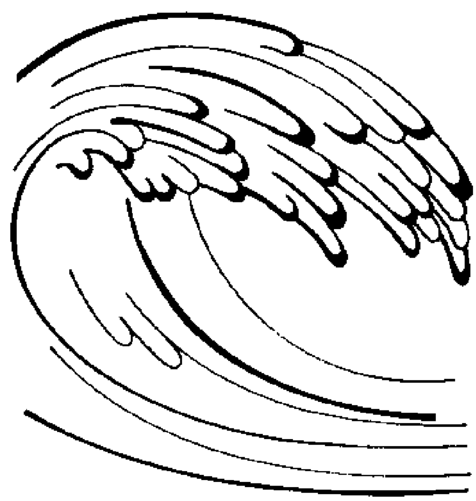
FIVE-YEAR CLIMATOLOGY (1972-1976) OFF YAQUINA BAY, OREGON

Clayton Creech



OREGON STATE UNIVERSITY
SEA GRANT COLLEGE PROGRAM
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CLAYTON CREECH is a research assistant unclassified in oceanography at Oregon State University.

acknowledgment

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INTRODUCTION AND SUMMARY

This report describes the nearshore wave climatology off Yaquina Bay (Newport), Oregon, for the five-year period 1972 through 1976; it also includes a brief description of the wave measurement system, calibration procedures, and data reduction techniques. The data are presented as tables and diagrams showing mean, percentage exceedence, occurrence distributions, and persistence of given conditions.

Major results are:

- the mean October-March wave height was 7.3 feet (10.3 second period).
- the mean April-September wave height was 3.9 feet (8.4 second period).
- the maximum significant height recorded was 24 feet (December 1972) associated with a period of 17 seconds.
- the maximum significant wave period recorded was 18 seconds (December 1975) associated with a wave height of 9 feet.
- 10% of October-March waves were 12 feet or larger.
- 50% of October-March waves were 7 feet or larger.
- 10% of April-September waves were 7 feet or larger.

INSTRUMENTATION AND CALIBRATION

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 miles from the ocean (Fig. 1). The seismometer is in a room that is temperature

