COASTAL PROCESSES AT
POINT PELEE, LAKE ERIE

QUANTITATIVE ASSESSMENT OF COASTAL RESPONSE AT POINT PELEE ON LAKE ERIE, 1974-75

by

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A 4C6 Research Paper
Submitted to the Department of Geography
in Partial Fulfilment of the Requirements
for the Honours Degree
Bachelor of Arts

McMaster University

June, 1977

Bachelor of Arts (1977)
(Honours Geography)

McMaster University
Hamilton, Ontario

TITLE : QUANTITATIVE ASSESSMENT OF COASTAL RESPONSE AT POINT PELEE ON LAKE ERIE 1974-75

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NUMBER OF PAGES:

ABSTRACT : The concern about the preservation of a valuable natural resource such as Point Pelee is readily apparent, yet along with this concern is the need for raw materials such as aggregates dredged from submarine sand and gravel deposits. This could involve a conflict in resource management, therefore the question of how significant commercial dredging is as a process element in the local coastal dynamics needs to be resolved. To provide a basis for this assessment, offshore and onshore surveys, bottom sediment analyses, wind-wave analyses, and current measurements have been taken over the last two years to derive a sediment budget for the Point Pelee spit and shoal system.

The magnitude of response was measured by the morphologic and volumetric variation between successive profiles at 18 sites throughout Point Pelee. The beach zone of the east shore evidenced the most dramatic morphologic and volumetric changes to its profile, with an average loss of 17.5 m^3/m from fall to spring of 1975.

Maximum material restored to the east beach in 1975 was 4.5 m^3/m. In terms of annual quantitative changes to the beach budget, the westward migration of the Point is five times greater for the east shore than for the west. The sediment budget for 1974-75 shows a net deposition to the south of Point Pelee on the order of 440,000 m^3.

NOTE : Opinions expressed within this report are solely those of the author.

ACKNOWLEDGMENTS

There have been a number of people who have contributed a great deal to the preparation of this report. In particular, I would like to thank Dr. S.B. McCann, Department of Geography, McMaster University, for his supervision and guidance throughout its duration. For his encouragement, patience, and generous contributions of time and constructive criticism, I am indebted to Mr. W.S. Haras, Ocean and Aquatic Sciences, Department of Fisheries and Environment. I appreciate also the valuable advice from Mr. N.G. Freeman, Research and Development Division, O&AS, DFE.

To those individuals from the Canada Centre for Inland Waters from whom I have received additional support, I wish to extend my gratitude.

Topographic/Hydrographic Surveys	G.L. Boyd, and Students from Civil Engineering and Geology Depts. University of Waterloo
Waves	M. Skafel
Bottom Currents	E. Bennet J. Coakley
Sedimentology	N. Rukavina
Computer Programming	B. Bork F. Deys A. Zingaro
Diagrams	J. Elliott W. Finn
Typing	C. Kennedy

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

Records indicate that the subaqueous deposits have been tapped commercially in the vicinity of Point Pelee since 1914 (DPW Report #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

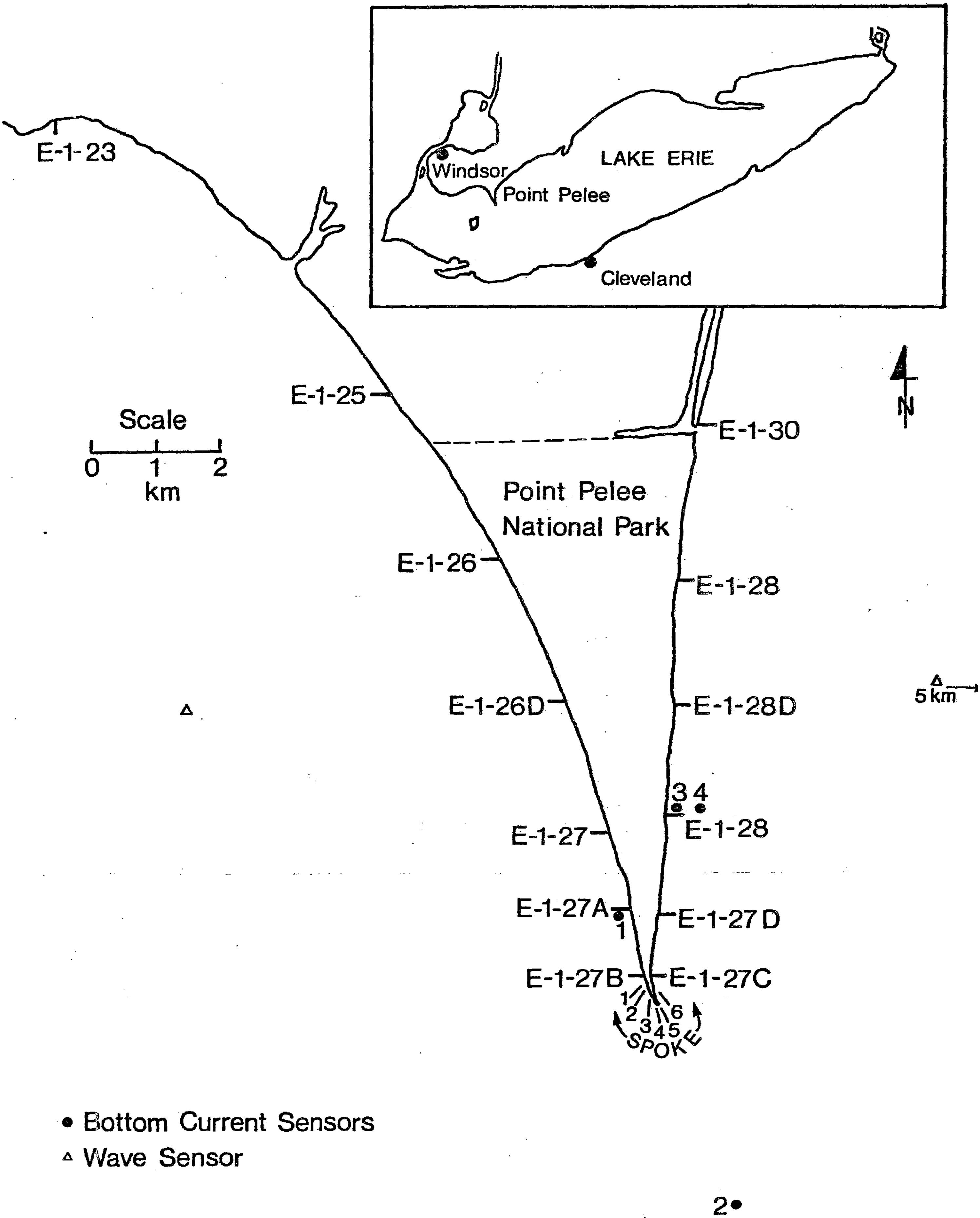


FIGURE 1.1 POINT PELEE STUDY AREA SHOWING NETWORK OF PROFILE-SITES AND LOCATION OF SENSOR INSTRUMENTATION

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 recommendation 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. Contrary to the conventional theories of progressive accumulation in spit formation and evolution, Coakley (1976) suggests a retrogressive process whereby, "post-glacial adjustments in lake level have reduced the Pelee foreland by two-thirds its original size". 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 DINA and the Ocean and Aquatic Sciences Branch of DFE.

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 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 diagrammetically expresses the terminology in the coastal zone.

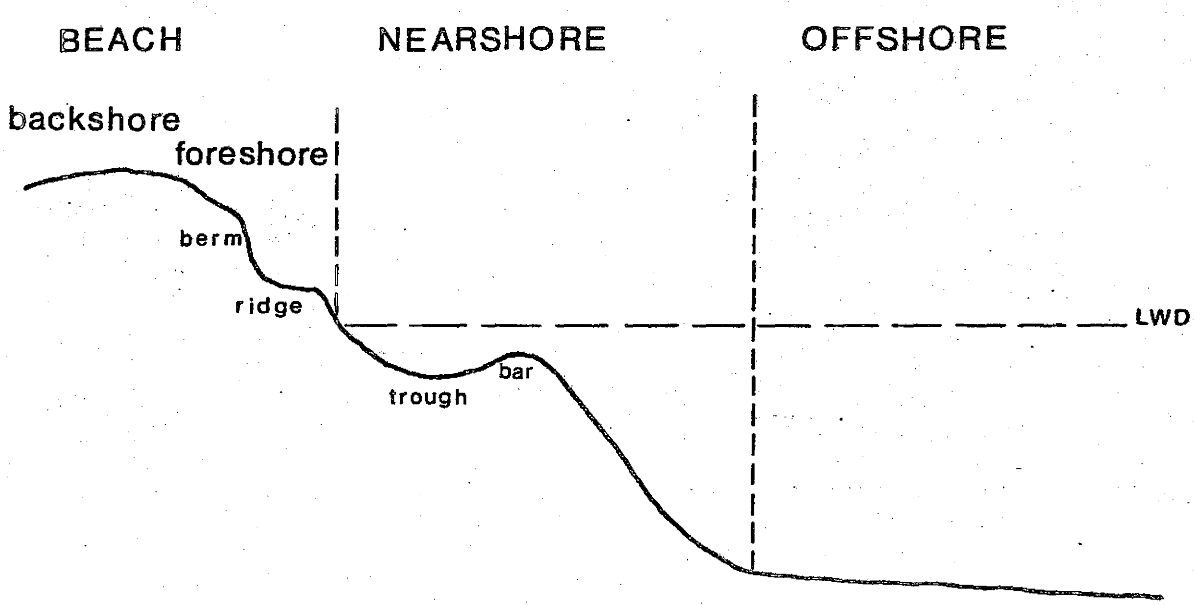


FIGURE 1.2 TERMINOLOGY OF THE COASTAL ZONE

1.3 METHOD OF DATA COLLECTION

Eighteen profile stations were established throughout the Point Pelee periphery. 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. Bluff areas to the east and west of the Point were also surveyed, but with less frequency, so as to derive relative input to the sediment budget. Conventional topographic survey methods were used to attain 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 profile to represent the nearshore and offshore zones using a Shipek Grab Sampler.

1.4 REPORT OUTLINE

The body of the report is organized into four 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 and recommendations are presented in Chapter 6.

PLATE 1.1 SURVEY LAUNCH 'CRESTLINER'

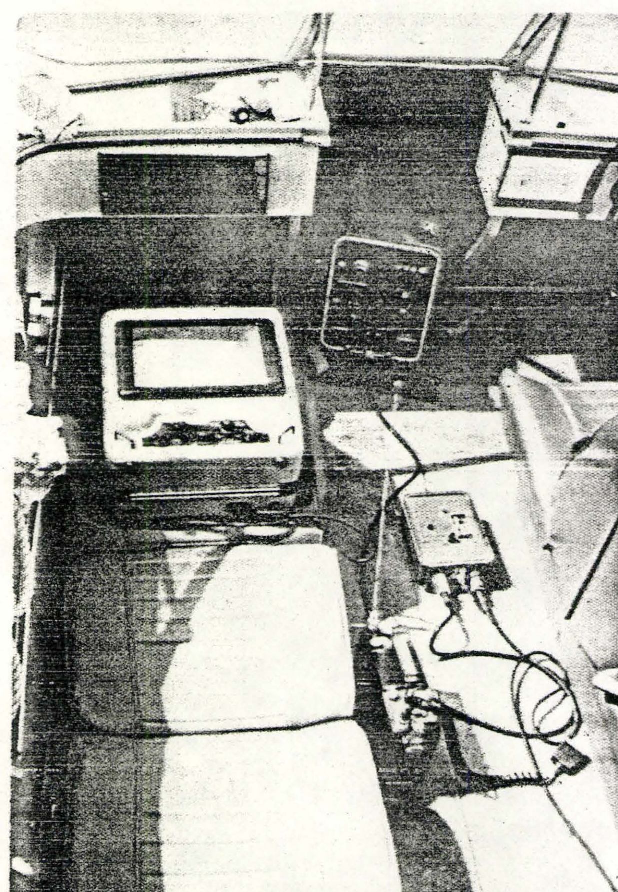


PLATE 1.2 SOUNDING AND POSITIONING EQUIPMENT ABOARD 'CRESTLINER' INCLUDES RAYTHEON SOUNDER, HYDRODIST AND RADIO TELEPHONE

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 which are referred to as the west, east, and south Pelee basins.

2.1 BATHYMETRY

The west basin encompasses the nearshore and offshore zones for the length of the National Park shoreline. It 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.

The east basin extends from the National Park boundary to the southernmost tip of Point Pelee and warrants separate identity based on the irregularity of the nearshore zone. 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.

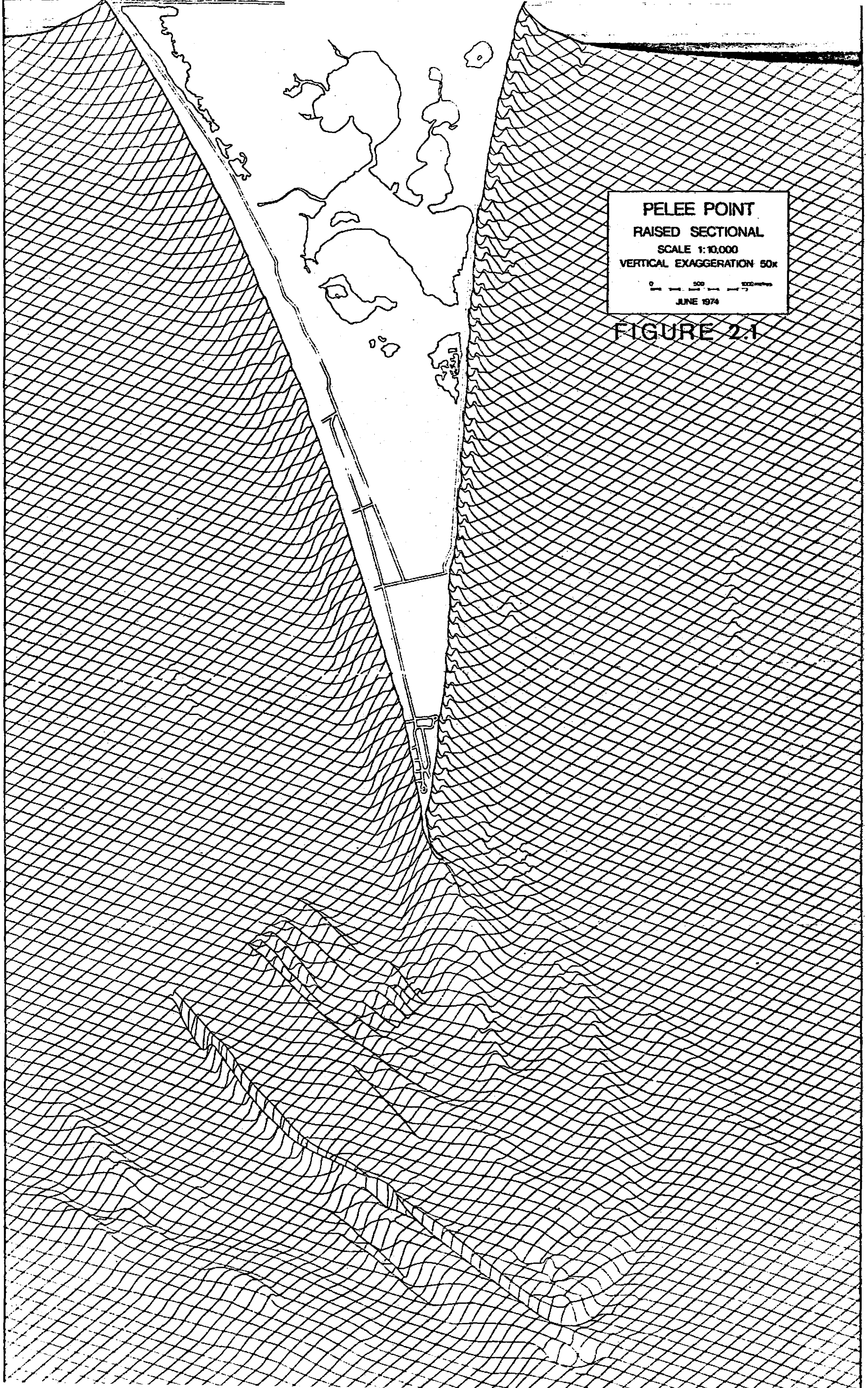
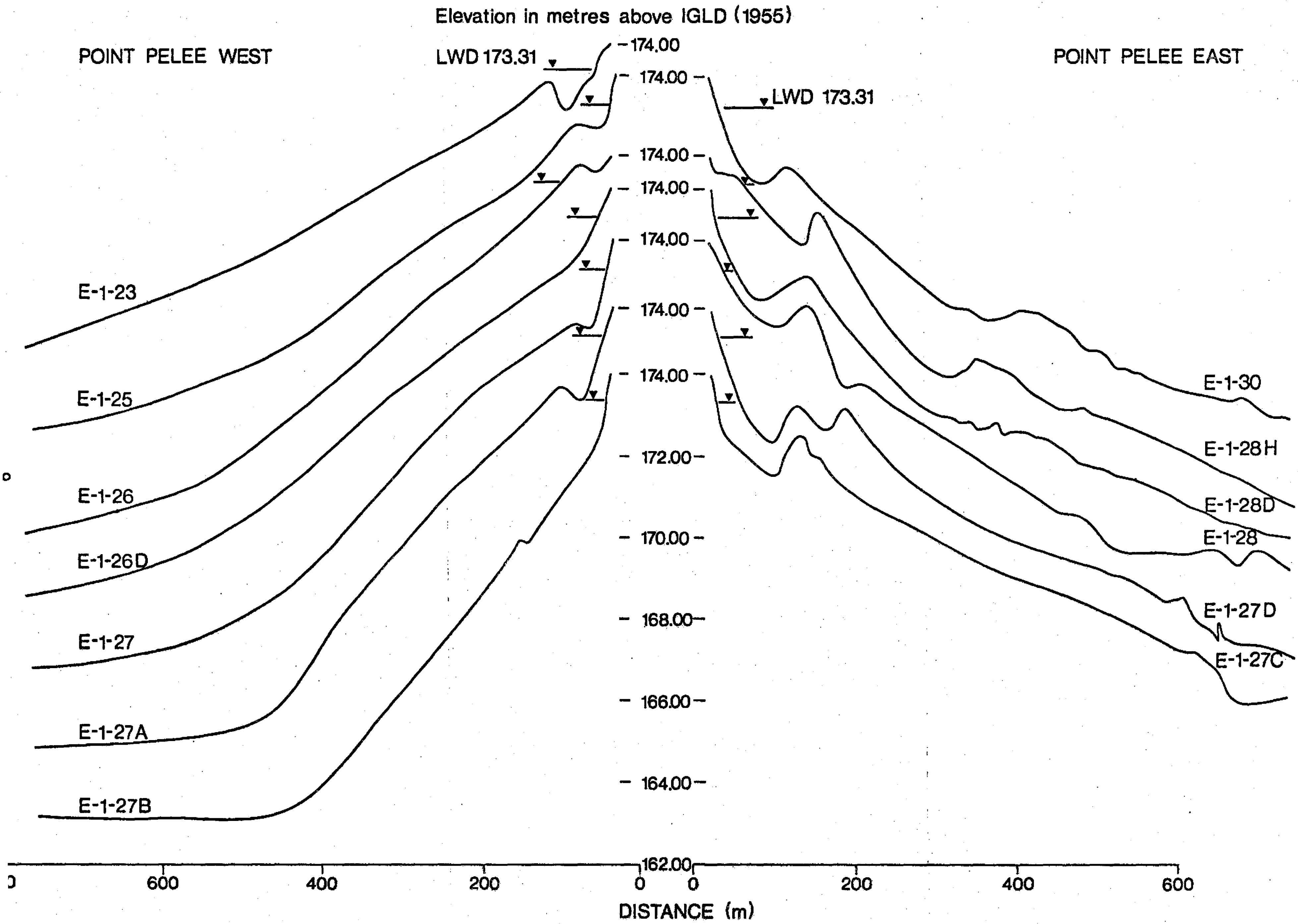

PELEE POINT
RAISED SECTIONAL
SCALE 1:10,000
VERTICAL EXAGGERATION 50x
0
500
1000 metres
JUNE 1974

FIGURE 2.1



GURE 2.2 NEARSHORE PROFILES OF POINT PELEE

A sharp contrast exists between the morphology of the south Pelee basin and that of the adjacent basins. It has an undulating hummocky surface consisting of a number of linear crests and troughs of 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 2.7. Figure 2.3 shows a cross-section of the trench at a scale of 1:1 and 33x vertical exaggeration. Because of the physical dimensions of this feature and the possibility that it may be in consequence to the dredging activities, it has also lead to the concern over the impact of commercial dredging on the sediment budget of Point Pelee.

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. Grab samples were taken along each profile to a distance of 4 km offshore and were plotted for textural analysis using the ternary classification of Folk (1954),

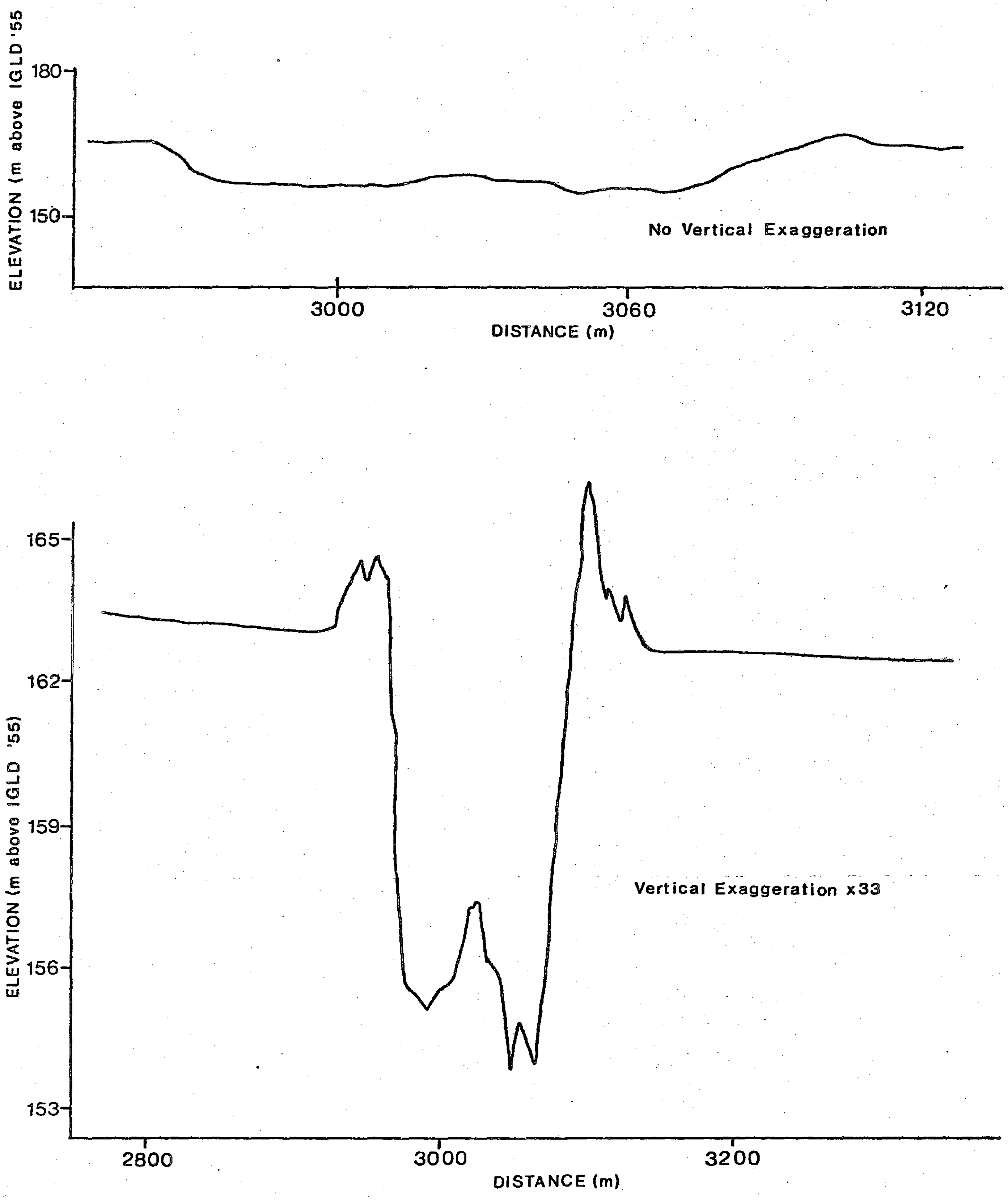


FIGURE 2.3 CROSS SECTION OF TRENCH IN LAKE BED SOUTH OF POINT PELEE (Spoke 1)

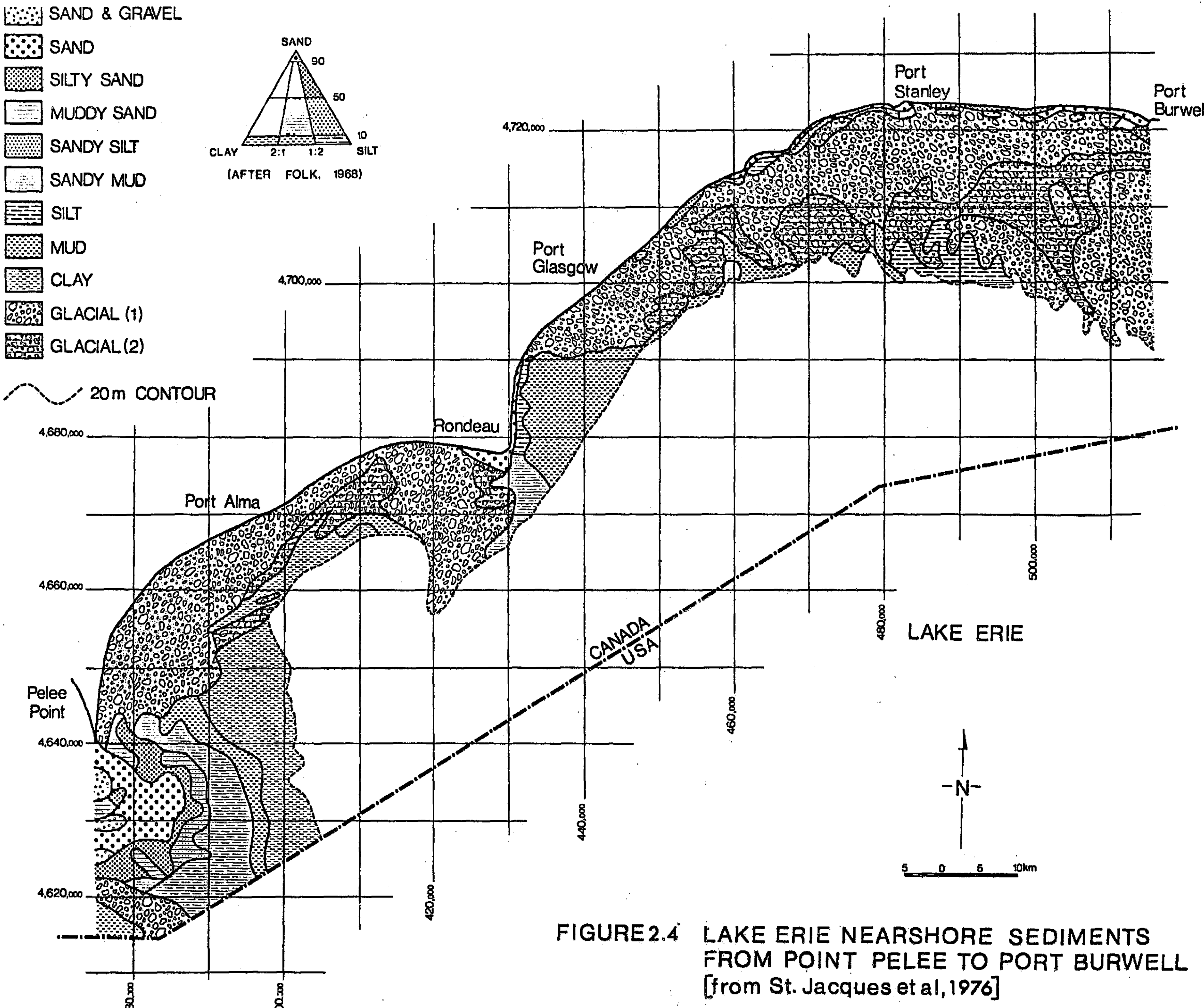


FIGURE 2.4 LAKE ERIE NEARSHORE SEDIMENTS FROM POINT PELEE TO PORT BURWELL [from St. Jacques et al, 1976]

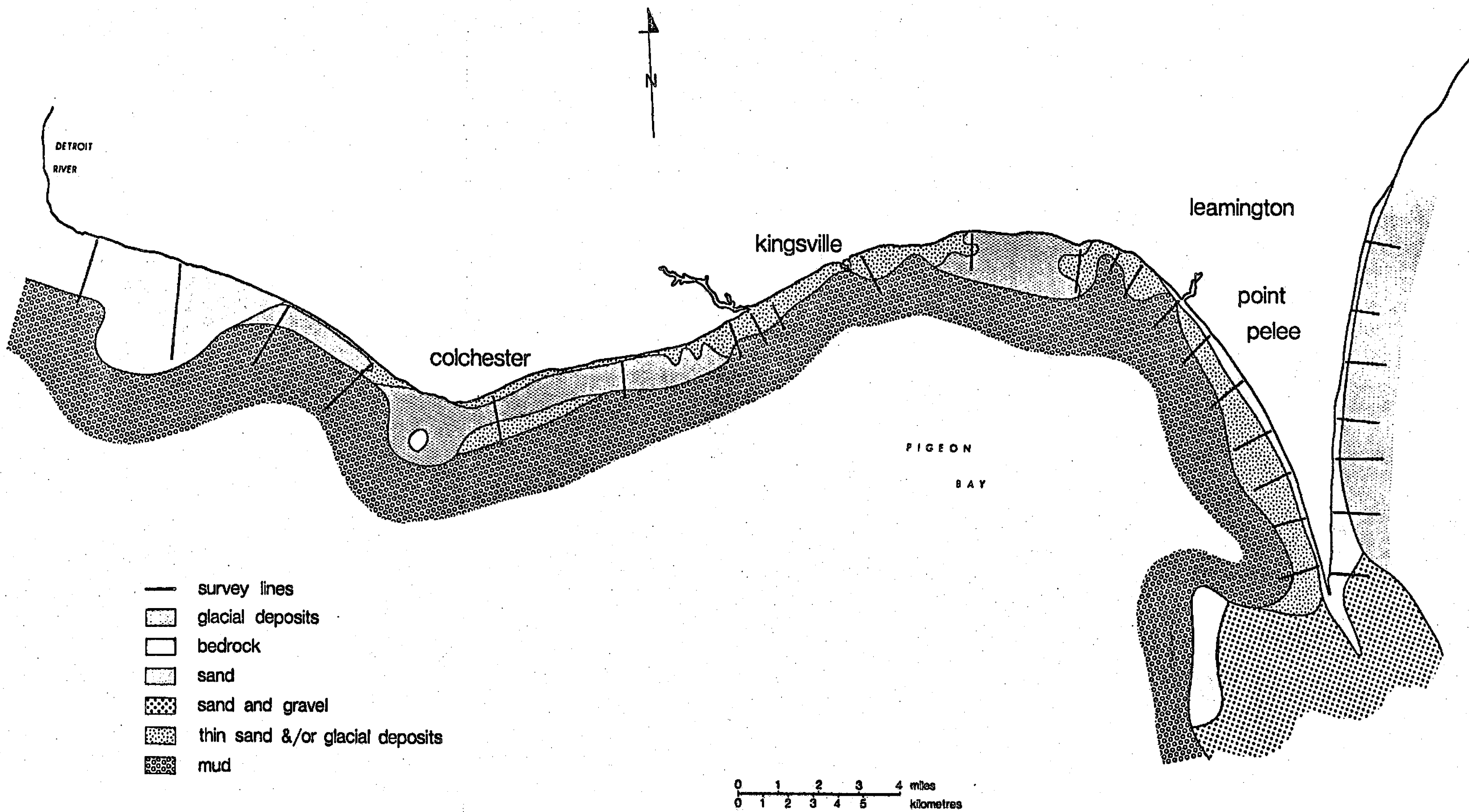


FIGURE 2.5 NEARSHORE BOTTOM SEDIMENTS, WESTERN LAKE ERIE
[from Coakley, 1972]

(after Rice, 1970).

