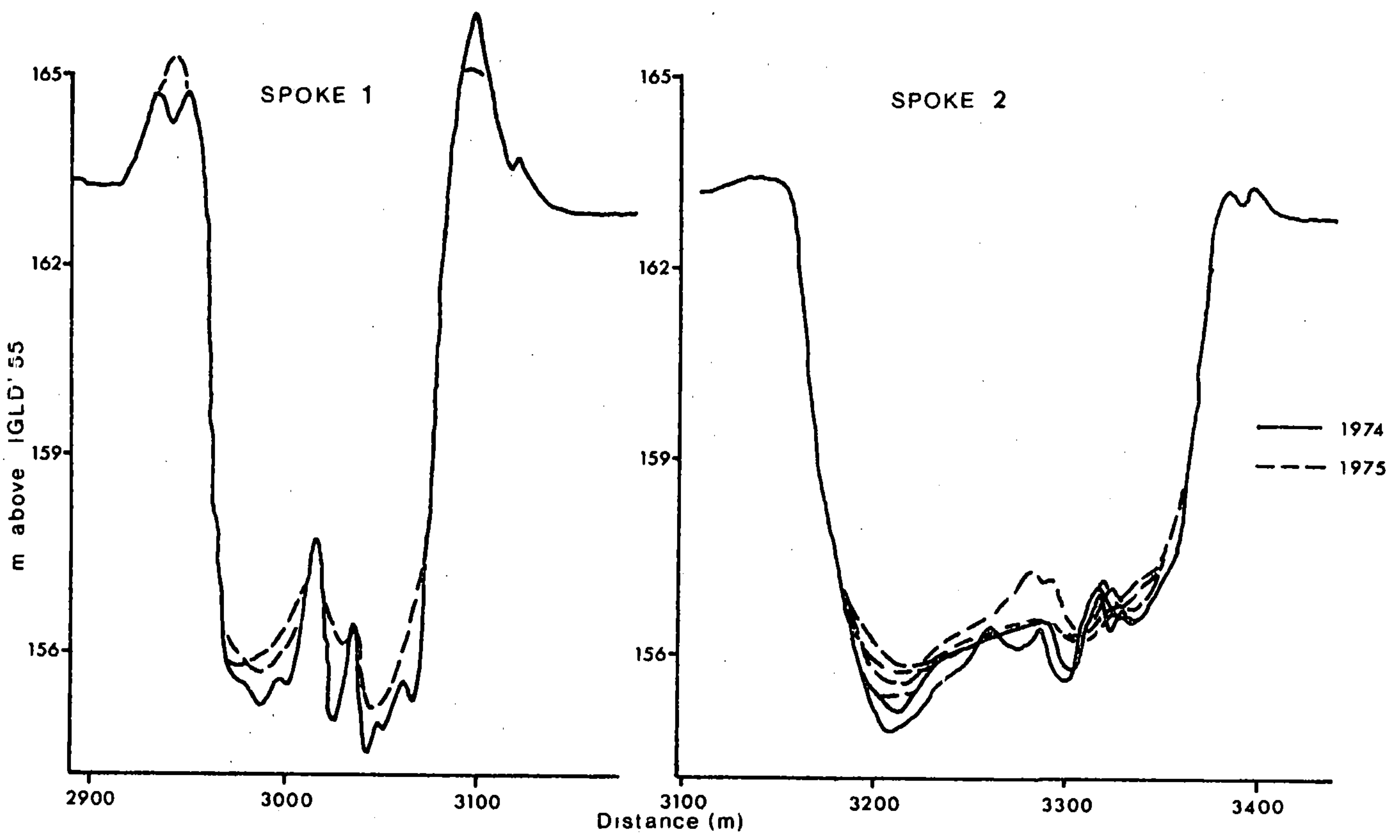


Figure 4.7: Evidence of Trench Infilling

Bottom relief at the base of the trench has been altered with sediment accumulating in depressions. This has had an overall smoothing effect. The probability of these changes being attributed to recording error is small, since the raised segments of the trench floor did not evidence equivalent changes. Average accumulation relative to September, 1974, was 22 m^2 and 68 m^2 for Spokes 1 and 2, respectively.

CHAPTER 5

5.0 POINT PELEE ANNUAL SEDIMENT BUDGET FOR 1974-1975

An annual record of changes to a beach profile is an inaccurate estimate of its sediment budget if it is based upon the planimetric difference of two profiles. This becomes particularly evident in reference to the variation in short-term rates of beach response. Therefore, in order to improve upon the budget estimate, it is best to compare the means of two sets of observations, which, in effect, eliminates episodic fluctuations in profile response. Consequently, the sediment budget merely represents a trend. Further smoothing of short-term fluctuations in profile was accomplished in reducing volumetric calculations by an error factor based on sounding and spacing errors and dimensions of the reach described by King (1972).

In comparing the means of the 1974 set of observations with that of 1975, Table 5.1 summarizes, by zone, the net volume of material gained or lost within the Point Pelee sediment budget to a distance of 1 km beyond the edge of the Pelee rise.

Table 5.1

Net Volumetric Changes
for the Point Pelee Budget Year 1974-1975

POINT PELEE WEST			POINT PELEE EAST		
Offshore	Nearshore	Beach	Beach	Nearshore	Offshore
+640,227m^3	-943,214m^3	+44,741m^3	-218,616m^3	-224,982m^3	+611,073m^3

Despite the averaging and reductions required in compensating for error, the magnitude of volumetric changes are significant not only in absolute terms but also on a relative basis.

Accretion to the west beach corresponds to the pattern of beach ridge development and the interpretation of a westerly migration of the shoreline by Kindle (1933), Coakley (1972) and Bukata et al. (1974). Furthermore, erosion to the east beach is in agreement with the suggestion by Coakley (1972) that the east shore is also migrating west as interpreted from an apparent wave cut abrasion ramp in the nearshore till outcrop.

Profile data indicates, in quantitative terms, the rates at which the shorelines are changing. Variation in the "rates" of migration for the west and east shorelines is of particular importance as it is the magnitude of this variation which ultimately decides the fate of Point Pelee. Volumes derived from 1974-1975 data, if they may be used as a measure of "migration", indicate a rate for the east beach (trailing edge) five times that of the west shoreline (leading edge).

Changes to the nearshore zone in budget terms indicate a net loss of material on both sides of the Point with the west exceeding the east by approximately four times. This corresponds to further observations of Coakley (1972) whereby it was found that between the years 1964 to 1971, the west edge of the Pelee rise evidenced a pronounced eastward advance. Both offshore zones evidenced net accumulation from 1974 to 1975 of approximately equal magnitude.

Collectively, the sub-budgets of Point Pelee east and west show a net loss of beach and lake bed sediments on the order of 91,000 m^3. This is more than compensated for, however, in accumulation of sediments to the south of Point Pelee. Volume calculations of the spoke network profiles show a net gain of 531,000 m^3, and thus a residual of 440,000 m^3 deposition represents a positive short term trend in the overall Point Pelee sediment budget.

St. Jacques et al. (1976) calculated a sediment budget for Point Pelee based on the thickness and age of sediments in the shoal area south of the Point. For a deposit with an age range of 5,000 to 10,000 years, the annual incremental ranges were estimated at 126,000 m^3 to 63,000 m^3. Skafel (1975) calculated a net longshore sediment transport rate induced by waves on the east shore of Point Pelee at 26,000 m^3.