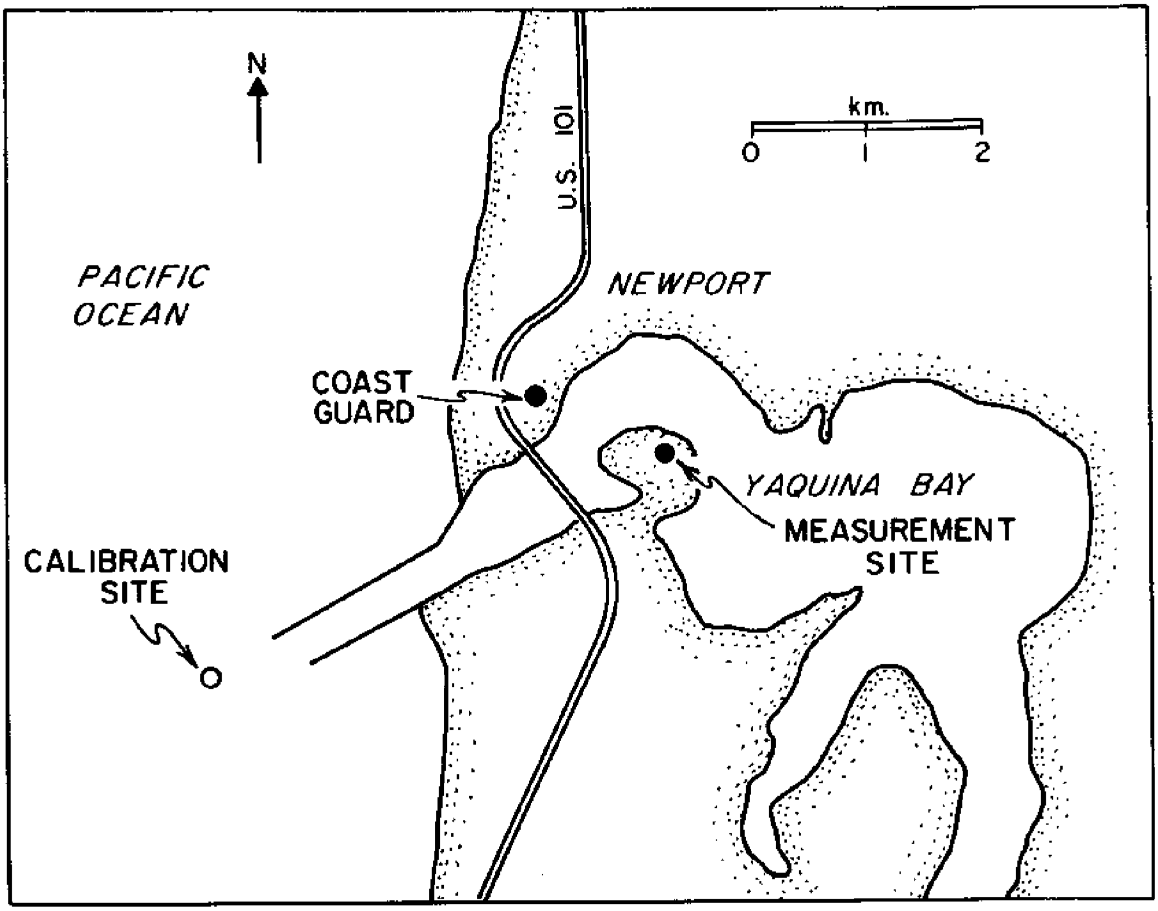

Fig. 1.

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 10 sec/in. A separate timer activates the recorder for 10 minutes at six-hour intervals. The seismometer is also connected to a linearizer that displays wave height directly (Zopf et al. 1976). The strip chart peak-to-peak deflections of the seismometer signal and concurrent zero-crossing periods are read to determine wave height and period for each recording sequence.

Correlation tests at our location confirmed the utility of the Longuet-Higgins (1950) theory in producing 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 two years 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 liner 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 N = 403 observations. Chart periods were approximately one-half ocean wave periods as Darbyshire (1950) reported and Longuet-Higgins (1950) predicted.

DATA REDUCTION

A technician read each strip chart sequence to determine a significant height (nearest whole foot) and associated zero-crossing period (nearest half-second) of significant waves. The seismic period was multiplied by two to approximate ocean wave periods. When both sea and swell were present in the record, the higher height (usually swell) and associated period were used. An average zero-crossing period for each sequence was not determined because the amplitude of the deflections varies with the period cubed (Zopf et al. 1976). It was easier to determine the average height of the highest 10% of the waves in the record, $H_{1/10}$. This value was reduced by 20% ($H_s = .8 \; H_{1/10}$) according to the Longuet-Higgins (1952) formula to yield an H_s (average height of highest 33% of waves) for that record. The same person read all records for the five-year period, thus maintaining consistency. 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, wave forecasts/hindcasts, nearshore ship reports, and Yaquina Bay Coast Guard visual observations. Most gaps were 18 hours (three records) or less with an occasional gap of three days. About 3% of the total 7308 observations were interpolated.

DATA PRESENTATION

The diagrams follow the format presented by Draper (1967) plus some additional tables and diagrams.

Table 1 shows the average monthly, quarterly, seasonal, and yearly statistics for both height and period for the five years 1972-76. 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 2, 3, and 4 are cumulative distribution diagrams, which indicate that 25% of wave records had significant wave heights that exceeded 8 feet based on a 10-minute sample every six hours. During the winter (October-March), 45% exceeded 8 feet compared to only 5% in summer.

Figures 5 and 6 are log-linear height exceedence plots. A straight line was drawn between points greater than 12 feet.

Figures 7, 8, and 9 are height histograms showing the percentage occurrence distributions of H_s at 1-foot intervals. A bias at 6 feet is caused by $H_{1/10}$ values of both 7 and 8 feet being reduced by 20% to give H_s = 6 feet (nearest whole foot). This also occurs to a lesser extent at 9 feet for $H_{1/10}$ values of 11 and 12 feet. The accompanying period percentage histograms show distribution of wave periods with a chart reader bias toward even number periods due to the spacing of the lines on the chart paper.

Figures 10, 11, and 12 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. Waves of 12 feet or more are generally associated with periods of 11 seconds or longer.

Figures 13, 14, and 15 are persistence diagrams, which indicate the continuity of a given or higher wave height for given periods of time. Minimum time is six hours due to the sampling period. A 12-hour duration means two consecutive observations at the given level. For instance, a height of 12 feet or more for 12 consecutive hours occurred only 2% of the total year or 4% of the winter observations. However, 8% of the winter observations were 8 feet or higher for 24 consecutive hours (one day).

