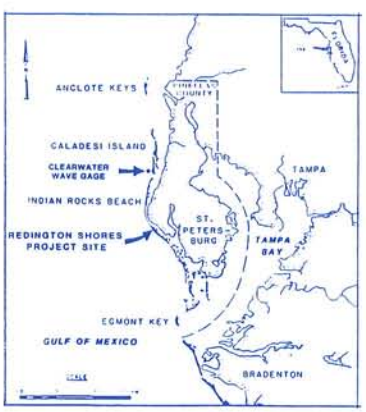
US Army Corps of Engineers



MISCELLANEOUS PAPER CERC-89-15

REDINGTON SHORES, FLORIDA WAVE CLIMATOLOGY STUDY SUMMARY DATA REPORT

by

James Rosati III

Coastal Engineering Research Center

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

September 1989

Final Report

Approved For Public Release; Distribution Unlimited

Prepared for US Army Engineer District, Jacksonville
Jacksonville, Florida 32232-0019

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Miscellaneous Paper CERC-89-15	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION USAEWES, Coastal Engineering Research Center 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) 3909 Halls Ferry Road Vicksburg, MS 39180-6199	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING / SPONSORING ORGANIZATION U.S. Army Engineer District, Jacksonville 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Jacksonville, FL 32232-0019	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Redington Shores, Florida, Wave Climatology Study, Summary Data Report

12. PERSONAL AUTHOR(S)
Rosati, James III

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final report	FROM Feb 1986 TO Jul 1988	September 1989	52

16. SUPPLEMENTARY NOTATION
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB-GROUP		
			Florida	Redington Shores
			Gulf of Mexico	Statistics
			Ocean waves	Wave measurements

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Directional wave data were collected at Redington Shores, FL, between February 1986 and February 1987 as part of a plan to monitor the performance of a newly constructed breakwater and beach fill. A Sea Data 635-12 internally recording bottom-mounted directional wave gage was deployed in a tripod mount 4,100 ft offshore of the breakwater in 17 ft of water. Wave data were recorded for 1024 sec every 4 to 6 hr between 20 February 1986 and 23 February 1987.

The data show wave heights that agree closely with the wave heights measured at the University of Florida wave gage at Clearwater, FL. The majority of waves recorded came from southerly directions. The wave heights varied from less than 0.1 m to values exceeding 1.2 m during one storm event on 21 August 1986.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code) / 22c. OFFICE SYMBOL

DD Form 1473, JUN 86 — Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

Preface

The work described in this report was conducted from February 1986 through July 1988 by the Coastal Engineering Research Center (CERC) of the U.S. Army Engineer Waterways Experiment Station (WES) in cooperation with the U.S. Army Engineer District, Jacksonville (SAJ).

Mr. James Rosati III, Hydraulic Engineer, prepared this report with the assistance of Mr. James P. McKinney, Mathematician, Prototype Measurement and Analysis Branch (PMAB). The work was under the general supervision of Mr. Thomas W. Richardson, Chief, Engineering Development Division, and Dr. James R. Houston, Chief, CERC.

The field work was accomplished with the assistance of SAJ and Pinellas County, FL. SAJ Palatka Area Office divers, Messrs. Bill Stephens and Terry Baker, and PMAB's Messrs. Bill Hegge, Ray Townsend, and Don Donaldson assisted in servicing the gage.

Pinellas County, FL, provided facilities for data collection equipment, personnel for surveying, dive support, and lifting equipment. Mr. James B. Terry (Pinellas County Engineering) helped immeasurably in serving as a point of contact to Pinellas County. Captain C. V. Weil and the crew of the artificial reef ship "Tortuga" provided a valuable service as a diving platform and crane ship. The tripod installation and gage servicing were made much easier due to the facilities provided by Pinellas County. The county survey department assisted in fixing the gage position and in locating it again during servicing trips.

COL Larry B. Fulton, EN, is Commander and Director of WES. Dr. Robert W. Whalin is Technical Director.

Contents

Conversion Factors, Non-SI to SI (Metric) Units of Measurement

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
miles (US statute)	1.609347	kilometers

REDINGTON SHORES, FLORIDA, WAVE CLIMATOLOGY STUDY

SUMMARY DATA REPORT

Introduction

1. In January 1986 a detached breakwater was completed at the Redington Shores County Park for the purpose of shore protection. Twenty-three thousand cubic meters of beach fill was placed shoreward of the structure. One of the important design parameters for breakwaters and beach fill is the wave climate. As part of a program to monitor the performance of the breakwater and the placed beach fill, the Jacksonville District of the Corps of Engineers requested that CERC acquire and analyze wave data from Redington Shores for 1 year. The purpose of this report is to present the results of the wave gaging effort.

Project and Gage Location

2. Redington Shores is located on the West coast of Florida on Sand Key in Pinellas County. The breakwater project is approximately 8 km north of Johns Pass and 13 km south of Clearwater Pass (Figure 1). The structure is in front of the Redington Shores County Park.

3. In order to arrive at the wave height and direction at the structure, wave data measured offshore must be transformed to account for shoaling and refraction between the gage location and the structure. To minimize the transformation, it was desired to place the wave gage as close as possible to the structure. However, several considerations prevented the gage from being placed directly offshore of the structure. First, as waves come onshore and begin shoaling, the linear wave theory assumption that the wave amplitude is small in relation to the wave length (a necessary assumption in the analysis process) becomes less valid. Second, if the waves break offshore or at the wave gage location, an accurate conversion of the bottom pressure to wave height is not possible due the entrainment of air in the water column over the gage. Finally, the gage would present a significant hazard to navigation if it were not covered by at least 10 ft of water at all times. Surface marking buoys would only increase the attention received by the gage site from

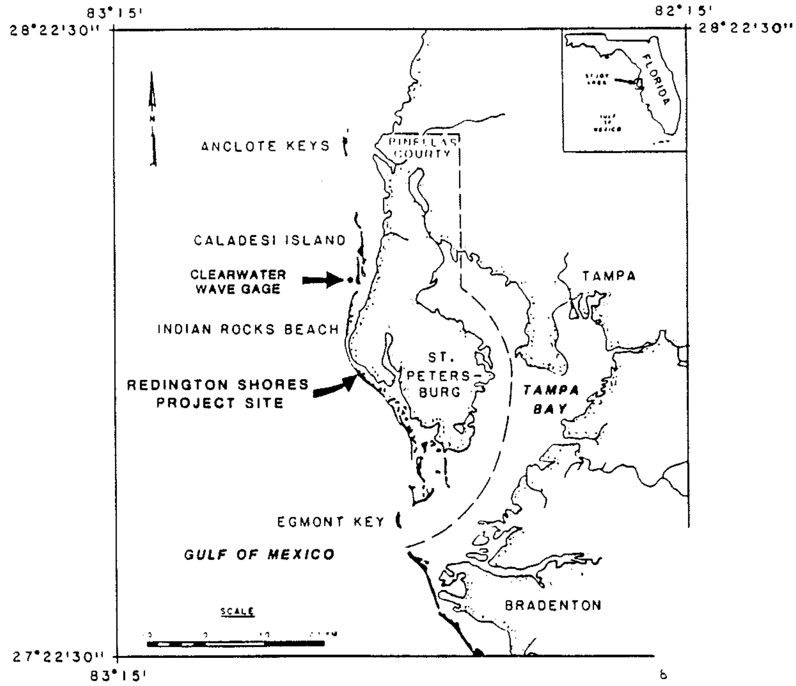


Figure 1

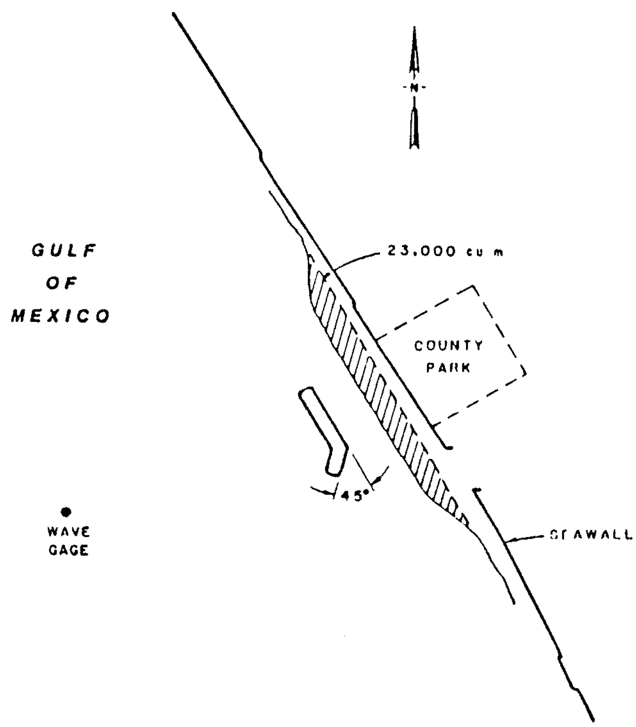


Figure 2

recreational boaters in the Redington Shores area. With these factors in mind, the gage was sited 4,100 ft off the North corner of the Redington Shores breakwater in 17 ft of water at 27 deg 49 min and 37.01 sec North latitude and 32 deg 50 min 42.27 sec West longitude (Figure 2).

Instrumentation

4. A Sea Data 635-12 internally recording directional wave and water level gage was used for this project. The gage simultaneously samples pressure and the u and v horizontal components of velocity and records them digitally on a cassette tape. When set to record 1024 sec of wave data sampled once per second once every 4 hrs, the duration of gage recording is about 2 months. If wave data are recorded at 6-hr intervals, the duration is about 3 months. Pressure is measured with a highly accurate quartz crystal sensor manufactured by Digiquartz Corp. Velocity is measured with a Marsh McBirney Model 511 electromagnetic current meter.

5. The gage was mounted in a tripod designed to provide a large degree of stability while minimizing interference with the flow around the gage. Since trawlers do not frequent the area where the tripod was located, it was not necessary to consider them in the tripod design. Securing each leg of the tripod to pipes jetted into the seabed was considered, but since the geotechnical conditions at the tripod site were not known and a substantial cost would be involved if a hard bottom was encountered while jetting, a 700-lb railroad wheel was attached to each leg of the tripod to provide stability. An acoustic pinger was attached to the tripod so that divers using a directional hydrophone could home in on the pinger signal (range 3/4 mile) once they reached the general vicinity of the tripod. The tripod could be located by a surface vessel with a hydrophone if it was moved by either a storm or a trawler. Surveyors provided by Pinellas County triangulated the position of the tripod and could subsequently place divers within 50 ft of the tripod.

Gage Deployment History

6. On 20 February 1986 the first gage deployment took place (Table 1). The tripod and gage were sited with the aid of Pinellas County, FL, surveyors. The Tortuga (a modified landing craft with a high capacity

Table 1

Significant Events for Redington Shores Wave Gaging

Date	Event Description
January 1986	Redington Shores breakwater completed.
20 February 1986	Tripod placed, Sea Data 635-12 S/N 37 wave gage placed. Wave data every 4 hr.
14 April 1986	S/N 40 deployed. Gage S/N 37 retrieved.
7 August 1986	S/N 35 deployed. S/N 40 retrieved.
14 August 1986	Discovered bad data from gage S/N 40 due to a partially obstructed pressure port.
10 October 1986	Gage S/N 35 was retrieved and checked for fouling and then redeployed.
6 November 1986	Retrieved gage S/N 35 deployed gage 635-9 S/N 3 - changed to 6-hr samples.
1 December 1986	Gage S/N 3 fails - electronic failure.
20 April 1987	Gage S/N 3 retrieved, tripod left in place.
9 December 1987	Tripod removed.

crane) was provided by Pinellas County to lift and place the tripod and gage. The gage was set to record 1024 sec of wave data every 4 hr. On 14 April, the gage was retrieved and another placed with the same recorder settings. Subsequent data analysis indicated excellent data recovery. On 7 August gage Serial Number S/N 40 was retrieved and gage S/N 35 deployed in its place. Analysis of the data from gage S/N 40 showed the pressure port to be partially obstructed by fine sand. Because of fears that the pressure port on gage S/N 35 could also be obstructed, the gage was retrieved and the pressure port cleaned and protected. Subsequent analysis indicated that the pressure port was indeed partially obstructed. The gage was redeployed and recovered on 6 November 1986. Gage S/N 3 was set to record 1024 sec of wave data every 6 hr and deployed the same day. Although the gage recorded data for more than 3 months, data analysis showed only the first 3 weeks of acquired data to be intelligible. This was attributed to a failure in the gage's tape drive circuitry. After the gage was recovered on 20 April 1987, data acquisition was discontinued at the request of the sponsor.

Data Correction

7. Analysis of raw data obtained from the sensor with the partially obstructed pressure port showed that the significant wave height calculated for each wave record was substantially less than expected. An attempt to recover wave information was made using data from the University of Florida's Clearwater site and the following procedure.

8. This correction procedure is based on assumptions that weather influencing the wave climate at Redington Shores and Clearwater is similar, the bathymetry of the collection locations are similar, and the ratio of mean significant heights between Redington Shores and Clearwater for any particular period is constant. The more important assumptions are that the partially obstructed pressure sensor data are proportional to the actual pressure and that any resulting phase shift in the recorded data due to the partially obstructed port is constant in the wave periods of interest. If these assumptions are valid, then a multiplier can be calculated and used to amplify the diminished significant heights due to the partially obstructed pressure port.

9. Mean significant wave heights were calculated for both Redington Shores and Clearwater during periods of data overlap. Let RS and CW denote the mean significant heights of Redington Shores and Clearwater, respectively, when the Redington Shores pressure sensor was working properly. Then for any two collection periods,

$$\frac{RS1}{CW1} = \frac{RS2}{CW2}$$

based on an above assumption. Thus,

$$RS2 = \frac{RS1 \times CW2}{CW1} \quad ,$$

solving for RS2.

10. If significant wave height data calculated for the partially obstructed pressure port are proportional to the significant wave height data calculated for the unobstructed pressure port, then

$$RS2 = K \times SH2 \quad ,$$

where K is the constant of proportionality and SH2 is the significant height resulting from partially obstructed pressure port data. Solving for K ,

$$K = \frac{RS1 \times CW2}{CW1 \times SH2} ,$$

which is the multiplier used to amplify the partially obstructed pressure port data. Although two data sets were collected from sensors with partially obstructed pressure ports, only one value for K was calculated as no Clearwater data were available for calculation of a second K value.

Data Analysis

11. Samples of the recorded wave records are visually inspected for each gage to insure the viability of data analysis. Only those data records are analyzed which pass both visual observation and a numerical data editing routine, which eliminates records containing points outside the expected pressure range of 14.0 to 31.0 psia.

12. All good records are zero-meaned in order to comply with the Gaussian assumption for stochastic data. Influences of low frequency energy, such as tides, are removed from pressure, u and v velocity records by linear detrending. Pressure records from the partially obstructed port sensor, in addition to being zero-meaned and linearly detrended, had each of their 1024 data points multiplied by the correction factor K (23.990).

13. Since finite length data records are used to simulate an infinite random process, each time series is windowed with a 10 percent cosine bell taper to simulate a stationary periodic time series for calculation of spectral estimates (Harris 1974). The problems of decreased resolution, negative energy, and spectral leakage due to side lobes are minimized by the windowing process. The 10 percent cosine bell taper window used is described by:

$$W(n) = 1/2 \, [1.0 - \cos\,(10\,\pi\,(n-1)/(N-1))] \qquad n = 1,2,\ldots N ,$$

where N is the total number of points being analyzed (1024).

14. Windowed pressure, u-velocity and v-velocity time series are transformed from the time domain to the frequency domain by using an FFT algorithm. The relationship of the Fourier transform pairs for a modified pressure time series, for example, is given by:

$$p'(n) = \sum_{m=0}^{N-1} \left(a_p(m) - i\ b_p(m) \right) \exp \left(\frac{i2\pi mn}{N} \right) \qquad n = 0,1,2,\ldots N-1$$

$$P(m) = \left(a_p(m) - i\ b_p(m) \right) = \frac{1}{N} \sum_{n=0}^{N-1} p'(n)\ \exp \left(- \frac{i2\pi mn}{N} \right) \qquad m = 0,1,2,\ldots N-1$$

where

$p'(n)$ = modified pressure time series

N = total number of data points (1024)

m = discrete time reference for $m\Delta t$

$a_p(m)$ = real FFT coefficients for pressure

$b_p(m)$ = imaginary FFT coefficients for pressure

Δt = time increment between data points (1 sec)

i = $\sqrt{-1}$

$P(m)$ = Fourier transformed pressure series

15. The Fourier coefficients represent the discrete energy at each spectral line frequency, $f(m) = m\Delta f$, where $\Delta f = 1/(N\Delta t)$. The $a(m)$ and $b(m)$ coefficients are symmetric functions about the Nyquist frequency, $f(m) = (N/2)\Delta f$, and are respectively even and odd functions. For this analysis, the $a(0)$ coefficient is zero, as well as the $a(N/2)$ term at the Nyquist frequency. Since the time series is real-valued, $b(0)$ and $b(N/2)$ are also zero. Magnitude and phase components of the line spectra for each $f(m)$ are computed as follows:

$$P(m) = \left[a_p^2(m) + b_p^2(m) \right]^{1/2}$$

$$\phi_p(m) = \arctan\left(\frac{b_p(m)}{a_p(m)}\right)$$

16. The above description also applies to u and v velocity time series analysis.

17. The windowing process reduces the energy contained within the signal. This effect is compensated for by multiplying the spectral magnitudes of pressure and velocities by the inverse of the area of the 10 percent cosine taper window.

18. The cross-spectra between velocity and pressure spectra must be calculated before the directional wave coefficients can be determined. Since the pressure and velocity data are in phase, the auto and cross-spectral estimates (Jenkins and Watts 1968) are expressed by:

$$Spp(m) = P(m)**2,$$

$$Suu(m) = U(m)**2,$$

$$Svv(m) = V(m)**2, \text{ and}$$

$$Spu(m) = P(m)\ U(m) \cos\ \phi u(m) - \phi p(m) \quad ,$$

where $Sxx(m)$ = cross spectral estimate.

19. To increase their statistical stability, the spectral estimates were band averaged in the frequency domain. This increased stability comes at the cost of decreased spectral resolution. Band averaging maximizes the information content of the signal since each point is used in context with neighboring points. The spectral estimates are band averaged before the calculation of the directional Fourier coefficients so that a statistically more stable estimate is produced.

20. Pressure and velocity spectra are transformed into equivalent surface displacement cross-spectra by using the pressure and velocity response functions given by:

$$K_p(m) = \gamma \frac{\cosh [k(m)B_p]}{\cosh [k(m)d]}$$

$$K_\mu(m) = \sigma(m) \frac{\cosh [k(m)B_c]}{\sinh [k(m)d]}$$

where

$K_p(m)$ = pressure response factor

γ = specific weight of sea water

B_p = distance of pressure sensor above bottom

d = water depth

$K_\mu(m)$ = velocity response factor

B_c = distance of current sensor above bottom

$k(m)$ = $2\pi/L(m)$, wave number

$L(m)$ = wave length, determined from the linear dispersion relationship:

$$L(m) = \frac{g}{2\pi f^2(m)} \tanh (dk(m))$$

where g is the acceleration due to gravity.