The 1974-75 budget year estimated as the difference in averaging the two sets of annual profiles is significantly higher than either of the two previous estimates. This may be expected, however, as it is difficult to compare long term averaged annual budget estimates with any one year record due to short term perturbations in the system.

The distribution of erosion rates on the west and east beaches of Point Pelee during 1974-75, furthermore, do not correspond with the predicted pattern by Skafel (1975). Again this may be due to the fact that the quantitative assessment is for a specific period as opposed to a long term estimate; however, the disparity is interesting to note. From the distribution of longshore transport rates Skafel suggests that the west shore is approximately stable, but with the likelihood of some accretion in the north and some erosion in the south. On the east side, erosion prevails, however, it increases toward the south.

From the beach profile data taken in 1974-75, accretion increased toward the south on the west side and erosion on the east shore increased both toward the north and toward the south from the centrally located station E-1-28D.

CHAPTER 6

6.0 CONCLUSIONS

From the preceding analysis of the coastal process and response elements within the Point Pelee spit and shoal system, the following conclusions can be drawn:

(a) Bottom currents exceed critical-traction speeds for sand and fine gravel-sized particles. Currents capable of transporting these sediments accounted for 13% of the period of record at the mooring located near the area licensed for dredging, south of Point Pelee. It also should be noted that 3/4 of the faster currents were toward the northerly direction (toward the shore).

(b) Under wind set-up conditions, the difference between the west and east water levels of Point Pelee may vary as much as 63 cm. Because of prevailing westerly winds, water level elevations on the west side of the Point usually exceed those of the east. However, because effective fetch lengths on the west side of Pelee are less than 50 km, the range of storm levels and wave development are limited. Consequently, beach berms developed on the west side are rarely exposed to destructive storm conditions because of the limiting fetch factor. Therefore relic beach ridges continue to accumulate.

(c) Hindcast wave methods are generally inaccurate for the Point Pelee area. Typical calculated wave heights by reach averaged 22% to 50% less than those observed. However, in relative terms, the west side of Point Pelee is characterized by low, short waves, .56 m in height and 9.6 m in length. Wave heights averaged slightly higher on the east side (.70m) but with much longer wave lengths of 13.2 m. Wave steepness all tended to be destructive in character with reference to critical steepness values after King (1972). Therefore, it appears that the variation in average wave lengths may be the most significant dimension in distinguishing constructive versus destructive waves at Point Pelee. The longer waves reaching the east shoreline permit a more effective backwash when compared to the more swash-effective action of the low, shorter waves on the west side.

(d) The greatest amount of beach erosion occurred on the east side of Point Pelee during the winter months. April 1975 profiles indicated an average cross-sectional net loss of 18.2 m^2. The maximum sediment restored to the beach profile was 4.5 m^2 by the end of the 1975 survey period in November. The east beach also had the greatest variability of response.

(e) The west shoreline of Point Pelee shows the greatest rates of response. Beach recovery was twice that of the east shore with an average rate of .34 m^2/day and maximum of 1.03 m^2/day. The maximum rate of beach erosion was slightly higher on the west side at .81 m^2/day.

(f) Point Pelee annual sediment budget calculations show a net gain of 45,000 m^3 for the west beach, while the east beach lost 220,000 m^3. Therefore, based on the above observations, the east beach is receding westward at five times the rate of advance of the west side.

(g) In total, the east and west coastal zones show a net loss of beach and lake bed sediments of 90,000 m^3. However, to the south of Point Pelee, spoke profiles indicate a net gain of five times this amount which is a positive trend in the sediment budget.

It has not been confidently resolved as to whether the 10 m deep trench south of the Point is a product of the dredging process or a natural depression in the lake bed. The author's opinion is that it is a man-made feature. Not only does the trench enter the area licensed for dredging where sand and gravel deposits are of extensive thickness, but it also closely resembles an example of a mined section in the bed of the St. Mary's River, Figure 6.1.

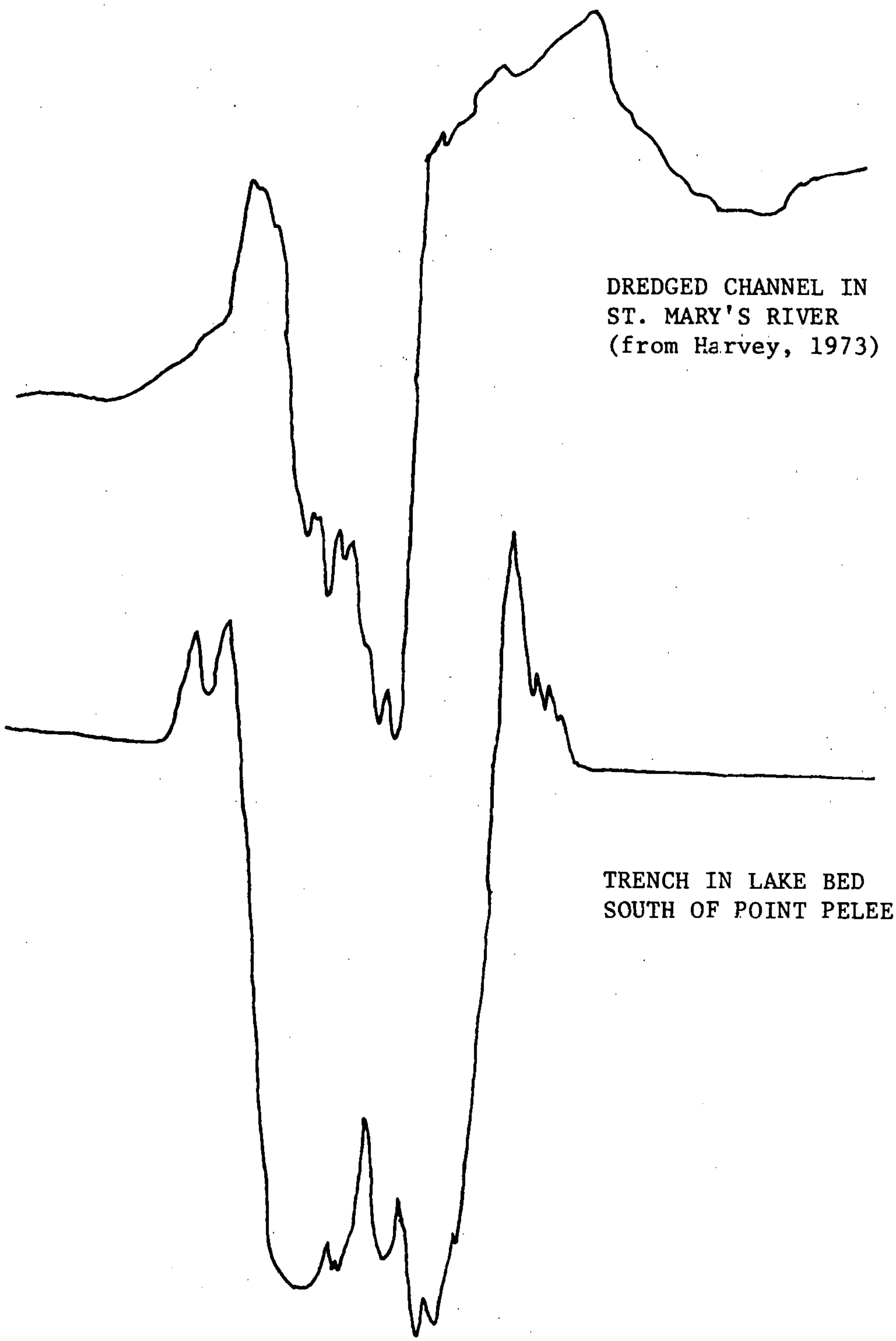


Figure 6.1: Comparison of the Cross-Sections of a Dredged Channel in the St. Mary's River and that of the Trench in the Lake Bed South of Point Pelee.