Figure 16 is a height and period versus time plot for a typical winter month (January 1974), and Figure 17 for a summer month (August 1974). Note the several cases of abrupt increase in wave height in January followed by a rapid decrease. This typically results as an intense storm forms in the Northeast Pacific Ocean generating waves aimed at the Oregon coast. As the fetch (wave generating area) reaches the coast, the wave height at Yaquina Bay will rapidly increase. After the wind in the fetch decreases, the wave height will also decrease. Compare the sharp peaks of the January plot with the relative smoothness of the August plot. During the summer months, the normal storm tracks are more northerly and further west of Oregon producing less wave activity. However, an occasional storm of gale force might reach the coast in summer, producing 10-foot waves.

Table 2 shows the percent of possible days per month on which the daily maximum significant height exceeds a given height. Note the seasonal trend at N>8 feet between March and April and September-October. A fisherman could use this table and expect

19% of January days to have a maximum significant height greater than 12 feet and 3% to be greater than 16 feet.

The data from which these diagrams and tables were generated can be made available to other users by request to the author.

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TABLE 1
SUMMARY STATISTICS 1972-1976
YAQUINA BAY, OREGON

SIGNIFICANT WAVE HEIGHT H_s FEET

	JAN	FEB	MAR	JAN-MAR	APR	MAY	JUN	APR-JUN	JUL	AUG	SEP	JUL-SEP	OCT	NOV	DEC	OCT-DEC	JAN-DEC	OCT-MAR	APR-SEP
Sample size	620	568	620	1808	600	620	600	1820	620	620	600	1840	620	600	620	1840	7308	3648	3660
Mean	7.9	7.4	6.8	7.4	5.5	4.5	3.7	4.6	3.2	2.9	3.7	3.3	5.6	7.9	8.0	7.2	5.6	7.3	3.9
Standard deviation	3.4	2.7	3.0	3.1	2.1	2.4	1.8	2.2	1.6	1.3	1.8	1.6	2.7	3.3	3.1	3.2	3.2	3.2	2.1
Minimum	2	2	1	1	2	1	1	1	1	1	1	1	1	2	2	1	1	1	1
Maximum	19	20	16	20	13	13	11	13	8	8	10	10	14	18	24	24	24	24	13

WAVE PERIOD, SECONDS

	JAN	FEB	MAR	JAN-MAR	APR	MAY	JUN	APR-JUN	JUL	AUG	SEP	JUL-SEP	OCT	NOV	DEC	OCT-DEC	JAN-DEC	OCT-MAR	APR-SEP
Sample size	620	568	620	1808	600	620	600	1820	620	620	600	1840	620	600	620	1840	7308	3648	3660
Mean	10.6	10.2	9.7	10.1	9.3	8.8	8.0	8.7	7.8	7.9	8.6	8.1	10.0	10.6	10.6	10.4	9.3	10.3	8.4
Standard deviation	3.2	1.6	1.6	1.7	1.4	1.7	1.3	1.6	1.2	1.2	1.6	1.4	1.8	1.8	1.9	1.9	1.9	1.8	1.5
Minimum	6	7	6	6	5	5	4	4	5	4	4	4	6	6	6	6	4	6	4
Maximum	16	15	16	16	15	14	13	15	12	12	14	14	16	15	18	18	18	18	15

Table 1.

