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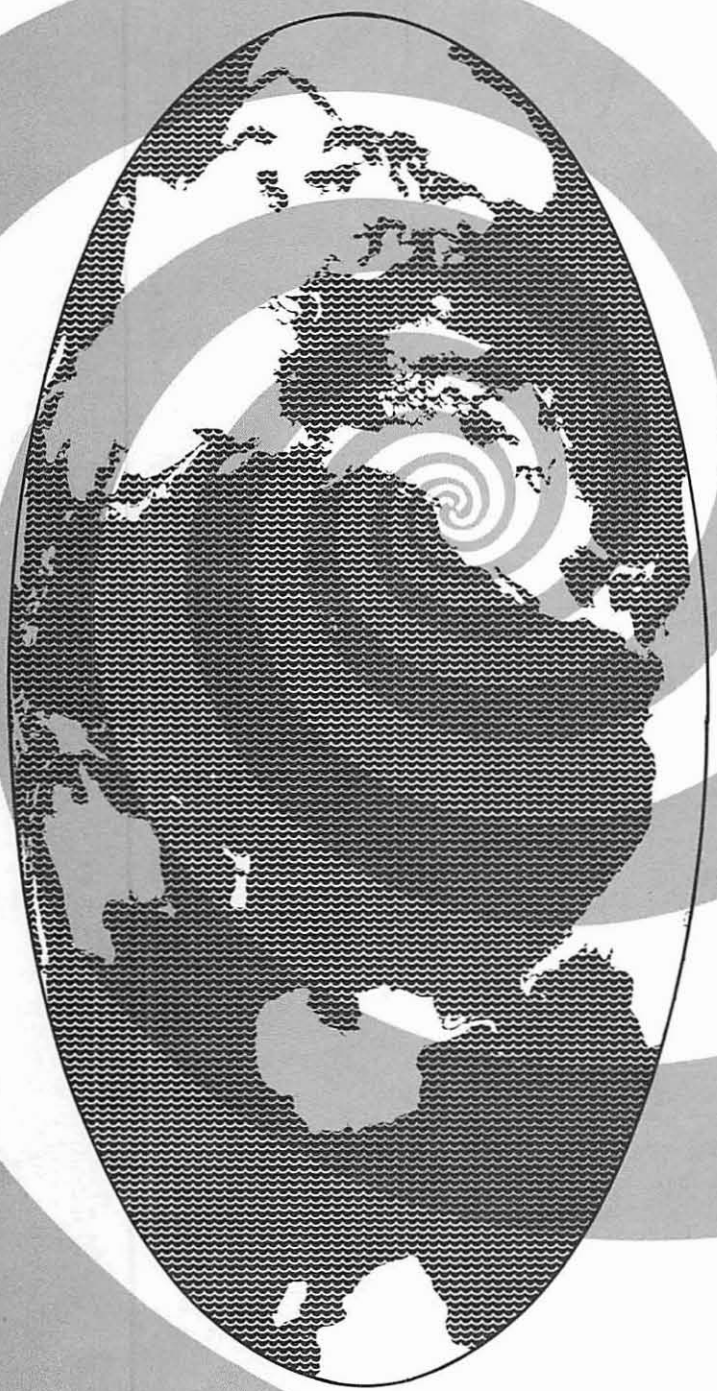

Special Report No. 82

Current Meter Observations in Colvos Passage: Puget Sound, March 1977

by

L. H. Larsen

Nungjane Shi

J. G. Dworski

National Science Foundation
Grant Number OCE77-17660

Reference M77-117
December 1977

seattle, washington 98195

UNIVERSITY OF WASHINGTON
DEPARTMENT OF OCEANOGRAPHY
SEATTLE, WASHINGTON 98195

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CURRENT METER OBSERVATIONS IN COLVOS PASSAGE: PUGET SOUND, MARCH 1977

by

L. H. Larsen

Nungjane Shi

J. G. Dworski

Lawrence H. Larsen
Principal Investigator

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Associate Chairman for Research

REFERENCE M77-119
December 1977

ABSTRACT

Velocity, salinity and temperature data at four depths of Colvos Passage in Central Puget Sound are reported. The observations span 28 days in spring of 1977, with reported measurements at half-hourly intervals. Time series for all variables, spectra and statistics of currents, including banded tidal decomposition, are displayed. The noteworthy dominance of north-setting flow at all depths is highlighted.

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INTRODUCTION

The current meter observations discussed in this report were taken in Colvos Passage, Puget Sound, during February and March of 1977. The mooring was one of eight moorings used in a study of these parts of Puget Sound. One mooring was in the Main Basin of Puget Sound, one was in the East Passage, two were in Dalco Passage, two were in the Tacoma Narrows, and two were in Colvos Passage. One of these latter ones is the subject of the present report. The seven other moorings were deployed by NOAA (PMEL). The purpose of the two moorings in Colvos Passage was to look for currents associated with the intrusion of mixed water into Colvos Passage. This report is preliminary to a joint investigation of the information gathered from the multiple moorings.

As expected we find that the currents almost always flow northward in Colvos Passage. We do note that realizations of southerly flow are more frequent during times of mixed tides. Furthermore, during mixed tide periods the salinity fluctuations are much more diurnal than at other times. This is found even though the magnitude of the semidiurnal tide exceeds by a factor of 4 the diurnal tide currents. The tides are also found to have a strong baroclinic component.

The location of all eight moorings is shown on the chart labeled Figure 1. NOAA's moorings are identified by numbers 1 through 7, and the subject mooring is identified by UW. A more detailed view of its topographic location is presented in Figure 2.

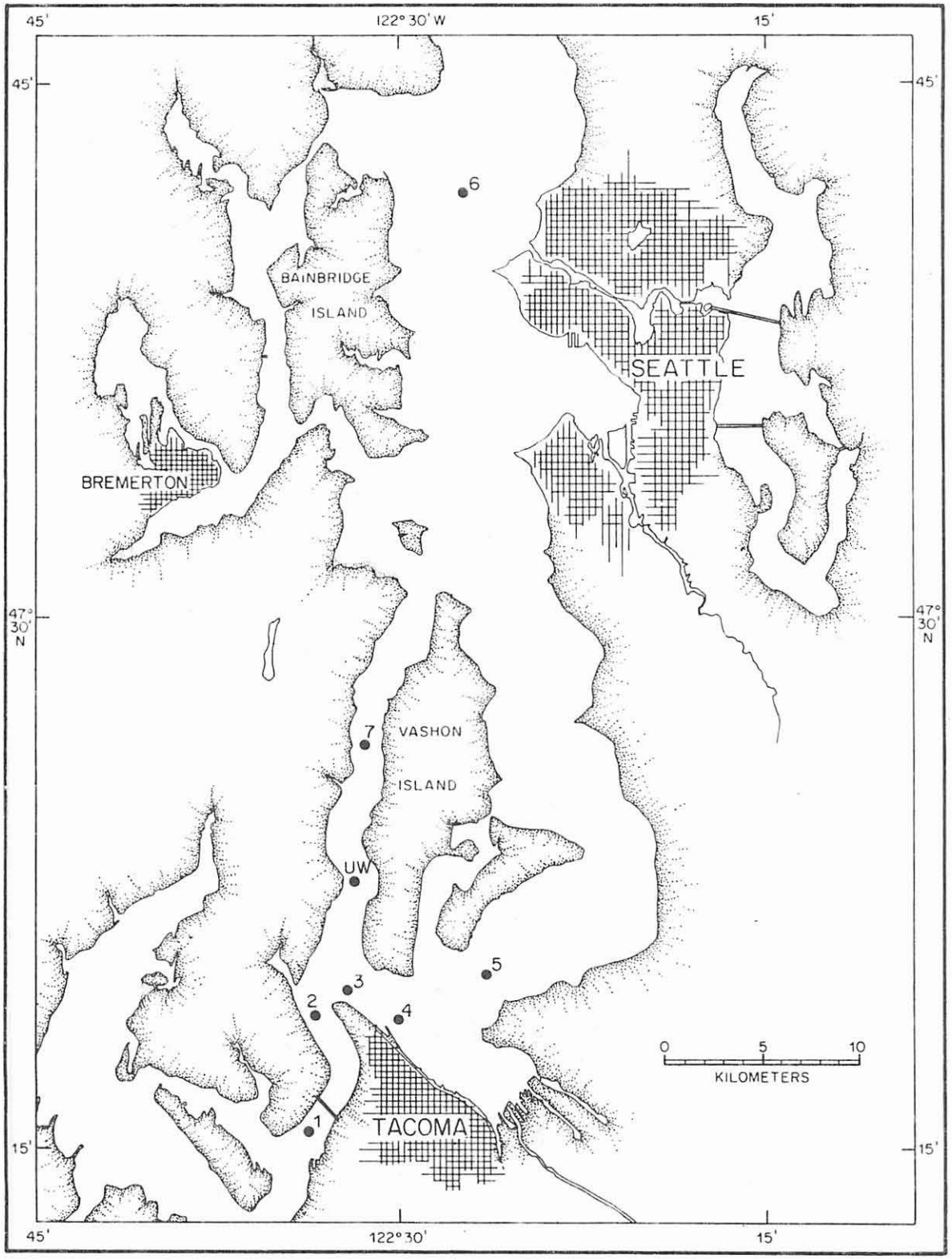

45'
122° 30' W
15'
45'
BAINBRIDGE
ISLAND
SEATTLE
BREMERTON
47° 30' N
VASHON
ISLAND
UW
TACOMA
0 5 10
KILOMETERS
15'
122° 30'

Figure 1

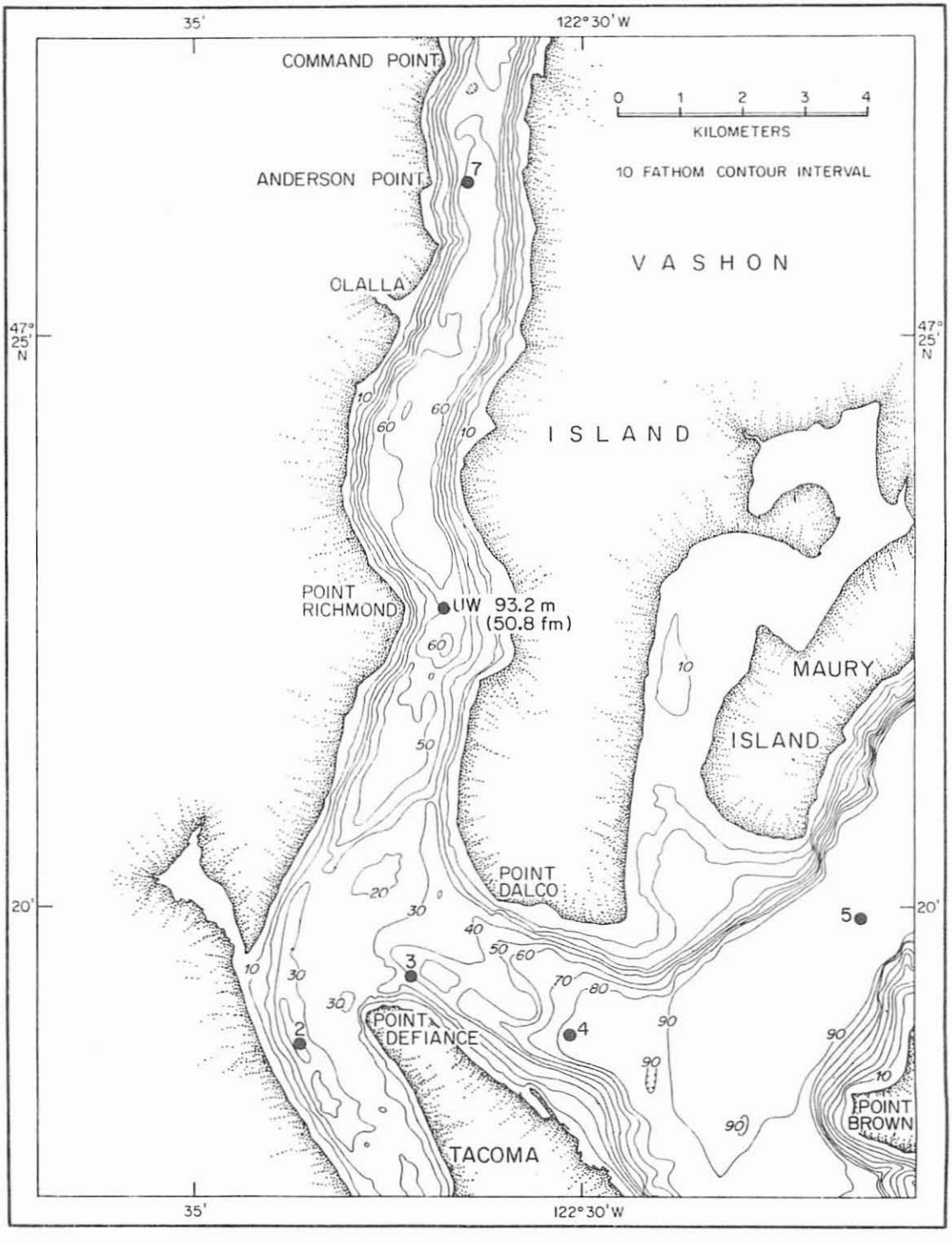

35'
122°30'W
COMMAND POINT
0 1 2 3 4
KILOMETERS
10 FATHOM CONTOUR INTERVAL
ANDERSON POINT
7
VASHON
OLALLA
47° 25' N
ISLAND
POINT RICHMOND
UW 93.2 m (50.8 fm)
MAURY ISLAND
POINT DALCO
20'
5
3
2
4
POINT DEFIANCE
POINT BROWN
TACOMA
35'
122°30'W

Figure 2

DATA REDUCTION AND PRESENTATION

The data discussed in this report were obtained from Aanderaa current meters placed within a taught mooring. The mooring details are illustrated in Figure 3.

Following recovery of the meters the data tapes were duplicated onto thicker 1½ mil tapes and these tapes were read using the PMEL facility at Sand Point. Both channels were read and the best selected for further editing. A listing of data was obtained and bad points corrected. None of the tapes contained worse than .5% error. In most cases errors were handled by averaging preceding and subsequent records. No time base errors were found as calculated on the basis of number of records vs. on-and-off times for each instrument. Edited tapes compatible with the University of Washington CDC computer system were then constructed and utilized in producing this report. The data returned from the current meter located at a depth of 42.8 m was poor and hence is not included in this report.

OBSERVATIONS

The intent of this report is to display the data from individual current meters in a concise fashion that provides basic reference to the data content. In order to accomodate a wide range of possible realizations from an instrument the programs are written in a free format with uniform graph size. The scales are varied to suit the realization.

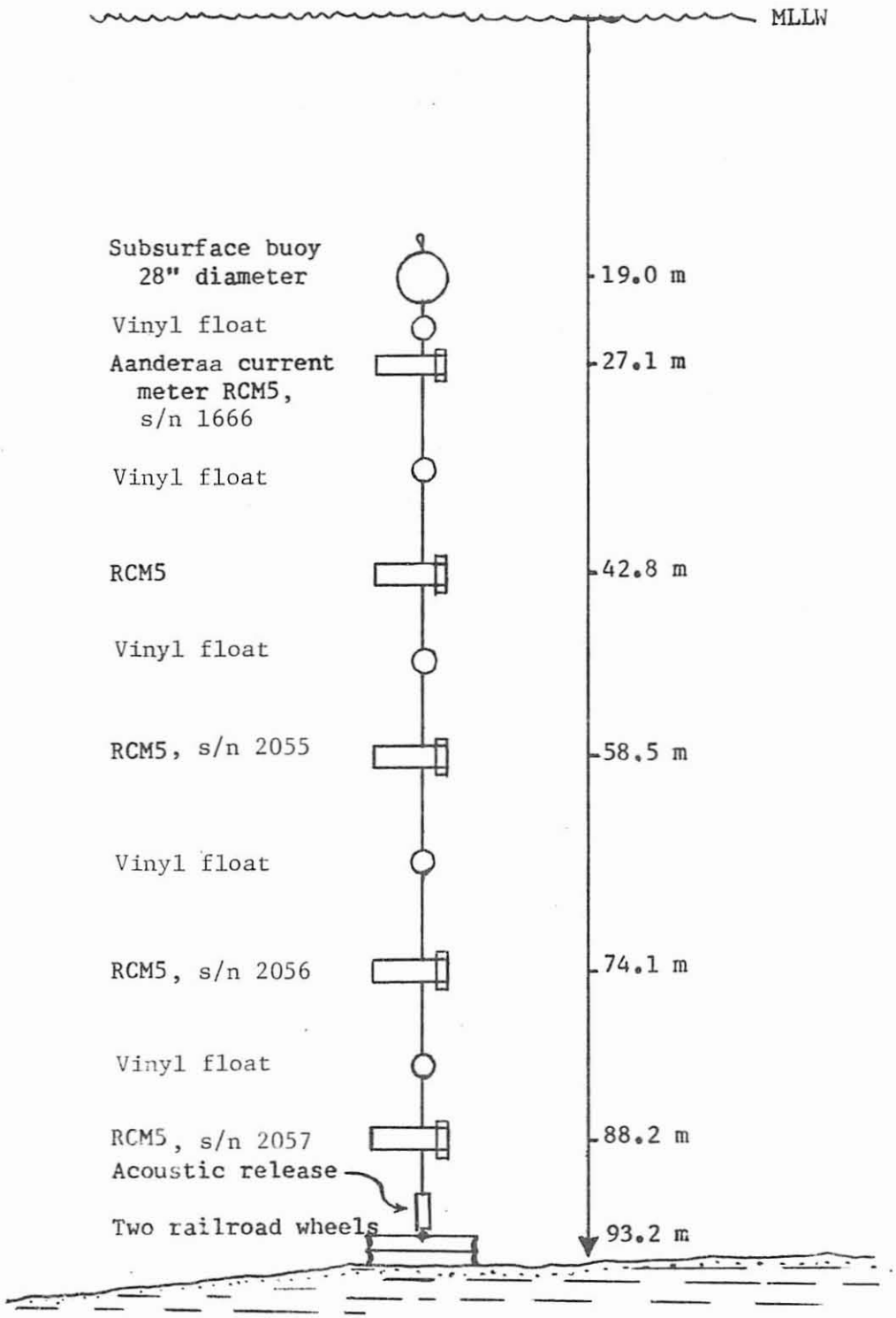

MLLW
Subsurface buoy
28" diameter
19.0 m
Vinyl float
Aanderaa current
meter RCM5,
s/n 1666
27.1 m
Vinyl float
RCM5
42.8 m
Vinyl float
RCM5, s/n 2055
58.5 m
Vinyl float
RCM5, s/n 2056
74.1 m
Vinyl float
RCM5, s/n 2057
88.2 m
Acoustic release
Two railroad wheels
93.2 m

Figure 3

Nine different displays of data are included for each current meter. These are:

A. Basic Statistics of the observations

B. A Scatter Diagram of the individual data points

C. A Progressive vector diagram

D. A time series graph of the data seen through a low pass filter

E. A time series point graph of all of the data

F. The tide ellipse for the semi-diurnal tide

G. The tide ellipse for the diurnal tide

H. A 'smooth' graph of the spectral estimates

I. A 'raw' graph of the spectral estimates

The following guide should be used to interpret each of the displays.

A. Basic Statistics

This page gives the statistics of the west to east velocity, U, the south to north velocity, V, the speed, and the direction.

For the U, V, and speed data we list the data point having the minimal value and the data point having the maximum value. The directions of the maximum and minimum currents are also shown. The mean of any variable is the expected value, denoted $< \ >$, of the entire data set $\{x\}$. The RMS is defined by

$$\sqrt{\mu_2} = \sqrt{< x - \mu >^2} \ ,$$

where μ is the mean of the data. The skewness is defined by

$$\mu_3 = \frac{<x - \mu>^3}{\mu_2^{3/2}} \ ,$$

and the kurtosis is defined

$$\mu_4 = \frac{<x - \mu>^4}{\mu_2^2}$$

Statistics for direction are more complicated because they are defined on a ring and not the real axis. The mean in this case is defined as the mode, that is the most likely direction. The other statistics are centered on this angle. The direction statistics parameters pertain to the distribution on the rectified ring segment of length π, centered on the mean.

Histograms are presented for the speed and direction observations. For speed we show the percent of the data found within 5 cm/s intervals and for direction we show the percent of the observations found within 15 degree intervals.

B. A Scatter Diagram of all Observations

On this diagram we show each individual observation with its U and V component as a dot. An ellipse is then drawn whose center is at the mean velocity and whose major and minor axis are the RMS values of the data in that direction. The major axis is in the direction of maximum variance and the minor axis, necessarily orthogonal, is located in the direction of minimum variance. U and V components could be defined along min-max variance directions but as these directions were practically east and north in the present case, the conventional U, V orientation has been retained.

C. The Progressive Vector Diagram

Progressive vector diagrams were constructed by vector addition of the hourly averaged east and north components of velocity. The plots begin at the origin of the coordinates indicated by 0 and are marked every 24 hours by a +.

The diagrams do not represent real water particle trajectories since the observations were taken at a single point, but they do give an indication of the longer period fluctuations at that point. The scales are adjusted so all progressive vector diagrams fit the same size graph.

D. Low Smoothed Time Series Data

On these diagrams we illustrate the low frequency and tidal behavior of the data. The variables shown are currents, and where applicable temperature, salinity, and depth. We apply a low pass filter, 7 weight (3-hour) binomial, to the data and then illustrate the data by graphing the filtered values. For currents the V axis is chosen to lie northward, the U component is orthogonal and positive eastwards. In the stick diagram currents directed northward are marked with a line normal to the time axis and directed towards the top of the paper.

E. Raw Time Series Data

In some cases it is of interest to examine the type of data removed by the low pass filter. To illustrate this we construct a point plot which shows each data point as a function of time. They are to the same scale as the low passed data, and may be used by overlaying the low passed data to note extreme events.

F. Semi-diurnal Tide Ellipse

This ellipse is constructed for the vector tide velocity of the major tide constituent in the semi-diurnal species. Its orientation is with respect to true north. The arrows on the ellipse indicate the sense of rotation and a line from the center of the ellipse to the ellipse is used to indicate the tide velocity at the reference time for the data set.

In order to construct this ellipse the data is examined to determine the major semi-diurnal constituent, most often the M_2 constituent. The frequency of this constituent is used to determine a record length such that a harmonic of a discrete Fourier transform (DFT) of the data will approximate the desired period. With this choice the DFT will have minimal energy in the periods adjacent to the desired period. For example for

the M_2 tide we choose 1317 points which results in a constituent of period 12.4245283 hours as opposed to the actual tide period of 12.4206012 hours; this is a frequency accuracy of 1 in 3000.

G. Diurnal Tide Ellipse

This ellipse is constructed for the vector tide velocity of the major tide constituent in the diurnal species. It is oriented with respect to true north-south coordinates. The arrows on the ellipse indicate the sense of rotation and a line from the center of the ellipse to the ellipse is used to indicate the tide velocity at the reference time for the data set. Its calculation is similar to that used for semi-diurnal tides. We chose a data set of 1296 points for which a harmonic of a DFT has a period of 24.0 hours; although not as good as the M_2 calculation, it is an acceptable approximation to the dominant diurnal constituent, K_1, whose actual period is 23.9344697 hours.

H. Smoothed Spectra

This depiction of the observed spectra is based on applying the DFT to 1024 of the data points. The estimates are smoothed by averaging adjacent spectral estimates, with greater averaging at higher frequencies. The confidence intervals for each averaging band are calculated on the basis of the Chi-square distribution statistics and are shown for 95% confidence limits for a given estimate.