Effects of gravel extraction on seabed topography near Hastings, Great Britain, have been studied by R. Dickson et al. (1973), from which repeated profile measurements indicate that the dredged pit had apparently deepened under natural conditions during an eleven-month period. It is believed that this was related to a settling of the trench bed due to its stratigraphic nature rather than to scour. The consequences of such alterations could therefore be irreversible. Profile measurements at Point Pelee seem to indicate some infilling, which is further supported by the fact that a sediment surplus was evidenced for the budget year 1974-75. The amount of annual infill, however, suggests that it will be several decades before such features are erased from the bed topography. Consequently, if the lag time in natural rehabilitation equals or is greater than the rate at which channels are made (which is more often the case), then synergistic effects may result.

As one year's record reveals significant variation from averaged long-term estimates, it is recommended that coastal response continue to be monitored in order to further delineate erosional and depositional processes within the budget system under an extended moratorium on commercial dredging.

REFERENCES

Bukata, R.P., W.S. Haras, and J.E. Bruton. 1974. The Application of ERTS-1 Digital Data to Water Transport Phenomena in the Point Pelee-Rondeau Area. Proc. 19th Congress International Association of Limnology, Winnipeg.

Bukata, R.P., W.S. Haras, J.E. Bruton, and J.P. Coakley. 1974. Satellite, Airborne and Ground-Based Observations of Suspended Sediment Transport off Point Pelee in Lake Erie. Proc. Conference on Human Environment, Poland.

Coakley, J.P. 1976. The Formation and Evolution of Point Pelee, Western Lake Erie. Canadian Journal of Earth Sciences, Vol. 13, No. 1, 136-144.

Coakley, J.P. 1972. Nearshore Sediment Studies in Western Lake Erie. Proc. 15th Conf. Great Lakes Res. 330-343.

Department of Mines & Northern Affairs, Toronto, Ontario. 1970. Point Pelee Dredging Area. Map ODM-a-49.

Department of Public Works, Canada. December 14, 1917. Report No. 2913.

Dickie, G.J. and D.F. Cape. 1974. The Effect of Winter Processes on the Shoreline of Point Pelee National Park. Industrial Research Institute of the University of Windsor, IRI, Project 7-44.

Dickson, R. and A. Lee. 1973. Gravel Extraction: effects on seabed topography. Part one of a paper specially written for Offshore Services. Fisheries Laboratory, Lowestoft, U.K.

Fricbergs, K.S. 1965. Beach Stabilization in the Toronto Area. Unpublished Thesis for registration in the association of Professional Engineers of Ontario.

Garriott, E.B. 1903. Storms of the Great Lakes. U.S. Department of Agriculture, Weather Bureau. Bulletin K, W.B. No. 288.

Gillis, J. 1975. A Wave Energy Analysis at Point Pelee. In fulfillment of C.E. 500, University of Waterloo.

Harvey, E. 1973. An Erosion Problem at Poines des Chene Park on the Upper St. Mary's River. Undergraduate Thesis. Environmental Studies, University of Waterloo.

Hunt, I.A. Jr. 1959. Winds, Wind Set-Ups and Seiches on Lake Erie. U.S. Corps of Engineers, Lake Survey Research Report No. 1-2.

Kindle, E.M. 1933. Erosion and Sedimentation at Point Pelee. Ontario Department of Mines, Vol. 42, Part 2.

King, C.A.M. 1972. Beaches and Coasts. Great Britain, Edward Arnold (Publishers) Ltd.

Marine Environmental Data Service, Environment Canada, 1975. Waves Recorded Off Point Pelee (Ont), East Stn. (76), May 10, 1974 - December 11, 1974.

Marine Environmental Data Service, Environment Canada, 1975. Waves Recorded Off Point Pelee (Ont), West Stn. (75), May 22, 1974 - January 6, 1975.

Nevin, C. 1946. Competency of Moving Water to Transport Debris. Bulletin of the Geological Society of America, Vol. 57, pp 651-674.

Rice, C.F. 1970. Introduction to Sediment Analysis. Arizona State University (1st Printing).

Richards, T.L. and D.W. Phillips. 1970. Synthesized Winds and Wave Heights for the Great Lakes, Climatological Studies No. 17. Meteorological Branch, Canada Department of Transport, Toronto.

Rondy, D.R. 1971. Great Lakes Ice Atlas. U.S. Lake Survey Center, NOAA Technical Memorandum NOS LSCR 1.

Rukavina, N.A. and G.A. Duncan. 1970. F.A.S.T. - Fast Analysis of Sediment Texture. Proc. 13th Conf. Great Lakes Res. 274-281.

St. Jacques, D. and N.A. Rukavina. 1976. Lake Erie Nearshore Sediments from Point Pelee to Port Burwell. Hydraulics Research Division, Environment Canada, Burlington. Unpublished Report.

Skafel, M.G. 1975. Longshore Sediment Transport at Point Pelee. Hydraulics Research Division, Canada Centre for Inland Waters. Environment Canada. Unpublished Report.

Sly, P.G. 1969. Bottom Sediment Sampling. Proc. 12th Conf. Great Lakes Res. 883-898.

U.S. Army Corps of Engineers. 1973. Shore Protection Manual. Coastal Engineering Research Center, Vol. I.

BIBLIOGRAPHY

Bajorunas, L. and D.B. Duane. 1968. Shifting Offshore Bars and Harbour Shoaling. U.S. Corps of Engineers, Miscellaneous Paper 68-1.

Coakley, J.P., W.S. Haras, and N. Freeman. 1973. The Effect of Storm Surge On Beach Erosion, Point Pelee. Proc. 16th Conf. Great Lakes Res. 377-389. Internat. Assoc. Great Lakes Res.

Crysler & Lathem Consulting Engineers. 1974. Northeast Beach Erosion Study, Point Pelee National Park.

Dubois, R. 1972. Seasonal Variations in Beach and Nearshore Morphology, Thesis, University of Wisconsin.

Gillie, R.D. 1974. The Nearshore Morphology of Sand Beaches on the Great Lakes Shoreline of Southern Ontario. Undergraduate Thesis for the Degree Master of Sciences, McMaster University.

Hartley, R.P. 1960. Sand Dredging Areas in Lake Erie, State of Ohio, Department of Natural Resources, Technical Report No. 5.

Hobson, G.D., C.E. Herdendorf, and C.F.M. Lewis. 1969. High Resolution Reflection Seismic Survey in Western Lake Erie. Proc. 12th Conf. Great Lakes Res., 210-224. Internat. Assoc. Great Lakes Res.

Hudec, P.P. 1975. Composition and Grain Size of Lake Erie Nearshore Sediments at Point Pelee, Ontario. Industrial Research Institute, University of Windsor, Report IRI 7-61.

Ingle, J.C. Jr. 1966. The Movement of Beach Sand. Developments in Sedimentology 5. Dept. of Geology, University of Southern California.

