# Nearshore Wave Climatology Yaquina Bay, Oregon (1971-1981)

by Clayton Creech

OREGON STATE UNIVERSITY
SEA GRANT COLLEGE PROGRAM
Ads 418
Corvallis, Or 97331

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# Acknowledgements

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# Introduction and Summary

This report describes the nearshore wave climatology off Yaquina Bay (Newport), Oregon for the period October 1971 - March 1981, and extends the time period for the wave climatology reported earlier, Creech (1977). It includes a brief description of the wave measurement system, calibration procedures, and data reduction techniques employed. Resulting data are presented as tables and diagrams showing mean, percentage exceedance, occurrence and persistence of given conditions; three-month time history plots of wave height and period are also included for the entire record length.

Major results are:

- Mean winter (Oct-Mar) wave height is 7.6 feet.
- Mean summer (Apr-Sep) wave height is 4.1 feet.
- Maximum significant wave height recorded was 24 feet in December 1972 with an associated period of 17 seconds.
- 50% of winter waves were 8 feet or higher.
- 10% of winter waves were 12 feet or higher.
- 1% of winter waves were 17 feet or higher.
- 17% of winter wave conditions persisted at 8 feet or greater for 2 consecutive days.
- 90% of summer waves were 6 feet or less, maximum summer waves reach 16 feet.

# Instrumentation

The wave measuring system consists of a portable commercial long-period vertical seismometer (Teledyne-Geotech Model SL 210) connected to a strip chart recorder. An electrical signal proportional to the vertical velocity of the case is produced by a moving coil transducer. The seismometer rests on the floor (large concrete pad) of the OSU Marine Science Center 1.5 mi (2 km) from the ocean, Fig. 1. The seismometer is

in a room that is temperature controlled by a thermostat, for pendulum stability, and in an area as free of foot traffic as possible. The seismometer signal is prefiltered for ambient seismic noise by a low pass filter with a break point at 0.7 Hz before input to the recorder. We use a potentiometric chart recorder (Honeywell Model 193) with a 1.0 mv full-scale span and a chart speed of 1 min/inch. A separate timer activates the recorder for 10 minutes at six-hour intervals.

Beginning in January 1977, the seismometer was connected to a signal linearizer (Zopf, et al., 1976) prior to being recorded. The linearizer or wavemeter displays wave height directly on an analog meter. The wavemeter contains an active filter with $1/\omega^3$ response between 0.1 and 0.4 Hz (equivalent to ocean wave periods of 20-5 seconds) which removes the wave period ($\omega^2$) dependence and compensates for the $\omega$ dependence of the velocity transducer as well. The output of the wavemeter is recorded on a chart recorder.

# Calibration

Correlation tests at our location confirmed the utility of the Longuet-Higgins (1950) theory depicted in Fig. 2. We obtained useful estimates of nearshore wave height and period for water depths of 40 feet (as opposed to either breaker heights or true deep water wave heights). These estimates were compared with one year of visual observations augmented by occasional pressure sensor and fathometer data taken from the OSU research vessel R/V Paiute. The visual observations were made from shore against a 12-foot-high Coast Guard buoy anchored in 40 feet of water. By observing the buoy motions for ten minutes through binoculars from a hill, an observer estimated the wave height ($H_o$) and period of the waves passing the buoy. A linear regression of $H_o$ versus seismometer inferred waves ($H_s$) gave $H_o = 1.07\ H_s - .87$ feet with a correlation coefficient of 0.87 and a standard error of the estimate of 1.6 feet for 403 observations, Fig. 3. Chart periods were approximately one-half ocean wave periods as Darbyshire (1950) reported and Longuet-Higgins (1950) predicted.

# Data Reduction

A technician reads each strip chart sequence to determine significant wave height (nearest whole foot). Prior to 1977 the concurrent zero-crossing period (nearest half-second) and peak-to-peak deflection of seismometer signal was determined. An average zero-crossing period for each sequence could not be determined because the amplitude of the deflections varies with the period cubed (Zopf, et al., 1976).

Since 1977 with the recording of the wavemeter output, the number of zero crossings in 10 minutes are counted and converted to an average period. The average zero-crossing period is multiplied by two to approximate ocean wave periods. Because the method of determining average zero-crossing period from the wavemeter output ignores small humps that do not cross zero, the periods are much longer (~4-5 sec.) than prior to 1977. When wave heights of 4 feet or lower occurred, the seismic signal level was barely perceptable above noise causing the number of zero-crossings to decrease and an apparent increase in zero-crossing period. Periods greater than 20 seconds at low wave heights were ignored.

An overlay template is used to determine wave height from the strip chart recording of wavemeter output. It was assumed that the larger waves in a recording sequence approximated, $H_1/10$, the average height of the highest 10% of the waves in a record. This value was reduced by 20% according to the Longuet-Higgins (1952) formula to yield $H_s$, average of highest 33% of waves, for that record. ($H_s = .8\ H_1/10$). Four significant wave heights and periods were determined and tabulated each day at six-hour intervals.

A strong earthquake in the Pacific basin occurring during or one hour preceding a recording sequence causes full-scale recorder deflections, making determination of wave height and period impossible. Occasionally, the chart recorder failed to ink or ran out of paper, causing brief gaps in the recording. These missing sequences from either cause were interpolated for height and period based on adjacent records, nearshore ship reports, and Yaquina Bay Coast Guard visual observations. Only gaps of 24 hours (four records) or less were interpolated.

# Data Presentation

The following diagrams show exceedance, persistence and occurrence by year and season. Only the wave periods after 1976 are presented here, because the wave period before and after January 1977 was determined by different techniques, as explained in the data reduction section.

Table 1 shows the average monthly, quarterly, seasonal, and yearly statistics for both height and period. The table indicates a definite change in height between September-October and March-April, thus justifying the division of winter-summer seasons between those months.

Figures 4, 5, and 6 are long-linear height exceedance plots. A dashed line indicates estimated 50-and 100-year occurrence intervals.

Figures 7, 8, and 9 are persistence diagrams, which indicate the continuity of a given or higher wave height for given periods of time. Minimum time is 1/4 day (6 hours) due to the sampling period. A 1-day duration means 4 consecutive observations at the given level. For instance, a height of 12 feet or more for 1 day occurred only 2% of the total year or 5% of the winter observations.

Figures 10, 11, and 12 are height histograms showing the percentage occurrence distribution at 1-foot intervals. A bias toward 6 feet is caused by $H_{1/10}$ values of both 7 and 8 feet being reduced by 20% to give an $H_s$ of 6 feet (nearest whole foot).

Figures 13, 14, and 15 are height and period histograms for the second half of the record (January 1977 - March 1981).

Figures 16, 17, and 18 are height versus period diagrams, which show distribution of heights at various periods. The number of occurrences at each specific height and period are indicated with contouring to emphasize predominant occurrences.

Appendix A includes 3-month plots of wave height and period versus time from October 1971 through March 1981.

# References


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Darbyshire, J. 1950. Identification of microseismic activity with sea waves. Proc. Roy. Soc. (London) Serial A 202:439-448.

Draper, L. 1967. The analysis and presentation of wave data - a plea for uniformity. Proc. 10th Conf. on Coastal Engr., Tokyo, 1966. Am. Soc. Civ. Eng. Vol. I:1-11.

Longuet-Higgins, M. S. 1950. A theory of the origin of microseisms. Trans. Roy. Soc. (London) Serial A 234:1-35.

Longuet-Higgins, M. S. 1952. On the statistical distribution of the heights of sea waves. J. Mar. Res. 11:245-266.

Zopf, D. O., H. C. Creech, and W. H. Quinn. 1976. The wavemeter: a land-based system for measuring nearshore ocean waves. Mar. Tech. Soc. J. 10(4):19-25.



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Figure 1

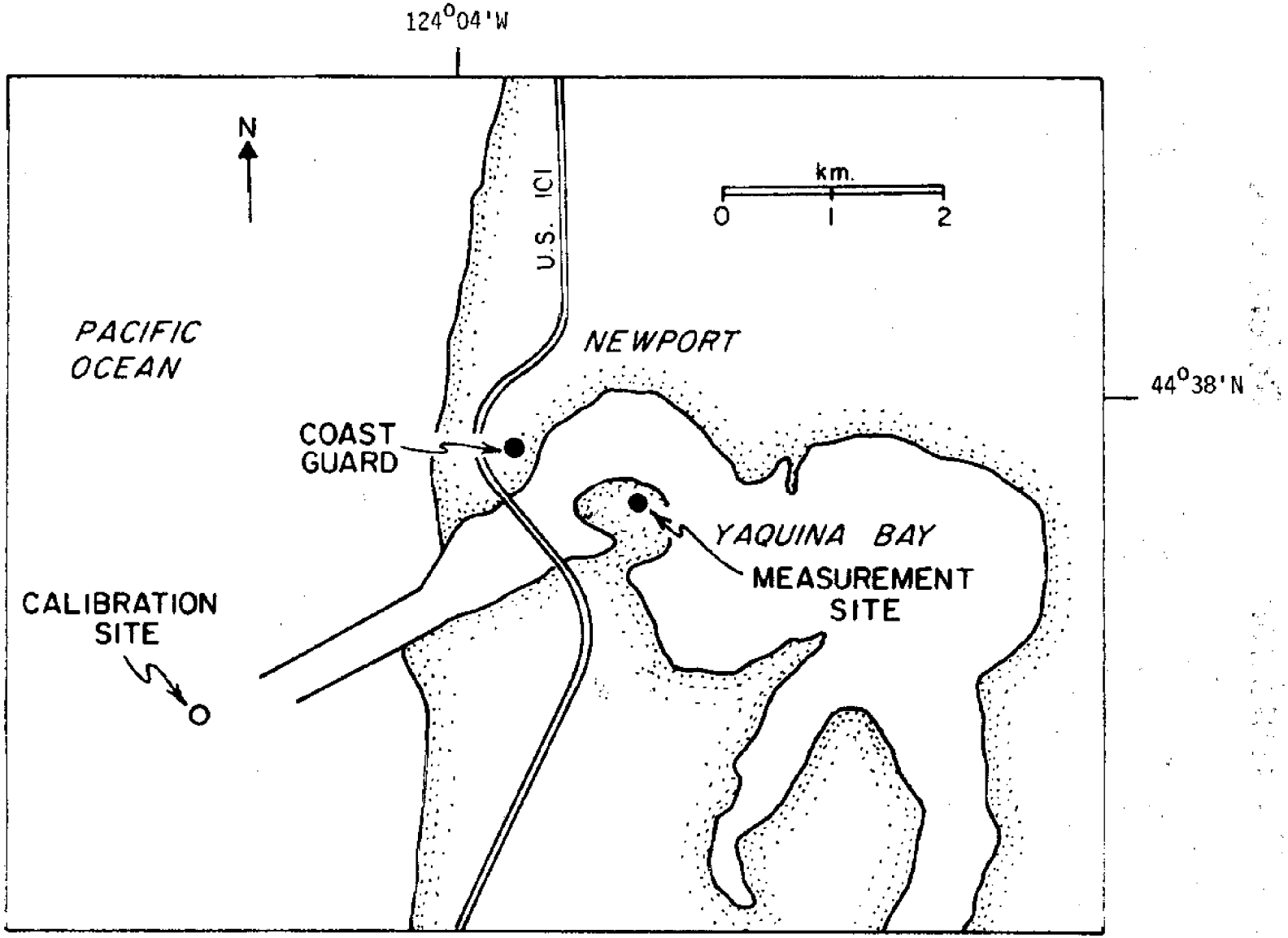

124°04'W
N
km.
0
1
2
U.S. 101
PACIFIC
OCEAN
NEWPORT
44°38'N
COAST
GUARD
YAQUINA BAY
MEASUREMENT
SITE
CALIBRATION
SITE

Figure 2

# NEARSHORE GENERATION OF MICROSEISMS BY OCEAN WAVES

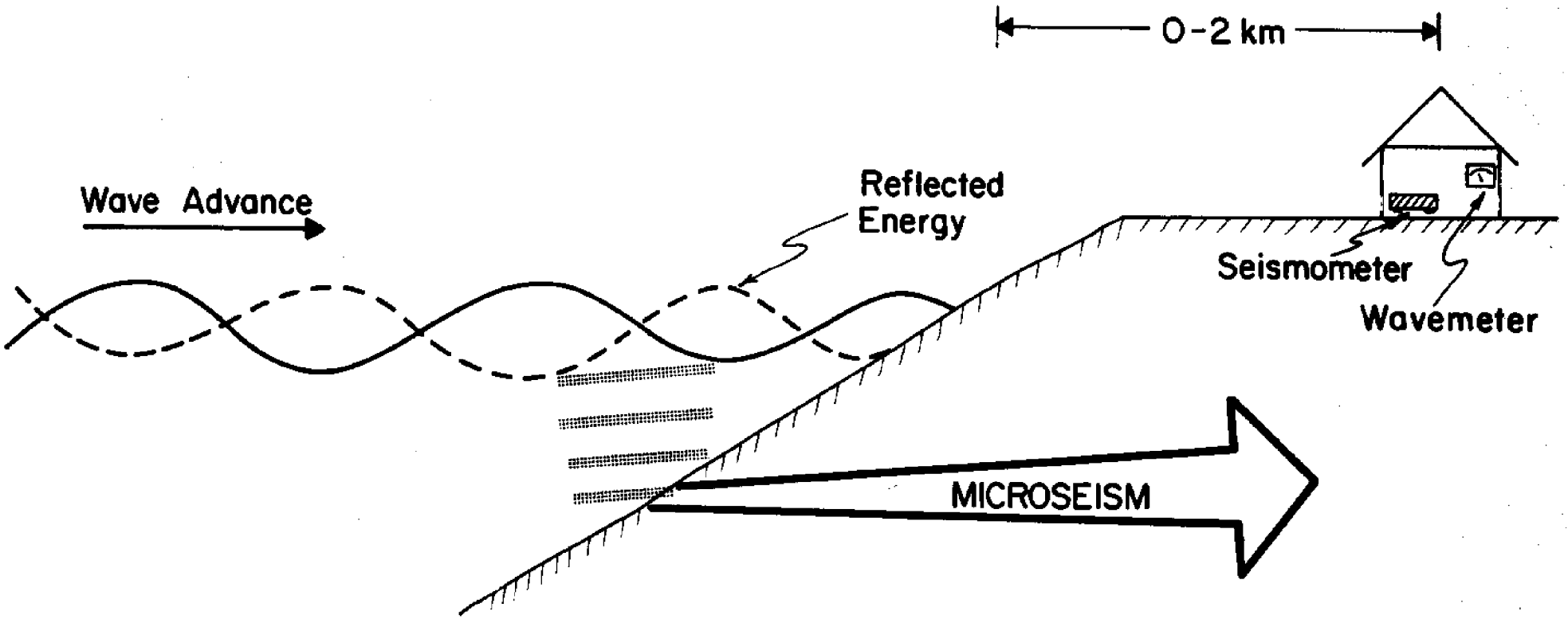


Figure 3

SIGNIFICANT WAVE HEIGHT

JUL 71 - JUN 72

YAQUINA BAY, OREGON

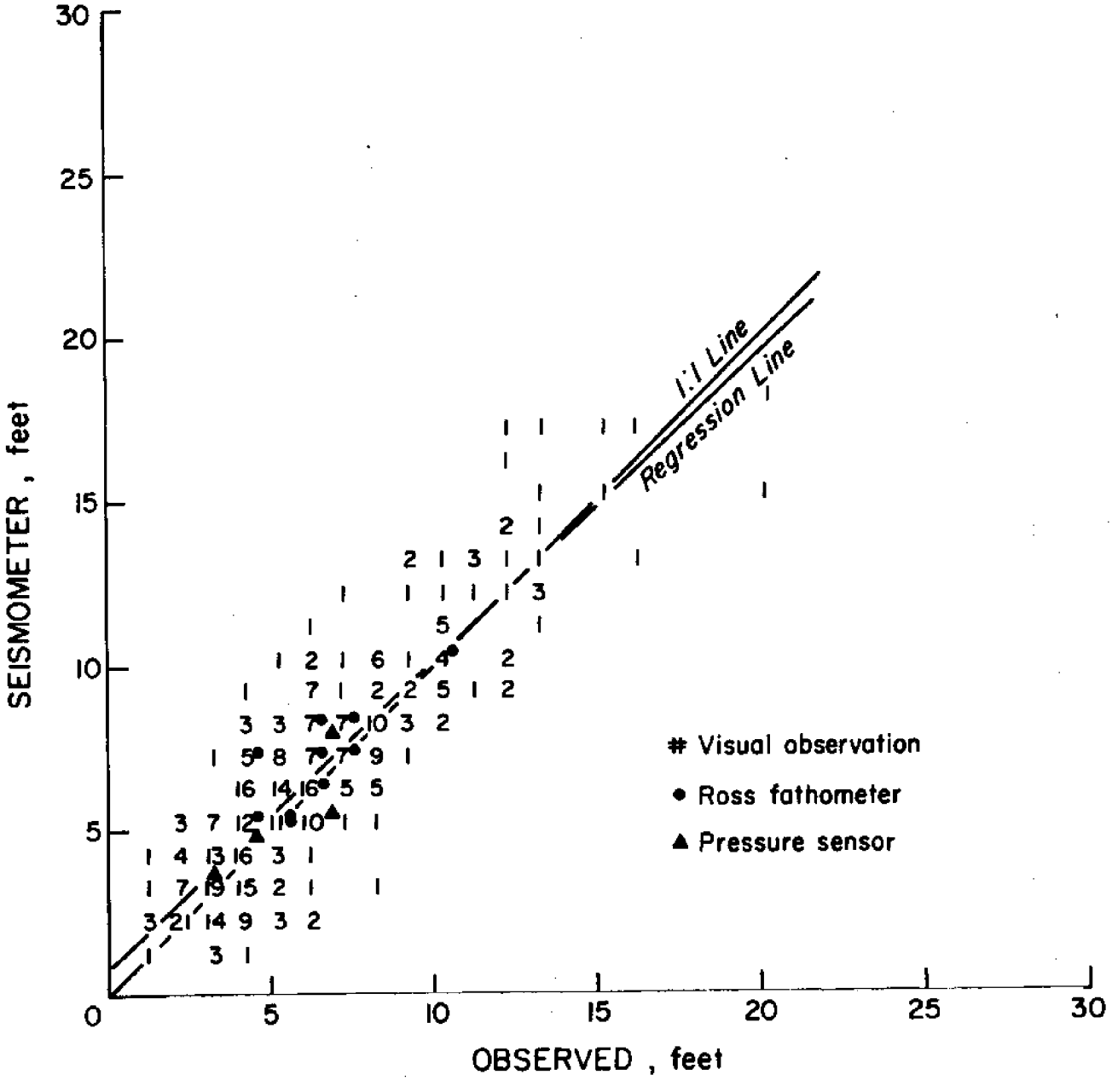


TABLE 1

SUMMARY STATISTICS

YAQUINA BAY, OREGON

Significant Wave Height, $H_s$, Feet (October 1971 - March 1981)

| | Months | | | | | | | | | | | | Quarters | | | | S | W | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | Apr-Sep | Oct-Mar | Jan-Dec |
| Mean | 8.1 | 8.0 | 7.3 | 5.6 | 4.9 | 3.8 | 3.3 | 3.2 | 4.1 | 6.4 | 7.9 | 8.2 | 7.8 | 4.8 | 3.5 | 7.5 | 4.1 | 7.6 | 6.0 |
| Standard deviation | 3.0 | 2.8 | 2.9 | 2.2 | 2.2 | 1.6 | 1.5 | 1.3 | 1.9 | 3.1 | 3.1 | 3.0 | 2.9 | 2.2 | 1.6 | 3.2 | 2.0 | 3.1 | 3.1 |
| Minimum | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Maximum | 20 | 20 | 18 | 15 | 13 | 11 | 9 | 9 | 16 | 19 | 20 | 24 | 20 | 15 | 16 | 24 | 16 | 24 | 24 |
| Sample Size | 1240 | 1129 | 1240 | 1080 | 1103 | 1068 | 1116 | 1116 | 1080 | 1190 | 1191 | 1240 | 3609 | 3251 | 3312 | 3621 | 6563 | 7230 | 13793 |

Zero Crossing Period, $T_z$, seconds (April 1977 - September 1980)

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 15.2 | 14.8 | 14.8 | 14.1 | 13.4 | 13.8 | 13.5 | 12.7 | 13.1 | 14.8 | 14.1 | 13.8 | 14.9 | 13.8 | 13.1 | 14.2 | 13.4 | 14.6 | 14.1 |
| Standard deviation | 1.6 | 1.7 | 1.6 | 2.1 | 1.9 | 2.2 | 2.2 | 2.1 | 2.1 | 1.7 | 1.6 | 1.5 | 1.6 | 2.1 | 2.1 | 1.6 | 2.1 | 1.7 | 2.0 |
| Minimum | 11 | 10 | 10 | 8 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 9 | 10 | 8 | 9 | 9 | 8 | 9 | 8 |
| Maximum | 21 | 20 | 20 | 20 | 18 | 20 | 20 | 19 | 20 | 19 | 19 | 18 | 21 | 20 | 20 | 19 | 20 | 21 | 21 |
| Sample Size | 612 | 555 | 594 | 402 | 404 | 251 | 283 | 312 | 439 | 443 | 461 | 489 | 1761 | 1057 | 1034 | 1393 | 2091 | 3154 | 5245 |

Figure 4

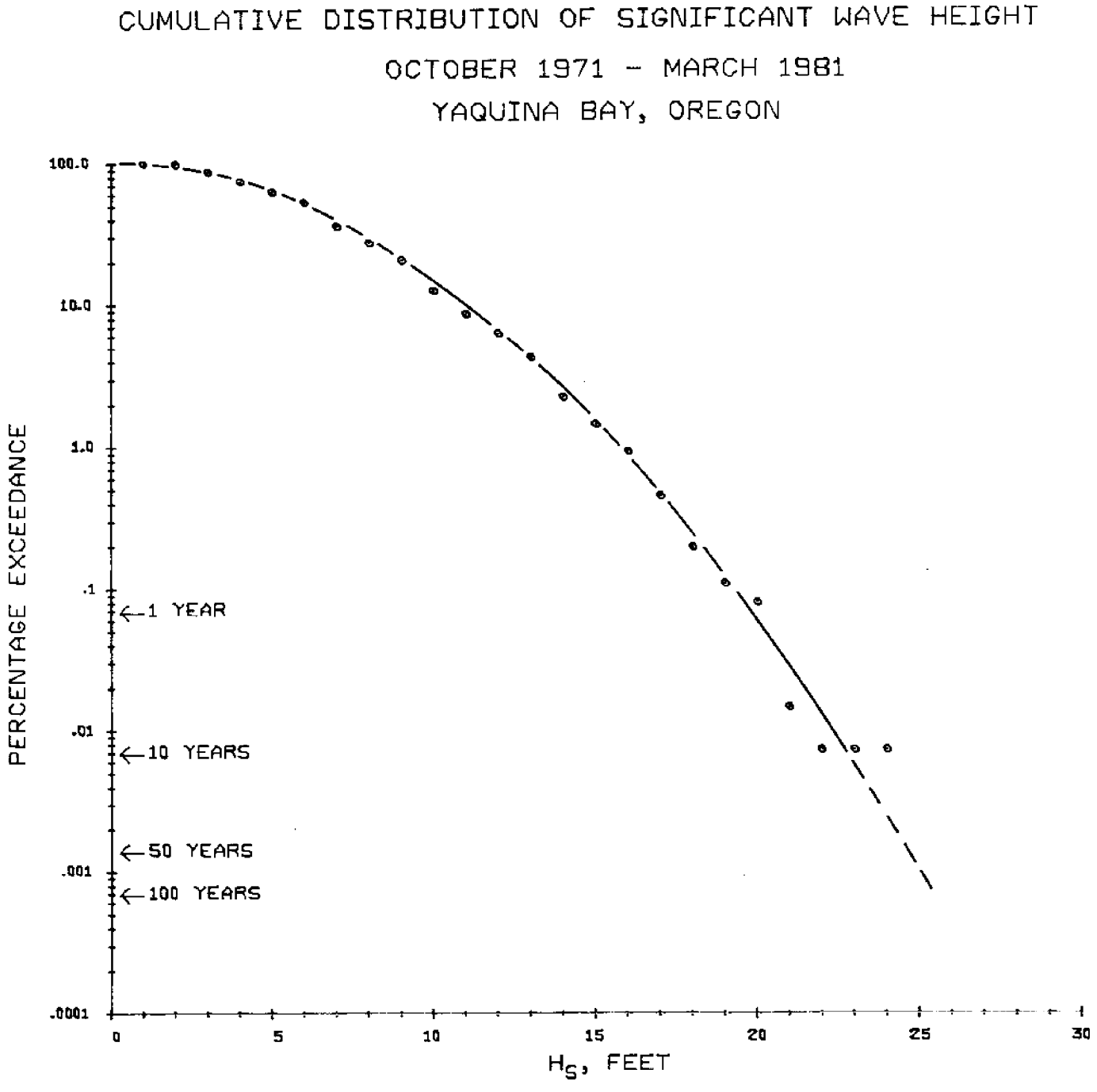

CUMULATIVE DISTRIBUTION OF SIGNIFICANT WAVE HEIGHT
OCTOBER 1971 - MARCH 1981
YAQUINA BAY, OREGON
PERCENTAGE EXCEEDANCE
100.0
10.0
1.0
.1
.01
.001
.0001
←1 YEAR
←10 YEARS
←50 YEARS
←100 YEARS
0
5
10
15
20
25
30
$H_S$, FEET

Figure 5

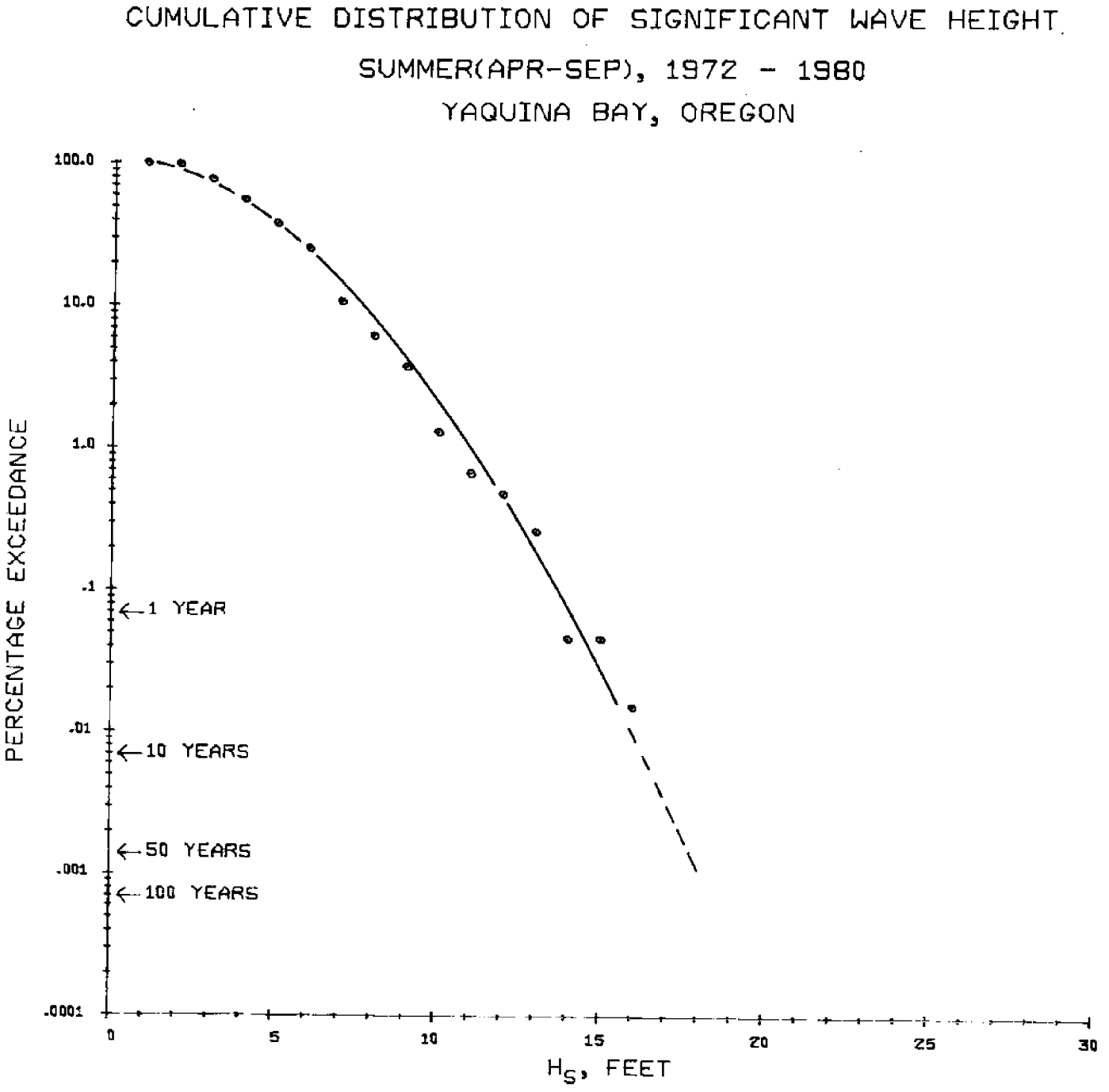

CUMULATIVE DISTRIBUTION OF SIGNIFICANT WAVE HEIGHT
SUMMER(APR-SEP), 1972 - 1980
YAQUINA BAY, OREGON
PERCENTAGE EXCEEDANCE
100.0
10.0
1.0
.1
.01
.001
.0001
1 YEAR
10 YEARS
50 YEARS
100 YEARS
0
5
10
15
20
25
30
$H_S$, FEET