J. Partially Smoothed Spectra

The difference between this spectra and the previous is that the smoothing is restricted to frequencies larger than that of the sixth-diurnal tide. The 95% confidence intervals are shown in the upper right hand corner of each spectra.

SPECIFIC OBSERVATIONS RELATING TO COLVOS PASSAGE

TIDES

The reference station for this data is Seattle. The data indicate the presence of strong baroclinic tides at both the semi-diurnal and diurnal periods. The following table gives the time of slack water following flood relative to high water in Seattle.

Depth	Time of slack following high water	Max Current
	Semi-Diurnal Tide	
27.1 m	1.59 hrs	27.0 cm/s
58.5 m	1.37 hrs	31.3 cm/s
74.1 m	1.25 hrs	32.0 cm/s
88.2 m	1.16 hrs	28.8 cm/s
	Diurnal Tide	
27.1 m	2.84 hrs	7.9 cm/s
58.5 m	1.48 hrs	7.4 cm/s
74.1 m	1.04 hrs	7.1 cm/s
88.2 m	.85 hrs	6.8 cm/s

For each of these constituents the phase at depth leads that at the surface. The amplitude of tide is greatest at mid-depth for the semi-diurnal tide and greatest near the surface for the diurnal tide.

MEAN FLOW CONDITIONS

The flow in Colvos Passage is directed northward most of the time at all depths. Occasions of southerly flow are infrequent near the surface. The frequency and intensity of southerly flow observations increase with sensor depth. Although the statistical sample is small, southerly flow appears to occur more frequently when the moon's zenith is removed from the equator; that is, during periods of mixed tides. Although the currents associated with the diurnal tides are much smaller than those of the semidiurnal tides

the salinity appears to go from a predominately semidiurnal structure when diurnal tides are weak to a diurnal structure when diurnal tides are large. This is noticable at all depths.

ACKNOWLEDGEMENTS

This work was supported by the National Science Foundation under Grant OCE77-17660. Dr. Glenn A. Cannon of NOAA (PMEL) was the principal investigator for NOAA's contribution to the joint investigation and furnished NOAA's reference data shown in Figure 1.

DATA SET A

CURRENT METER 1666, LOCATED AT DEPTH 27.1 m

COLVOS PASSAGE, PUGET SOUND

47-22-20 N, 122-31-42 W

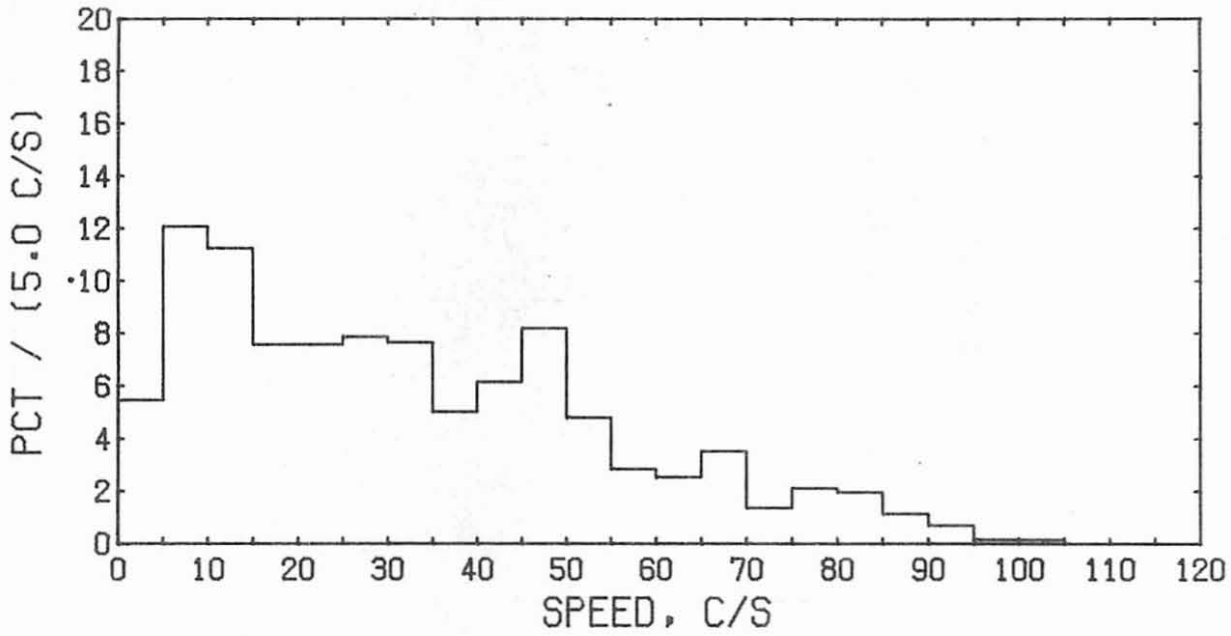
METER S/N 1666, SENSOR AT 27.1 M, BOTTOM AT 93.2 M

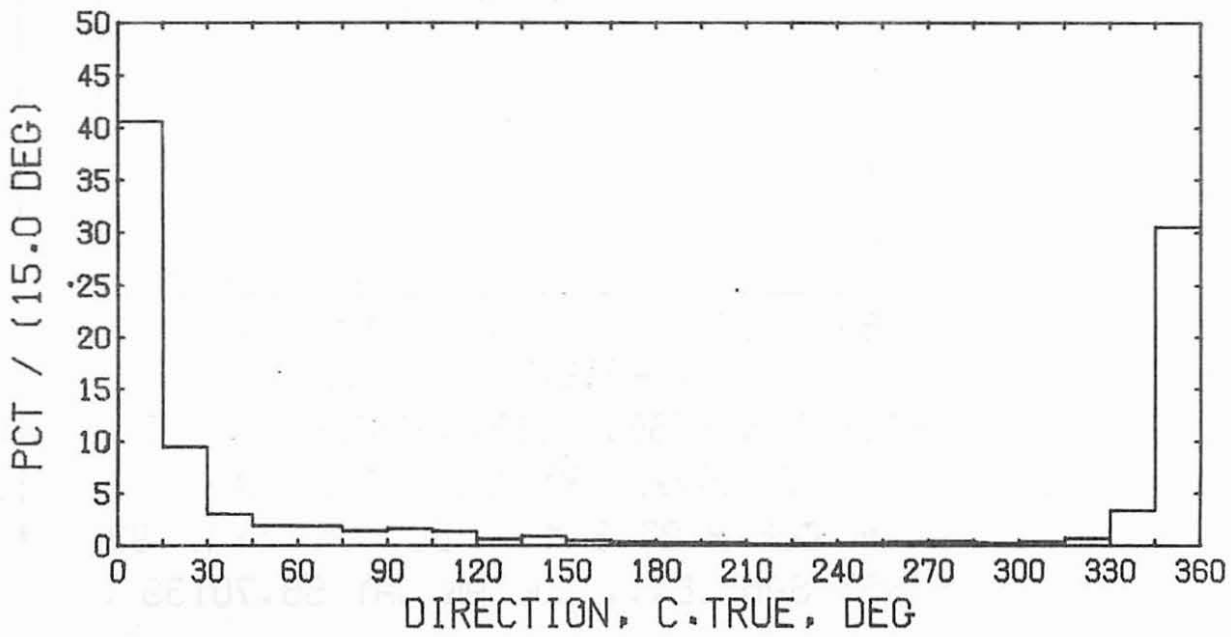
STARTING JUL.DAY 56.70139 (PST), 1977

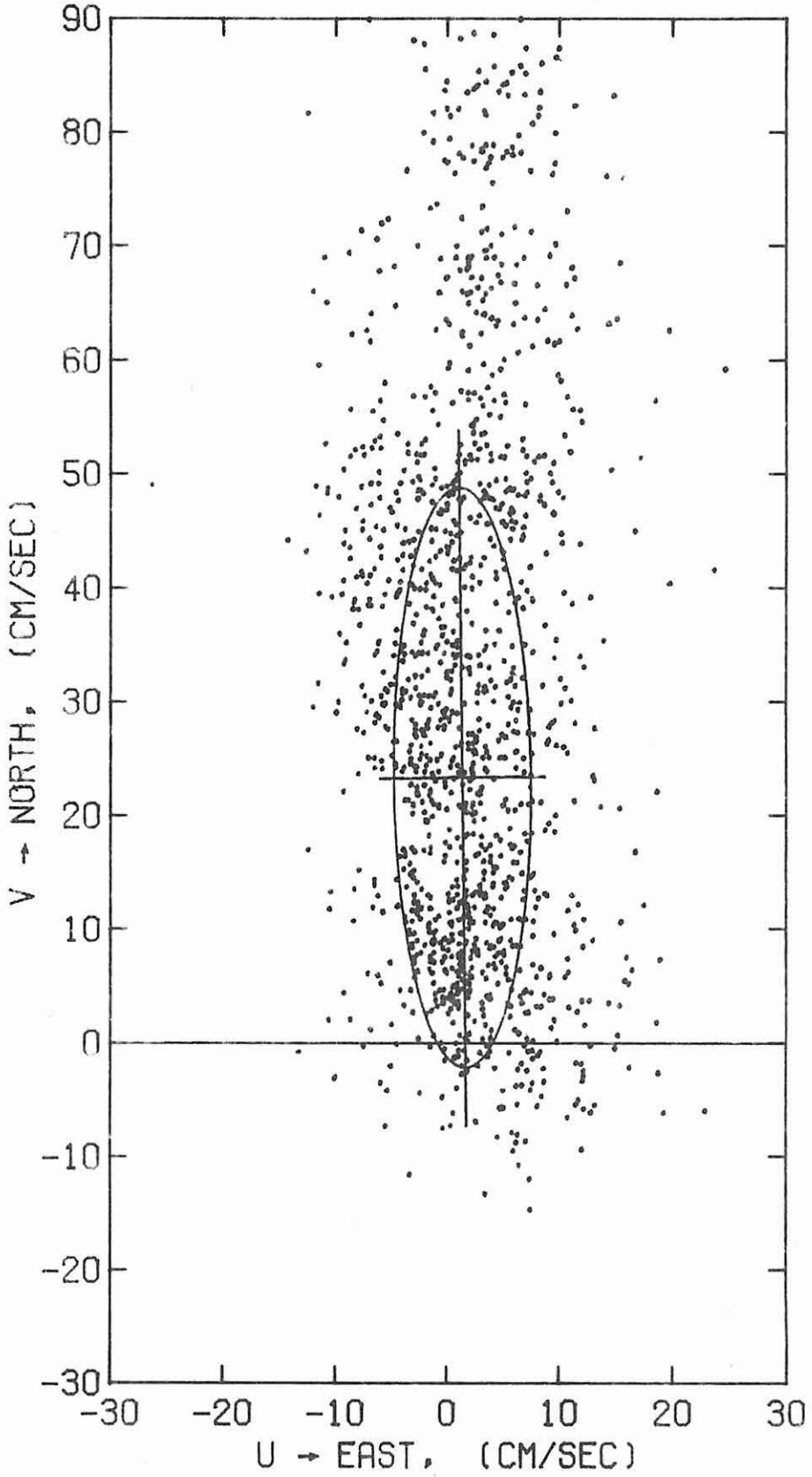
1334 SAMPLES AT DT = 0.5 HR

D E S C R I P T I V E S T A T I S T I C S

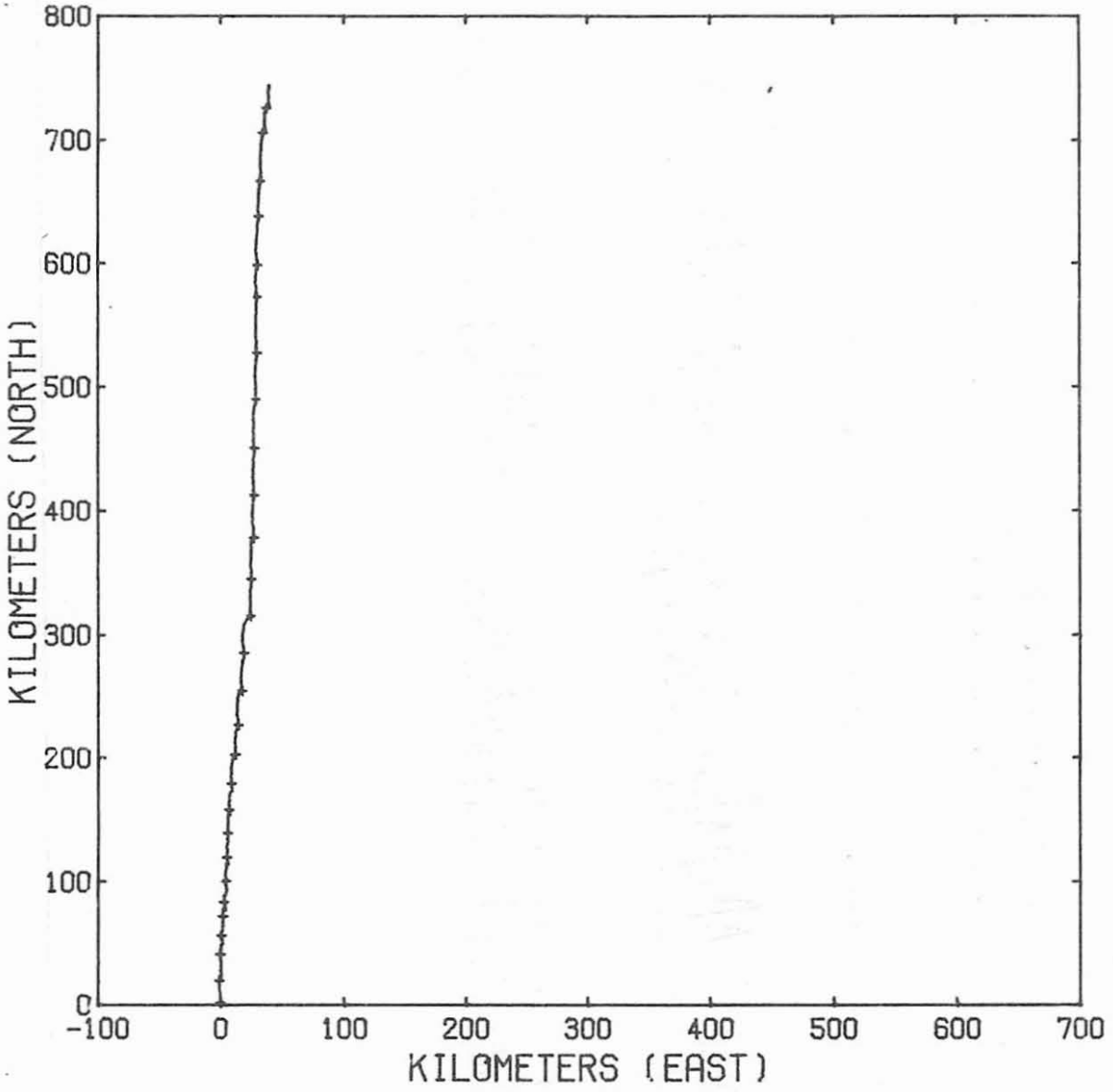
	PT	MIN	PT	MAX	MEAN	RMS	SKEW	CURT
U - COMP.	1	-26.4	350	34.4	1.8	5.8	.365	4.678
V - COMP.	830	-14.6	520	104.8	31.2	24.0	.536	2.579
SPEED	603	.5	520	104.8	32.8	22.6	.695	2.690
DIRECTION	603	204.3	520	359.7	3.1	12.5	.473	4.474







METER S/N 1666, 1334 SAMPLES AT DT = 0.5 HRS,
COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
SENSOR DEPTH 27.3 M. BOTTOM DEPTH 93.2 M.
TIME OF FIRST SAMPLE... JULIAN DAY 56.70139 (PST), 1977.



PROGRESSIVE VECTOR DIAGRAM

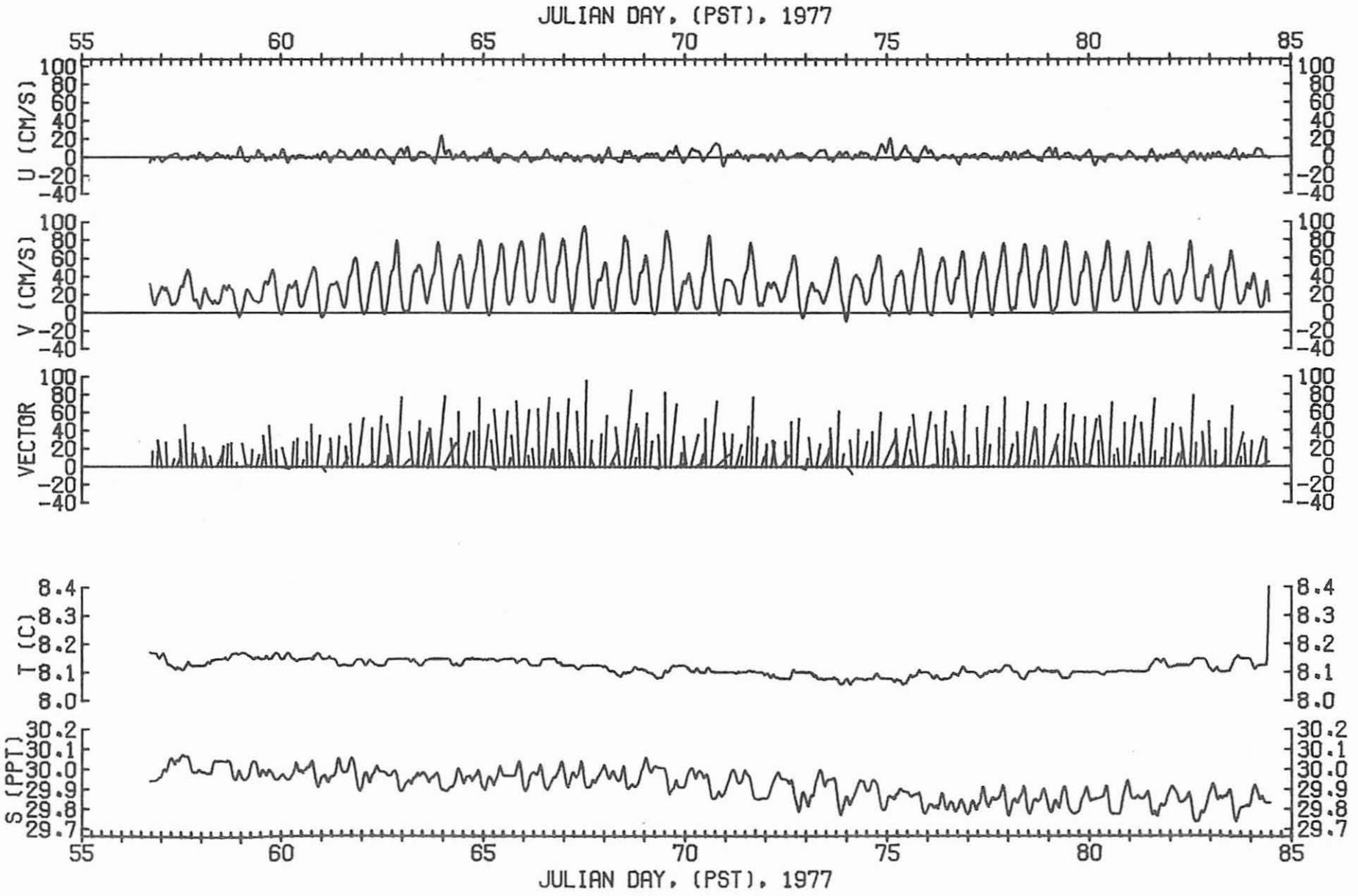
NUMBER OF POINTS = 667, SPACED AT DT = 1.000 HRS.
(EVERY 24-TH POINT IS TAGGED BY A +)

COLVOS PASSAGE, PUGET SOUND

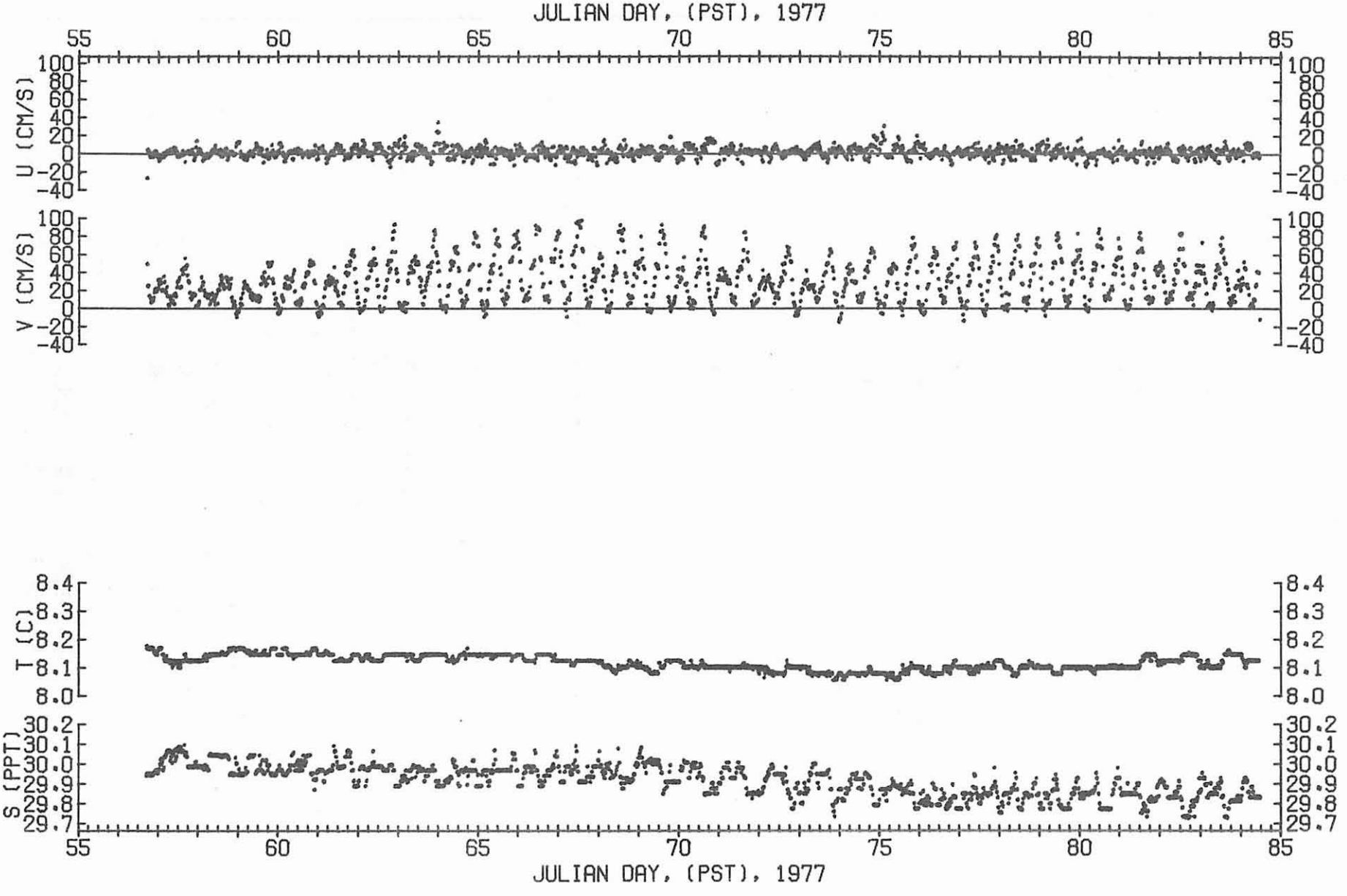
47-22-20 N, 122-31-42 W

METER S/N 1666, SENSOR AT 27.1 M, BOTTOM AT 93.2 M

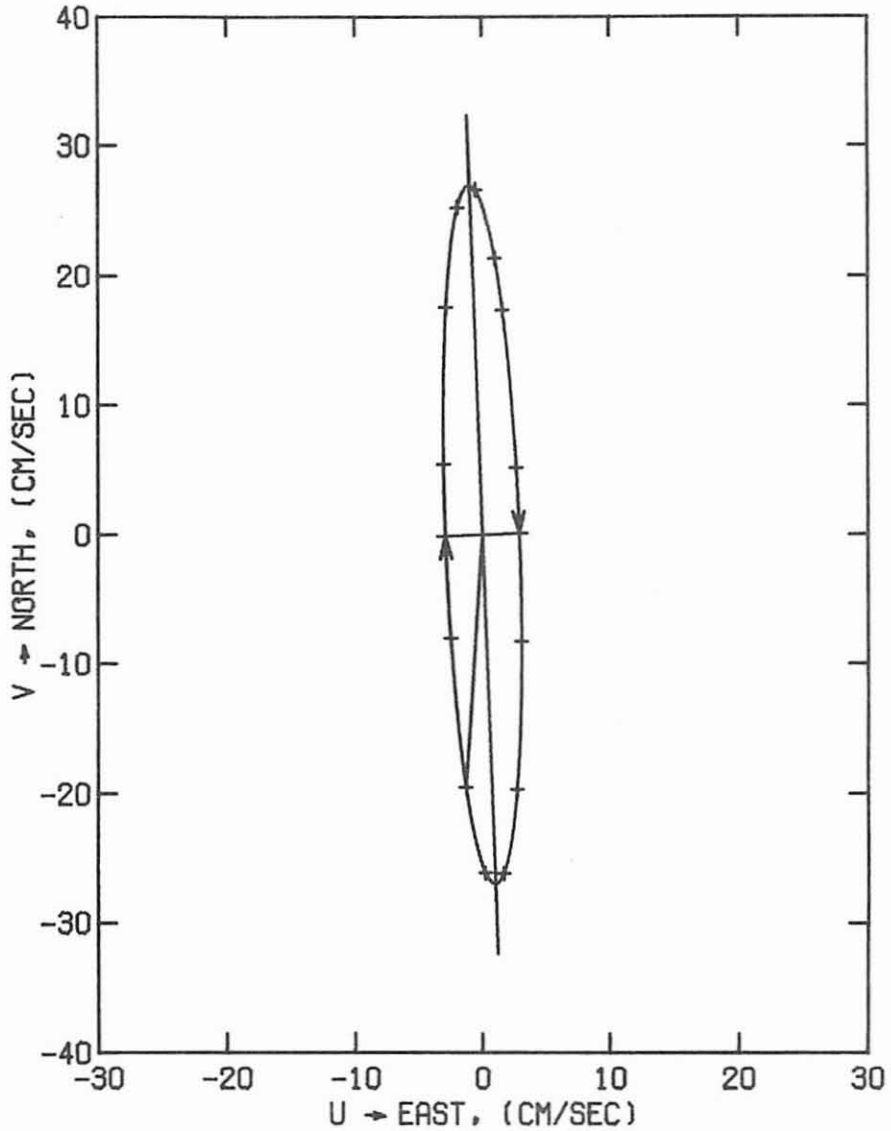
STARTING JUL.DAY 56.70139 (PST), 1977



METER S/N 1666, SENSOR AT 27.1 M.