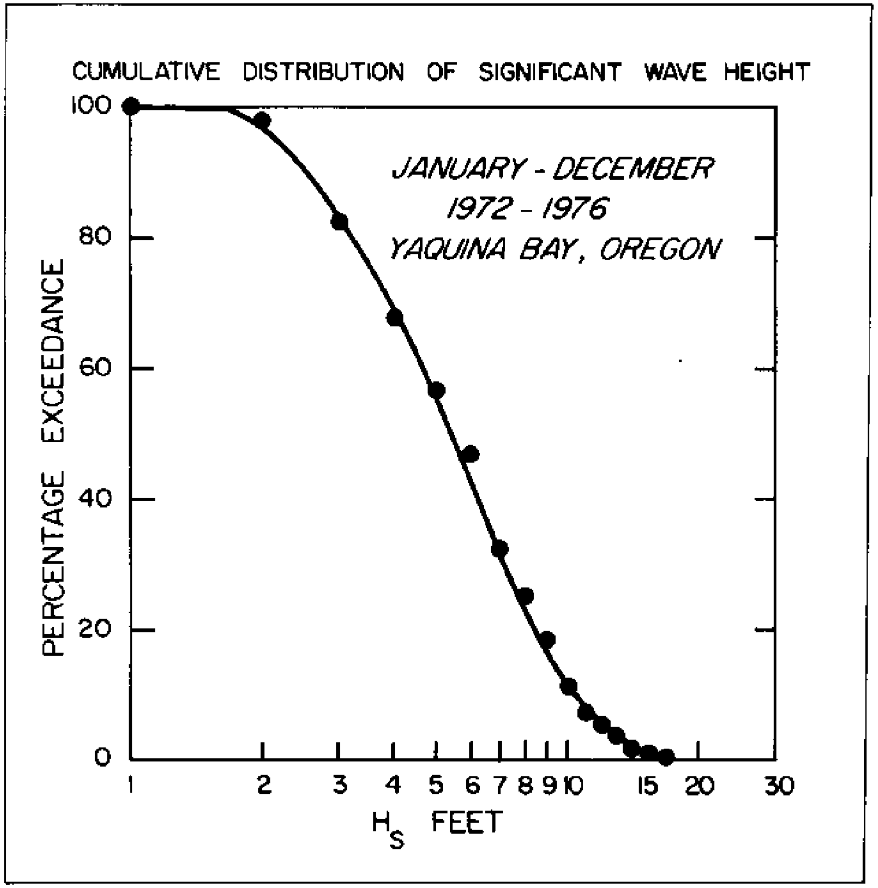

CUMULATIVE DISTRIBUTION OF SIGNIFICANT WAVE HEIGHT
JANUARY - DECEMBER
1972 - 1976
YAQUINA BAY, OREGON
PERCENTAGE EXCEEDANCE
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
15
20
30
H S FEET

Fig. 2.

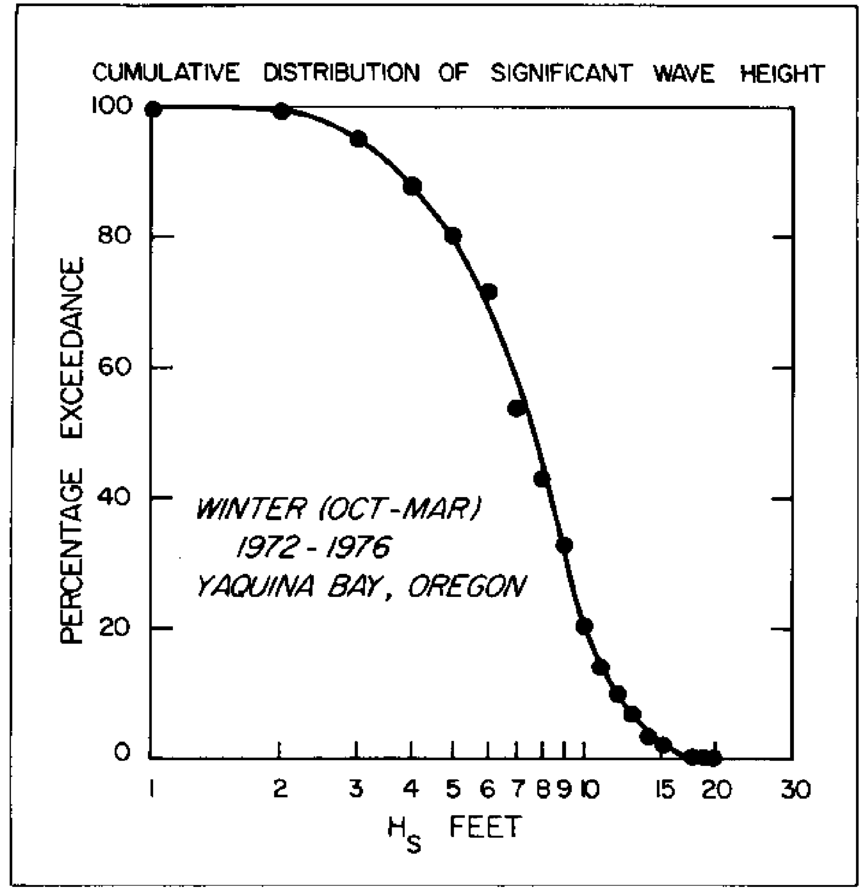

CUMULATIVE DISTRIBUTION OF SIGNIFICANT WAVE HEIGHT
WINTER (OCT-MAR)
1972 - 1976
YAQUINA BAY, OREGON
PERCENTAGE EXCEEDANCE
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
15
20
30
H S FEET

Fig. 3.