From the ternary plot, Figure 2.6, three distinct clusters are apparent: 1) the upper nearshore zone for most of the Point Pelee shoreline has a sand-size composition greater than 90%; 2) offshore samples throughout the spoke network south of the Point indicate extensive sand and gravel deposits; and 3) the west side of Point Pelee shows relatively high concentrations of fines with silt composition of up to 75%.

Although there is general agreement with the sediment distributions of Coakley and St. Jacques, Figure 2.7 shows a particle-size gradation with the axis of decreasing grain size aligned in a south to north direction on the west side of Point Pelee. This suggests deposition from a northerly current flow which is somewhat contradictory of the depositional sequence found in the previous interpretation of St. Jacques' sediment map requiring an easterly flow. Therefore, it is likely that the currents at Point Pelee have seasonal variations, which alters the direction of sediment deposit. The effects of currents and waves in changing bottom sediments and topography (to an 8m depth) was noted by Kindle (1933).

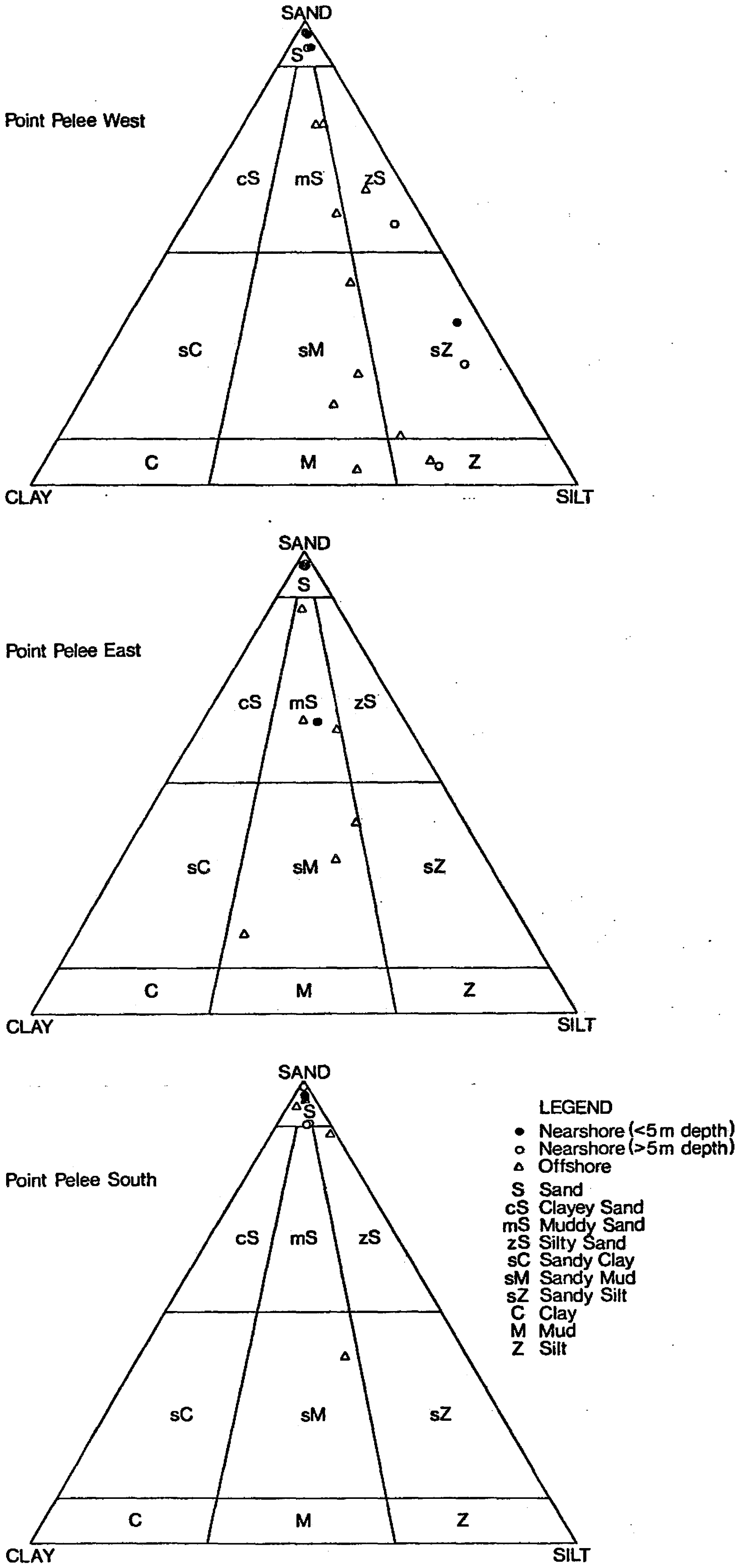


FIGURE 2.6 TEXTURAL ANALYSIS OF BOTTOM SEDIMENTS AFTER CLASSIFICATION BY FOLK, 1954.

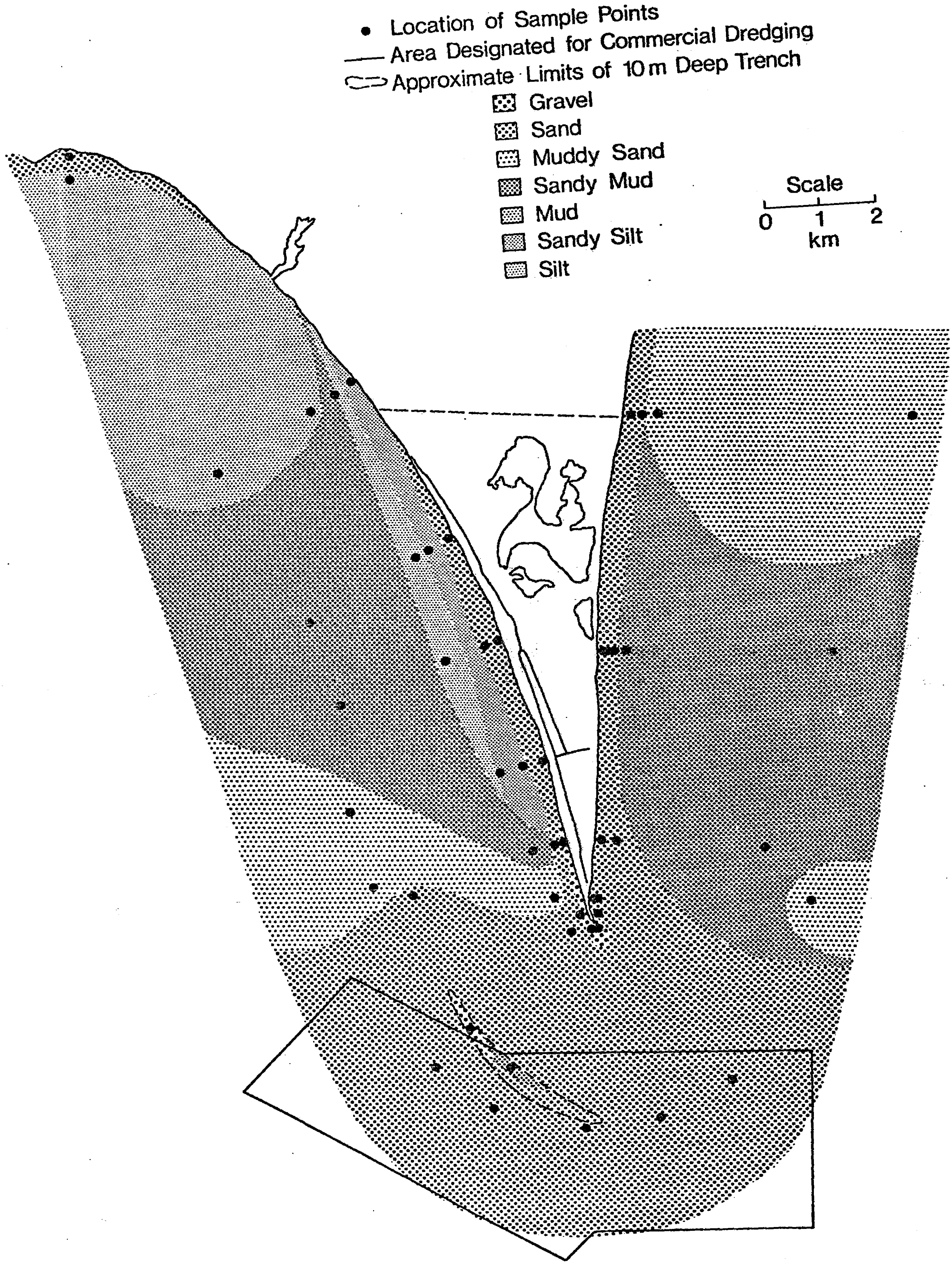


FIGURE 2.7 DISTRIBUTION OF BOTTOM SEDIMENTS AT POINT PELEE

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 component. 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 '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 velocities ranging from 43 cm/sec to 80 cm/sec for the east and west sides of Point Pelee. Generally these currents were in a southward direction. However, anomalies such as flow oscillations and 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 reflect on some of these earlier observations. For example, drogue movements at 1m and 5m depths, Figure 3.1, show evidence of:

1) June 27, 1974

   Excessive nearshore velocities on the east side at 11 cm/sec under northeast winds of 19-32 km/hr, while currents further offshore, at the 5m depth, were calculated at 6 cm/sec.

2) June 28, 1974

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

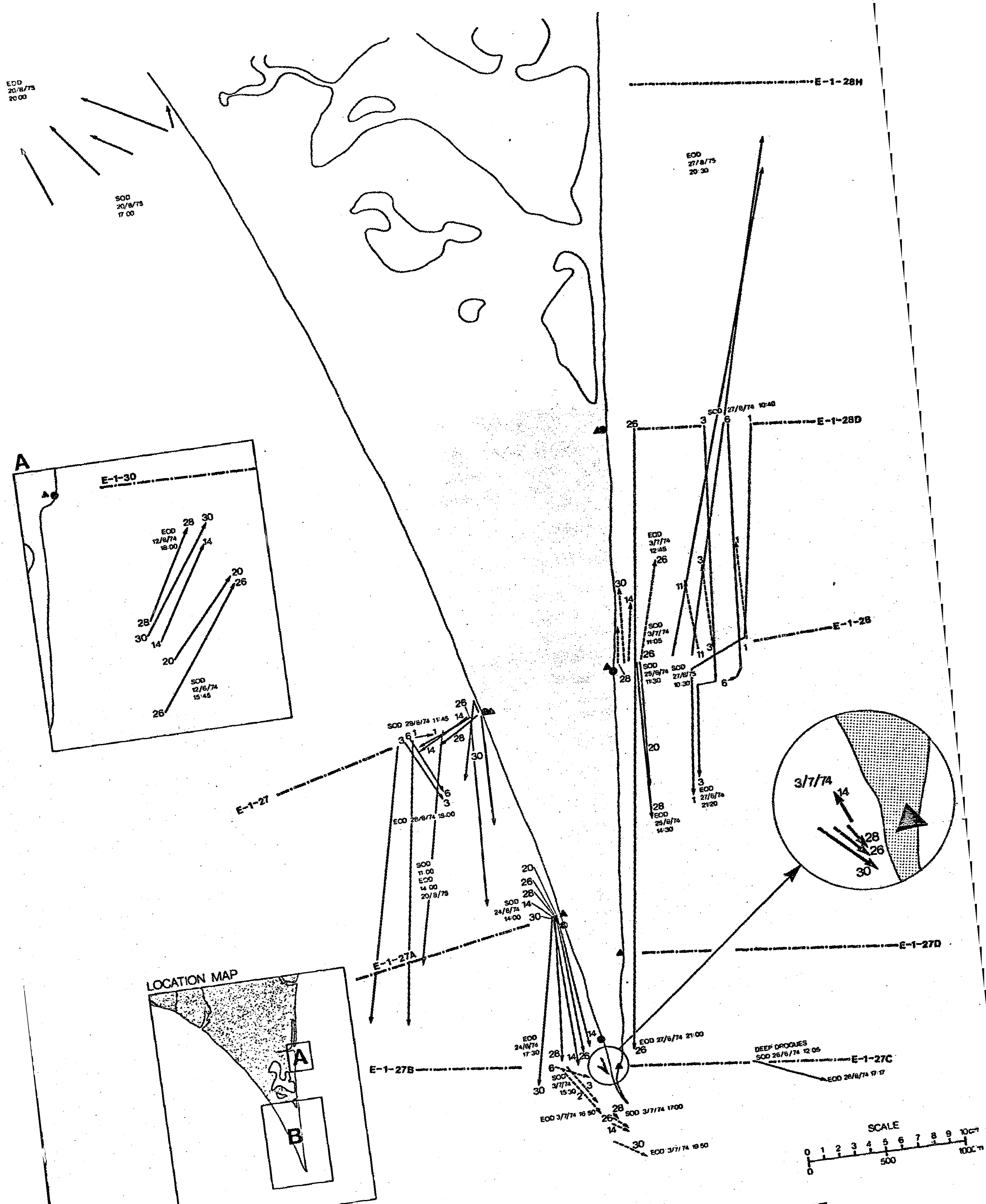


FIGURE 3.1 DROGUE MOVEMENTS AT POINT PELEE , 1974-75

3) July 3, 1974

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

4) August 20, 1975

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 observation taken 2 hours hence at a location 5 km north. This current, however, had a velocity of 4 cm/sec.

5) August 20, 1975

Maximum current velocity recorded was 17 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, preventing survey operations.

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 and class-frequency tables in Appendix A in addition to figures referenced under this section.

Maximum mean and instantaneous current velocities were observed on the west side of Point Pelee at 15.3 cm/sec and 68 cm/sec, respectively. Mean velocities 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 31 when winds were light and variable, Figure 3.2. This short term record shows a weak oscillating current with a mean velocity of 2.6 cm/sec for the inner nearshore on the east side, while velocities 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 velocities with an average of 15.3 cm/sec and 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 velocity 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 velocity occurred during August at 55 cm/sec. It is also noteworthy, in light of sediment transport processes, that the higher velocities tended toward northerly flows.

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 mid summer (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

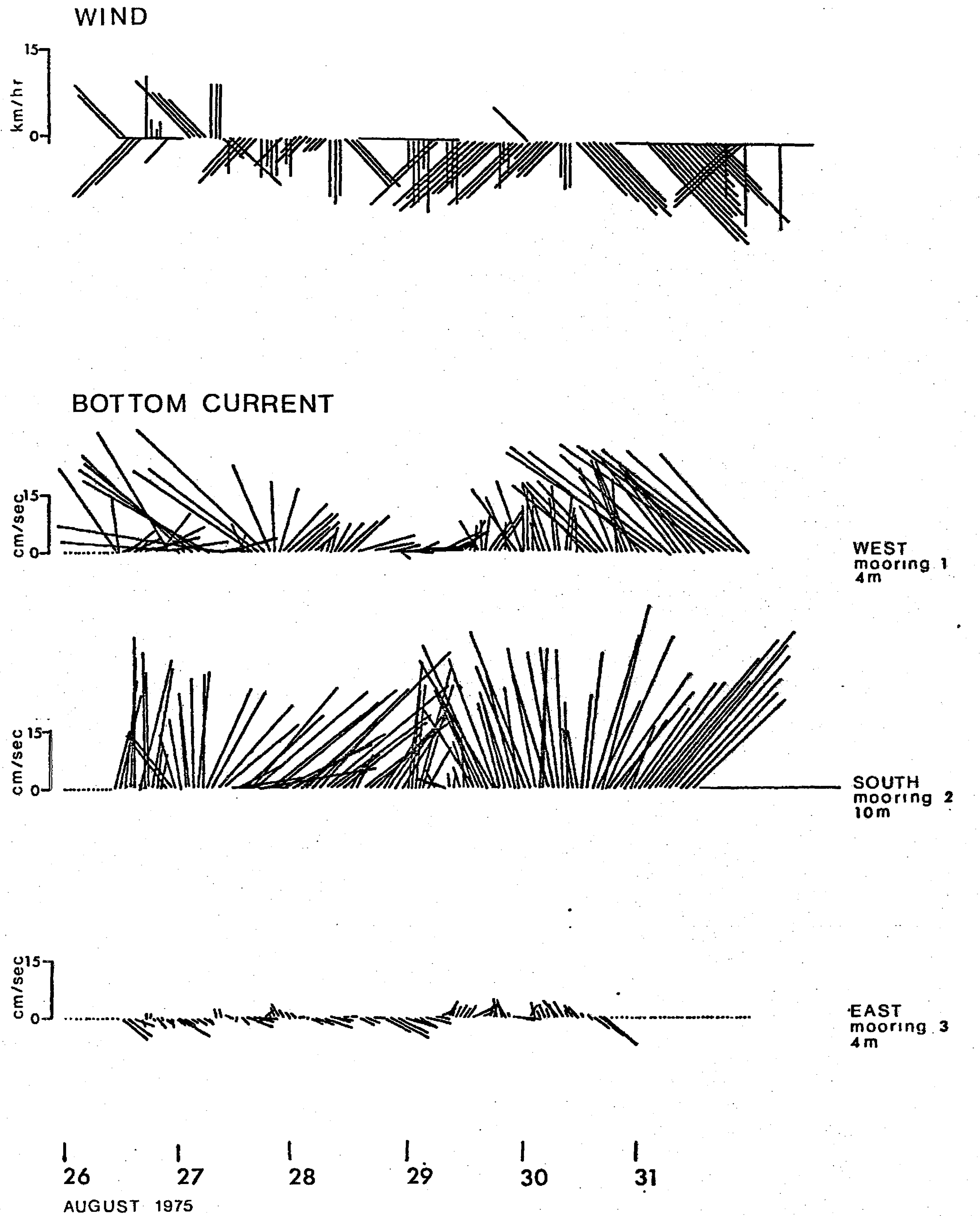


FIGURE 3.2 TIME–SERIES PLOT OF BOTTOM CURRENT AT MOORINGS 1,2 AND 3 [August 26-31 1975]

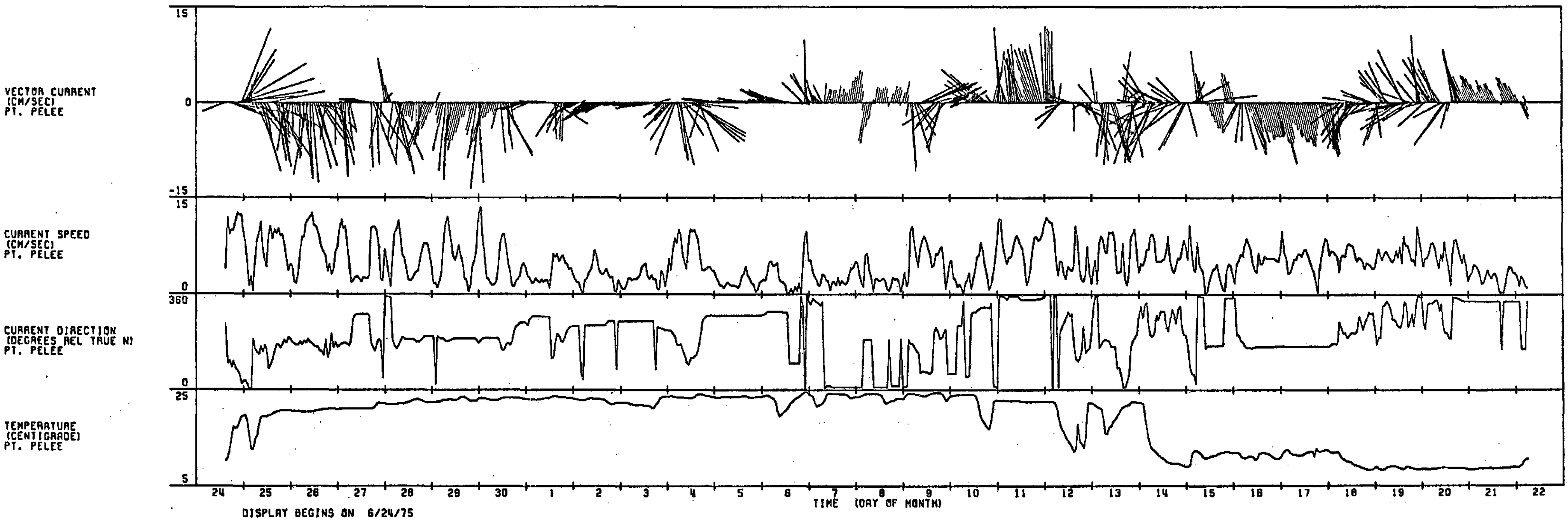


FIGURE 3.3 TIME-SERIES PLOT OF BOTTOM CURRENT AND TEMPERATURE AT POINT PELEE, MOORING 4 [JUNE/JULY 1975]

the predominant orientation of currents when they are at their maximum velocities. The contribution of sediments to the beach and nearshore budgets under these conditions, therefore, is theoretically possible, especially in association with the work of constructive waves in summer months.

Nevin (1946) calculated a minimum critical-traction velocity 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 velocities, 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, with 8.9% in 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 vascillating motion.