METER S/N 1666, SENSOR AT 27.1 M.



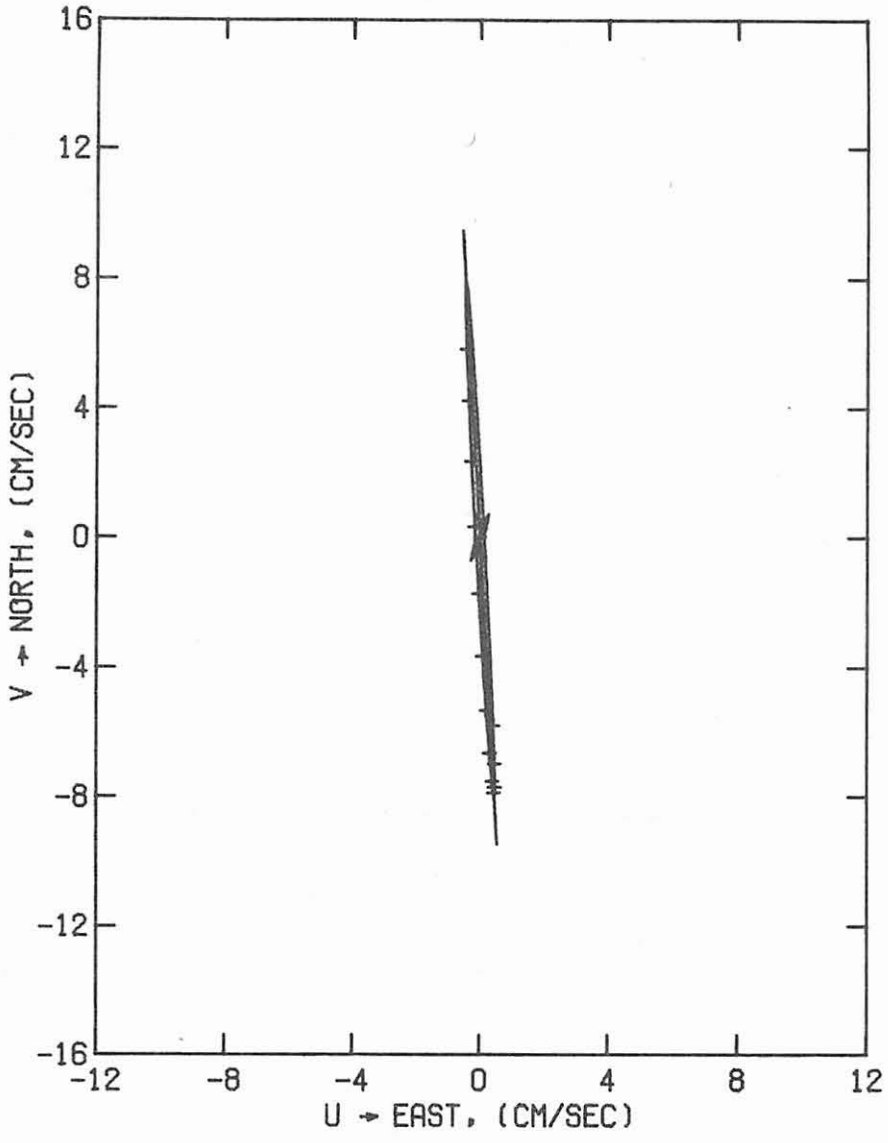
ELLIPSE FOR TIDAL CURRENT OF PERIOD 12.4245283 HRS

REFERENCE IS HIGH WATER TIME OF SURFACE CONSTITUENT
AT SEATTLE, WITH PERIOD OF 12.4206012 HRS
CURRENT AT REF.TIME IS SHOWN BY RADIAL LINE
DIRECTIONS LISTED ARE COMPASS (TRUE)

SEQUENTIAL EXTREMA ...

MIN. CURRENT	2.9 CM/S, AT	4.62 HRS	BEFORE REF.,	SETTING	88 DEG.
MAX. CURRENT	27.0 CM/S, AT	1.52 HRS	BEFORE REF.,	SETTING	178 DEG.
MIN. CURRENT	2.9 CM/S, AT	1.59 HRS	AFTER REF.,	SETTING	268 DEG.
MAX. CURRENT	27.0 CM/S, AT	4.69 HRS	AFTER REF.,	SETTING	358 DEG.

METER S/N 1666, AT 27.1 M, BOTTOM AT 93.2 M.
COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
667 HR SERIES STARTING JUL.DAY 50.70139 (PST), 1977.



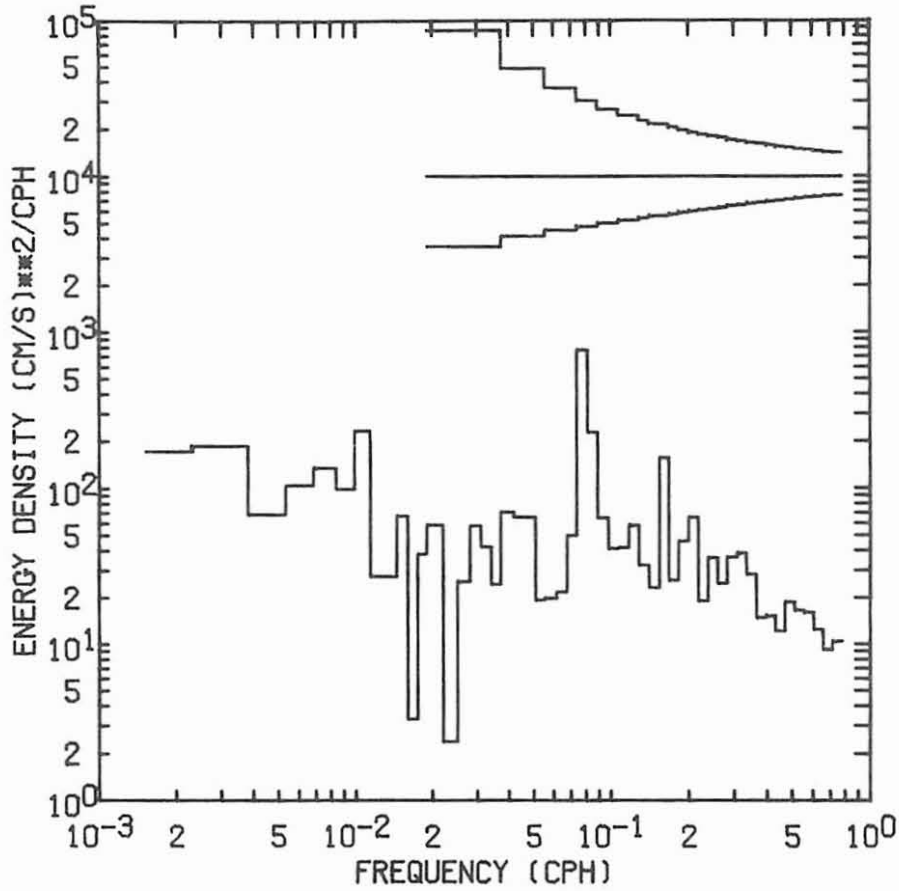
ELLIPSE FOR TIDAL CURRENT OF PERIOD 24.0000000 HRS

REFERENCE IS HIGH WATER TIME OF SURFACE CONSTITUENT
AT SEATTLE, WITH PERIOD OF 23.9344697 HRS
CURRENT AT REF.TIME IS SHOWN BY RADIAL LINE
DIRECTIONS LISTED ARE COMPASS (TRUE)

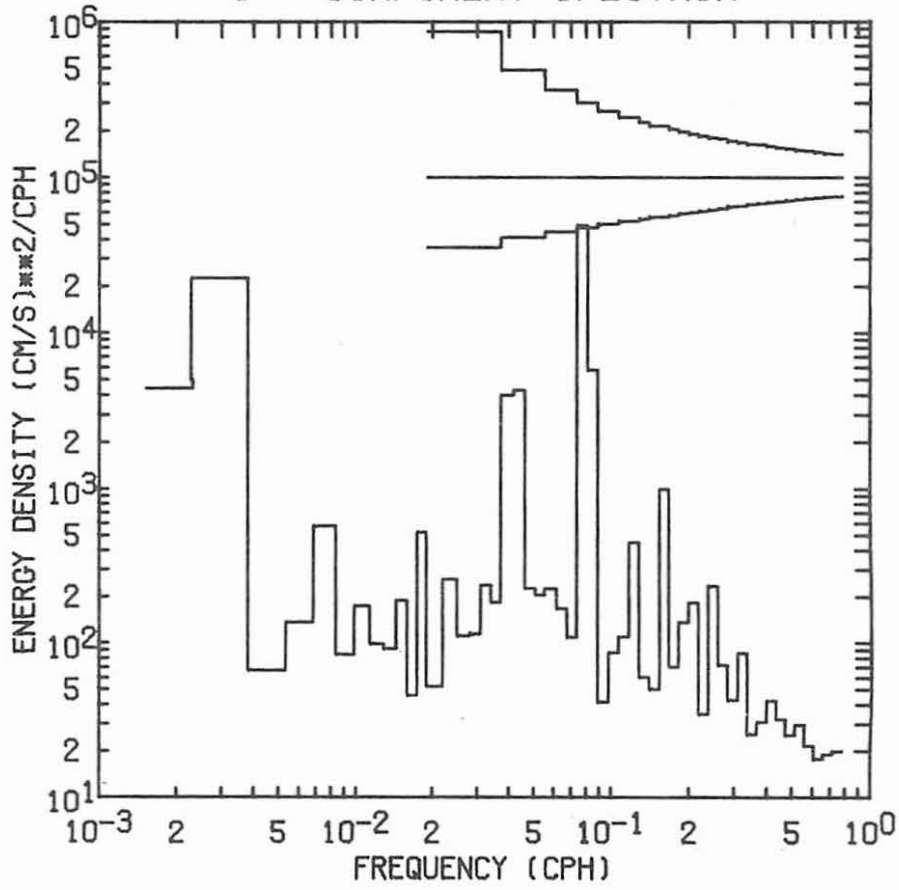
SEQUENTIAL EXTREMA ...

MIN. CURRENT	.1 CM/S, AT	9.16 HRS	BEFORE REF.,	SETTING	87 DEG.
MAX. CURRENT	7.9 CM/S, AT	3.16 HRS	BEFORE REF.,	SETTING	177 DEG.
MIN. CURRENT	.1 CM/S, AT	2.84 HRS	AFTER REF.,	SETTING	267 DEG.
MAX. CURRENT	7.9 CM/S, AT	8.84 HRS	AFTER REF.,	SETTING	357 DEG.

METER S/N 1666, AT 27.1 M, BOTTOM AT 93.2 M.
COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
667 HR SERIES STARTING JUL.DAY 50.70139 (PST), 1977.



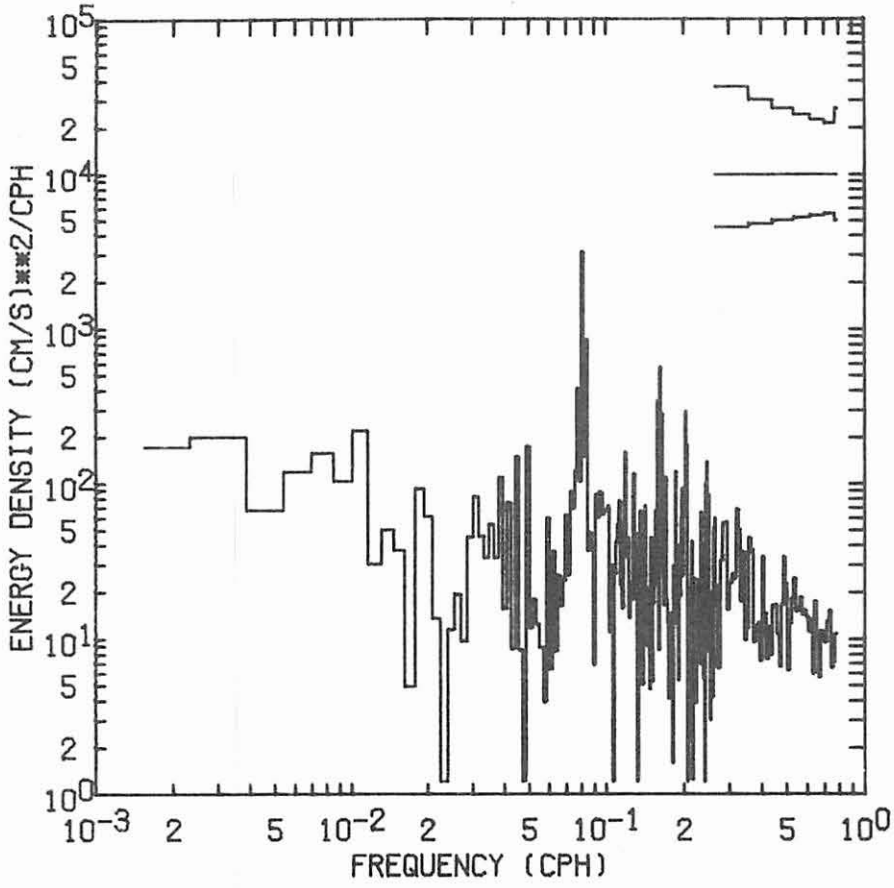
U - COMPONENT SPECTRUM



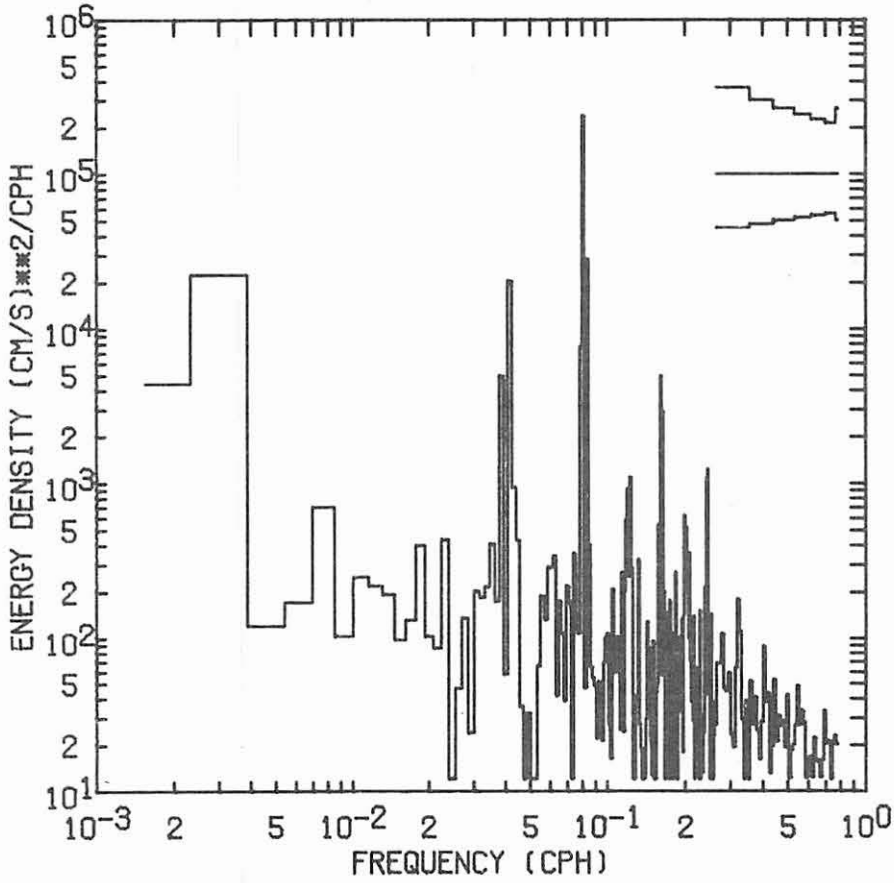
V - COMPONENT SPECTRUM

METER S/N 1666, AT DEPTH 27.1 (M)

STARTING TIME 56.70139 JUL.DAY (PST) 1977



U - COMPONENT SPECTRUM



V - COMPONENT SPECTRUM

METER S/N 1666, AT DEPTH 27.1 (M)

STARTING TIME 56.70139 JUL.DAY (PST) 1977

DATA SET B

CURRENT METER 2055, LOCATED AT DEPTH 58.5 m

COLVOS PASSAGE, PUGET SOUND

47-22-20 N, 122-31-42 W

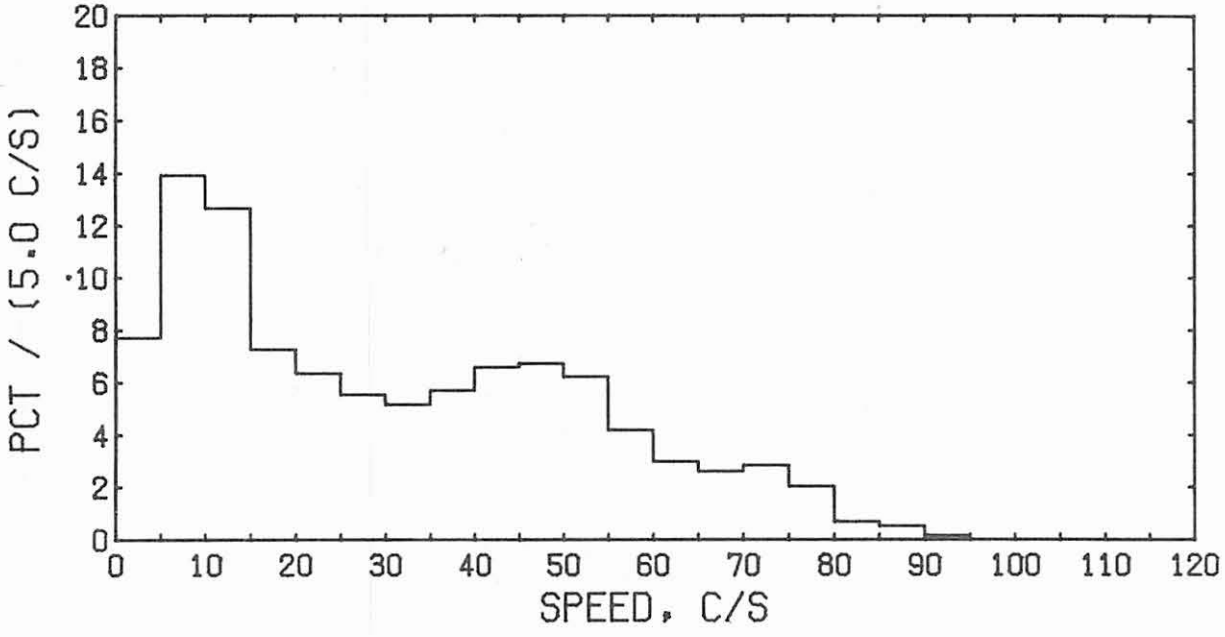
METER S/N 2055, SENSOR AT 58.5 M, BOTTOM AT 93.2 M