Figure 6

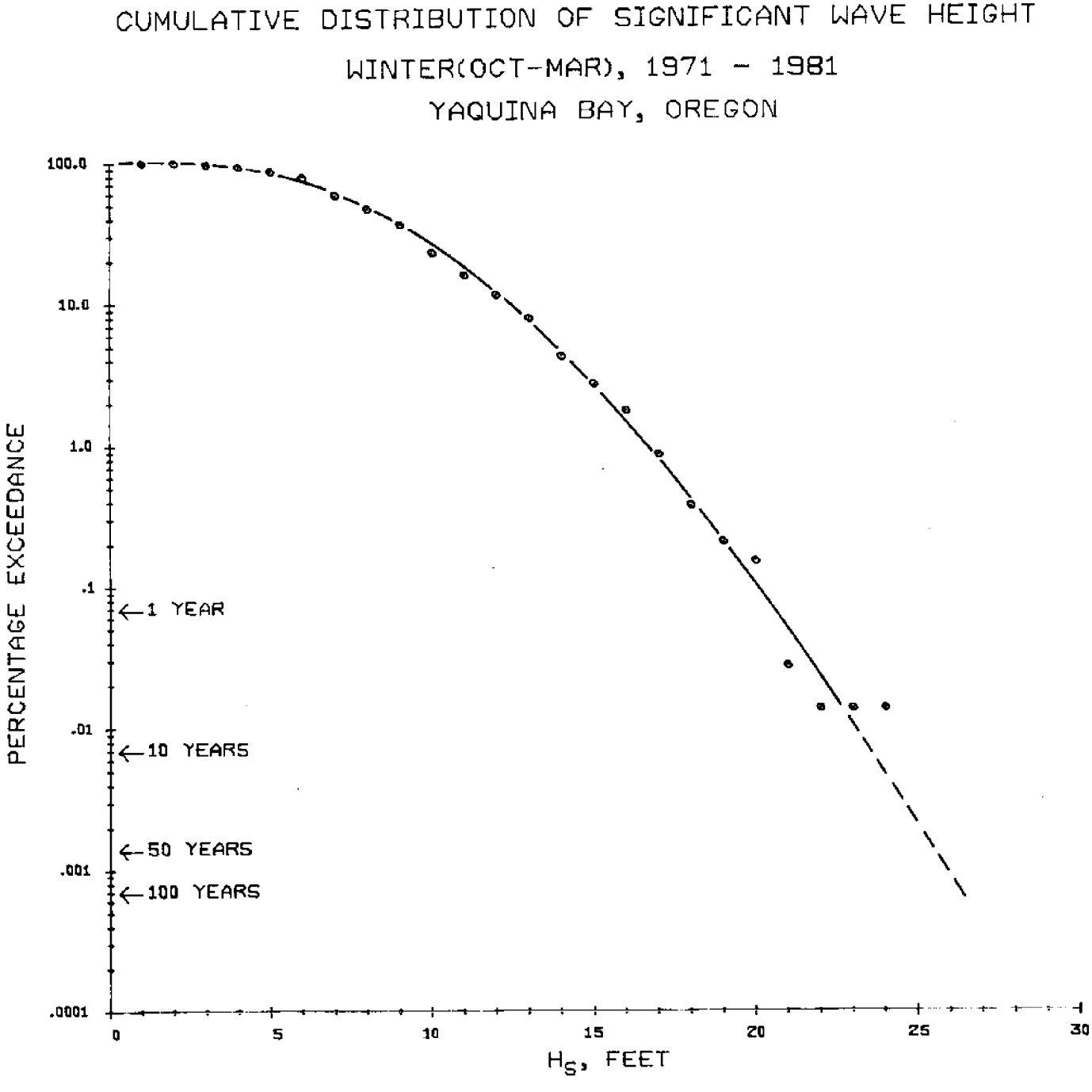

CUMULATIVE DISTRIBUTION OF SIGNIFICANT WAVE HEIGHT
WINTER(OCT-MAR), 1971 - 1981
YAQUINA BAY, OREGON
PERCENTAGE EXCEEDANCE
100.0
10.0
1.0
.1
.01
.001
.0001
1 YEAR
10 YEARS
50 YEARS
100 YEARS
0
5
10
15
20
25
30
$H_S$, FEET

Figure 7

PERSISTENCE OF WAVE HEIGHT

OCTOBER 1971 - MARCH 1981

YAQUINA BAY, OREGON

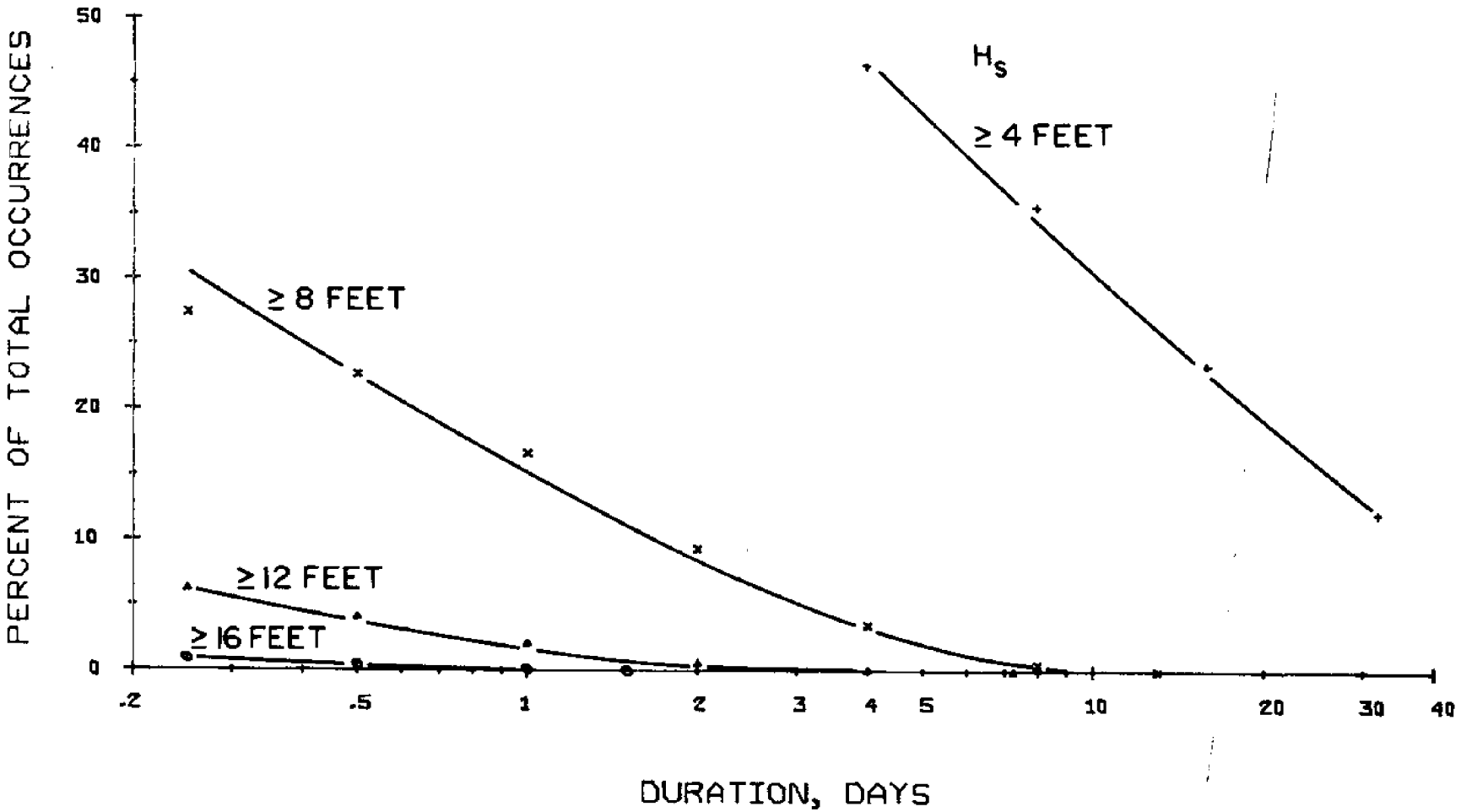


Figure 8

PERSISTENCE OF WAVE HEIGHT

SUMMER(APR-SEP), 1972 - 1980

YAQUINA BAY, OREGON

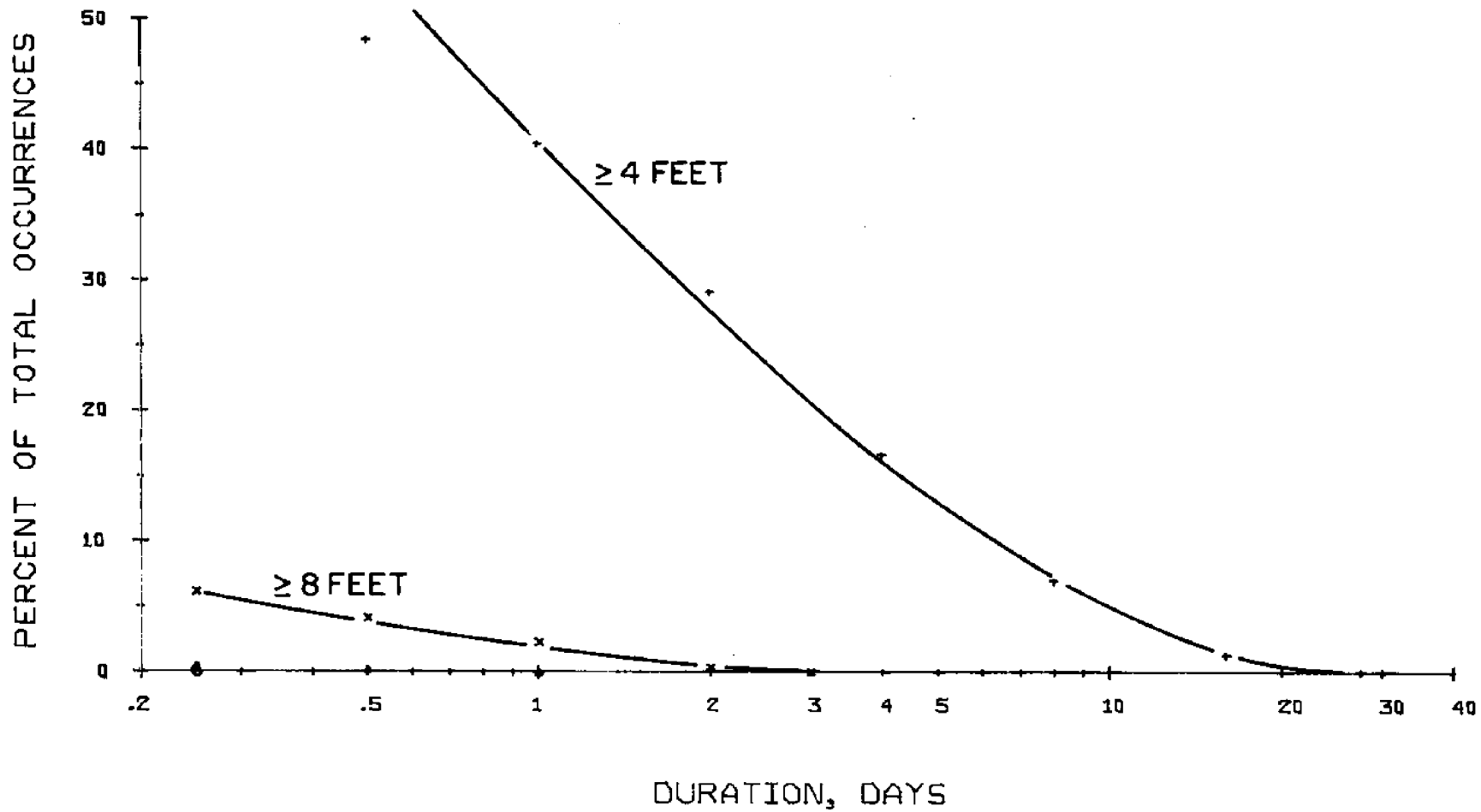


Figure 9

PERSISTENCE OF WAVE HEIGHT

WINTER(OCT-MAR), 1971 - 1981

YAQUINA BAY, OREGON

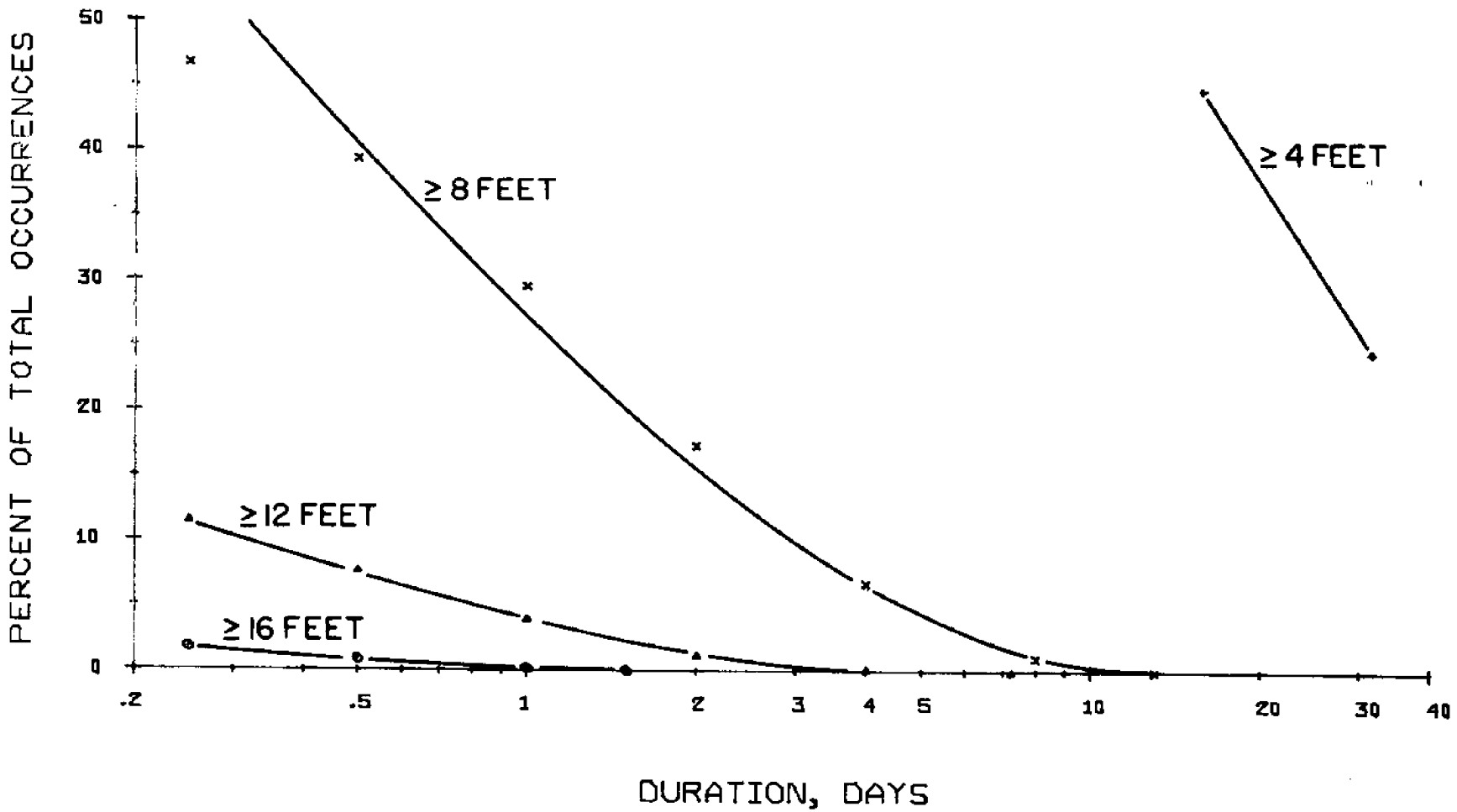


Figure 10

DISTRIBUTION OF WAVE HEIGHT

OCTOBER 1971 - MARCH 1981

YAQUINA BAY, OREGON

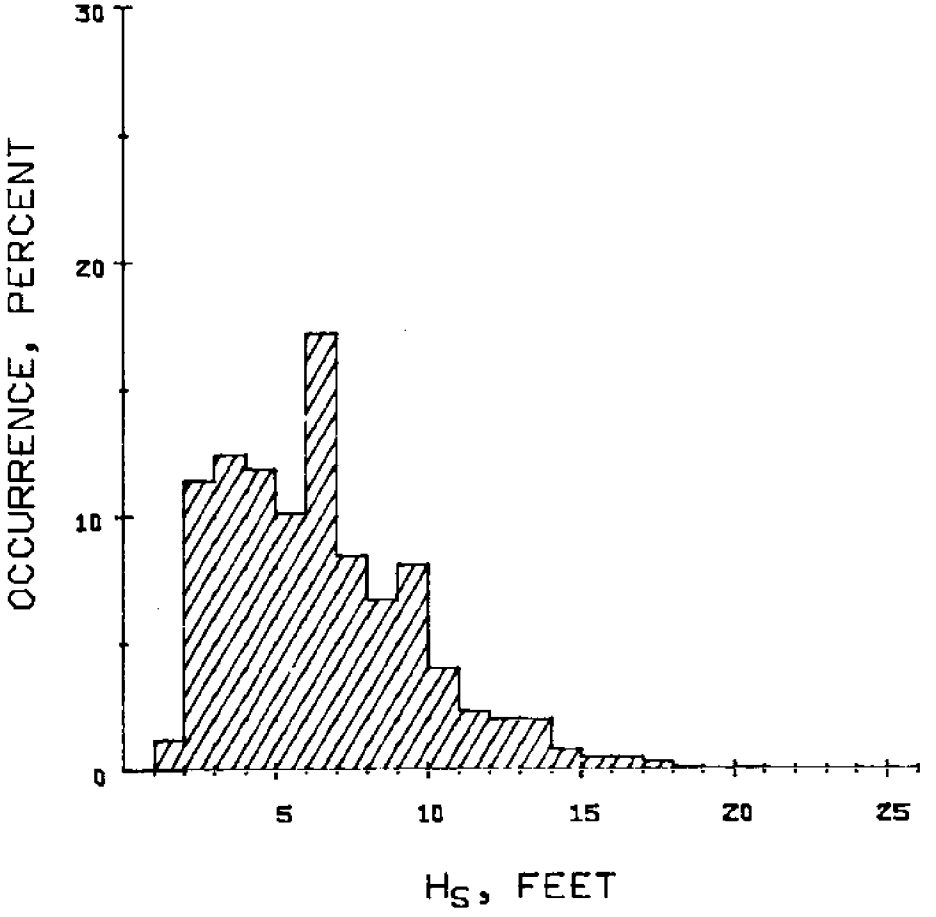


Figure 11

DISTRIBUTION OF WAVE HEIGHT

SUMMER(APR-SEP), 1972 - 1980

YAQUINA BAY, OREGON

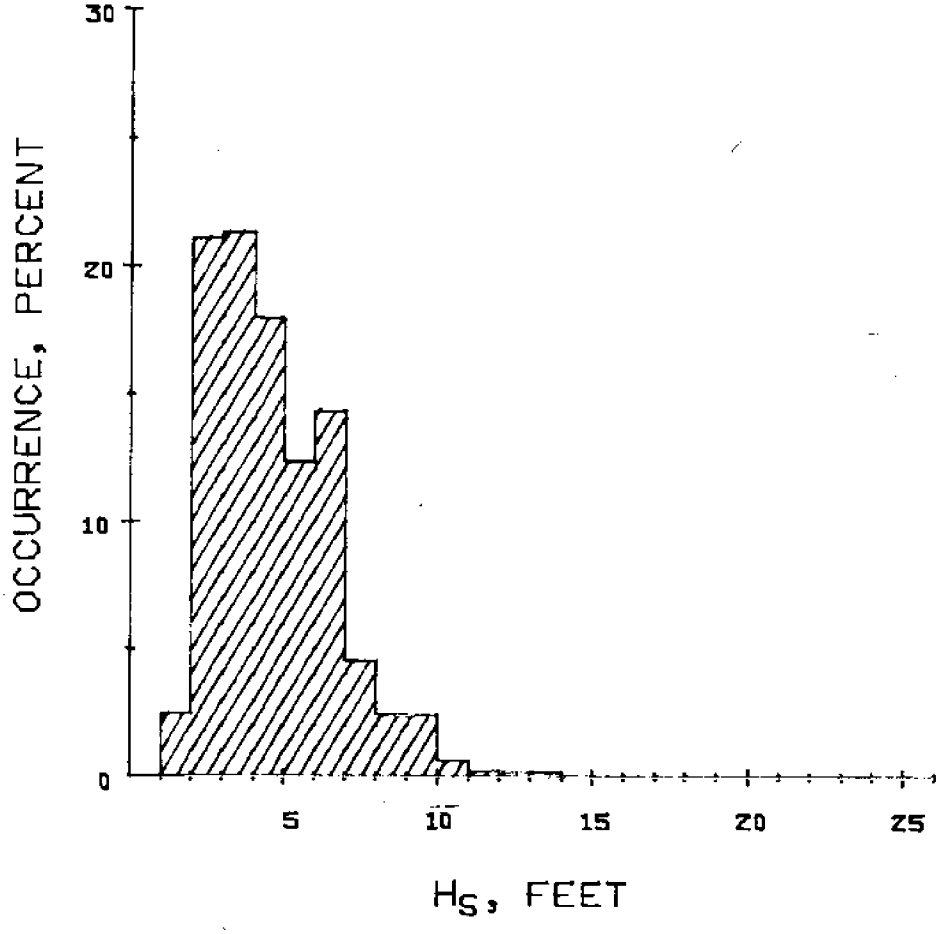


Figure 12

DISTRIBUTION OF WAVE HEIGHT

WINTER(OCT-MAR), 1971 - 1981

YAQUINA BAY, OREGON

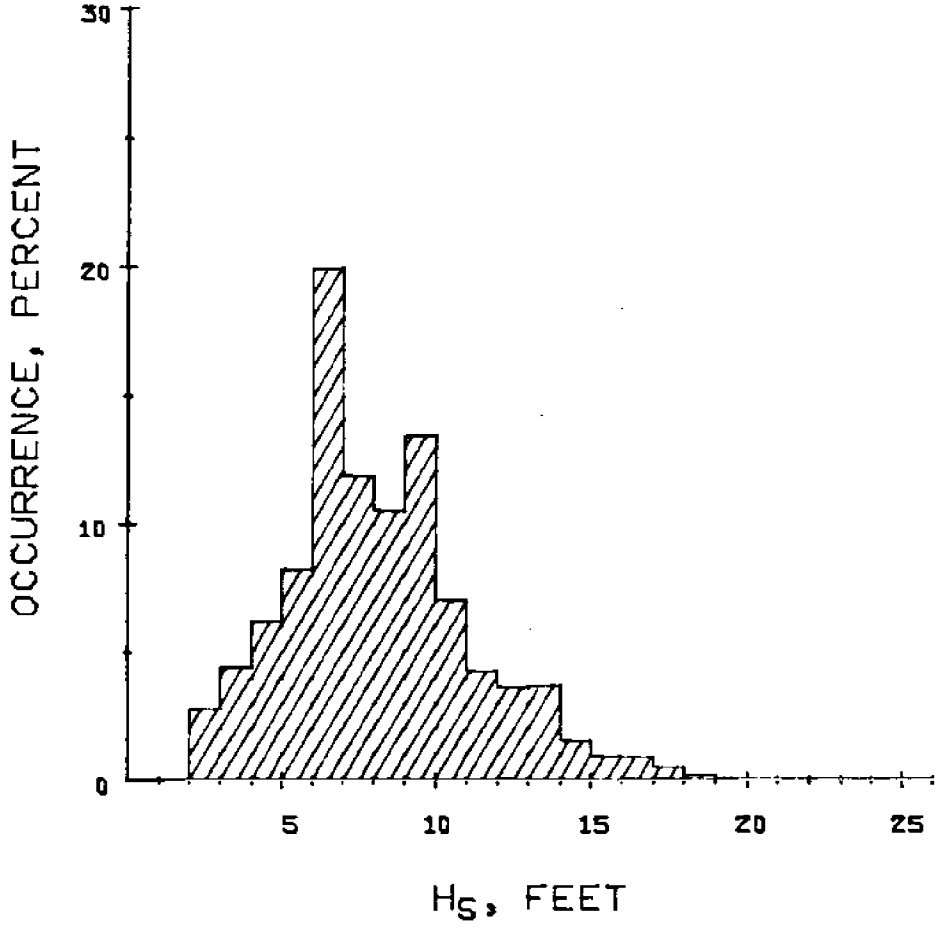
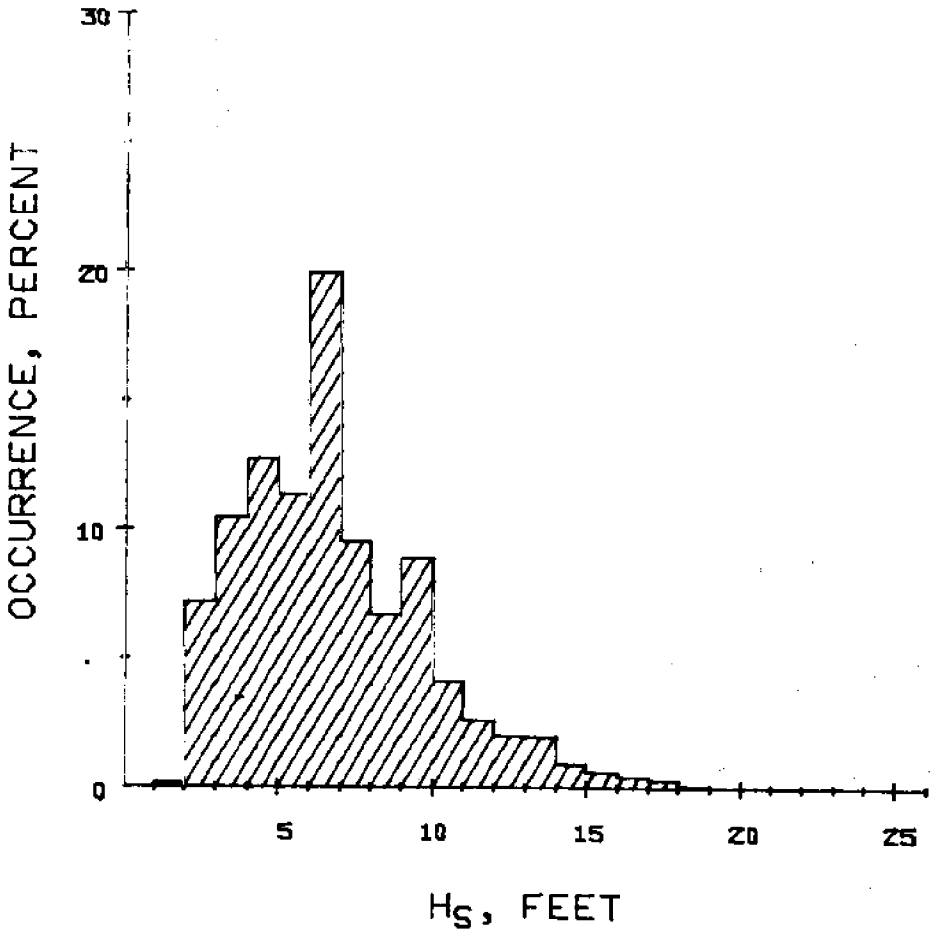