21. To minimize erroneous spectral estimates due to attenuation of the pressure signal with depth, a high frequency cutoff of 0.27 Hz was selected. A low frequency cutoff of 0.024 Hz was used to restrict the spectral estimates to the wind wave frequency regime and to provide a statistically sufficient number of waves in each frequency band for the sampling length used.

Spectral Estimate Analysis

22. A PUV directional wave sensor such as the Sea Data 635-12 gage measures three independent variables. Using a (Longuet-Higgins et al. 1963) type analysis only the first five directional Fourier coefficients can be determined. Using the previously defined single-sided autospectral estimates, coincident spectral estimates, pressure and velocity response factors, the five real and imaginary directional coefficients are expressed by:

$$A_o(m) = \frac{G_{pp}(m)}{2\pi K_p^2(m)}$$

$$A_1(m) = \frac{1}{\pi\ K_p(m)\ K_\mu(m)}$$

$$A_2(m) = \frac{G_{uu}(m) - G_{vv}(m)}{\pi\ K_\mu^2(m)}$$

$$B_1(m) = \frac{1}{\pi\ K_p(m)\ K_\mu(m)}$$

$$B_2(m) = \frac{2}{\pi\ K_\mu^2(m)}$$

where the $A_n(m)$ and $B_n(m)$ are the real and imaginary coefficients, respectively, and where Gxx = 2Sxx.

23. At each center frequency, m , the frequency spectral estimate, energy density in M^2/Hz , is calculated by:

$$\text{engyden}(m) = \frac{T\ G_{pp}(m)}{K_p^2(m)} = 2\pi A_o(m) \ ,$$

where T is the record length in seconds.

24. In general, the directional wave spectra are represented by the theoretical infinite Fourier series:

$$S(m,Q) = W_o A_o(m) + \sum_{n=1}^{\infty} W_n\Big(A_n(m)\ \cos(nQ) + B_n(m)\ \sin(nQ)\Big)$$

where Q is the radian angle in 5 deg increments from 0 - 355 deg and W_n are weighting coefficients for a particular weighting function. If an infinite number of directional coefficients could be calculated, each W_n would be unity. Since only five directional coefficients are available, use of weights equal to unity would result in a loss of resolution and energy and would cause negative side lobes and a broadened spectrum. A binomial distribution weighting function (Longuet-Higgins, et al. 1963) is employed to minimize loss of resolution and eliminate the negative side lobes. The weights are:

$$W_o = 1$$
$$W_1 = 2/3$$
$$W_2 = 1/6 \ .$$

Therefore, the truncated Fourier series representation of the directional wave spectrum is expressed by:

$$S(m,Q) = A_o(m) + 2/3\ [A_1(m)\ \cos(Q) + B_1(m)\ \sin(Q)]$$
$$+ 1/6\ [A_2(m)\ \cos(2Q) + B_2(m)\ \sin(2Q)] \ .$$

These values are adjusted to give degrees measured from true north.

25. The significant wave height for any one record is determined by:

$$Hm_o = 4.0\sqrt{M_o}$$

where M_o is the sum of the energy in all frequency and direction bands (zeroth moment) and is equivalent to the integration of the directional spectral density function between the low and high frequency cutoffs.

26. The mean wave direction is determined by calculating the mean direction of waves in each band of frequencies and is defined by:

$$Q(m) = \arctan\left(\frac{B_1(m)}{A_1(m)}\right)$$

where $A_1(m)$ and $B_1(m)$ are the directional coefficients which correspond to a particular center frequency. This value is adjusted to give angles in degrees measured clockwise from true north toward which the waves are moving, although the accompanying rose plots indicate the direction from which the waves are coming. The directional spread is an estimate of the spread of energy about the mean wave direction at a center frequency and is given by:

$$Q\ (m) = \left| 2 - \left[\frac{A_1^2(m) + B_1^2(m)}{A_o(m)}^{1/2} \right] \right|^{1/2}$$

where $A_o(m)$, $A_1(m)$, and $B_1(m)$ are the directional Fourier coefficients of a particular band (Cartwright, 1963).

Results

27. From the monthly wave rose plots (Figures 3 to 10), it is apparent that most waves during the months of data recording came from southerly directions. During the winter months, many weather systems come from the north and the rose plots would be expected to show more waves coming from this direction.

28. Figures 11 to 18 show monthly vector stick plots of significant wave height and direction. The peak spectral frequency for each gage deployment is shown in Figures 19 to 23. The significant wave height calculated at each recording interval is shown in Figures 24 to 28.

Comparison With Other Data Sets

29. Davis, Cline and Belknap (1985) state that typical waves at Caladesi Island range from 6-30 cm in height with a period from 2-4 sec. Most frontal systems are reported to generate waves from 50-60 cm in height with periods of about 5 sec. No information on wave directions is included in their report.

30. The University of Florida has operated a nondirectional wave gage at Clearwater, FL (about 14 km north of the project site) since 1978. Its pressure sensor is at approximately the same depth as the Redington Shores gage; however, it is about 2,000 ft farther offshore. Figures 29 to 33 compare the significant wave heights between the two stations. Agreement is in

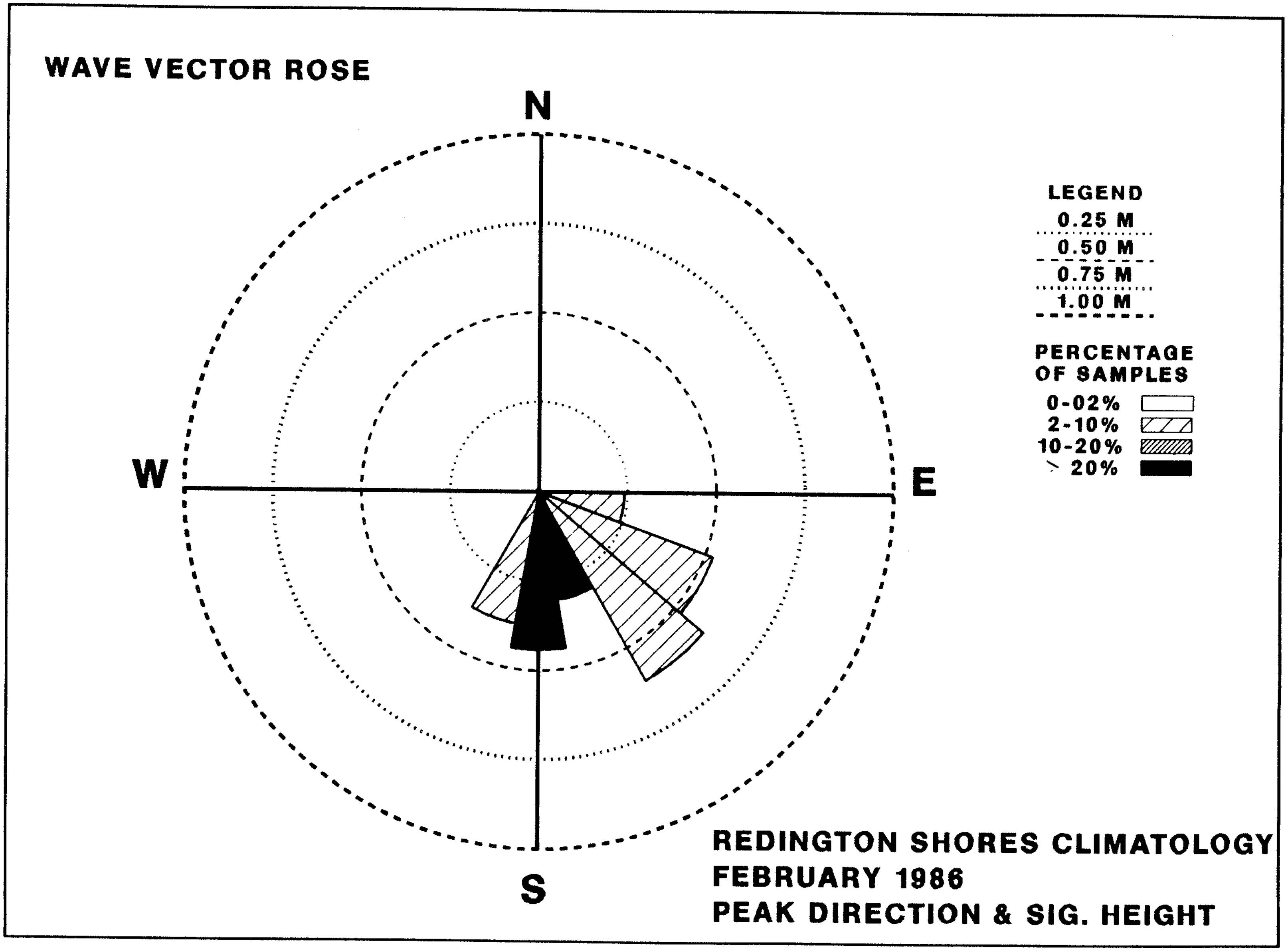

WAVE VECTOR ROSE
N
W
E
S
LEGEND
0.25 M
0.50 M
0.75 M
1.00 M
PERCENTAGE OF SAMPLES
0-02%
2-10%
10-20%
> 20%
REDINGTON SHORES CLIMATOLOGY
FEBRUARY 1986
PEAK DIRECTION & SIG. HEIGHT

Figure 3

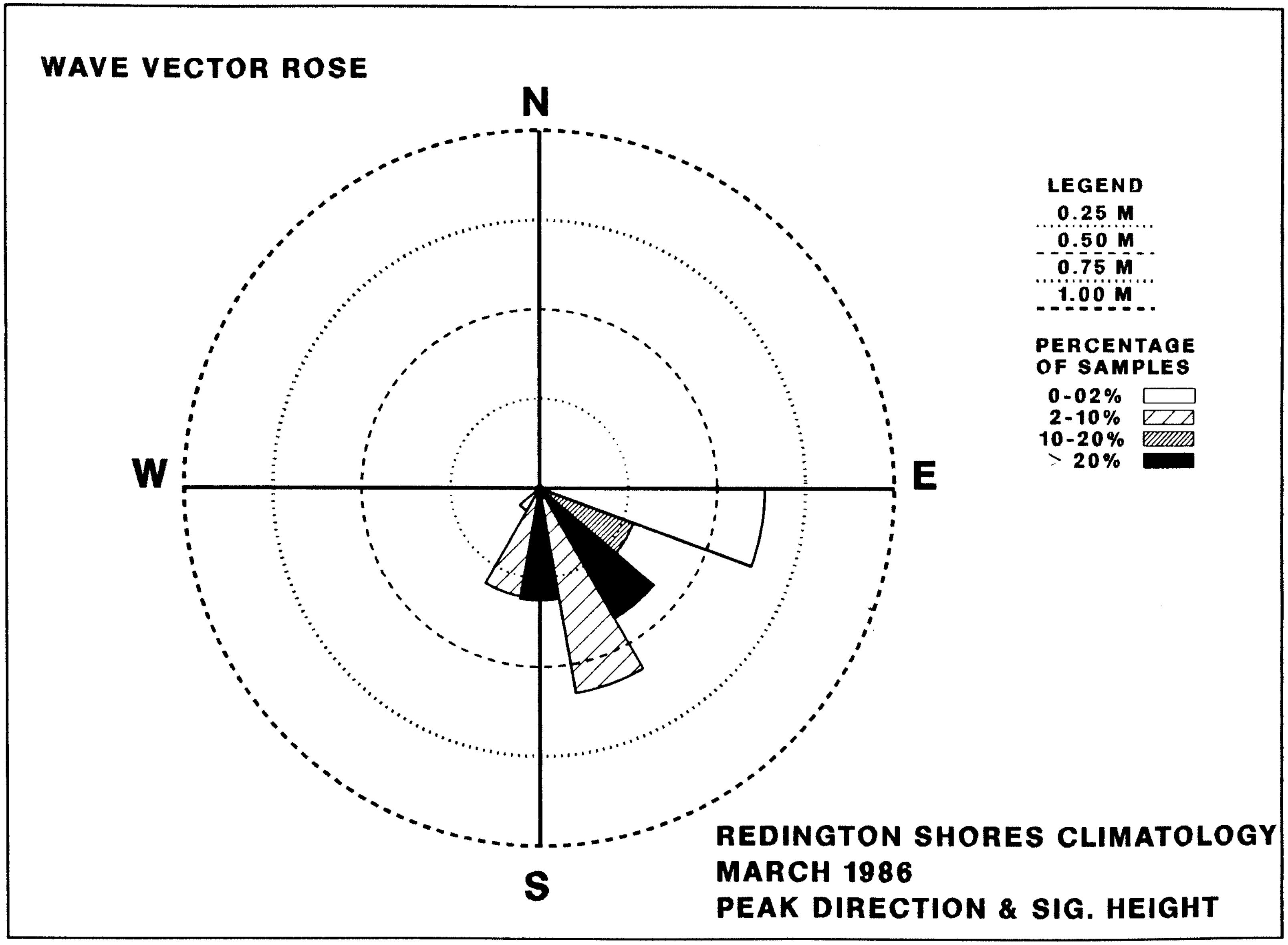

WAVE VECTOR ROSE
N
E
S
W
LEGEND
0.25 M
0.50 M
0.75 M
1.00 M
PERCENTAGE OF SAMPLES
0-02%
2-10%
10-20%
> 20%
REDINGTON SHORES CLIMATOLOGY
MARCH 1986
PEAK DIRECTION & SIG. HEIGHT

Figure 4

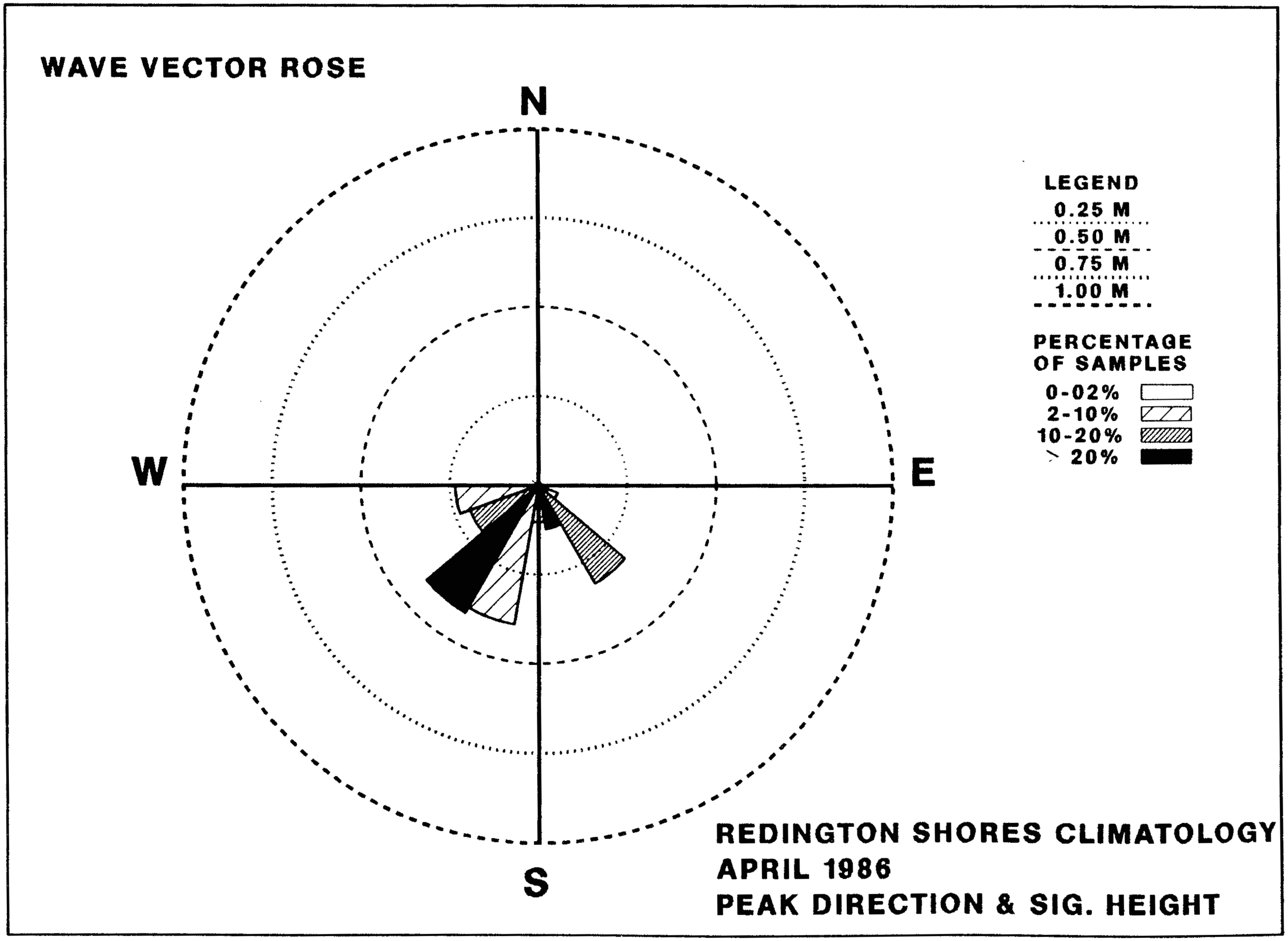

WAVE VECTOR ROSE
N
W
E
S
LEGEND
0.25 M
0.50 M
0.75 M
1.00 M
PERCENTAGE
OF SAMPLES
0-02%
2-10%
10-20%
> 20%
REDINGTON SHORES CLIMATOLOGY
APRIL 1986
PEAK DIRECTION & SIG. HEIGHT