Current response on the west side of Point Pelee was largely evident in a distinct shift in direction toward the NW, corresponding to the reciprocal of wind direction, and a periodic increase in velocities 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 velocity of 30 - 32

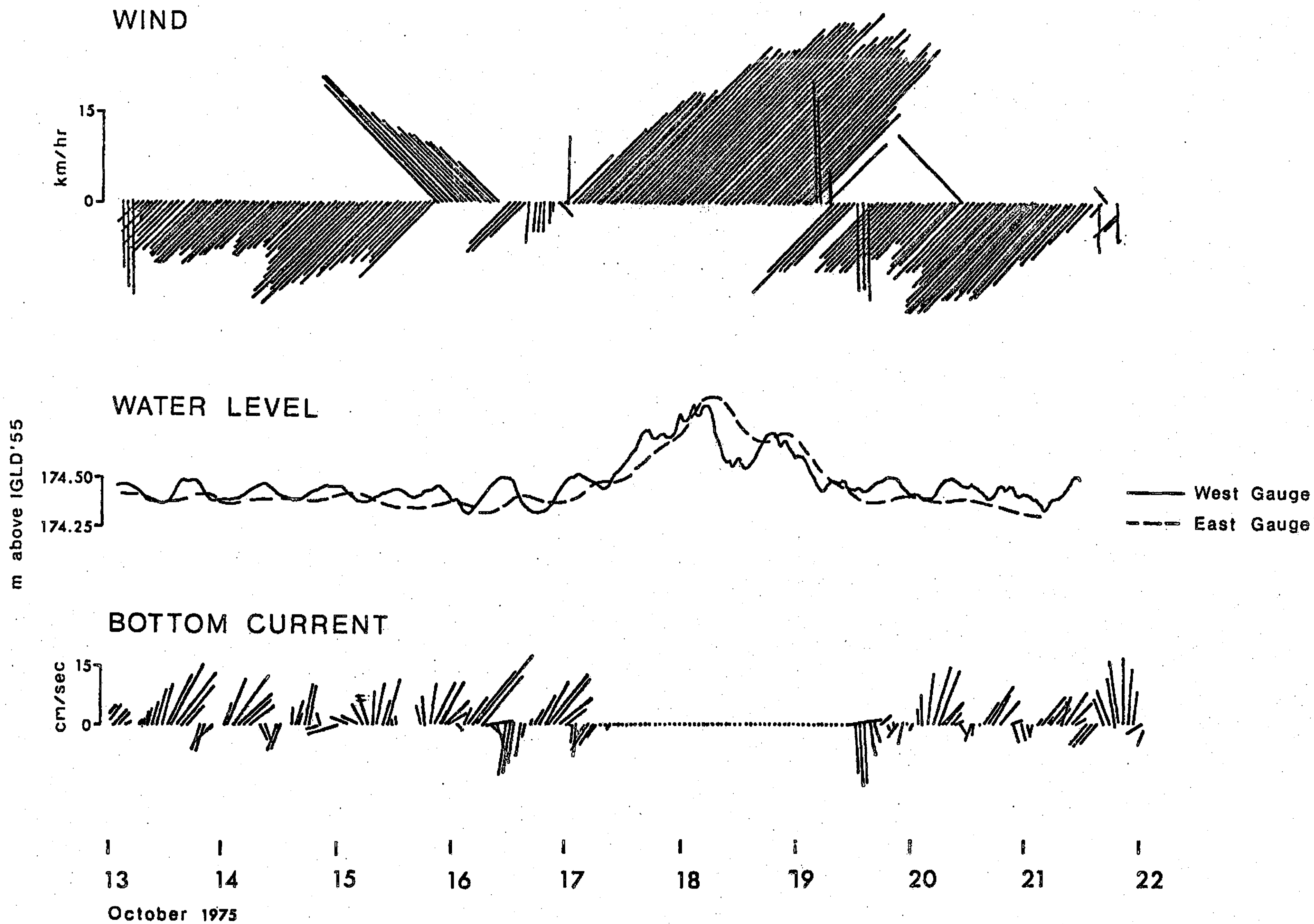


FIGURE 3.4 TIME–SERIES PLOT OF WIND, WATER LEVEL AND BOTTOM CURRENT AT POINT PELEE [October 1975]

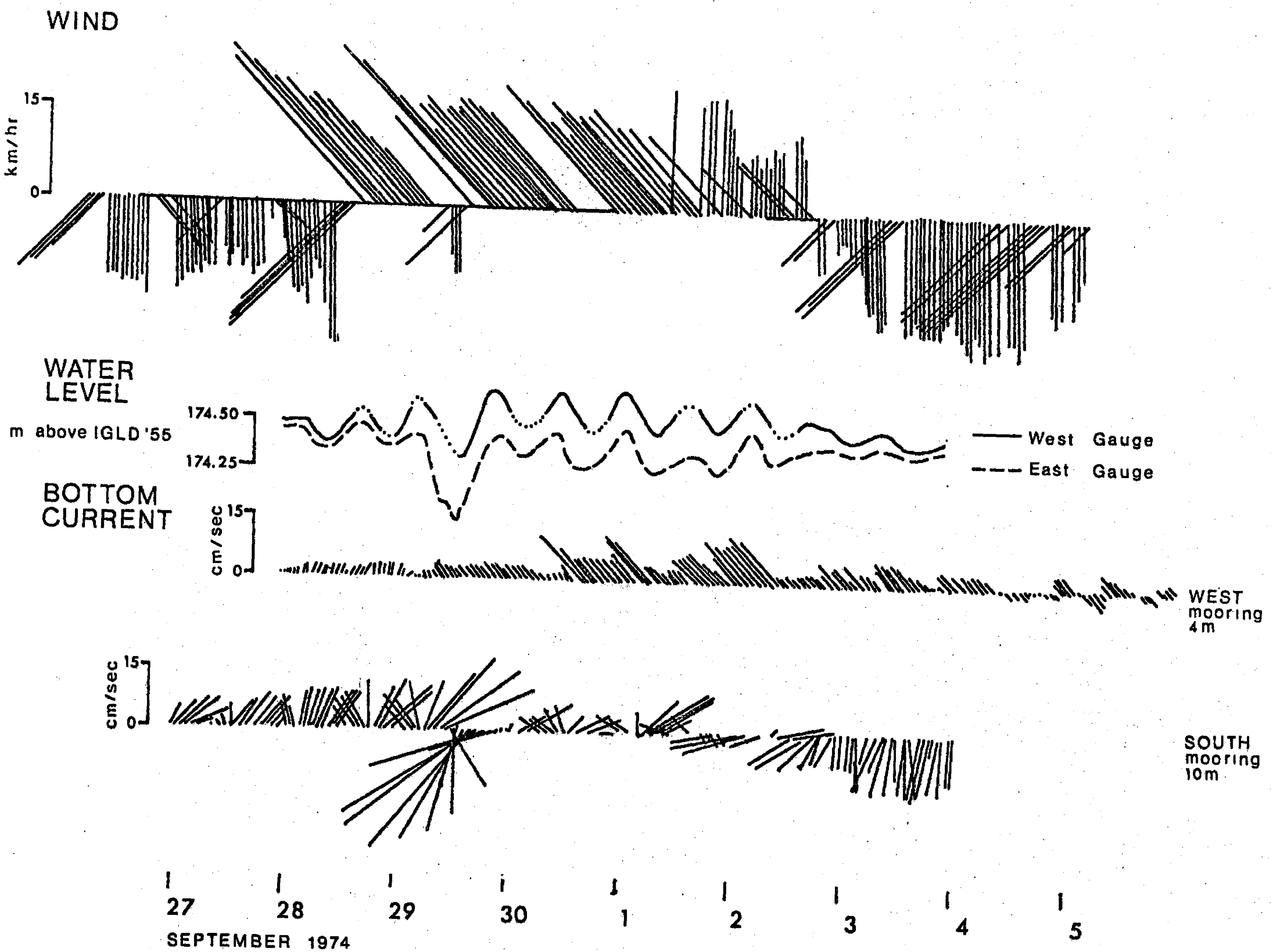


FIGURE 3.5 TIME-SERIES PLOT OF WIND, WATER LEVEL AND BOTTOM CURRENT AT POINT PELEE [September/October 1974]

cm/sec at the initial drop of water levels, which was on the order of 50 cm on the east side. Thereafter, current was unstable both in direction and speed until a shift in winds to the south reduced the difference in water levels between the west and east sides. At this point currents settled to a northerly flow at about 15 cm/sec.

Table 3.1 includes a summary of the differences in water levels between the west and east sides of Point Pelee during the 1974-75 survey periods. 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 relevance of water levels at Point Pelee in beach dynamics may be further appreciated in view of the wave characteristics associated with westerly and easterly fetches.

3.3 WIND CLIMATE

Richards and 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. This is summarized, by season, on percentage frequency tables in Appendix B.

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 5% 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 3.2).

Table 3.2

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 Shore Protection Manual relations:

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

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

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 3.3, were used as input to the formulae.

Table 3.3

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 Table 3.1.

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.

Table 3.1: Point Pelee Wind, Wave, and Water Level Data 1974-75

Date	Wind Direction	Wind Velocity (km/h)	Wind Duration (h)	Effective Fetch (km)	Average Depth (m)	Hindcast Wave Significant Height (m)	Hindcast Wave Significant Period (sec)	Observed Wave Pelee West Significant Height (m)	Observed Wave Pelee East Significant Height (m)	Mean Daily Water Level Above IGLD (m) P.W.	max. hr. diff. >.15m	P.E.
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

Table 3.1

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.
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

Table 3.1

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.	mnx. hr. diff. >.15m	P.E.
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
1975												
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					

Table 3.1

Date	Wind			Effective Fetch	Average Depth	Hindcast Wave		Observed Wave		Mean Daily Water Level Above IGLD (m)		
	Direction	Velocity (km/h)	Duration (h)	(km)	(m)	Significant Height (m)	Significant Period (sec)	Pelee West Significant Height (m)	Pelee East Significant Height (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					

Table 3.1

Date	Wind			Effective Fetch	Average Depth	Hindcast Wave		Observed Wave		Mean Daily Water Level Above IGLD (m)		
	Direction	Velocity (km/h)	Duration (h)	(km)	(m)	Significant Height (m)	Significant Period (sec)	Pelee West Significant Height (m)	Pelee East Significant Height (m)	P.W.	max. hr. diff. >.15m	P.E.
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

Table 3.1

Date	Wind			Effective Fetch	Average Depth	Hindcast Wave		Observed Wave		Mean Daily Water Level Above IGLD (m)		
	Direction	Velocity (km/h)	Duration (h)	(km)	(m)	Significant Height (m)	Significant Period (sec)	Pelee West Significant Height (m)	Pelee East Significant Height (m)	P.W.	max. hr. diff. >.15m	P.E.
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

The dimensions and frequency of waves are important variables 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 character from constructive to destructive, 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 Table 3.1, wave dimensions were calculated for the '74 and '75 survey periods (Table 3.4) in order to detect any of the above relations when compared to beach response at Point Pelee. Volumetric data was found to be generally consistent with long-term trends with a net loss of beach material from the east shoreline and a net gain on the west beach.

Table 3.4

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 suggests that wave frequency may be the most significant dimension in distinguishing 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 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 coast, on the other hand, may be exposed to open water conditions for greater lengths 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, more vulnerable to erosion. Furthermore, where ice ridges did not form, there was evidence of severe wave action which lead to breaks in the sand bar at the south tip. Therefore, winter conditions on the east coast tend to have considerable

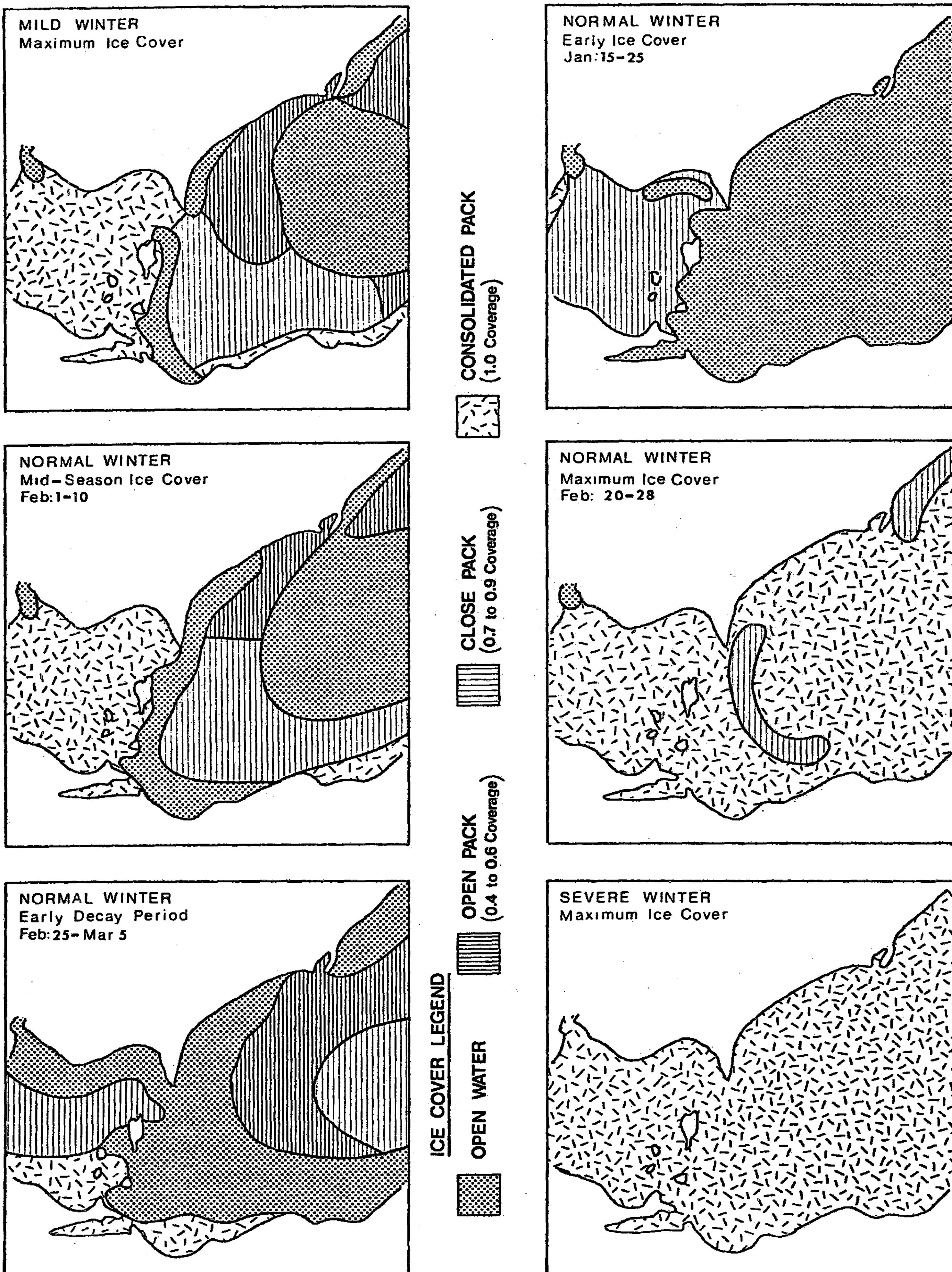


FIGURE 3.6 EXTENT OF ICE COVER ON LAKE ERIE DURING MILD, NORMAL AND SEVERE WINTERS [from Rondy, 1971]

impact despite ice formation and may, in fact, augment the erosive 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 discussed in the next section.

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 circumventing 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 0.10 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 above datum; the nearshore extending from the foreshore (≈1m depth) to the base of the slope or edge of the Pelee rise; and the offshore extending 1 km beyond the base of the nearshore slope. This data is presented as cross-sectional units (m^2/m) under this Chapter to quantify the morphologic change in profile and in m^3 under 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 becomes evident in comparing the morphologic changes to sweep zones for the west and east beaches. Sweep zones represent the physical limits or envelope within which beach oscillations 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 '74'75 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. 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. Quantitatively, this represents an average cross-sectional loss as of April, 1975, of 17.5 m^2 from the east beach of Point Pelee with a maximum loss of 31.4 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 narrower with a slight drop in 1975. Erosion limits for 1974-75 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.

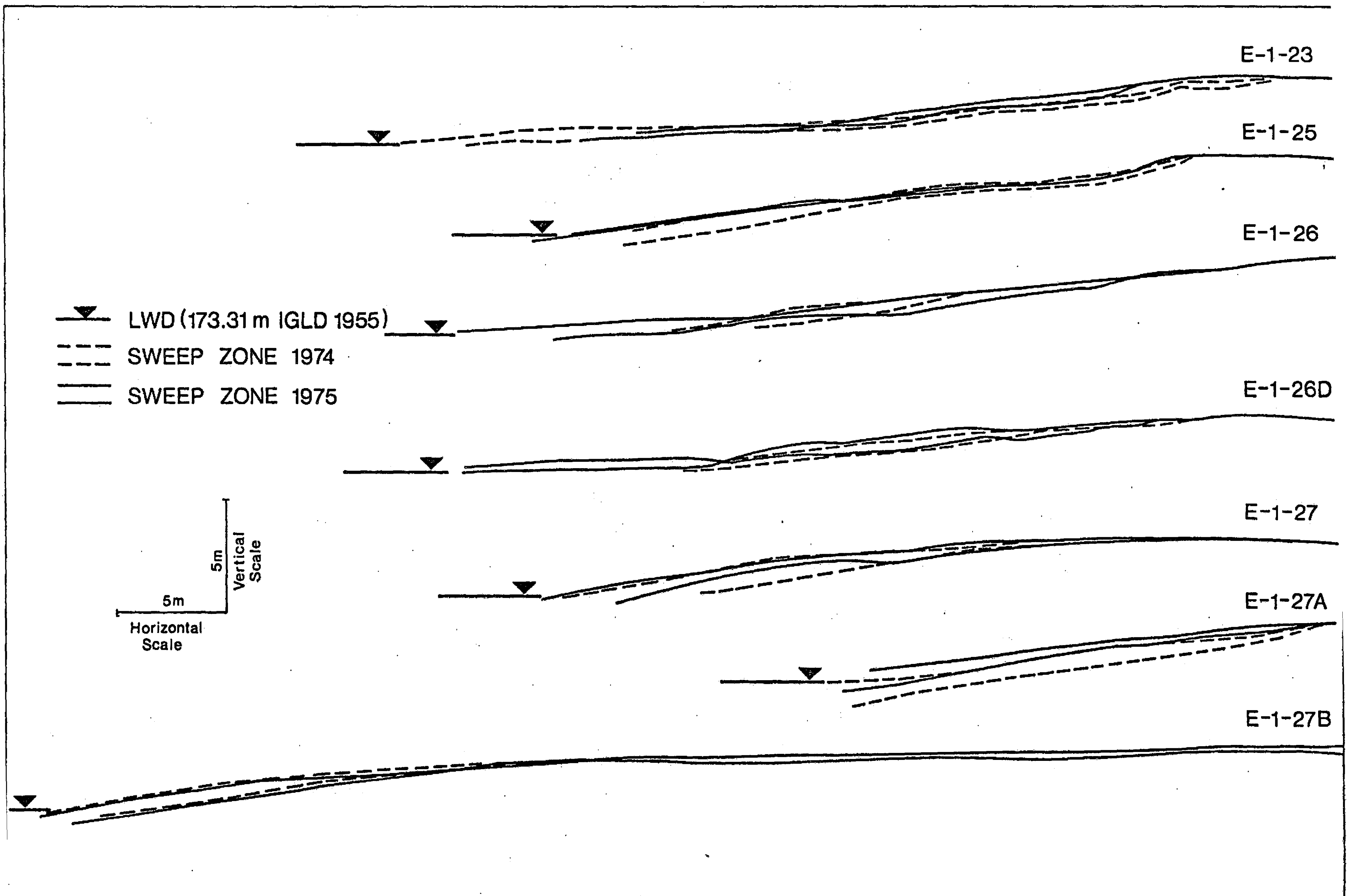


Figure 4.1 Sweep zones of beach profiles for the west shore of Point Pelee.

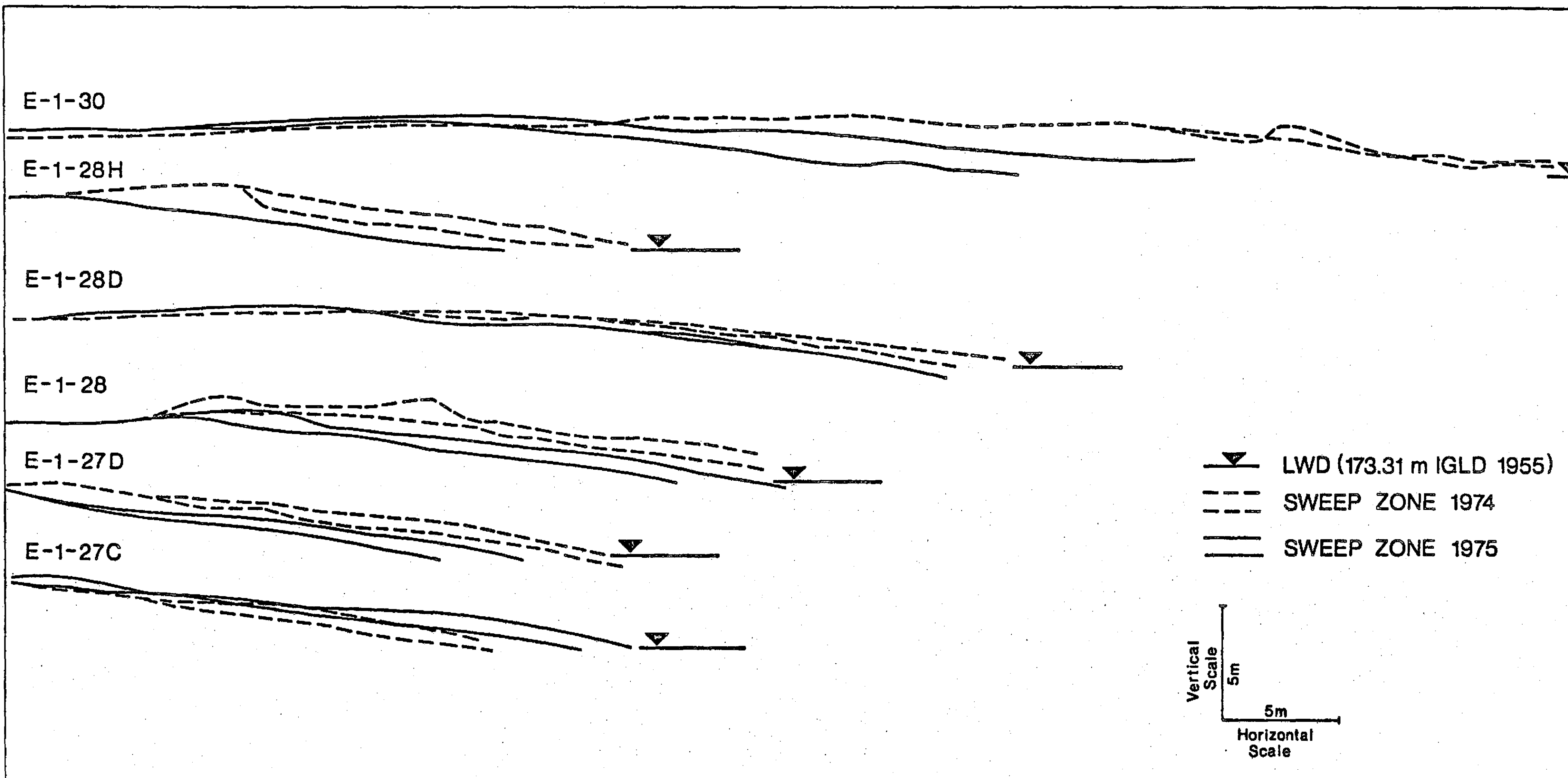


Figure 4.2 Sweep zones of beach profiles for the east shore of Point Pelee.

Sweep zones for the spoke network, Figure 4.3, represent changes to the treeless subaerial spit 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 unstable east shoreline. The difference being, however, that the dimensions of the sweep zones of the spoke network simply reflect the transfer of beach material as the spit shifts in broad east-west sweeps in which the net amount of material loss to the spit system is much less than that indicated by the lower limits of the sweep zones. A good example of such a transfer occurred within a 57-day interval between May 1st and June 27, 1975, when 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 gained an average of 13.84 m^2. The excessive rate of erosion/deposition, however, was limited to within 0.5 km of the tip, as the remaining profiles throughout Point Pelee indicate insignificant beach change with a 0.24 m^2 average rate of deposition on the west side and a 0.7 m^2 average rate of erosion on the east side during the corresponding period. Therefore, it is unlikely that the displacement of spit material was in response to any significant wind/wave climates (Table 3.1) during the 57-day interval.

Further evidence of ineffective winds during the survey period is the fact that simultaneous water level records for the west and east gauges at Point Pelee did not vary more than 4 cm. Hydraulic-gradient induced currents, therefore, would also not have likely been a significant agent in the transport of the spit material during the spring interval. Current strengths caused by the variation in water levels would only act in either further augmenting or weakening the prevailing littoral currents, depending on the direction of gradient. Prevailing current velocities were not recorded during the period.

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), one standard deviation (σ) was calculated for the changes in cross-sectional area for each survey interval and listed in the following table. Stations are from N to S for Pelee west and east beaches.

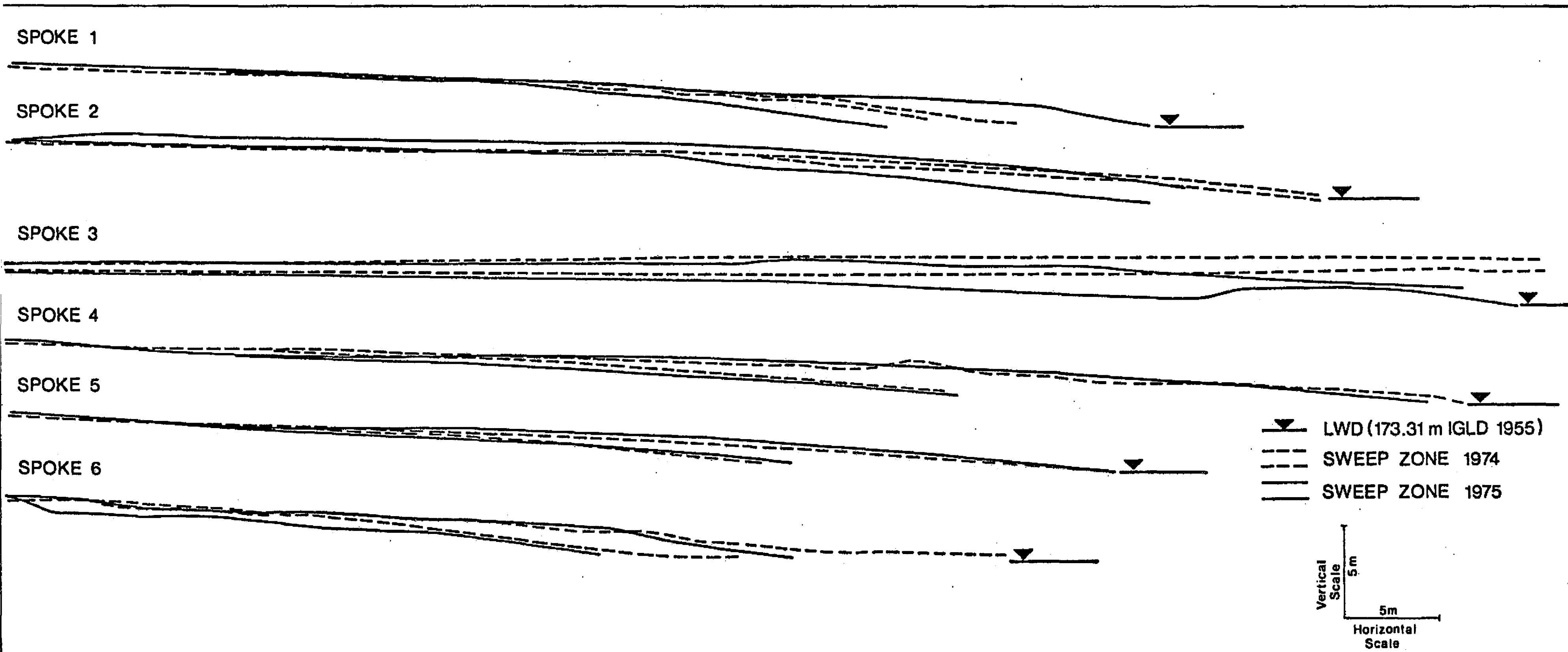


Figure 4.3 Sweep zones of beach profiles for the treeless tip of Point Pelee.

Table 4.1

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 in response to fluctuations in water levels, currents, and waves. 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 inner 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. Beach recovery 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) 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 and producing 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 significant in considering that 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 may only be determined by increasing the number of observations.

Table 1 of Appendix C summarizes the cross-sectional area changes at each profile station for each of the survey intervals.

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 and spring surveys of '74-'75 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 two-crested bar by May of 1975 which was maintained throughout the remainder of the 1975 survey period. The alteration of the nearshore profile extending 800 m offshore involved a total accumulation of 32 m^2 in cross-sectional area.

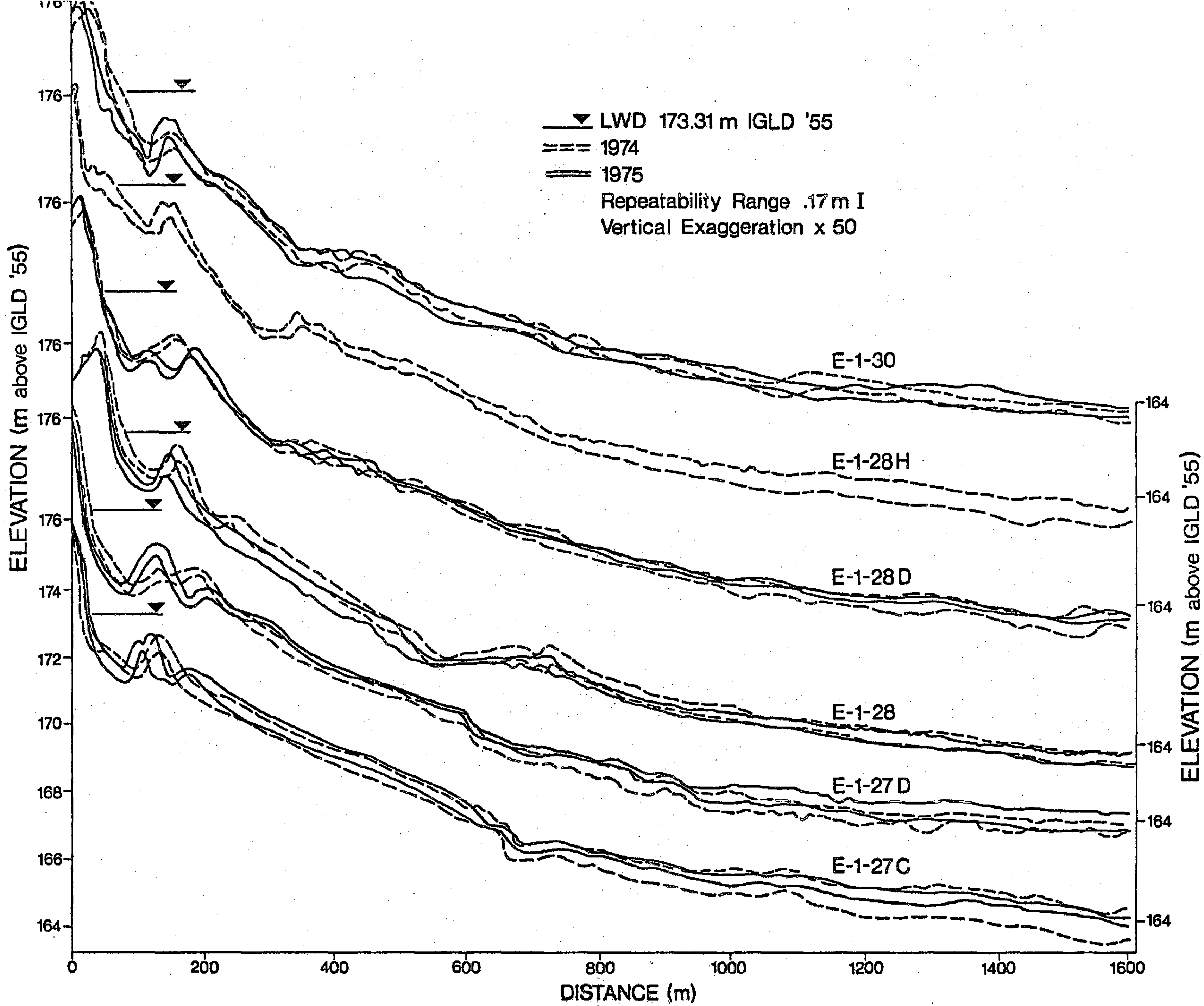


FIGURE 4.4 SWEEP ZONES OF THE 1974-75 NEARSHORE-OFFSHORE PROFILES OF POINT PELEE EAST

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 two-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 and a weaker crest at 300 m offshore. Cross-sectional area showed a gain of material of 141 m^2.