Jarlan, G.E. 1966. Preliminary Recommendations for the Protection of the Shore Line Against Erosion at Point Pelee National Park, Ontario. National Research Council, Laboratory Memorandum 2-17-14. N31.

Kemp, A.L.W., T.W. Anderson, R.L. Thomas, and A. Mudrochova. 1974. Sedimentation Rates and Recent Sediment History of Lakes Ontario, Erie, and Hudson. Journal of Sedimentary Petrology. Vol. 44, No. 1, 207-218.

Kolberg, T.O. and Ming So. 1969. Littoral Drift Processes, Lake Erie. Lake Erie Task Force, Dept. Public Works, Canada.

Olson, F.C.W. 1950. Currents of Western Lake Erie. Graduate Research Paper, Ohio State University.

Parks Canada. Insight and Information: Point Pelee National Park.

A P P E N D I X

Point Pelee Wind, Wave, and Water Level Data 1974-75

Date	Wind			Effective Fetch	Average Depth	Hindcast Wave		Observed Wave		Mean Daily Water Level Above IGLD (m)		
	Direction	Velocity	Duration			Significant Height	Significant Period	Pelee West Significant Height	Pelee East Significant Height	P.W.	max. hr. diff. >.15m	P.E.
		(km/h)	(h)	(km)	(m)	(m)	(sec)	(m)	(m)			
1974												
July 2	S	19	9	47	12	0.50	2.43	0.67	0.58	1.44		1.42
3	SW	18	8	50	10	0.46	2.32	0.82	0.58			
4	S	18	13	47	12	0.46	2.37	0.82	0.73			
11	NE	19	9	74	16	0.57	2.65	0.34	1.10	1.48		1.47
18	SW	16	9	50	10	0.40	2.18	0.61	0.52			
19-20	NE	18	15	74	16	0.52	2.57	0.34				
22-23	E	21	12	138	22	0.77	3.09	0.46	1.01	1.41		1.39
Aug. 3	S	19	11	47	12	0.50	2.43		0.61	1.36		1.31
4	SW	24	13	50	10	0.66	2.67		0.98	1.33	(.18)	1.23
10	E	19	15	138	22	0.66	2.91	0.43	0.85	1.40		1.38
10-11	SE	19	8	72	19	0.57	2.69	1.04	1.07	1.39		1.35
11-12	S	19	21	47	12	0.50	2.43	0.55	0.82	1.36		1.32
14	NE	18	7	74	16	0.52	2.57	0.18	0.61			
27	SW	19	11	50	10	0.50	2.39	0.79	0.40	1.29		1.25
28	E	18	9	138	22	0.60	2.82	0.37	0.91			
30-31	SW	23	14	50	10	0.63	2.62		0.82	1.29		1.21
31	W	18	8	47	9	0.45	2.27		0.40			
Sep.1- 2	NE	19	11	74	16	0.57	2.65		1.07	1.30		1.29
3	NE	21	5	74	16	0.65	2.79		1.58	1.34		1.31
6	E	16	7	138	22	0.50	2.62		0.79			
11-12	S	19	9	47	12	0.50	2.43		1.07	1.23		1.17
13	SW	18	10	50	10	0.46	2.32		0.85			
15	SW	27	14	50	10	0.46	2.82		1.31	1.24	(.26)	1.06

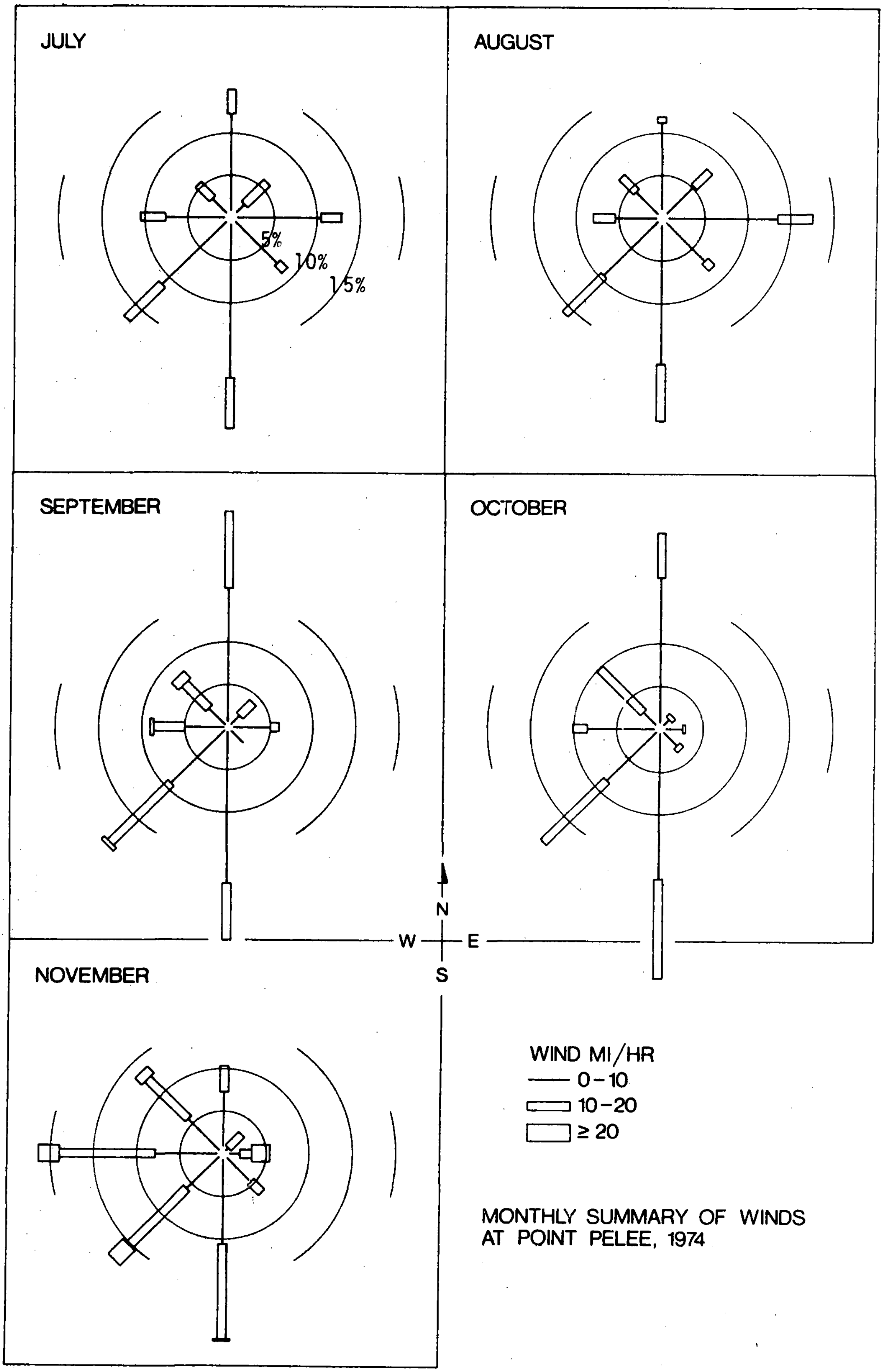
Date	Wind			Effective Fetch	Average Depth	Hindcast Wave		Observed Wave		Mean Daily Water Level Above IGLD (m)		
	Direction	Velocity	Duration			Significant Height	Significant Period	Pelee West Significant Height	Pelee East Significant Height	P.W.	max. hr. diff. >.15m	P.E.
		(km/h)	(h)	(km)	(m)	(m)	(sec)	(m)	(m)			
Sep. 17	SW	19	8	50	10	0.50	2.39	1.04	0.73	1.23	(.21)	1.11
19	S	16	7	47	12	0.39	2.22	0.61	0.64			
24	S	18	10	47	12	0.46	2.37	0.58	0.52			
24-25	S	23	6	47	12	0.63	2.68	1.16	1.13	1.20	(.23)	1.07
25	SW	24	9	50	10	0.66	2.67	1.52	1.31			
25	W	24	6	47	9	0.64	2.61	1.13	0.61	1.21	(.23)	1.02
26	SW	18	8	50	10	0.46	2.32	0.61	0.70			
29	NW	32	5	14	8	0.60	2.54	0.79	0.76	1.20	(.51)	0.96
Oct.												
30- 1	NW	23	13	14	8	0.41	2.19	0.91	0.76	1.24	(.26)	1.03
1- 2	NW	23	16	14	8	0.41	2.19	0.91	0.49	1.23	(.24)	1.05
4- 5	S	19	26	47	12	0.50	2.43	1.07	1.19			1.01
5	SW	23	5	50	10	0.63	2.62	0.58	0.85			1.01
6	S	18	13	47	12	0.46	2.37	0.79	0.79			
6- 7	NW	23	10	14	8	0.41	2.19	0.58	0.43			
8- 9	S	18	7	47	12	0.46	2.37	0.88	0.73			
14	S	19	10	47	12	0.50	2.43	1.04	1.10	1.12		0.96
14	SW	19	9	50	10	0.50	2.39	0.70	0.91	1.12		0.96
14-15	NW	19	7	14	8	0.33	1.99	0.61	0.52	1.10		0.99
16-17	SW	26	13	50	10	0.73	2.78	1.28	1.31	1.08		0.98
21	SW	16	5	50	10	0.40	2.18	0.61	0.55			
22	SW	24	14	50	10	0.66	2.67	1.28	1.10			0.87
22-23	SW	18	6	50	10	0.46	2.32	0.85	0.73			
Nov. 1	S	18	6	47	12	0.46	2.37	0.43	0.37	0.98		0.95