Figure 13

# DISTRIBUTION OF WAVE HEIGHT AND PERIOD

## JANUARY 1977 - MARCH 1981

## YAQUINA BAY, OREGON



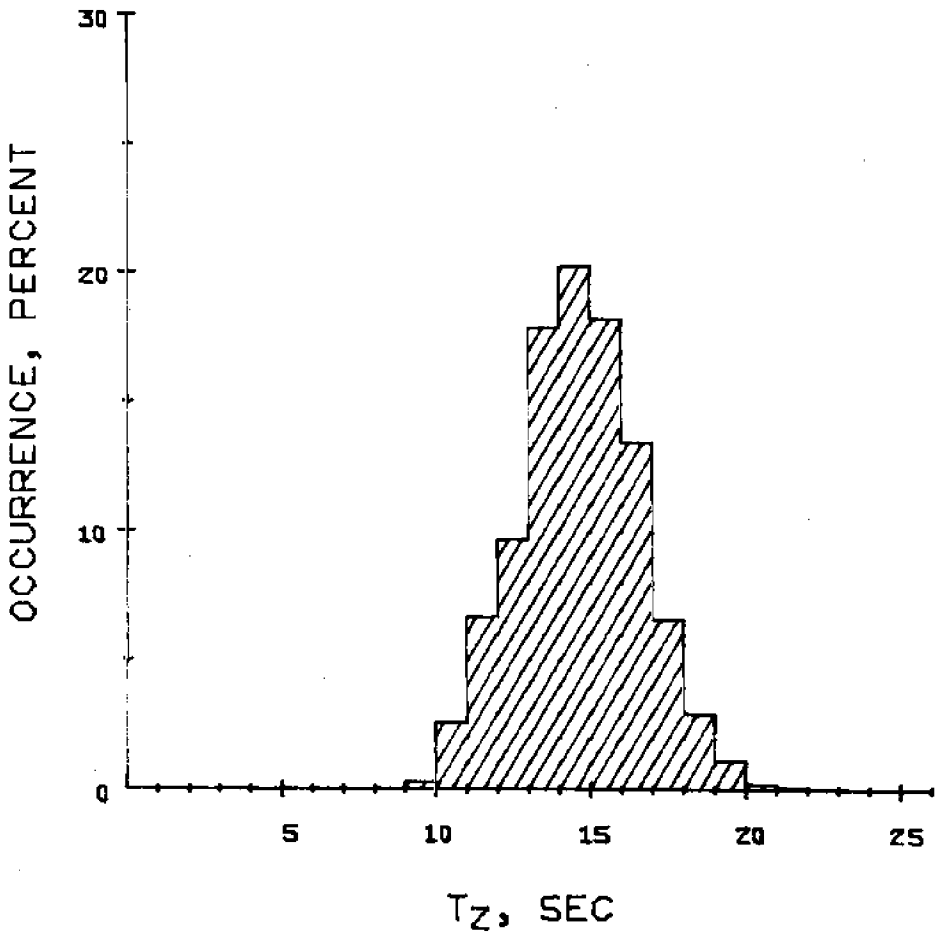
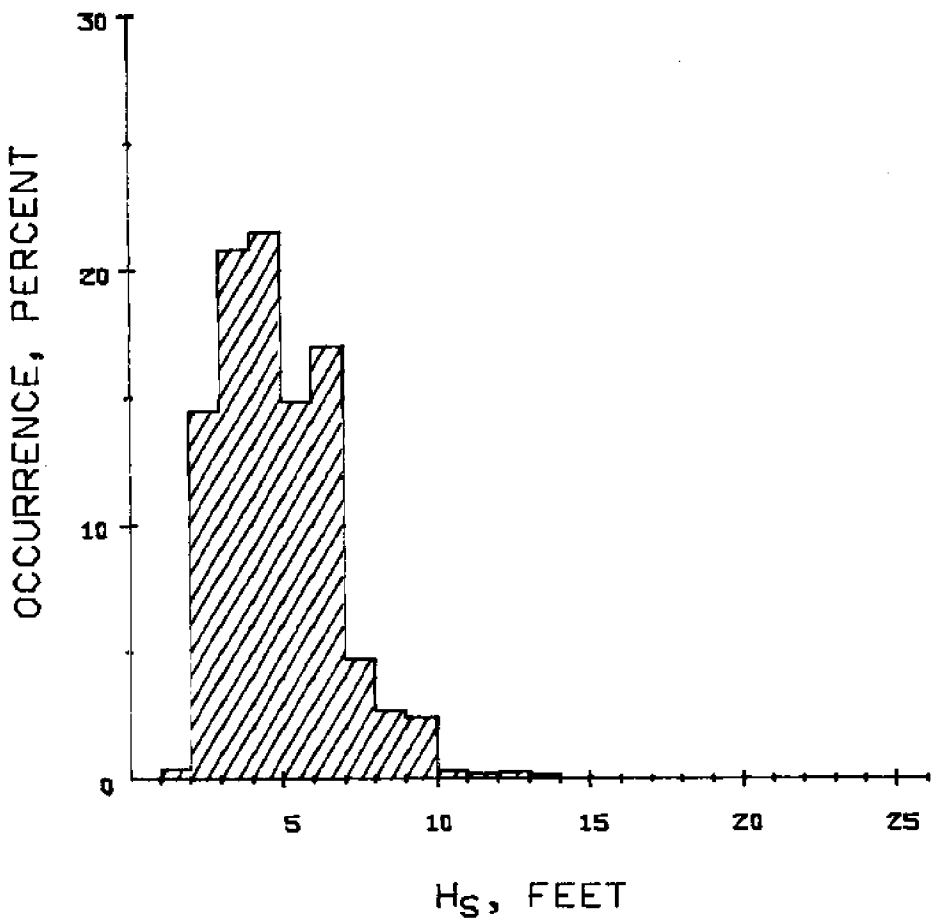



Figure 14

DISTRIBUTION OF WAVE HEIGHT AND PERIOD

SUMMER(APR-SEP), 1977 - 1980

YAQUINA BAY, OREGON



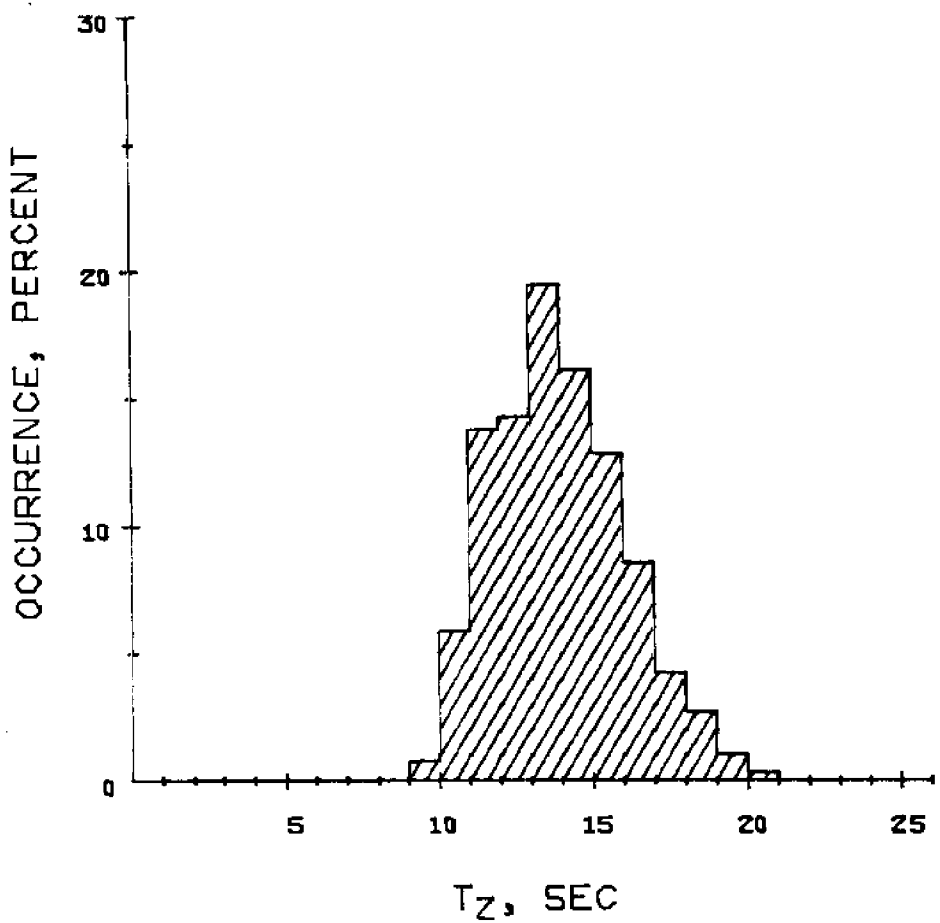
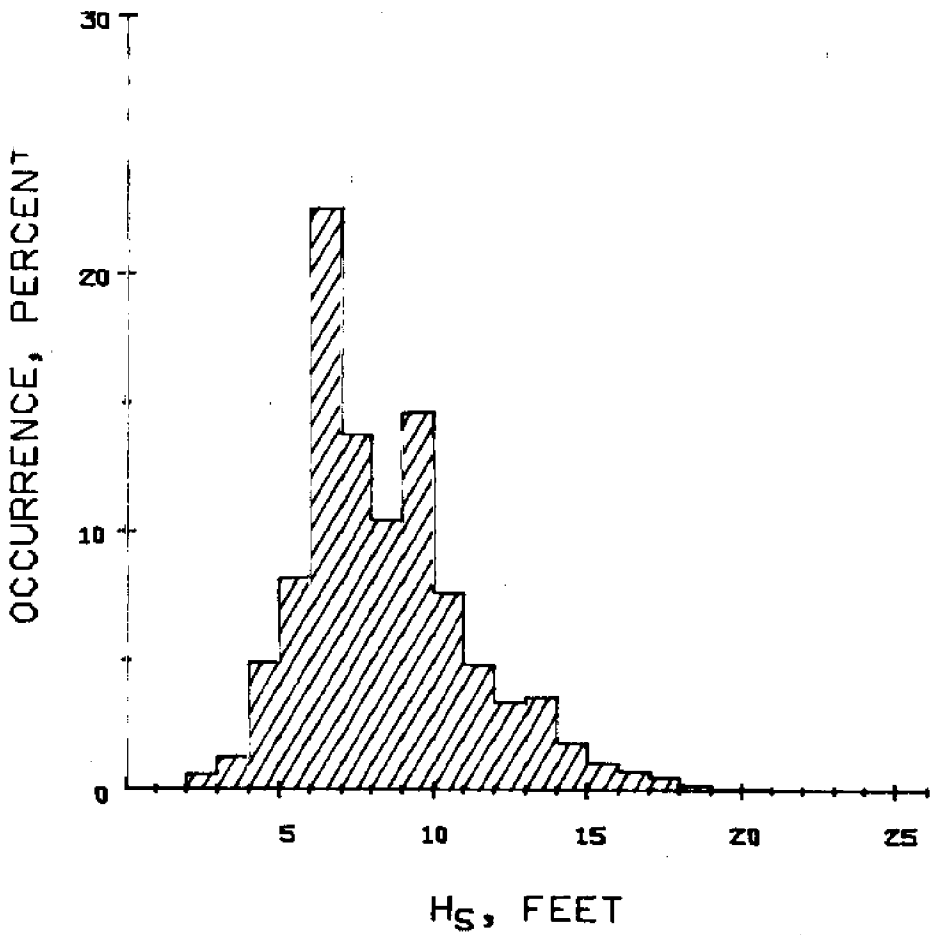



Figure 15

# DISTRIBUTION OF WAVE HEIGHT AND PERIOD

## WINTER(OCT-MAR), 1977 - 1981

## YAQUINA BAY, OREGON



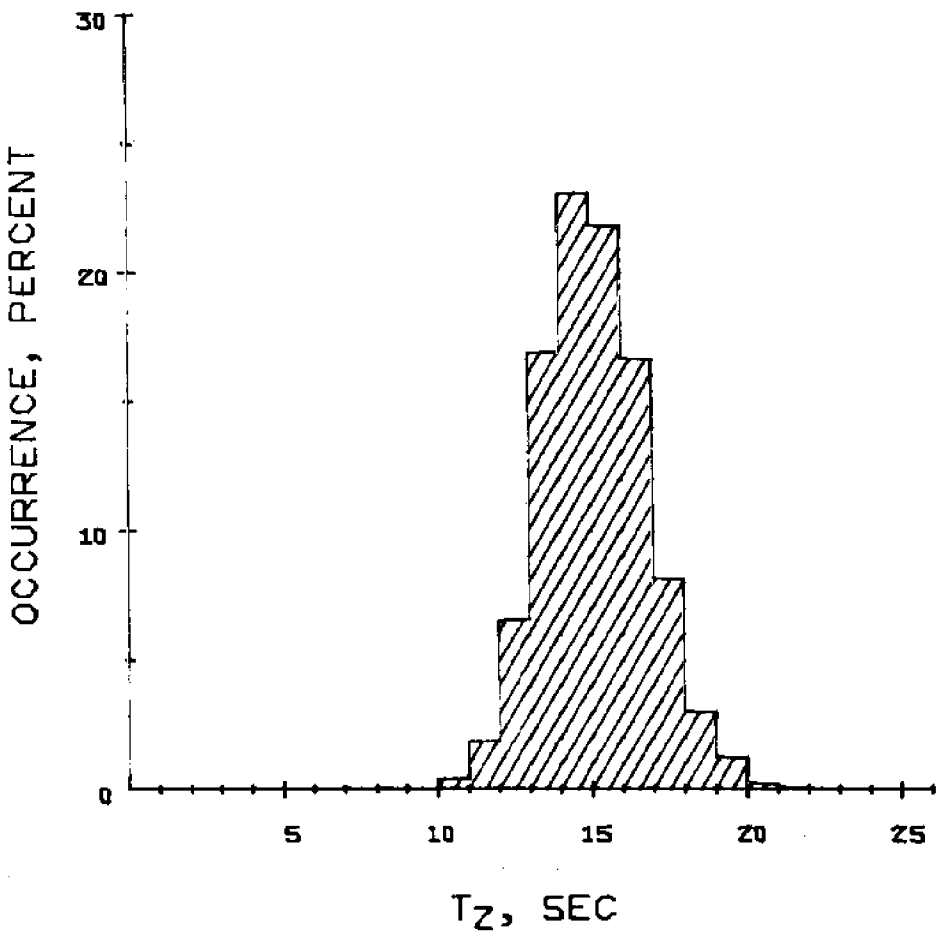



Figure 16

# DISTRIBUTION OF WAVE HEIGHT VERSUS PERIOD
## JANUARY 1977 - MARCH 1981
## YAQUINA BAY, OREGON

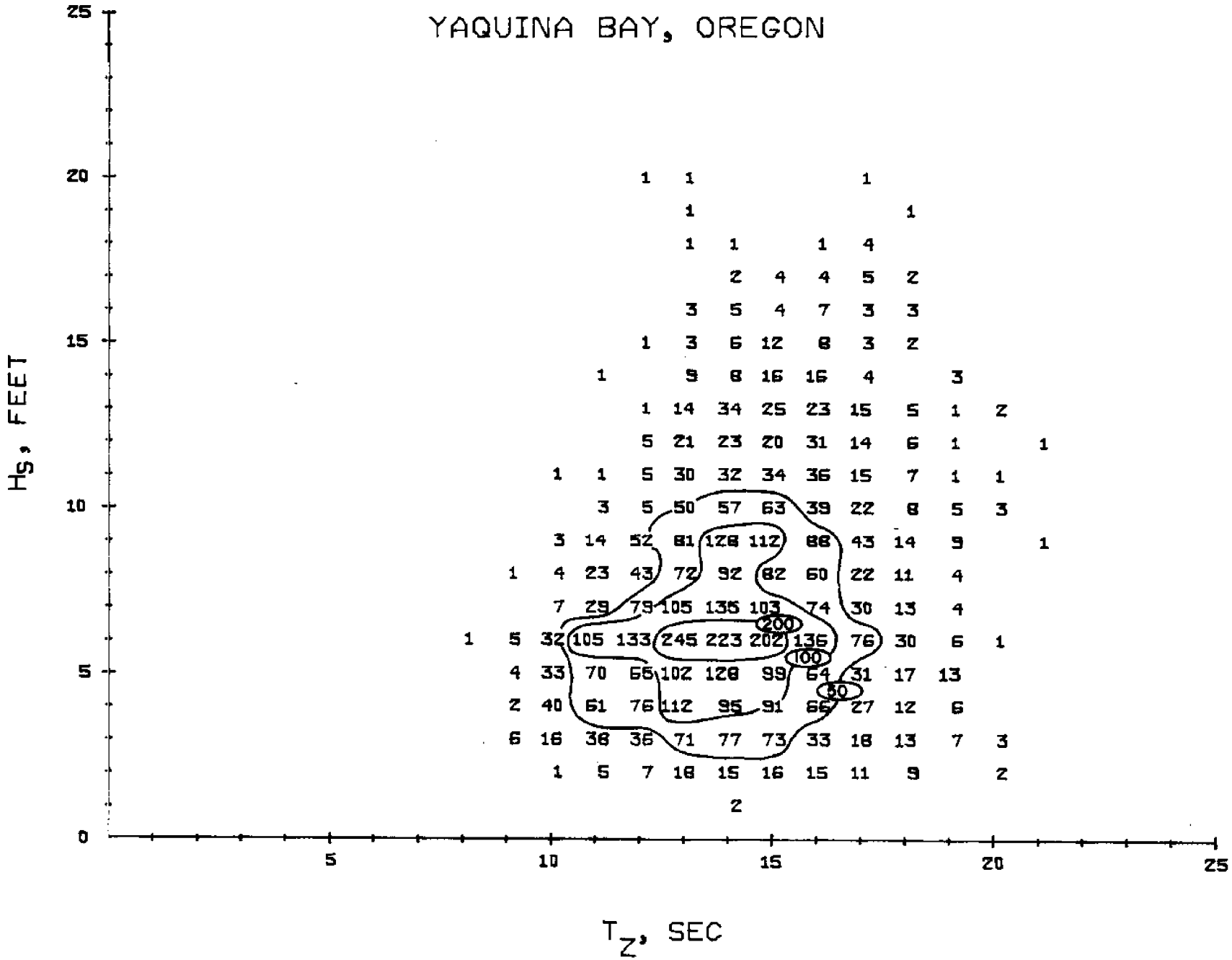


Figure 17

DISTRIBUTION OF WAVE HEIGHT VERSUS PERIOD
SUMMER(APR-SEP), 1977 - 1980
YAQUINA BAY, OREGON

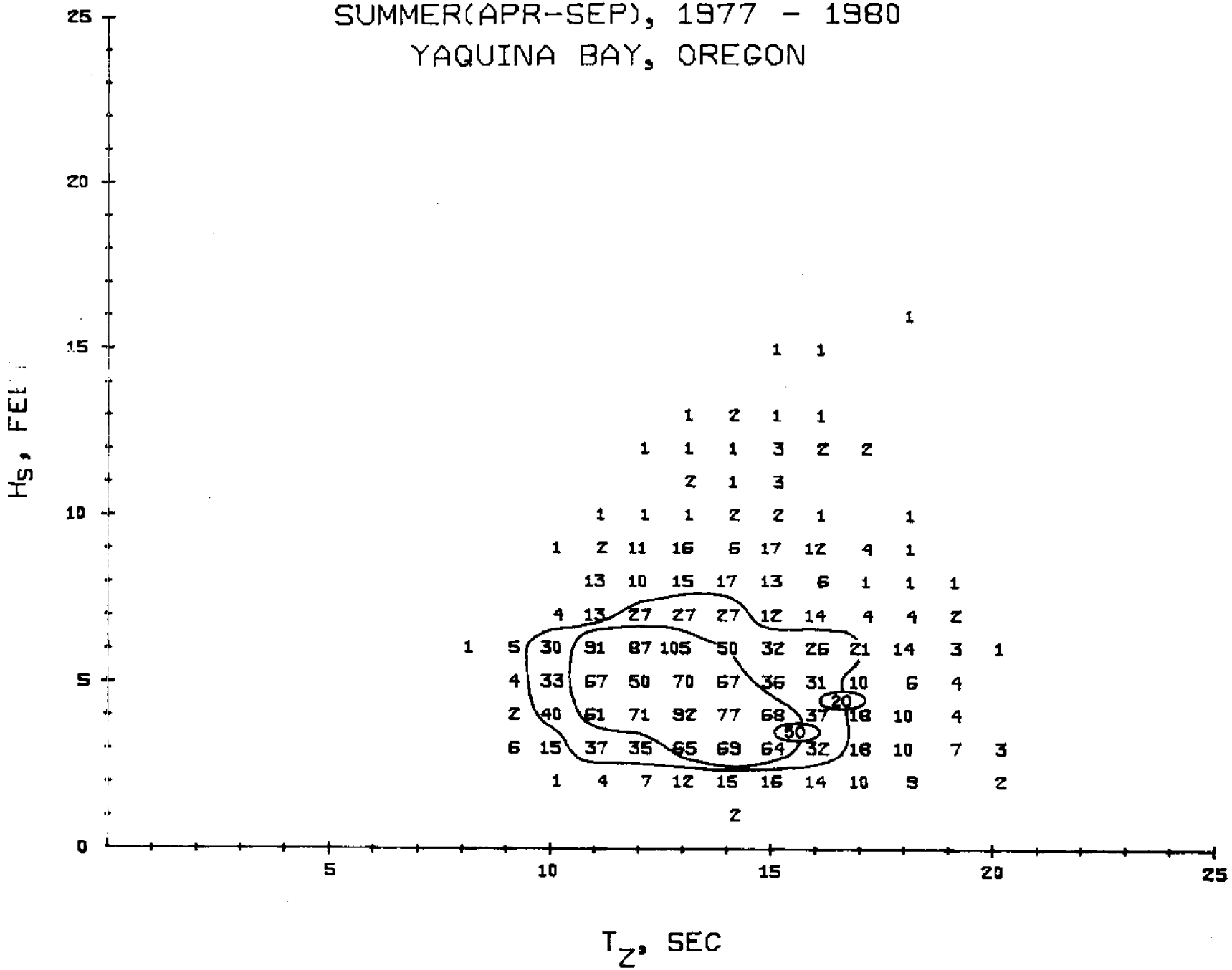
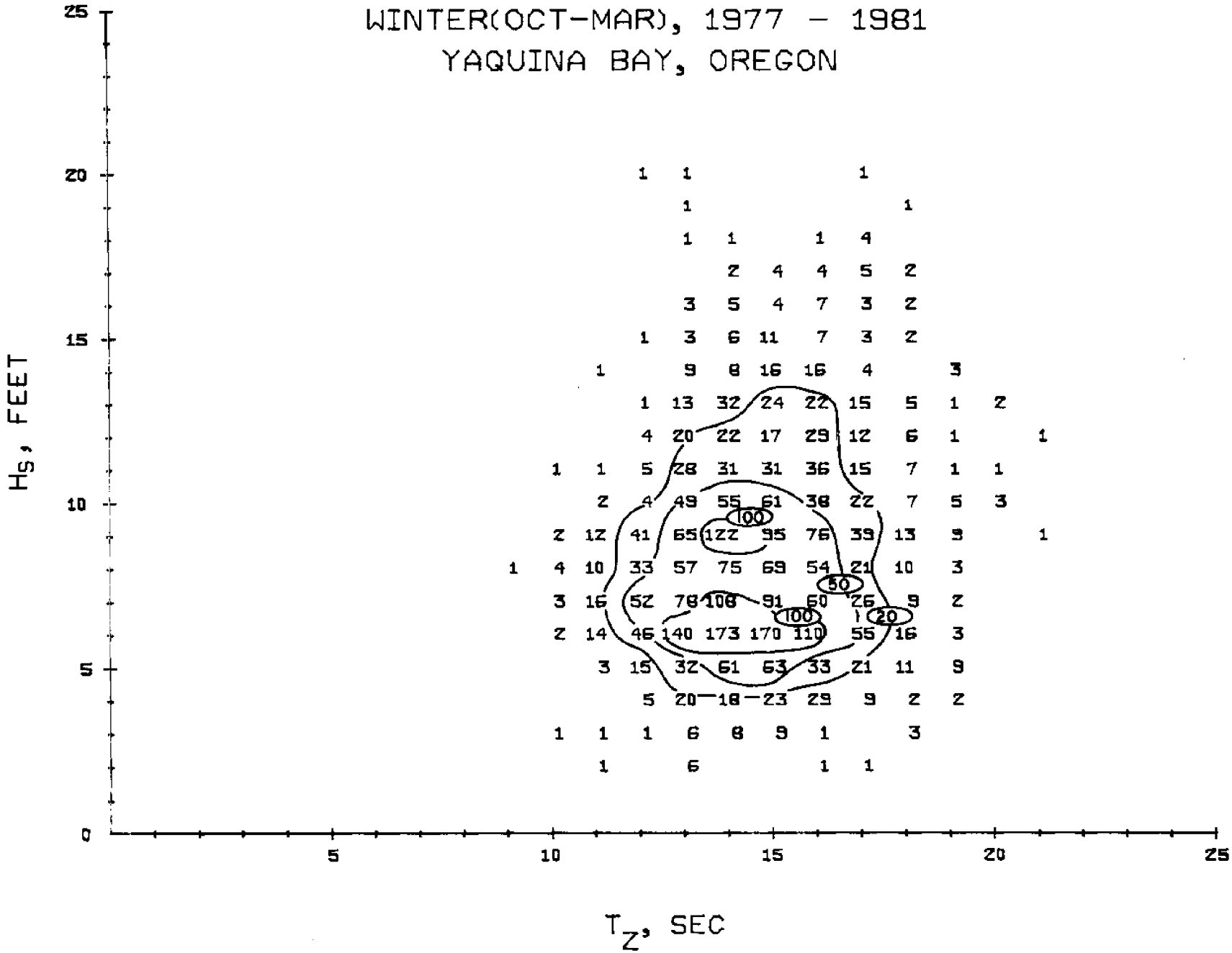


Figure 18

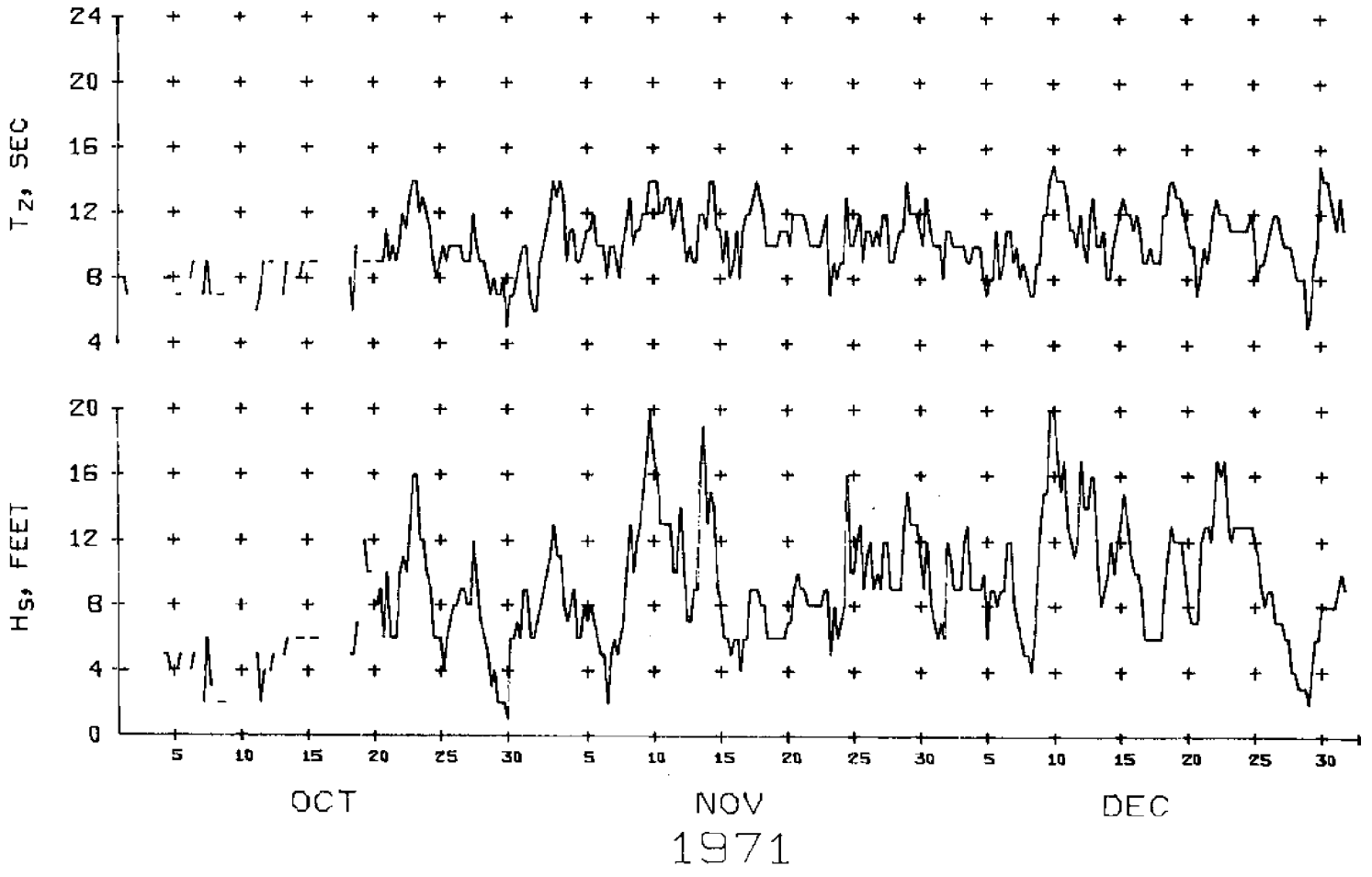
DISTRIBUTION OF WAVE HEIGHT VERSUS PERIOD
WINTER(OCT-MAR), 1977 - 1981
YAQUINA BAY, OREGON