Figure 5

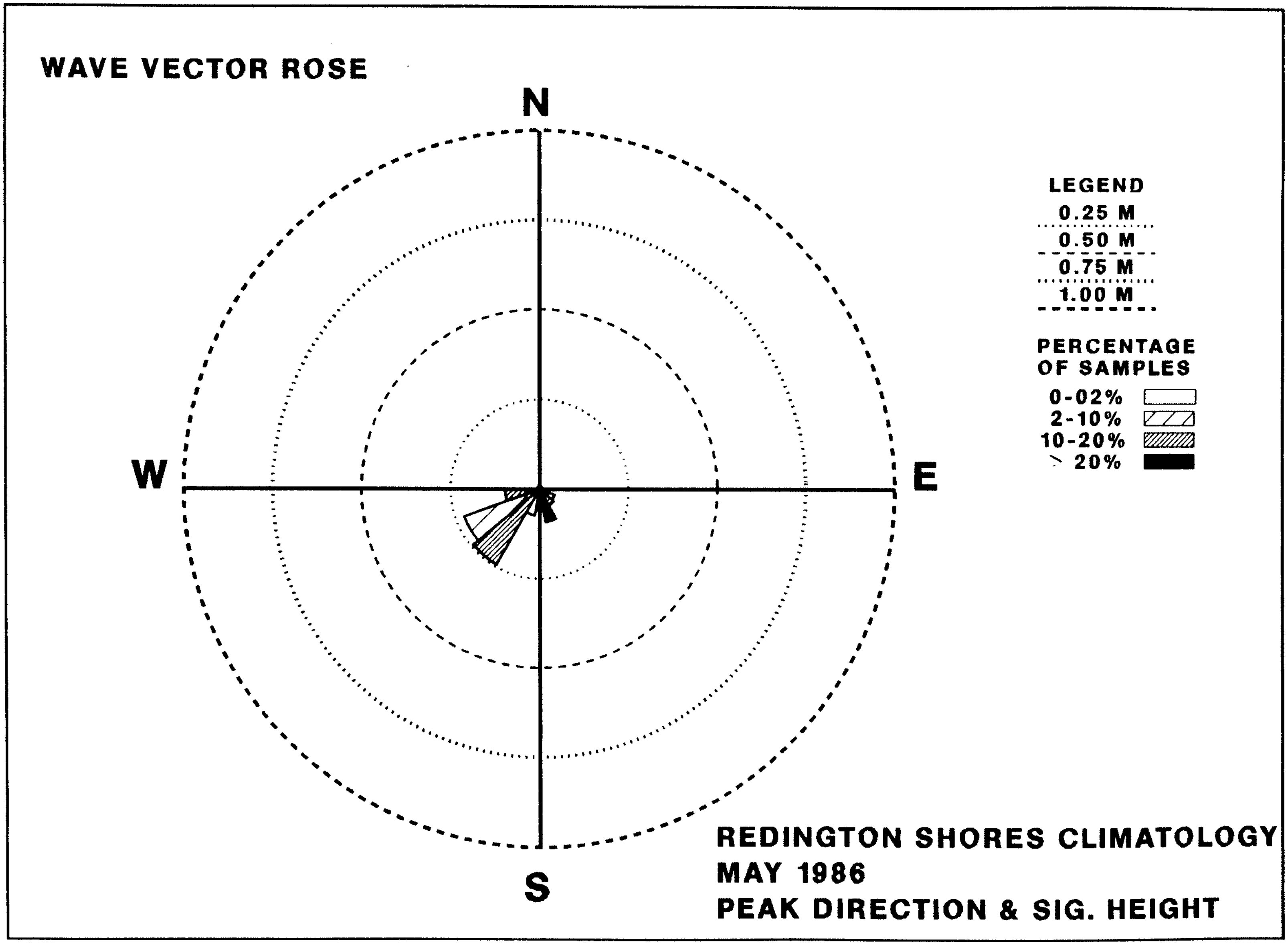

WAVE VECTOR ROSE
N
W
E
S
LEGEND
0.25 M
0.50 M
0.75 M
1.00 M
PERCENTAGE
OF SAMPLES
0-02%
2-10%
10-20%
> 20%
REDINGTON SHORES CLIMATOLOGY
MAY 1986
PEAK DIRECTION & SIG. HEIGHT

Figure 6

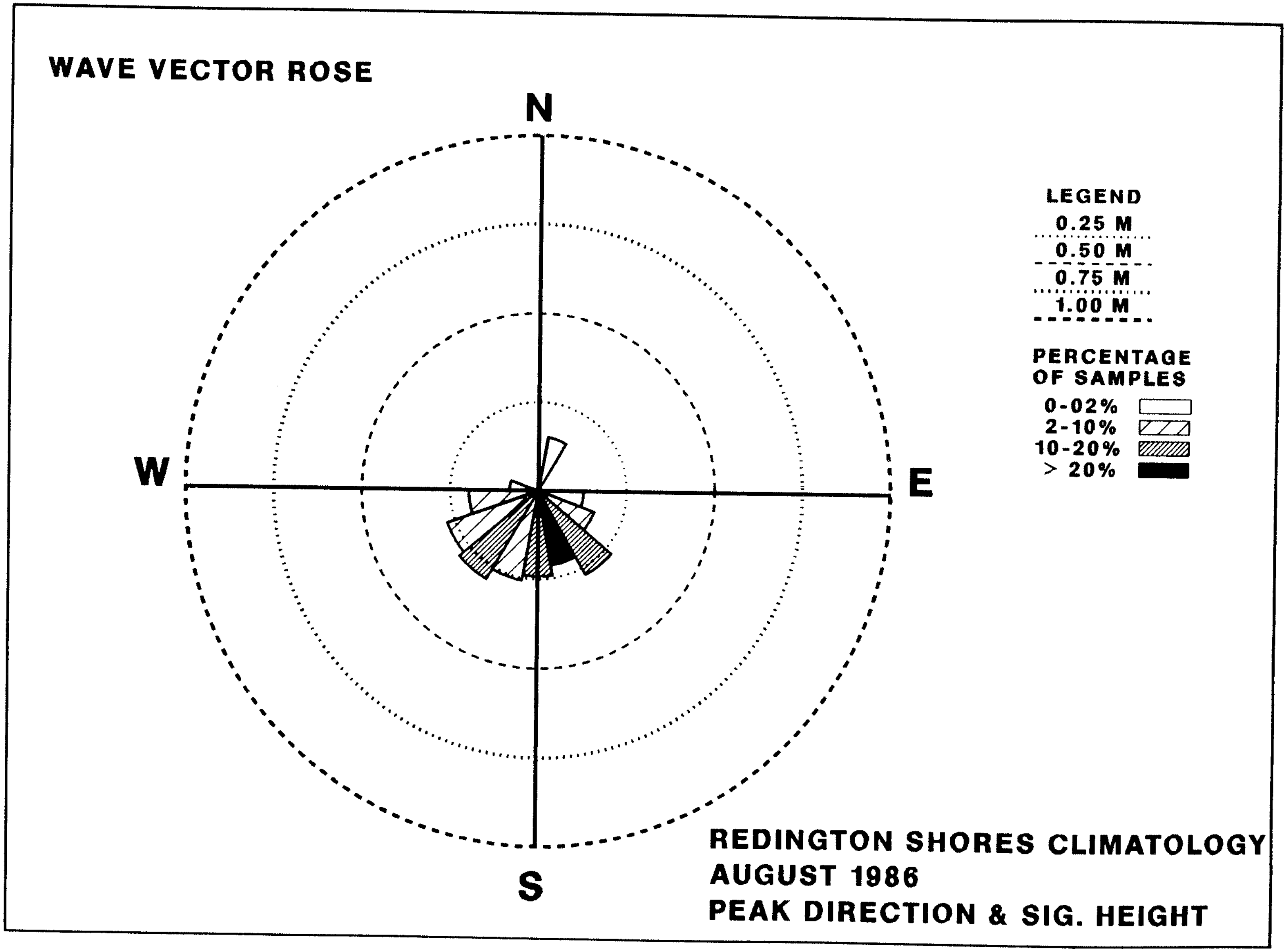

WAVE VECTOR ROSE
N
E
S
W
LEGEND
0.25 M
0.50 M
0.75 M
1.00 M
PERCENTAGE
OF SAMPLES
0-02%
2-10%
10-20%
> 20%
REDINGTON SHORES CLIMATOLOGY
AUGUST 1986
PEAK DIRECTION & SIG. HEIGHT

Figure 7

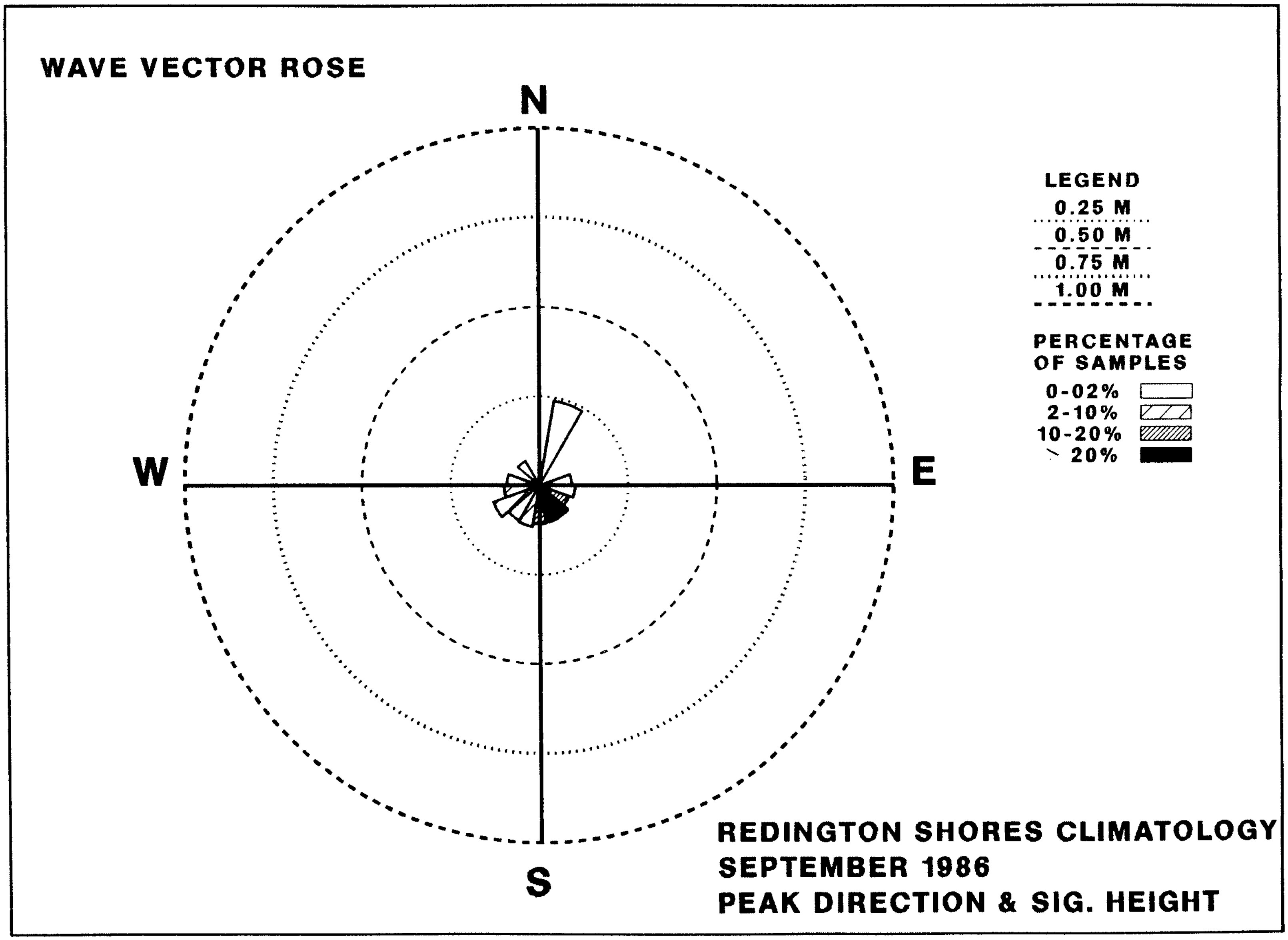

WAVE VECTOR ROSE
N
W
E
S
LEGEND
0.25 M
0.50 M
0.75 M
1.00 M
PERCENTAGE
OF SAMPLES
0-02%
2-10%
10-20%
> 20%
REDINGTON SHORES CLIMATOLOGY
SEPTEMBER 1986
PEAK DIRECTION & SIG. HEIGHT

Figure 8

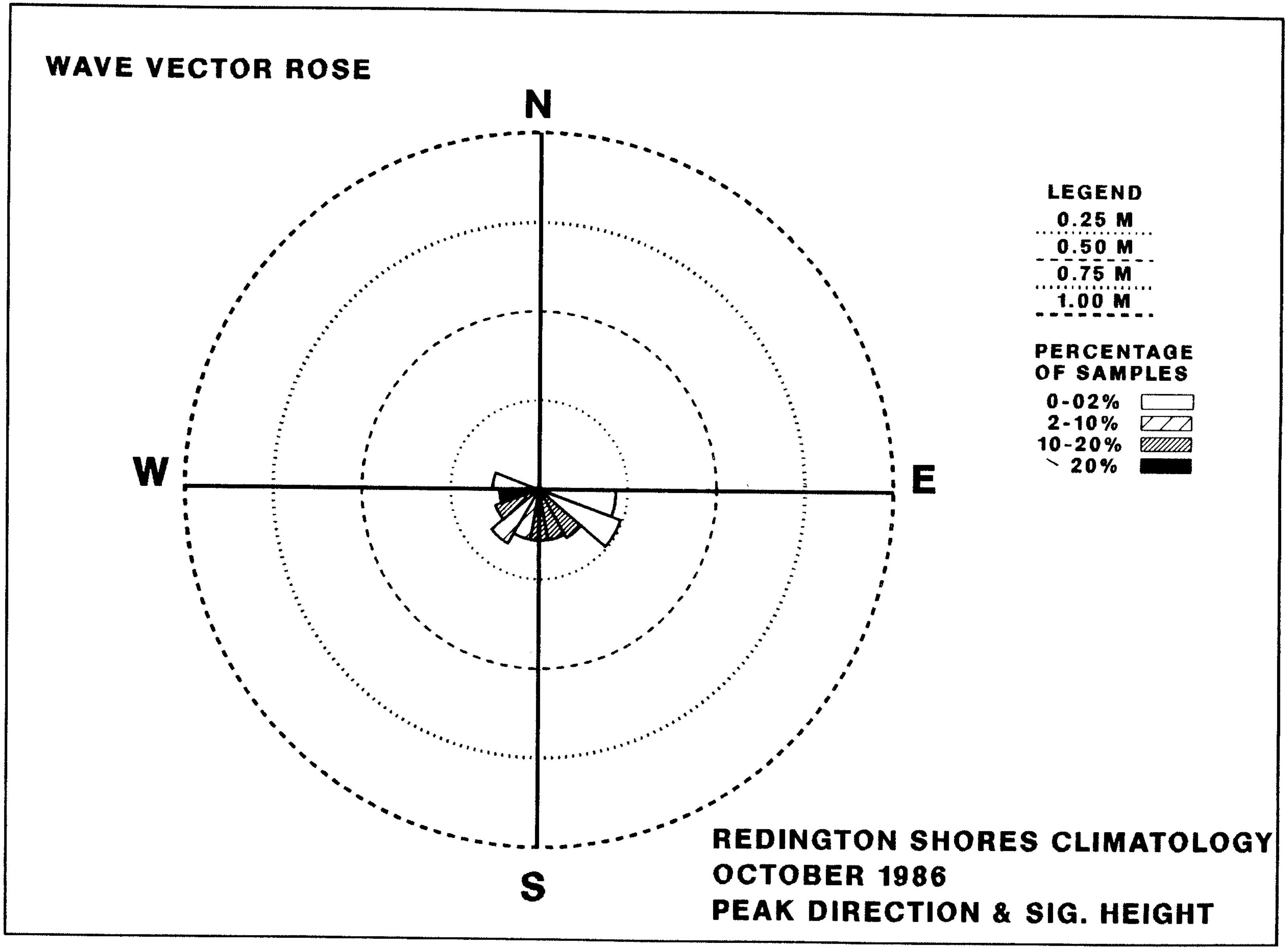

WAVE VECTOR ROSE
N
W
E
S
LEGEND
0.25 M
0.50 M
0.75 M
1.00 M
PERCENTAGE OF SAMPLES
0-02%
2-10%
10-20%
20%
REDINGTON SHORES CLIMATOLOGY
OCTOBER 1986
PEAK DIRECTION & SIG. HEIGHT

Figure 9

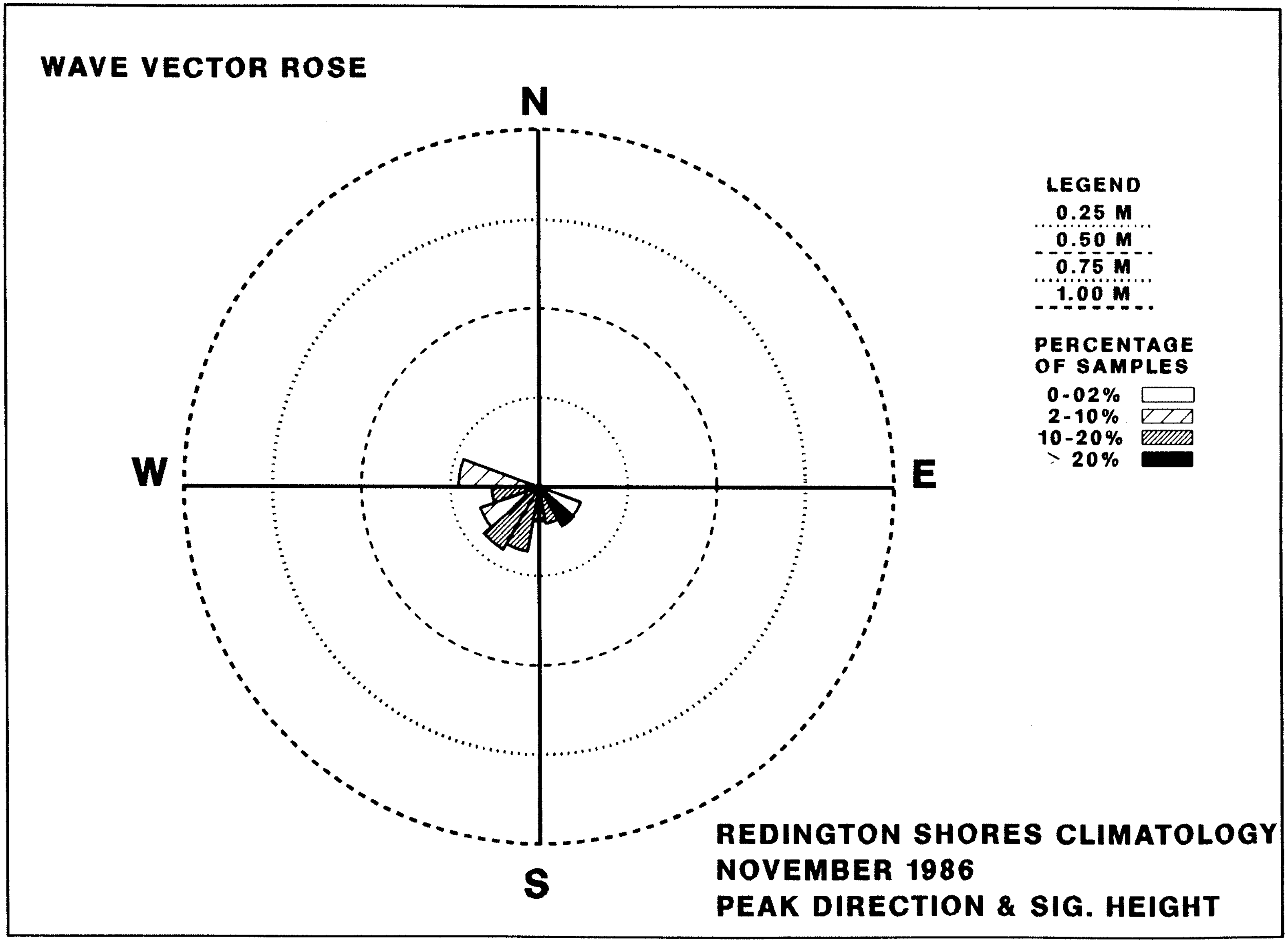

WAVE VECTOR ROSE
N
W
E
S
LEGEND
0.25 M
0.50 M
0.75 M
1.00 M
PERCENTAGE
OF SAMPLES
0-02%
2-10%
10-20%
> 20%
REDINGTON SHORES CLIMATOLOGY
NOVEMBER 1986
PEAK DIRECTION & SIG. HEIGHT