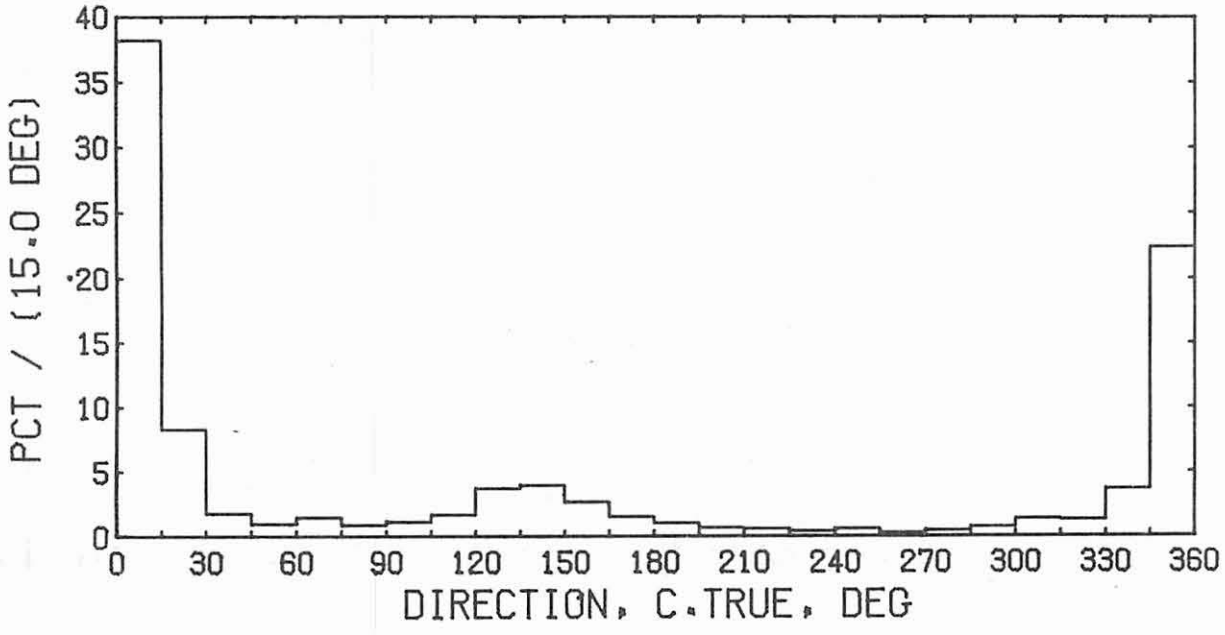
STARTING JUL.DAY 56.70139 (PST), 1977

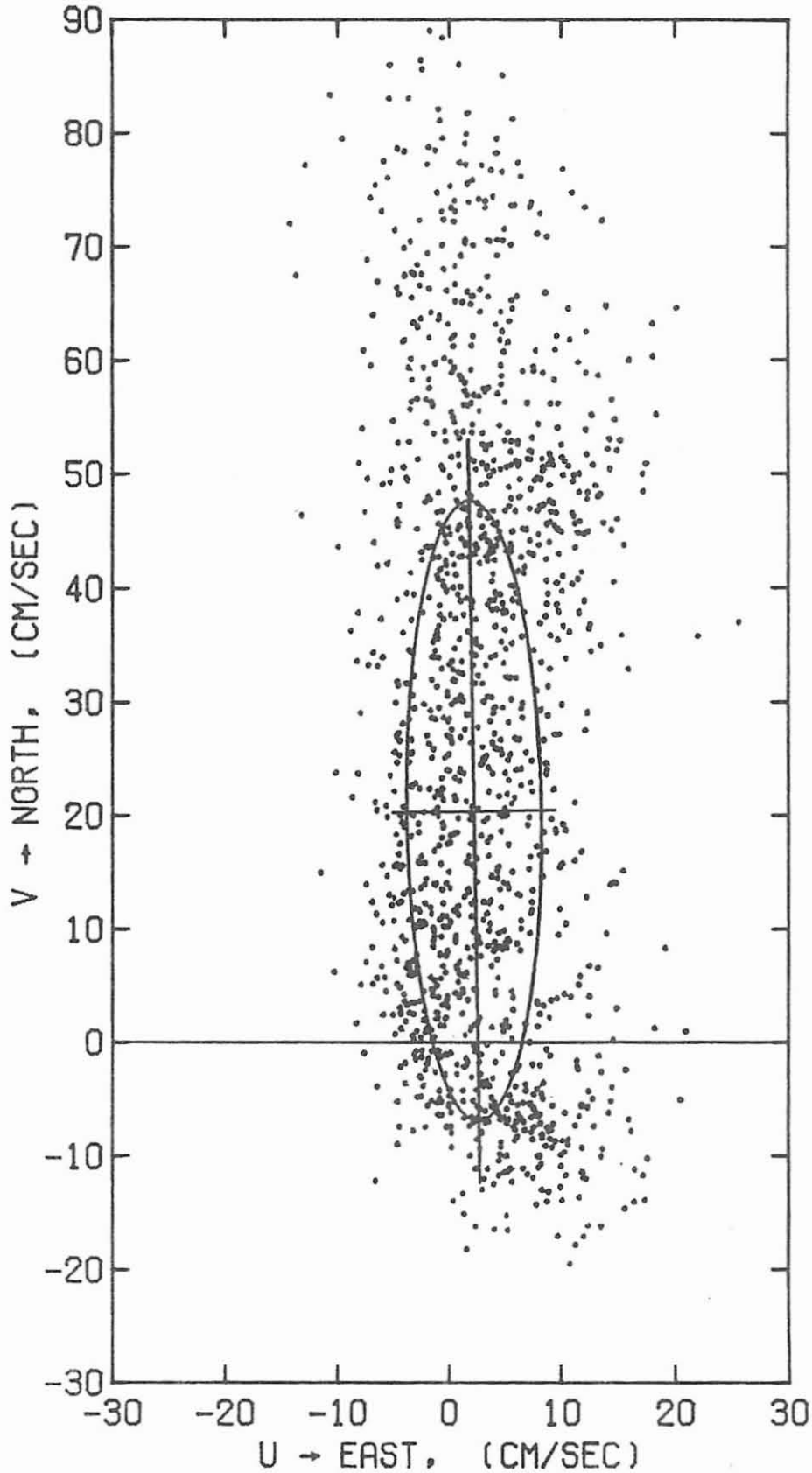
1334 SAMPLES AT DT = 0.5 HR

D E S C R I P T I V E S T A T I S T I C S

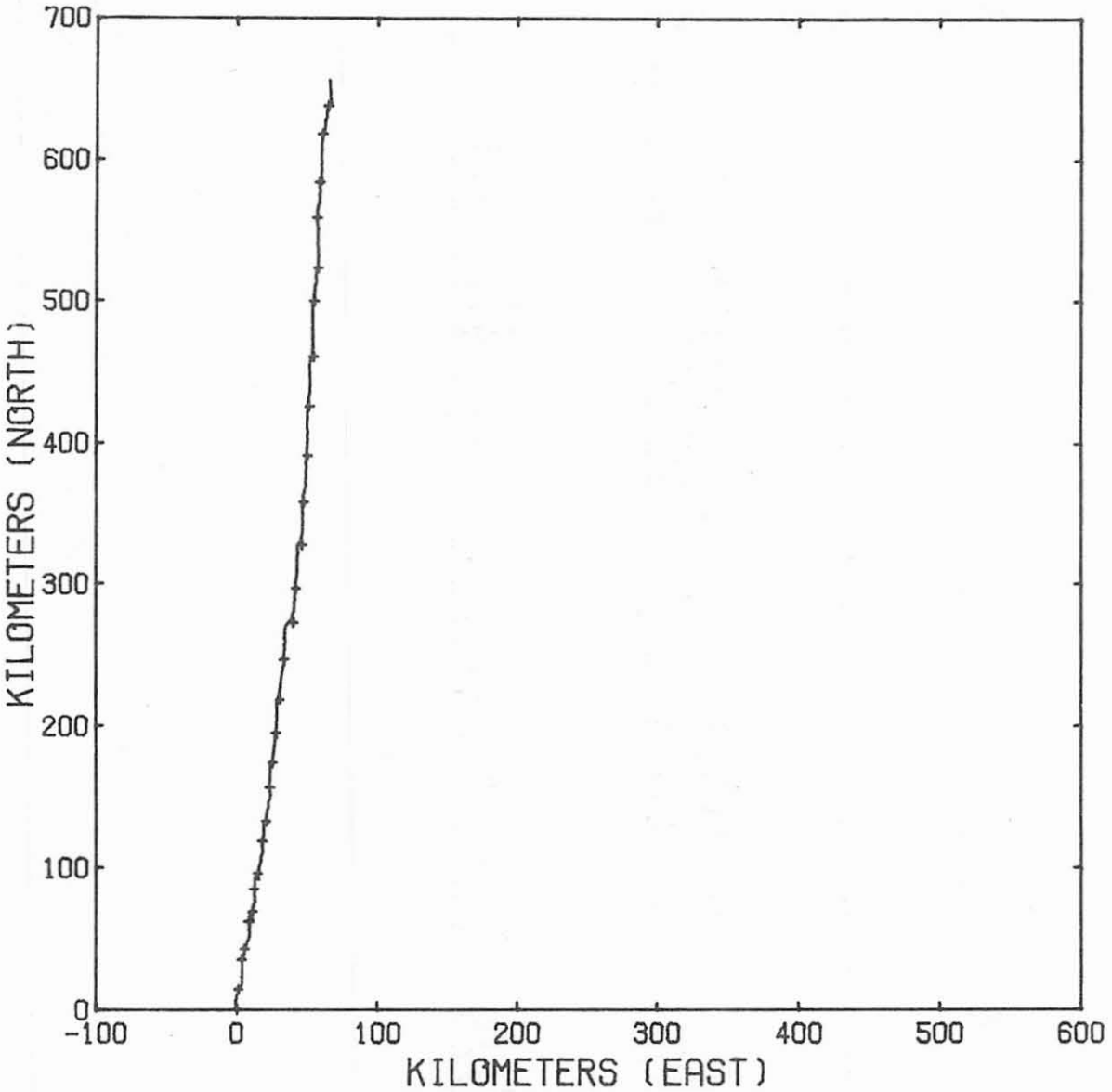
	PT	MIN	PT	MAX	MEAN	RMS	SKEW	CURT
U - COMP.	1141	-14.3	350	38.5	2.9	5.7	.505	4.067
V - COMP.	830	-19.4	516	93.8	27.3	25.7	.236	2.048
SPEED	531	.9	516	93.8	31.0	22.0	.539	2.224
DIRECTION	531	172.6	516	.0	3.6	12.3	.109	4.667







METER S/N 2055, 1334 SAMPLES AT DT = 0.5 HRS,
COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
SENSOR DEPTH 58.5 M. BOTTOM DEPTH 93.2 M.
TIME OF FIRST SAMPLE... JULIAN DAY 56.70139 (PST), 1977.



PROGRESSIVE VECTOR DIAGRAM

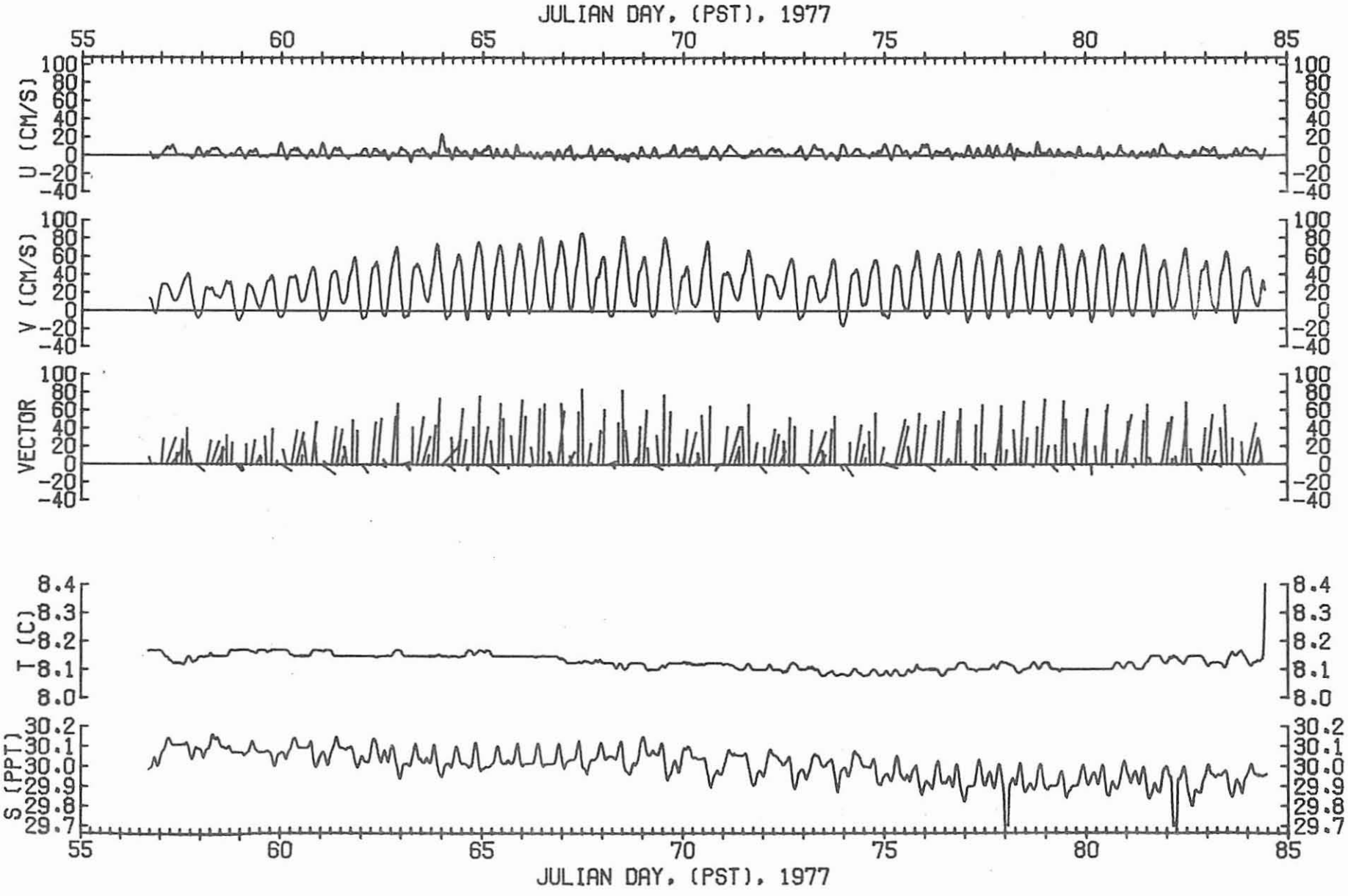
NUMBER OF POINTS = 667, SPACED AT DT = 1.000 HRS.
(EVERY 24-TH POINT IS TAGGED BY A +)

COLVOS PASSAGE, PUGET SOUND

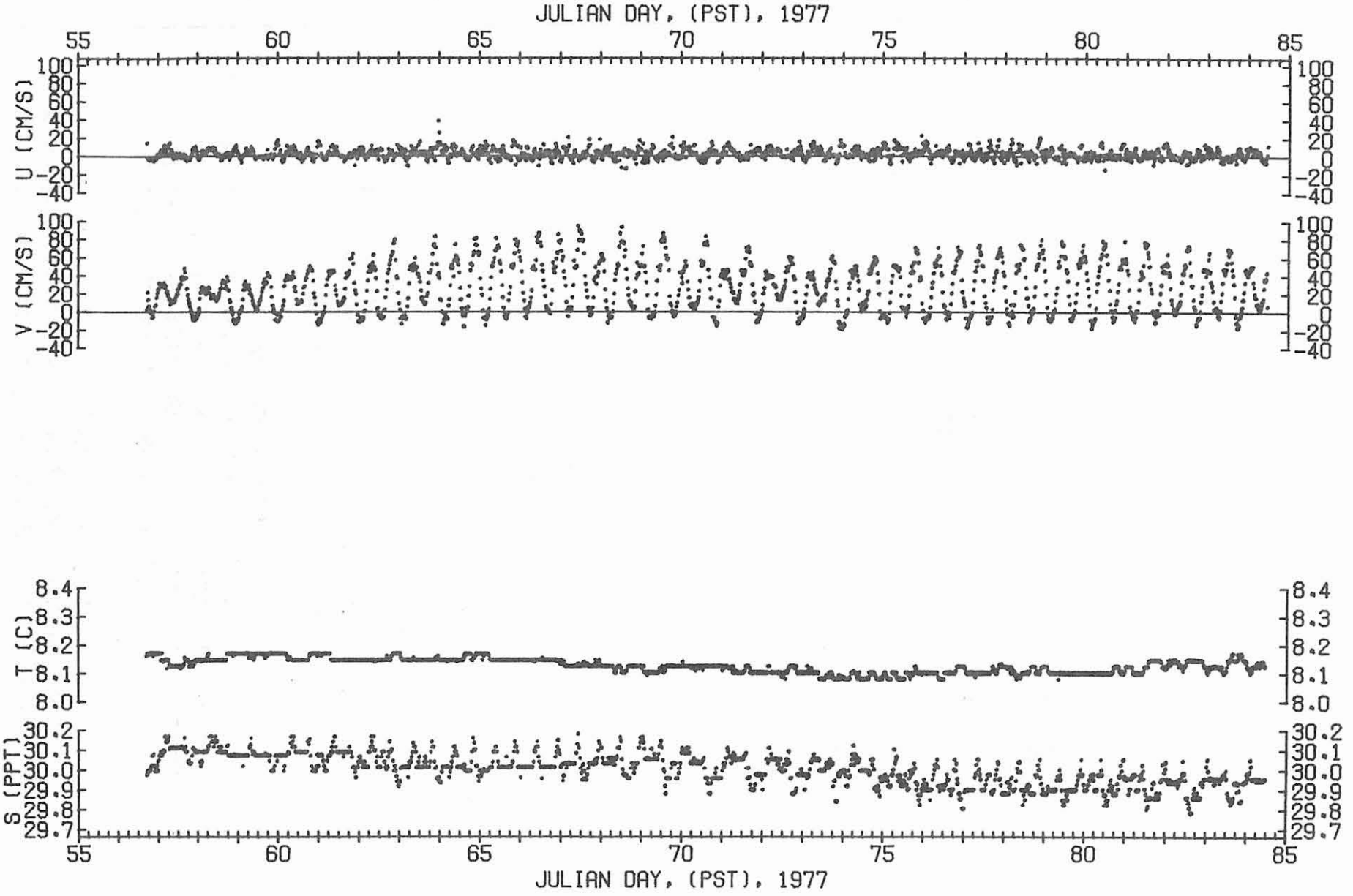
47-22-20 N, 122-31-42 W

METER S/N 2055, SENSOR AT 58.5 M, BOTTOM AT 93.2 M

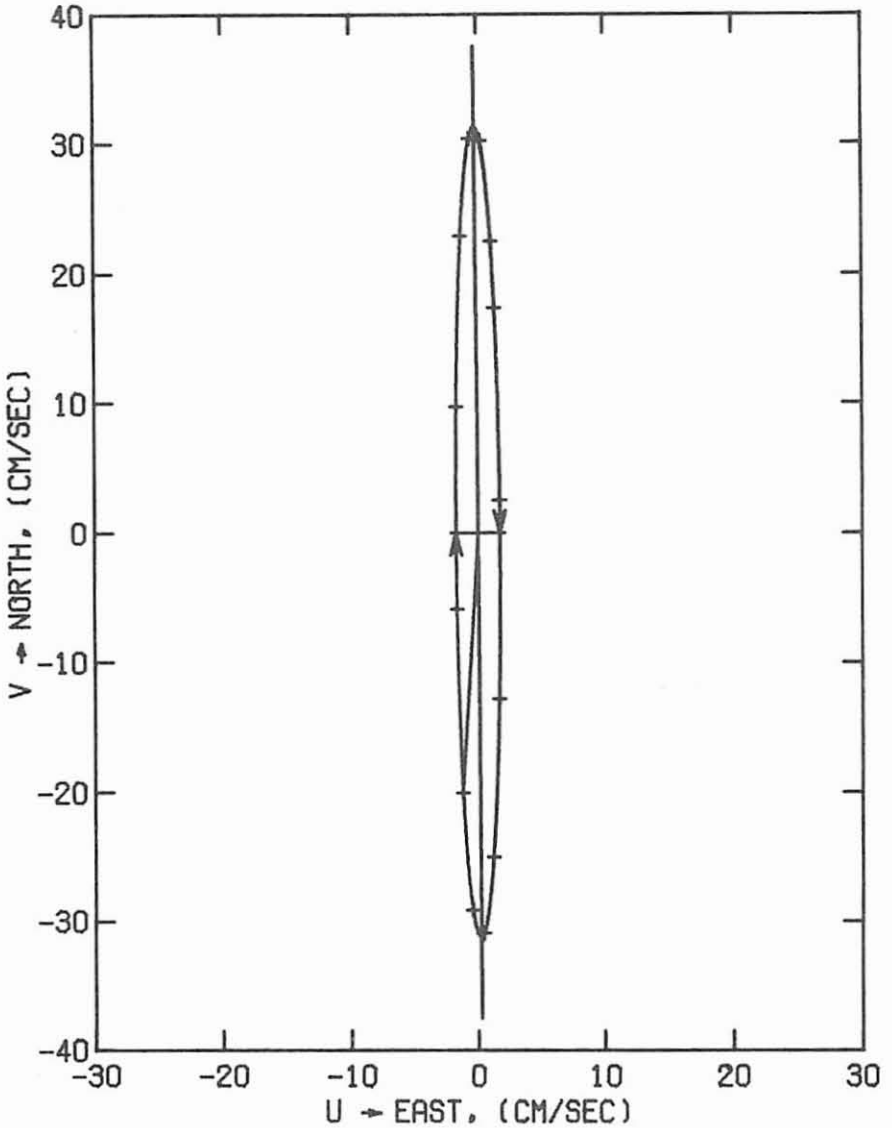
STARTING JUL.DAY 56.70139 (PST), 1977



METER S/N 2055, SENSOR AT 58.5 M.



METER S/N 2055, SENSOR AT 58.5 M.



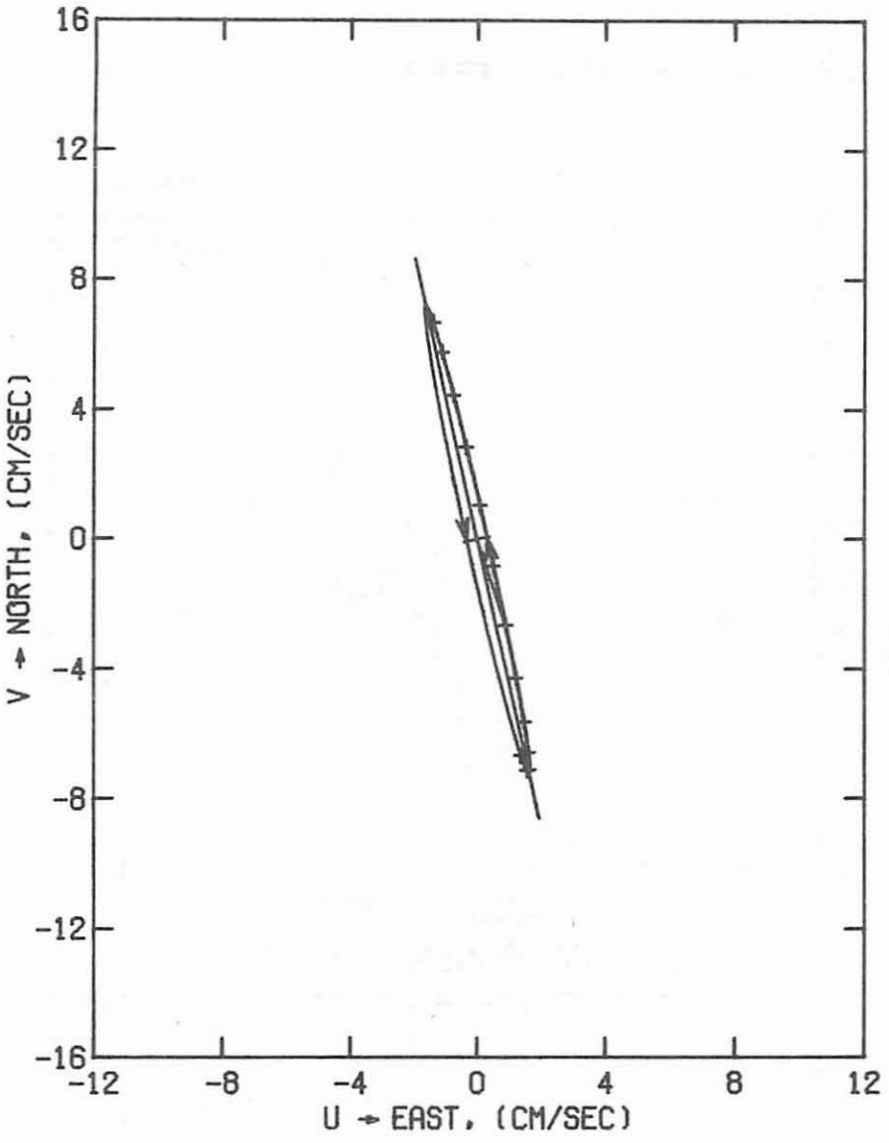
ELLIPSE FOR TIDAL CURRENT OF PERIOD 12.4245283 HRS

REFERENCE IS HIGH WATER TIME OF SURFACE CONSTITUENT
AT SEATTLE, WITH PERIOD OF 12.4206012 HRS
CURRENT AT REF.TIME IS SHOWN BY RADIAL LINE
DIRECTIONS LISTED ARE COMPASS (TRUE)

SEQUENTIAL EXTREMA ...