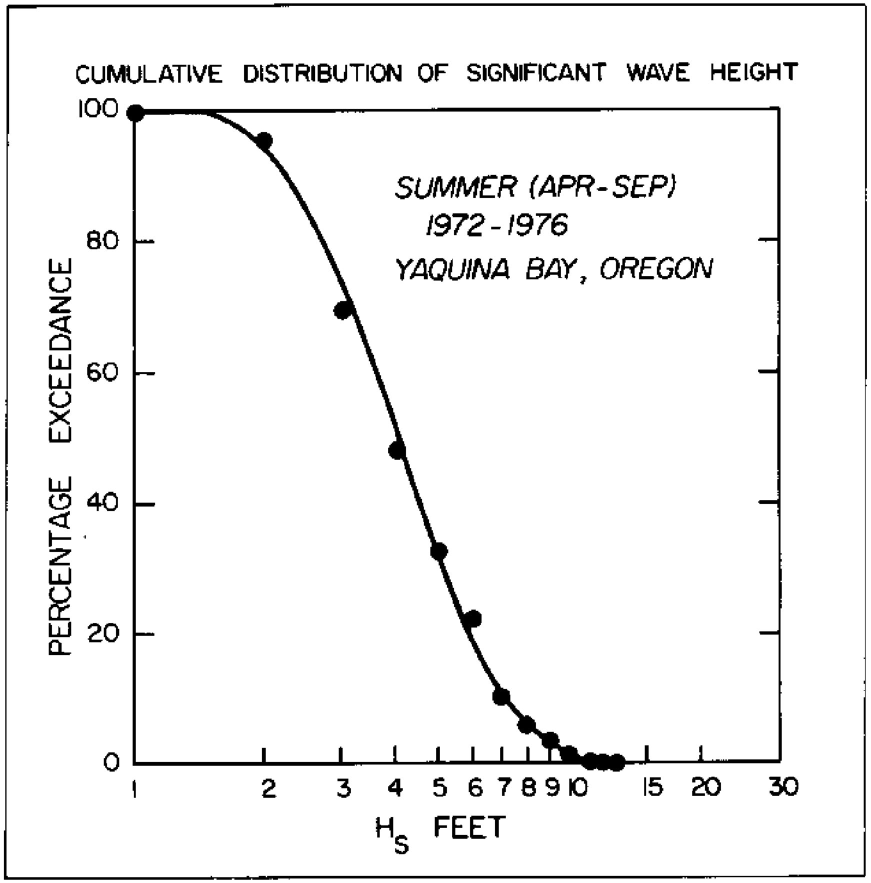

CUMULATIVE DISTRIBUTION OF SIGNIFICANT WAVE HEIGHT
SUMMER (APR-SEP)
1972-1976
YAQUINA BAY, OREGON
PERCENTAGE EXCEEDANCE
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
15
20
30
H_S FEET

Fig. 4.