Figure 10

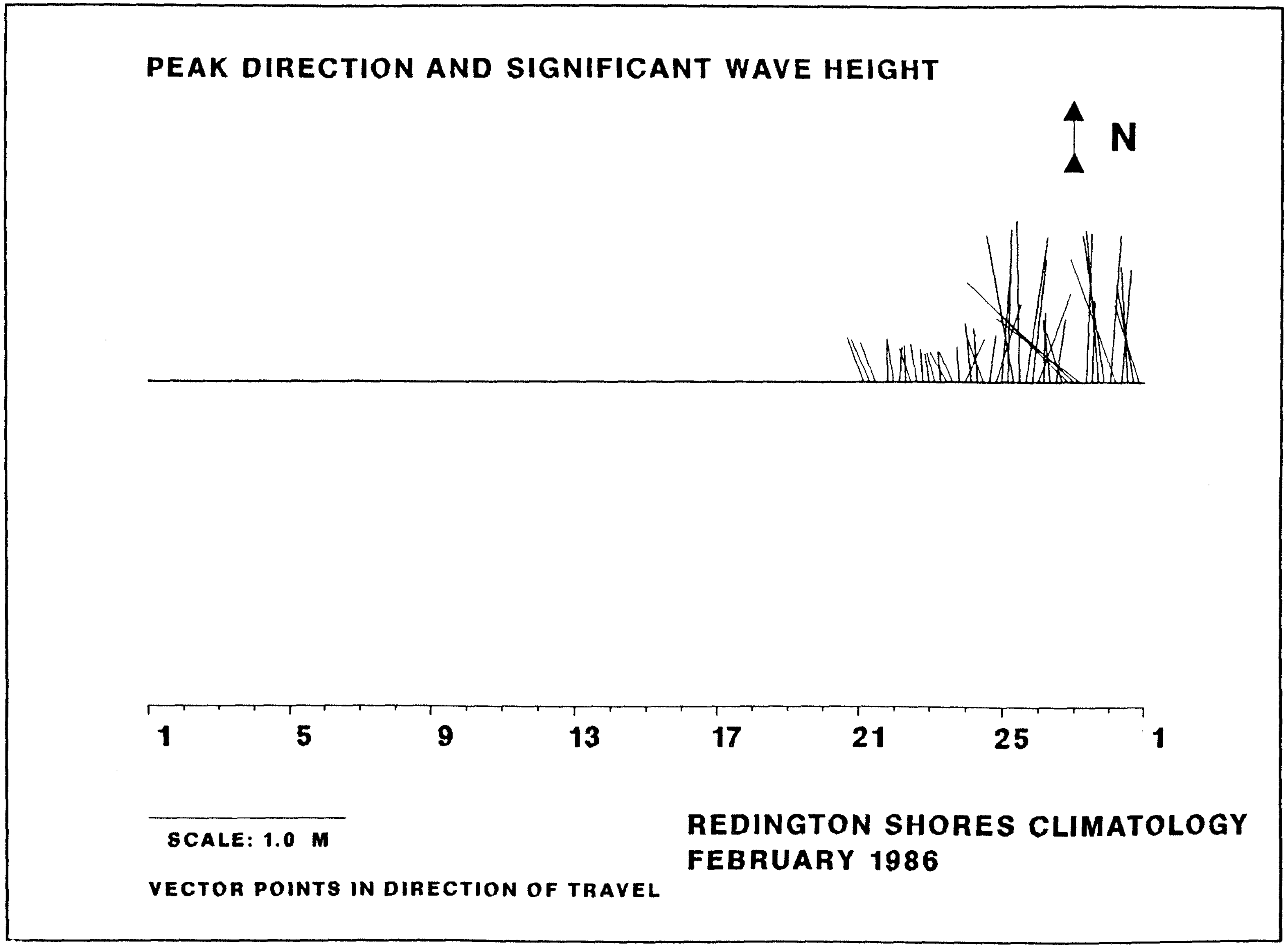

PEAK DIRECTION AND SIGNIFICANT WAVE HEIGHT
N
1
5
9
13
17
21
25
1
SCALE: 1.0 M
VECTOR POINTS IN DIRECTION OF TRAVEL
REDINGTON SHORES CLIMATOLOGY
FEBRUARY 1986

Figure 11

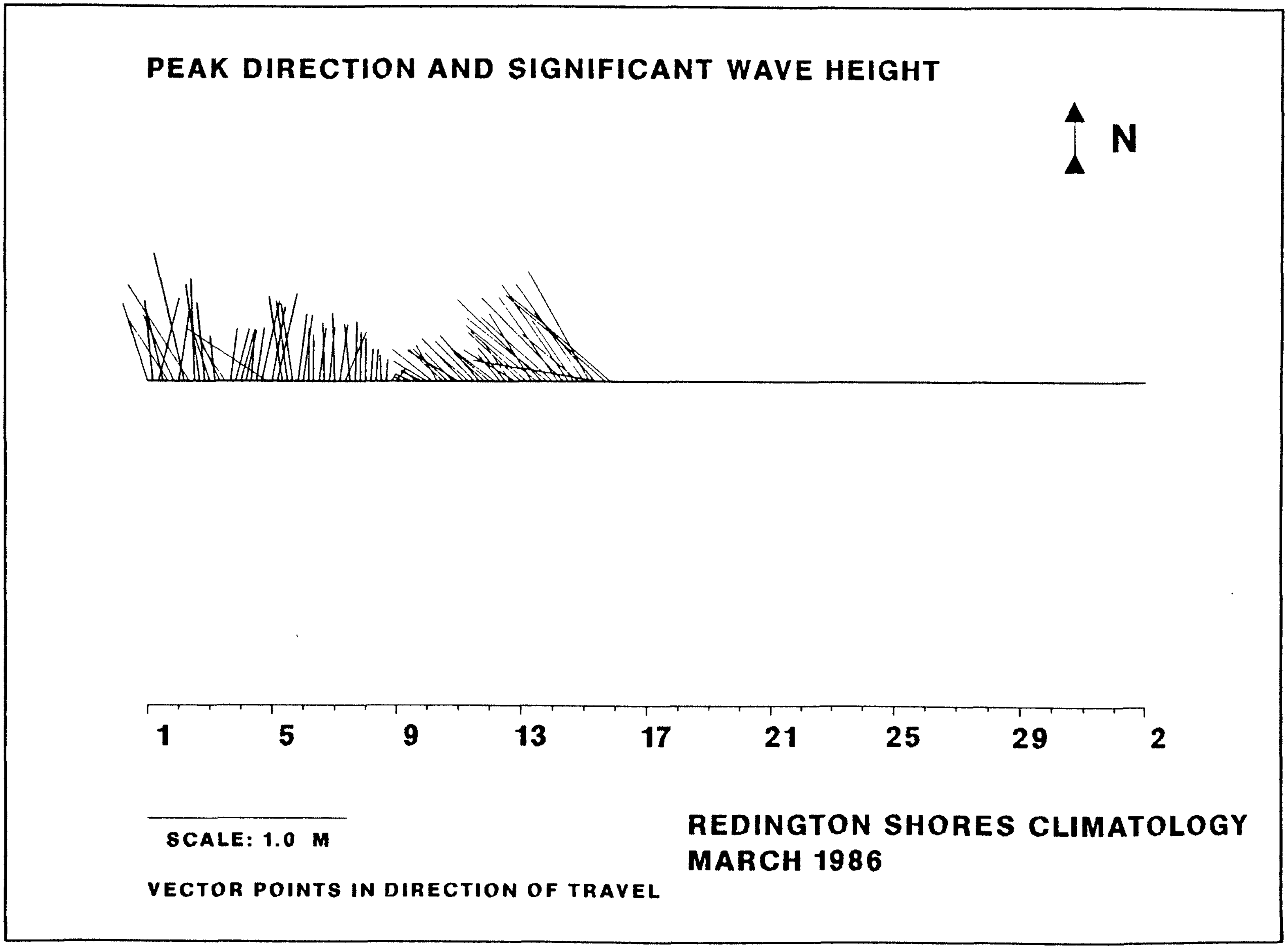

PEAK DIRECTION AND SIGNIFICANT WAVE HEIGHT
N
1
5
9
13
17
21
25
29
2
SCALE: 1.0 M
VECTOR POINTS IN DIRECTION OF TRAVEL
REDINGTON SHORES CLIMATOLOGY
MARCH 1986

Figure 12

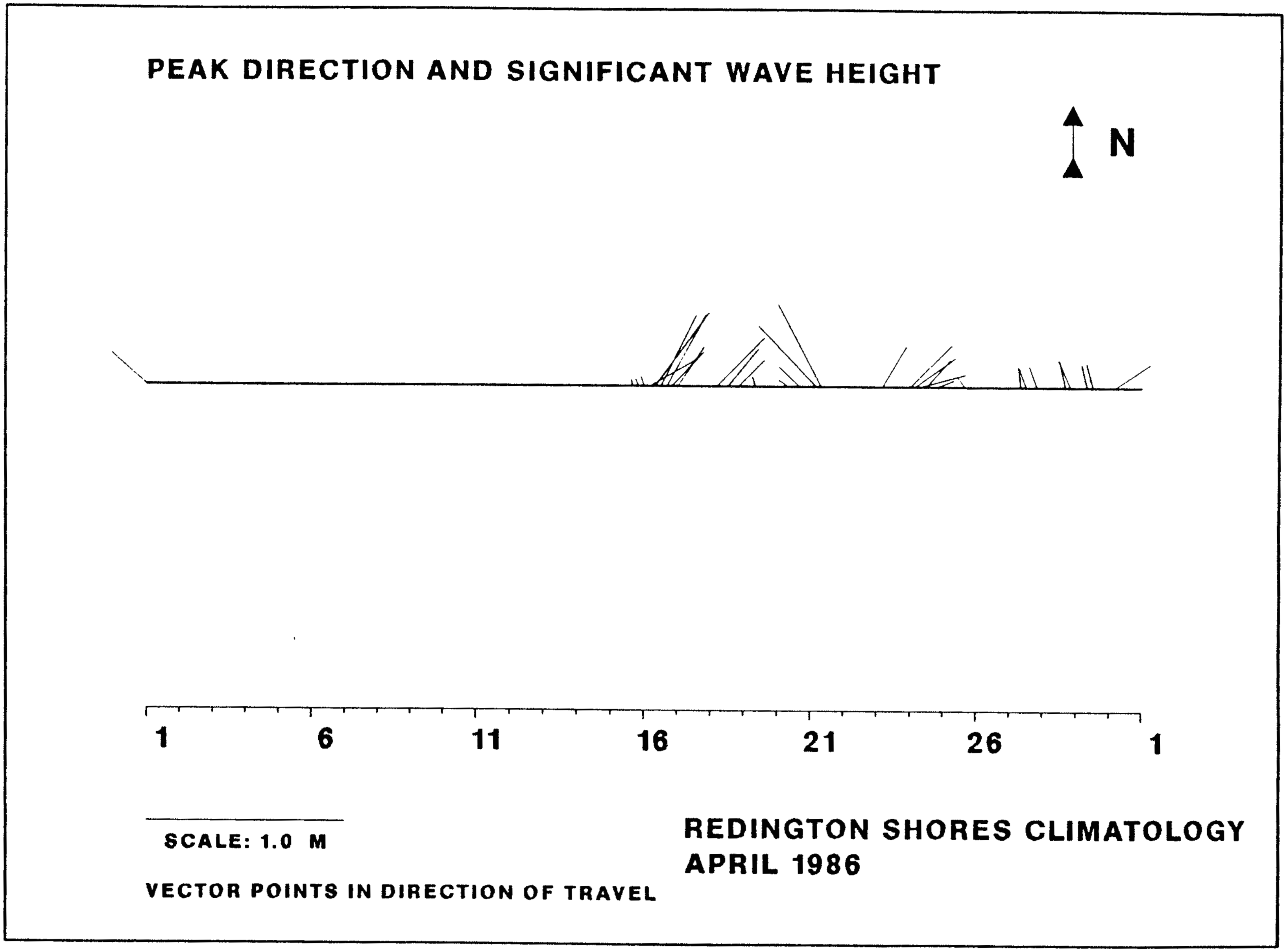

PEAK DIRECTION AND SIGNIFICANT WAVE HEIGHT
N
1
6
11
16
21
26
1
SCALE: 1.0 M
VECTOR POINTS IN DIRECTION OF TRAVEL
REDINGTON SHORES CLIMATOLOGY
APRIL 1986

Figure 13

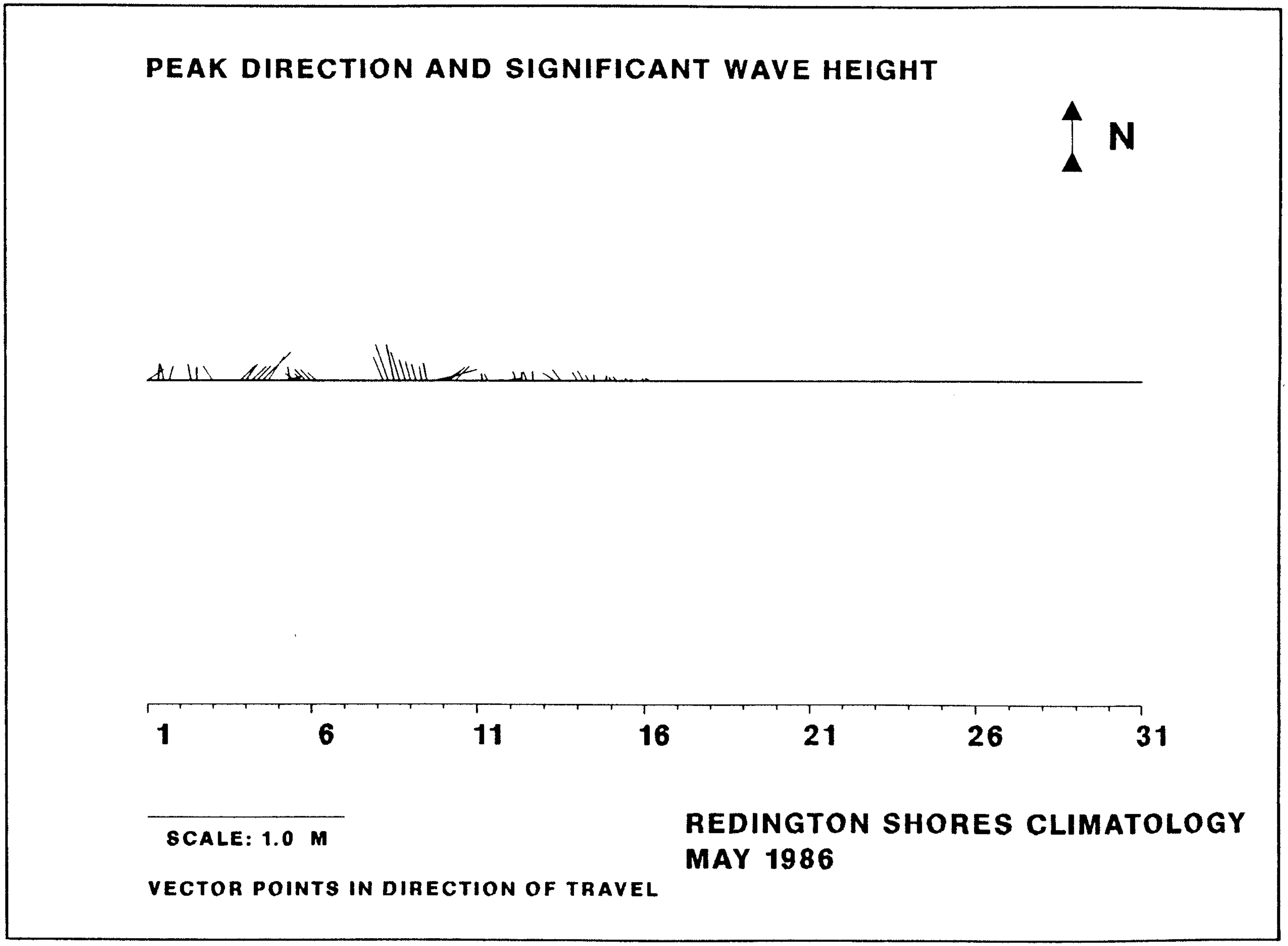

PEAK DIRECTION AND SIGNIFICANT WAVE HEIGHT
N
1
6
11
16
21
26
31
SCALE: 1.0 M
VECTOR POINTS IN DIRECTION OF TRAVEL
REDINGTON SHORES CLIMATOLOGY
MAY 1986

Figure 14

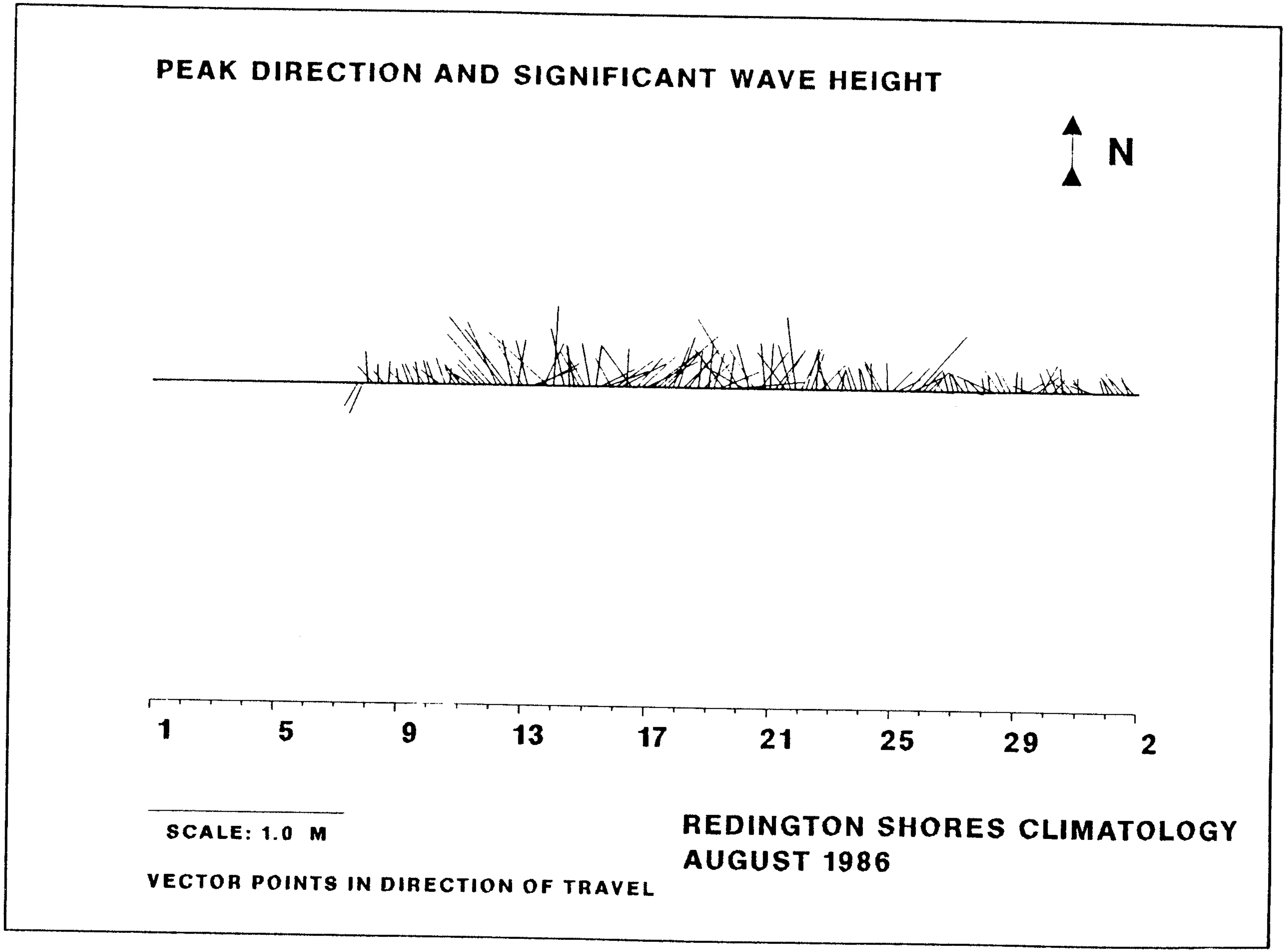

PEAK DIRECTION AND SIGNIFICANT WAVE HEIGHT
N
1
5
9
13
17
21
25
29
2
SCALE: 1.0 M
VECTOR POINTS IN DIRECTION OF TRAVEL
REDINGTON SHORES CLIMATOLOGY
AUGUST 1986