The transformation of the nearshore morphology reflects on an abundance of material available for such bar development during the '74-'75 survey interim and secondly on a wave climate which was significantly varied from one year to the next to maintain the morphologic changes which had occurred. (The relationship between the break-point and position of the submarine bar was established by Otto (1912), Evan (1940), and Keulegan (1945), after King, 1972, p. 336). There is evidence to substantiate that the supply of material to submarine bar development of '75 originated from excessive erosion to the east beaches during the corresponding period where average erosion measured 17.5 m^3/m. Furthermore, wind data at Point Pelee (Appendix B) shows that the prevailing direction during the survey periods switched from a N-S 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.

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, Figure 4.5. In contrast, the subaqueous extension of the sand spit evidenced dramatic changes largely in response to: 1) the west to east transgression described in the beach response section; and 2) the large supply of eroded beach material from the east shoreline. Figure 4.6 depicts the transposition of the spit with an 80-m recession of the upper nearshore slope at Spoke 3 and subsequent buildup of material to the southeast-oriented Spokes 4 and 5.

Volumetrically, on a station-to-station basis, the amount of material displaced over the nearshore zone in consequence to the profile readjustments is summarized in Table 2 of Appendix C. Changes are expressed in m^2/m relative to April, 1975, as the breadth of the nearshore zone varies by as much as 400 m.

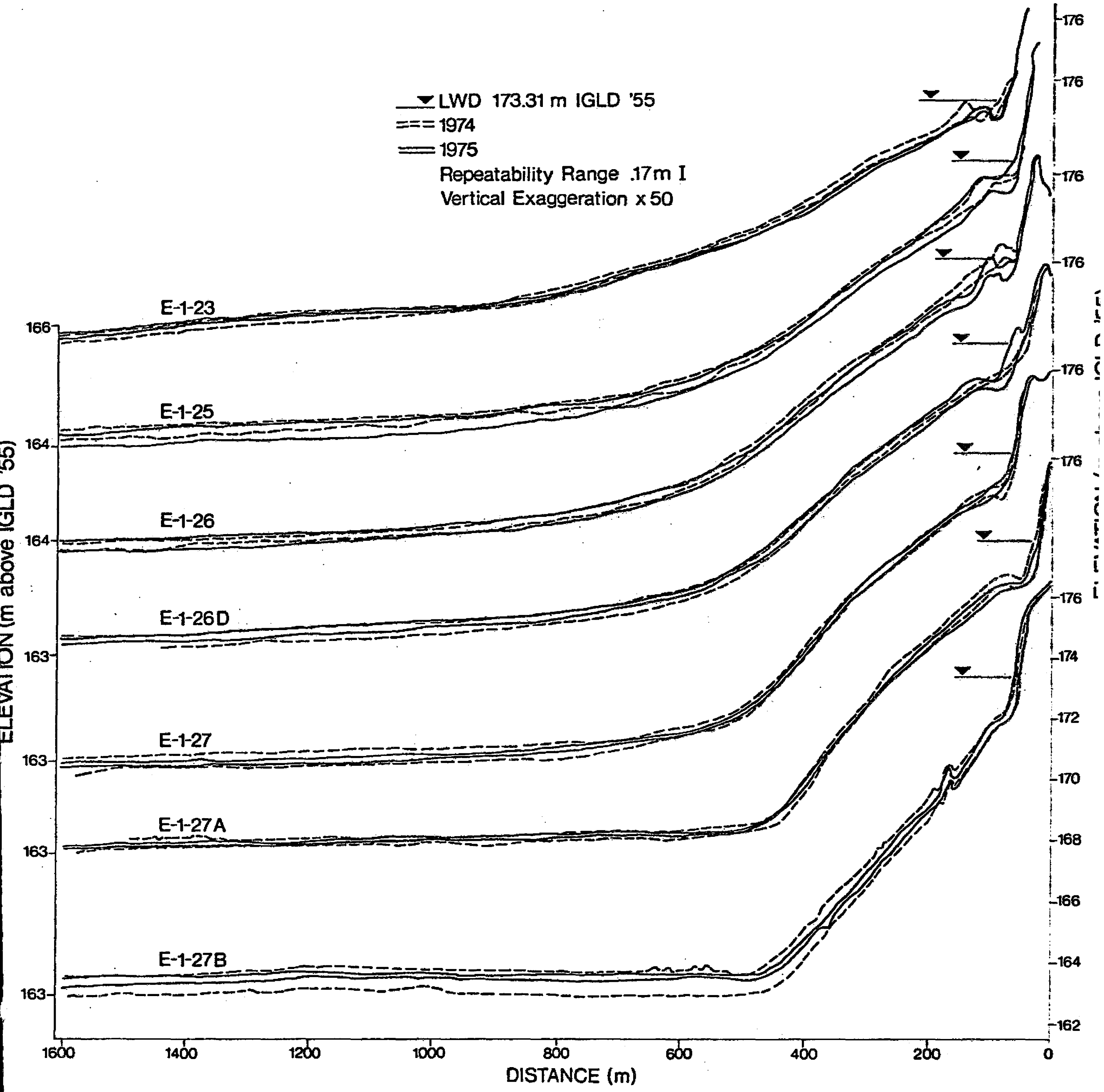


FIGURE 4.5 SWEEP ZONES OF THE 1974-75 NEARSHORE–OFFSHORE PROFILES OF POINT PELEE WEST

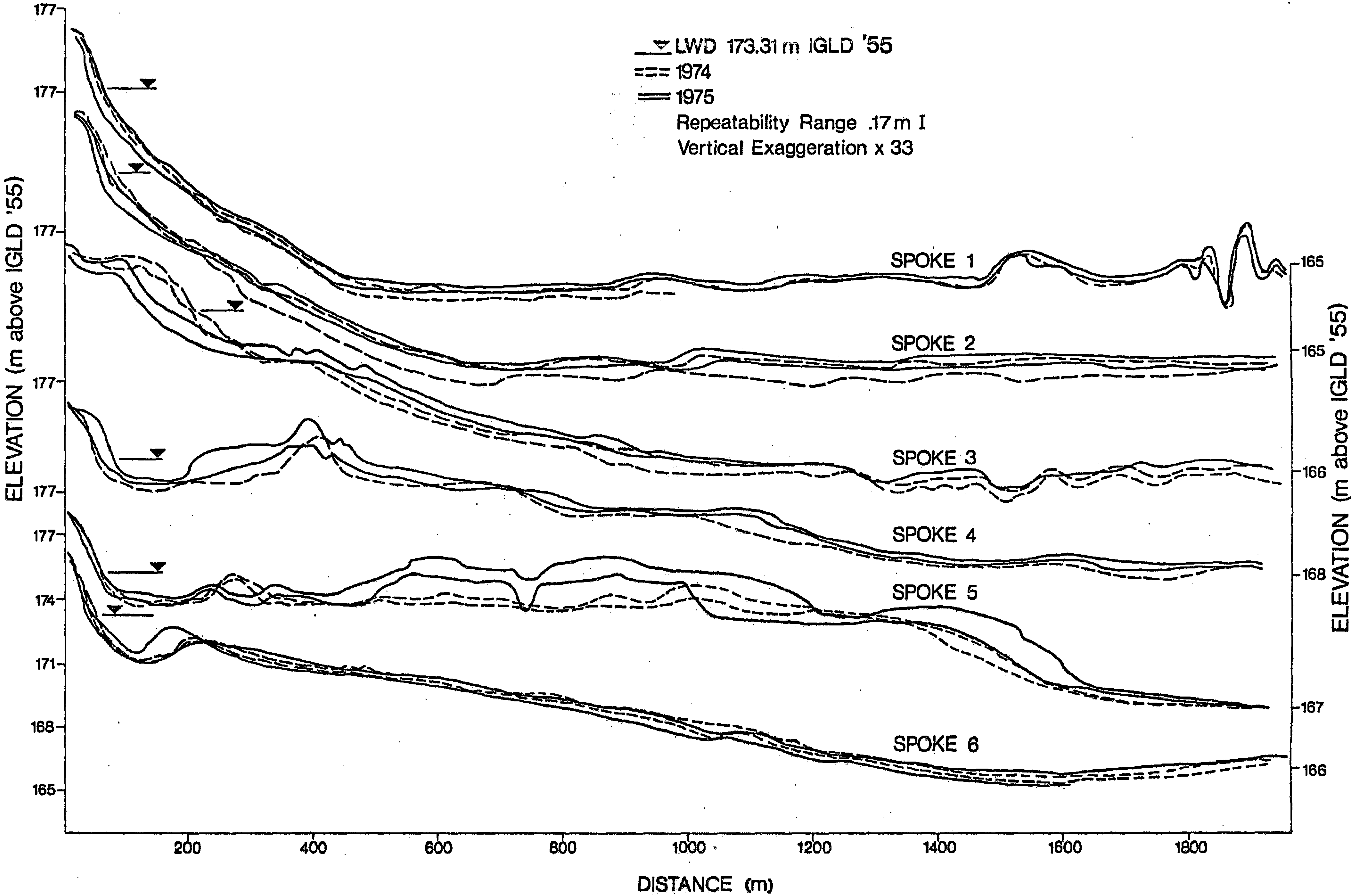


FIGURE 4.6 SWEEP ZONES OF THE 1974-75 NEARSHORE-OFFSHORE PROFILES OF POINT PELEE SOUTH

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.

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 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 '74-'75 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 4.2, 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 4.2

Variability of Nearshore Response at Point Pelee

PELEE WEST		SUBAERIAL 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 3 of Appendix C 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 '75 profiles averaged 0.04 m^2/m greater than fall '74 profiles and 0.19 m^2/m greater than subsequent June '75 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 '74 profiles and 0.23 m^2/m relative to June '75 profiles.

Approximately half of the quantitative changes are within the 20σ 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 below in a north to south listing.

Table 4.3

Variability of Offshore Response at Point Pelee

PELEE WEST (Station)	(σ)	SUBAERIAL 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 '74-'75 sounding surveys.

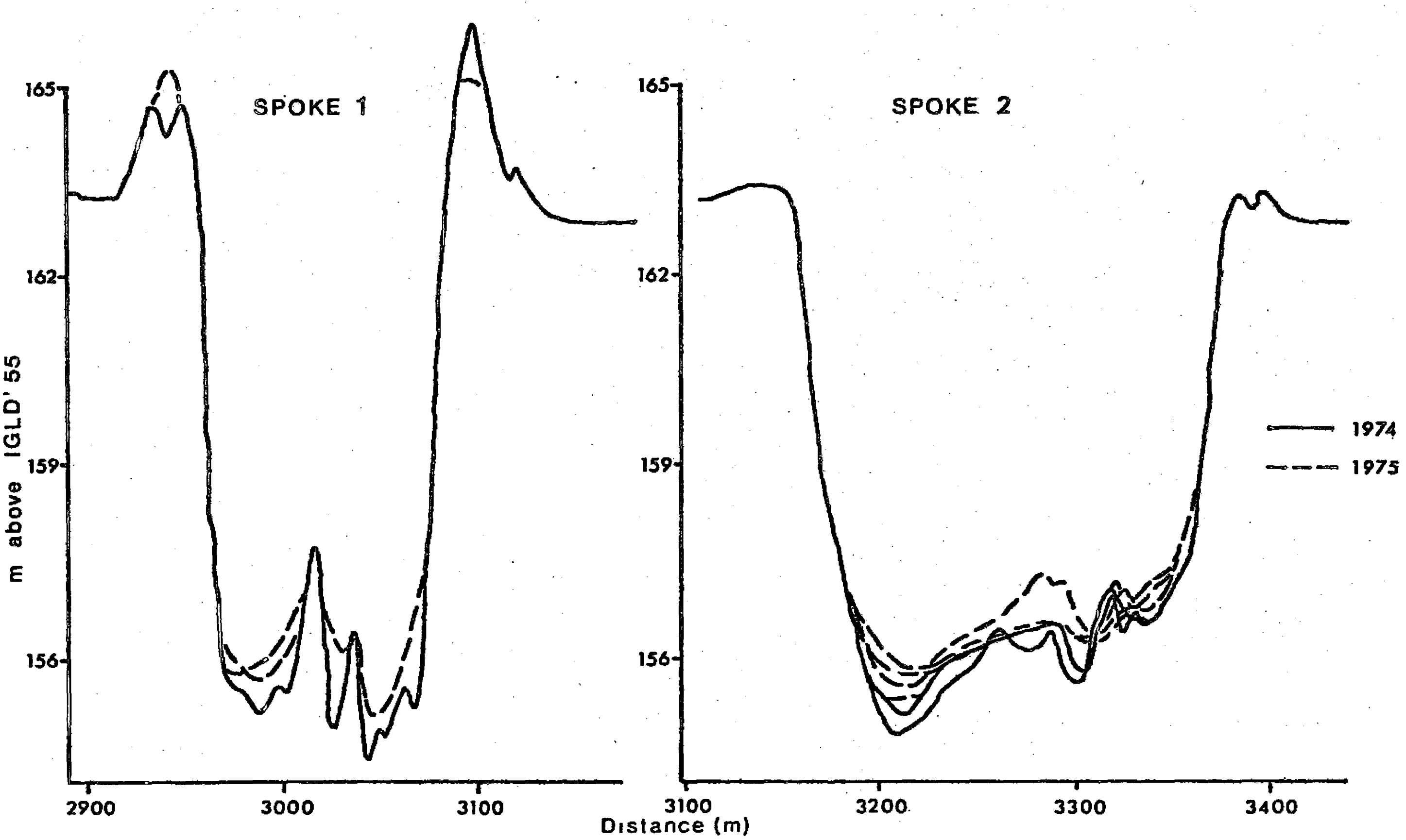


Figure 4.7: Evidence of Trench Infilling

Bottom relief at the base of the trench has been altered with sediment accumulating in depressions which 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/m and 68 m^2/m for Spokes 1 and 2 respectively.

CHAPTER 5

5.0 POINT PELEE ANNUAL SEDIMENT BUDGET

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 now shows, in quantitative terms, the rates at which the shorelines are changing. Furthermore, variation in the "rates" of transgression between 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 show a trend, or an approximation of the sediment budget which, if it may be used as a measure of "migration", indicates 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 trend in the overall Point Pelee sediment budget.

CHAPTER 6

6.0 CONCLUSIONS

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

(a) Distribution of bottom sediments south of Point Pelee indicates net deposition in both an easterly and northwesterly direction.

(b) Bottom currents exceed critical-traction velocities 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).

(c) 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 supersede 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, the extent of the breaking wave on the beach is much less than that for the east side. With the restricted maximum of surge levels, beach berms developed are not exposed to destructive storm conditions.

(d) Hindcast wave methods are generally inaccurate for the Point Pelee area. Characteristic 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 tended to be all destructive in character in 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.

(e) Extensive alterations to the lake bed south of Point Pelee could effect the dissipation of wave energy on the shoreline as 26% of the wave observations begin to refract at water depths of 10 m. This becomes even more significant at low lake level stages.

(f) 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 17.5 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.

(g) 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.

(h) 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, as a quantitative measure of westward migration of the Point, the east beach is advancing at five times the rate of the west side. Providing this trend will continue, it would appear that the sustentation of the Point is doomed.

(i) 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, Figures 6.1 and 6.2.

Effects of gravel extraction on seabed topography near Hastings, Great Britain, has been studied by R. Dickson et al (1973) from which repeated profiles 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 years 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 "cumulative" effects may result.

6.1 RECOMMENDATIONS

The study has concentrated on quantifying coastal response at Point Pelee from the perspective of evaluating the impact of commercial dredging. Future investigations which may have similar objectives would benefit if they included the following:

(1) Profile data should be taken continually over a minimum of twelve months. The maximum amount of beach material eroded was between November and April when there were no field surveys being undertaken. The effect of ice at Point Pelee may be a significant factor in accounting for this loss; however, this could not be substantiated. If it were, then non-structural management alternatives might include such

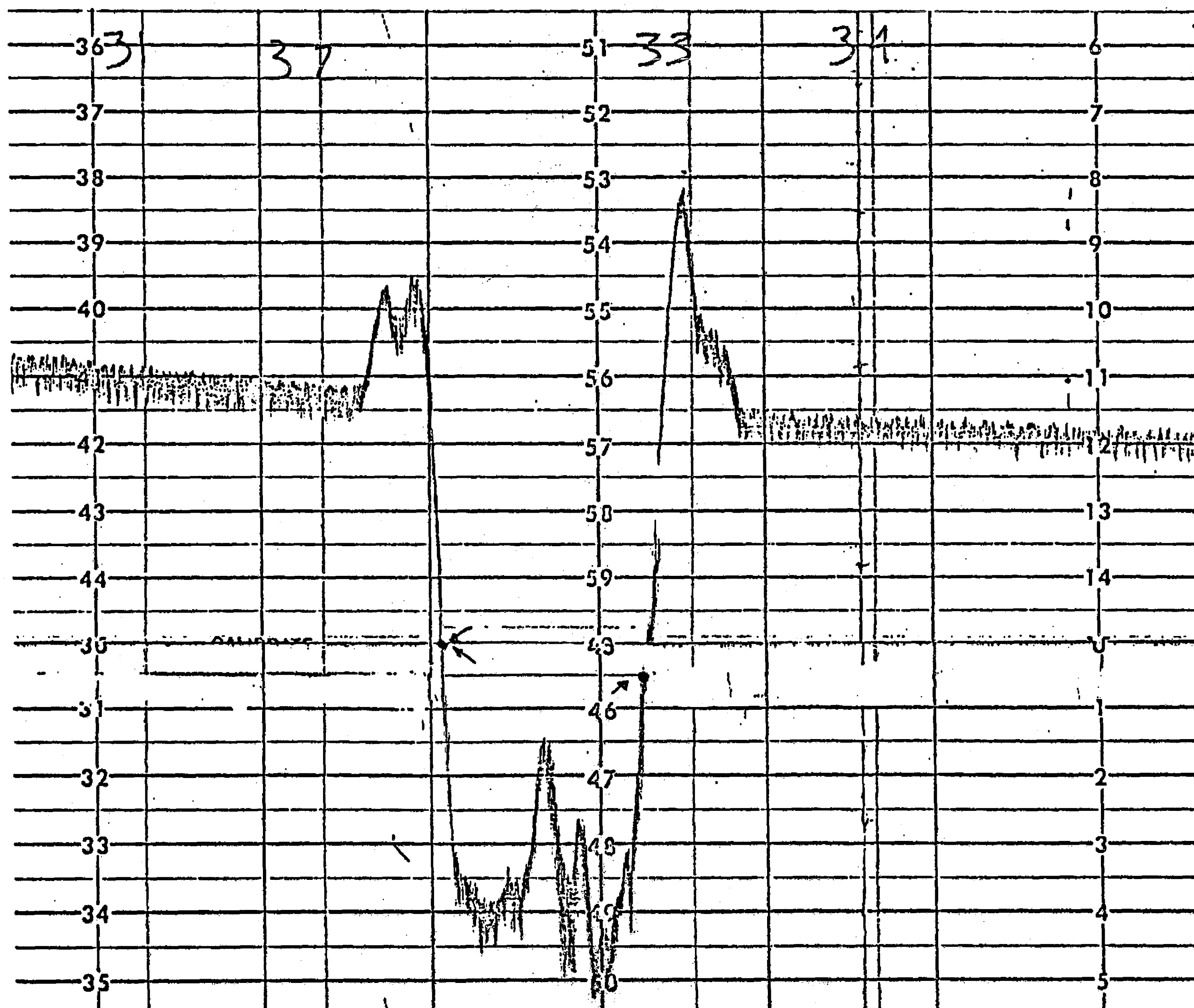


Figure 6.1: Cross-Section of Trench In Lake Bed South of Point Pelee

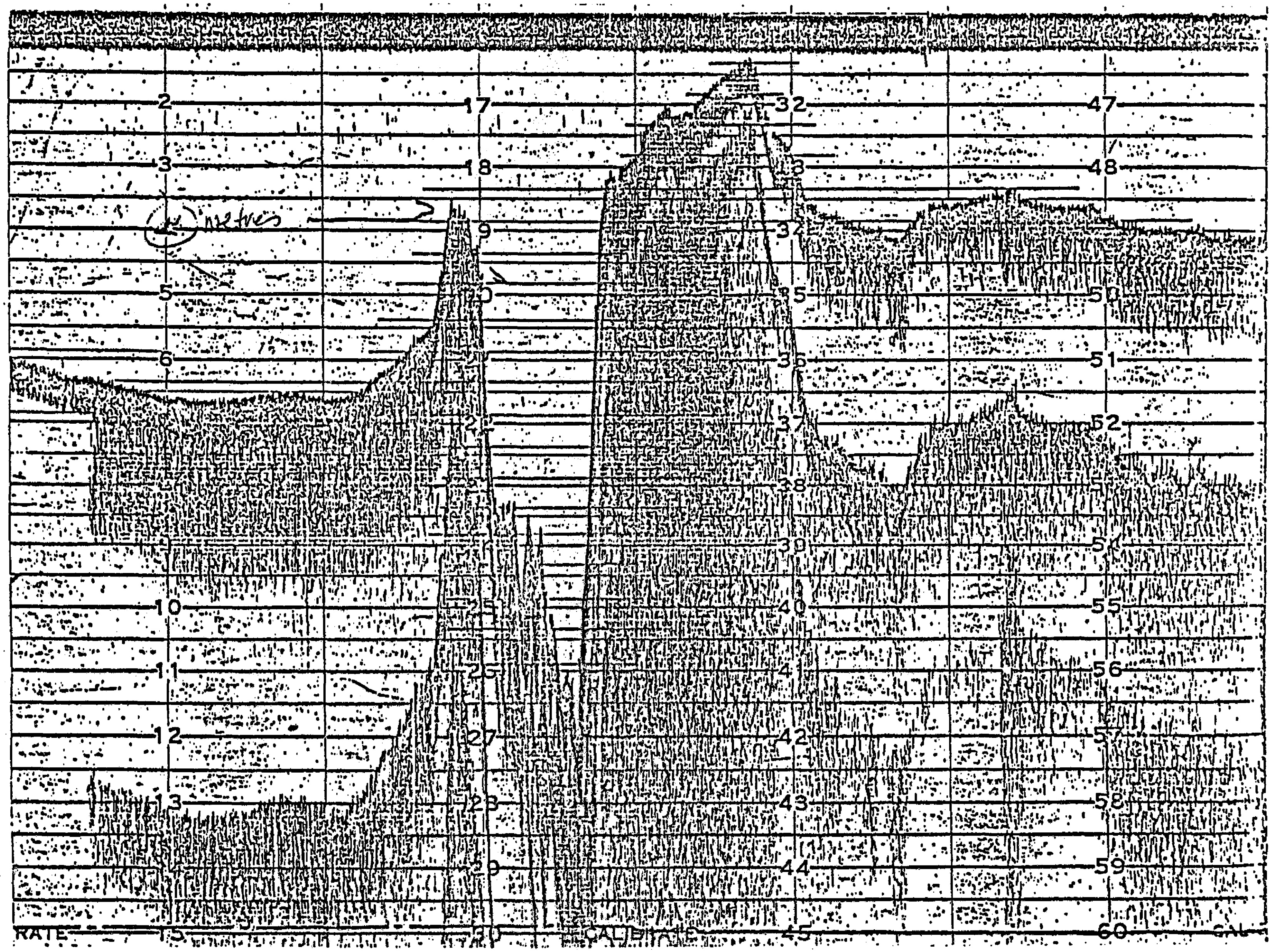


Figure 6.2: Cross-Section of Dredged Channel in the St. Mary's River (from Harvey, 1973)

things as the application of waste heat discharge from future shoreline development such as hydro generating plants.

(2) Bottom current data over a one-year record to identify seasonal variations in flow would provide an annual frequency of currents capable of transporting bed material.

(3) Correlation of beach response to process elements of wind, waves, and currents requires a high survey frequency which should record at least the effects of episodic events.

(4) In order to derive critical wave criteria to differentiate between constructive and destructive waves, accurate wave dimensions are needed to correlate with profile data over the entire survey period.

(5) Offshore profile data should be expanded to include a greater density of profiles within the area licensed for dredging. This would provide more information as to the recovery rate of mined areas.