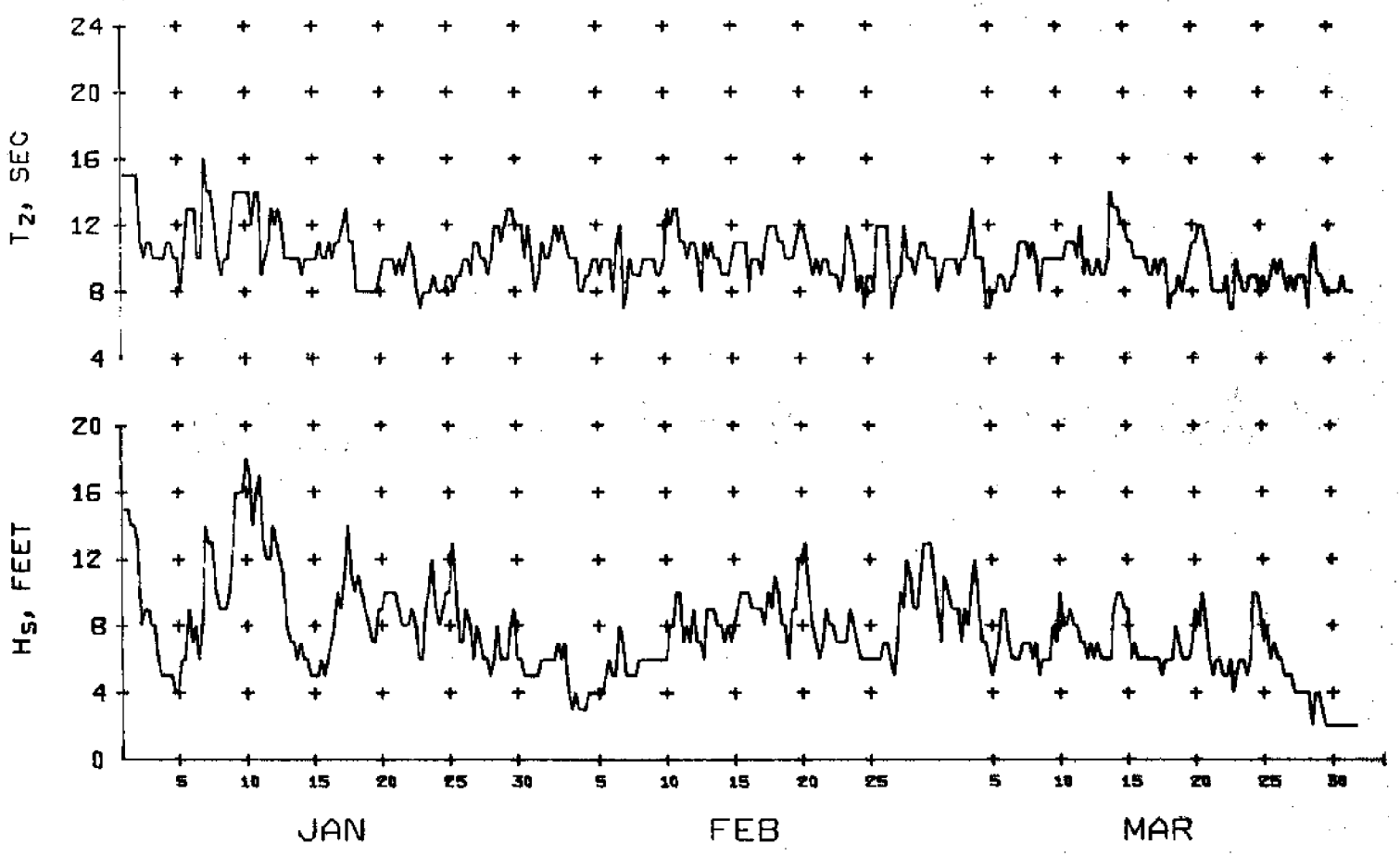
# Appendix A

TIME HISTORY PLOTS

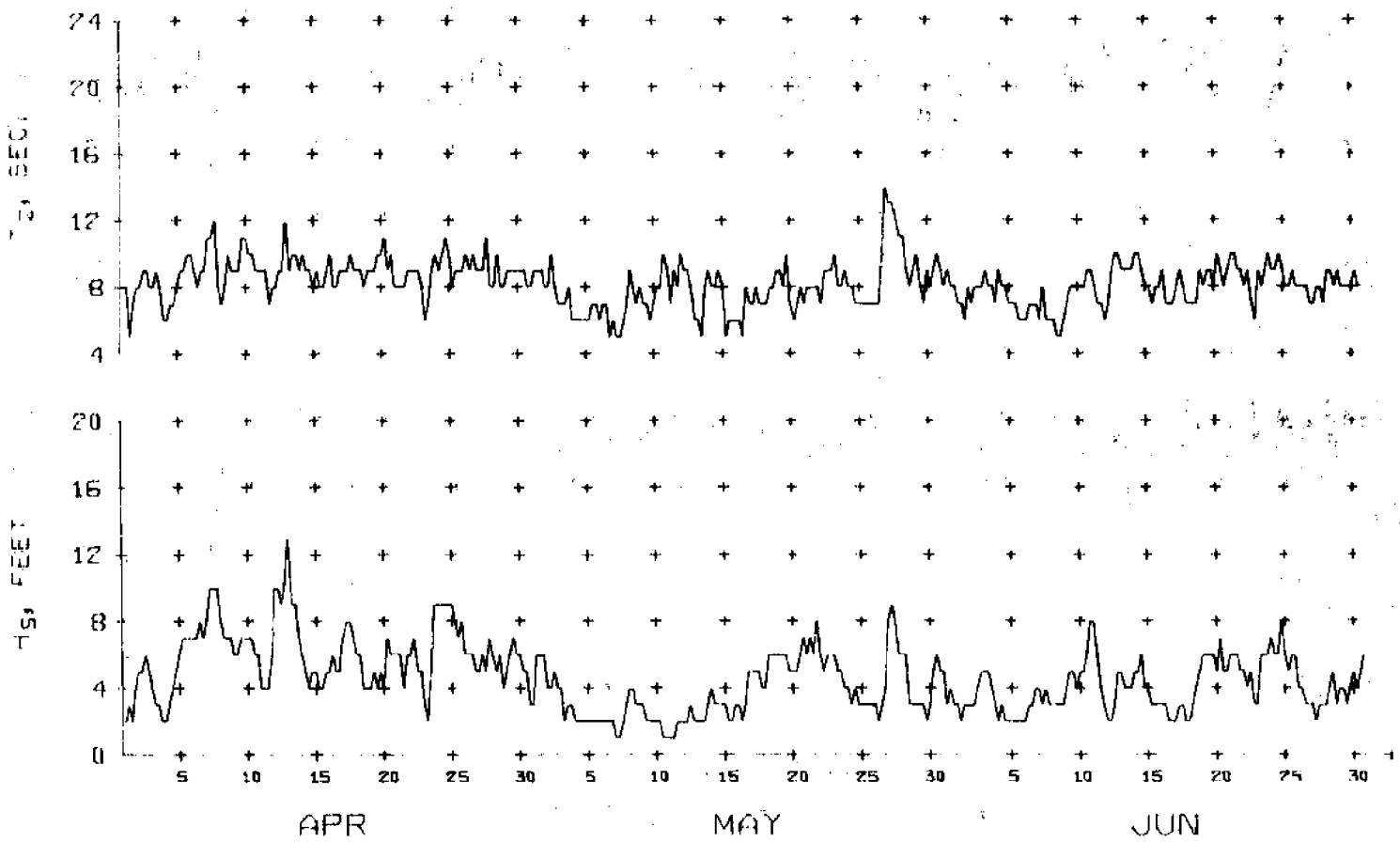
SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER



SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER

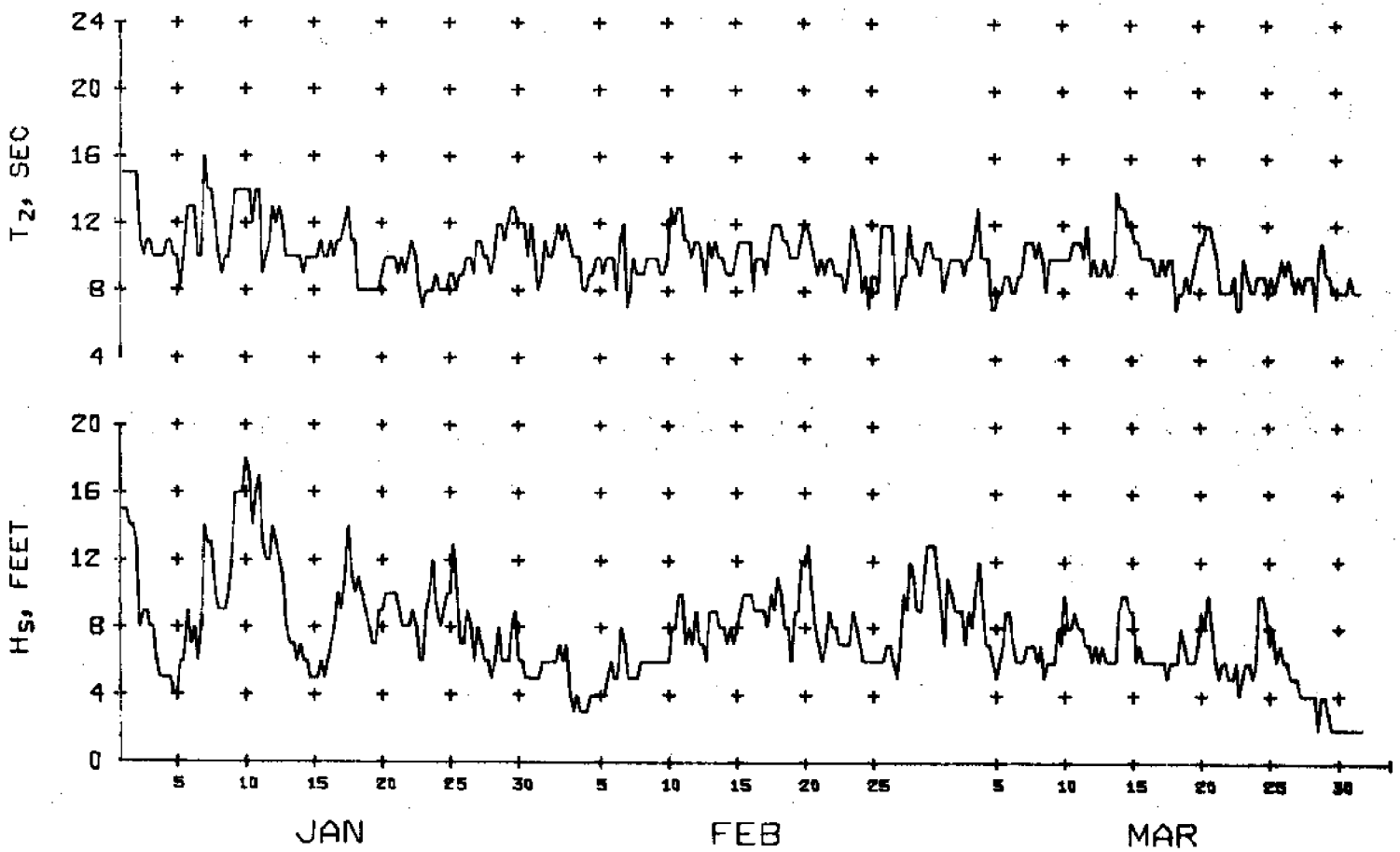


SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER

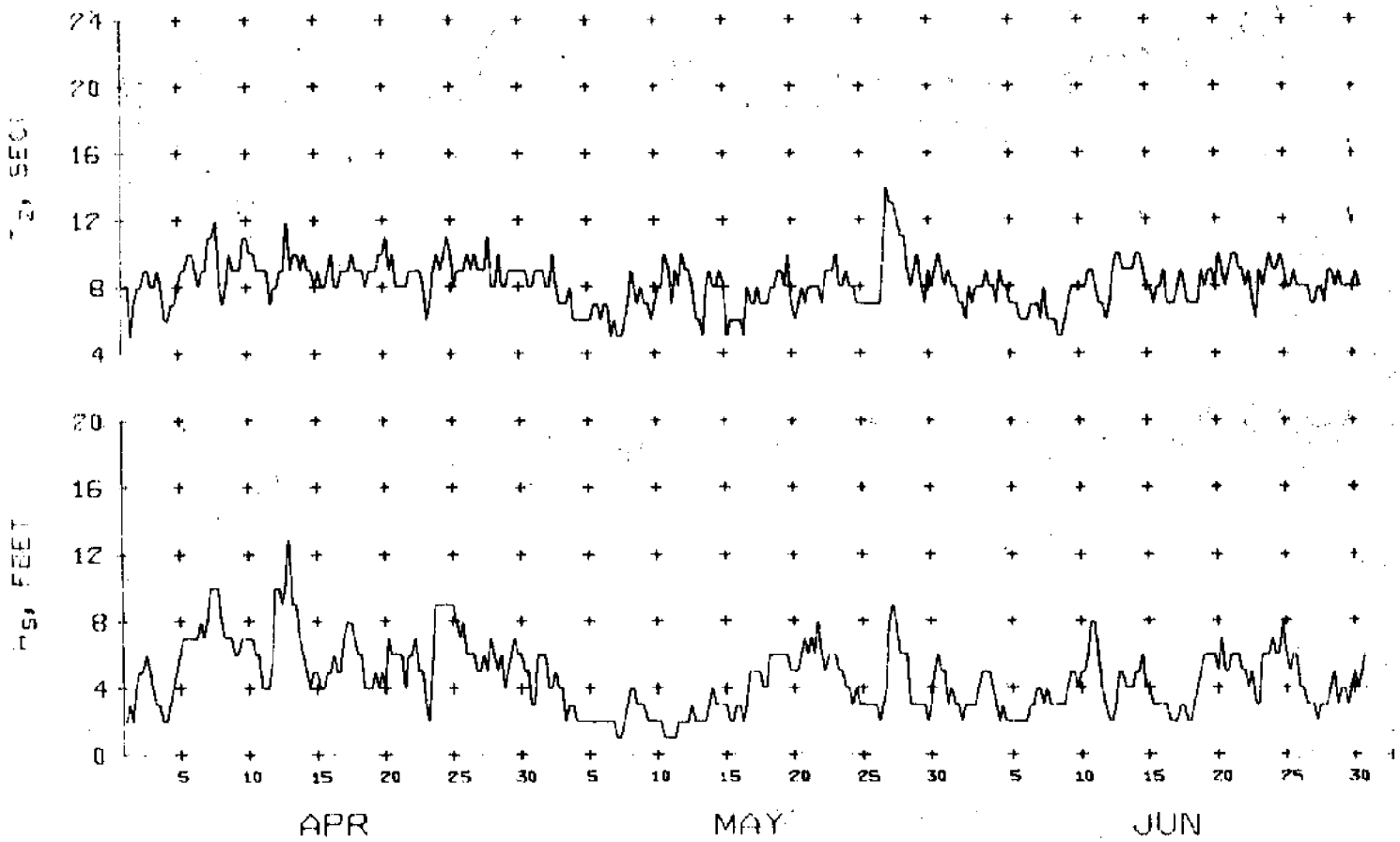



1972

SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER

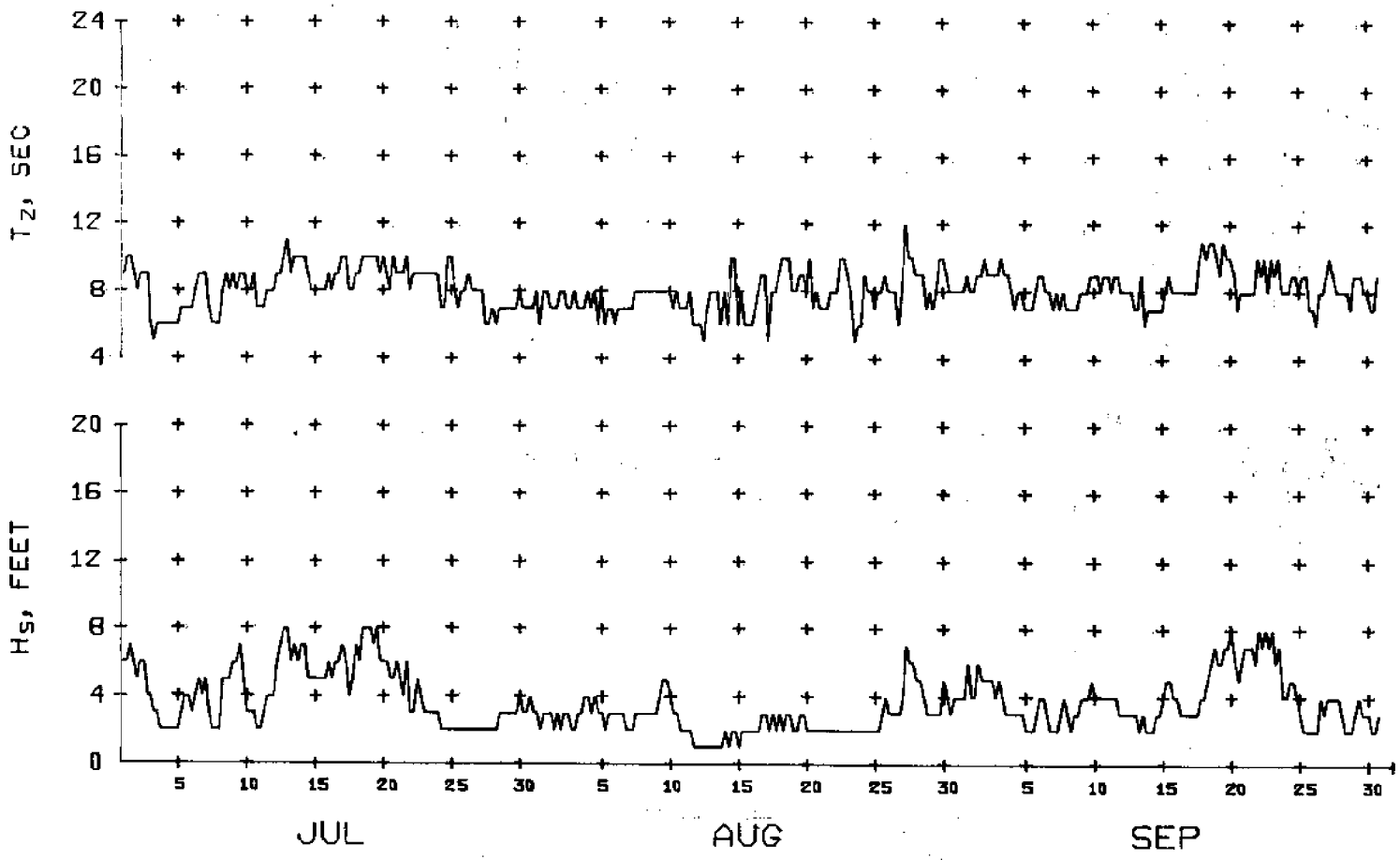


SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER



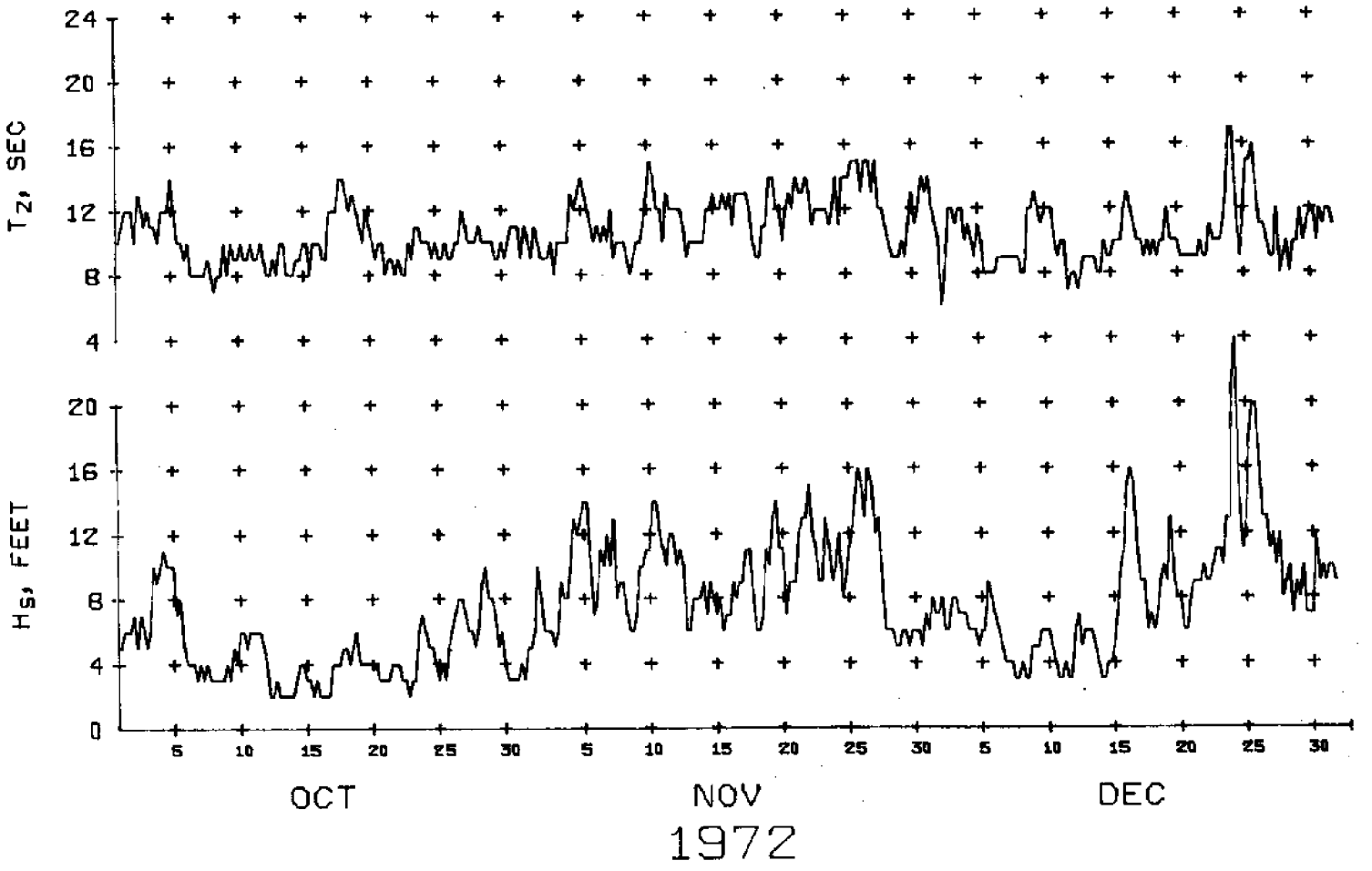

1972

SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER

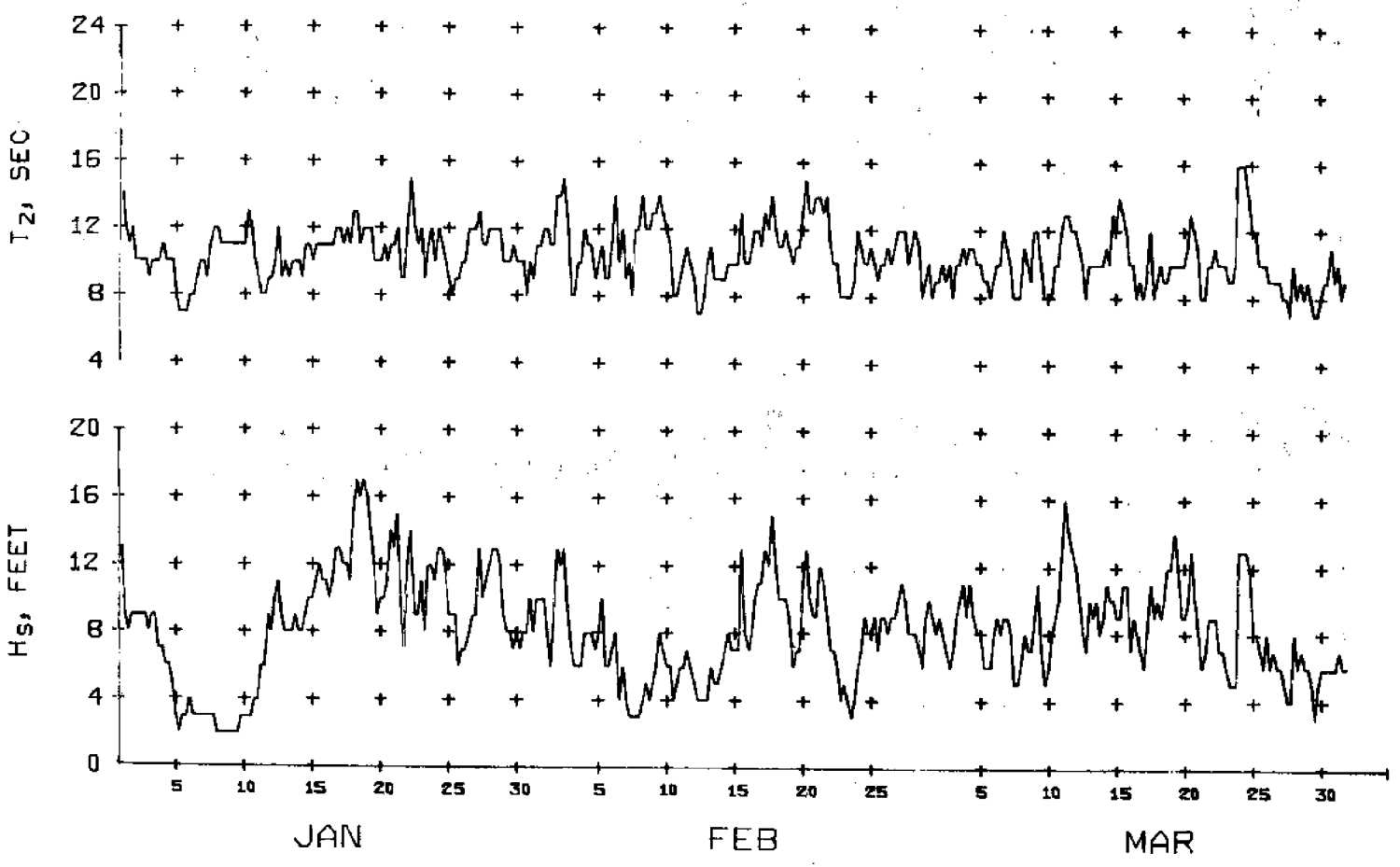



1972

SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER

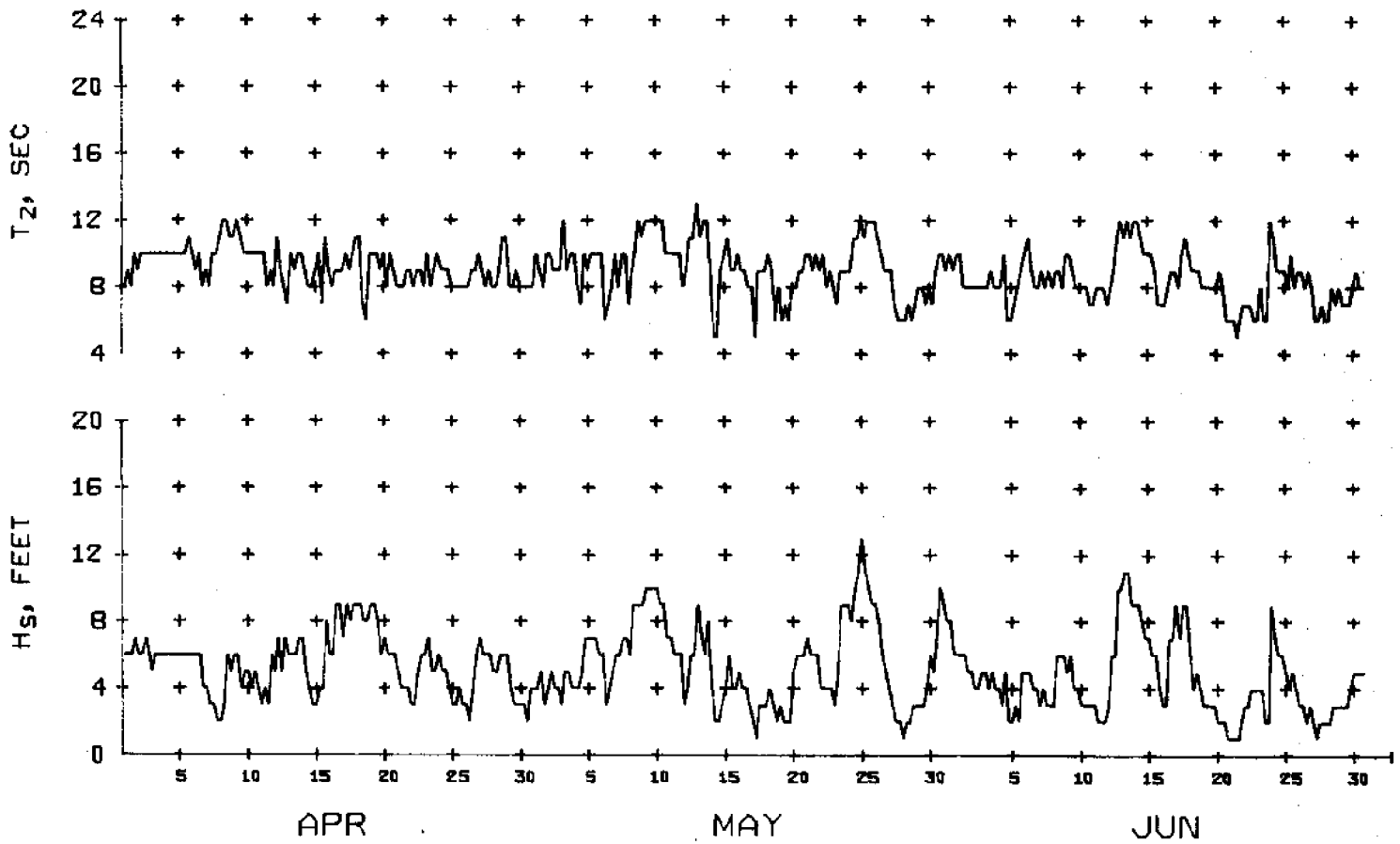


SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER

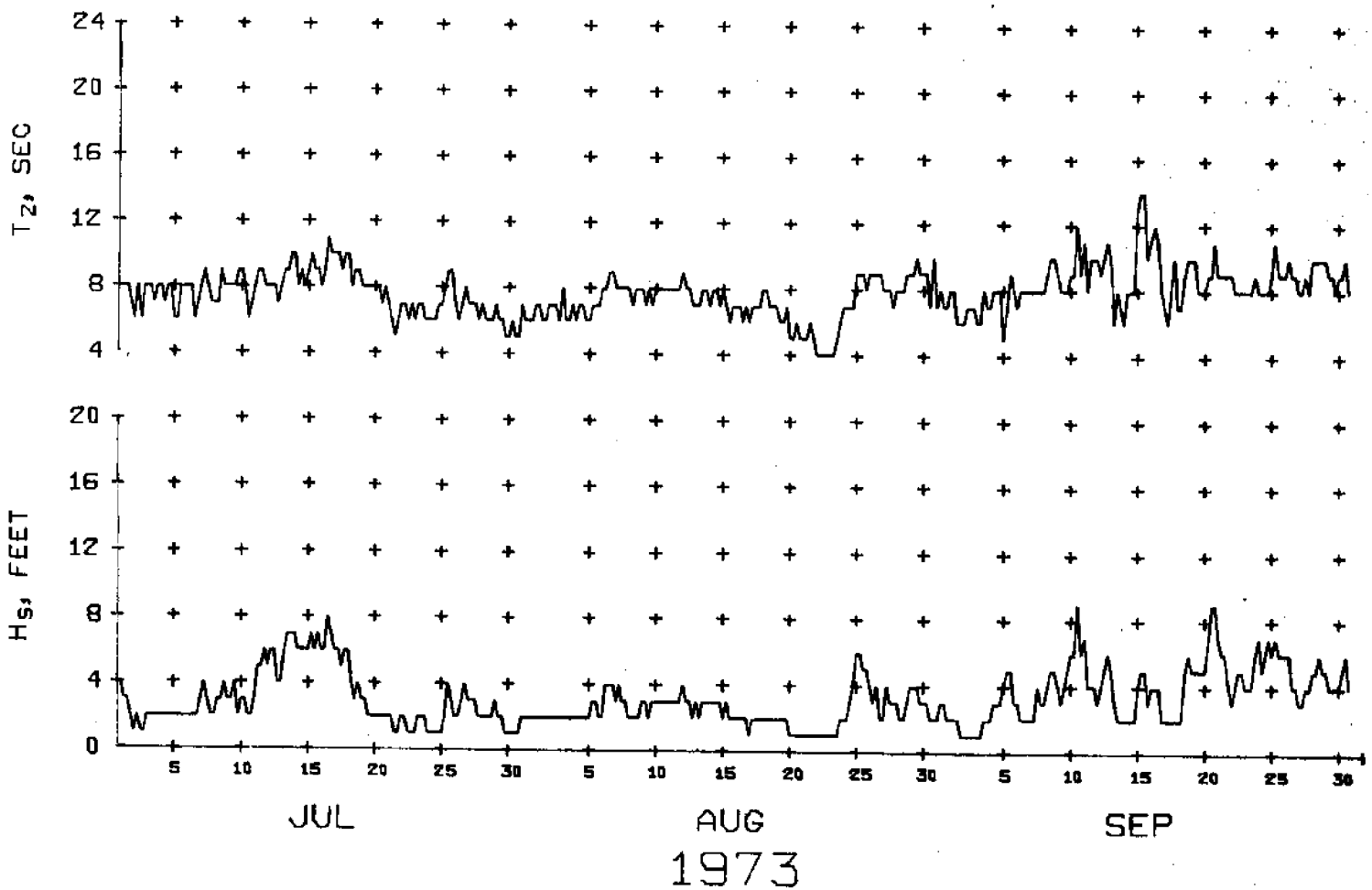



1973

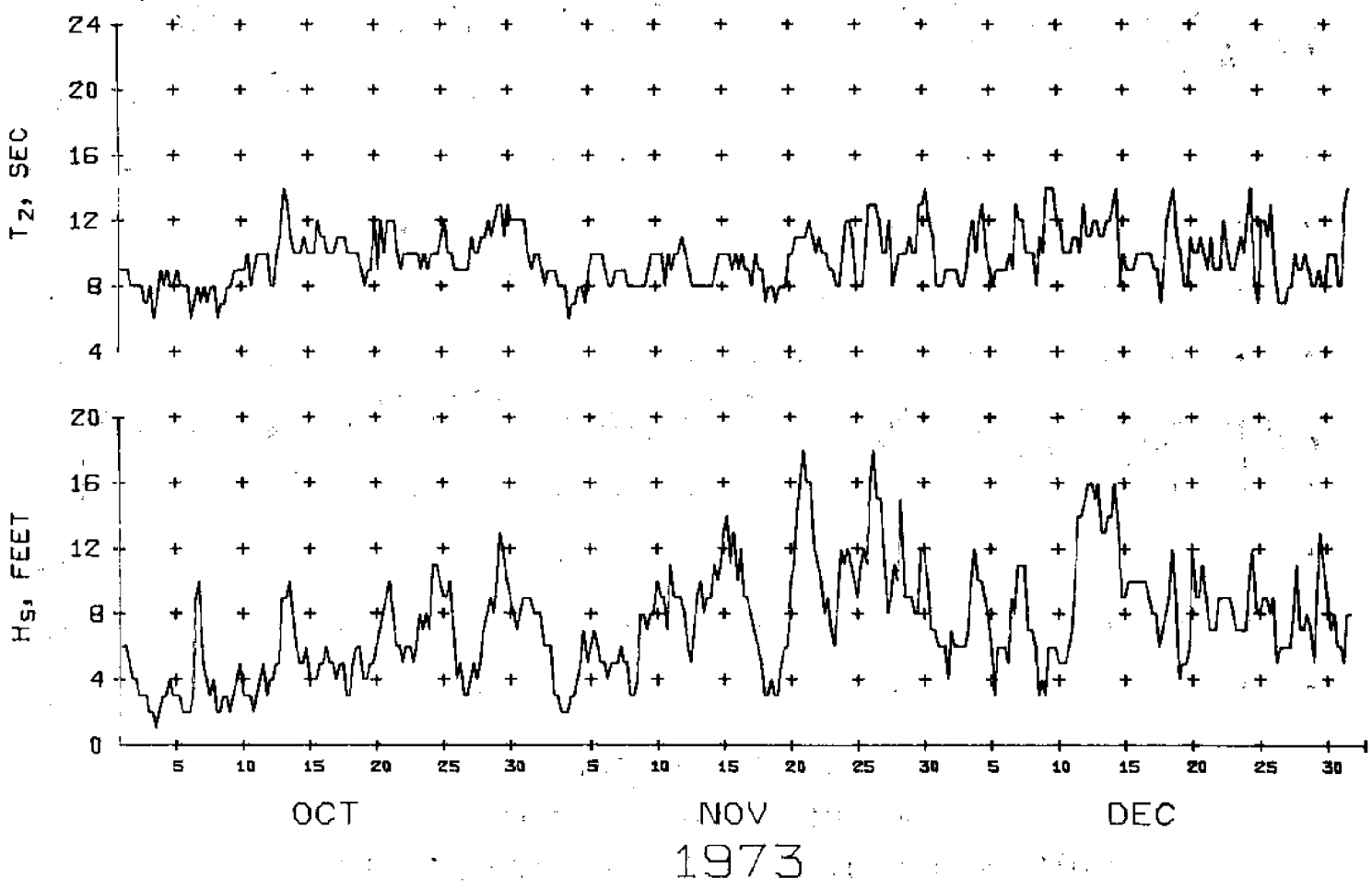
SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER



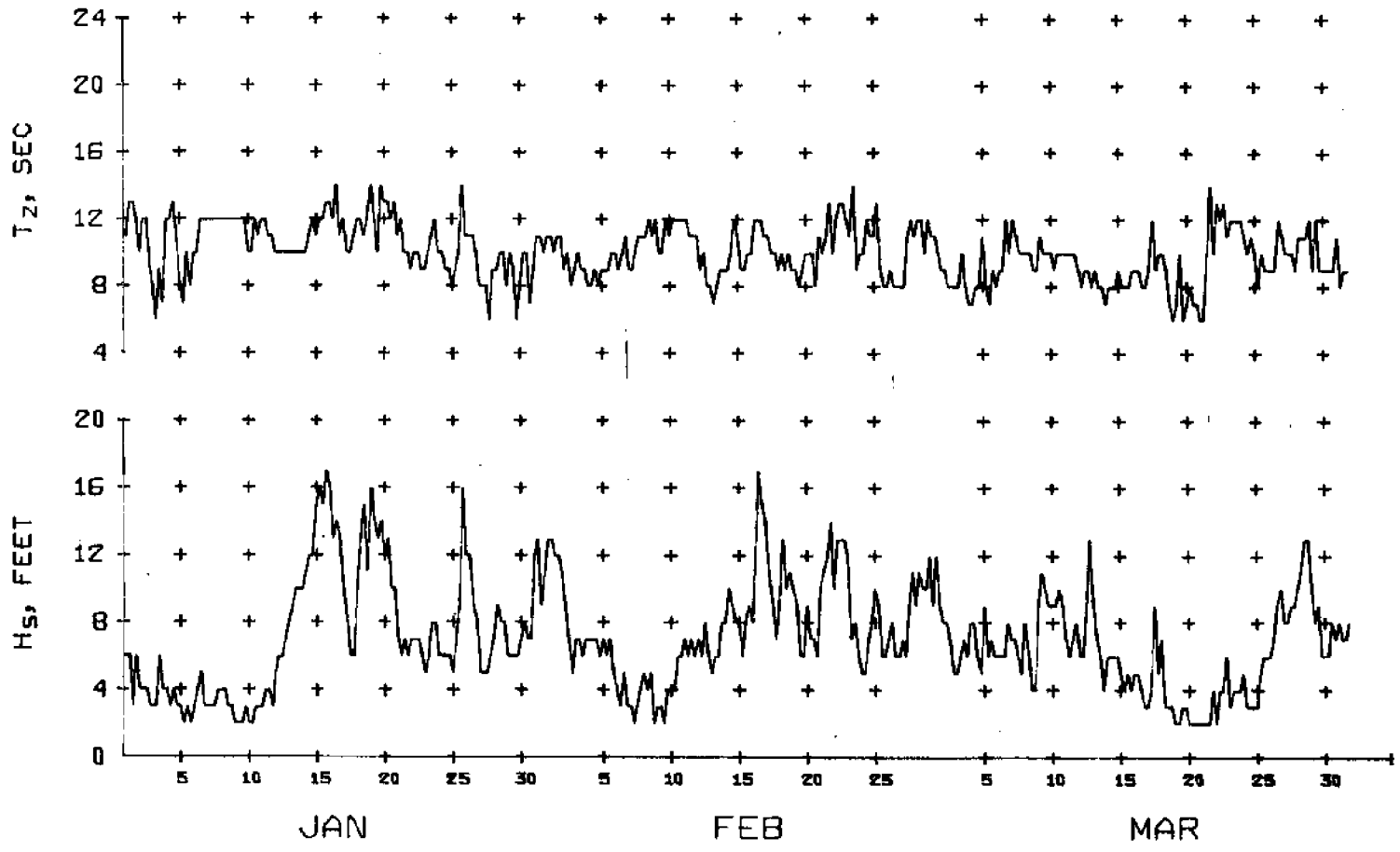
SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER



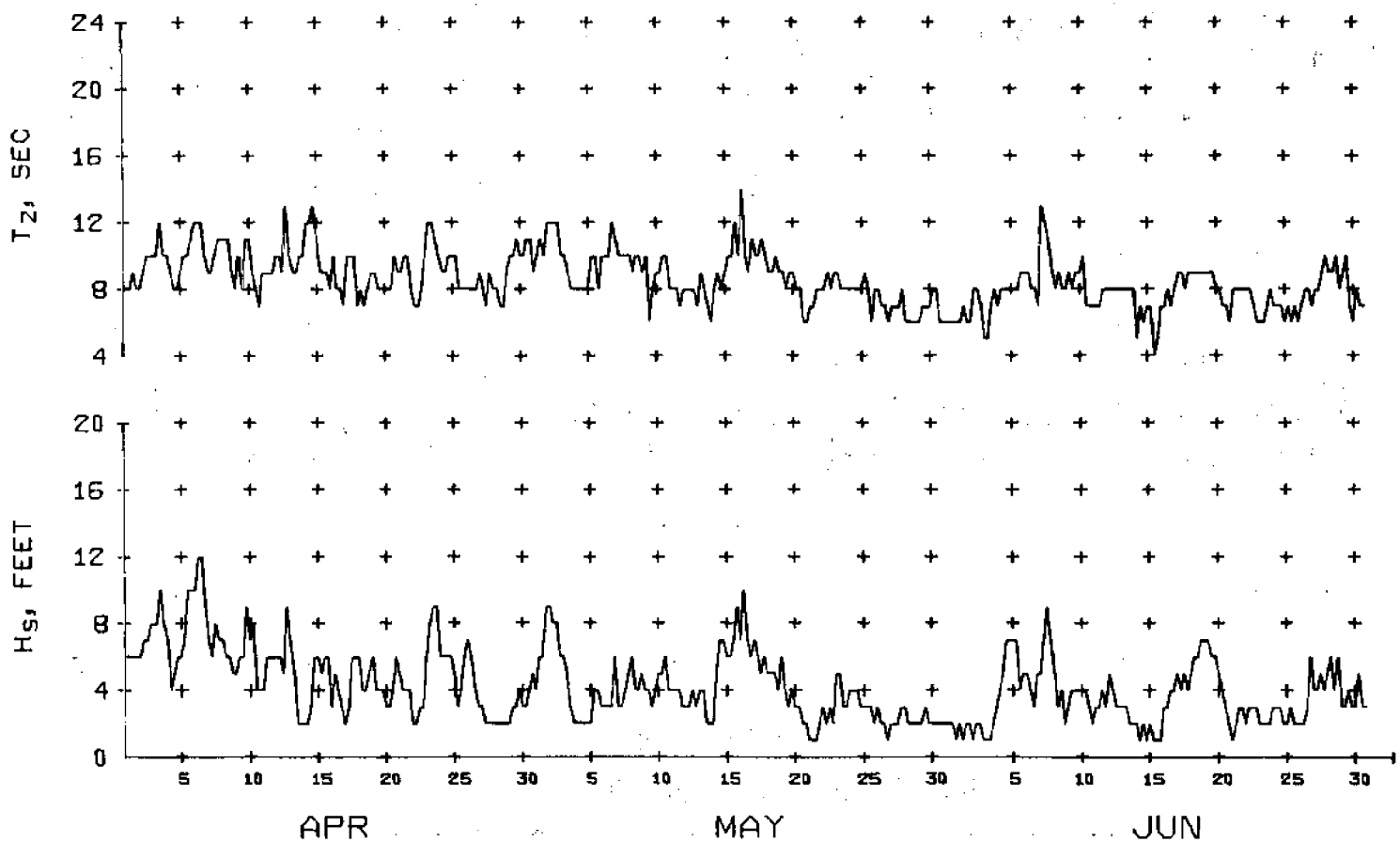
SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER



SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER

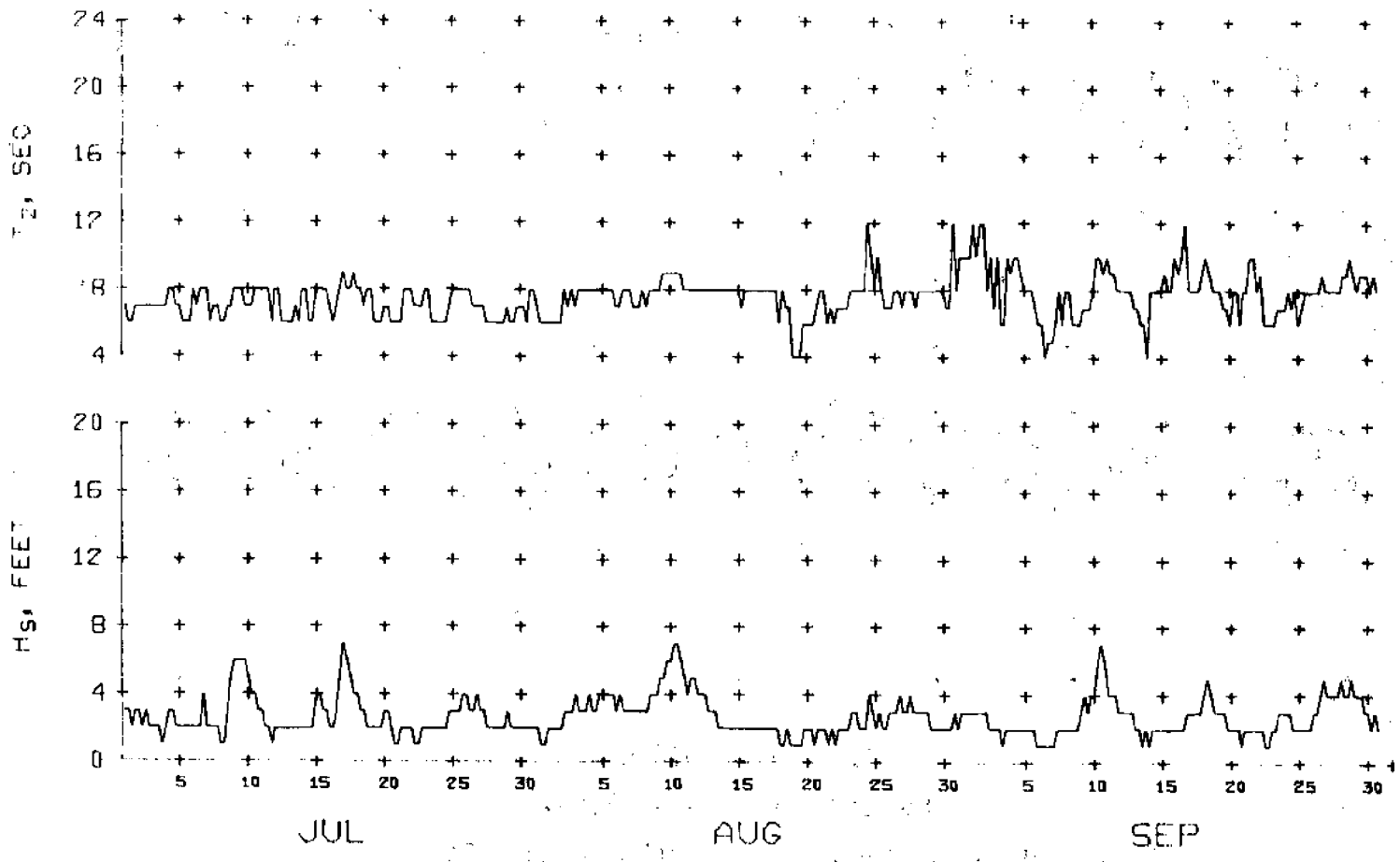


SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER



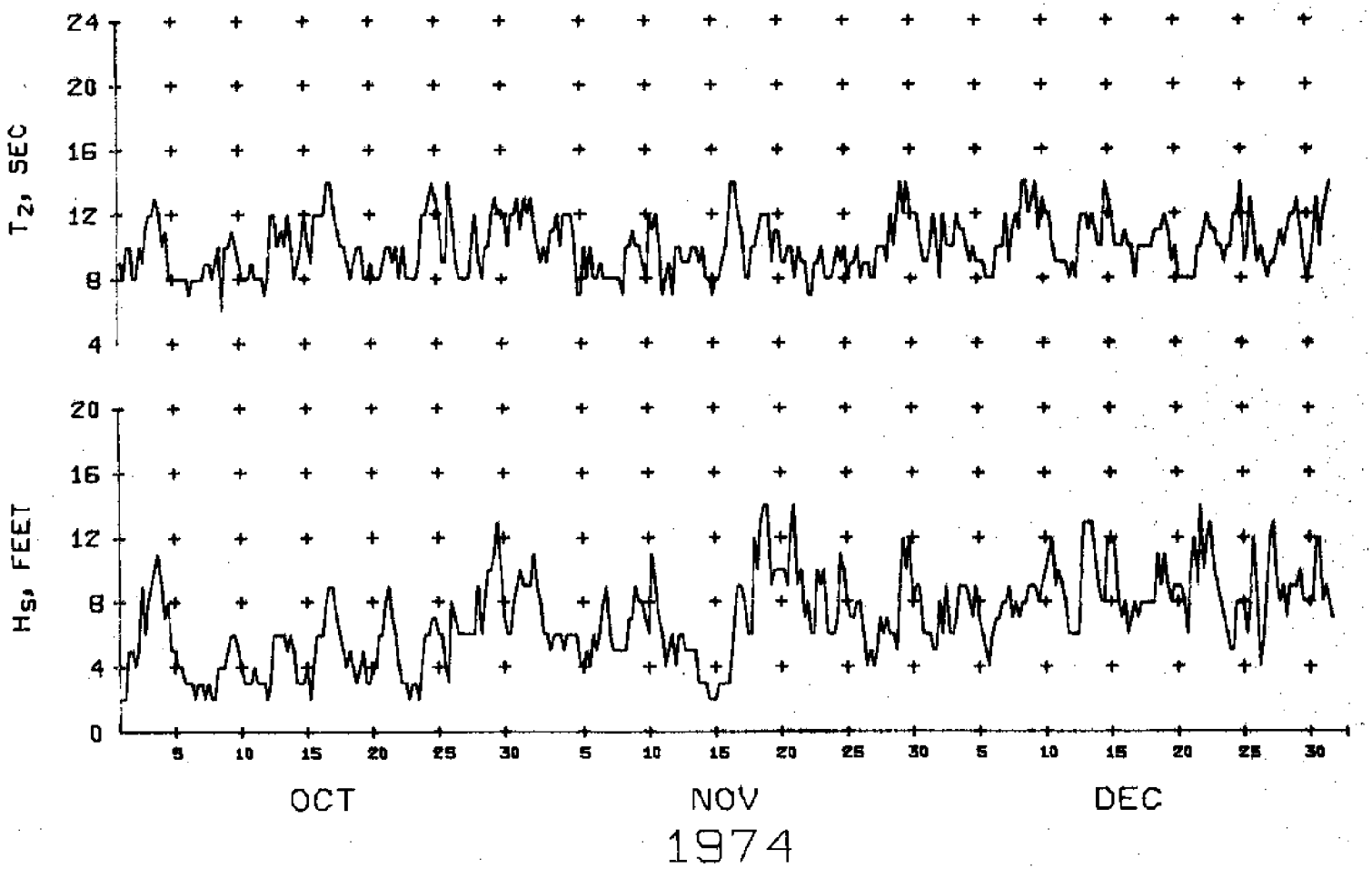

1974

SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER

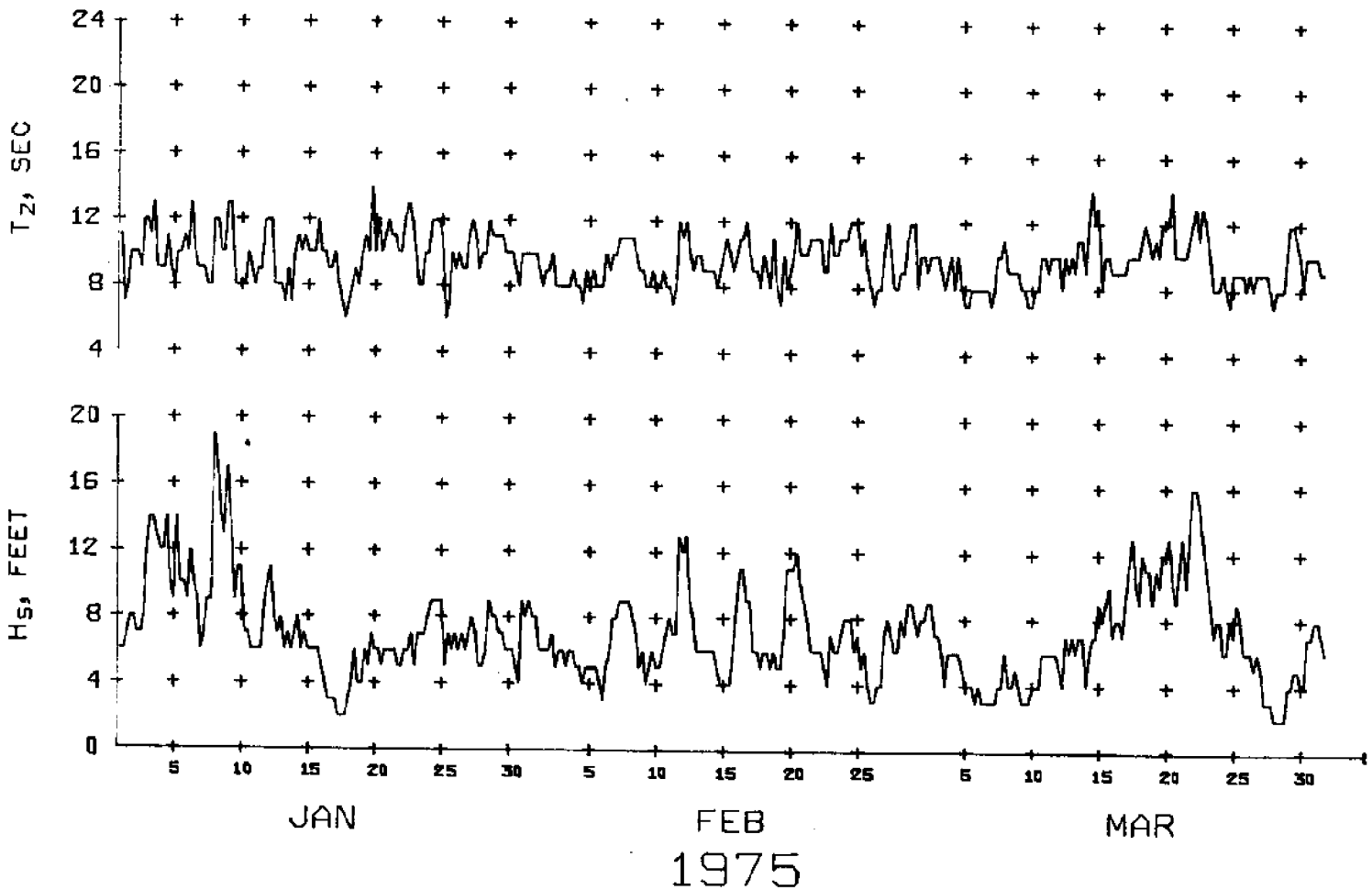



1974

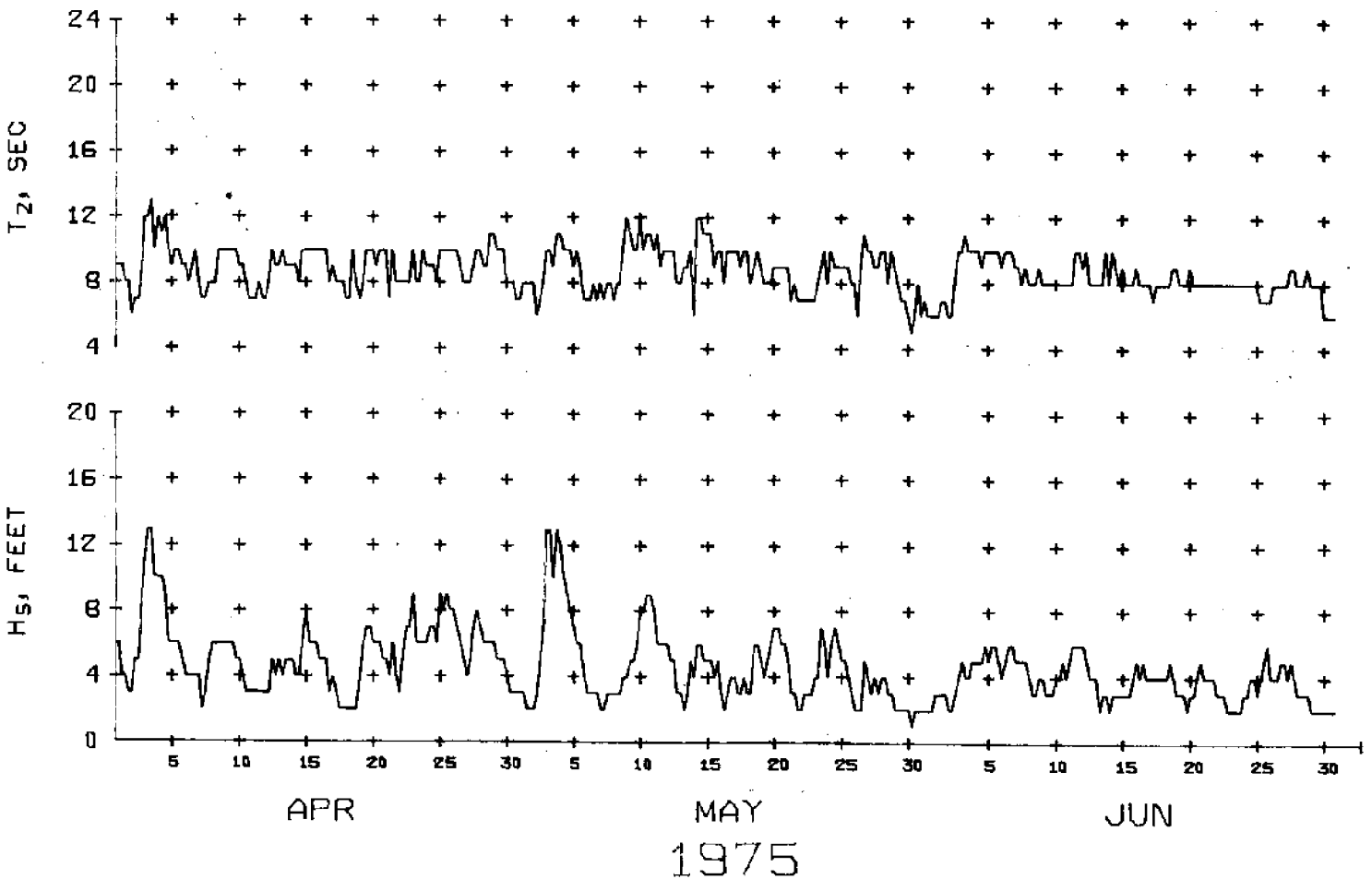
SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER



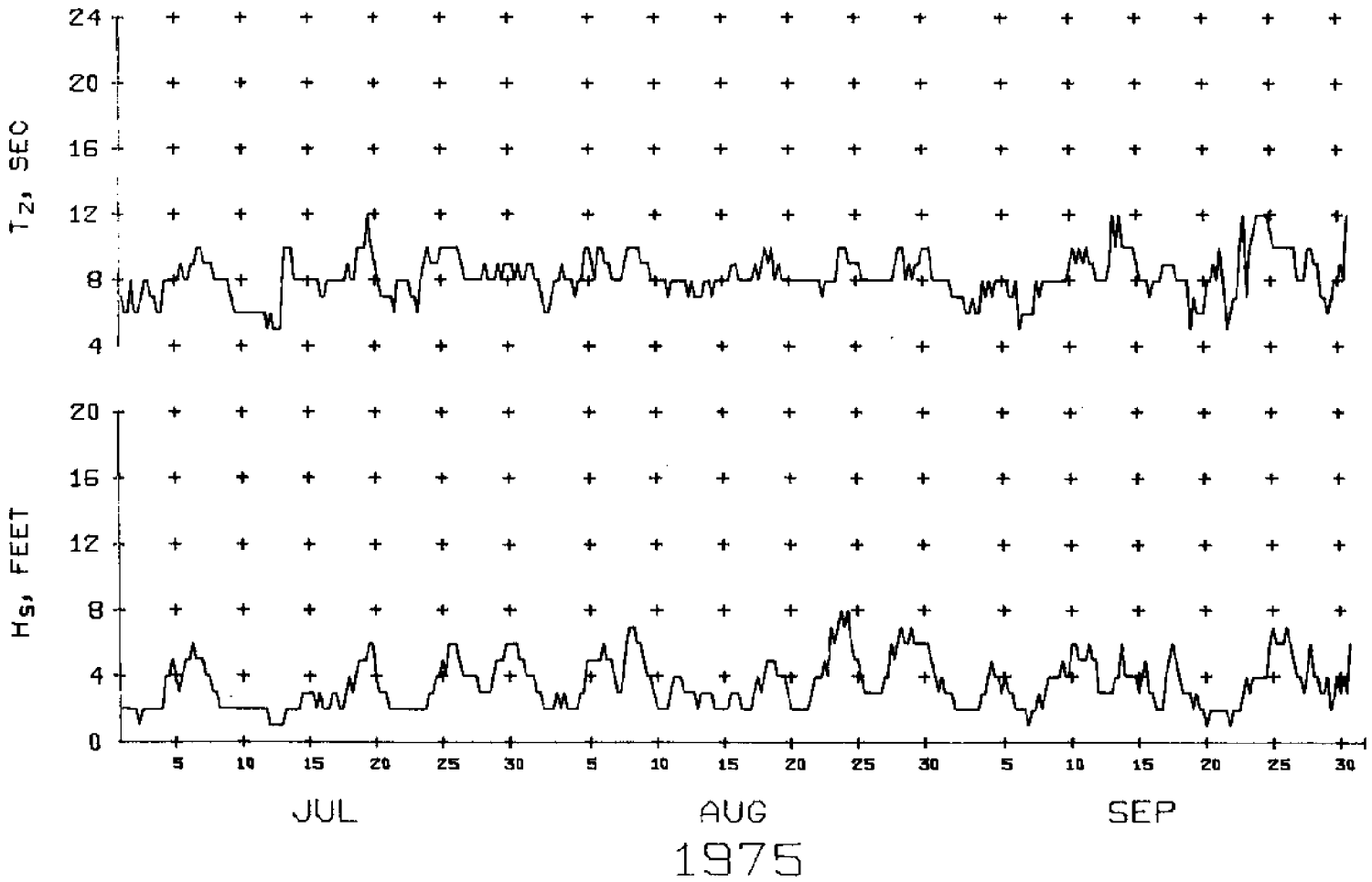
SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER



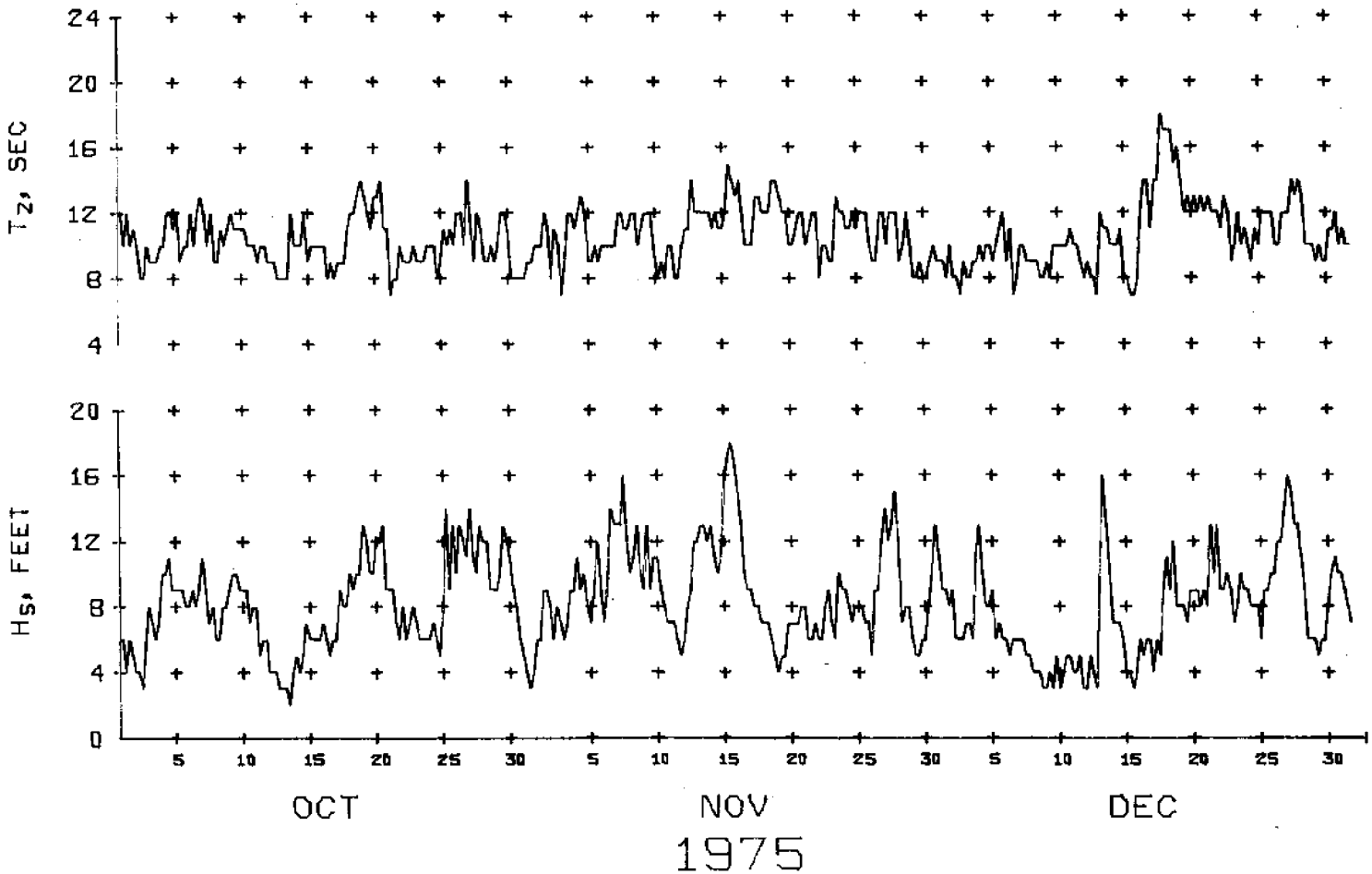
SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER



SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER



SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
SEISMOMETER



SIGNIFICANT WAVE HEIGHT AND PERIOD
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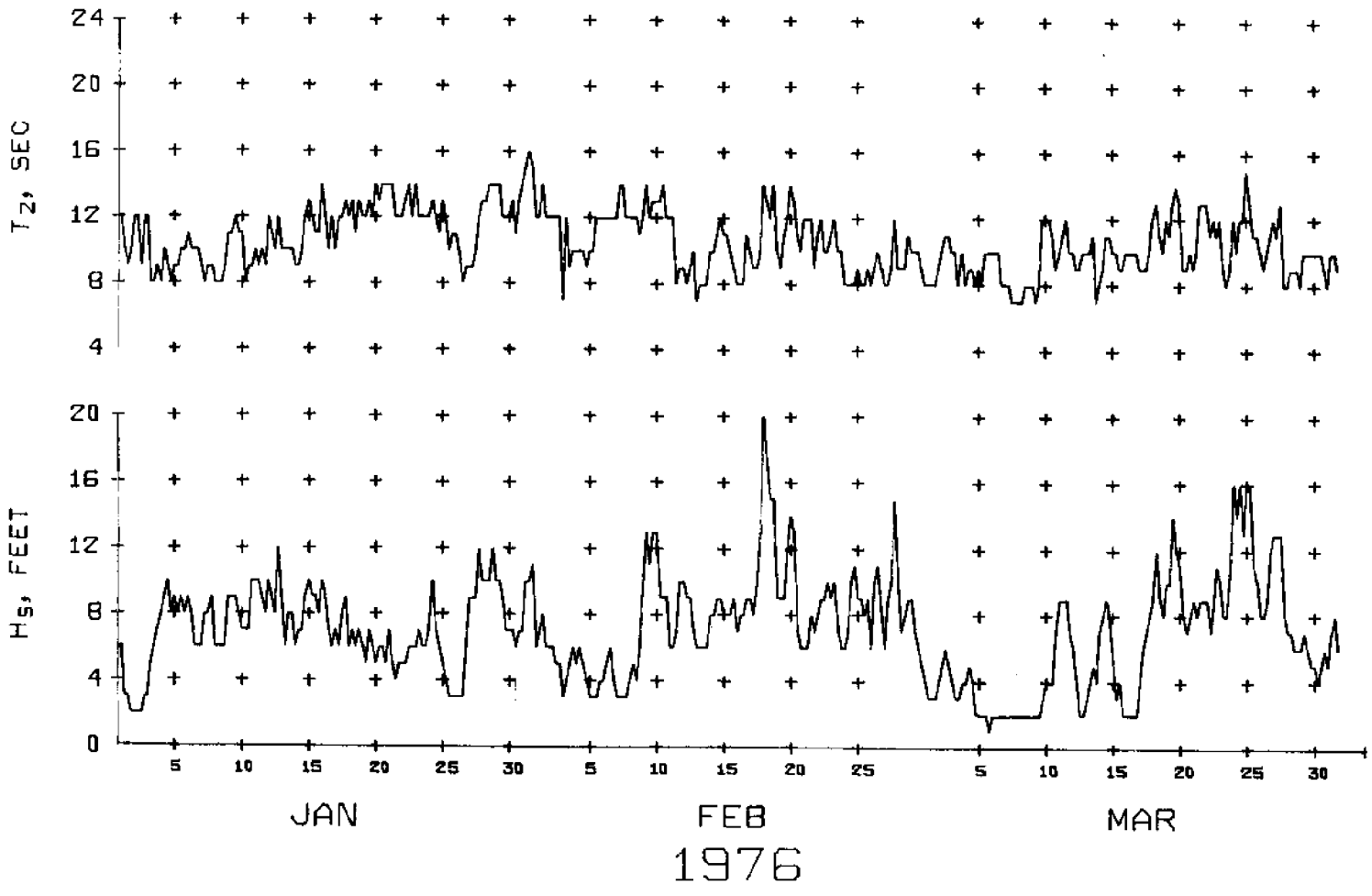

SIGNIFICANT WAVE HEIGHT AND PERIOD
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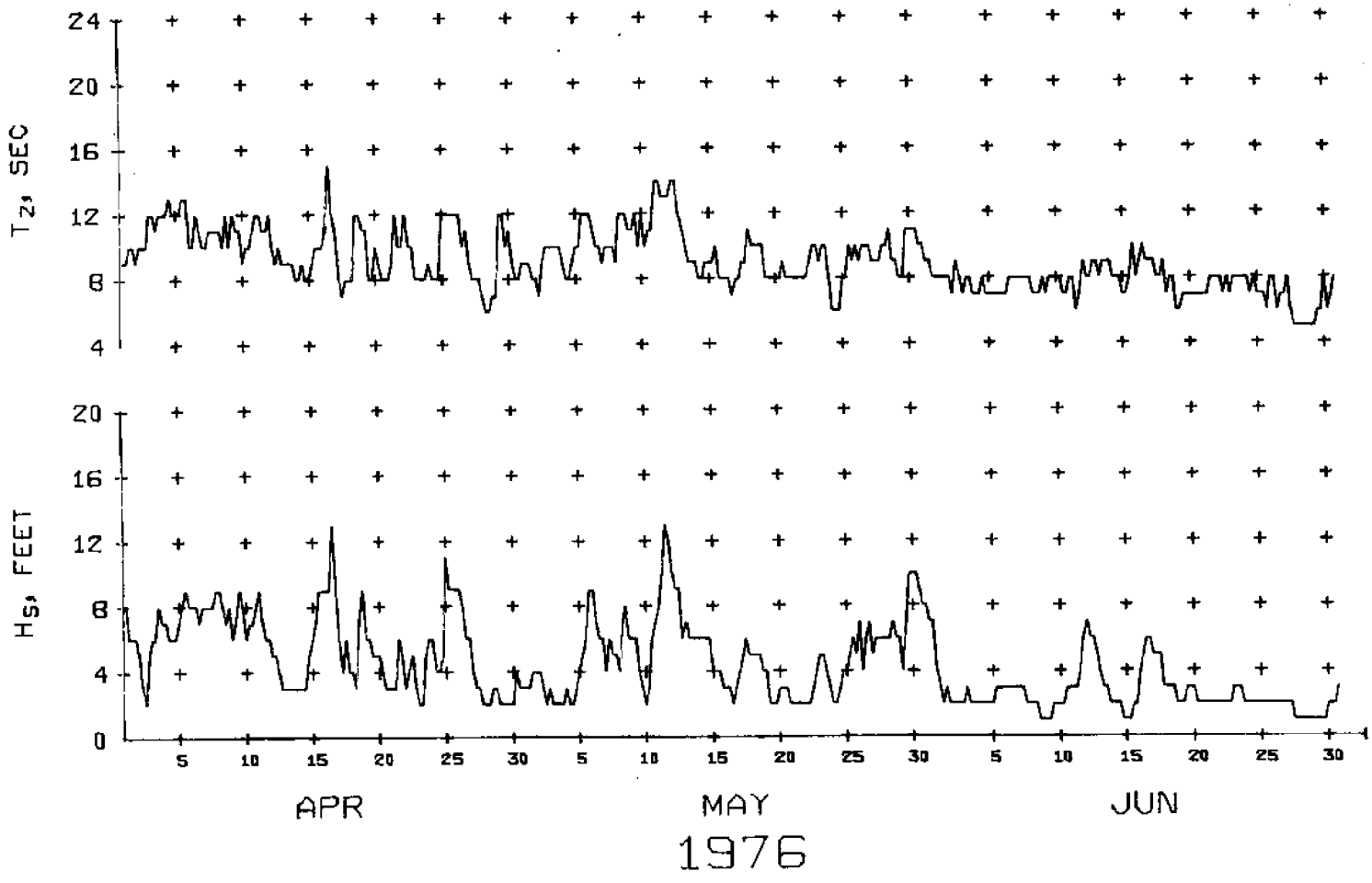

SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
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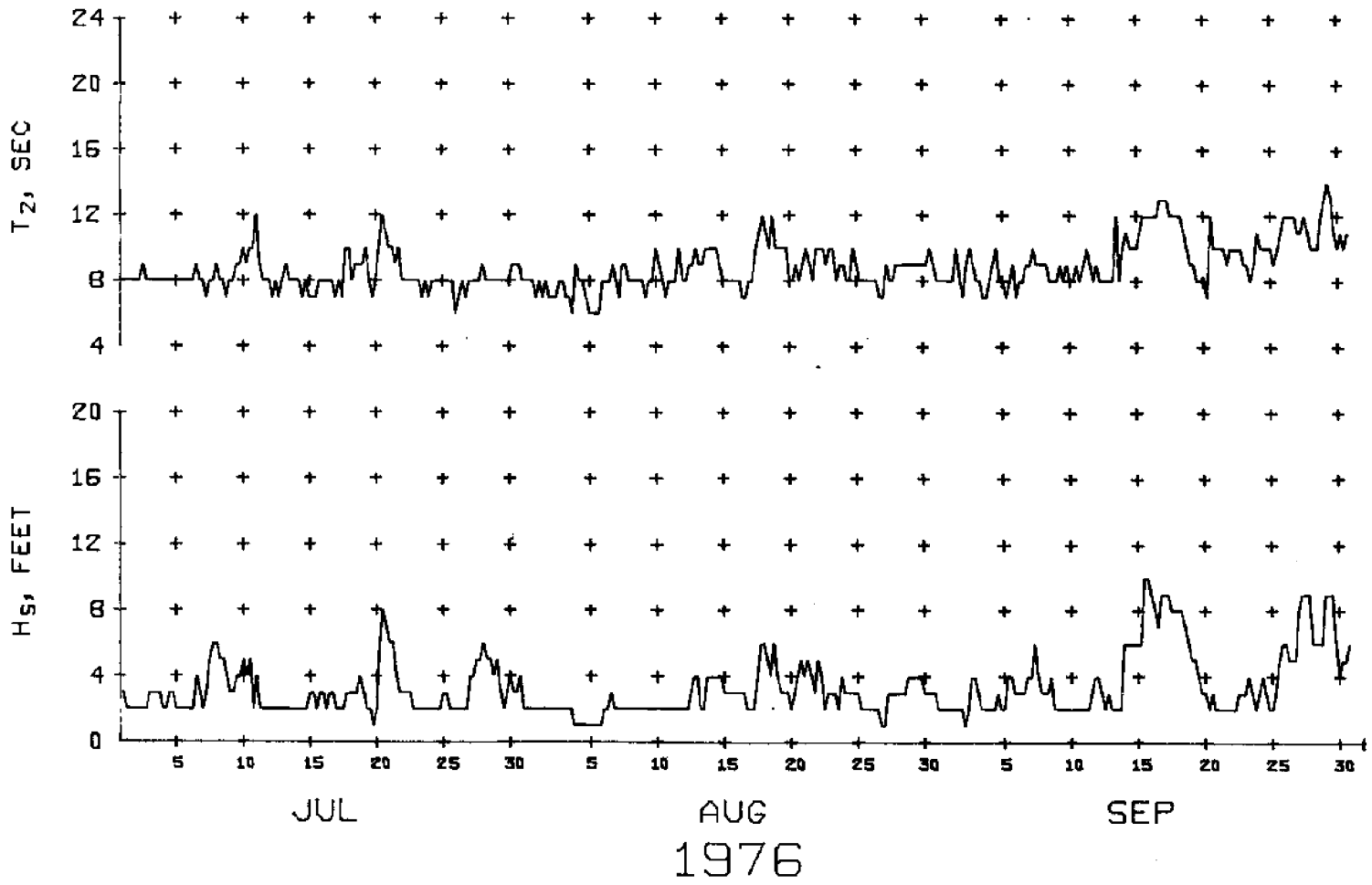

SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
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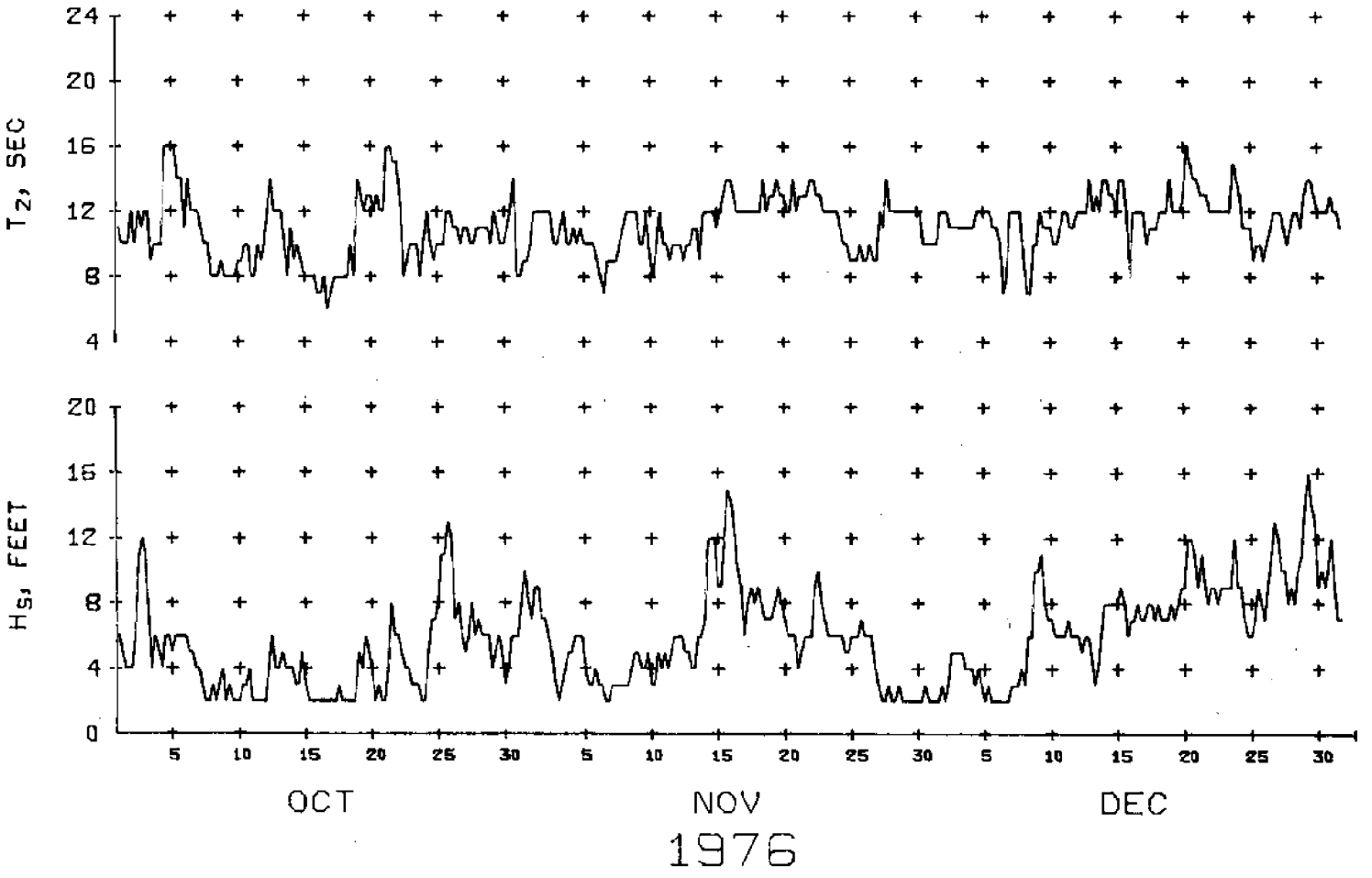
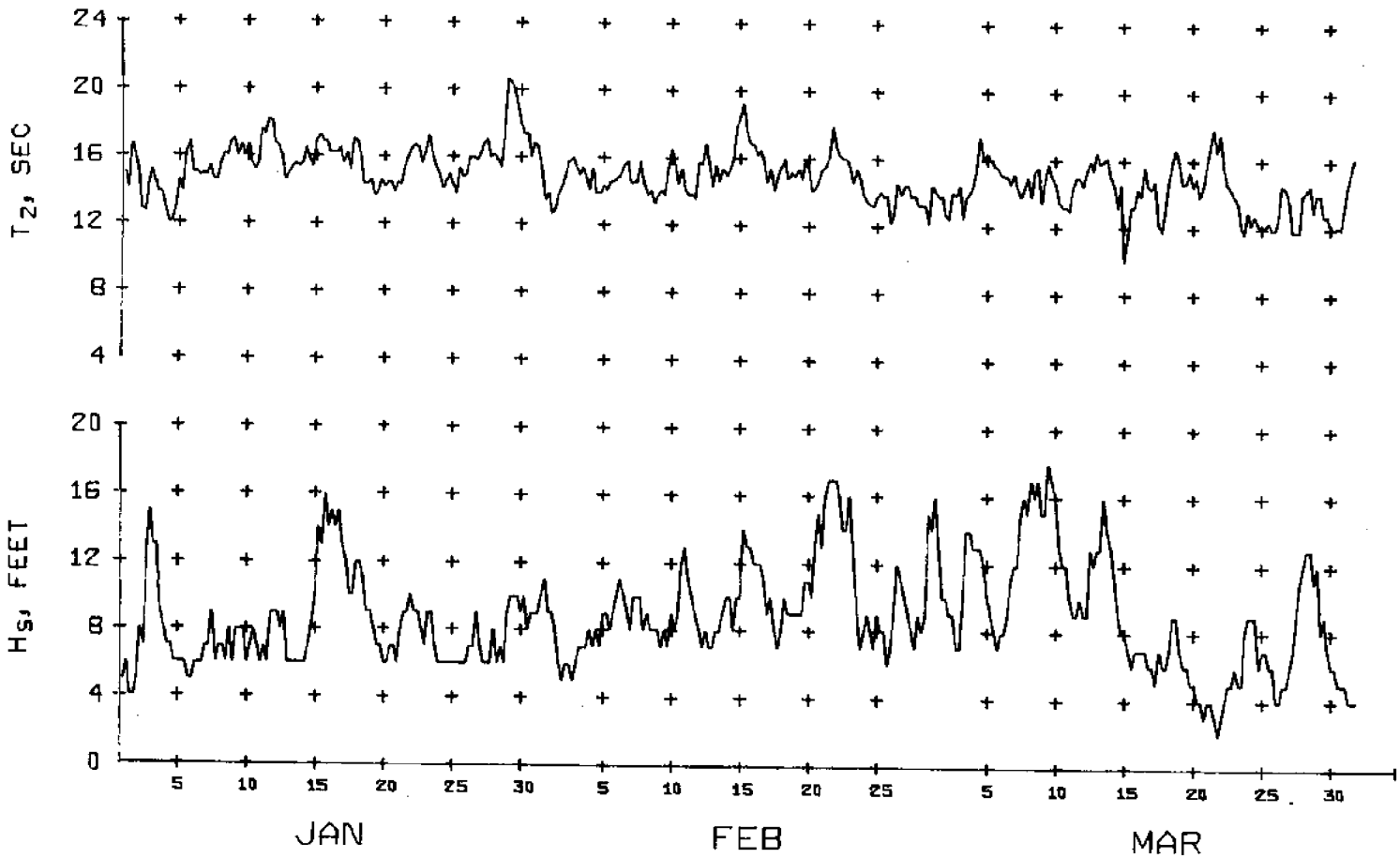
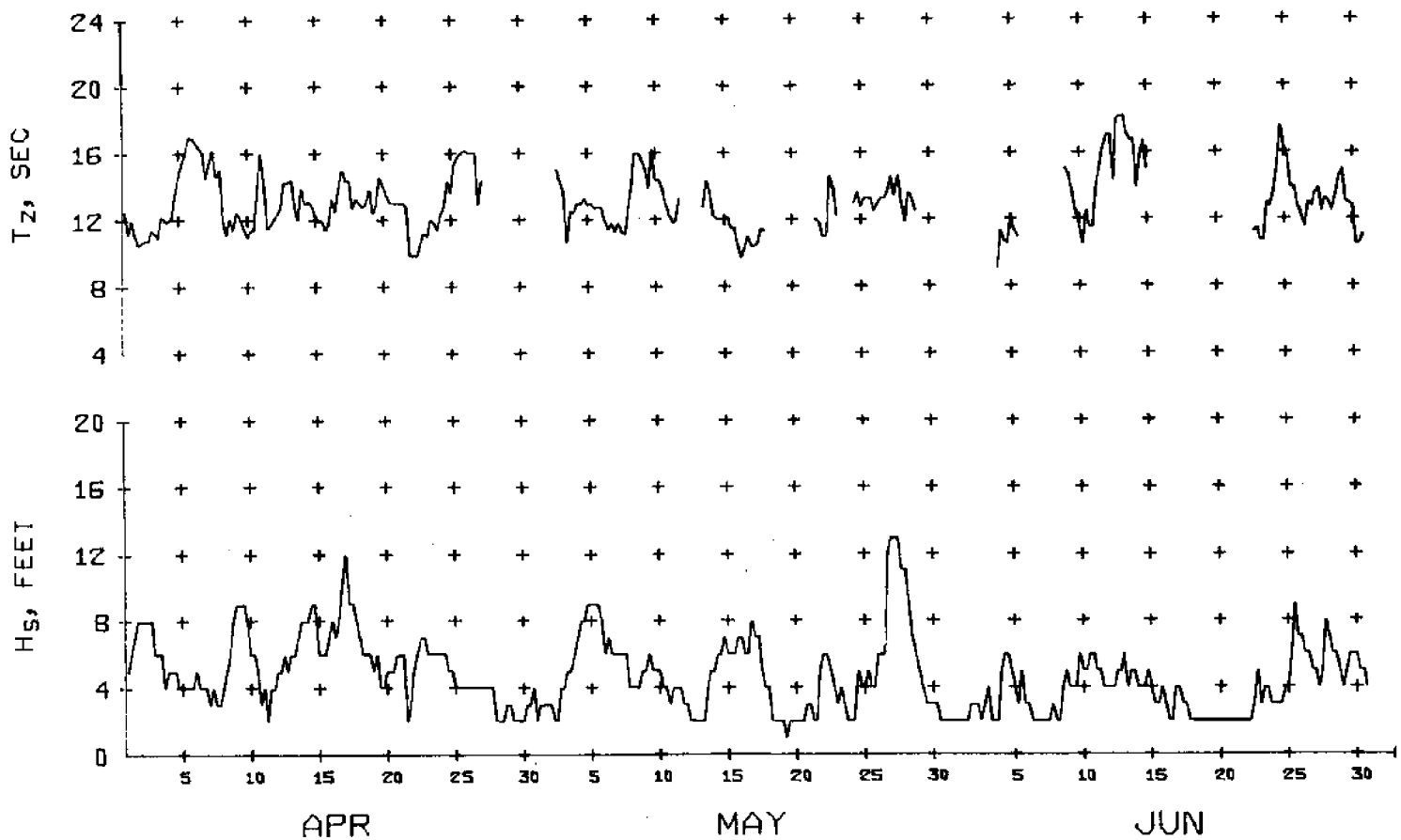


SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
WAVEMETER



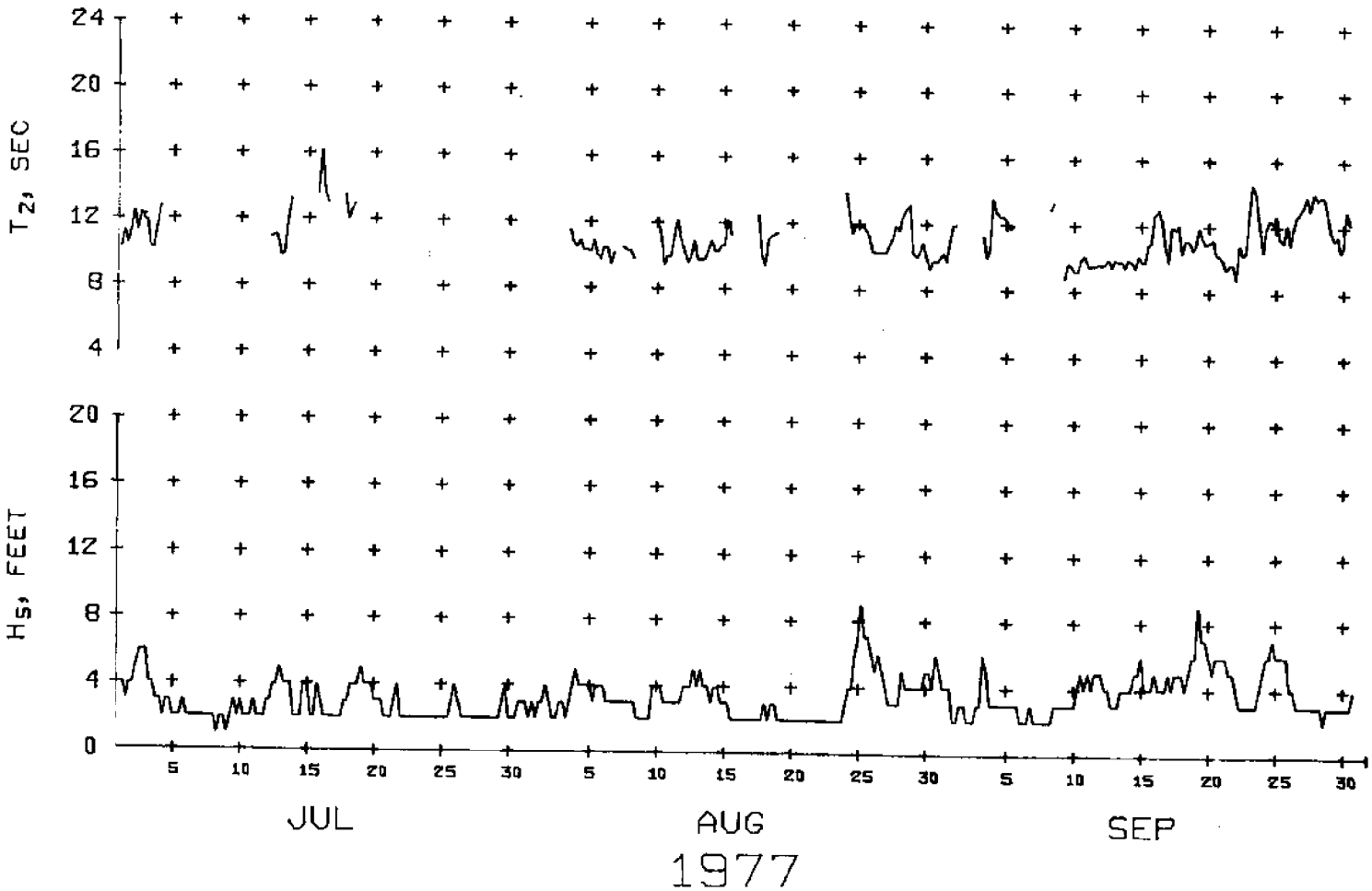

1977

SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
WAVEMETER

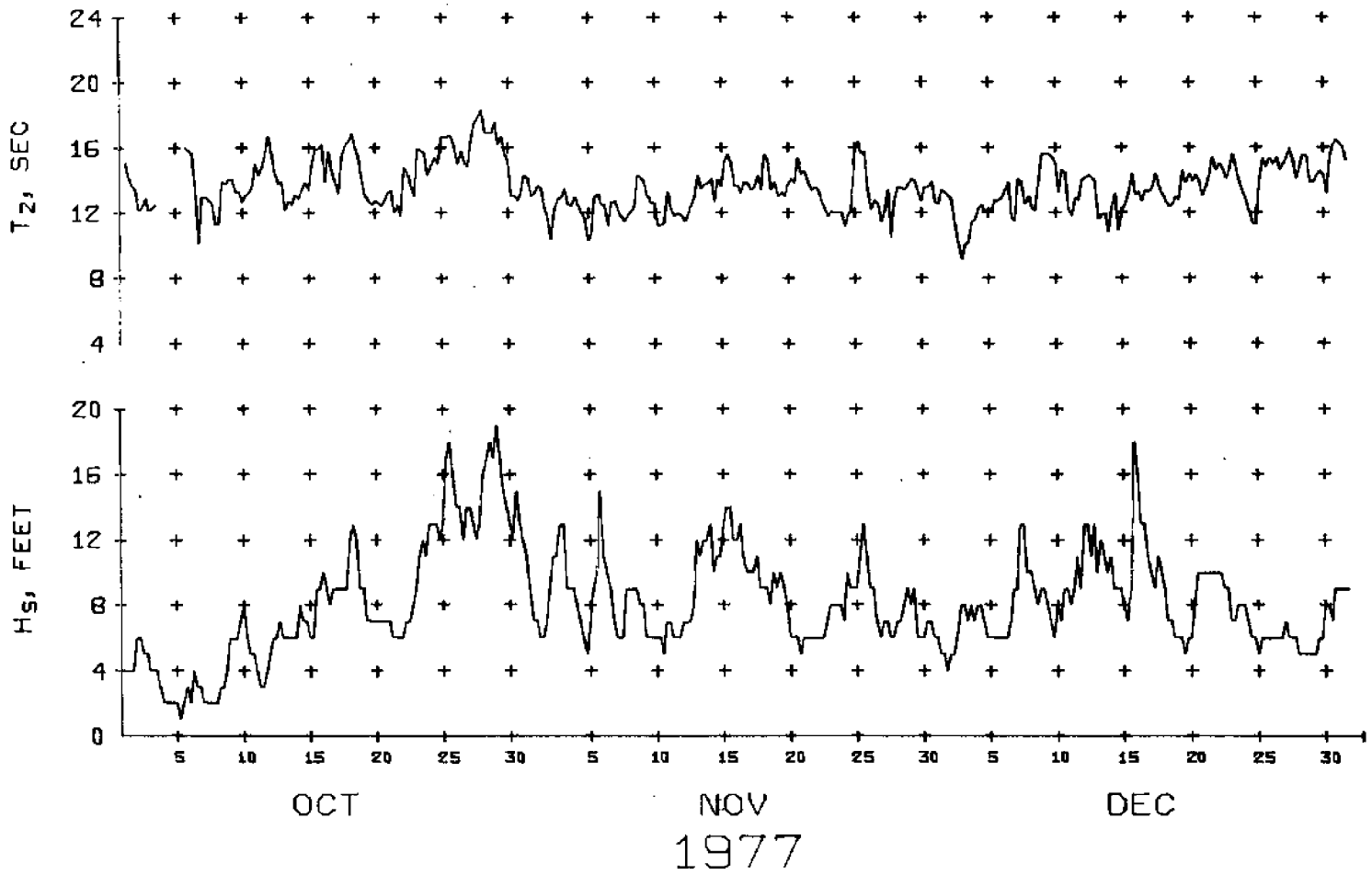



1977

SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
WAVEMETER



SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
WAVEMETER



SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
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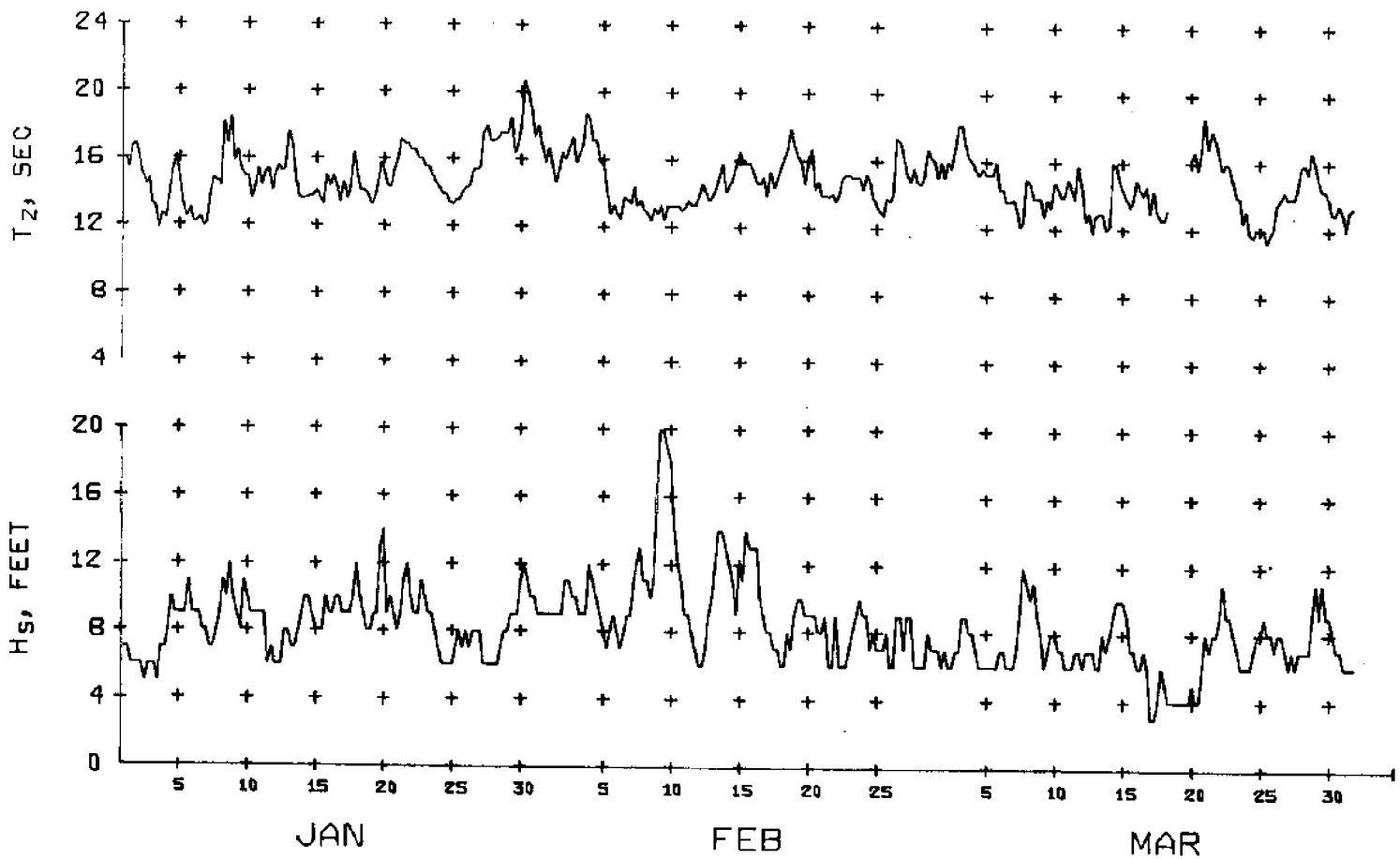
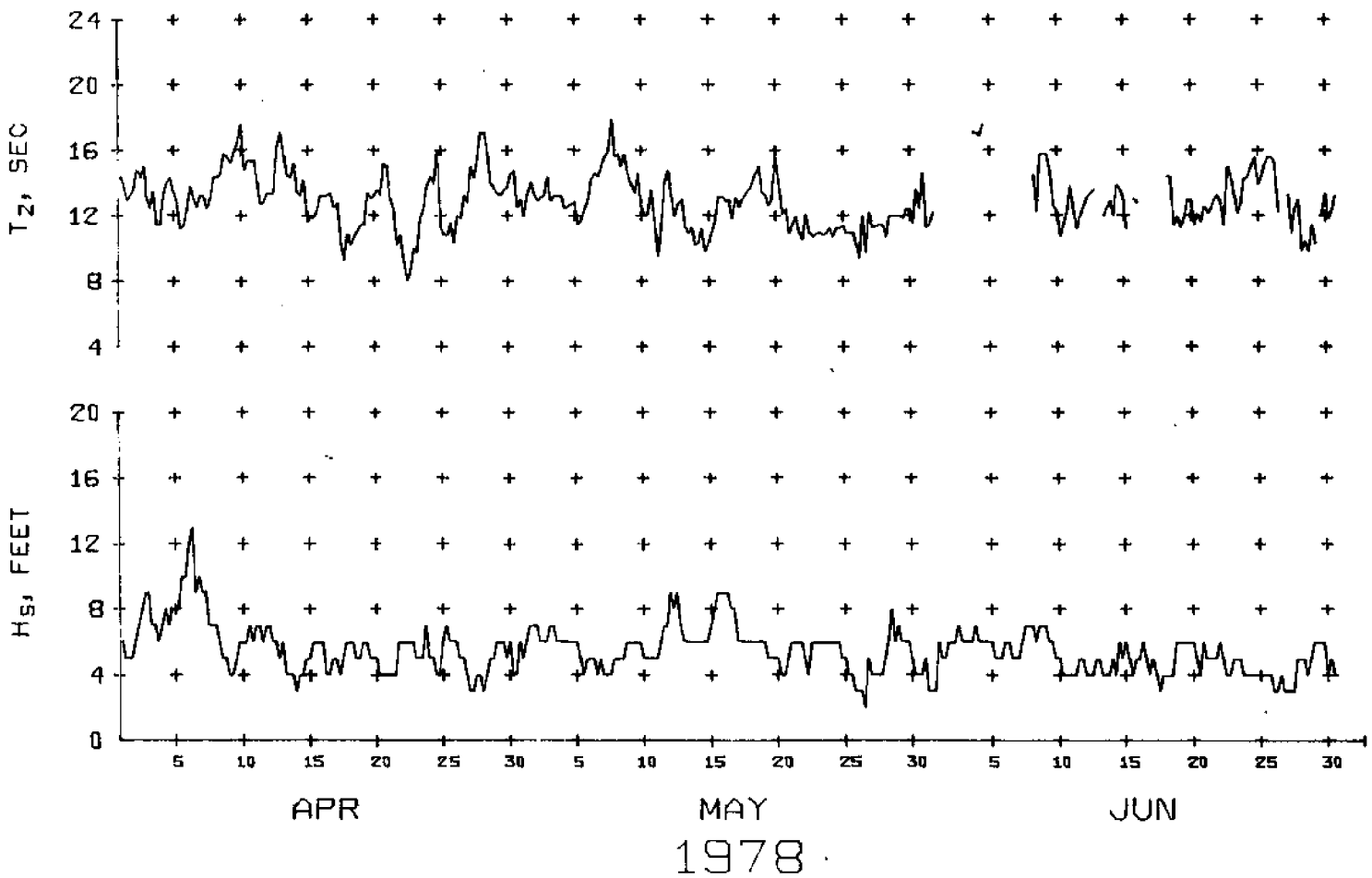



1978

SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
WAVEMETER



SIGNIFICANT WAVE HEIGHT AND PERIOD
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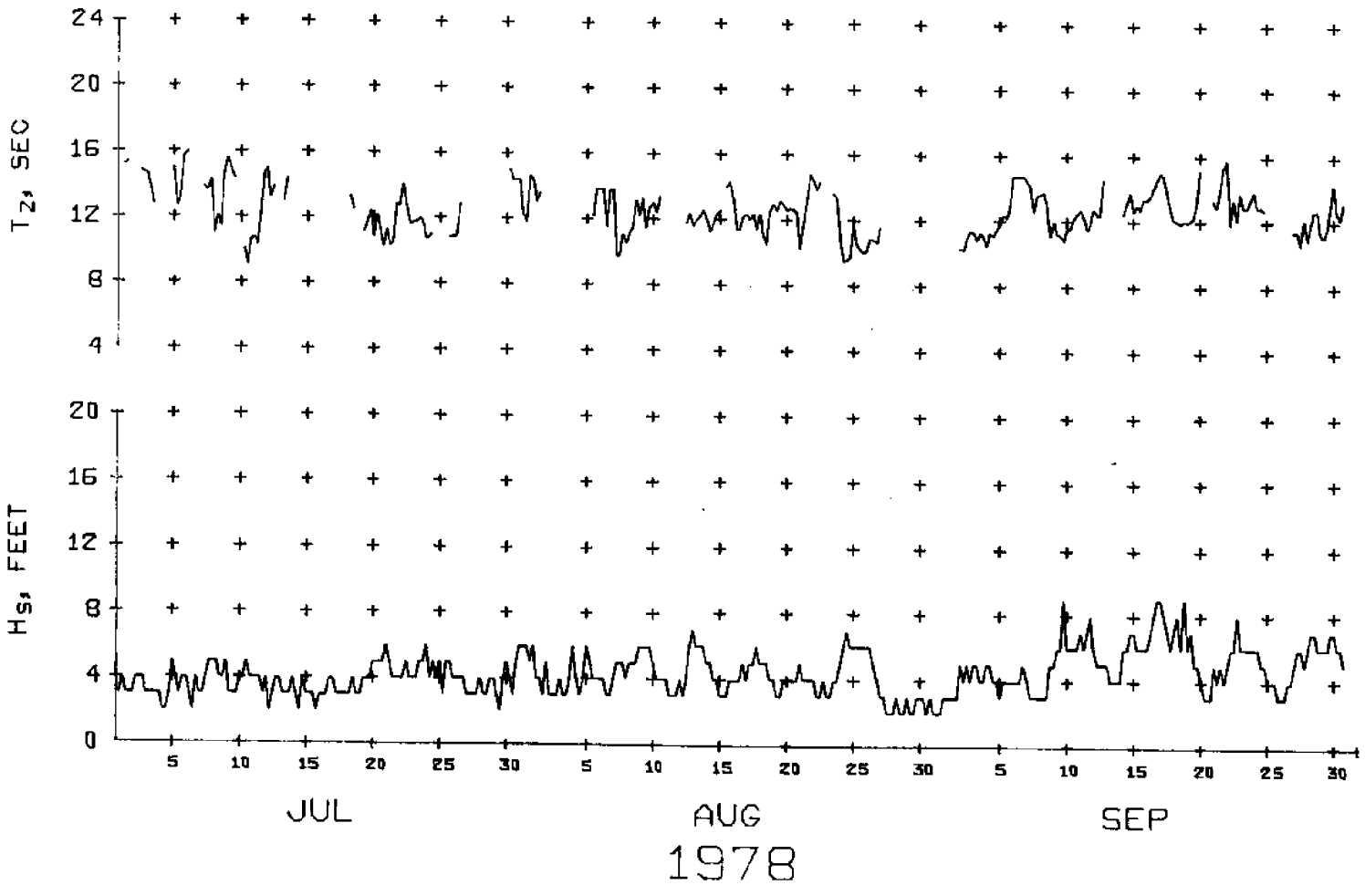

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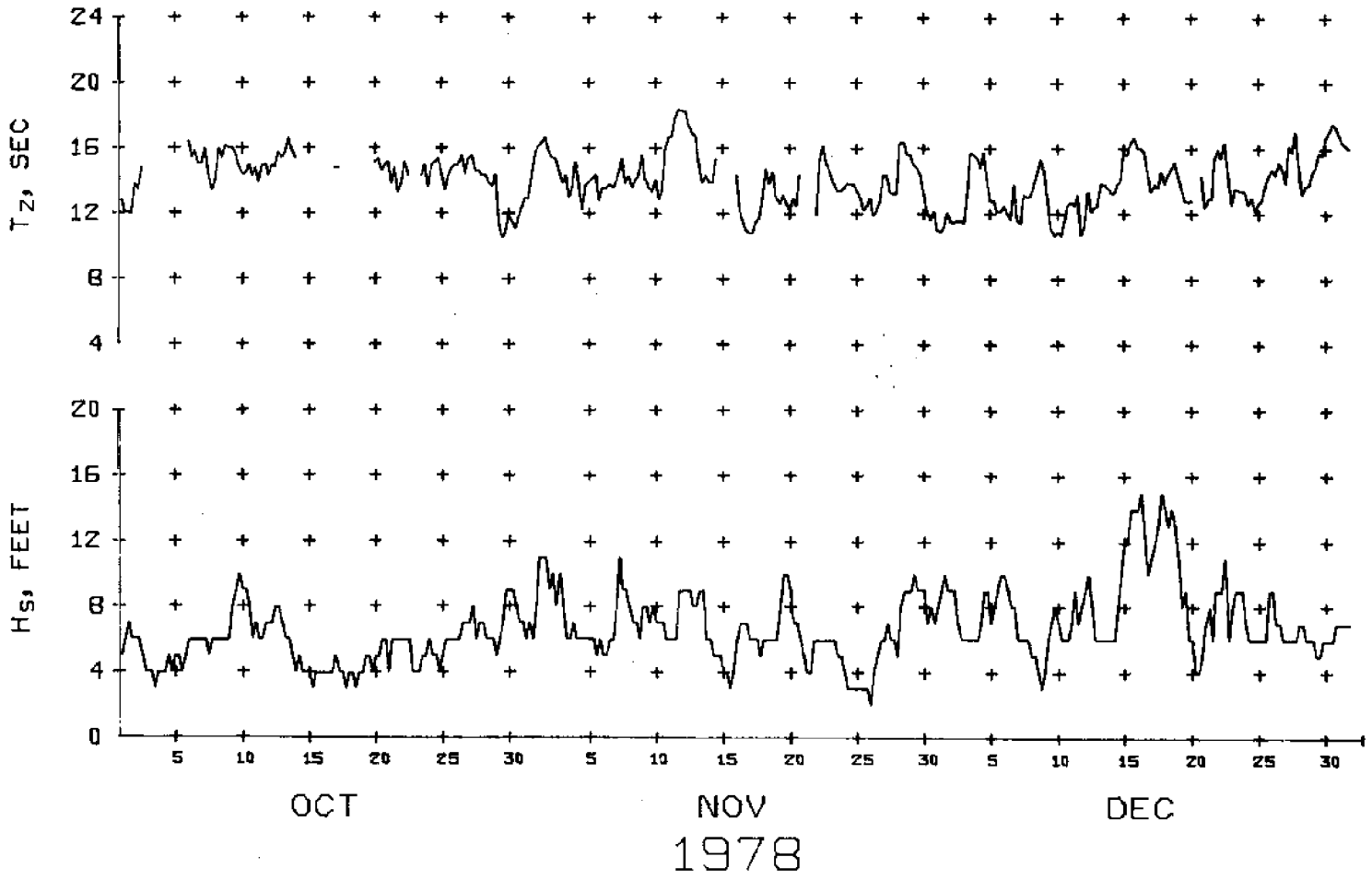

SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
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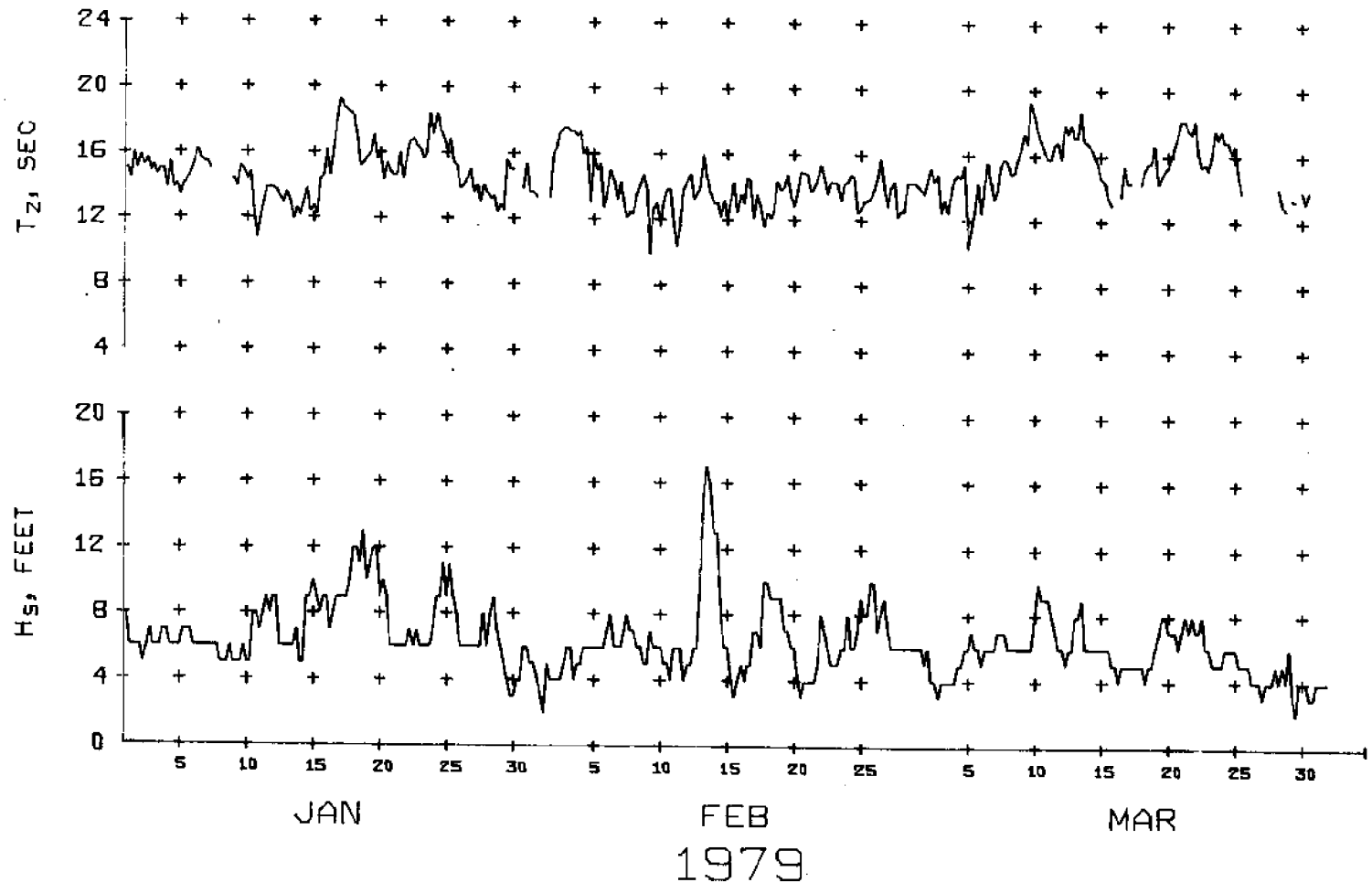