Figure 15

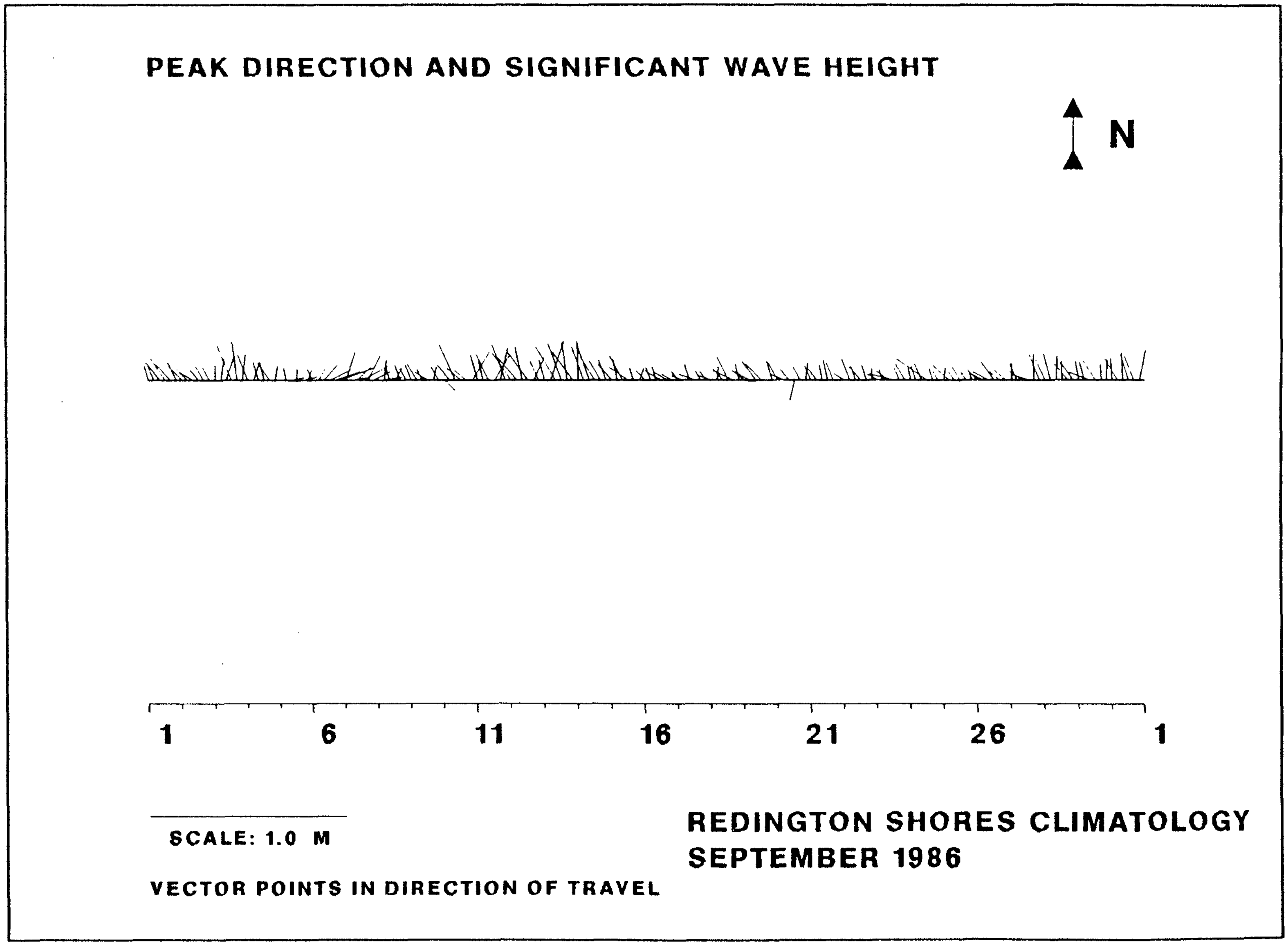

PEAK DIRECTION AND SIGNIFICANT WAVE HEIGHT
N
1
6
11
16
21
26
1
SCALE: 1.0 M
VECTOR POINTS IN DIRECTION OF TRAVEL
REDINGTON SHORES CLIMATOLOGY
SEPTEMBER 1986

Figure 16

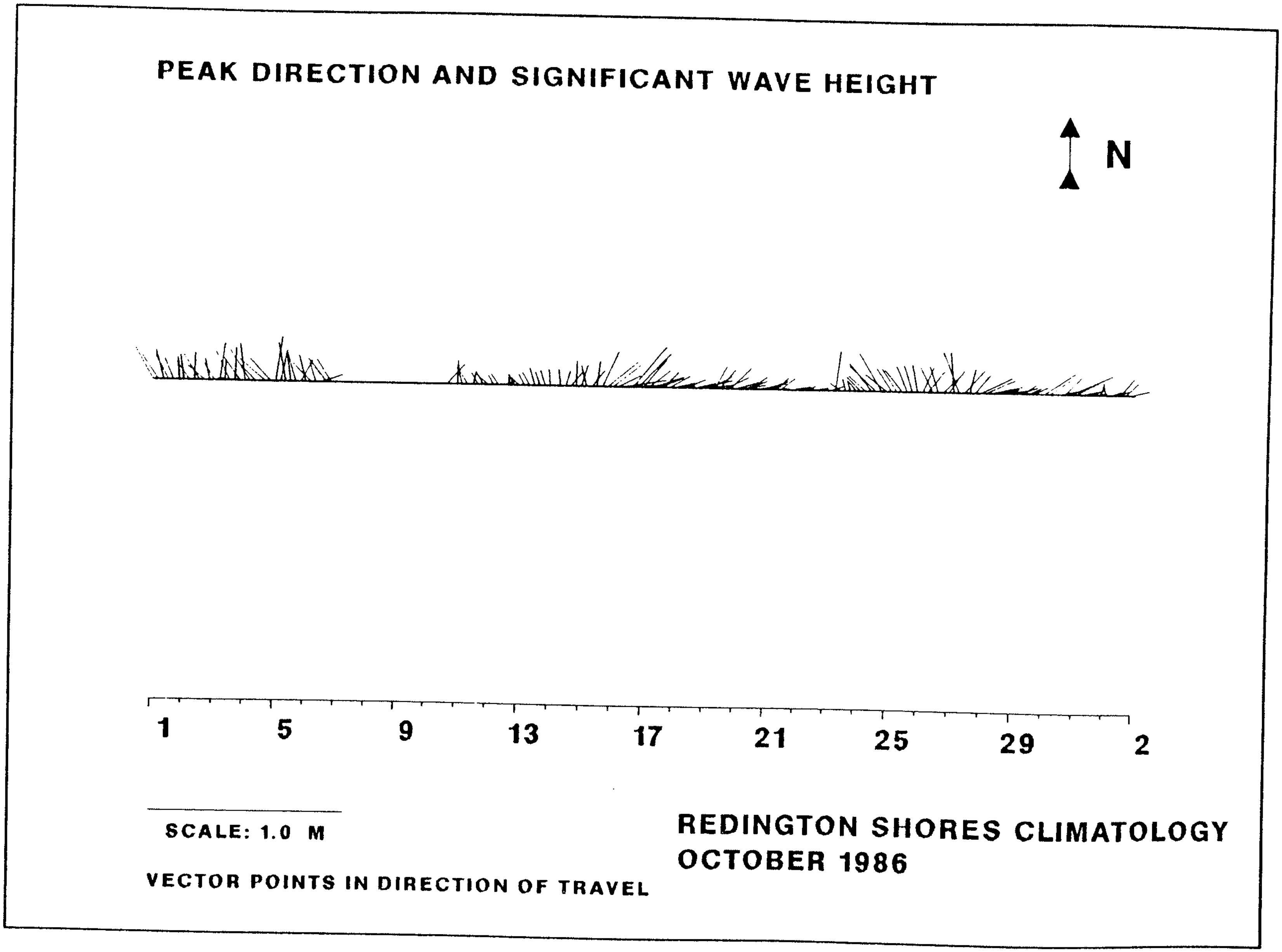

PEAK DIRECTION AND SIGNIFICANT WAVE HEIGHT
N
1
5
9
13
17
21
25
29
2
SCALE: 1.0 M
VECTOR POINTS IN DIRECTION OF TRAVEL
REDINGTON SHORES CLIMATOLOGY
OCTOBER 1986

Figure 17

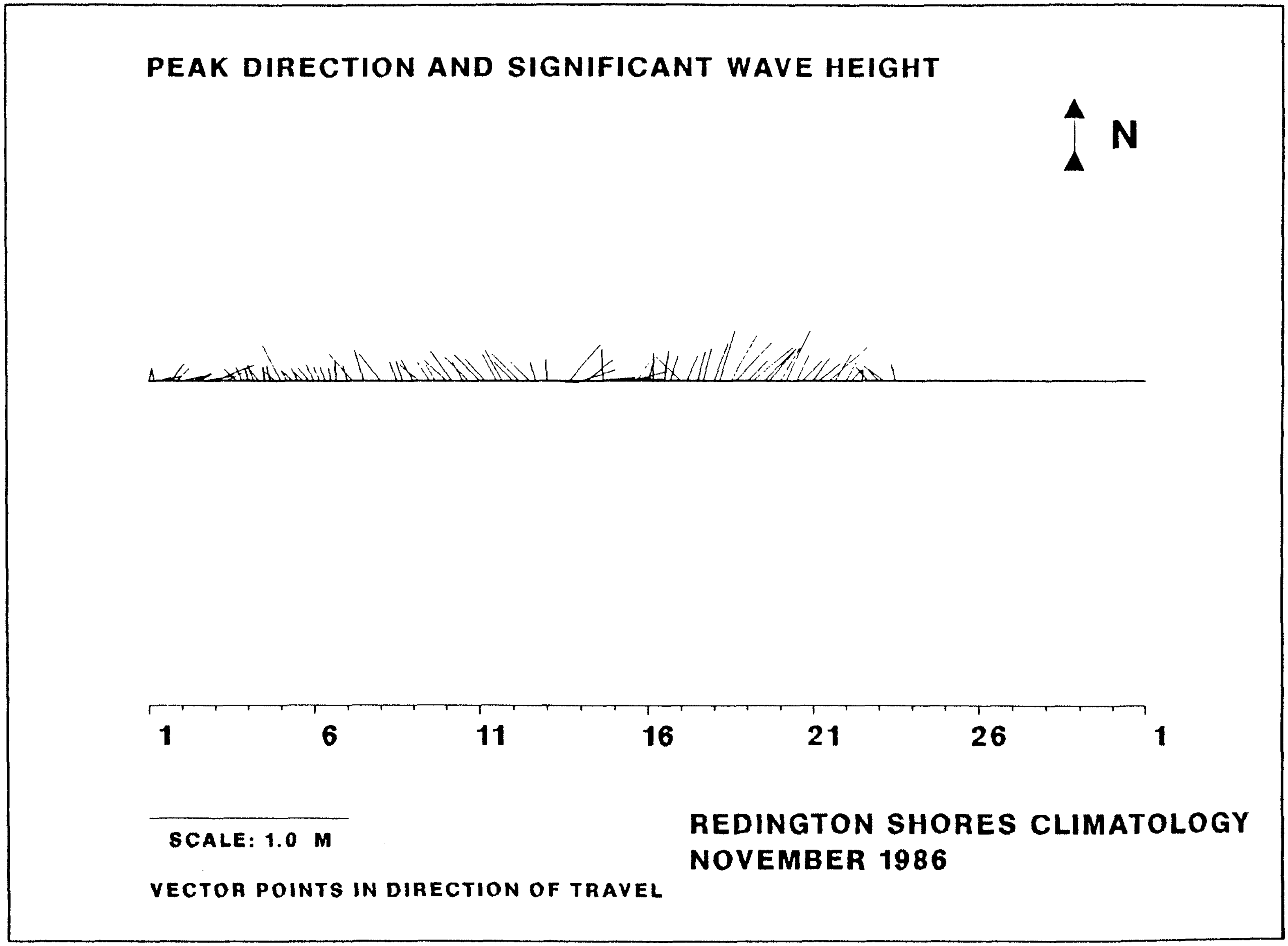

PEAK DIRECTION AND SIGNIFICANT WAVE HEIGHT
N
1
6
11
16
21
26
1
SCALE: 1.0 M
VECTOR POINTS IN DIRECTION OF TRAVEL
REDINGTON SHORES CLIMATOLOGY
NOVEMBER 1986

Figure 18

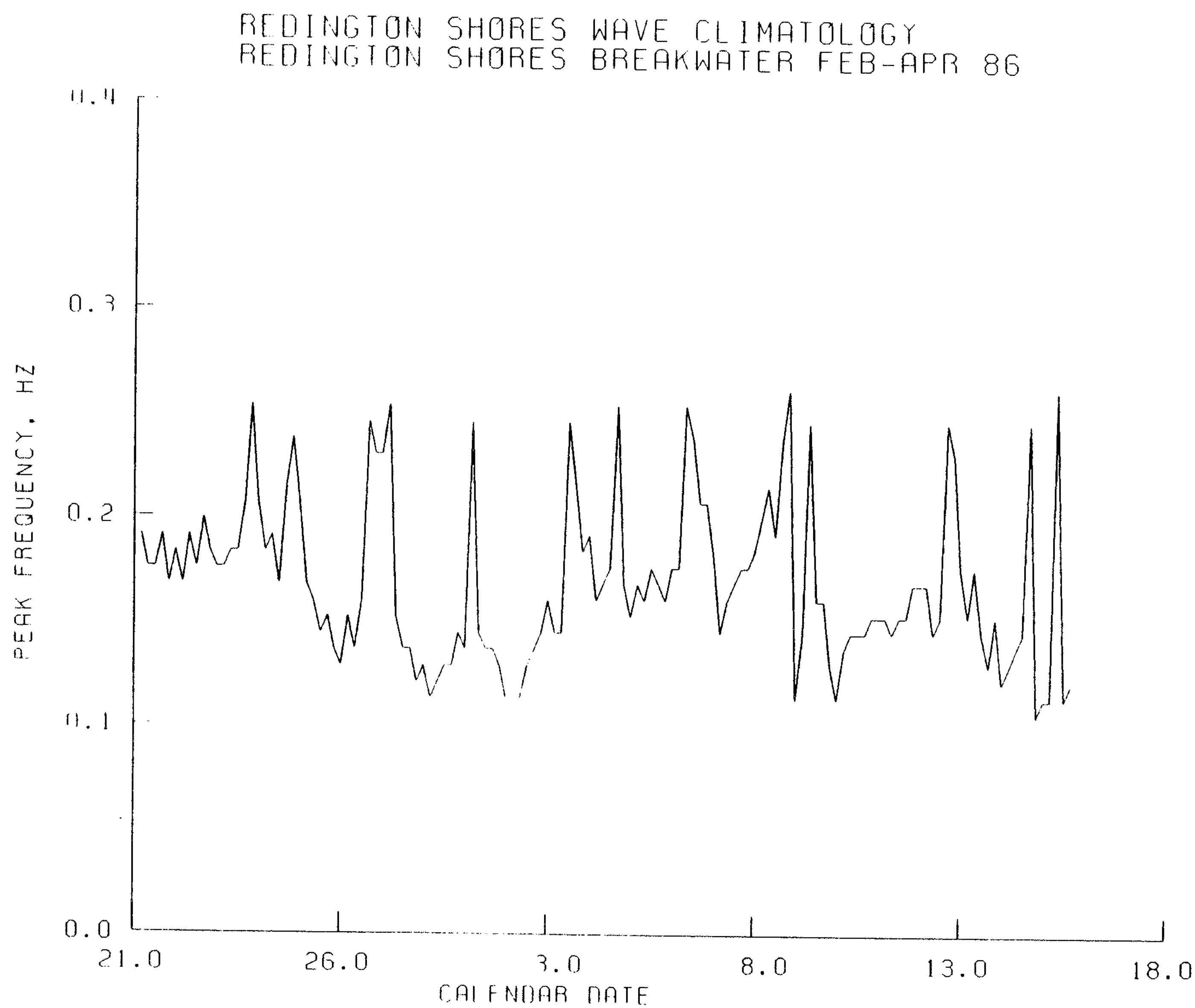

REDINGTON SHORES WAVE CLIMATOLOGY
REDINGTON SHORES BREAKWATER FEB-APR 86
0.3
0.2
0.0
PEAK FREQUENCY, HZ
21.0
26.0
3.0
8.0
13.0
18.0
CALENDAR DATE

Figure 19

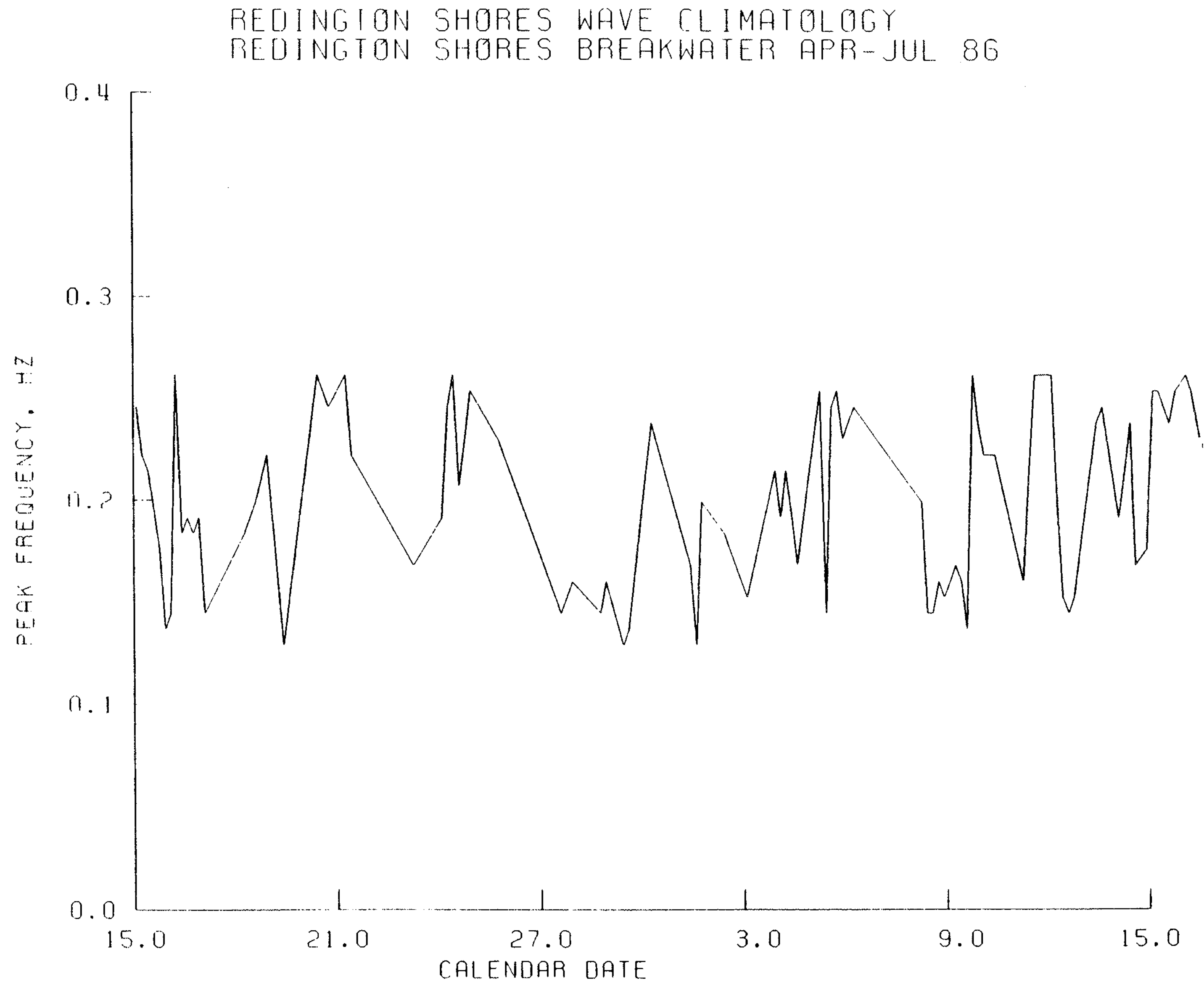

REDINGION SHORES WAVE CLIMATOLOGY
REDINGTON SHORES BREAKWATER APR-JUL 86
0.4
0.3
0.2
0.1
0.0
PEAK FREQUENCY, HZ
15.0
21.0
27.0
3.0
9.0
15.0
CALENDAR DATE