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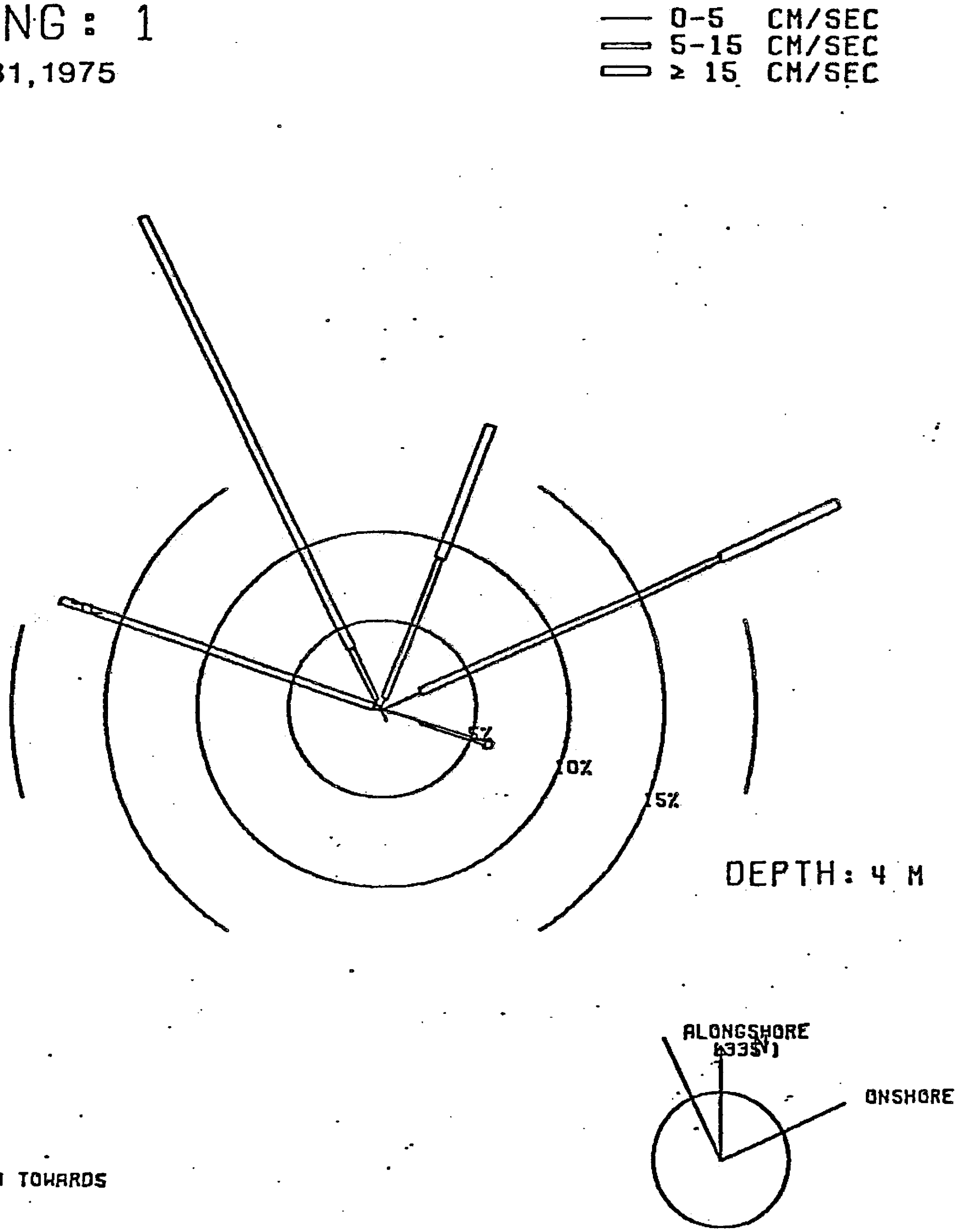
A P P E N D I C E S

Appendix A: BOTTOM CURRENT DATA

MONTHLY SUMMARY: CURRENT*

MOORING: 1

AUG 26-31,1975



* DIRECTION TOWARDS

POINT PELEE CUR RENT ,MOORING 1 (WEST),AUG 26-AUG 31 1975

FIRST DAY 26 8 11
FINAL DAY 31 8 23

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 335

DIRECTION DEG TRUE TOWARD	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM CURRENT CM/S	MEAN DURATION HOURS	MEAN EXCURSION KM	MEAN CURRENT CM/S	MEAN TEMP DEG C	
335.0	30.5	0.6	3.2	26.7	47.8	6.8	6.2	25.4	0.0	PARALLEL
290.0	18.5	0.0	0.4	18.1	68.3	9.8	14.6	41.3	0.0	
245.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	OFFSHORE
200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
155.0	0.8	0.8	0.0	0.0	4.1	4.0	0.4	3.0	0.0	ANTIPARA
110.0	6.2	2.3	3.6	0.4	25.4	4.7	1.2	7.2	0.0	
65.0	27.1	2.3	17.7	7.2	26.4	9.6	4.2	12.2	0.0	ONSHORE
20.0	16.9	0.6	8.5	7.9	26.8	4.7	2.3	13.5	0.0	

MEAN SCALAR SPEED = 21.4 CM/S MEAN SQUARE SPEED = 641.8 CM2/S2 VARIANCE = 419.0 CM2/S2

MEAN VELOCITY = 15.0 CM/S, 336 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 531

PERCENT OBSERVED
LIGHT 0.0 - 5.0 MEDIUM 5.0 - 15.0 HIGH GE 15.0
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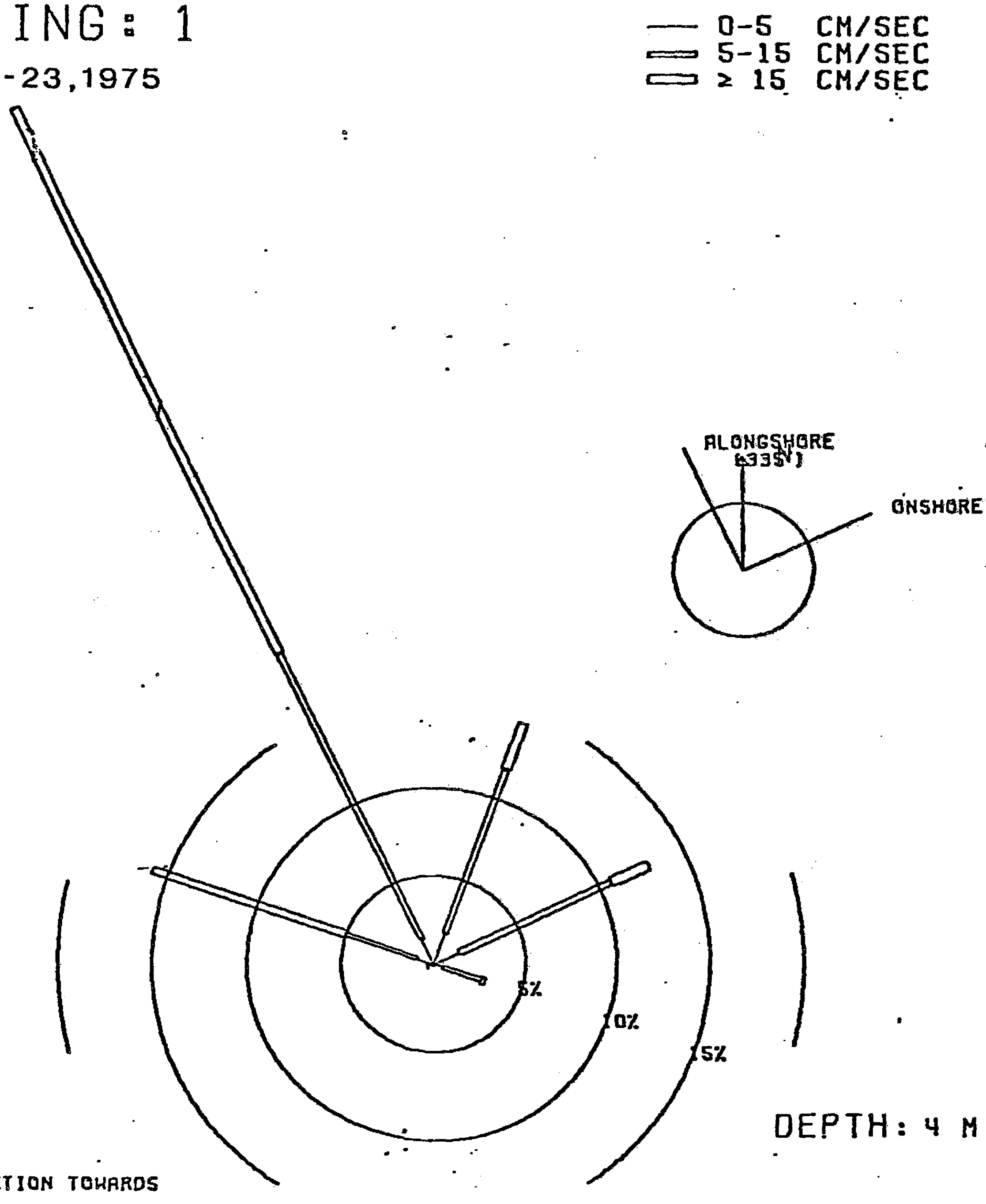
O= 8IDTYPE= 2
K= 0.000MO= 8IDTYPE= 3

MONTHLY SUMMARY: CURRENT*

MOORING: 1

SEPT 1-23,1975



DEPTH: 4 M

* DIRECTION TOWARDS

PT.PELEE CURREN   T DATA ,SEPT 1975,STA.1 WEST

FIRST DAY 1 9 0
FINAL DAY 23 9 15

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 335

DIRECTION DEG TRUE TOWARD	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM CURRENT CM/S	MEAN DURATION HOURS	MEAN EXCURSION KM	MEAN CURRENT CM/S	MEAN TEMP DEG C	
335.0	53.1	1.5	17.9	33.7	49.1	10.8	8.4	21.5	0.0	PARALLEL
290.0	15.9	0.9	4.1	10.8	49.0	5.1	4.6	25.0	0.0	
245.0	0.4	0.3	0.0	0.0	6.4	4.0	0.4	2.8	0.0	OFFSHORE
200.0	0.1	0.1	0.0	0.0	1.2	2.0	0.1	0.9	0.0	
155.0	0.1	0.0	0.1	0.0	7.2	1.5	0.3	5.5	0.0	ANTIPARA
110.0	3.0	0.6	2.1	0.2	19.9	3.8	1.2	8.6	0.0	
65.0	13.0	1.5	9.2	2.3	29.8	8.7	3.4	11.0	0.0	ONSHORE
20.0	14.4	1.8	9.9	2.8	26.4	5.6	2.2	11.0	0.0	

MEAN SCALAR SPEED = 18.7 CM/S   MEAN SQUARE SPEED = 490.3 CM2/S2   VARIANCE = 251.7 CM2/S2

MEAN VELOCITY = 15.4 CM/S, 332 DEG TRUE   MEAN TEMPERATURE = 0.0 C   TOTAL HOURS = 2140

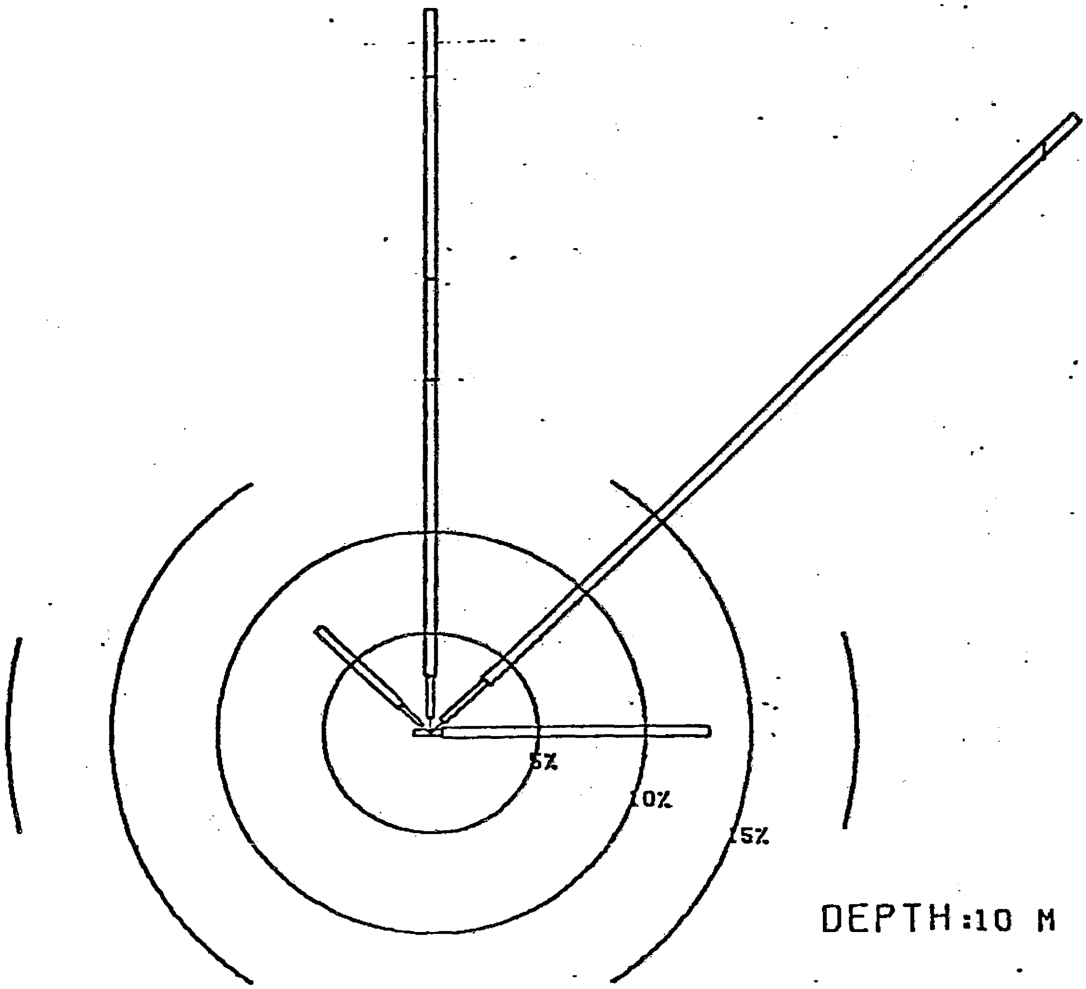
PERCENT OBSERVED

MONTHLY SUMMARY: CURRENT*

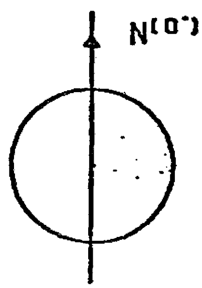
MOORING: 2

AUG 26-31, 1975

— 0-5 CM/SEC
═ 5-15 CM/SEC
▭ ≥ 15 CM/SEC



DEPTH: 10 M



* DIRECTION TOWARDS

POINT PELEE CURRENT,STA.2 LIGHT HOUSE AUG26-AUG 31 1975

FIRST DAY 26 8 11
FINAL DAY 31 8 23

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 0

DIRECTION DEG TRUE TOWARD	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM CURRENT CM/S	MEAN DURATION HOURS	MEAN EXCURSION KM	MEAN CURRENT CM/S	MEAN TEMP DEG C	
0.0	35.9	0.8	2.1	33.1	51.0	11.9	12.7	29.7	0.0	PARALLEL
315.0	7.4	0.6	1.3	5.5	41.8	4.9	4.1	23.6	0.0	
270.0	0.8	0.0	0.8	0.0	11.7	4.0	1.3	8.9	0.0	OFFSHORE
225.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ANTIPARA
135.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
90.0	13.0	0.0	0.6	12.5	37.9	11.5	12.0	29.1	0.0	ONSHORE
45.0	42.9	0.8	2.8	39.3	55.4	16.2	18.9	32.4	0.0	

MEAN SCALAR SPEED = 30.1 CM/S MEAN SQUARE SPEED =1027.0 CM2/S2 VARIANCE = 395.0 CM2/S2

MEAN VELOCITY = 25.2 CM/S, 29 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 529

PERCENT OBSERVED
LIGHT 0.0 - 5.0 MEDIUM 5.0 - 15.0 HIGH GE 15.0

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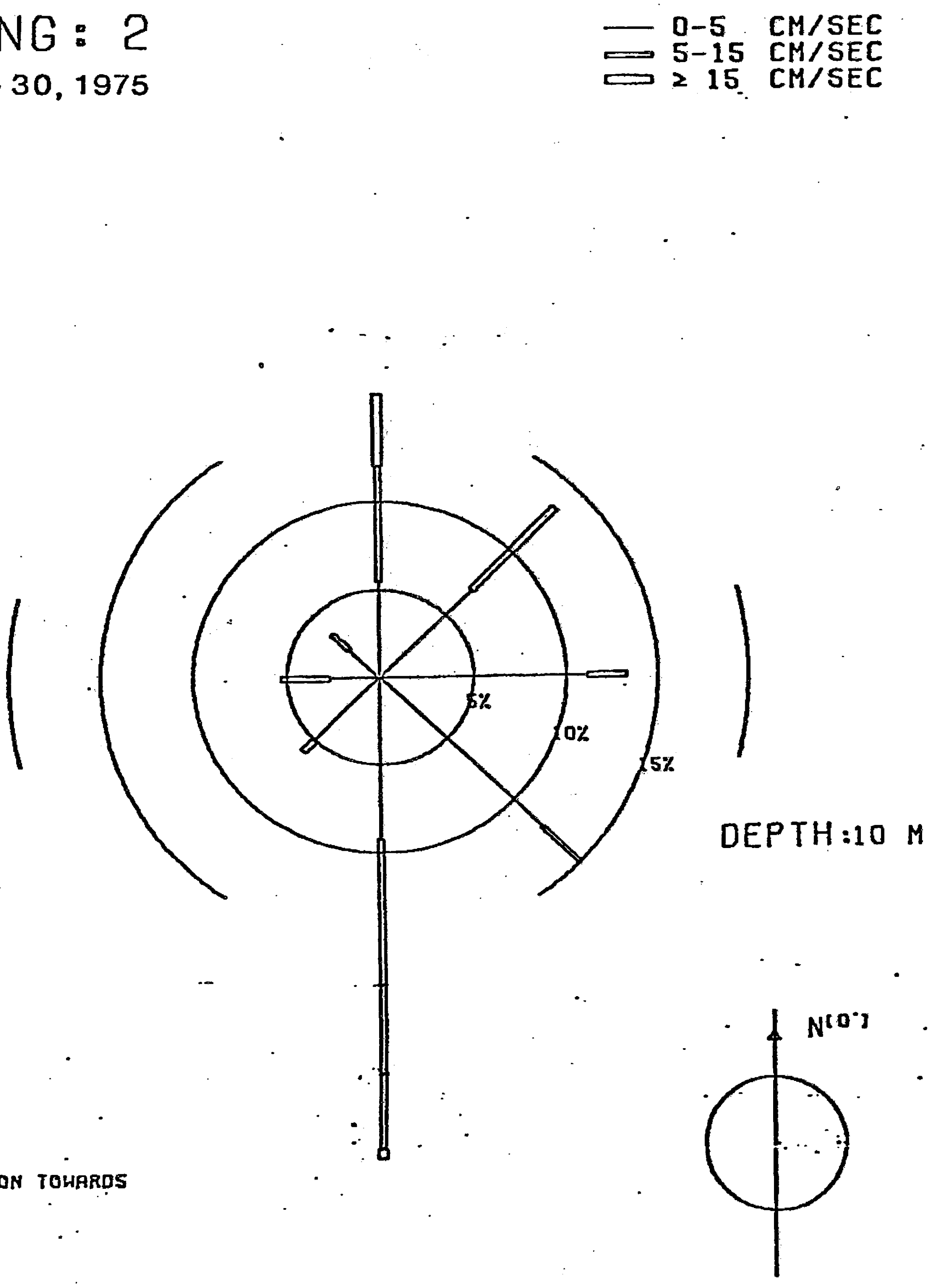
O= 8IDTYPE= 2
K= 0.000MO= 8IDTYPE= 3

MONTHLY SUMMARY: CURRENT*

MOORING: 2
SEPT 23-30, 1975



* DIRECTION TOWARDS

POINT PELEE ,ST A.2,SHOAL,SEPT 23-30 1975 CURRENT DATA

FIRST DAY 23 9 10
FINAL DAY 30 9 23

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 0

DIRECTION DEG TRUE TOWARD	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM CURRENT CM/S	MEAN DURATION HOURS	MEAN EXCURSION KM	MEAN CURRENT CM/S	MEAN TEMP DEG C	
0.0	16.1	5.5	6.6	4.1	24.7	5.1	1.7	9.4	0.0	PARALLEL
315.0	3.5	2.3	1.2	0.0	6.3	4.0	0.6	4.2	0.0	
270.0	5.3	2.7	2.7	0.0	6.8	7.5	1.2	4.5	0.0	OFFSHORE
225.0	5.9	5.0	0.9	0.0	5.9	3.7	0.4	2.9	0.0	
180.0	27.3	9.2	17.6	0.5	15.5	10.3	2.6	6.9	0.0	ANTIPARA
135.0	15.1	12.2	2.8	0.0	6.9	4.0	0.5	3.3	0.0	
90.0	13.3	11.2	2.1	0.0	5.8	3.7	0.4	3.2	0.0	ONSHORE
45.0	13.5	6.9	6.6	0.0	12.9	3.8	0.7	5.2	0.0	

MEAN SCALAR SPEED = 5.6 CM/S MEAN SQUARE SPEED = 48.6 CM2/S2 VARIANCE = 48.1 CM2/S2

MEAN VELOCITY = 0.8 CM/S, 104 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 564

PERCENT OBSERVED
LIGHT 0.0 - 5.0 MEDIUM 5.0 - 15.0 HIGH GE 15.0

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:      0.000MO=     9IDTYPE=    3
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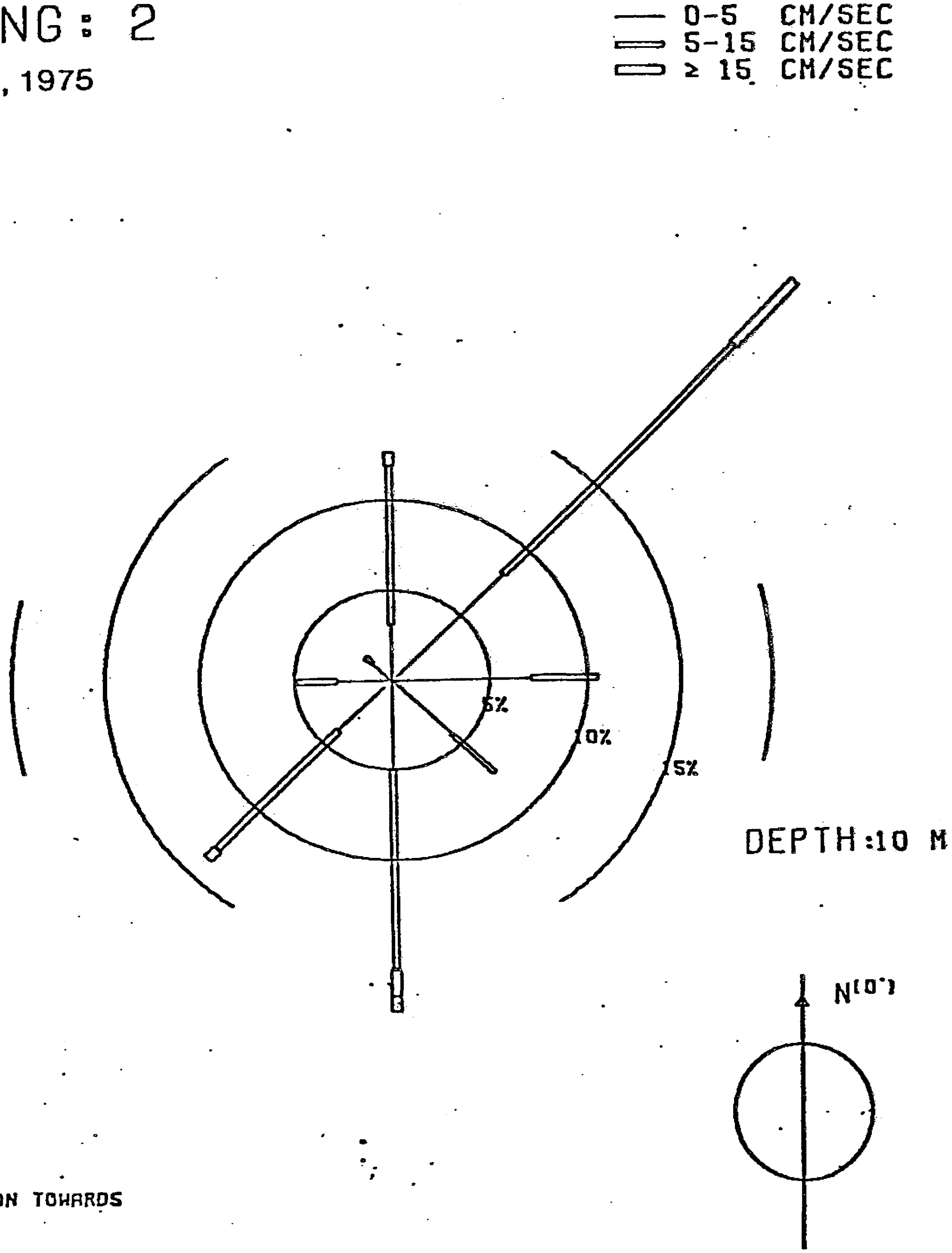
*PLOT TAPE SUCCESSFULLY WRITTEN***

STOP

MONTHLY SUMMARY: CURRENT*

MOORING: 2

OCT 1-22, 1975



* DIRECTION TOWARDS

POINT PELEE,STA .2 SHOAL,OCT.1-22 1975,CURRENT DATA

FIRST DAY 1 10 0
FINAL DAY 22 10 12

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 0

DIRECTION DEG TRUE TOWARD	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM CURRENT CM/S	MEAN DURATION HOURS	MEAN EXCURSION KM	MEAN CURRENT CM/S	MEAN TEMP DEG C	
0.0	12.6	3.1	8.8	0.7	17.3	7.6	2.2	8.0	0.0	PARALLEL
315.0	1.8	1.4	0.4	0.0	6.7	2.1	0.3	3.4	0.0	
270.0	4.9	2.8	2.1	0.0	8.1	3.2	0.5	4.2	0.0	OFFSHORE
225.0	13.7	3.8	9.1	0.8	22.7	7.3	1.9	7.1	0.0	
180.0	18.4	5.0	11.1	2.3	24.1	10.8	3.4	8.7	0.0	ANTIPARA
135.0	7.4	4.3	3.0	0.0	12.6	3.5	0.6	4.8	0.0	
90.0	10.6	7.1	3.5	0.0	11.7	3.7	0.6	4.4	0.0	ONSHORE
45.0	30.7	8.1	17.6	5.0	27.8	10.6	3.5	9.2	0.0	

MEAN SCALAR SPEED = 7.5 CM/S   MEAN SQUARE SPEED = 79.7 CM2/S2   VARIANCE = 76.5 CM2/S2
MEAN VELOCITY = 1.8 CM/S, 72 DEG TRUE   MEAN TEMPERATURE = 0.0 C   TOTAL HOURS = 1874

PERCENT OBSERVED
LIGHT 0.0 - 5.0 MEDIUM 5.0 - 15.0 HIGH GE 15.0
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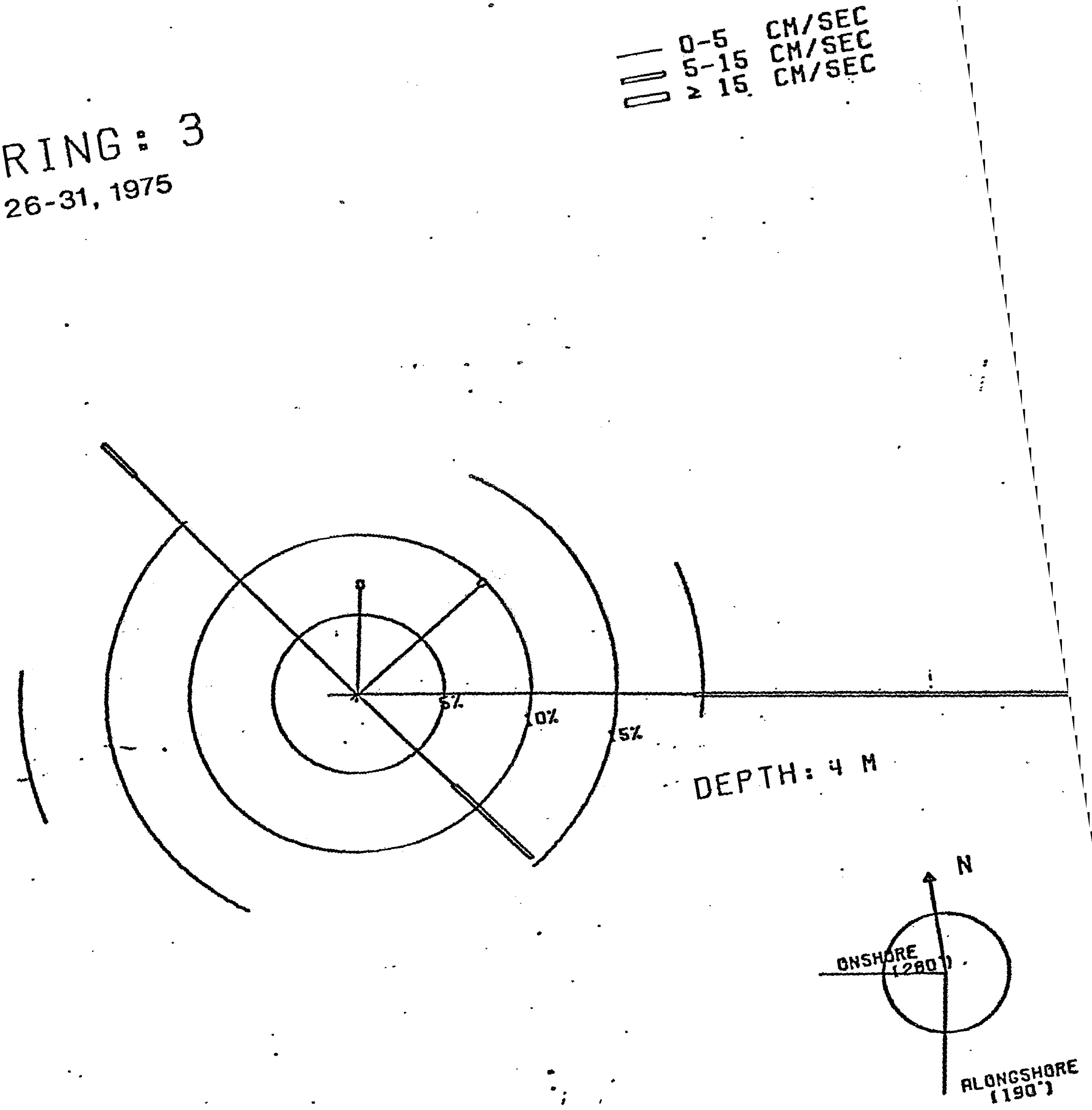
MONTHLY SUMMARY: CURRENT*

MOORING: 3
AUG 26-31, 1975



* DIRECTION TOWARDS

POINT PELEE STA .3 EAST AUG 26-31 1975,CURRENT DATA

FIRST DAY 26 8 12
FINAL DAY 31 8 23

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 190

DIRECTION DEG TRUE	PERCENT OBSERVED				MAXIMUM CURRENT	MEAN DURATION	MEAN EXCURSION	MEAN CURRENT	MEAN TEMP	
TOWARD	TOTAL	LIGHT	MEDIUM	HIGH	CM/S	HOURS	KM	CM/S	DEG C	
190.0	0.5	0.5	0.0	0.0	1.8	1.0	0.1	1.5	0.0	PARALLEL
145.0	14.6	8.1	6.4	0.0	11.4	3.7	0.7	5.1	0.0	
100.0	43.5	19.5	24.0	0.0	13.0	8.4	1.6	5.3	0.0	OFFSHORE
55.0	10.1	9.6	0.5	0.0	5.3	3.2	0.4	3.4	0.0	
10.0	7.2	6.7	0.5	0.0	5.8	1.8	0.2	3.0	0.0	ANTIPARA
325.0	22.0	19.3	2.7	0.0	6.3	8.9	1.1	3.5	0.0	
280.0	1.7	1.7	0.0	0.0	3.0	7.0	0.6	2.4	0.0	ONSHORE
235.0	0.5	0.5	0.0	0.0	0.9	1.0	0.0	0.8	0.0	