Date	Wind			Effective Fetch	Average Depth	Hindcast Wave		Observed Wave		Mean Daily Water Level Above IGLD (m)		
	Direction	Velocity	Duration			Significant Height	Significant Period	Pelee West Significant Height	Pelee East Significant Height	P.W.	max. hr. diff. >.15m	P.E.
		(km/h)	(h)	(km)	(m)	(m)	(sec)	(m)	(m)			
Nov. 4	NE	24	13	74	16	0.78	2.99	0.52	1.49	0.98		1.02
5	E	31	5	138	22	1.31	3.79	0.43	1.65	0.98		1.02
5	W	21	10	47	9	0.55	2.45	0.64	0.64	0.98		1.02
11	SE	16	6	72	19	0.44	2.44	0.76	0.94			
11	S	24	10	47	12	0.67	2.74	0.64	0.70	0.98		0.99
12-13	W	23	10	47	9	0.61	2.56	1.37	1.01	1.01		0.89
13	SW	27	12	50	10	0.76	2.82	0.82				
13-14	S	27	8	47	12	0.77	2.89	1.22	1.19	1.04	(.35)	0.86
14	W	29	6	47	9	0.79	2.84	1.46	1.16	1.06	(.35)	0.85
14	SW	29	8	50	10	0.82	2.92	1.55	1.19	1.06	(.35)	0.85
14-15	W	32	7	47	9	1.88	2.96	1.98	1.37	0.98	(.32)	0.78
<u>1975</u>												
Apr. 1	SW	18	8	50	10	0.46	2.32					
2	E	23	5	138	22	0.89	3.25			1.38		
2- 3	NE	29	18	74	16	1.98	3.29					
3- 6	NW	29	88	14	8	0.53	2.43			1.26		
9-10	NE	19	5	74	16	0.57	2.65					
18	S	24	6	47	12	0.67	2.74			1.27		
20	SW	24	49	50	10	0.66	2.67			1.26		
23	SE	21	7	72	19	0.65	2.85			1.28		
23-24	SW	24	15	50	10	0.66	2.67			1.27		
24	NE	19	11	74	16	0.57	2.65			1.26		
30	SE	19	6	72	19	0.57	2.69					

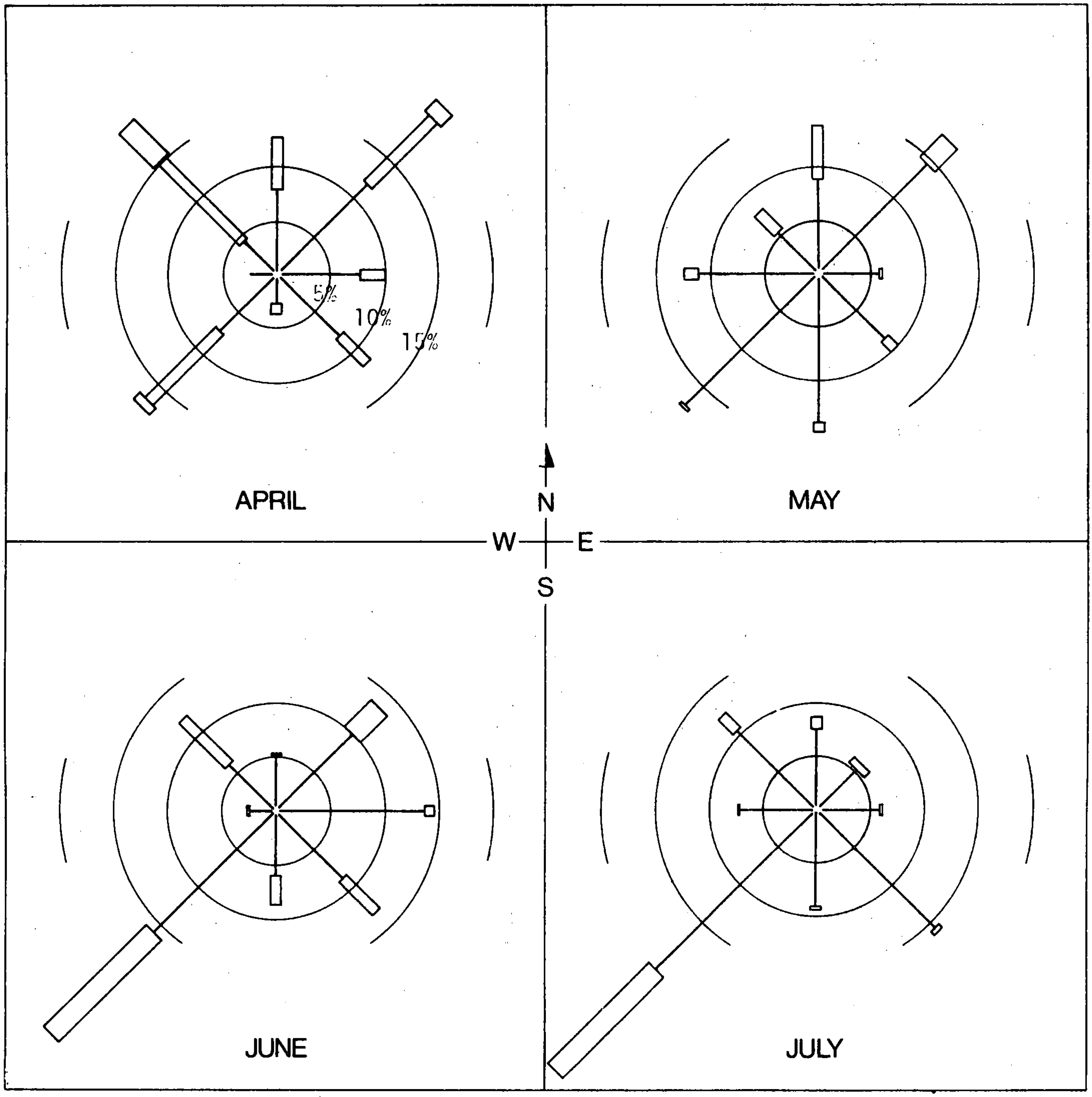
Date	Wind			Effective Fetch	Average Depth	Hindcast Wave		Observed Wave		Mean Daily Water Level Above IGLD (m)		
	Direction	Velocity	Duration			Significant Height	Significant Period	Pelee West Significant Height	Pelee East Significant Height			
		(km/h)	(h)	(km)	(m)	(m)	(sec)	(m)	(m)	P.W.	max. hr. diff. >.15m	P.E.
May 31	SW	19	7	50	10	0.50	2.39					1.24
June 6	SW	19	7	50	10	0.50	2.39			1.30		1.26
6- 7	NW	21	34	14	8	0.37	2.09					
10	NE	21	12	74	16	0.65	2.79			1.33		1.32
11	SE	19	9	72	19	0.57	2.69			1.31		1.32
11-12-13	SW	19	40	50	10	0.50	2.39			1.30		1.28
15-16	SW	21	14	50	10	0.57	2.51			1.30		1.26
17	SE	23	9	72	19	0.74	2.99			1.32		1.29
17-18	SW	19	9	50	10	0.50	2.39			1.31		1.27
July 10	NW	21	7	14	8	0.37	2.09					
13-14	SW	19	21	50	10	0.50	2.39			1.23		1.23
18-19	SW	21	21	50	10	0.57	2.51			1.22		1.24
20	SW	21	12	50	10	0.57	2.51					
24	SW	18	11	50	10	0.46	2.32			1.20		1.19
24-25	NW	19	6	14	8	0.33	1.99					
27	SW	21	12	50	10	0.57	2.51			1.18		1.17
Aug. 3	SW	18	5	50	10	0.46	2.32					
5- 6	NE	23	6	74	16	0.74	2.93			1.23		1.24
15	NE	19	6	74	16	0.57	2.65					
21	SW	19	8	50	10	0.50	2.39			1.12		1.13
24	SW	19	8	50	10	0.50	2.39			1.14		1.15
24-25	SW	18	14	50	10	0.46	2.32					
31	SE	19	7	72	19	0.57	2.69					