Figure 20

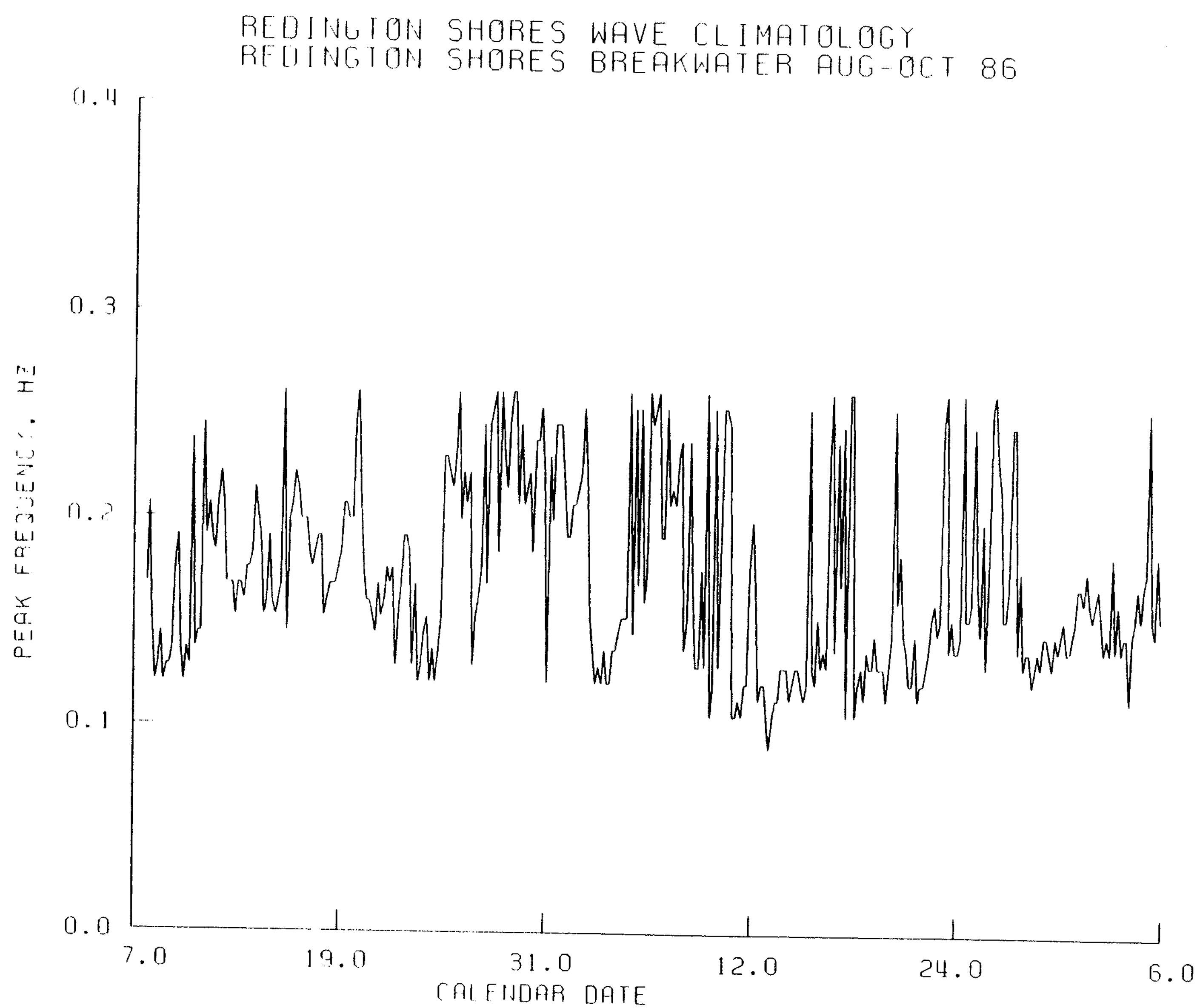

REDINGTON SHORES WAVE CLIMATOLOGY
REDINGTON SHORES BREAKWATER AUG-OCT 86
PEAK FREQUENCY, HZ
0.0
0.1
0.2
0.3
0.4
7.0
19.0
31.0
12.0
24.0
6.0
CALENDAR DATE

Figure 21

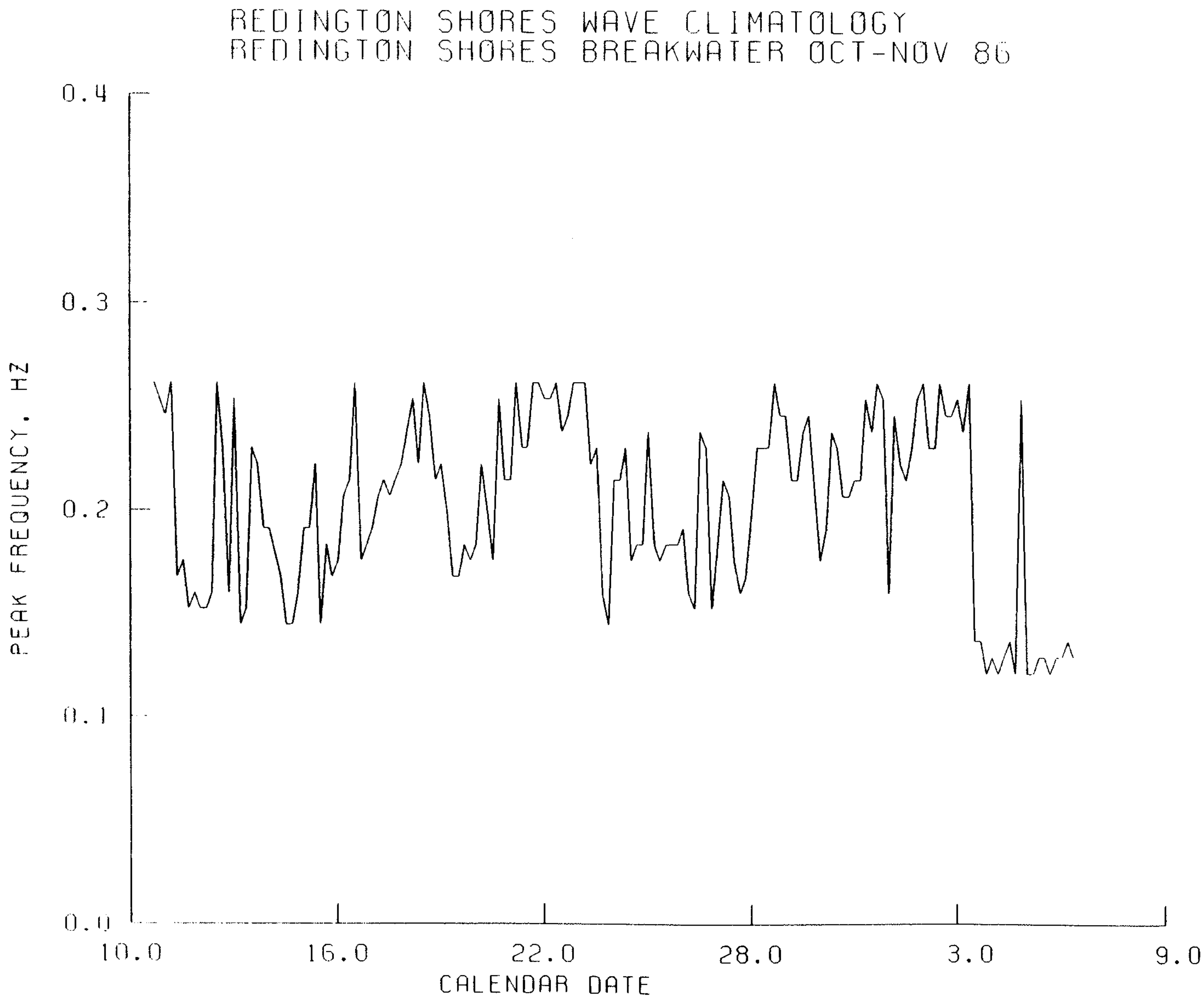

REDINGTON SHORES WAVE CLIMATOLOGY
REDINGTON SHORES BREAKWATER OCT-NOV 86
PEAK FREQUENCY, HZ
0.0
0.1
0.2
0.3
0.4
10.0
16.0
22.0
28.0
3.0
9.0
CALENDAR DATE

Figure 22

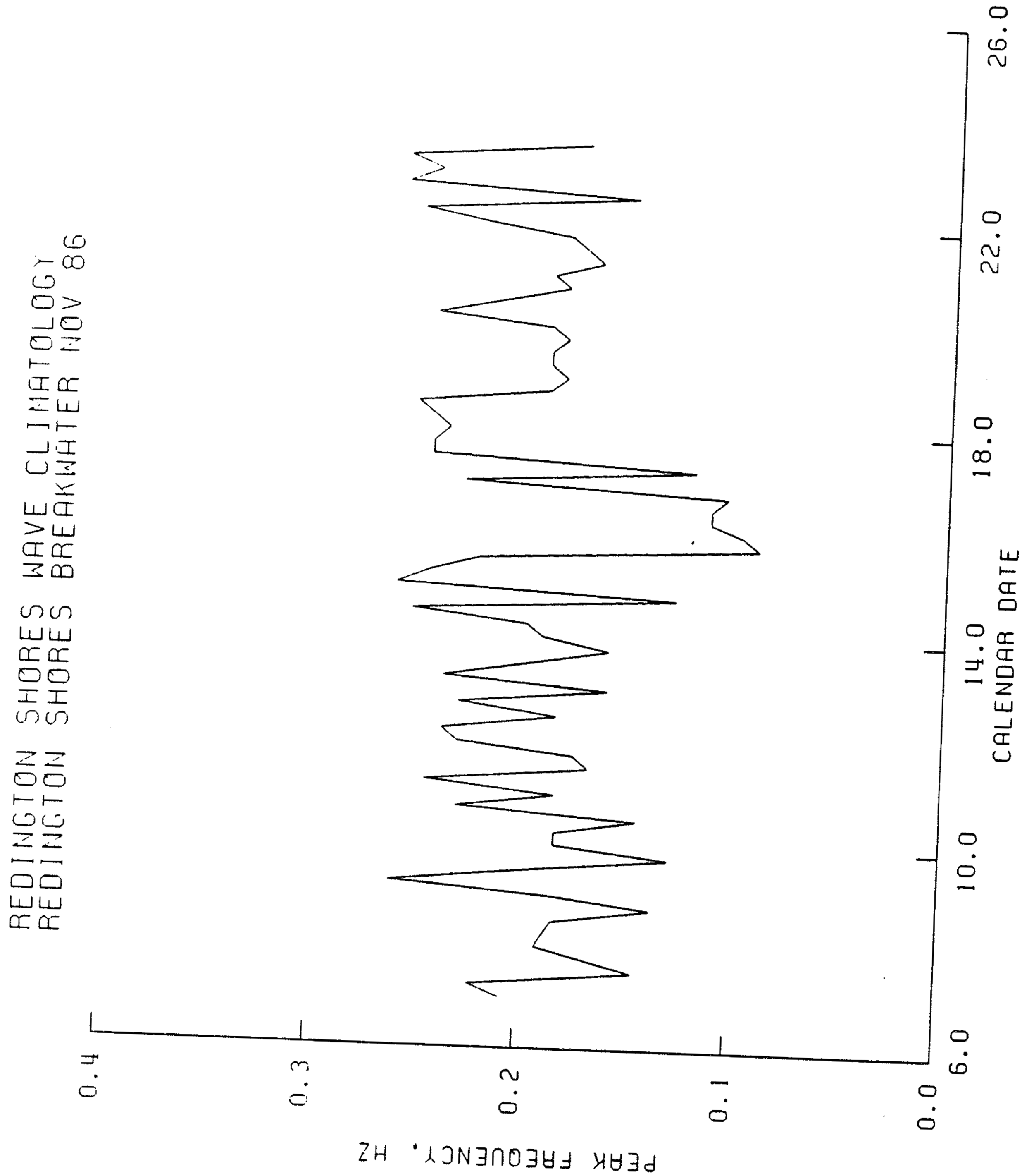

REDINGTON SHORES WAVE CLIMATOLOGY
REDINGTON SHORES BREAKWATER NOV 86
PEAK FREQUENCY, HZ
0.0
0.1
0.2
0.3
0.4
CALENDAR DATE
6.0
10.0
14.0
18.0
22.0
26.0

Figure 23

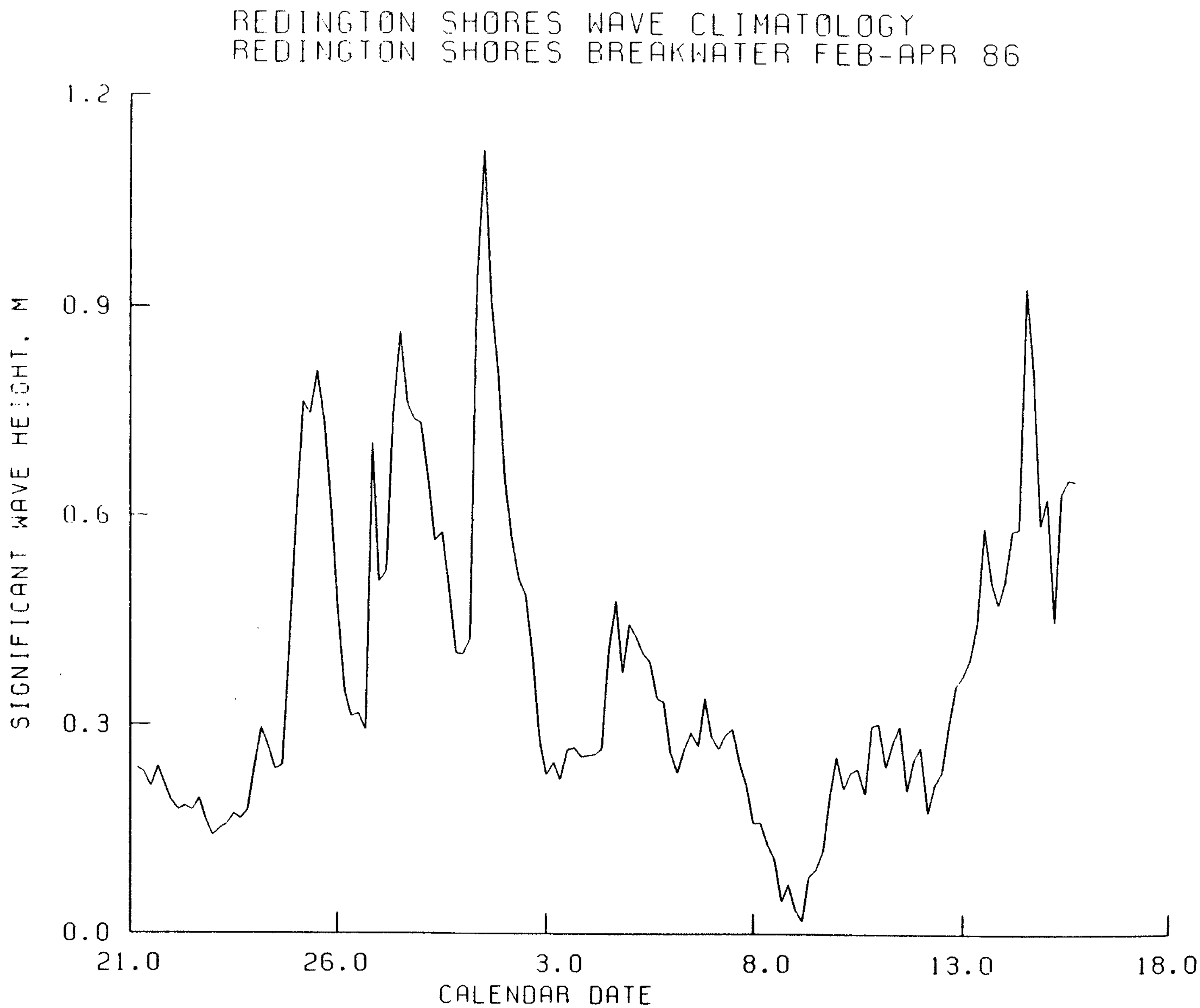

REDINGTON SHORES WAVE CLIMATOLOGY
REDINGTON SHORES BREAKWATER FEB-APR 86
SIGNIFICANT WAVE HEIGHT, M
1.2
0.9
0.6
0.3
0.0
21.0
26.0
3.0
8.0
13.0
18.0
CALENDAR DATE