MEAN SCALAR SPEED = 4.4 CM/S MEAN SQUARE SPEED = 24.5 CM2/S2 VARIANCE = 17.7 CM2/S2

MEAN VELOCITY = 2.6 CM/S, 93 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 405

PERCENT OBSERVED
LIGHT 0.0 - 5.0 MEDIUM 5.0 - 15.0 HIGH GE 15.0

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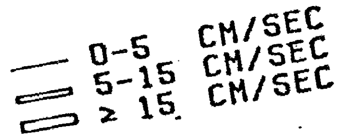
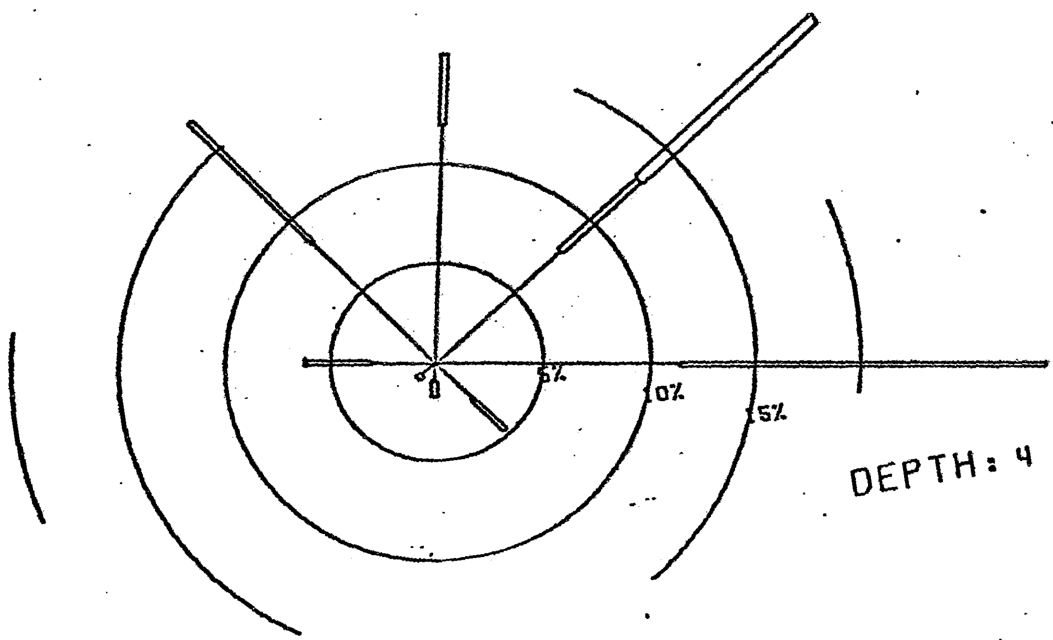
MØNTHLY SUMMARY: CURRENT*



MØØRING: 3

SEPT 1-23, 1975



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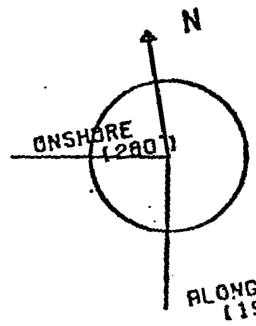


* DIRECTION TOWARDS

PT.PELEE STA.3 EAST,SEPT.1975

FIRST DAY 1 9 0
FINAL DAY 23 9 10

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 190

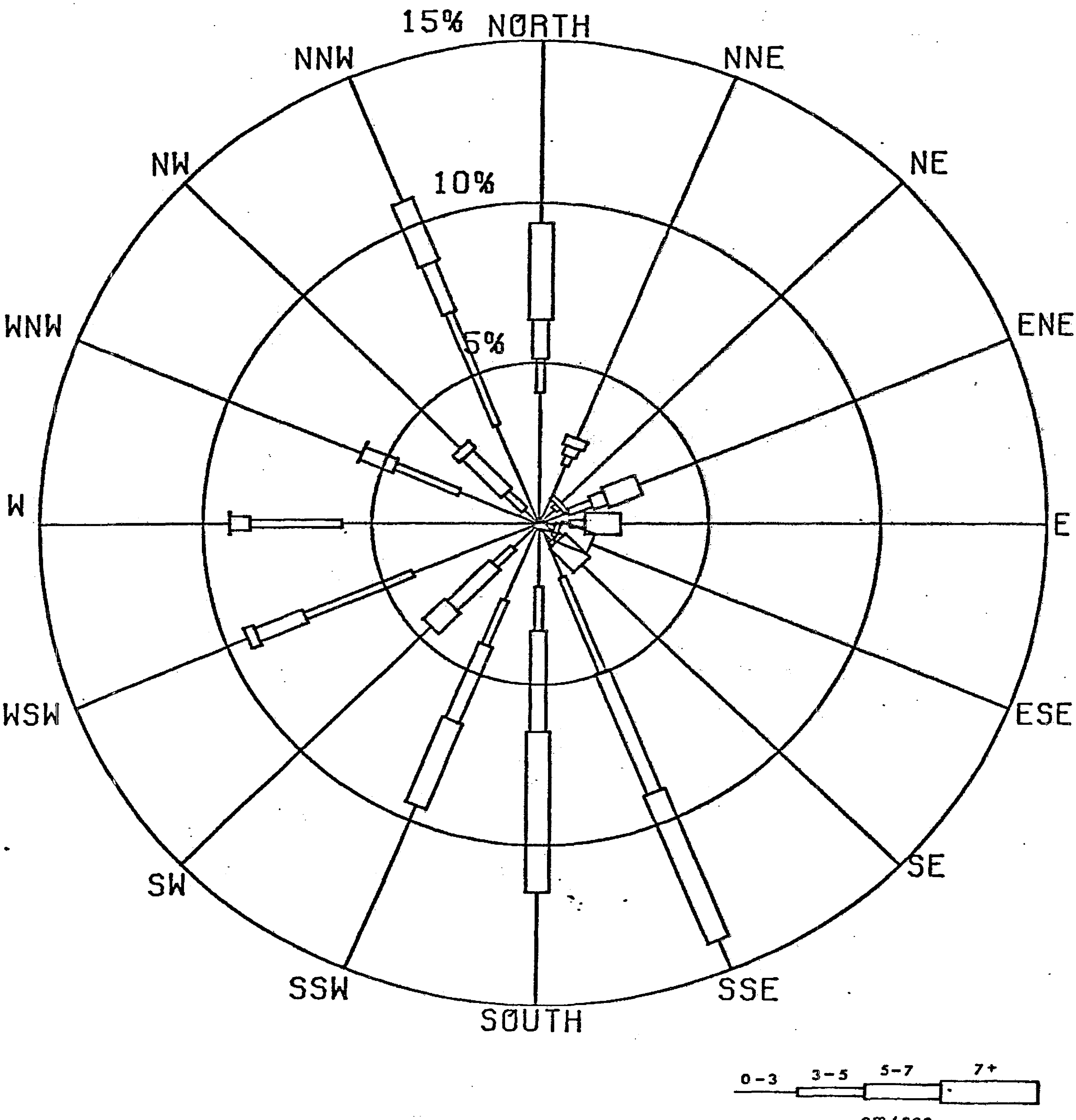
DIRECTION DEG TRUE	PERCENT OBSERVED				MAXIMUM CURRENT	MEAN DURATION	MEAN EXCURSION	MEAN CURRENT	MEAN TEMP	
TOWARD	TOTAL	LIGHT	MEDIUM	HIGH	CM/S	HOURS	KM	CM/S	DEG C	
190.0	1.7	0.9	0.9	0.0	8.4	5.6	1.0	5.0	0.0	PARALLEL
145.0	4.8	2.5	2.2	0.0	14.1	3.3	0.7	5.5	0.0	
100.0	29.0	11.4	17.5	0.0	14.6	10.0	2.2	6.2	0.0	OFFSHORE
55.0	24.6	8.0	5.1	11.6	39.7	8.3	4.4	14.6	0.0	
10.0	15.6	11.9	3.6	0.1	15.2	4.9	0.8	4.5	0.0	ANTIPARA
325.0	17.0	8.5	8.5	0.0	14.4	5.5	1.1	5.6	0.0	
280.0	6.2	3.0	3.1	0.1	15.3	3.5	0.7	5.6	0.0	ONSHORE
235.0	1.2	0.9	0.3	0.0	6.9	1.9	0.3	3.9	0.0	

MEAN SCALAR SPEED = 7.8 CM/S MEAN SQUARE SPEED = 113.4 CM2/S2 VARIANCE = 89.6 CM2/S2

MEAN VELOCITY = 4.9 CM/S, 53 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 1620

PERCENT OBSERVED
LIGHT 0.0 - 5.0 MEDIUM 5.0 - 15.0 HIGH GE 15.0
K= 0.562MO= 9IDTYPE= 2
D= 3IDTYPE= 2
K= 0.000MO= 9IDTYPE= 3

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



Appendix B: WIND DATA

ANALYSIS OF OVERLAND WINDS
PERCENTAGE FREQUENCY OF WIND BY DIRECTION AND SPEED CLASS
London A 1957–1966
SPRING

Wind Direction	*Speed Class (Knots)*											*Totals %*
	1-3	*4-6*	*7-10*	*11-16*	*17-21*	*22-27*	*28-33*	*34-40*	*41-47*	*48-55*	*56-63*	
APRIL												
CALM	3.92											3.92
N	.40	1.88	2.25	1.44	.35	.08	.04					6.44
NE	.43	1.88	2.35	1.90	.58	.17						7.31
E	.49	2.49	4.07	5.51	3.56	1.25	.24	.06				17.67
SE	.54	1.81	2.73	2.01	.75	.14						7.98
S	.53	2.06	3.53	2.99	1.07	.38	.01					10.57
SW	.35	1.81	3.92	3.64	1.57	.60	.01	.03				11.93
W	.85	3.00	5.35	5.01	3.13	1.39	.10	.01				18.84
NW	.50	2.25	4.69	4.42	2.43	.79	.15					15.23
TOTALS	8.01	17.18	28.89	26.92	13.44	4.80	.55	.10				100
MAY												
CALM	5.99											5.99
N	.52	1.96	2.84	1.87	.50	.09						7.78
NE	.47	1.71	1.95	.86	.58	.17	.05	.04				5.83
E	.66	2.47	5.19	4.18	1.44	.28						14.22
SE	.54	2.18	2.93	1.91	.42	.11						8.09
S	.74	3.04	5.62	3.67	1.05	.08						14.20
SW	.52	2.66	4.95	4.10	1.33	.38						13.94
W	.60	3.16	5.23	4.21	1.61	.19				.01		15.01
NW	.59	1.85	4.78	5.46	1.79	.31	.01	.01				14.80
TOTALS	10.63	19.03	33.49	26.26	8.72	1.61	.06	.05		.01		1.00
JUNE												
CALM	10.36											10.36
N	.79	2.33	2.58	.85	.10	.03						6.68
NE	.74	2.00	2.19	.93	.29	.04						6.19
E	1.32	3.46	3.64	1.71	.26	.01						10.40
SE	.82	2.51	2.29	.54	.13							6.29
S	1.07	5.13	6.14	3.07	.42	.11						15.94
SW	.85	3.12	6.11	3.50	.76	.11	.03					14.48
W	.97	3.97	4.88	3.46	.79	.14	.01					14.22
NW	.83	3.26	5.99	3.90	1.24	.18						15.40
TOTALS	17.75	25.78	33.82	17.96	3.99	.62	.04					100

(from Richards et al 1970)

ANALYSIS OF OVERLAND WINDS
PERCENTAGE FREQUENCY OF WIND BY DIRECTION AND SPEED CLASS
London A 1957–1966
SUMMER

Wind Direction	*Speed Class (Knots)*											*Totals %*
	1-3	*4-6*	*7-10*	*11-16*	*17-21*	*22-27*	*28-33*	*34-40*	*41-47*	*48-55*	*56-63*	
JULY												
CALM	12.56											12.56
N	1.25	3.31	2.59	.78	.11							8.04
NE	1.08	2.50	1.90	.52	.05							6.05
E	1.59	3.45	2.73	.77	.09							8.63
SE	.95	2.08	1.98	.47	.17							5.65
S	1.49	4.76	5.23	2.50	.31	.03						14.32
SW	1.06	4.57	5.66	2.12	.28	.04	.03					13.76
W	1.33	4.42	5.86	2.98	.69	.08						15.36
NW	.95	3.63	6.24	3.62	1.04	.15						15.63
TOTALS	22.26	28.72	32.19	13.76	2.74	.30	.03					100
AUGUST												
CALM	12.02											12.02
N	1.03	2.31	2.42	.71	.09	.01						6.57
NE	.77	2.39	2.26	.58	.08							6.08
E	1.53	4.21	3.97	1.32	.17	.01						11.21
SE	.94	2.38	2.07	.54	.08	.01						6.02
S	1.25	4.30	5.16	2.38	.30							13.39
SW	1.24	4.81	6.77	2.54	.23	.03						15.62
W	1.47	4.93	4.99	3.04	.56	.09						15.08
NW	.82	3.43	5.62	3.09	.90	.13	.01					14.00
TOTALS	21.07	28.76	33.26	14.20	2.41	.28	.01					100
SEPTEMBER												
CALM	9.29											9.29
N	1.22	2.65	2.58	1.15	.44	.06						8.10
NE	.69	2.93	2.63	1.25	.22							7.72
E	1.29	4.81	5.43	2.56	.39	.01						14.49
SE	.93	3.14	3.07	1.21	.04							8.39
S	.79	3.51	5.07	3.17	.61	.07						13.22
SW	.99	4.11	6.35	3.21	.44	.07						15.17
W	1.00	3.78	4.64	3.07	1.00	.17						13.66
NW	.57	2.49	3.65	2.47	0.65	.13						9.96
TOTALS	16.77	27.42	33.42	18.09	3.79	.51						100

ANALYSIS OF OVERLAND WINDS
PERCENTAGE FREQUENCY OF WIND BY DIRECTION AND SPEED CLASS
London A 1957–1966
FALL

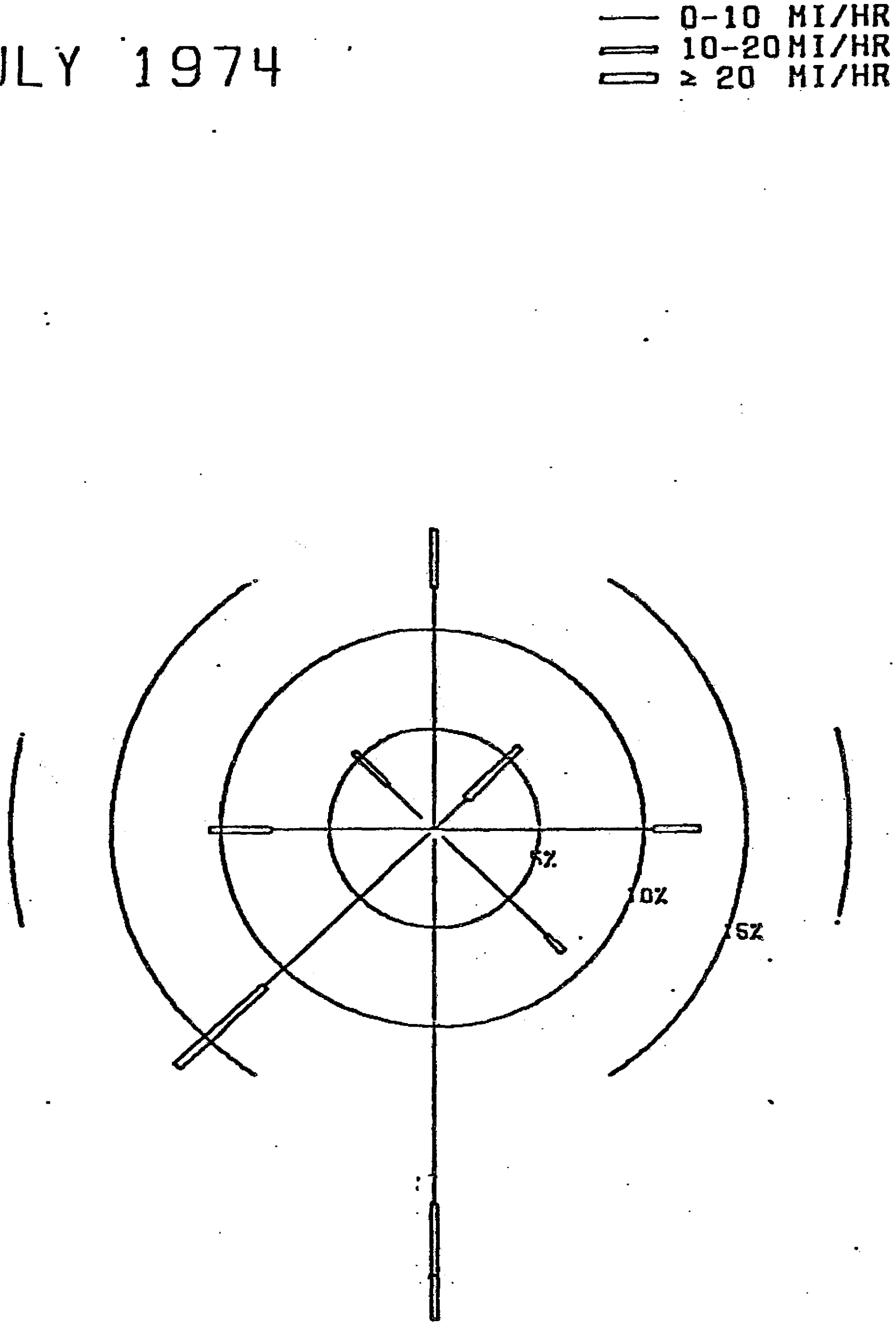
Wind Direction	*1-3*	*4-6*	*7-10*	*11-16*	*17-21*	*22-27*	*28-33*	*34-40*	*41-47*	*48-55*	*56-63*	*Totals %*
OCTOBER												
CALM	8.19											8.19
N	.77	2.30	2.57	1.32	.28	.07						7.31
NE	.71	1.81	1.79	.86	.19	.01						5.37
E	1.17	3.37	4.38	2.38	.43							11.73
SE	.58	2.18	2.41	1.33	.30							6.80
S	.78	3.55	4.02	2.82	.86	.15						12.18
SW	.86	4.35	8.09	5.59	.99	.24						20.12
W	1.06	4.01	4.81	3.91	1.20	.26	.03					15.28
NW	.77	2.37	4.53	3.83	1.20	.35						13.05
TOTALS	14.89	23.94	32.60	22.04	5.45	1.08	.03					100
NOVEMBER												
CALM	4.64											4.64
N	.53	1.08	1.21	.88	.42	.19						4.31
NE	.49	1.49	1.50	.75	.26	.11	.06					4.66
E	1.03	3.69	3.90	2.39	1.19	.26						12.46
SE	.65	2.40	2.64	1.24	.60	.08						7.61
S	.64	2.82	3.85	2.85	1.40	.47	.01					12.04
SW	.83	3.83	8.57	8.74	3.56	.94	.14					26.61
W	.71	3.38	5.57	5.86	2.61	.71	.04	0.04				18.92
NW	.46	1.29	2.25	2.83	1.46	.46						8.75
TOTALS	9.98	19.98	29.49	25.54	11.50	3.22	.25	.04				100
DECEMBER												
CALM	5.09											5.09
N	.48	1.49	1.77	1.64	.78	.07						6.23
NE	.43	1.55	1.53	.98	.60	.17	.01					5.27
E	.78	2.49	3.63	2.67	1.38	.79						11.74
SE	.47	1.52	1.73	1.34	.34	.16						5.56
S	.44	2.04	3.75	3.44	.77	.07	.01					10.52
SW	.58	3.15	9.72	12.55	3.74	.35	.04					30.13
W	.74	2.69	4.88	6.79	3.58	.74	.01					19.43
NW	.26	1.02	1.65	1.95	.87	.26						6.01
TOTALS	9.27	15.95	28.66	31.36	12.06	2.61	.07					100

ANALYSIS OF OVERLAND WINDS
PERCENTAGE FREQUENCY OF WIND BY DIRECTION AND SPEED CLASS
London A 1957–1966
WINTER

Wind Direction	*Speed Class (Knots)* 1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	56-63	*Totals %*
JANUARY												
CALM	3.67											3.67
N	.47	1.05	1.77	1.17	.47							4.93
NE	.32	1.40	1.57	.94	.72	.43	.02			.01		5.41
E	.47	1.57	3.14	3.36	2.04	.76	.32	.04	.02	.01		11.73
SE	.24	.92	1.66	1.27	.34	.05						4.48
S	.44	1.92	3.57	3.06	.99	.20						10.18
SW	.43	2.52	8.97	8.77	4.32	1.20	.24	.03				26.48
W	.70	2.85	5.11	7.00	4.66	2.00	.24	.03				22.59
NW	.50	1.59	2.96	2.93	1.73	.62	.04	.03				10.40
TOTALS	7.24	13.82	28.75	28.50	15.27	5.26	.86	.13	.02	.02		100
FEBRUARY												
CALM	4.79											4.79
N	.55	1.36	2.53	1.43	1.00	.50	.18					7.55
NE	.41	1.39	2.08	1.49	.58	.25	.01	.01				6.22
E	.69	2.08	3.95	4.00	2.20	1.12	.24	.15				14.43
SE	.46	1.54	2.26	1.21	.33	.10	.03					5.93
S	.61	2.20	2.97	2.02	.49	.09						8.38
SW	.56	2.45	5.16	6.10	2.62	.50	.13	.01				17.53
W	.80	3.12	5.57	6.59	4.67	2.20	.28	.04				23.27
NW	.59	2.56	3.66	2.64	1.68	.65	.06	.03				11.87
TOTALS	9.46	16.70	28.18	25.48	13.57	5.41	.93	.24				100
MARCH												
CALM	3.63											3.63
N	.39	1.59	3.12	1.68	.65	.27	.04					7.74
NE	.32	1.47	3.37	2.93	1.47	.50	.16	.07				10.29
E	.44	1.98	5.39	5.89	3.58	1.91	.38	.03	.01	.01		19.62
SE	.39	.93	2.00	1.37	.35	.08						5.12
S	.43	1.53	2.78	1.90	.58	.12	.01					7.35
SW	.36	2.00	4.29	3.29	1.42	.87	.26	.07	.05	.01		12.62
W	.71	3.33	5.79	5.32	2.45	.98	.08	.04				18.70
NW	.34	2.46	4.95	4.52	2.02	.65	.01					14.95
TOTALS	7.01	15.29	31.69	26.90	12.52	5.38	.94	.21	.06	.02		100

MONTHLY SUMMARY: WIND

JULY 1974



HOURLY WIND DAT   A ,POINT PELEE,JULY,1974

FIRST DAY 1/ 7
FINAL DAY 31/ 7

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 90

DIRECTION DEG TRUE	PERCENT OBSERVED				MAXIMUM WIND VEL	MEAN DURATION	MEAN	MEAN WIND VEL	MEAN TEMP	
TOWARD	TOTAL	LIGHT	MEDIUM	HIGH	MI/HR	HOURS		MI/HR	DEG C	
90.0	12.8	10.5	2.3	0.0	17.0	4.1		6.9	0.0	PARALLEL
45.0	5.8	2.2	3.6	0.0	16.0	3.3		10.2	0.0	
0.0	15.1	12.1	3.0	0.0	16.0	4.5		7.4	0.0	OFFSHORE
315.0	5.4	3.1	2.3	0.0	16.0	1.9		8.3	0.0	
270.0	10.5	7.7	2.8	0.0	15.0	2.8		7.4	0.0	ANTIPARA
225.0	16.9	11.2	5.8	0.0	13.0	3.2		8.2	0.0	
180.0	24.9	19.0	5.9	0.0	16.0	4.5		7.0	0.0	ONSHORE
135.0	8.7	7.7	1.1	0.0	12.0	3.0		7.0	0.0	

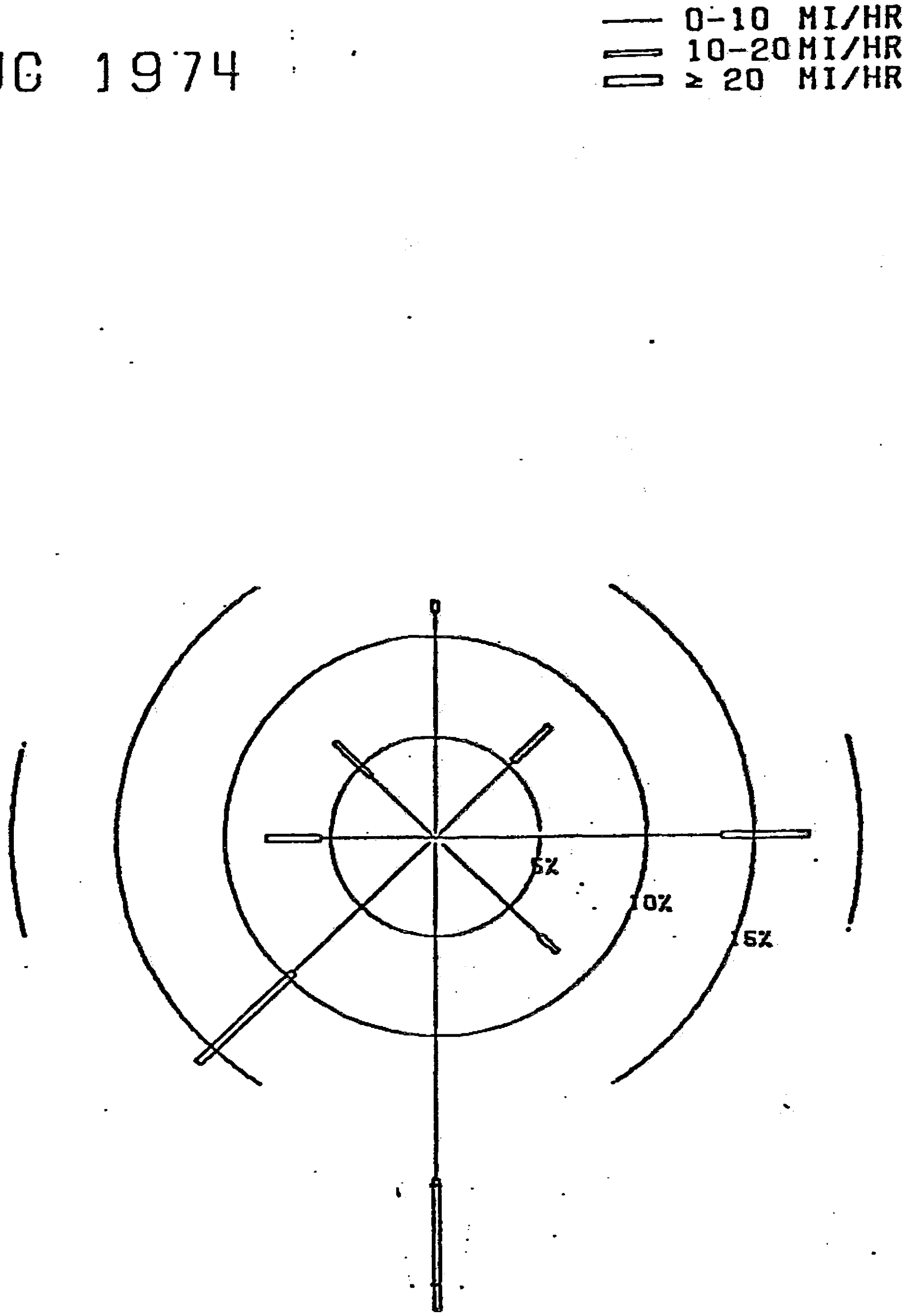
MEAN SCALAR SPEED = 7.5MI/HR   MEAN SQUARE SPEED = 66.7MI2/HR2   VARIANCE = 65.0MI2/HR2

MEAN VELOCITY = 1.3MI/HR, 194 DEG TRUE   MEAN TEMPERATURE = 0.0 C   TOTAL HOURS = 744

PERCENT OBSERVED   LIGHT 0- 10   MEDIUM 10- 20   HIGH

MONTHLY SUMMARY: WIND

AUG 1974



HOURLY WIND DAT A ,POINT PELEE,AUG.,1974

FIRST DAY 1/ 8
FINAL DAY 31/ 8

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 90

DIRECTION DEG TRUE	PERCENT OBSERVED				MAXIMUM WIND VEL	MEAN DURATION	MEAN	MEAN WIND VEL	MEAN TEMP	
TOWARD	TOTAL	LIGHT	MEDIUM	HIGH	MI/HR	HOURS		MI/HR	DEG C	
90.0	17.6	13.5	4.1	0.0	14.0	5.6		7.5	0.0	PARALLEL
45.0	7.8	5.3	2.5	0.0	13.0	3.0		7.8	0.0	
0.0	11.7	11.2	0.5	0.0	13.0	3.4		6.1	0.0	OFFSHORE
315.0	6.7	4.4	2.3	0.0	16.0	3.5		8.4	0.0	
270.0	8.1	5.5	2.6	0.0	17.0	2.3		8.2	0.0	ANTIPARA
225.0	16.0	9.6	6.4	0.0	19.0	3.4		9.5	0.0	
180.0	23.9	17.2	6.7	0.0	14.0	5.3		7.4	0.0	ONSHORE
135.0	8.2	7.1	1.1	0.0	13.0	3.3		6.6	0.0	