MIN. CURRENT	1.7 CM/S, AT	4.84 HRS	BEFORE REF.,	SETTING	90 DEG.
MAX. CURRENT	31.3 CM/S, AT	1.73 HRS	BEFORE REF.,	SETTING	180 DEG.
MIN. CURRENT	1.7 CM/S, AT	1.37 HRS	AFTER REF.,	SETTING	270 DEG.
MAX. CURRENT	31.3 CM/S, AT	4.48 HRS	AFTER REF.,	SETTING	360 DEG.

METER S/N 2055, AT 58.5 M, BOTTOM AT 93.2 M.
COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
667 HR SERIES STARTING JUL.DAY 50.70139 (PST), 1977.



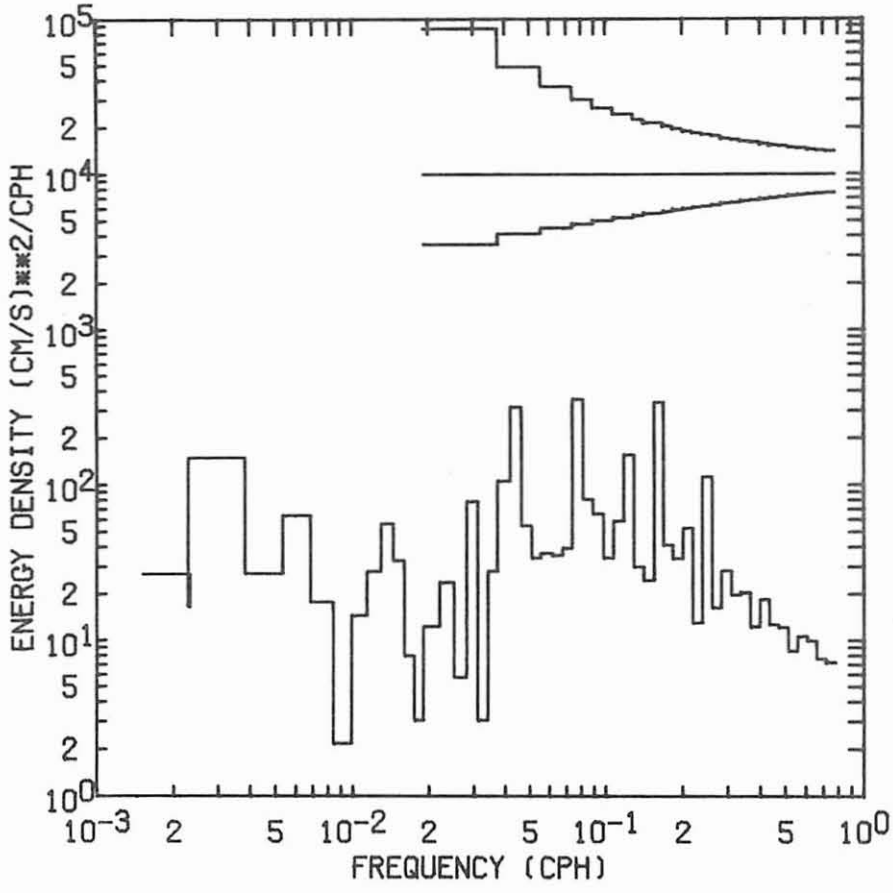
ELLIPSE FOR TIDAL CURRENT OF PERIOD 24.0000000 HRS

REFERENCE IS HIGH WATER TIME OF SURFACE CONSTITUENT
AT SEATTLE, WITH PERIOD OF 23.9344697 HRS
CURRENT AT REF.TIME IS SHOWN BY RADIAL LINE
DIRECTIONS LISTED ARE COMPASS (TRUE)

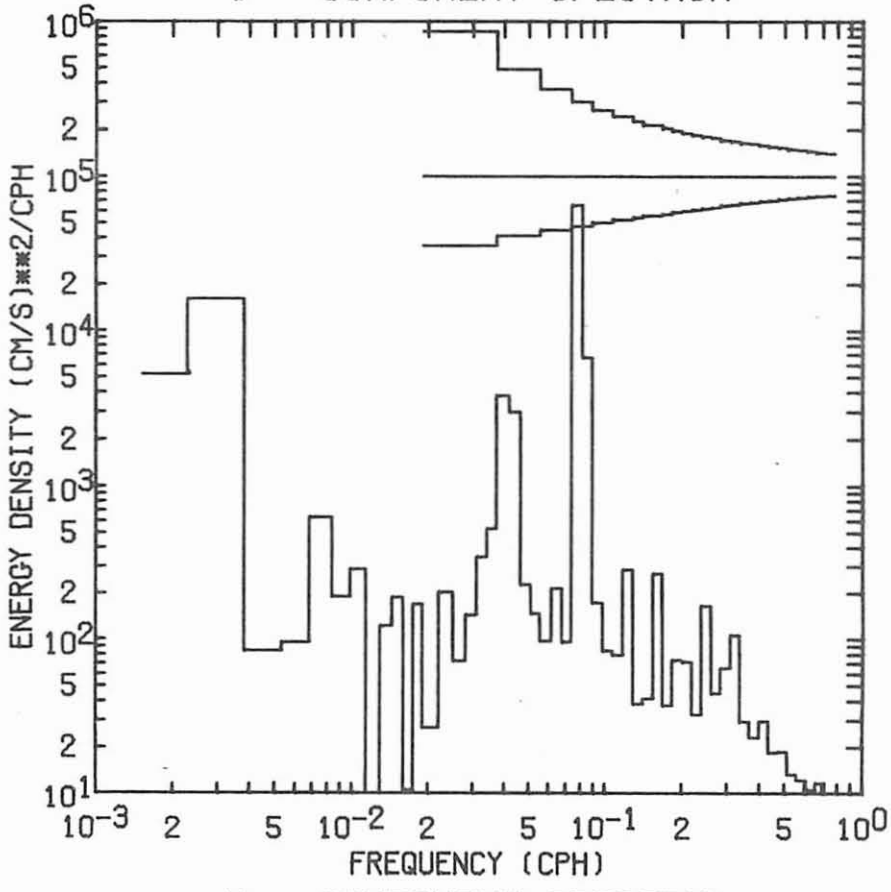
SEQUENTIAL EXTREMA ...

MIN. CURRENT	.3 CM/S,	AT 10.52 HRS	BEFORE REF.,	SETTING	257 DEG.
MAX. CURRENT	7.4 CM/S,	AT 4.52 HRS	BEFORE REF.,	SETTING	167 DEG.
MIN. CURRENT	.3 CM/S,	AT 1.48 HRS	AFTER REF.,	SETTING	77 DEG.
MAX. CURRENT	7.4 CM/S,	AT 7.48 HRS	AFTER REF.,	SETTING	347 DEG.

METER S/N 2055, AT 58.5 M, BOTTOM AT 93.2 M.
COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
667 HR SERIES STARTING JUL.DAY 50.70139 (PST), 1977.



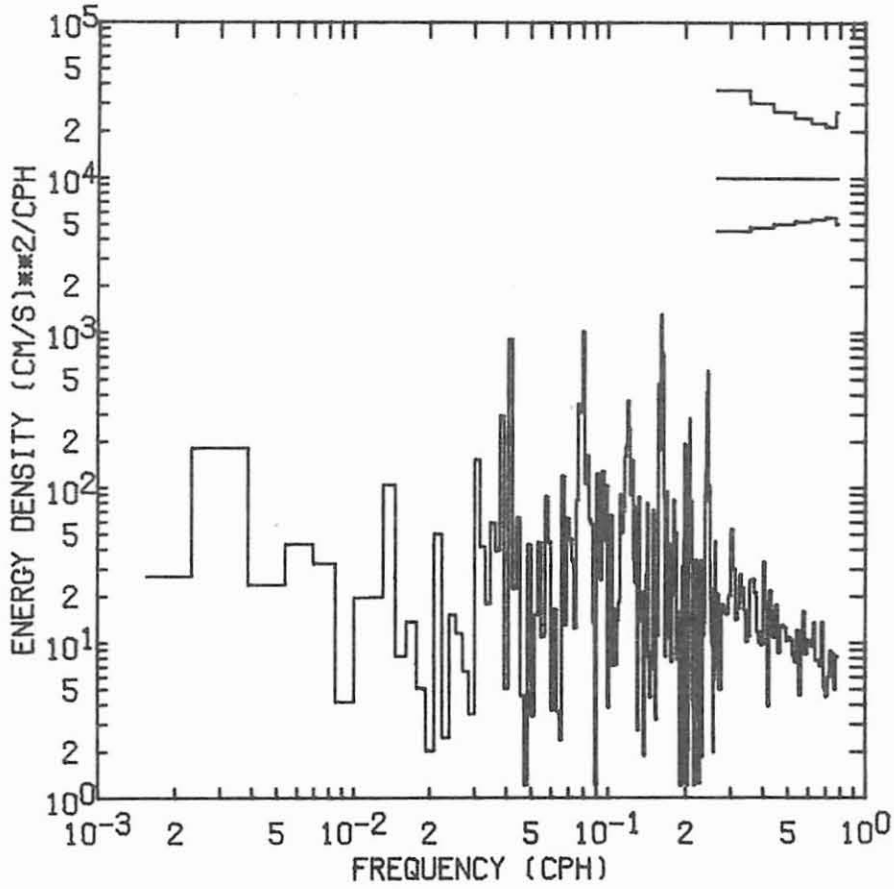
U - COMPONENT SPECTRUM



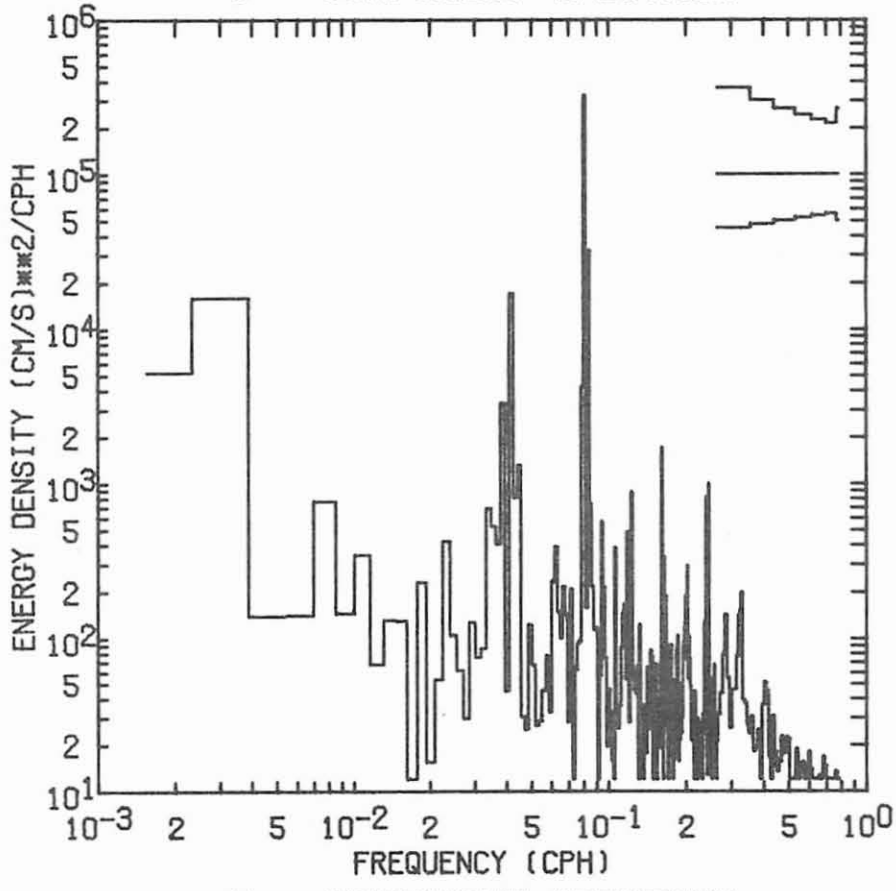
V - COMPONENT SPECTRUM

METER S/N 2055, AT DEPTH 58.5 (M)

STARTING TIME 56.70139 JUL.DAY (PST) 1977



U - COMPONENT SPECTRUM



V - COMPONENT SPECTRUM

METER S/N 2055, AT DEPTH 58.5 (M)

STARTING TIME 56.70139 JUL.DAY (PST) 1977

DATA SET C

CURRENT METER 2056, LOCATED AT DEPTH 74.1 m

COLVOS PASSAGE, PUGET SOUND

47-22-20 N, 122-31-42 W

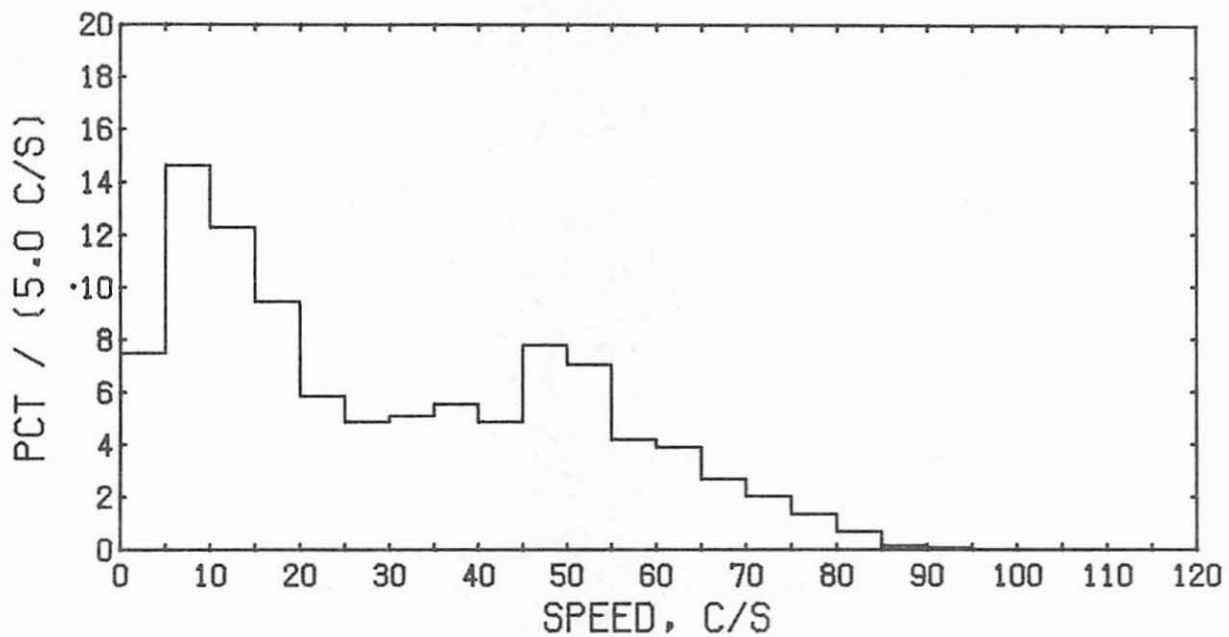
METER S/N 2056, SENSOR AT 74.1 M, BOTTOM AT 93.2 M

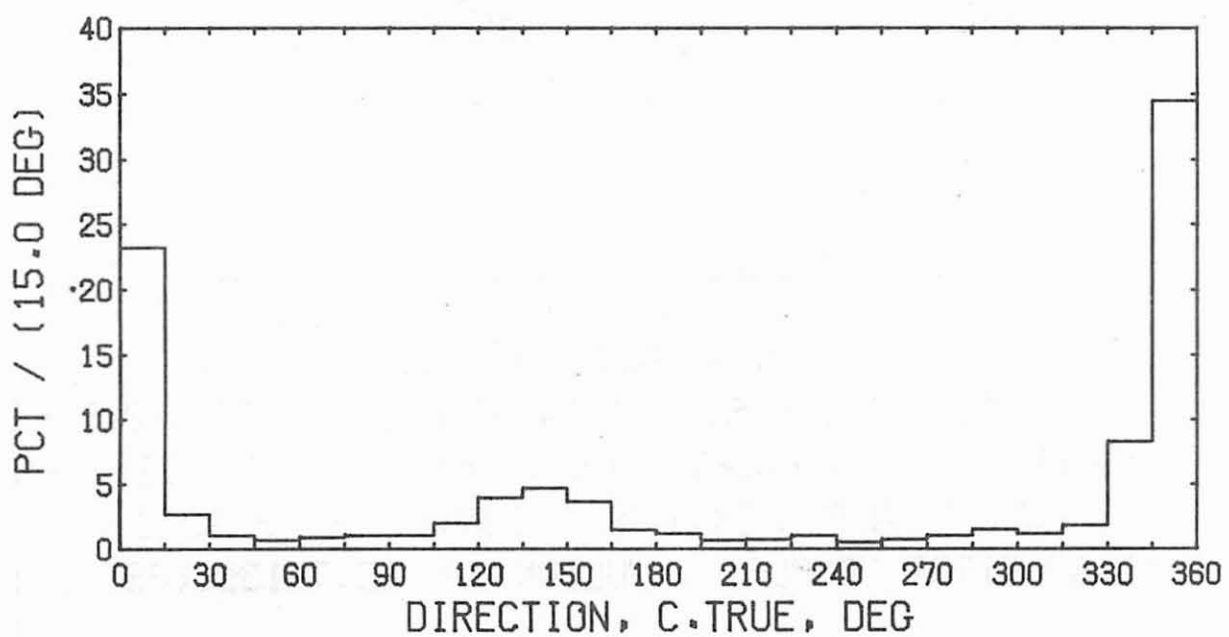
STARTING JUL.DAY 56.70139 (PST), 1977

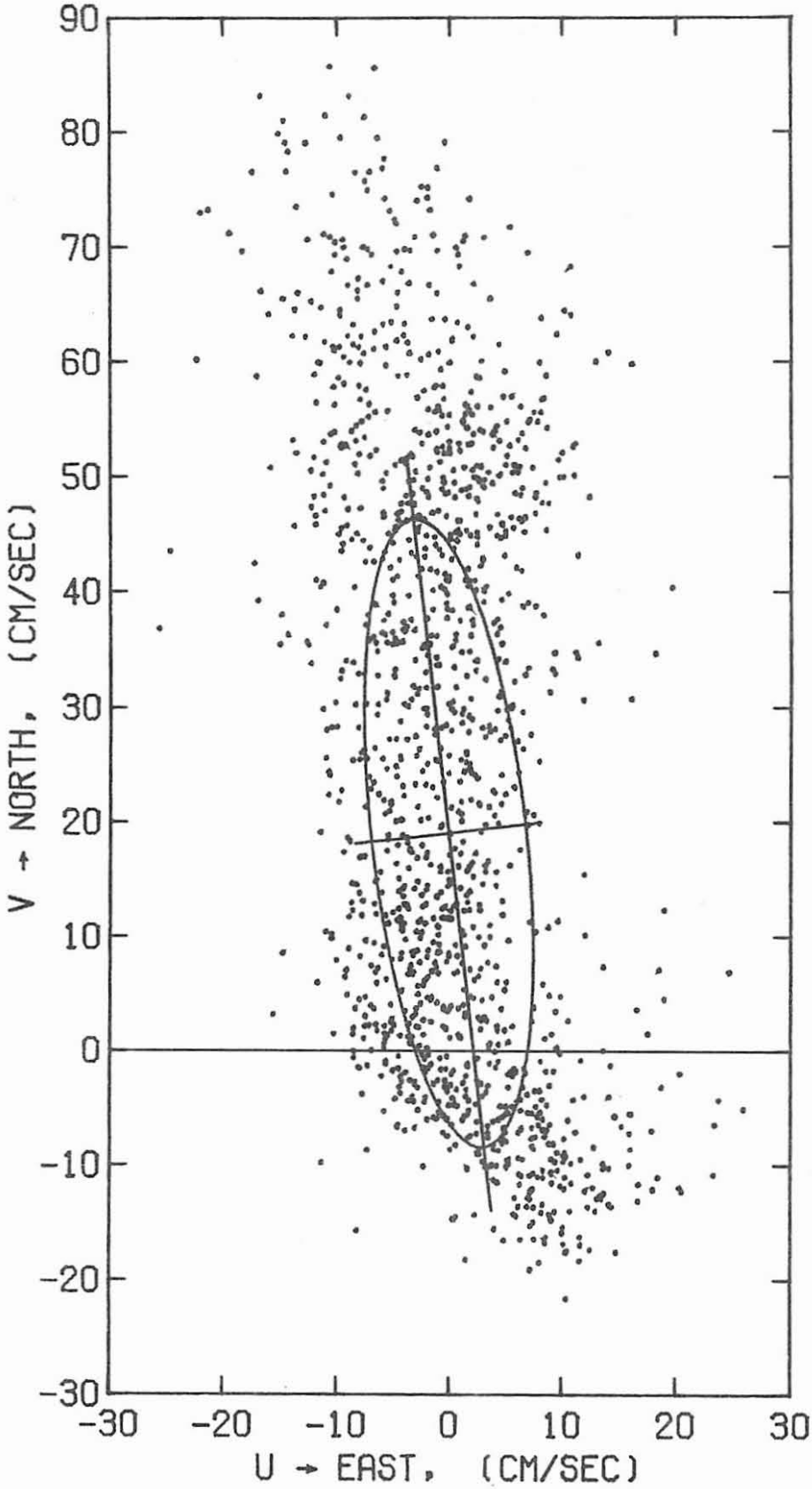
1334 SAMPLES AT DT = 0.5 HR

D E S C R I P T I V E S T A T I S T I C S

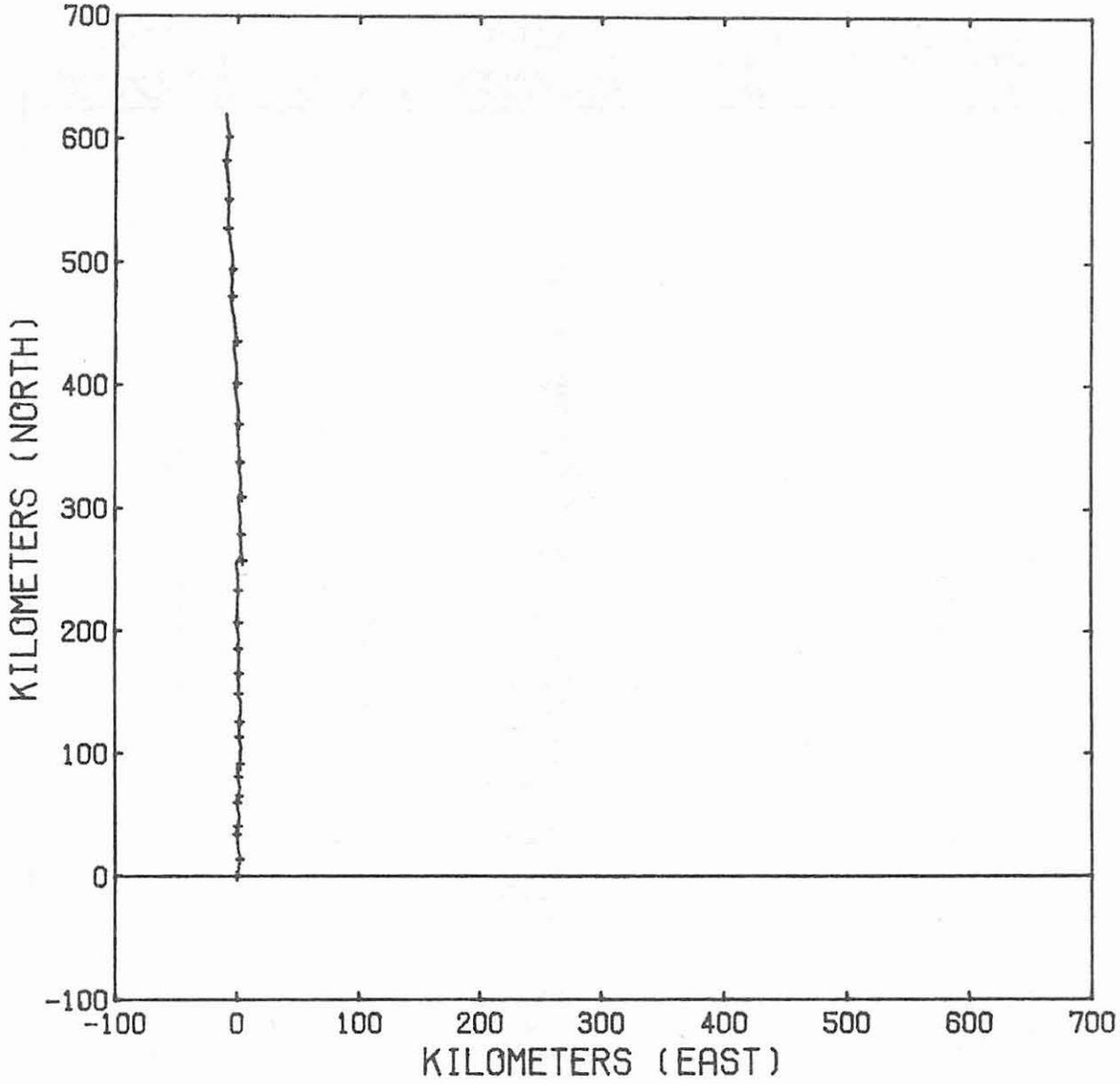
	PT	MIN	PT	MAX	MEAN	RMS	SKEW	CURT
U - COMP.	573	-25.7	350	34.9	-.2	7.1	.281	3.874
V - COMP.	827	-21.5	516	92.8	25.5	25.9	.181	1.888
SPEED	1303	.4	516	93.6	30.3	21.4	.504	2.108
DIRECTION	1303	221.1	516	352.8	356.3	12.7	-.185	4.682







METER S/N 2056, 1334 SAMPLES AT DT = 0.5 HRS,
COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
SENSOR DEPTH 74.1 M, BOTTOM DEPTH 93.2 M.
TIME OF FIRST SAMPLE... JULIAN DAY 56.70139 (PST), 1977.