Figure 24

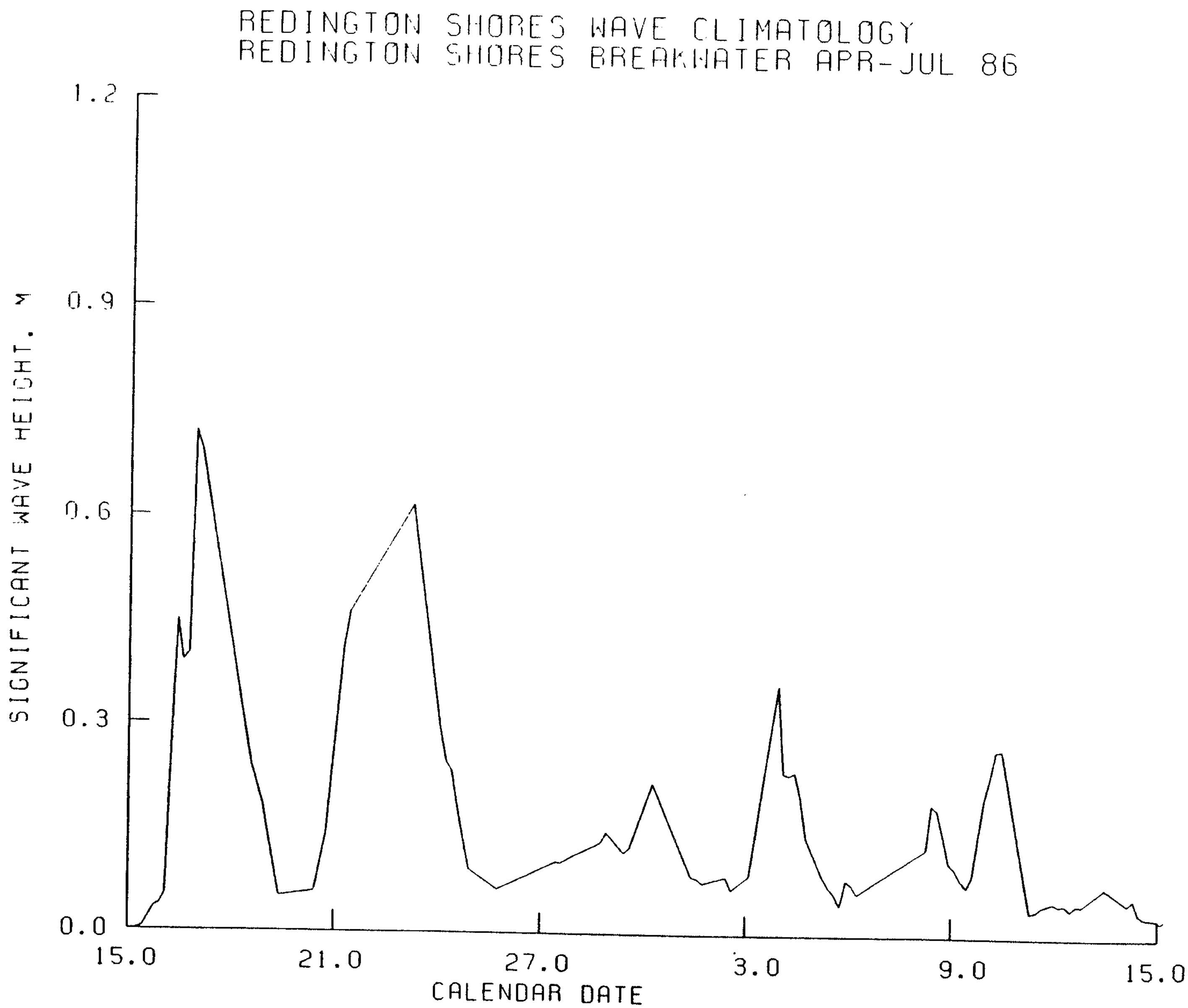

REDINGTON SHORES WAVE CLIMATOLOGY
REDINGTON SHORES BREAKWATER APR-JUL 86
SIGNIFICANT WAVE HEIGHT, M
1.2
0.9
0.6
0.3
0.0
15.0
21.0
27.0
3.0
9.0
15.0
CALENDAR DATE

Figure 25

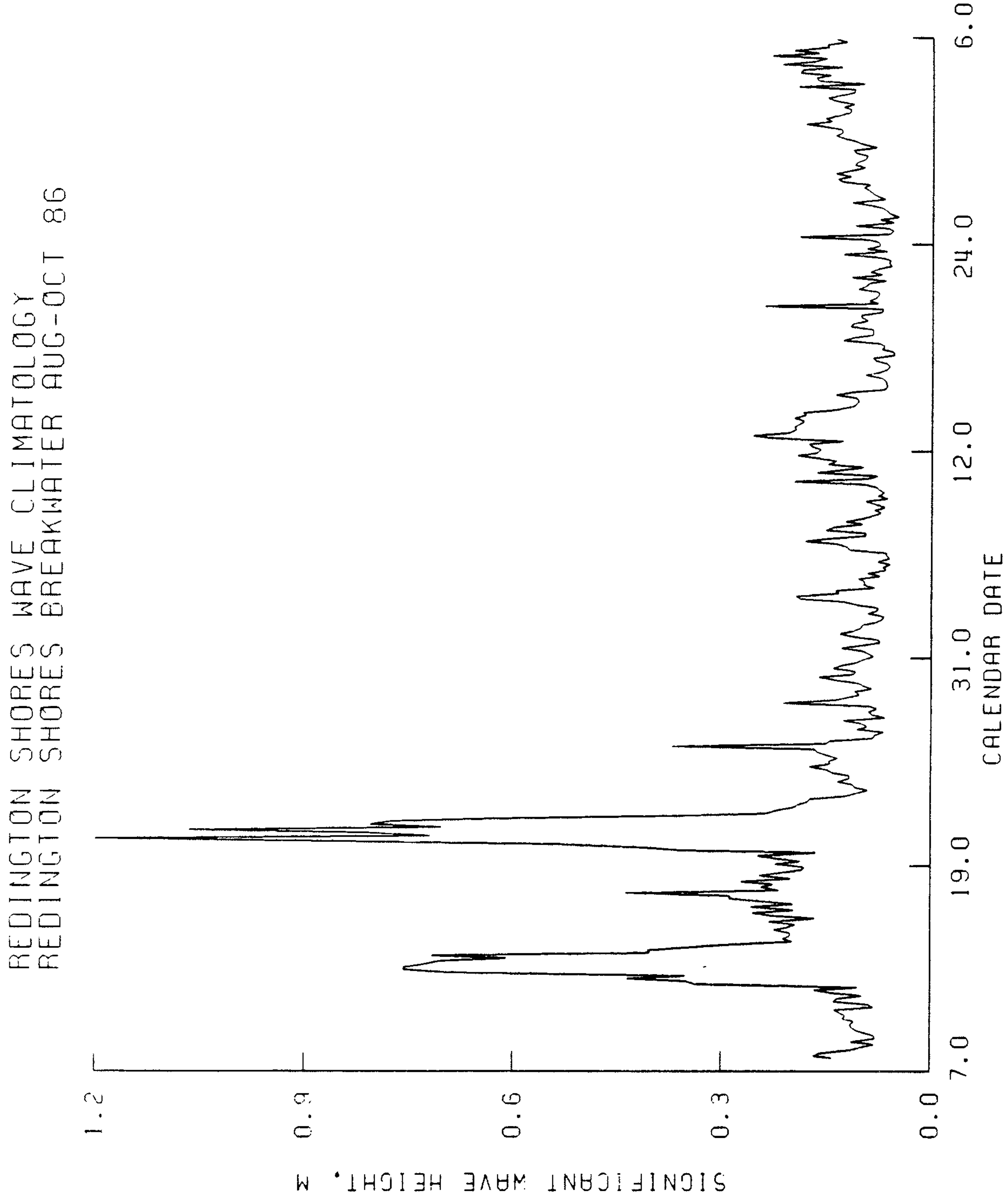

REDINGTON SHORES WAVE CLIMATOLOGY
REDINGTON SHORES BREAKWATER AUG-OCT 86
SIGNIFICANT WAVE HEIGHT, M
1.2
0.9
0.6
0.3
0.0
7.0
19.0
31.0
12.0
24.0
6.0
CALENDAR DATE

Figure 26

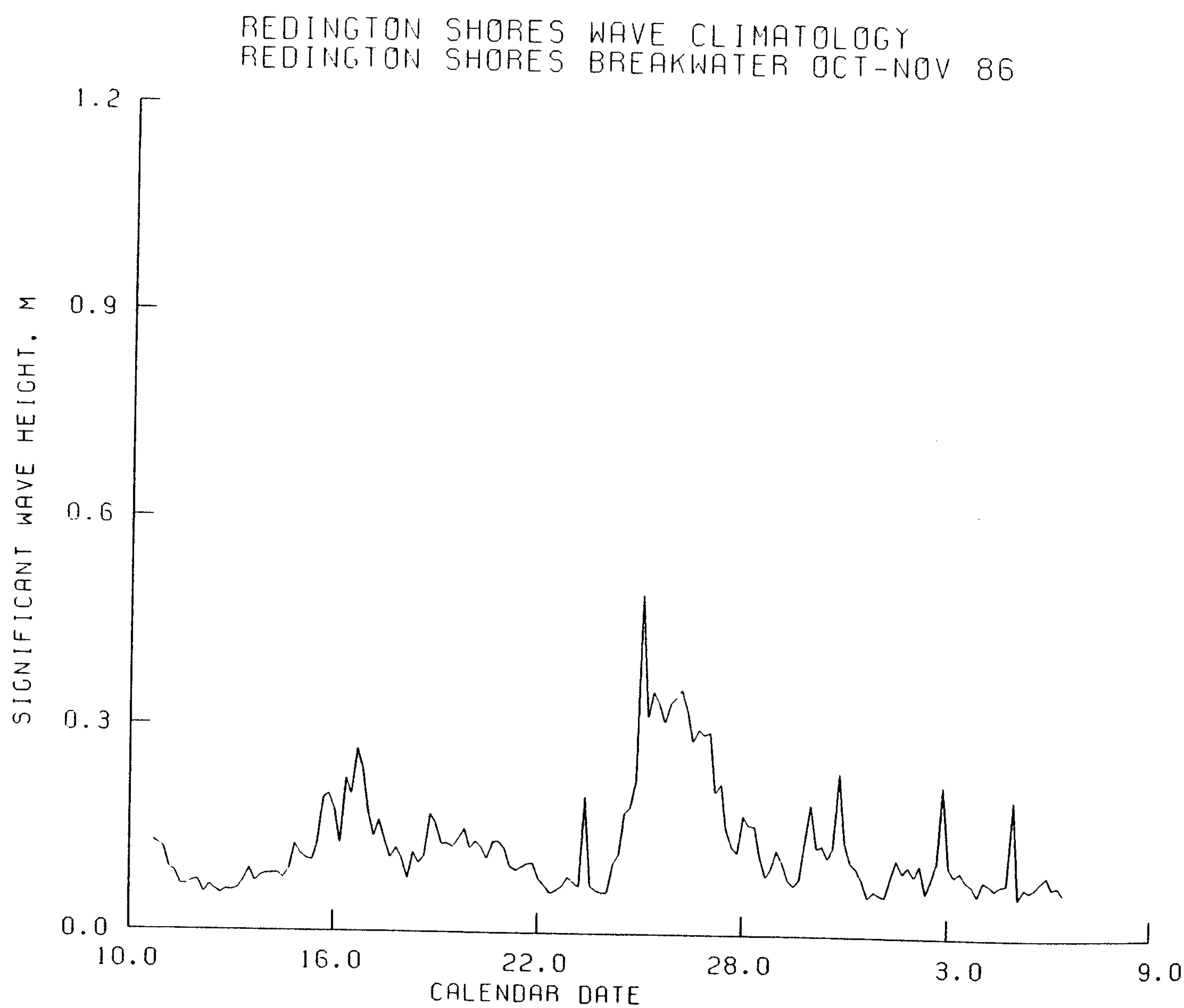

REDINGTON SHORES WAVE CLIMATOLOGY
REDINGTON SHORES BREAKWATER OCT-NOV 86
SIGNIFICANT WAVE HEIGHT, M
1.2
0.9
0.6
0.3
0.0
10.0
16.0
22.0
28.0
3.0
9.0
CALENDAR DATE

Figure 27

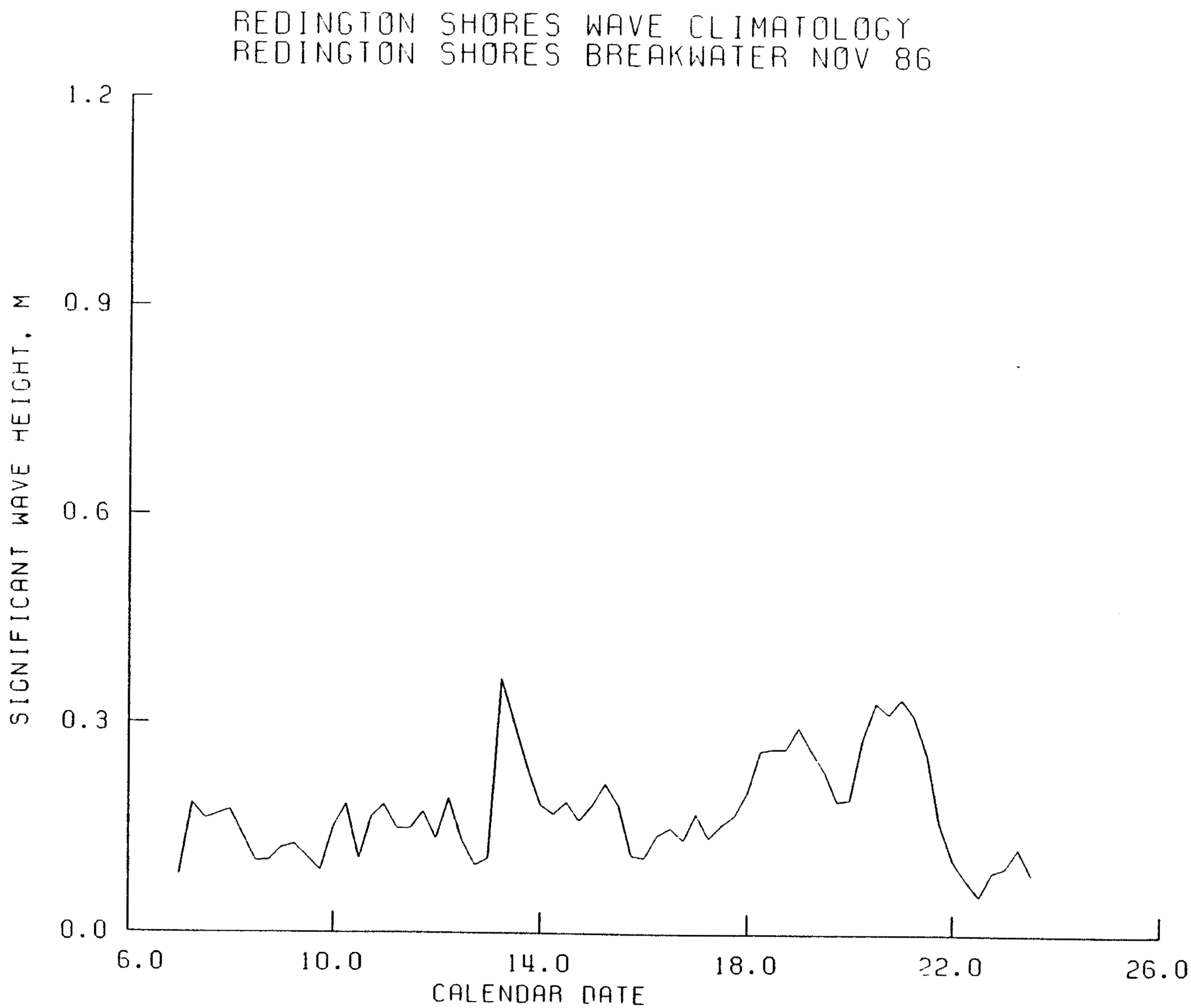

REDINGTON SHORES WAVE CLIMATOLOGY
REDINGTON SHORES BREAKWATER NOV 86
SIGNIFICANT WAVE HEIGHT, M
1.2
0.9
0.6
0.3
0.0
6.0
10.0
14.0
18.0
22.0
26.0
CALENDAR DATE

Figure 28

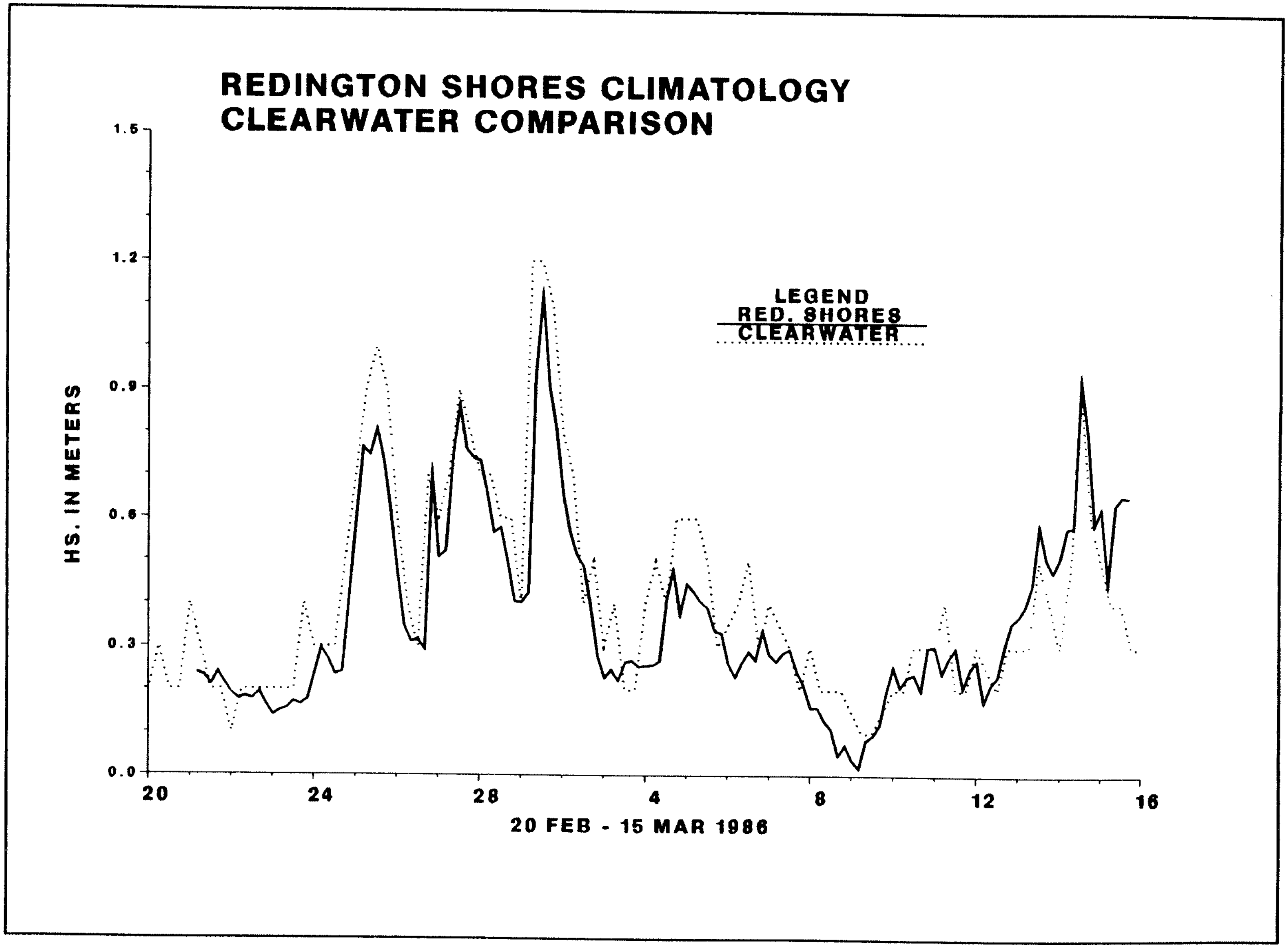

REDINGTON SHORES CLIMATOLOGY
CLEARWATER COMPARISON
LEGEND
RED. SHORES
CLEARWATER
HS. IN METERS
1.5
1.2
0.9
0.6
0.3
0.0
20
24
28
4
8
12
16
20 FEB - 15 MAR 1986