SIGNIFICANT WAVE HEIGHT AND PERIOD
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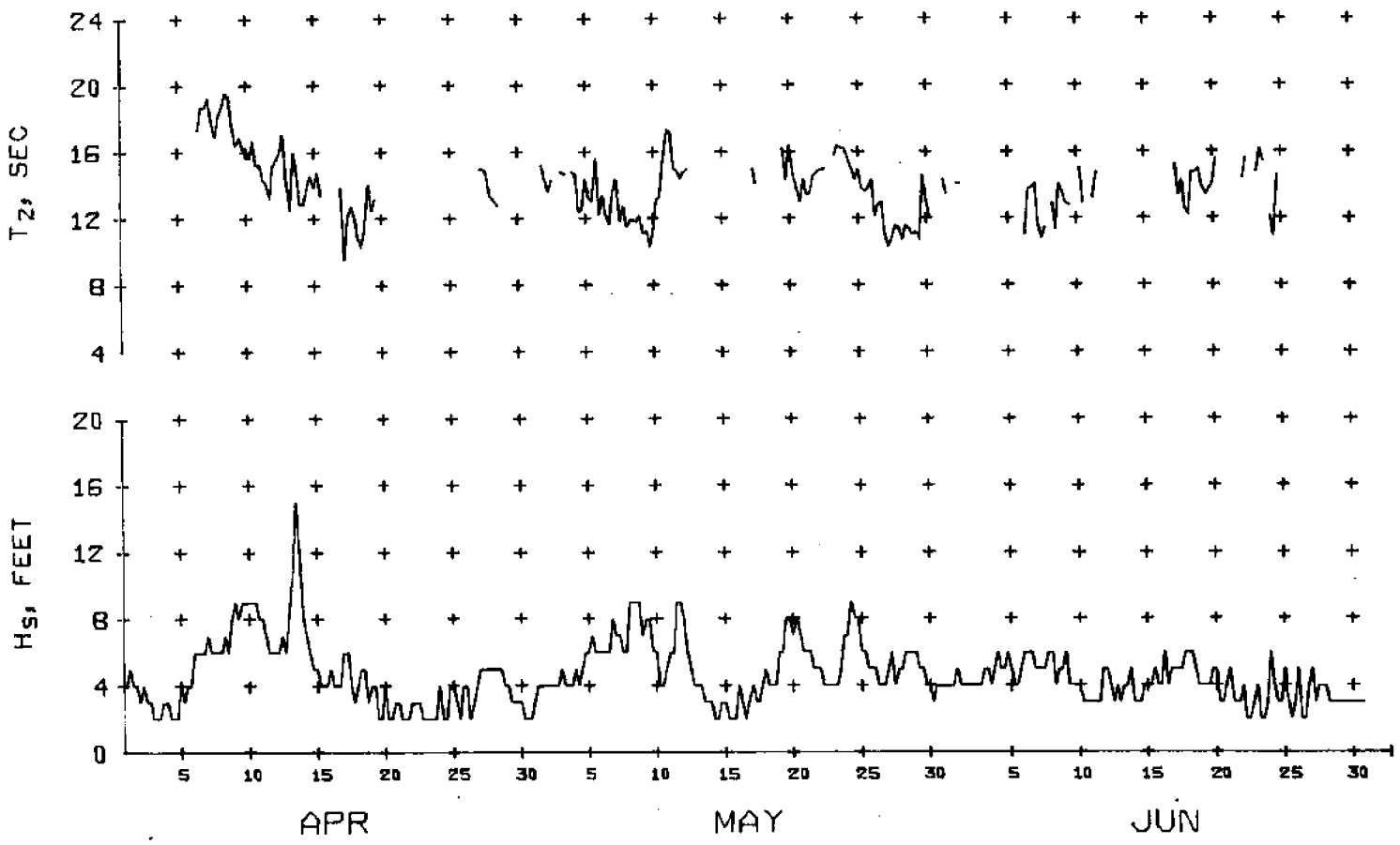
WAVEMETER




1979

SIGNIFICANT WAVE HEIGHT AND PERIOD
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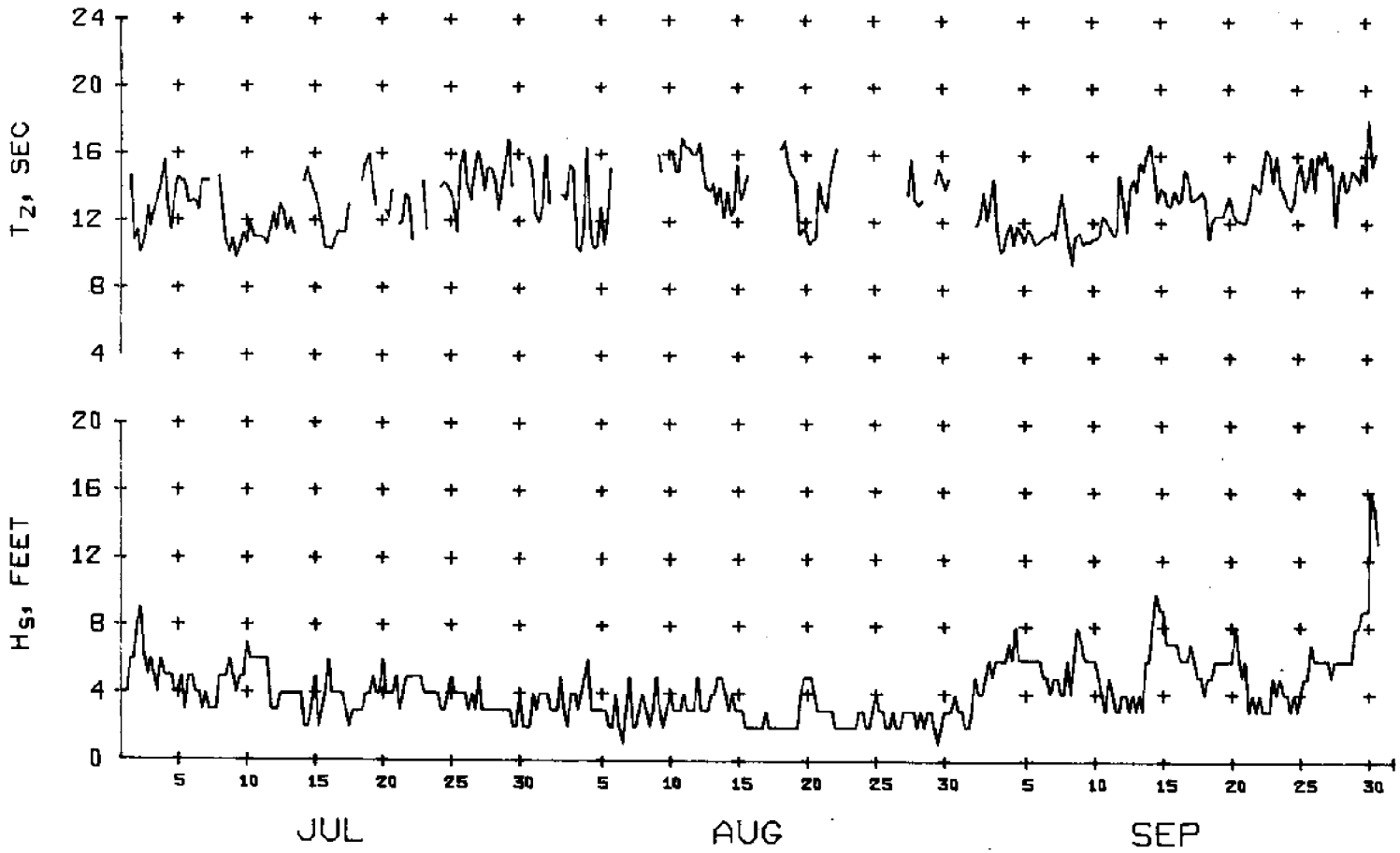
WAVEMETER




1979

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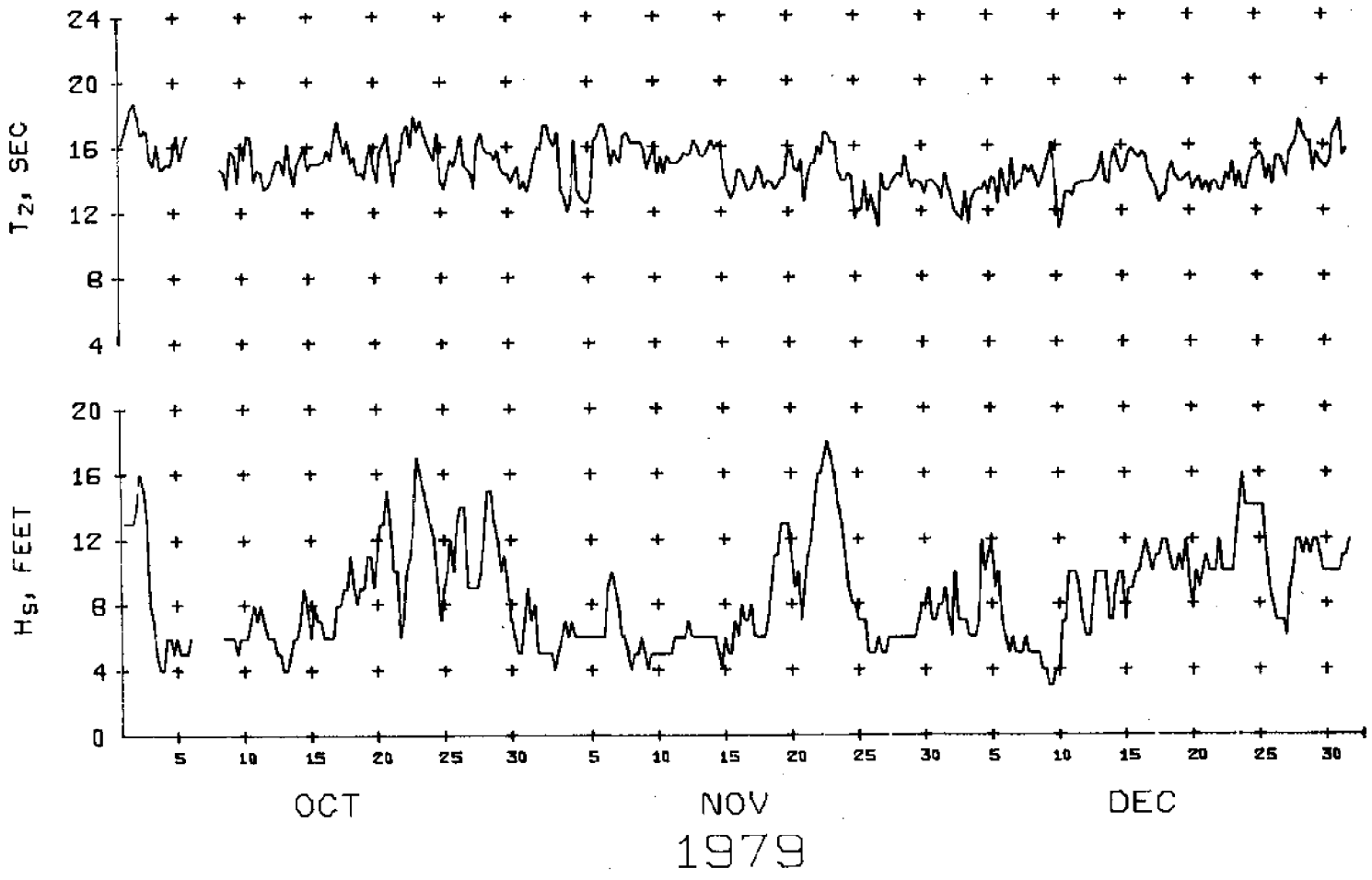
WAVEMETER



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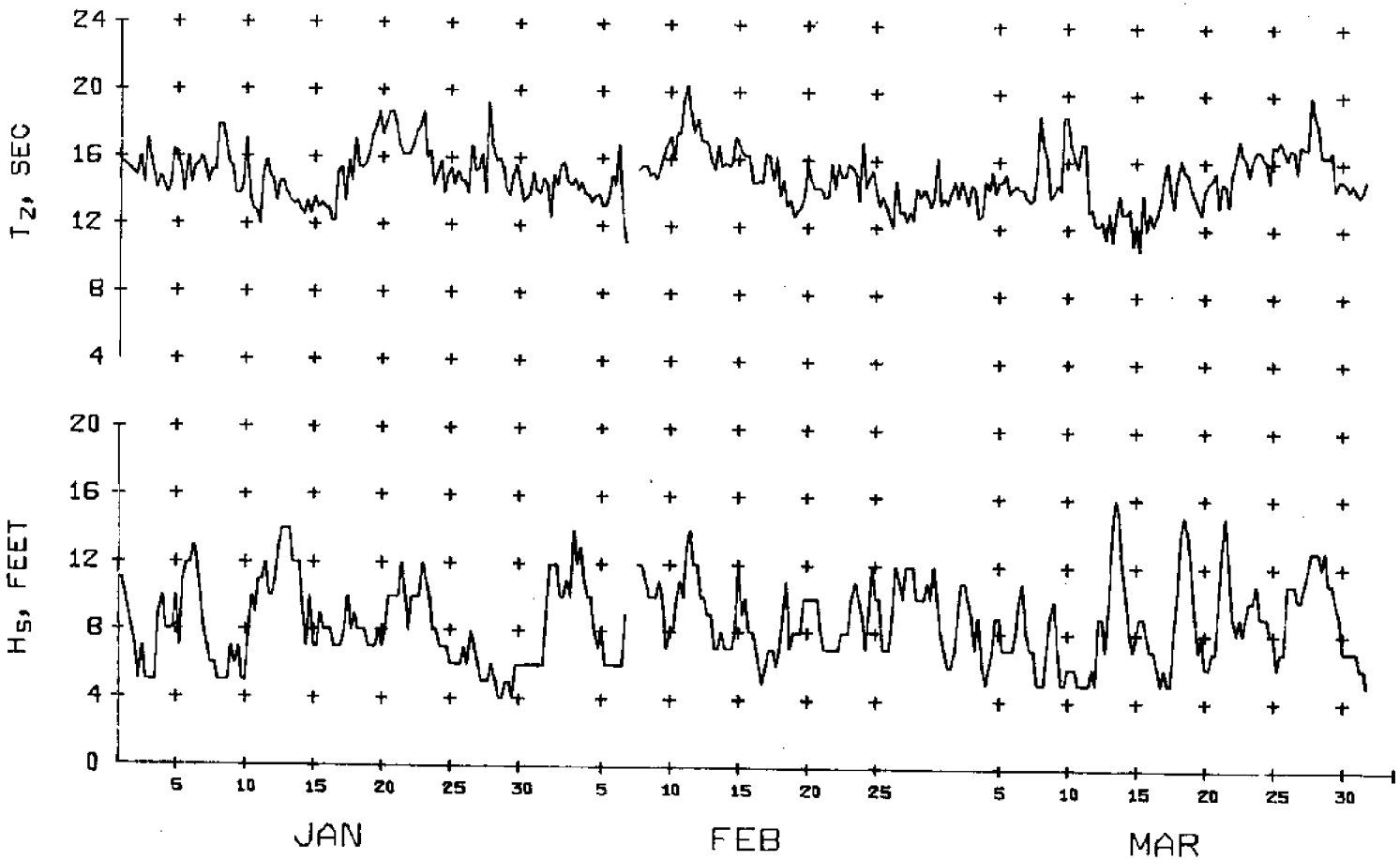
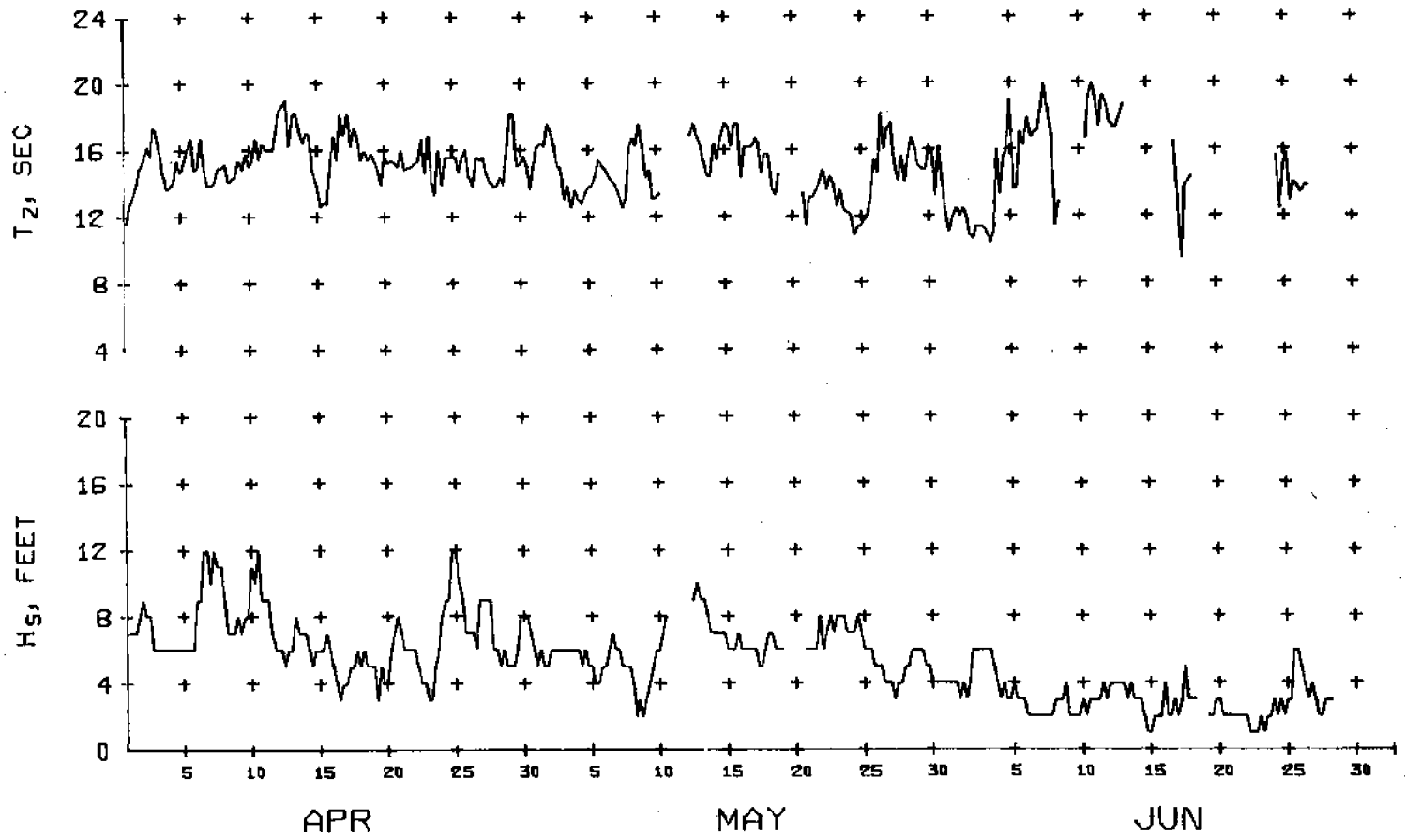
WAVEMETER




1980

SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
WAVEMETER




1980

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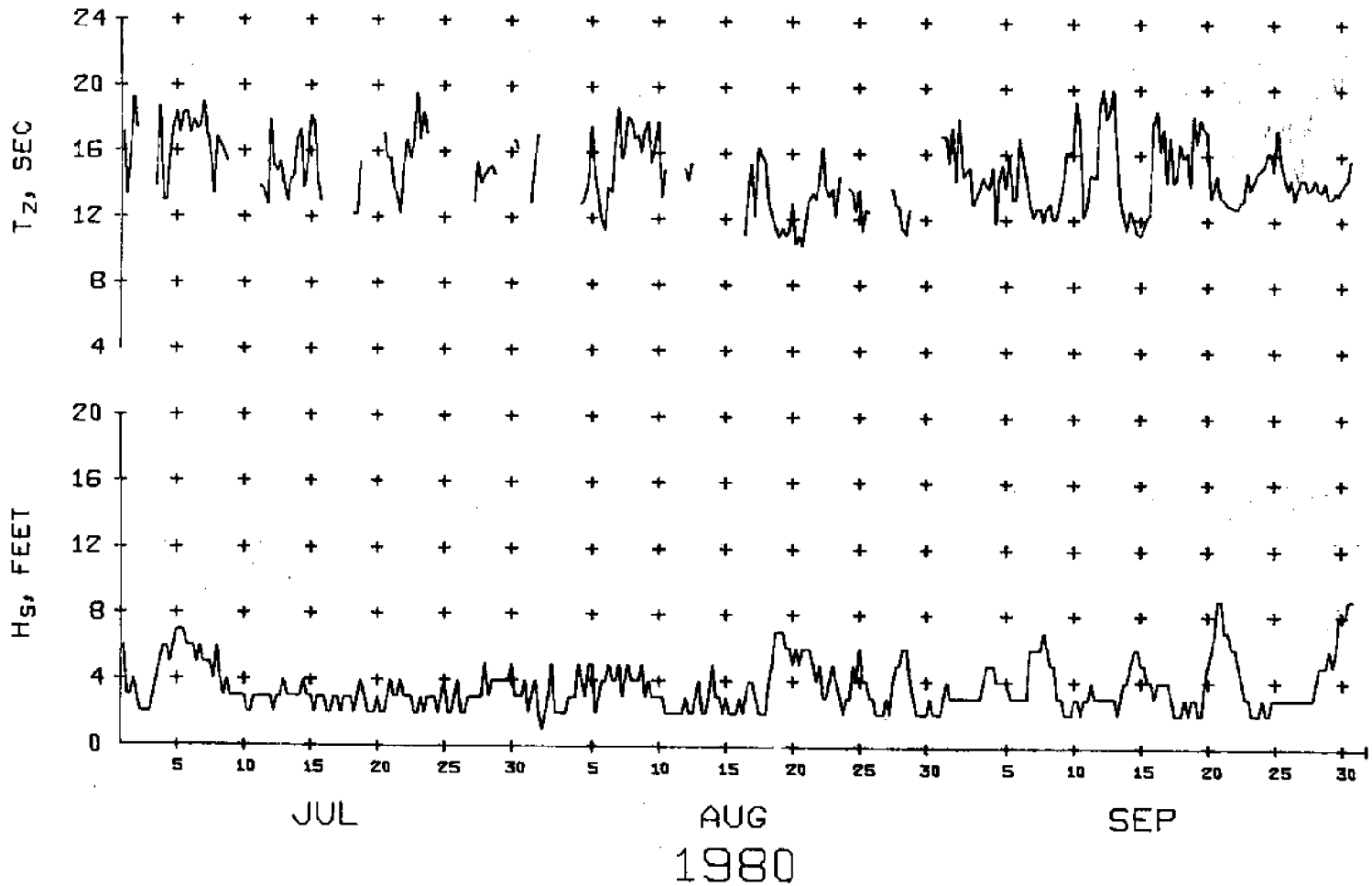
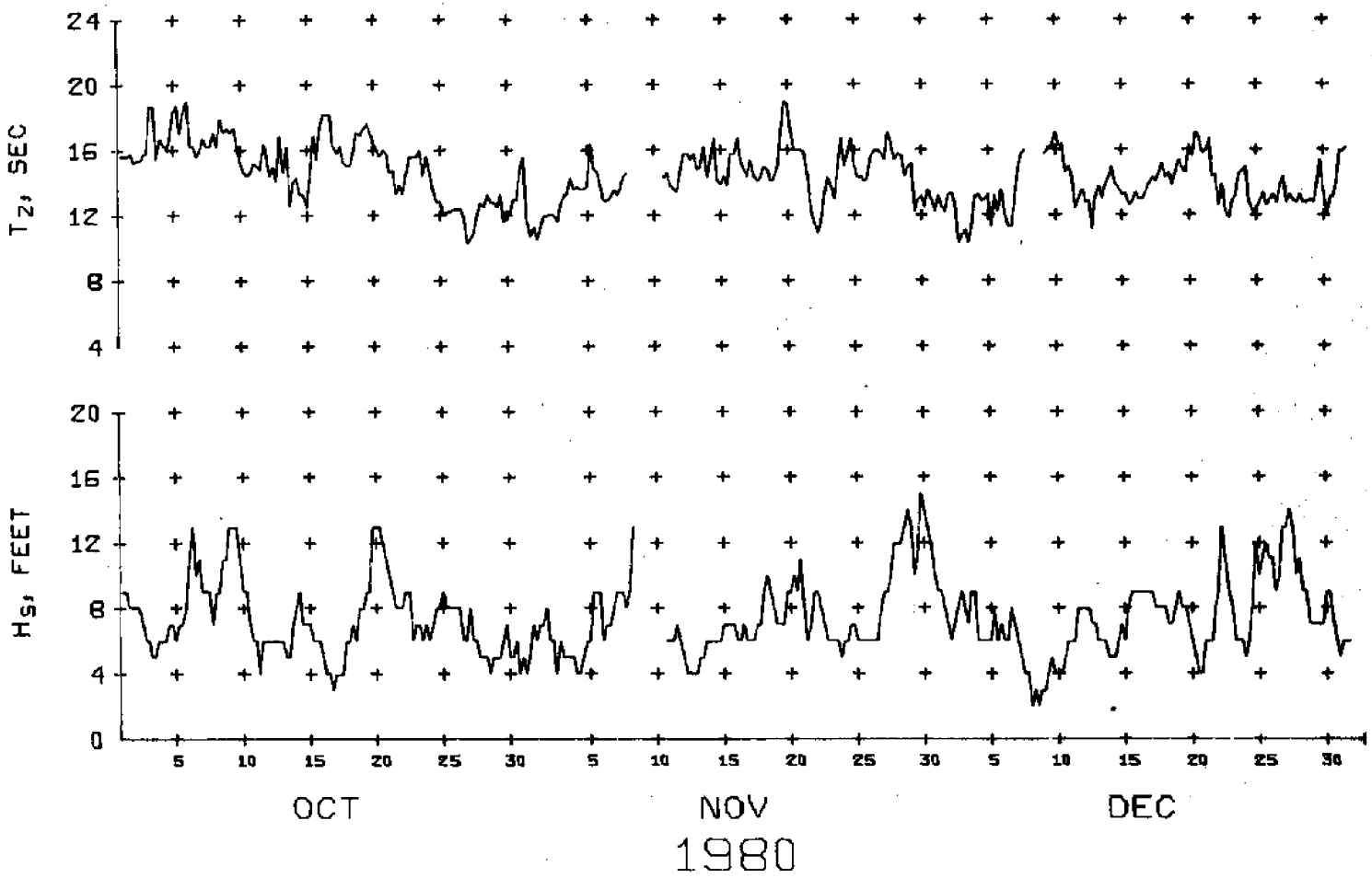
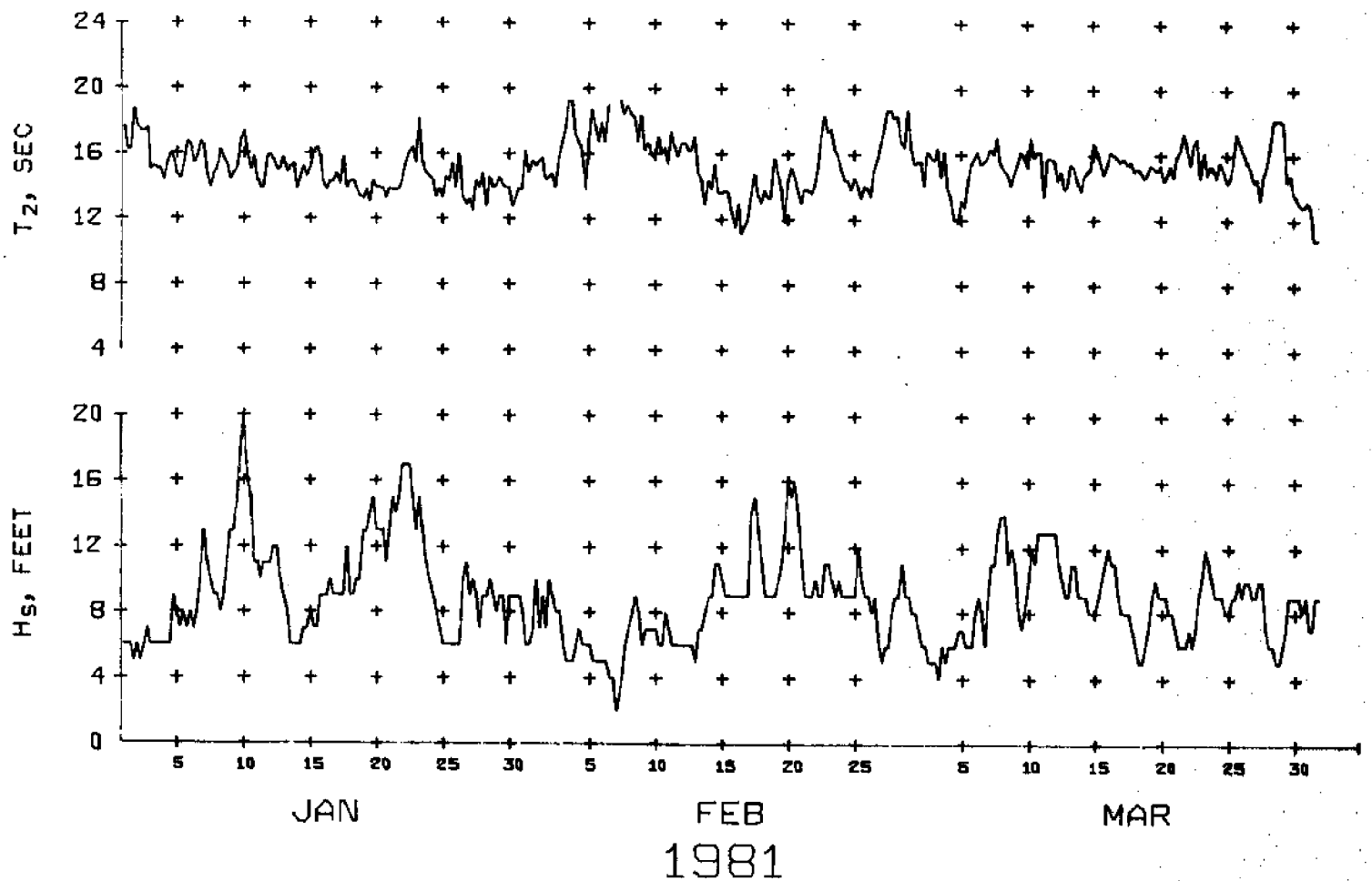
WAVEMETER



SIGNIFICANT WAVE HEIGHT AND PERIOD
YAQUINA BAY, OREGON
WAVEMETER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YAQUINA BAY, OREGON
WAVEMETER