PROGRESSIVE VECTOR DIAGRAM

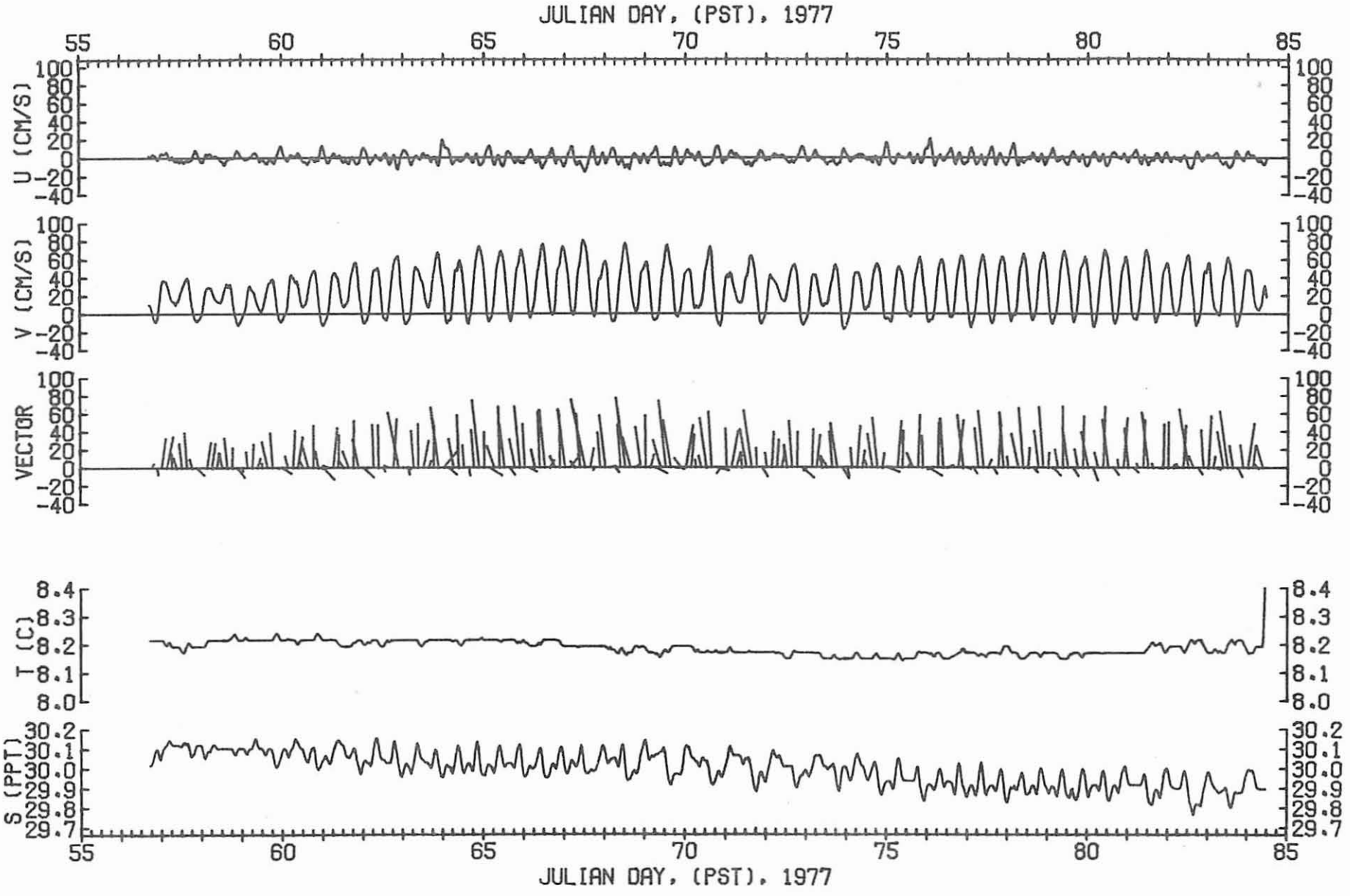
NUMBER OF POINTS = 667, SPACED AT DT = 1.000 HRS.
(EVERY 24-TH POINT IS TAGGED BY A +)

COLVOS PASSAGE, PUGET SOUND

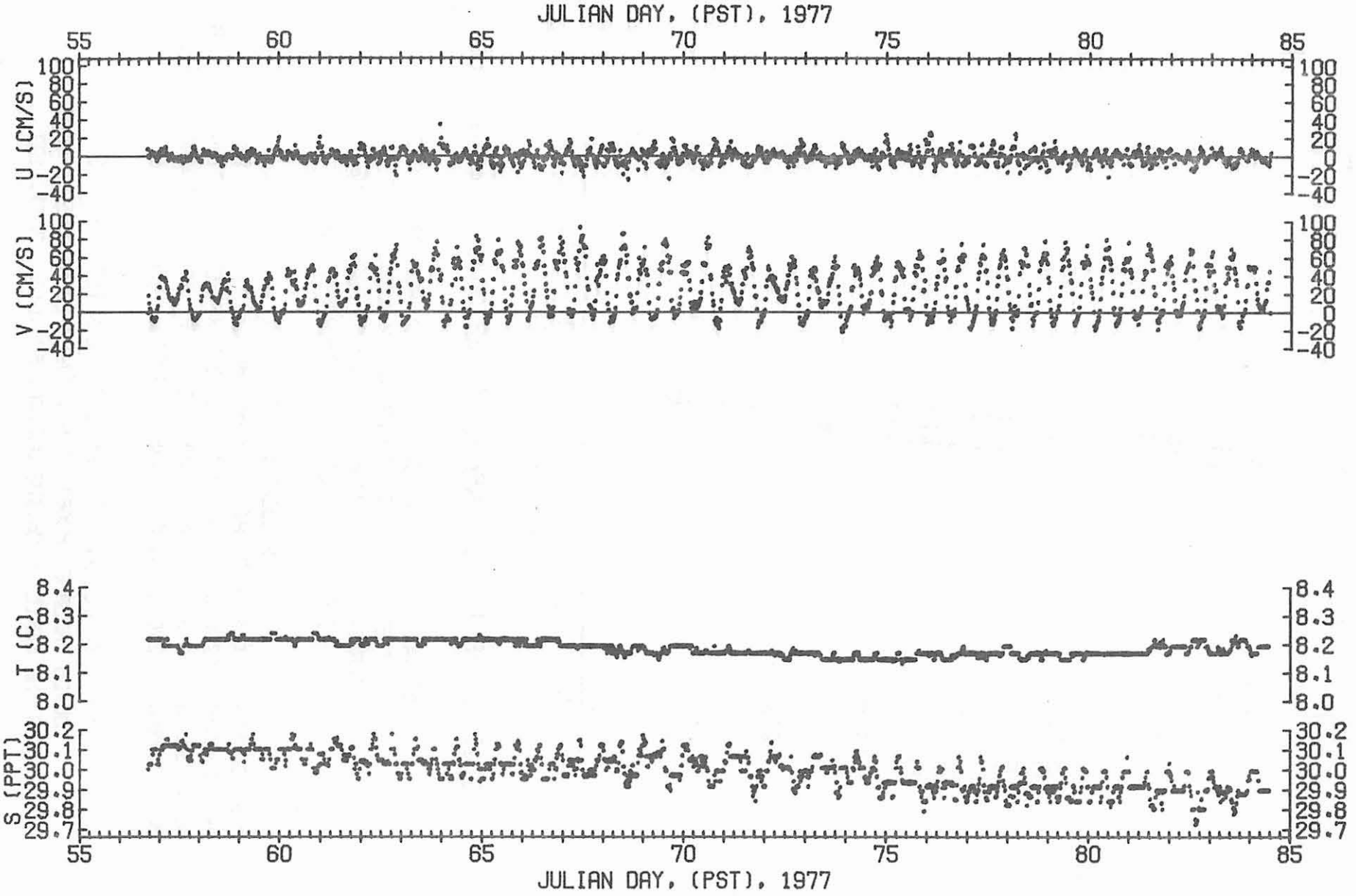
47-22-20 N, 122-31-42 W

METER S/N 2056, SENSOR AT 74.1 M, BOTTOM AT 93.2 M

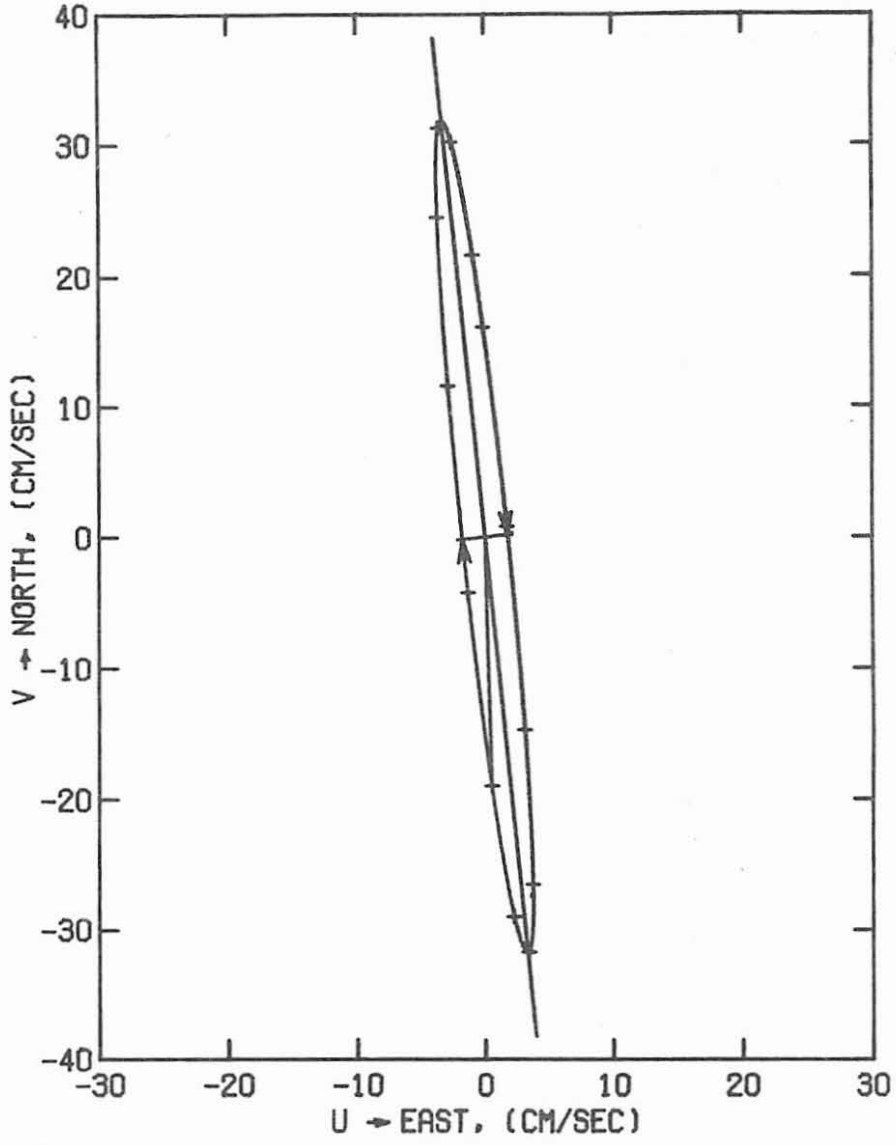
STARTING JUL.DAY 56.70139 (PST), 1977



METER S/N 2056, SENSOR AT 74.1 M.



METER S/N 2056, SENSOR AT 74.1 M.



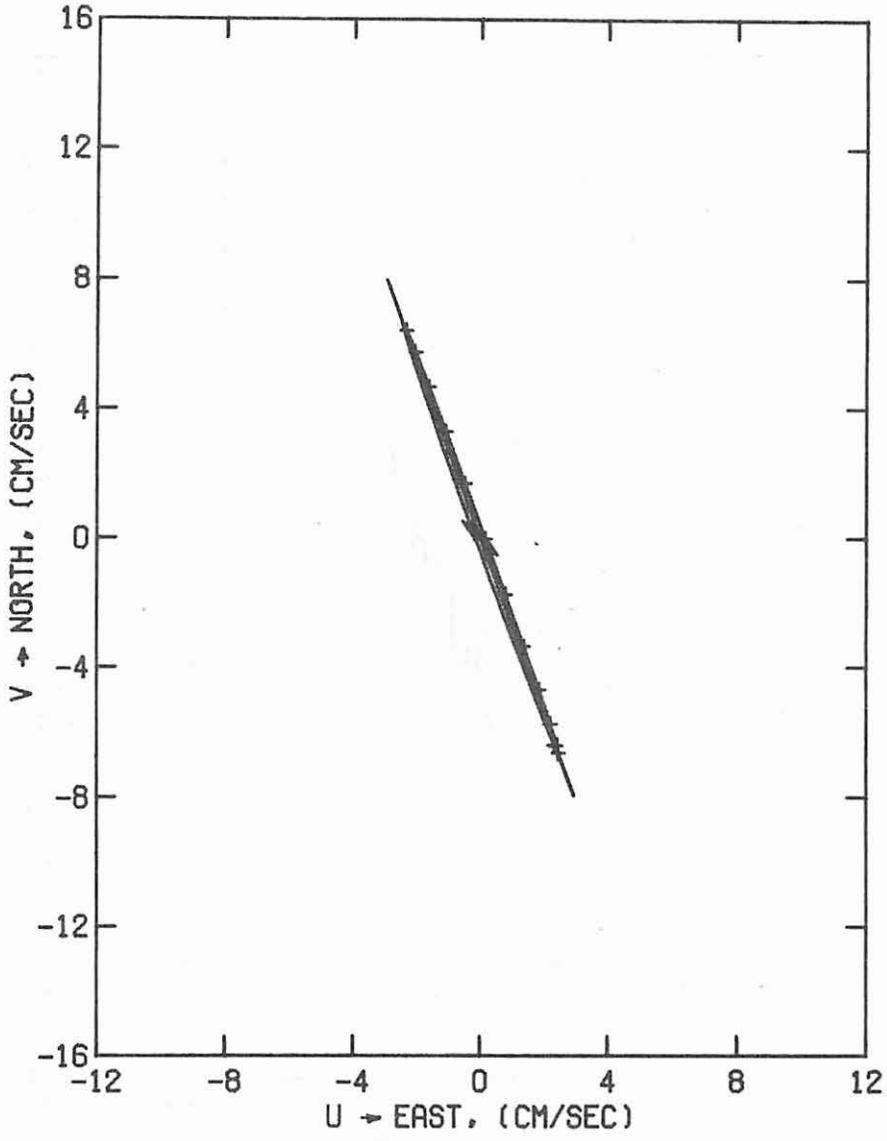
ELLIPSE FOR TIDAL CURRENT OF PERIOD 12.4245283 HRS

REFERENCE IS HIGH WATER TIME OF SURFACE CONSTITUENT
AT SEATTLE, WITH PERIOD OF 12.4206012 HRS
CURRENT AT REF.TIME IS SHOWN BY RADIAL LINE
DIRECTIONS LISTED ARE COMPASS (TRUE)

SEQUENTIAL EXTREMA ...

MIN. CURRENT	1.8 CM/S, AT	4.96 HRS	BEFORE	REF., SETTING	84	DEG.
MAX. CURRENT	32.0 CM/S, AT	1.85 HRS	BEFORE	REF., SETTING	174	DEG.
MIN. CURRENT	1.8 CM/S, AT	1.25 HRS	AFTER	REF., SETTING	264	DEG.
MAX. CURRENT	32.0 CM/S, AT	4.36 HRS	AFTER	REF., SETTING	354	DEG.

METER S/N 2056, AT 74.1 M, BOTTOM AT 93.2 M.
COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
667 HR SERIES STARTING JUL.DAY 50.70139 (PST), 1977.



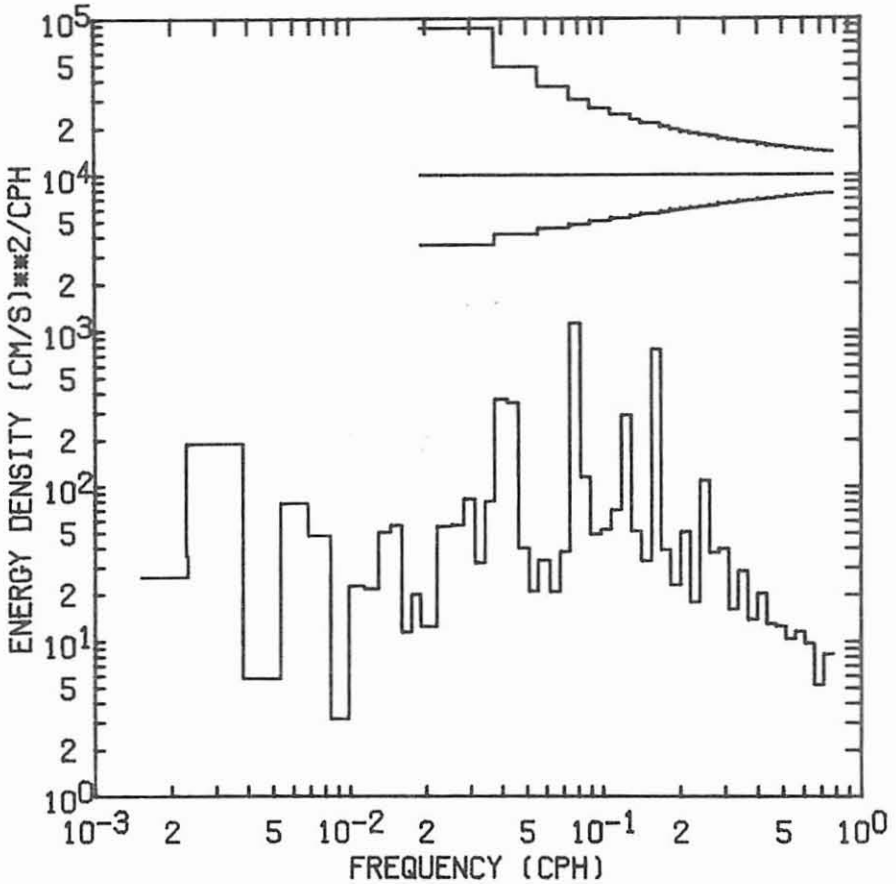
ELLIPSE FOR TIDAL CURRENT OF PERIOD 24.0000000 HRS

REFERENCE IS HIGH WATER TIME OF SURFACE CONSTITUENT
AT SEATTLE, WITH PERIOD OF 23.9344697 HRS
CURRENT AT REF.TIME IS SHOWN BY RADIAL LINE
DIRECTIONS LISTED ARE COMPASS (TRUE)

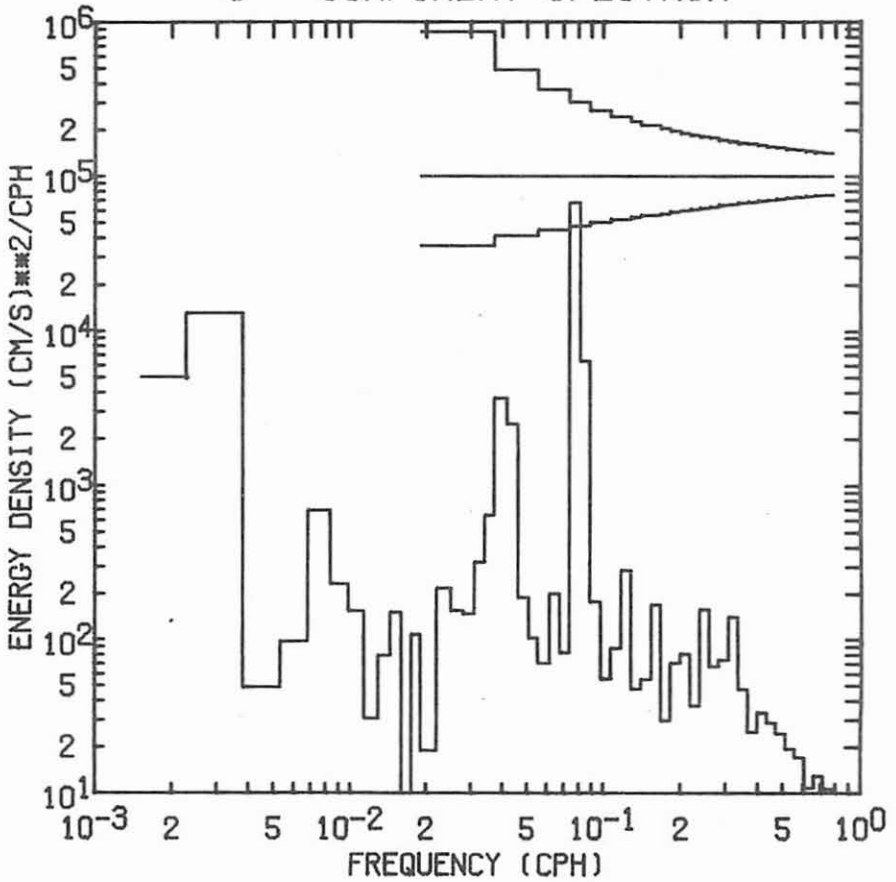
SEQUENTIAL EXTREMA ...