Figure 29

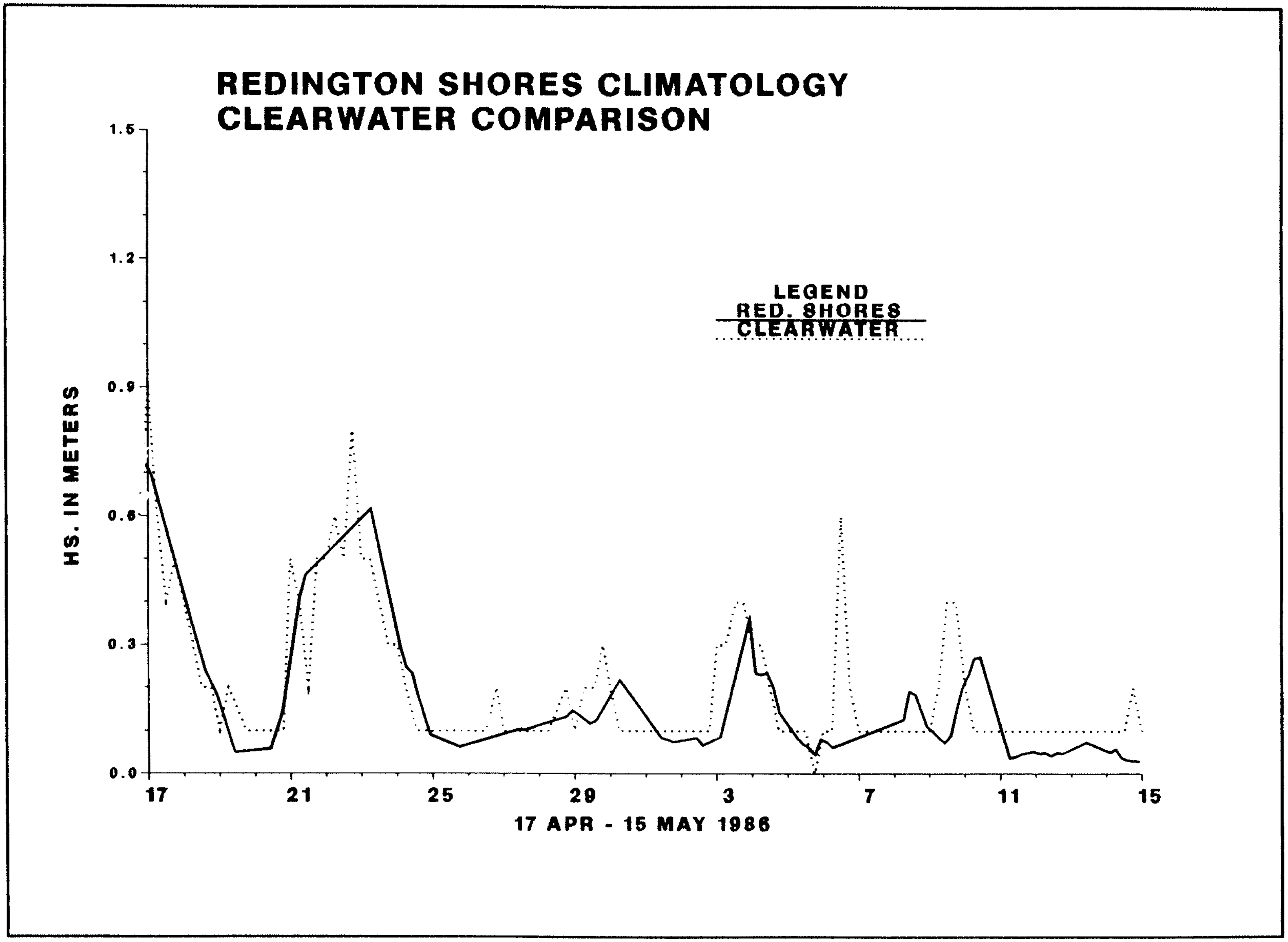

REDINGTON SHORES CLIMATOLOGY
CLEARWATER COMPARISON
HS. IN METERS
1.5
1.2
0.9
0.6
0.3
0.0
LEGEND
RED. SHORES
CLEARWATER
17
21
25
29
3
7
11
15
17 APR - 15 MAY 1986

Figure 30

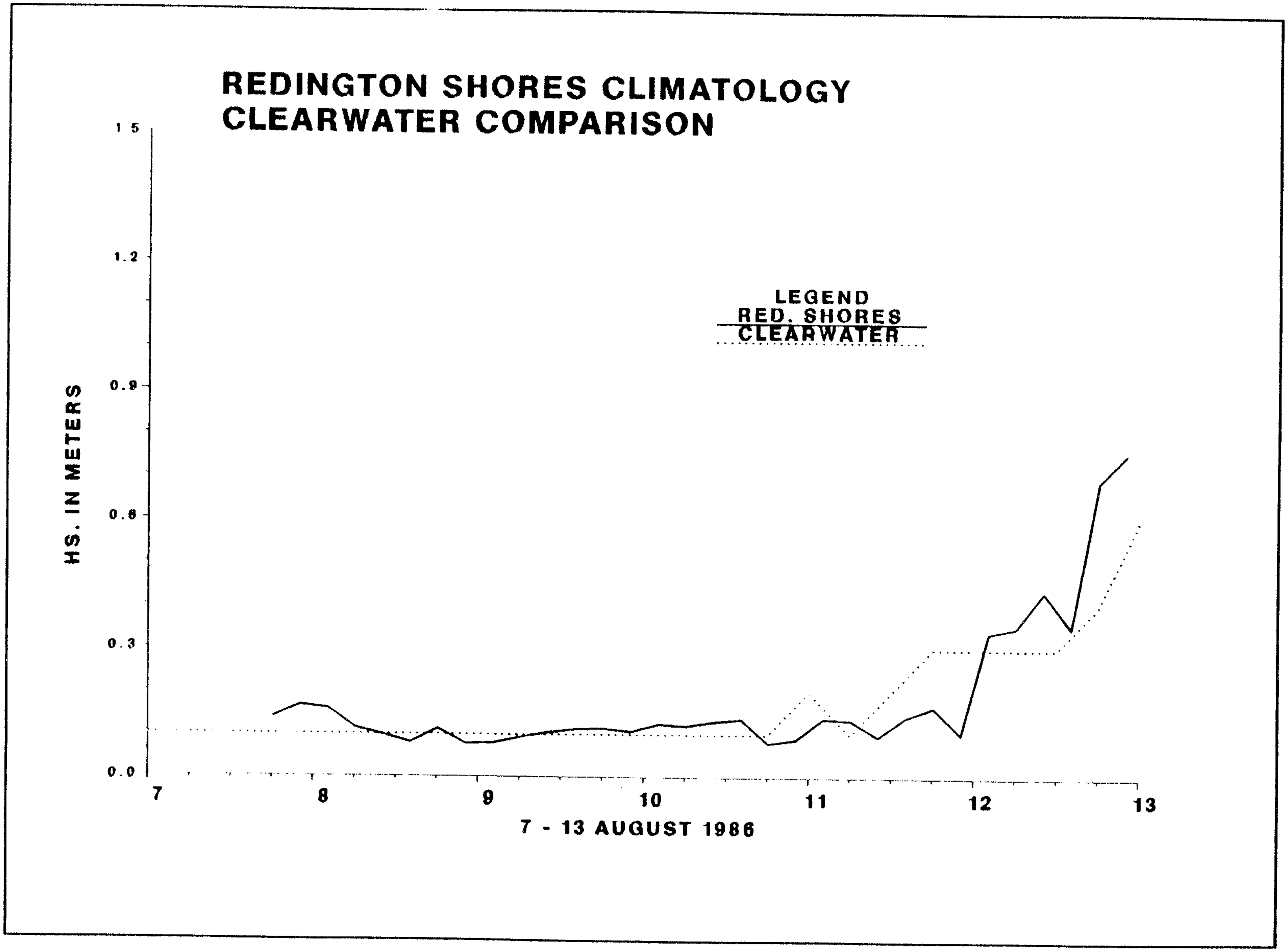

REDINGTON SHORES CLIMATOLOGY
CLEARWATER COMPARISON
LEGEND
RED. SHORES
CLEARWATER
HS. IN METERS
1.5
1.2
0.9
0.6
0.3
0.0
7
8
9
10
11
12
13
7 - 13 AUGUST 1986

Figure 31

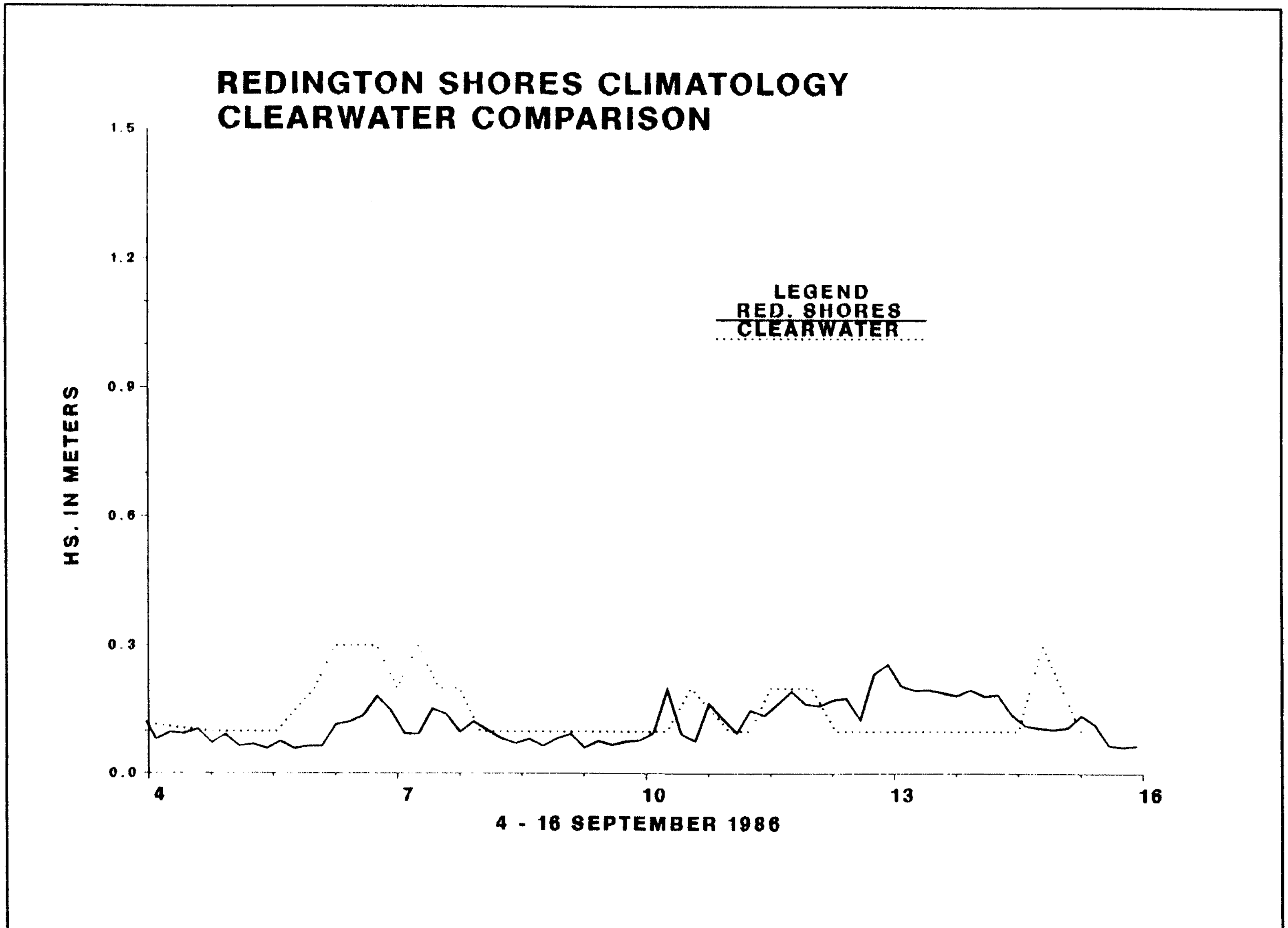

REDINGTON SHORES CLIMATOLOGY
CLEARWATER COMPARISON
LEGEND
RED. SHORES
CLEARWATER
HS. IN METERS
1.5
1.2
0.9
0.6
0.3
0.0
4
7
10
13
16
4 - 16 SEPTEMBER 1986

Figure 32

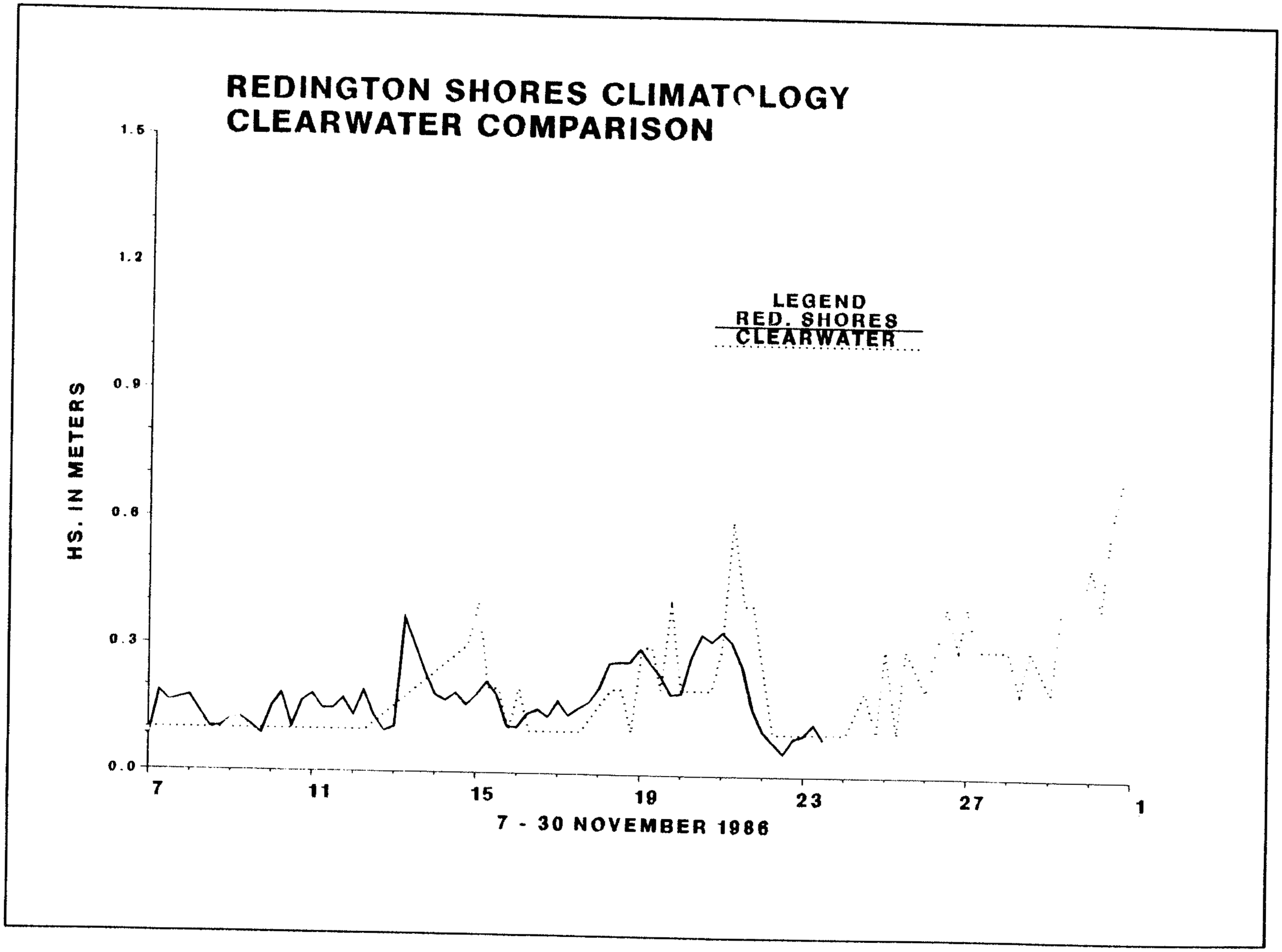

REDINGTON SHORES CLIMATOLOGY
CLEARWATER COMPARISON
LEGEND
RED. SHORES
CLEARWATER
HS. IN METERS
0.0
0.3
0.6
0.9
1.2
1.5
7
11
15
19
23
27
1
7 - 30 NOVEMBER 1986

Figure 33

Conclusions

31. The significant wave heights reported at the University of Florida gage at Clearwater are a good predictor (within ± 0.1 m) of the significant wave heights at Redington Shores.

32. The available directional data from the wave gaging effort indicate that most waves came from the southerly directions from 20 February to 23 November 1986.

33. Longer term data collection is necessary to accurately establish the winter directional wave climatology at Redington Shores.

References

Cartwright, D. E. 1963. "The Use of Directional Spectra in Studying the Output of a Wave Recorder on a Moving Ship," Ocean Wave Spectra, Prentice-Hall Inc., Englewood Cliffs, NJ.

Davis, R. A., Cline, A. C., Belknap, D. F., editors. 1985. "Geology of the Barrier Island and Marsh-Dominated Coast, West-Central Florida," 1985 Annual Meeting and Exposition, Geological Society of America, 119p.

Harris, D. L. 1974. "Finite Spectrum Analyses of Wave Records," Proceedings of the International Symposium on Ocean Wave Measurement and Analysis, American Society of Civil Engineers, Vol 1, pp 107-124.

Jenkins, G. M. and Watts, D. G. 1968. Spectral Analysis and Its Applications, Holden-Day, San Francisco, CA.

Longuet-Higgins, M. S., Cartwright, D. E., and Smith, N. D. 1963. "Observations of the Directional Spectrum of Sea Waves Using the Motions of a Floating Buoy," Ocean Wave Spectra, Prentice-Hall Inc., Englewood Cliffs, NJ.

Bibliography

Dean, J. L., Pope, J. 1987. "The Redington Shores Breakwater Project: Initial Response," Proceedings of the Coastal Sediments '87 Conference, American Society of Civil Engineers, pp 1369-1384.

Terry, J. B., Howard, E. 1986. "Redington Shores Beach Access Breakwater," Shore and Beach, Volume 54, No. 4, pp 7-9.

Weishar, L. L., Briggs, M. J. 1985. "Prototype Data Acquisition Program for a Proposed Dredged Material Offshore Bar, Virginia Beach, VA," MP-CR-85-01, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

University of Florida. 1986. "Wave Data Report (February 1986)," University of Florida, Gainesville, FL, UFL/COEL/DR-86/2.

University of Florida. 1986. "Wave Data Report (March 1986)," University of Florida, Gainesville, FL, UFL/COEL/DR-86/3.

University of Florida. 1986. "Wave Data Report (April 1986)," University of Florida, Gainesville, FL, UFL/COEL/DR-86/4.

University of Florida. 1986. "Wave Data Report (May 1986)," University of Florida, Gainesville, FL, UFL/COEL/DR-86/5.

University of Florida. 1986. "Wave Data Report (August 1986)," University of Florida, Gainesville, FL, UFL/COEL/DR-86/8.

University of Florida. 1986. "Wave Data Report (September 1986)," University of Florida, Gainesville, FL, UFL/COEL/DR-86/9.