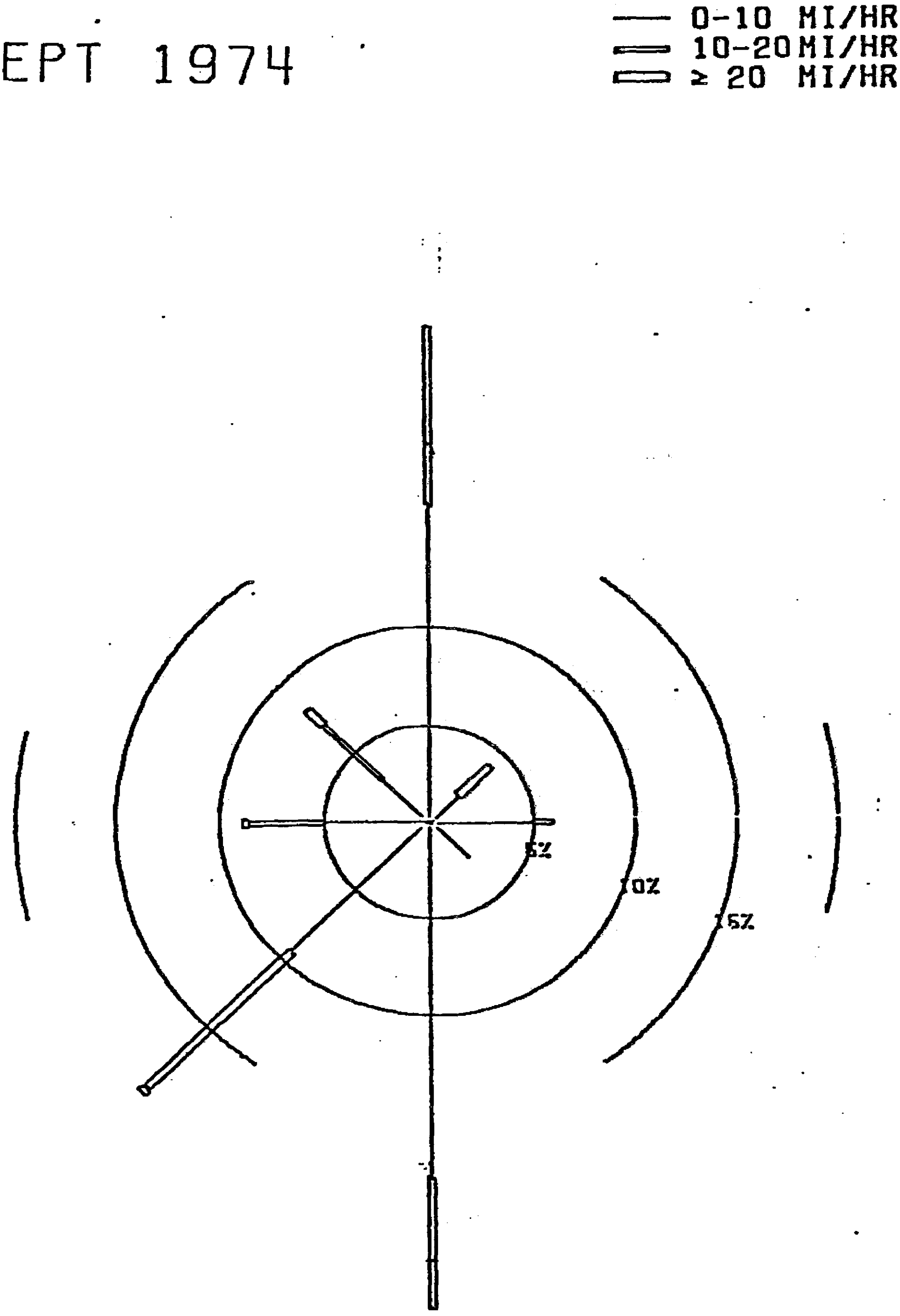
MEAN SCALAR SPEED = 7.7MI/HR MEAN SQUARE SPEED = 69.1MI2/HR2 VARIANCE = 66.4MI2/HR2

MEAN VELOCITY = 1.7MI/HR, 180 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 732

LIGHT 0-10 MEDIUM 10-20 HIGH GE 20

MØNTHLY SUMMARY:WIND

SEPT 1974



HOURLY WIND DAT A SUMMARY,POINT PELEE SEPT.,1974

FIRST DAY 1/ 9
FINAL DAY 30/ 9

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 90

DIRECTION DEG TRUE	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM WIND VEL MI/HR	MEAN DURATION HOURS	MEAN	MEAN WIND VEL MI/HR	MEAN TEMP DEG C	
90.0	6.0	5.0	1.0	0.0	11.0	5.4		6.4	0.0	PARALLEL
45.0	4.2	1.9	2.2	0.0	18.0	3.3		9.3	0.0	
0.0	25.4	16.2	9.2	0.0	19.0	9.6		8.4	0.0	OFFSHORE
315.0	8.2	3.2	3.9	1.1	23.0	3.0		12.1	0.0	
270.0	8.9	5.0	3.6	0.3	24.0	2.4		9.5	0.0	ANTIPARA
225.0	19.6	9.3	9.9	0.4	20.0	4.1		10.2	0.0	
180.0	25.1	18.3	6.8	0.0	17.0	6.0		8.1	0.0	ONSHORE
135.0	2.6	2.6	0.0	0.0	8.0	1.7		5.6	0.0	

95

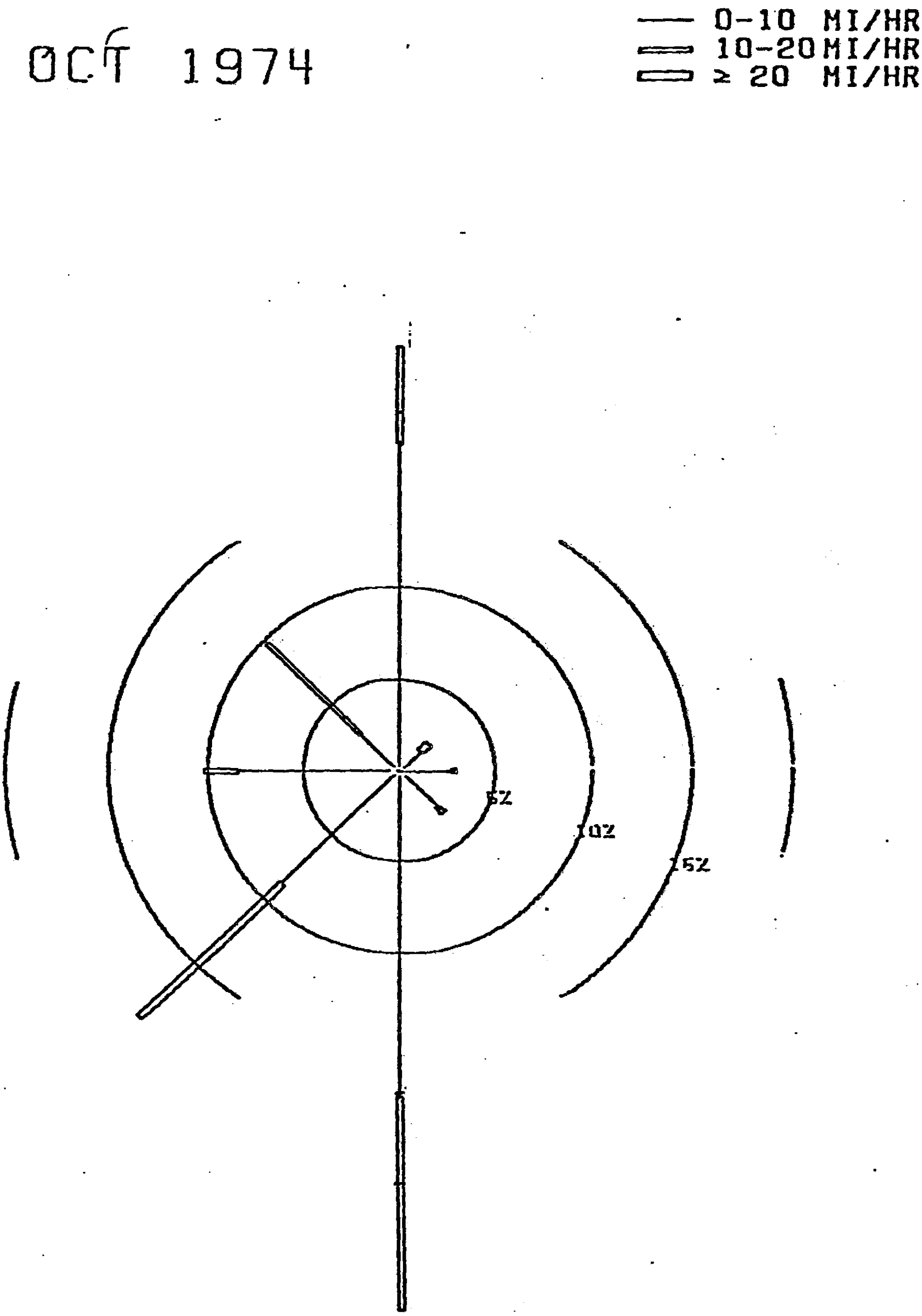
MEAN SCALAR SPEED = 8.9MI/HR   MEAN SQUARE SPEED = 95.3MI2/HR2   VARIANCE = 90.5MI2/HR2

MEAN VELOCITY = 2.2MI/HR, 258 DEG TRUE   MEAN TEMPERATURE = 0.0 C   TOTAL HOURS = 720

PERCENT OBSERVED

MONTHLY SUMMARY: WIND

OCT 1974



HOURLY WIND DAT A SUMMARY,POINT PELEE OCT.,1974

FIRST DAY 1/10
FINAL DAY 31/10

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 90

DIRECTION DEG TRUE	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM WIND VEL MI/HR	MEAN DURATION HOURS	MEAN	MEAN WIND VEL MI/HR	MEAN TEMP DEG C	
90.0	3.0	2.7	0.3	0.0	11.0	2.7		5.5	0.0	PARALLEL
45.0	2.2	1.5	0.7	0.0	13.0	1.8		7.1	0.0	
0.0	23.0	17.7	5.2	0.0	19.0	5.9		7.1	0.0	OFFSHORE
315.0	9.8	2.8	7.0	0.0	18.0	3.2		11.4	0.0	
270.0	10.2	8.5	1.7	0.0	17.0	3.2		7.2	0.0	ANTIPARA
225.0	19.1	8.6	10.5	0.0	19.0	3.4		10.3	0.0	
180.0	29.6	17.7	11.8	0.0	17.0	5.8		8.4	0.0	ONSHORE
135.0	3.2	2.8	0.4	0.0	11.0	2.2		7.5	0.0	

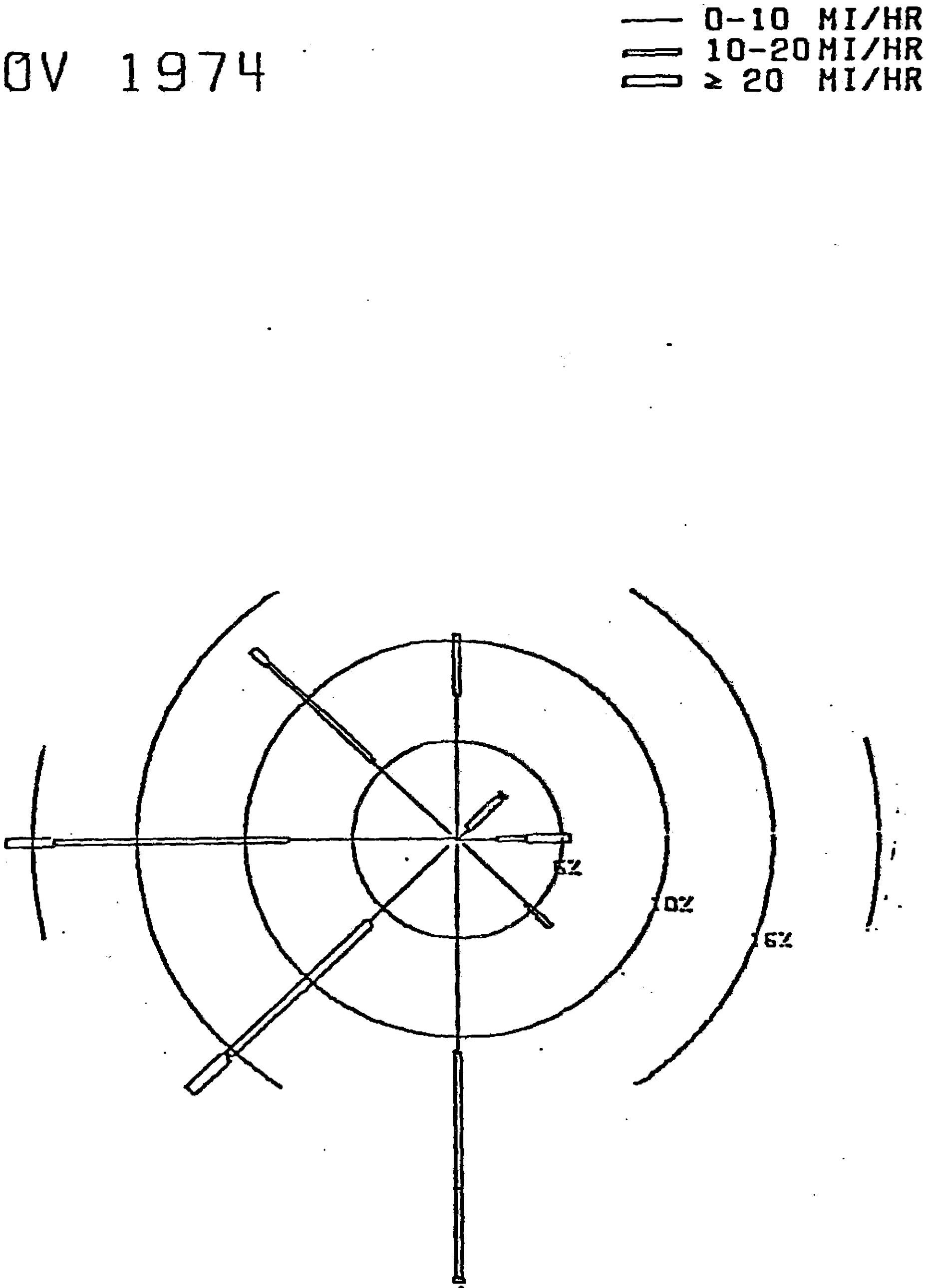
MEAN SCALAR SPEED = 8.5MI/HR MEAN SQUARE SPEED = 86.9MI2/HR2 VARIANCE = 78.6MI2/HR2

MEAN VELOCITY = 2.9MI/HR, 238 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 744

PERCENT OBSERVED

MONTHLY SUMMARY:WIND

NOV 1974



HOURLY WIND DAT A SUMMARY, POINT PELEE NOV., 1974

FIRST DAY 1/11
FINAL DAY 30/11

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 90

DIRECTION DEG TRUE	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM WIND VEL MI/HR	MEAN DURATION HOURS	MEAN	MEAN WIND VEL MI/HR	MEAN TEMP DEG C	
90.0	5.4	1.9	1.4	2.1	26.0	3.5		14.3	0.0	PARALLEL
45.0	3.2	0.7	2.4	0.1	24.0	4.6		12.7	0.0	
0.0	10.3	7.2	3.1	0.0	14.0	3.4		7.3	0.0	OFFSHORE
315.0	13.5	5.7	6.8	1.0	23.0	3.5		10.7	0.0	
270.0	21.2	7.9	11.0	2.4	23.0	4.6		11.9	0.0	ANTIPARA
225.0	17.8	5.8	9.4	2.5	25.0	3.6		12.6	0.0	
180.0	22.4	10.7	11.4	0.3	24.0	5.2		10.1	0.0	ONSHORE
135.0	6.3	4.7	1.5	0.0	14.0	2.5		7.8	0.0	

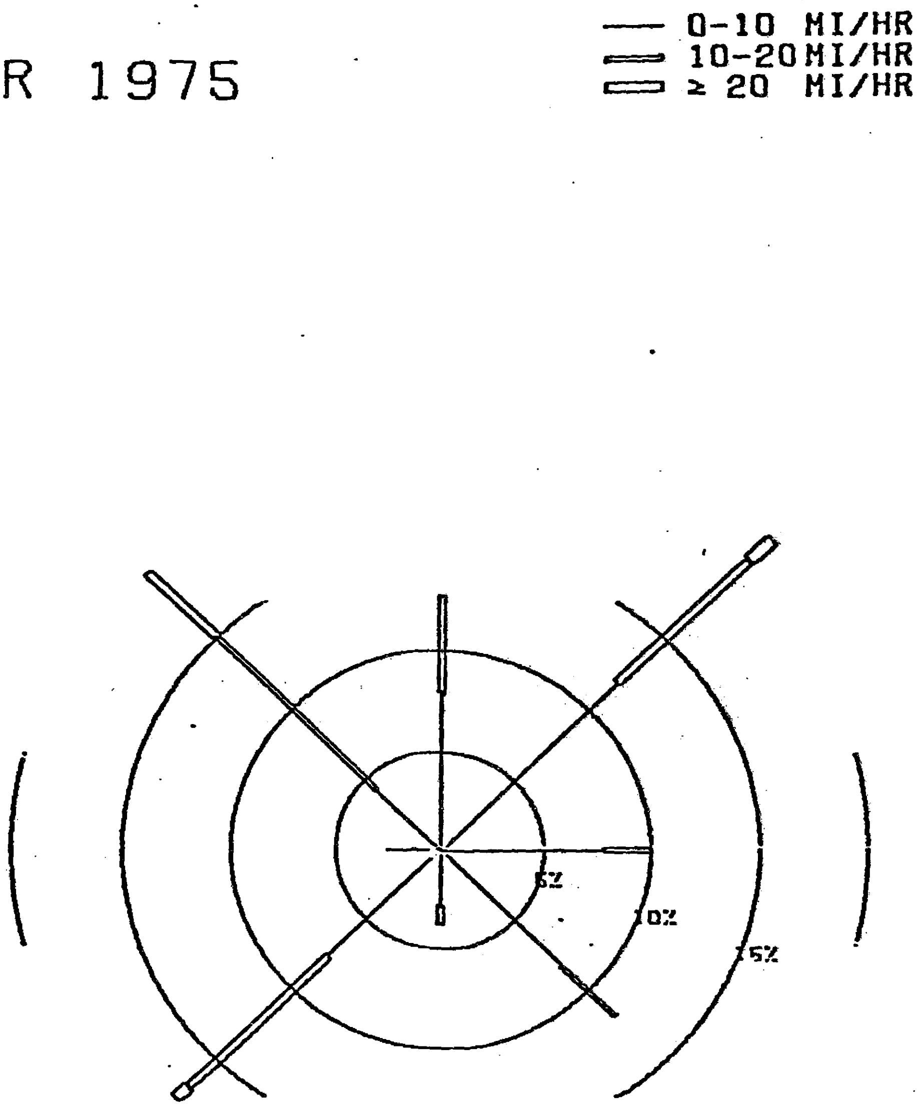
MEAN SCALAR SPEED = 10.9MI/HR MEAN SQUARE SPEED = 146.1MI2/HR2 VARIANCE = 127.9MI2/HR2

MEAN VELOCITY = 4.3MI/HR, 240 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 720

PERCENT OBSERVED

MONTHLY SUMMARY: WIND

APR 1975



HOURLY WIND DAT A SUMMARY,POINT PELEE APRIL,1975

FIRST DAY 1/ 4
FINAL DAY 30/ 4

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 90

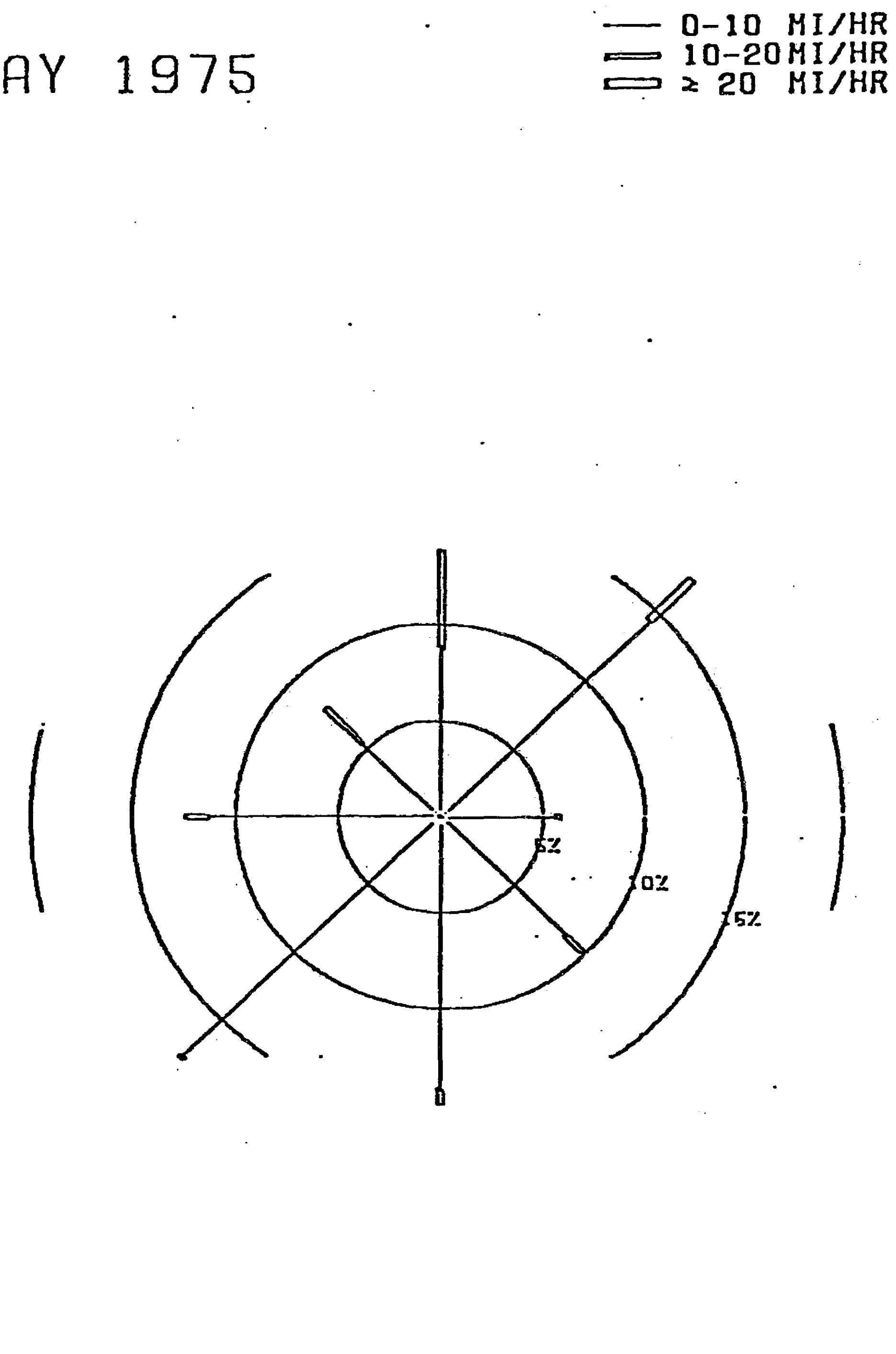
DIRECTION DEG TRUE	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM WIND VEL MI/HR	MEAN DURATION HOURS	MEAN	MEAN WIND VEL MI/HR	MEAN TEMP DEG C	
90.0	10.0	7.8	2.2	0.0	19.0	2.7		7.9	0.0	PARALLEL
45.0	21.9	11.6	8.6	1.5	26.0	4.8		10.1	0.0	
0.0	12.8	7.9	4.9	0.0	16.0	3.7		8.2	0.0	OFFSHORE
315.0	19.6	4.3	10.8	4.4	25.0	8.8		14.4	0.0	
270.0	2.5	2.5	0.0	0.0	8.0	2.0		5.3	0.0	ANTIPARA
225.0	17.6	7.5	9.3	0.8	23.0	8.5		11.2	0.0	
180.0	3.7	2.8	1.0	0.0	17.0	3.0		6.2	0.0	ONSHORE
135.0	11.8	8.3	3.5	0.0	17.0	3.5		8.4	0.0	

MEAN SCALAR SPEED = 10.3MI/HR MEAN SQUARE SPEED = 130.5MI2/HR2 VARIANCE = 125.6MI2/HR2

MEAN VELOCITY = 2.2MI/HR, 348 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 720

MØNTHLY SUMMARY:WIND

MAY 1975



HOURLY WIND DATA SUMMARY,POINT PELEE MAY,,1975

FIRST DAY 1/ 5
FINAL DAY 31/ 5

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 90

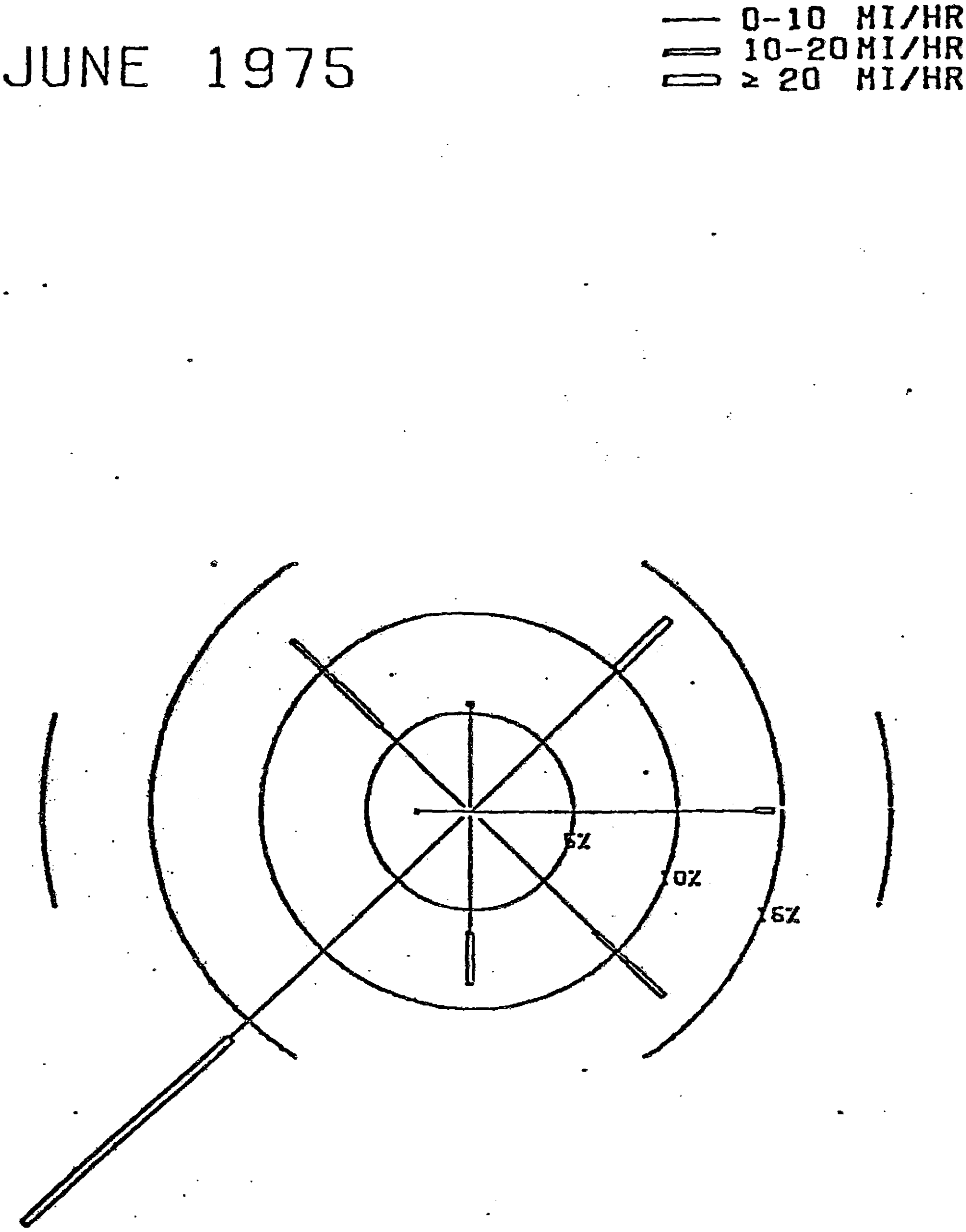
DIRECTION DEG TRUE	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM WIND VEL MI/HR	MEAN DURATION HOURS	MEAN	MEAN WIND VEL MI/HR	MEAN TEMP DEG C	
90.0	5.9	5.6	0.3	0.0	10.0	1.9		5.9	0.0	PARALLEL
45.0	17.5	14.4	3.1	0.0	13.0	4.8		7.0	0.0	
0.0	13.8	8.7	5.1	0.0	18.0	4.5		8.4	0.0	OFFSHORE
315.0	7.9	5.4	2.5	0.0	18.0	3.1		8.8	0.0	
270.0	12.4	11.3	1.1	0.0	10.0	4.8		6.0	0.0	ANTIPARA
225.0	17.7	17.5	0.3	0.0	10.0	3.5		6.4	0.0	
180.0	14.9	14.1	0.8	0.0	10.0	3.8		6.5	0.0	ONSHORE
135.0	9.9	8.7	1.1	0.0	11.0	3.9		7.2	0.0	