MIN. CURRENT	.1 CM/S, AT	10.96	HRS BEFORE	REF., SETTING	250 DEG.
MAX. CURRENT	7.1 CM/S, AT	4.96	HRS BEFORE	REF., SETTING	160 DEG.
MIN. CURRENT	.1 CM/S, AT	1.04	HRS AFTER	REF., SETTING	70 DEG.
MAX. CURRENT	7.1 CM/S, AT	7.04	HRS AFTER	REF., SETTING	340 DEG.

METER S/N 2056, AT 74.1 M, BOTTOM AT 93.2 M.
COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
667 HR SERIES STARTING JUL.DAY 50.70139 (PST), 1977.



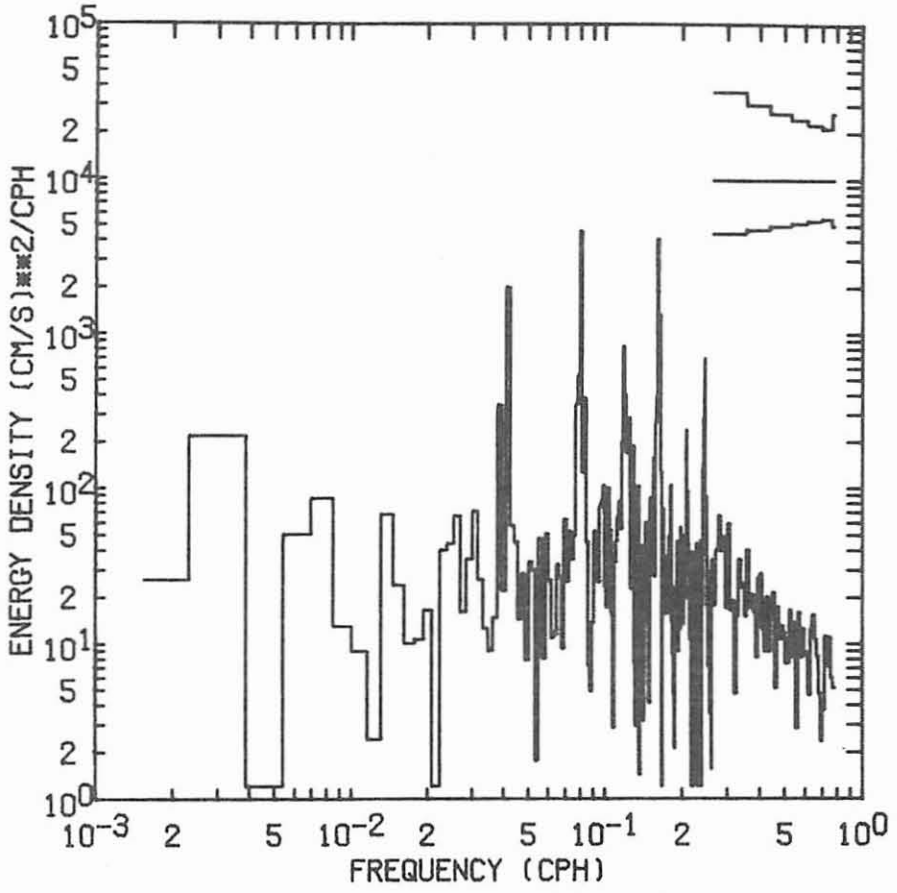
U - COMPONENT SPECTRUM



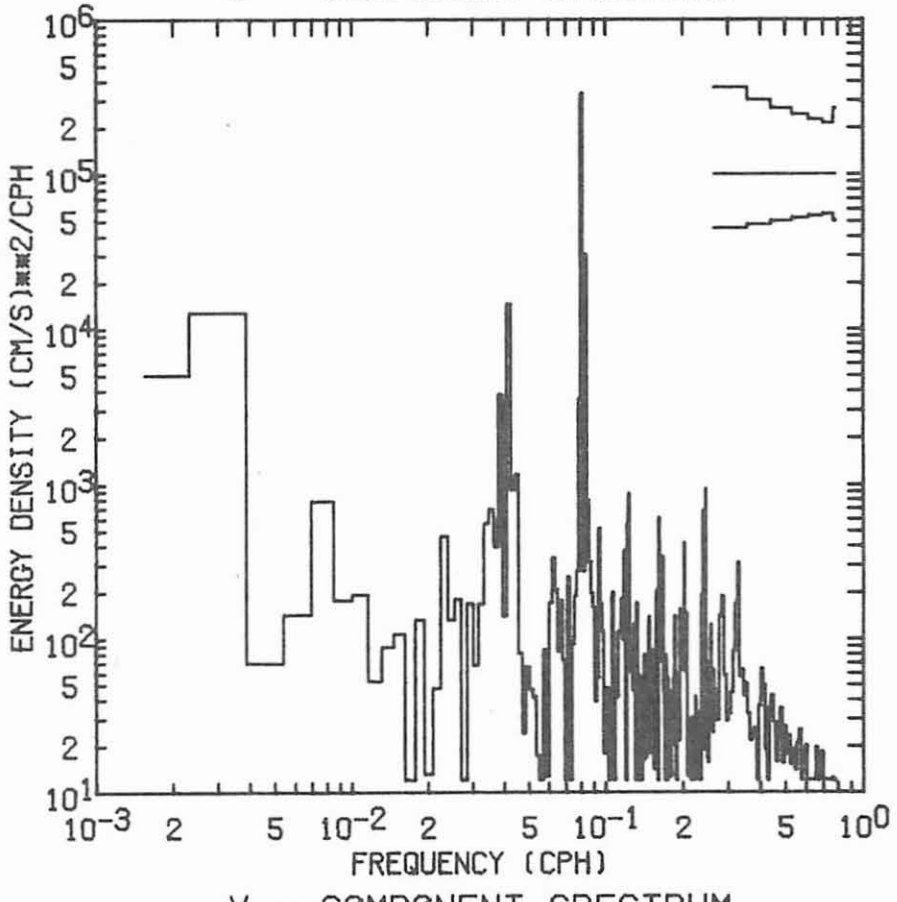
V - COMPONENT SPECTRUM

METER S/N 2056, AT DEPTH 74.1 (M)

STARTING TIME 56.70139 JUL.DAY (PST) 1977



U - COMPONENT SPECTRUM



V - COMPONENT SPECTRUM

METER S/N 2056, AT DEPTH 74.1 (M)

STARTING TIME 56.70139 JUL.DAY (PST) 1977

DATA SET D

CURRENT METER 2057, LOCATED AT DEPTH 88.2 m

COLVOS PASSAGE, PUGET SOUND

47-22-20 N, 122-31-42 W

METER S/N 2057, SENSOR AT 88.2 M, BOTTOM AT 93.2 M

STARTING JUL.DAY 56.70139 (PST), 1977

1334 SAMPLES AT DT = 0.5 HR

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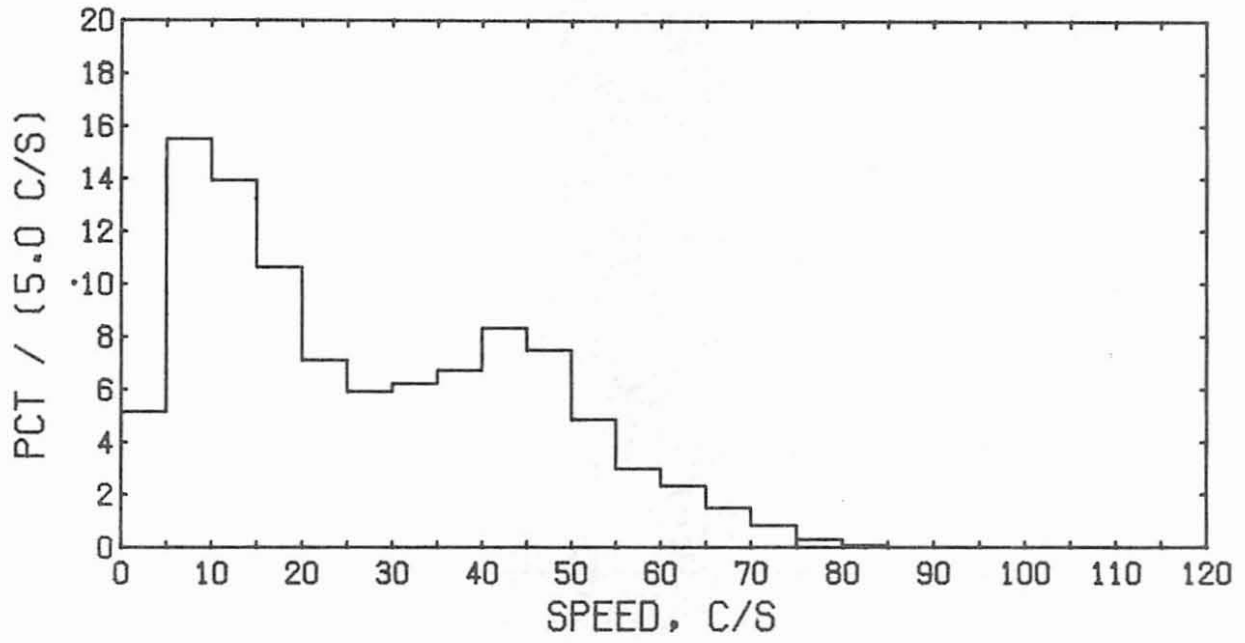
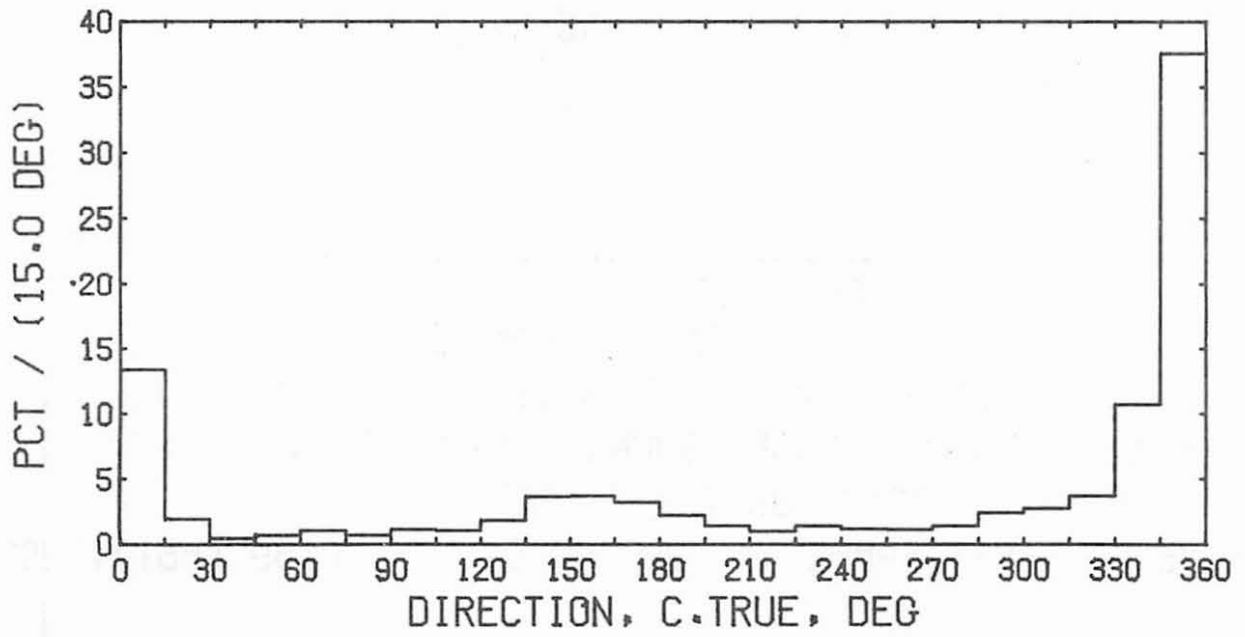
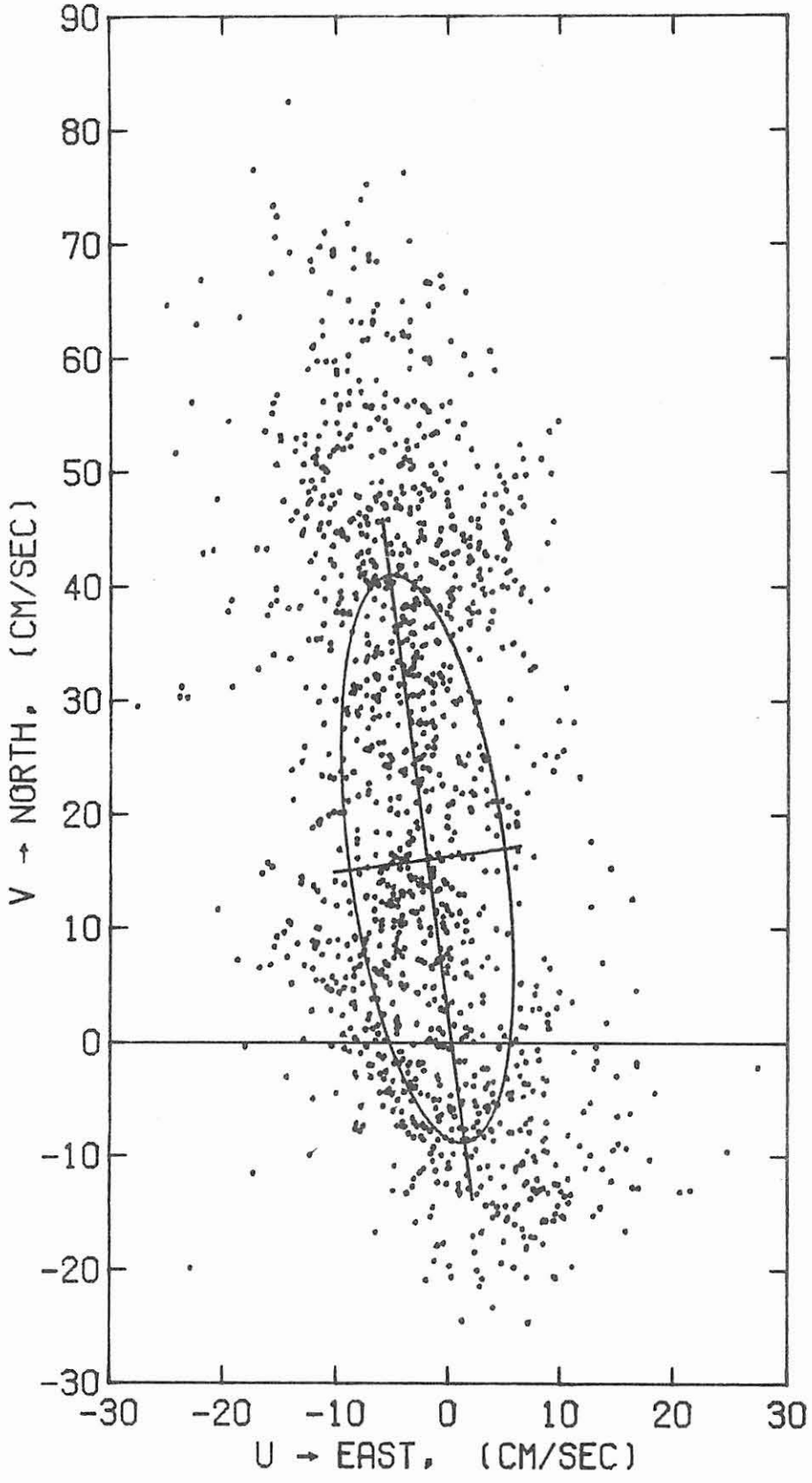
D E S C R I P T I V E S T A T I S T I C S

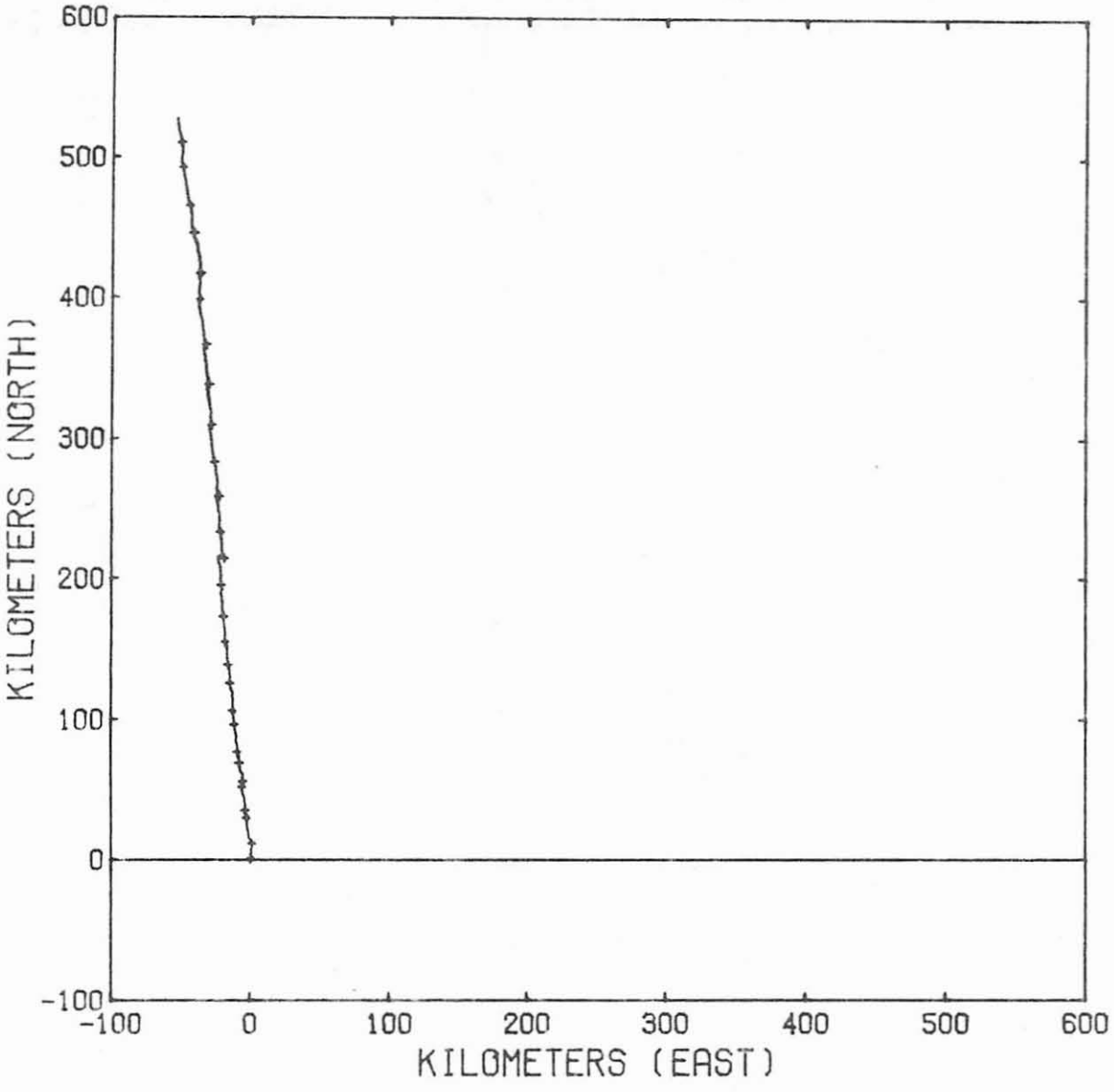
	PT	MIN	PT	MAX	MEAN	RMS	SKEW	CURT
				.				
U - COMP.	573	-27.6	351	34.1	-2.6	7.3	.397	4.445
V - COMP.	907	-34.0	516	82.5	21.6	23.5	.096	1.972
SPEED	1205	.4	516	83.7	27.4	18.1	.534	2.237
DIRECTION	1205	177.5	516	350.2	351.2	13.9	-.610	4.302







METER S/N 2057, 1334 SAMPLES AT DT = 0.5 HRS.
COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
SENSOR DEPTH 88.2 M, BOTTOM DEPTH 93.2 M.
TIME OF FIRST SAMPLE... JULIAN DAY 56.70139 (PST), 1977.