Date	Wind			Effective Fetch	Average Depth	Hindcast Wave		Observed Wave		Mean Daily Water Level Above IGLD (m)		
	Direction	Velocity	Duration			Significant Height	Significant Period	Pelee West Significant Height	Pelee East Significant Height	P.W.	max. hr. diff. >.15m	P.E.
		(km/h)	(h)	(km)	(m)	(m)	(sec)	(m)	(m)			
Sep.2- 3	NE	21	11	74	16	0.65	2.79					1.28
7- 8	SW	19	20	50	10	0.50	2.39					1.22
11	SW	23	14	50	10	0.63	2.62					1.19
12-13	NW	19	50	14	8	0.33	1.99					
20-21	SW	24	22	50	10	0.66	2.67			1.18		1.18
23- 4- 5	NE	29	41	74	16	0.98	3.29					1.28
Oct.3- 4	SW	21	27	50	10	0.57	2.51			1.13		1.07
5- 6	SW	21	12	50	10	0.57	2.51			1.13		1.09
14-15	SW	19	14	50	10	0.50	2.39			1.10		1.06
15-16	NW	23	10	14	10	0.42	2.25					
17- 8- 9	NE	32	51	74	16	1.11	3.44			1.10	(.27)	1.29
20-21	SW	21	23	50	10	0.57	2.51			1.11		
24	SE	19	6	72	19	0.57	2.69					
28	SW	18	7	50	10	0.46	2.32					
31	S	24	9	47	12	0.66	2.74			1.16	(.18)	1.05
Nov.(Oct)												
31- 1	SW	26	27	50	10	0.73	2.78			1.09	(.20)	0.97
2- 3	SW	18	8	50	10	0.46	2.32					
8	SW	18	12	50	10	0.46	2.32					
10-11	SW	37	19	50	10	1.07	3.23			1.01	(.63)	0.83
11-12	SE	16	7	72	19	0.44	2.44					
12	SW	21	12	50	10	0.57	2.51			1.05		0.98

Date	Wind			Effective Fetch	Average Depth	Hindcast Wave		Observed Wave		Mean Daily Water Level Above IGLD (m)		
	Direction	Velocity	Duration			Significant Height	Significant Period	Pelee West Significant Height	Pelee East Significant Height	P.W.	max. hr. diff. >.15m	P.E.
		(km/h)	(h)	(km)	(m)	(m)	(sec)	(m)	(m)			
Nov. 13	SW	21	6	50	10	0.57	2.51			1.12	(.22)	0.97
13- 4- 5	NW	26	43	14	8	0.47	2.31			1.10		0.94
15	SW	26	20	50	10	0.73	2.78			1.08	(.21)	0.89
20	SE	24	9	72	19	0.78	3.06			1.04		1.00
20-21	SW	26	26	50	10	0.73	2.78			1.00		0.91
21-22	NW	23	8	14	8	0.41	2.19					
24	SE	19	7	72	19	0.57	2.69			1.02		1.00
25	SW	16	6	50	10	0.40	2.18					
26-27	SE	35	5	72	19	1.24	3.68			1.02		0.93
27-28	SW	31	23	50	10	0.89	3.00			1.00	(.36)	0.87
29	E	23	8	138	22	0.88	3.25			1.02		0.98
29-30	S	29	9	47	12	0.83	2.99			0.97		0.94
30	SW	24	6	50	10	0.66	2.67			0.93		0.90
30	SW	35	9	50	10	1.01	3.16			0.93		0.90