MEAN SCALAR SPEED = 7.2MI/HR MEAN SQUARE SPEED = 83.5MI2/HR2 VARIANCE = 83.4MI2/HR2

MEAN VELOCITY = 0.6MI/HR, 295 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 355

MONTHLY SUMMARY: WIND

JUNE 1975



HOURLY WIND DAT A SUMMARY, POINT PELEE JUNE, 1975

FIRST DAY 1/ 6
FINAL DAY 30/ 6

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 90

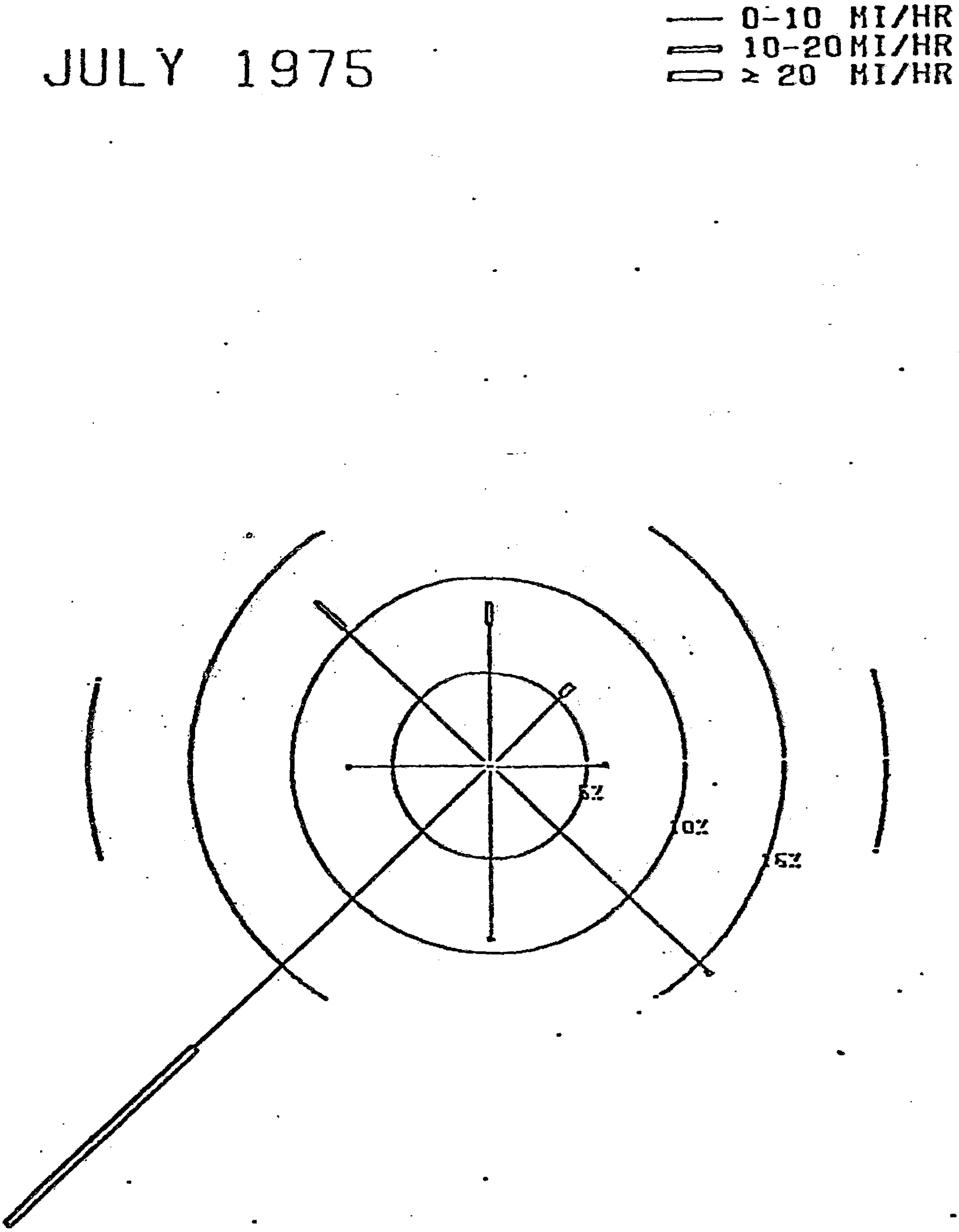
DIRECTION DEG TRUE	PERCENT OBSERVED				MAXIMUM WIND VEL	MEAN DURATION	MEAN	MEAN WIND VEL	MEAN TEMP	
	TOTAL	LIGHT	MEDIUM	HIGH	MI/HR	HOURS		MI/HR	DEG C	
90.0	14.6	13.8	0.8	0.0	13.0	3.4		6.2	0.0	PARALLEL
45.0	13.6	10.0	3.6	0.0	16.0	3.6		7.6	0.0	
0.0	5.6	5.3	0.3	0.0	11.0	2.7		5.0	0.0	OFFSHORE
315.0	12.1	6.1	6.0	0.0	18.0	5.1		10.1	0.0	
270.0	2.6	2.5	0.1	0.0	10.0	1.9		5.8	0.0	ANTIPARA
225.0	29.6	16.1	13.5	0.0	18.0	6.1		9.3	0.0	
180.0	8.7	6.1	2.6	0.0	19.0	2.2		8.3	0.0	ONSHORE
135.0	13.2	8.6	4.6	0.0	16.0	3.8		8.8	0.0	

MEAN SCALAR SPEED = 8.2MI/HR MEAN SQUARE SPEED = 79.1MI2/HR2 VARIANCE = 76.3MI2/HR2

MEAN VELOCITY = 1.7MI/HR, 198 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 720

MØNTHLY SUMMARY:WIND

JULY 1975



HOURLY WIND DAT   A SUMMARY,POINT PELEE JULY ,1975

FIRST DAY 1/ 7
FINAL DAY 31/ 7

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 90

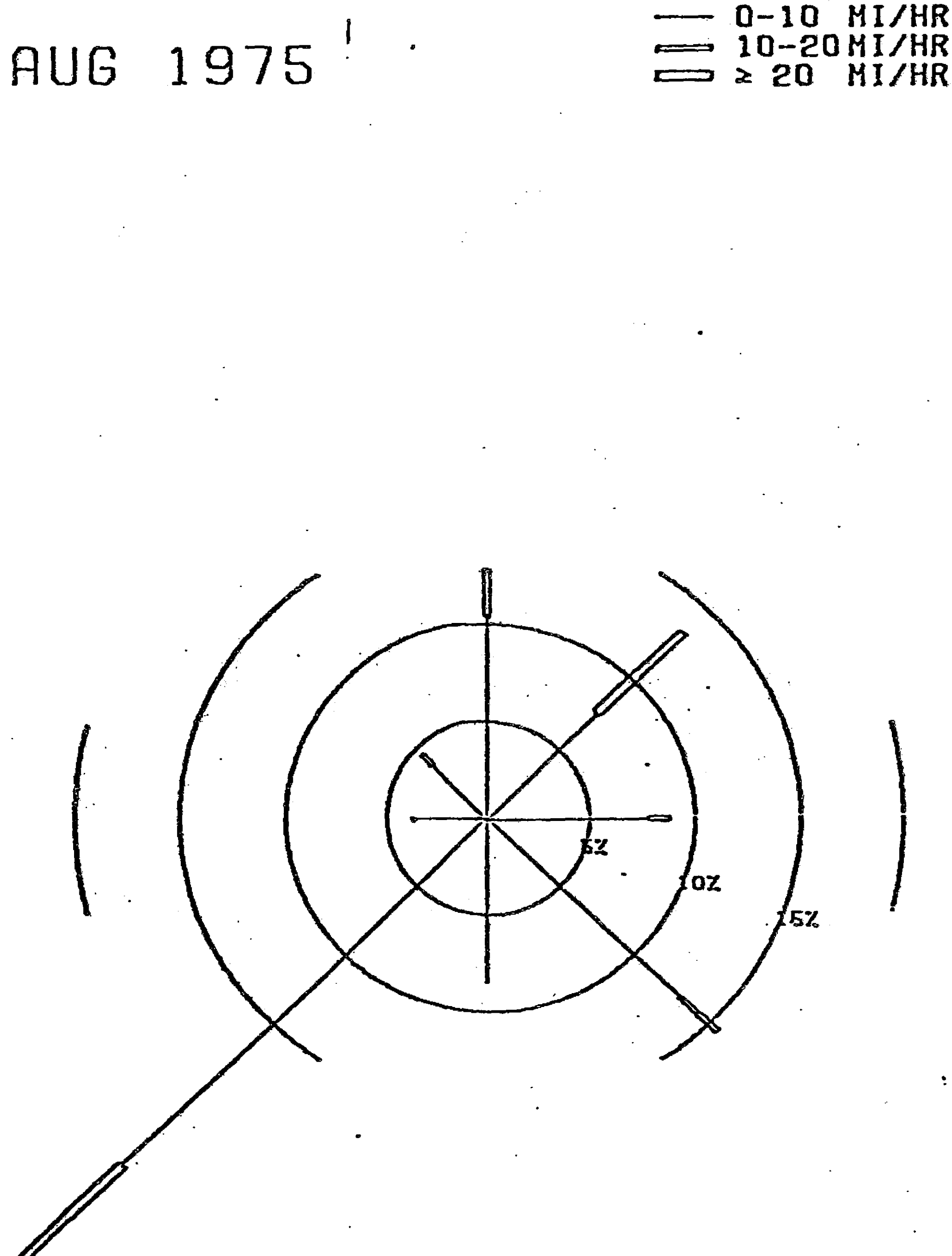
DIRECTION DEG TRUE	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM WIND VEL MI/HR	MEAN DURATION HOURS	MEAN	MEAN WIND VEL MI/HR	MEAN TEMP DEG C	
90.0	6.1	5.9	0.1	0.0	11.0	2.0		5.3	0.0	PARALLEL
45.0	6.1	5.2	0.8	0.0	12.0	2.0		6.0	0.0	
0.0	8.7	7.5	1.2	0.0	12.0	3.6		5.1	0.0	OFFSHORE
315.0	12.4	10.5	1.9	0.0	15.0	4.8		7.5	0.0	
270.0	7.3	7.1	0.1	0.0	10.0	2.5		4.8	0.0	ANTIPARA
225.0	34.3	21.0	13.3	0.0	17.0	6.7		8.4	0.0	
180.0	9.3	9.2	0.1	0.0	11.0	2.0		5.3	0.0	ONSHORE
135.0	15.9	15.6	0.3	0.0	10.0	3.5		6.0	0.0	

MEAN SCALAR SPEED =   6.7MI/HR   MEAN SQUARE SPEED = 54.7MI2/HR2   VARIANCE = 48.1MI2/HR2

MEAN VELOCITY = 2.6MI/HR, 224 DEG TRUE   MEAN TEMPERATURE = 0.0 C   TOTAL HOURS =   743

MONTHLY SUMMARY: WIND

AUG 1975



FIRST DAY 1/ 8
FINAL DAY 31/ 8

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 90

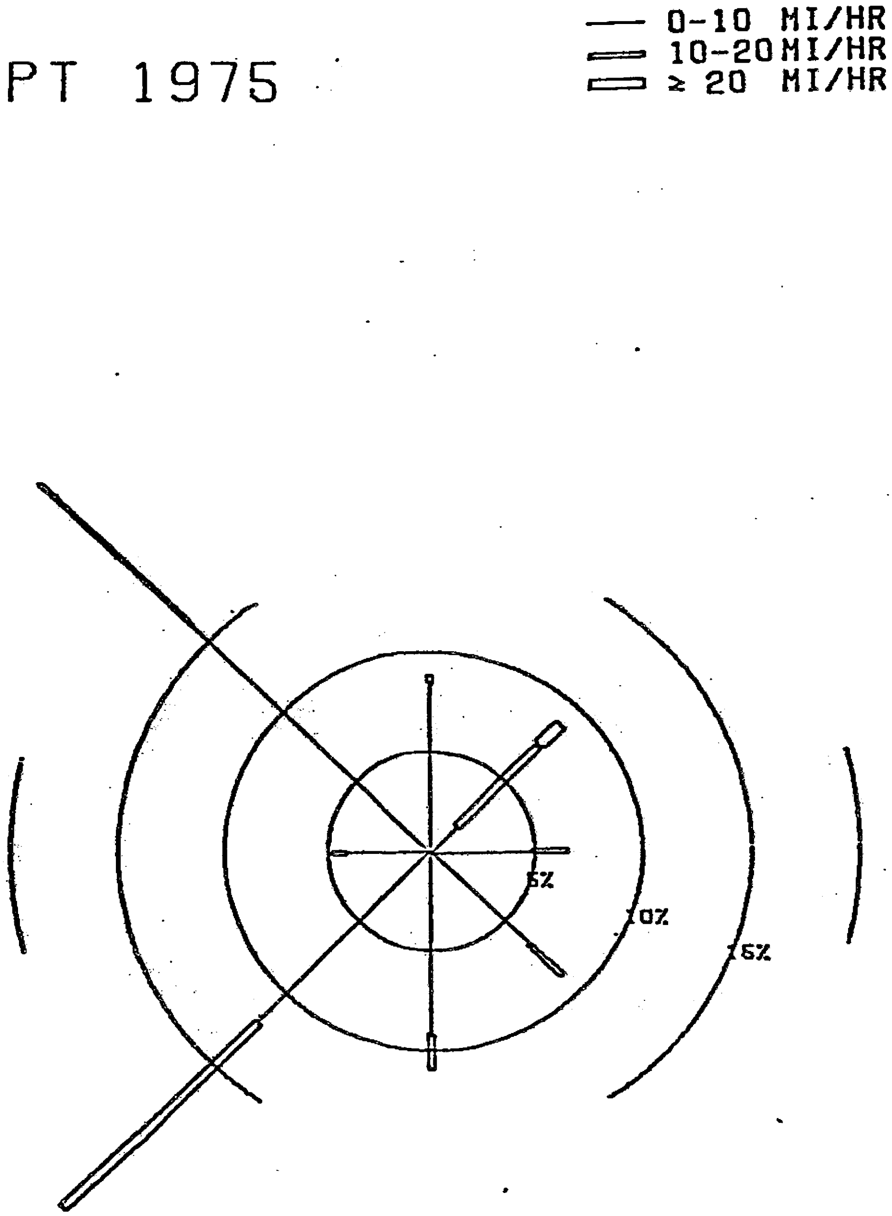
DIRECTION DEG TRUE	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM WIND VEL MI/HR	MEAN DURATION HOURS	MEAN	MEAN WIND VEL MI/HR	MEAN TEMP DEG C	
90.0	8.9	7.8	1.1	0.0	19.0	3.0		6.2	0.0	PARALLEL
45.0	13.4	7.5	5.9	0.0	16.0	4.2		9.1	0.0	
0.0	12.8	10.3	2.4	0.0	16.0	3.7		5.2	0.0	OFFSHORE
315.0	4.6	3.9	0.7	0.0	11.0	2.4		6.8	0.0	
270.0	3.8	3.6	0.1	0.0	13.0	1.9		5.2	0.0	ANTIPARA
225.0	32.5	25.0	7.5	0.0	14.0	5.6		7.4	0.0	
180.0	8.5	8.5	0.0	0.0	9.0	2.0		4.8	0.0	ONSHORE
135.0	15.6	13.2	2.4	0.0	15.0	4.5		6.7	0.0	

MEAN SCALAR SPEED = 6.8MI/HR MEAN SQUARE SPEED = 58.6MI2/HR2 VARIANCE = 57.4MI2/HR2

MEAN VELOCITY = 1.1MI/HR, 178 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 744

MONTHLY SUMMARY:WIND

SEPT 1975



HOURLY WIND DAT A SUMMARY,POINT PELEE SEPT.,1975

FIRST DAY 1/ 9
FINAL DAY 30/ 9

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 90

DIRECTION DEG TRUE	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM WIND VEL MI/HR	MEAN DURATION HOURS	MEAN	MEAN WIND VEL MI/HR	MEAN TEMP DEG C	
90.0	6.6	4.9	1.6	0.0	14.0	3.0		7.1	0.0	PARALLEL
45.0	8.9	1.8	5.6	1.5	26.0	8.1		15.1	0.0	
0.0	8.9	8.5	0.4	0.0	18.0	3.0		5.2	0.0	OFFSHORE
315.0	26.1	16.3	9.8	0.0	19.0	6.6		9.0	0.0	
270.0	4.8	4.1	0.7	0.0	14.0	1.5		6.5	0.0	ANTIPARA
225.0	25.0	11.9	13.1	0.0	17.0	5.1		9.7	0.0	
180.0	10.9	9.2	1.8	0.0	15.0	3.2		6.1	0.0	ONSHORE
135.0	8.9	6.7	2.2	0.0	16.0	2.7		7.9	0.0	

MEAN SCALAR SPEED = 8.7MI/HR MEAN SQUARE SPEED = 94.8MI2/HR2 VARIANCE = 91.7MI2/HR2

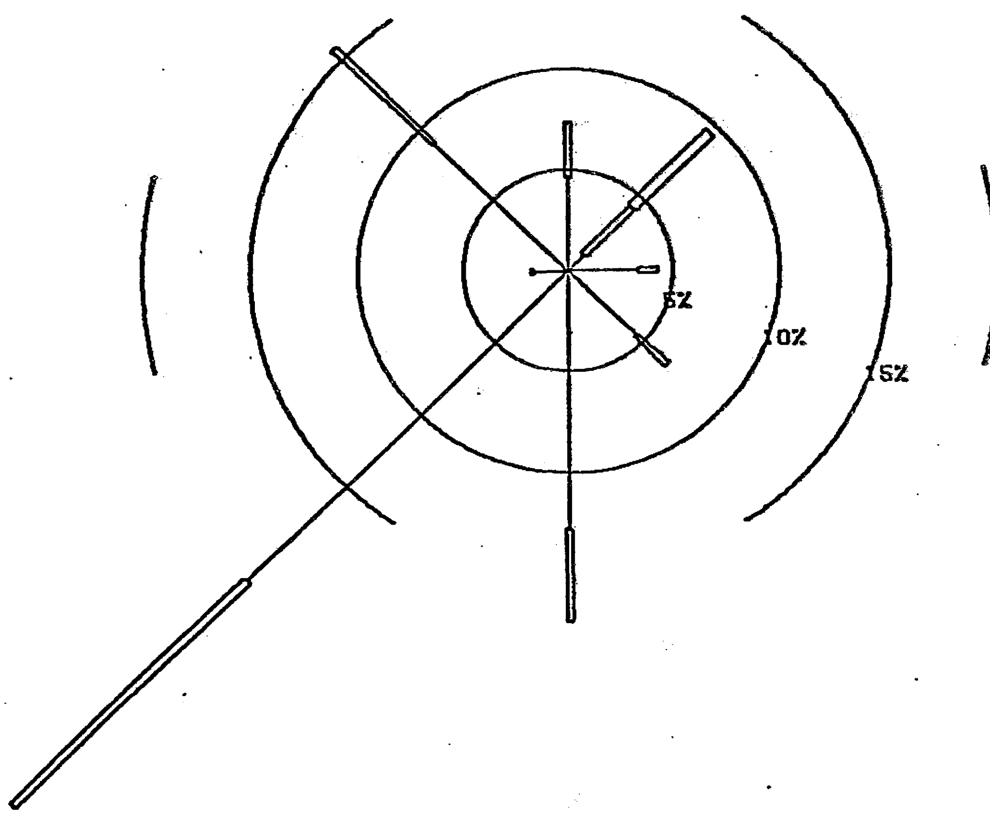
MEAN VELOCITY = 1.8MI/HR, 276 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 732

PERCENT OBSERVED

MØNTHLY SUMMARY:WIND

OCT 1975

— 0-10 MI/HR
═ 10-20 MI/HR
▭ ≥ 20 MI/HR



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POINT PELEE WIN    D DATA OCT.75HOURLY VALUES(FROM)

FIRST DAY  1/10
FINAL DAY 31/10

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS    0
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DIRECTION DEG TRUE TOWARD	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM WIND VEL MI/HR	MEAN DURATION HOURS	MEAN	MEAN WIND VEL MI/HR	MEAN TEMP DEG C	
0.0	7.4	4.6	2.8	0.0	16.0	2.7		8.6	0.0	PARALLEL
315.0	15.7	9.0	6.6	0.0	18.0	5.5		9.2	0.0	
270.0	1.8	1.6	0.1	0.0	15.0	1.6		5.9	0.0	OFFSHORE
225.0	37.2	21.5	15.8	0.0	18.0	9.2		9.5	0.0	
180.0	17.4	12.8	4.6	0.0	19.0	6.8		7.9	0.0	ANTIPARA
135.0	6.6	4.6	2.0	0.0	16.0	3.5		8.3	0.0	
90.0	4.3	3.4	0.9	0.0	16.0	3.2		7.4	0.0	ONSHORE
45.0	9.6	1.1	3.2	5.3	27.0	7.1		18.1	0.0	

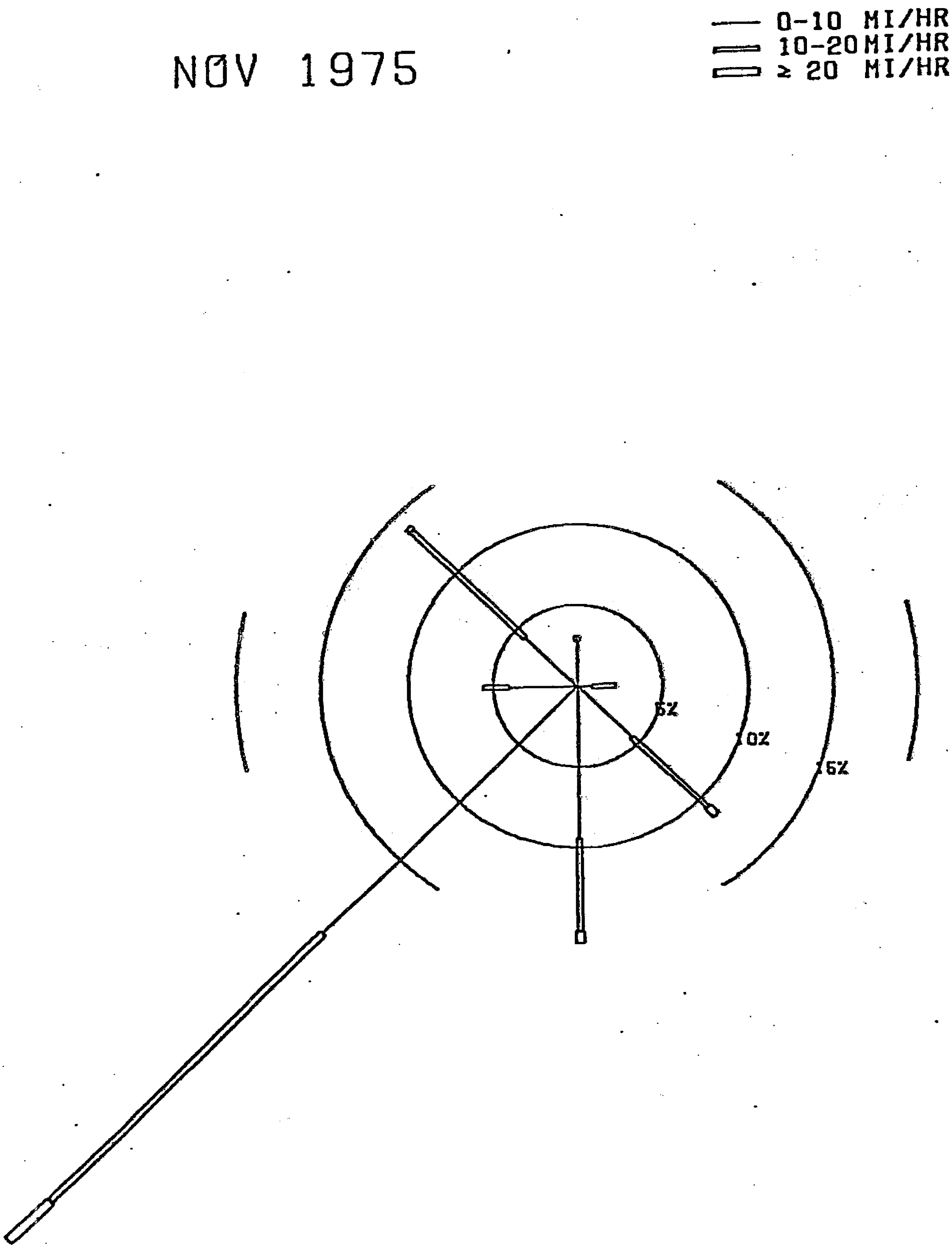
```
MEAN SCALAR SPEED =   9.7MI/HR     MEAN SQUARE SPEED = 114.9MI2/HR2     VARIANCE = 110.2MI2/HR2
MEAN VELOCITY =   2.2MI/HR,  231 DEG TRUE     MEAN TEMPERATURE =  0.0 C     TOTAL HOURS =   741

PERCENT OBSERVED
 LIGHT    0.0 -     10.0   MEDIUM    10.0 -     20.0   HIGH  GE     20.0
CK=      0.996MO=    10IDTYPE=     1
MO=   10IDTYPE=      1
CK=      0.000MO=    10IDTYPE=     2
CK=      0.000MO=    10IDTYPE=     3
***PLOT TAPE SUCCESSFULLY WRITTEN***

STOP
```

MØNTHLY SUMMARY:WIND

NØV 1975



POINT PELEE WIN D DATA NOV.75HOURLY VALUES(FROM)

FIRST DAY 1/11
FINAL DAY 30/11

SHORELINE ORIENTATION IN DEGREES TRUE SPECIFIED AS 0

DIRECTION DEG TRUE TOWARD	PERCENT OBSERVED TOTAL	LIGHT	MEDIUM	HIGH	MAXIMUM WIND VEL MI/HR	MEAN DURATION HOURS	MEAN	MEAN WIND VEL MI/HR	MEAN TEMP DEG C	
0.0	3.1	2.8	0.3	0.0	17.0	3.7		4.4	0.0	PARALLEL
315.0	14.0	4.3	9.4	0.3	20.0	5.0		12.1	0.0	
270.0	5.6	4.1	1.5	0.0	18.0	1.8		6.7	0.0	OFFSHORE
225.0	47.8	21.2	23.1	3.5	27.0	9.7		11.3	0.0	
180.0	15.8	9.4	5.8	0.7	25.0	4.0		9.8	0.0	ANTIPARA
135.0	11.4	4.5	6.2	0.7	24.0	4.5		11.1	0.0	
90.0	2.2	0.8	1.4	0.0	19.0	3.2		11.8	0.0	ONSHORE
45.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	

MEAN SCALAR SPEED = 10.7MI/HR MEAN SQUARE SPEED = 142.0MI2/HR2 VARIANCE = 99.8MI2/HR2

MEAN VELOCITY = 6.5MI/HR, 221 DEG TRUE MEAN TEMPERATURE = 0.0 C TOTAL HOURS = 713

PERCENT OBSERVED
LIGHT 0.0 - 10.0 MEDIUM 10.0 - 20.0 HIGH GE 20.0
CK= 0.990MO= 11IDTYPE= 1
MO= 11IDTYPE= 1
CK= 0.000MO= 11IDTYPE= 2
CK= 0.000MO= 11IDTYPE= 3

Appendix C: EROSION DATA

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

Note:

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

TABLE 1: Cross-Sectional Changes (m^2) to the Beach Zone of Point Pelee relative to April, 1975.

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

<u>Note</u>:

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

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

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

Note:

Negatives denote amount of material required to replenish profile to April 1975 levels.

TABLE 3: 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.