PROGRESSIVE VECTOR DIAGRAM

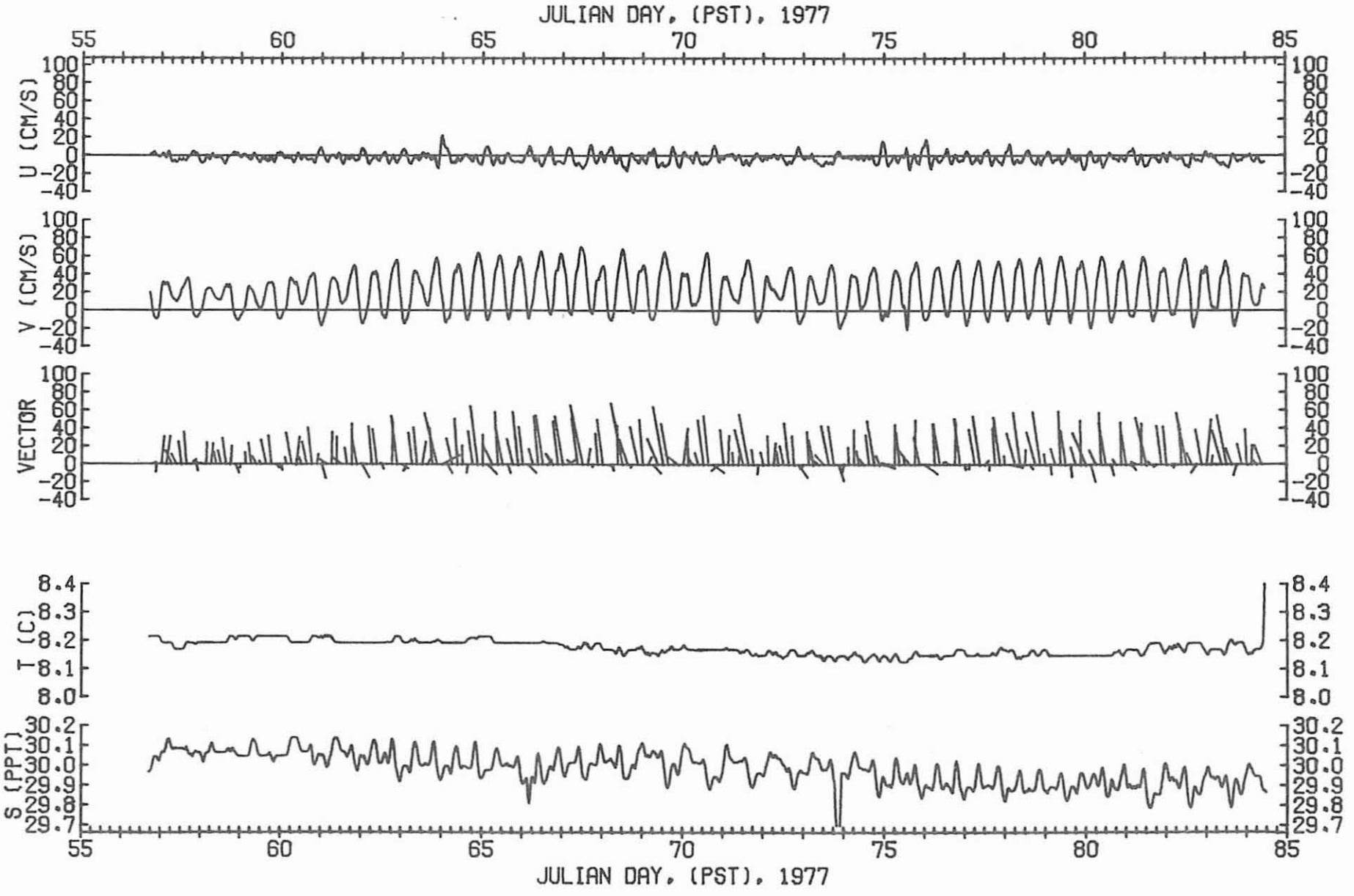
NUMBER OF POINTS = 667, SPACED AT DT = 1.000 HRS.
(EVERY 24-TH POINT IS TAGGED BY A +)

COLVOS PASSAGE, PUGET SOUND

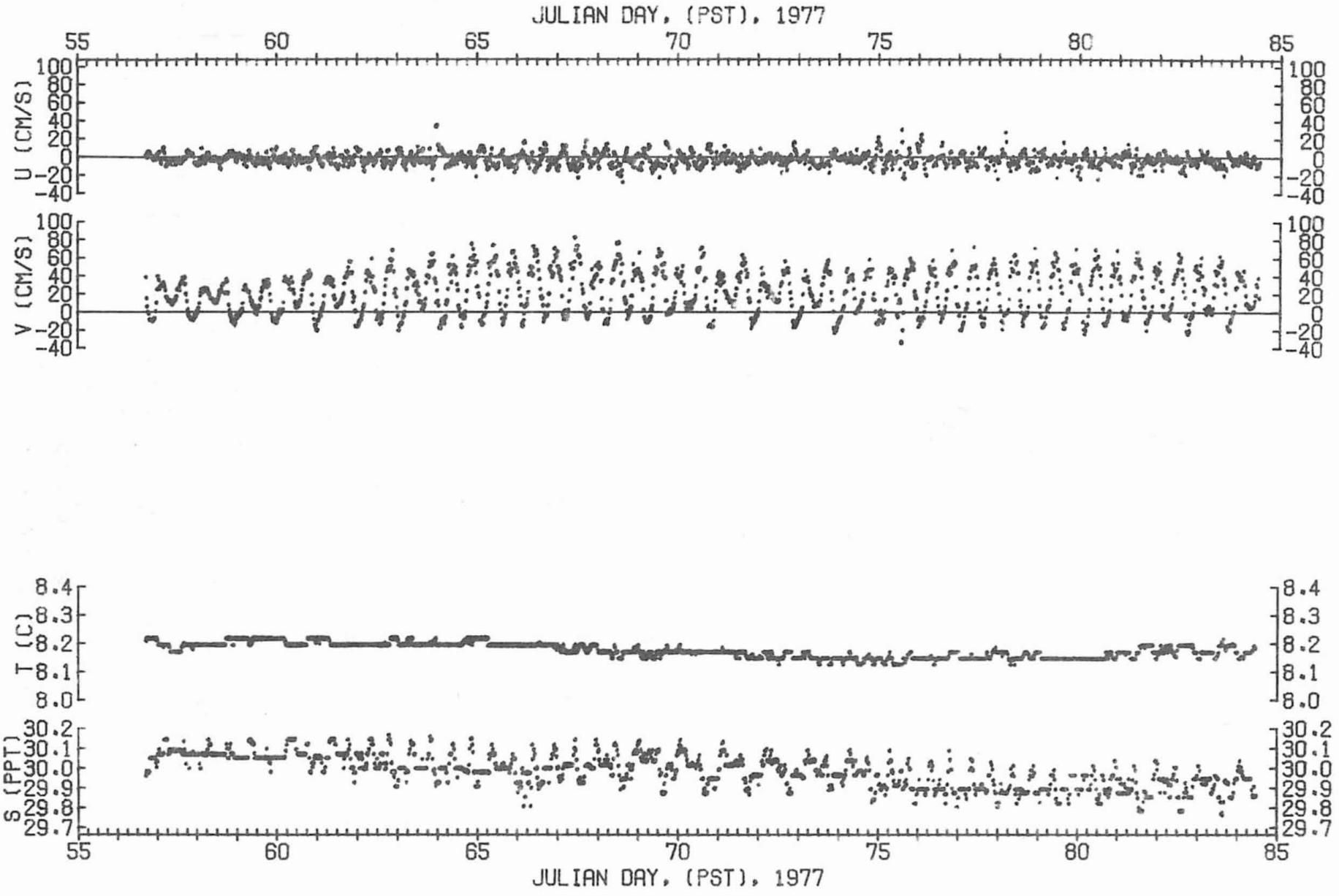
47-22-20 N, 122-31-42 W

METER S/N 2057, SENSOR AT 88.2 M, BOTTOM AT 93.2 M

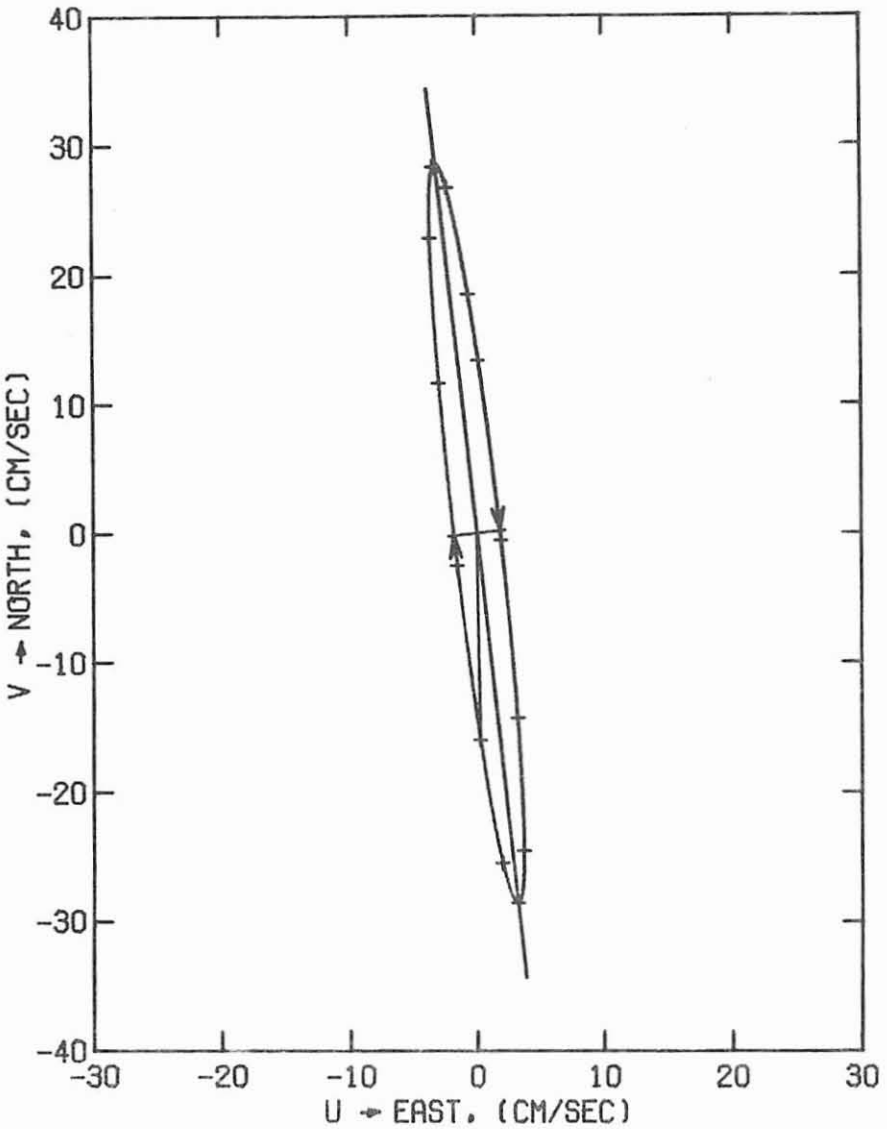
STARTING JUL.DAY 56.70139 (PST), 1977



METER S/N 2057, SENSOR AT 88.2 M.



METER S/N 2057, SENSOR AT 88.2 M.



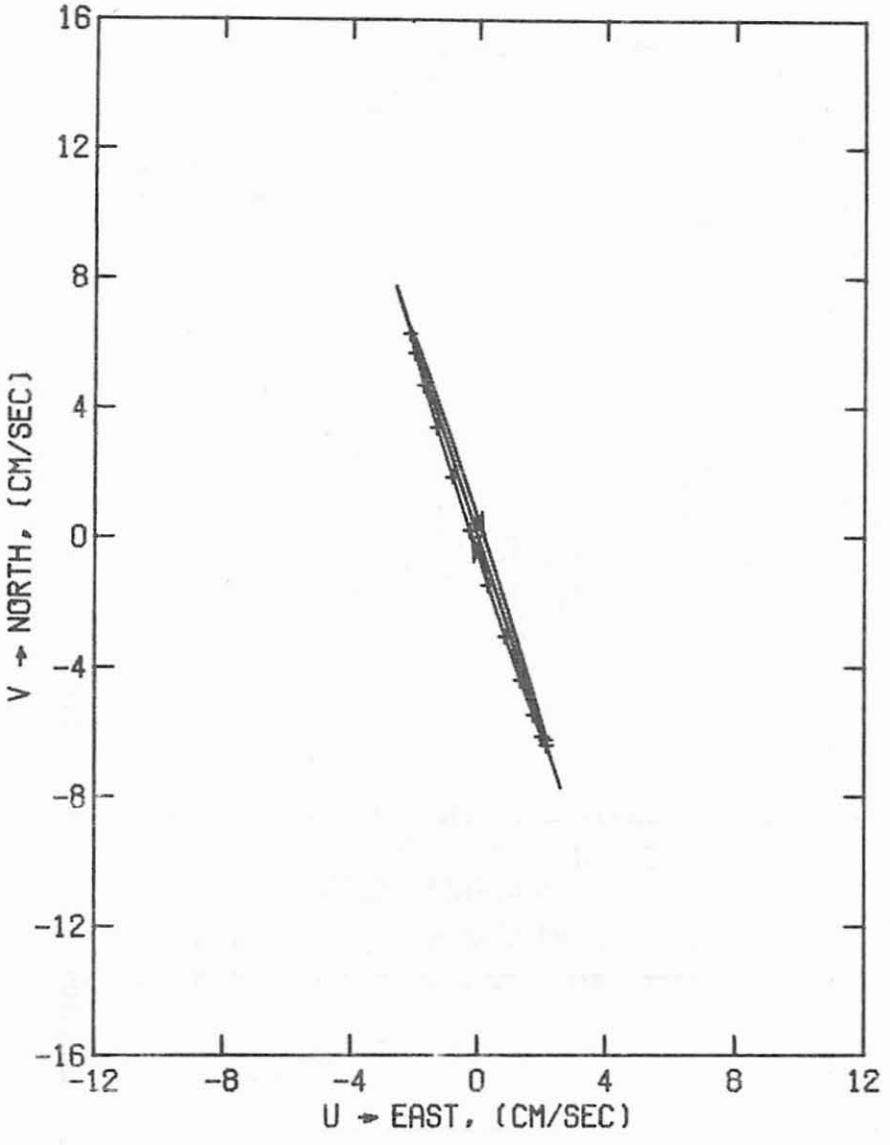
ELLIPSE FOR TIDAL CURRENT OF PERIOD 12.4245283 HRS

REFERENCE IS HIGH WATER TIME OF SURFACE CONSTITUENT
AT SEATTLE, WITH PERIOD OF 12.4206012 HRS
CURRENT AT REF.TIME IS SHOWN BY RADIAL LINE
DIRECTIONS LISTED ARE COMPASS (TRUE)

SEQUENTIAL EXTREMA ...

MIN. CURRENT	1.8 CM/S, AT	5.05 HRS	BEFORE REF.,	SETTING	84 DEG.
MAX. CURRENT	28.8 CM/S, AT	1.95 HRS	BEFORE REF.,	SETTING	174 DEG.
MIN. CURRENT	1.8 CM/S, AT	1.16 HRS	AFTER REF.,	SETTING	264 DEG.
MAX. CURRENT	28.8 CM/S, AT	4.27 HRS	AFTER REF.,	SETTING	354 DEG.

METER S/N 2057, AT 88.2 M, BOTTOM AT 93.2 M.
COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
667 HR SERIES STARTING JUL.DAY 50.70139 (PST), 1977.



ELLIPSE FOR TIDAL CURRENT OF PERIOD 24.0000000 HRS

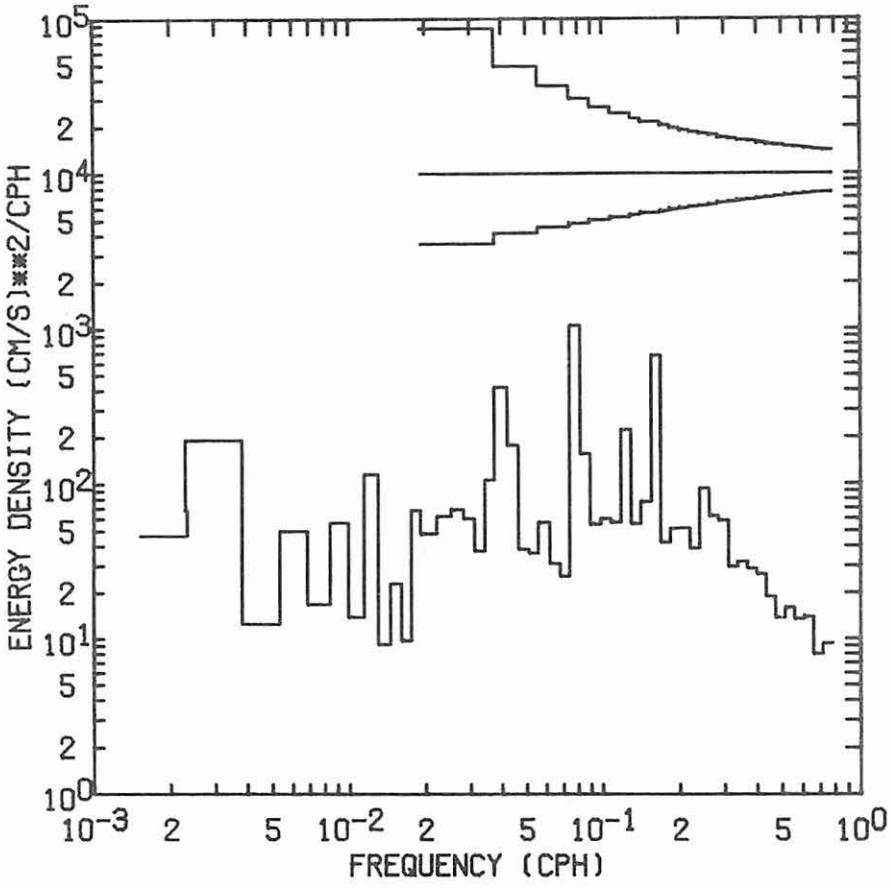
REFERENCE IS HIGH WATER TIME OF SURFACE CONSTITUENT
AT SEATTLE, WITH PERIOD OF 23.9344697 HRS
CURRENT AT REF.TIME IS SHOWN BY RADIAL LINE
DIRECTIONS LISTED ARE COMPASS (TRUE)

SEQUENTIAL EXTREMA ...

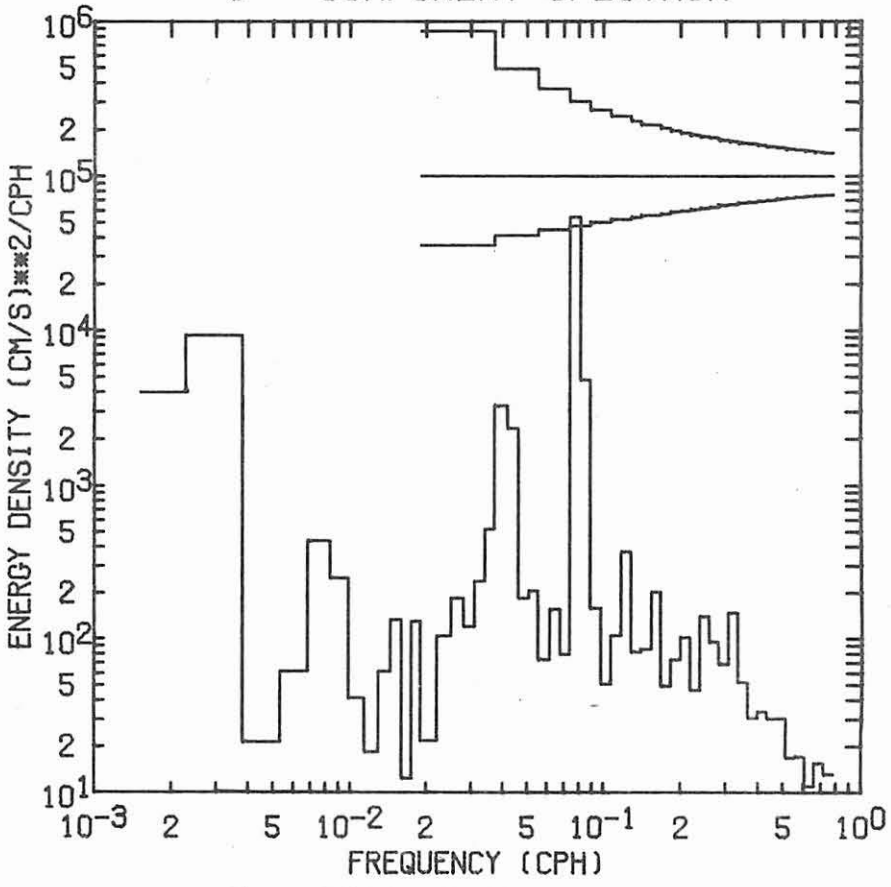
MIN. CURRENT	.2 CM/S, AT	11.15 HRS	BEFORE REF.,	SETTING	71 DEG.
MAX. CURRENT	6.8 CM/S, AT	5.15 HRS	BEFORE REF.,	SETTING	161 DEG.
MIN. CURRENT	.2 CM/S, AT	.85 HRS	AFTER REF.,	SETTING	251 DEG.
MAX. CURRENT	6.8 CM/S, AT	6.85 HRS	AFTER REF.,	SETTING	341 DEG.

METER S/N 2057, AT 88.2 M, BOTTOM AT 93.2 M.

COLVOS PASSAGE, PUGET SOUND, 47-22-20 N, 122-31-42 W
667 HR SERIES STARTING JUL.DAY 50.70139 (PST), 1977.



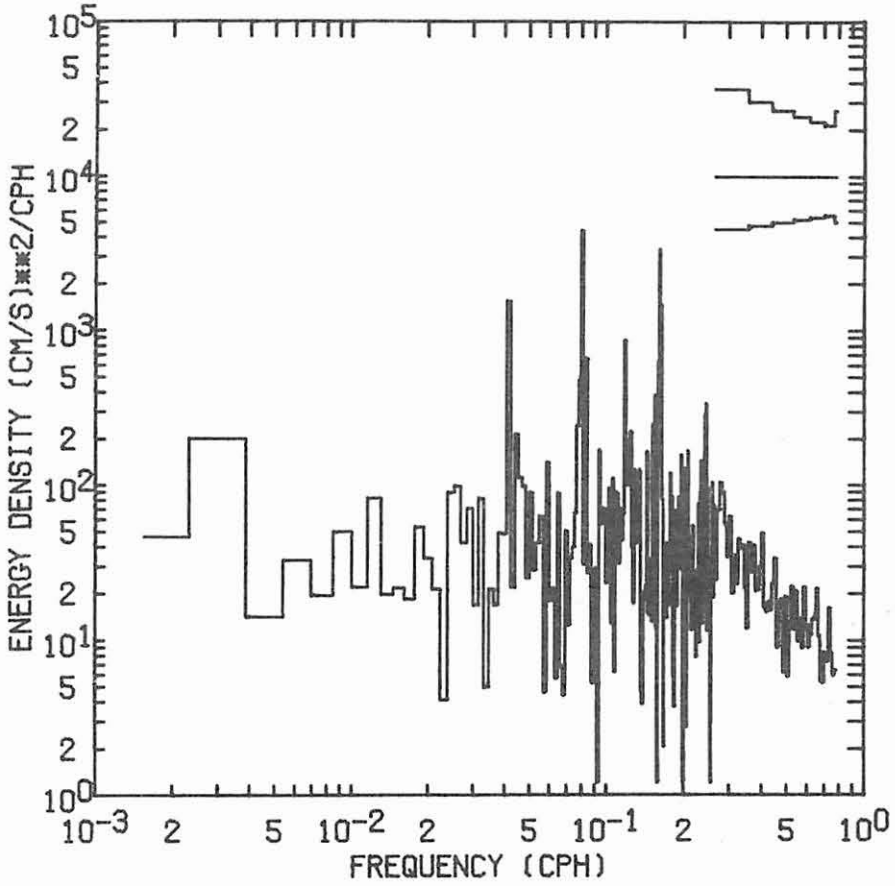
U - COMPONENT SPECTRUM



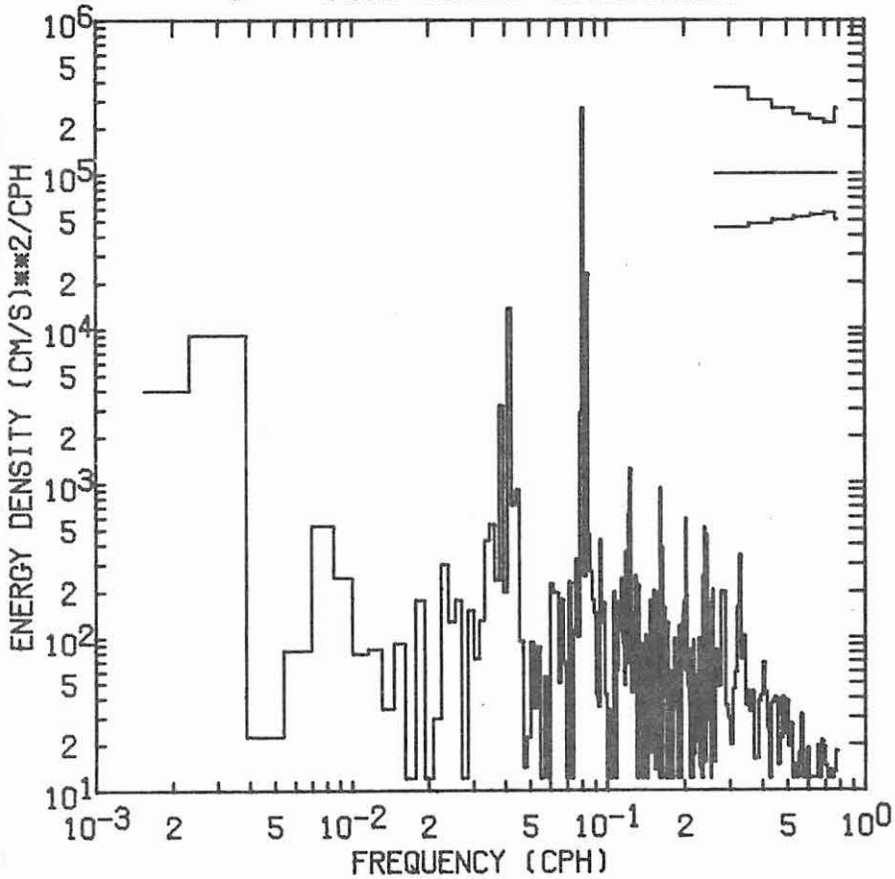
V - COMPONENT SPECTRUM

METER S/N 2057, AT DEPTH 88.2 (M)

STARTING TIME 56.70139 JUL.DAY (PST) 1977



U - COMPONENT SPECTRUM



V - COMPONENT SPECTRUM

METER S/N 2057, AT DEPTH 88.2 (M)

STARTING TIME 56.70139 JUL.DAY (PST) 1977