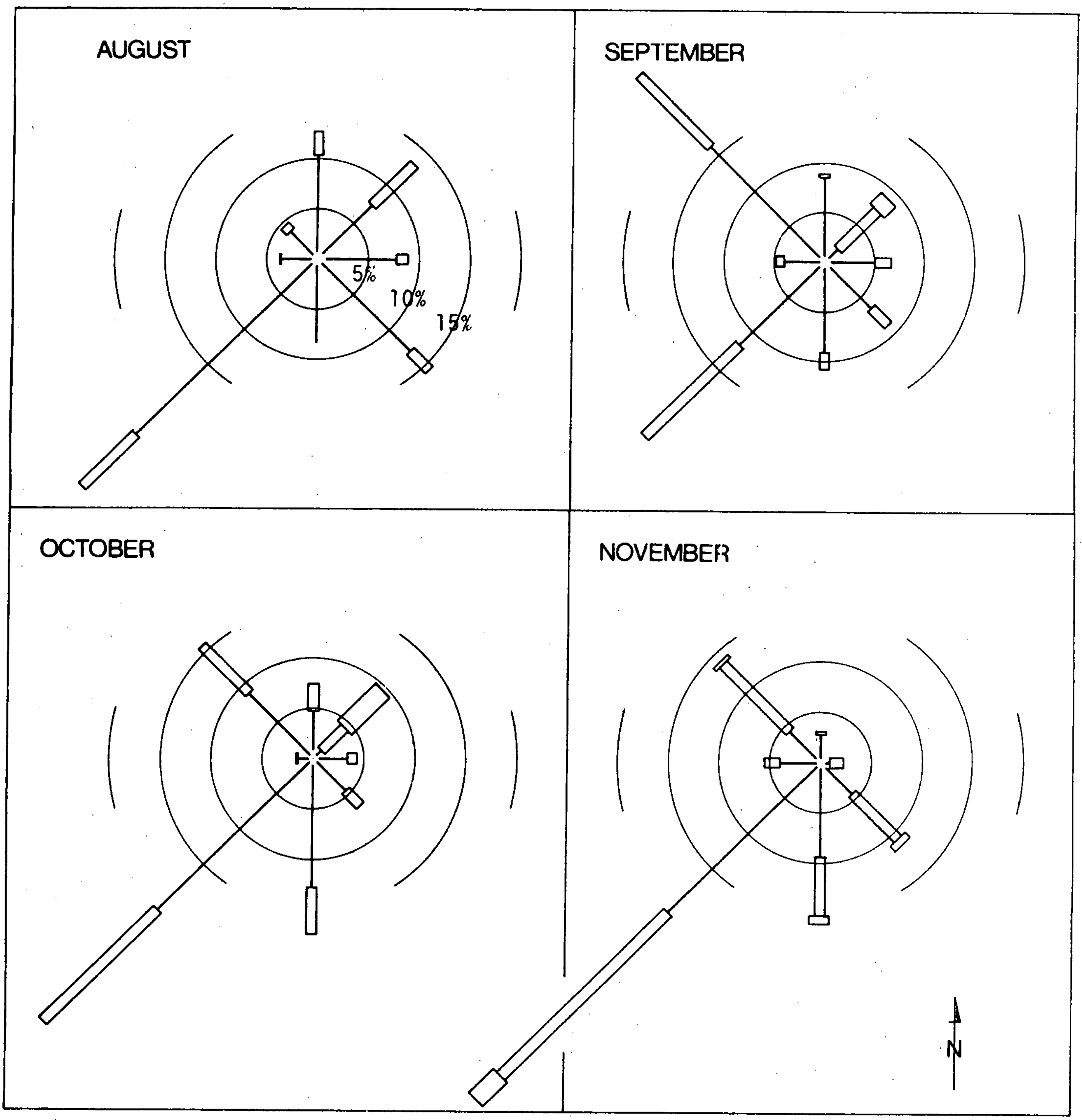


MONTHLY SUMMARY OF WINDS AT POINT PELEE, 1974



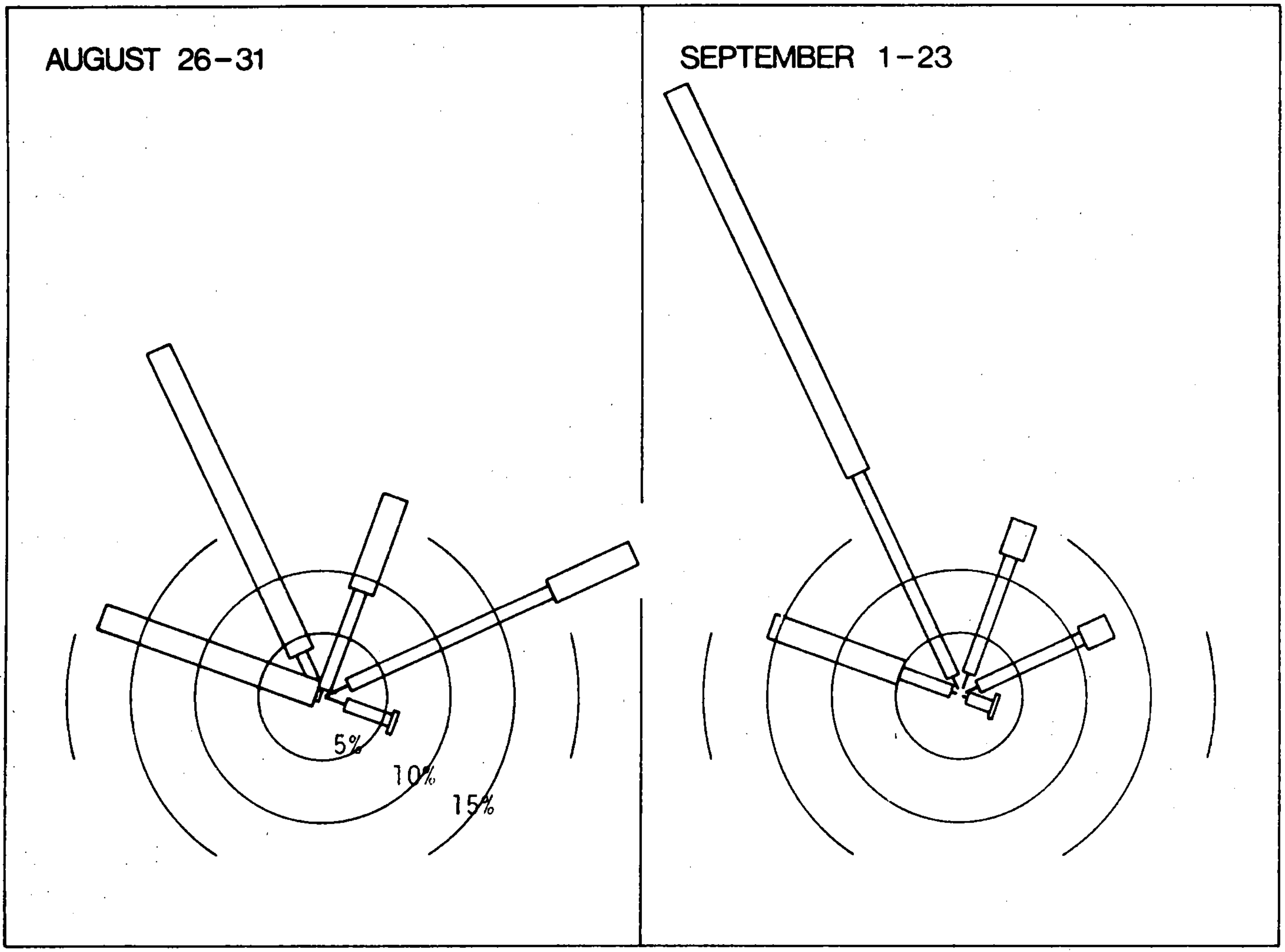
MONTHLY SUMMARY OF WINDS AT POINT PELEE, 1975

WIND MI/HR
— 0–10
▭ 10–20
▭ ≥ 20



MONTHLY SUMMARY OF WINDS AT POINT PELEE 1975

WIND MI/HR
0 – 10
10 – 20
≥ 20

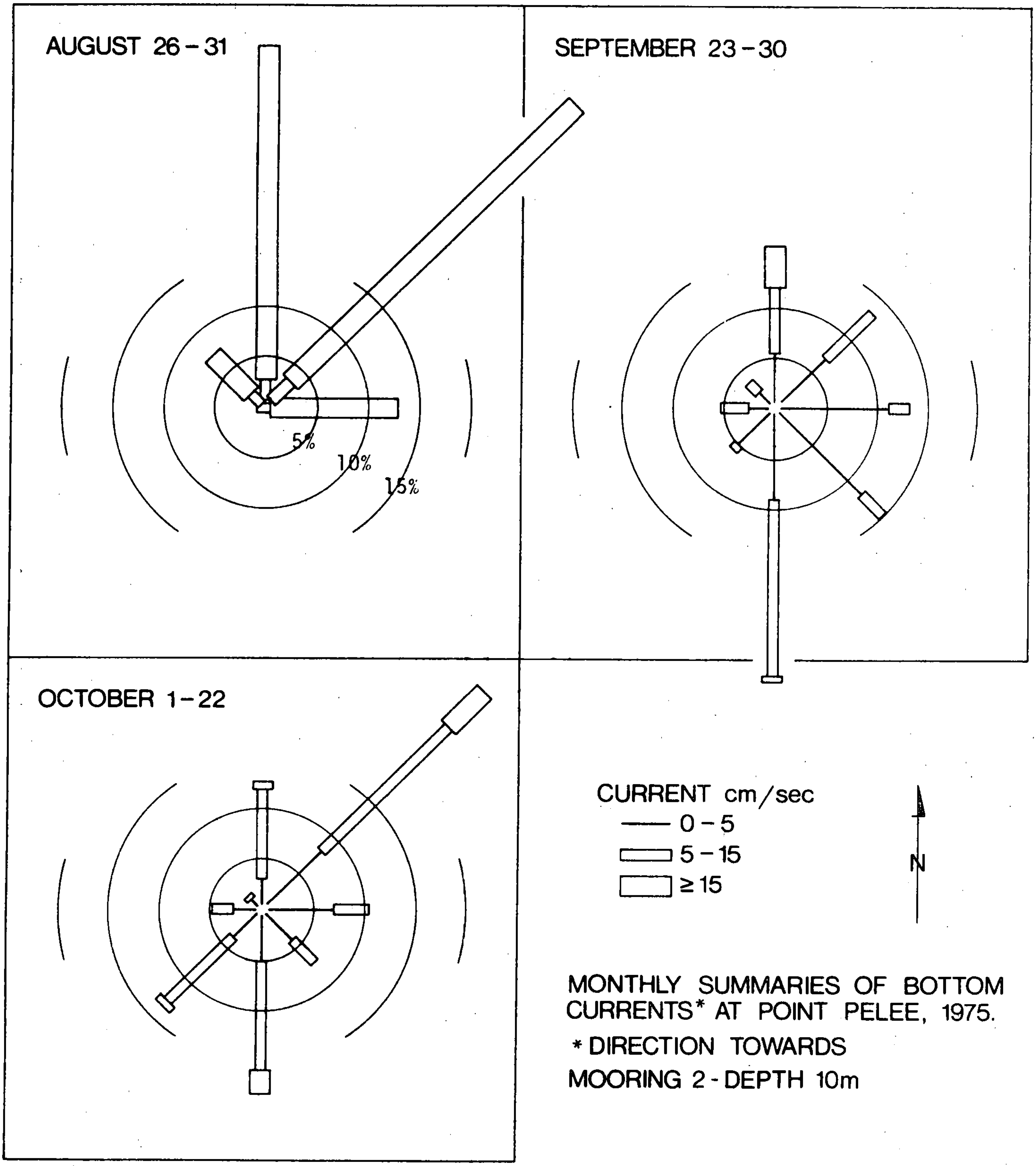


MONTHLY SUMMARIES OF BOTTOM CURRENTS* AT POINT PELEE, 1975.
MOORING 1 - DEPTH 4m

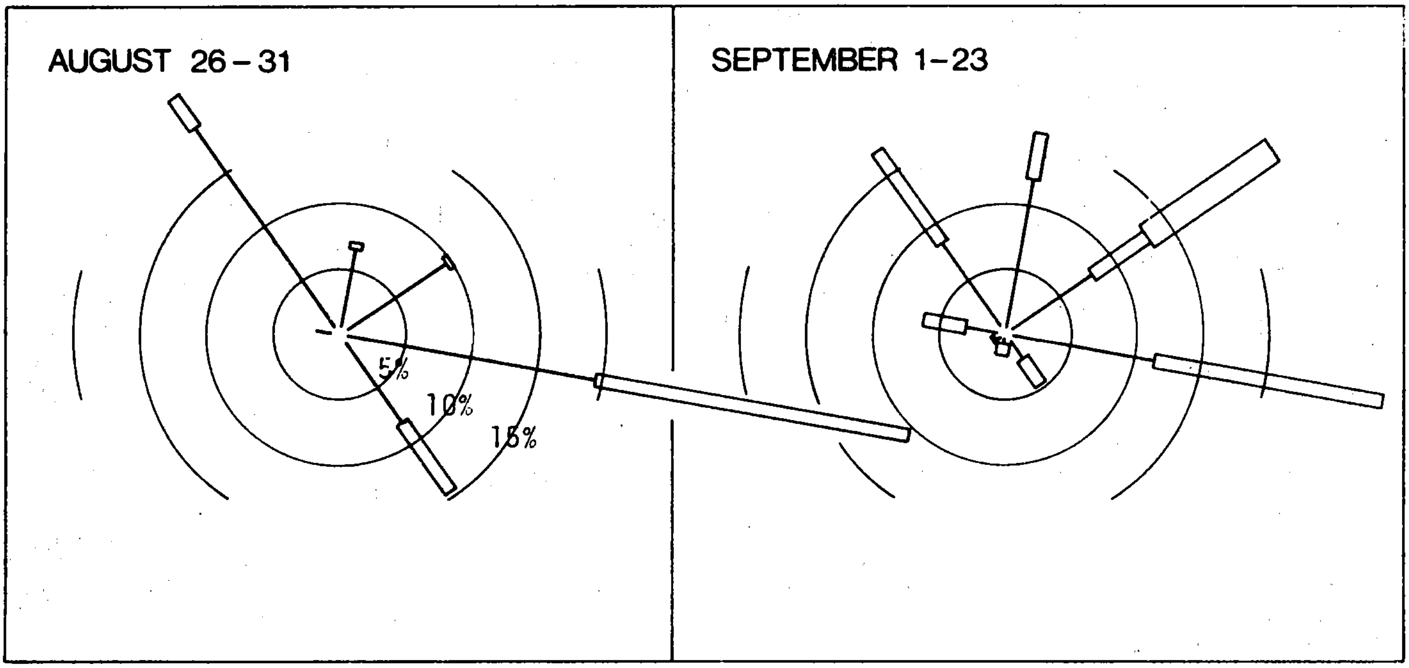
* DIRECTION TOWARDS

CURRENT cm/sec
— 0 - 5
▭ 5 - 15
▭ ≥ 15

N



MONTHLY SUMMARIES OF BOTTOM CURRENTS* AT POINT PELEE, 1975.
* DIRECTION TOWARDS
MOORING 2 - DEPTH 10m



MONTHLY SUMMARIES OF BOTTOM CURRENTS* AT POINT PELEE, 1975.
MOORING 3 - DEPTH 4m

* DIRECTION TOWARDS

CURRENT cm/sec
- 0 – 5
- 5 – 15
- ≥ 15

N

Point Pelee Current Data
Mooring 4 - Depth 7m
June 24 - July 22, 1975