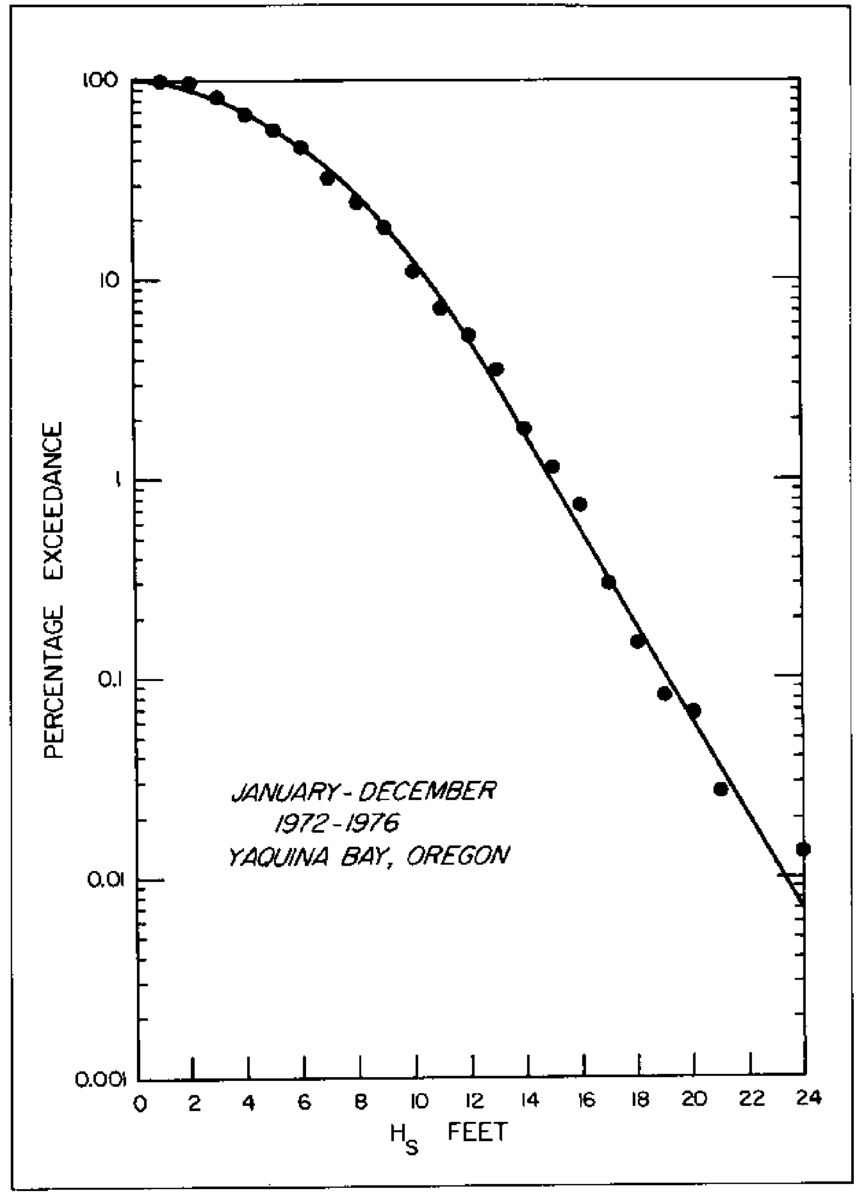

JANUARY-DECEMBER
1972-1976
YAQUINA BAY, OREGON
PERCENTAGE EXCEEDANCE
100
10
1
0.1
0.01
0.001
0
2
4
6
8
10
12
14
16
18
20
22
24
H_S FEET

Fig. 5.

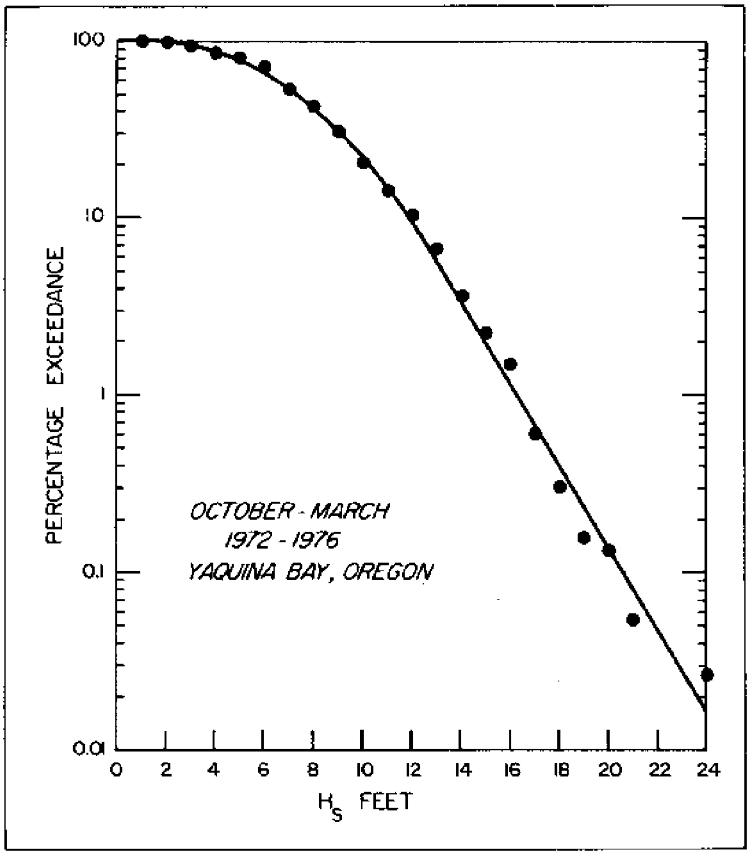

OCTOBER - MARCH
1972 - 1976
YAQUINA BAY, OREGON
PERCENTAGE EXCEEDANCE
100
10
1
0.1
0.01
0 2 4 6 8 10 12 14 16 18 20 22 24
H_S FEET

Fig. 6.

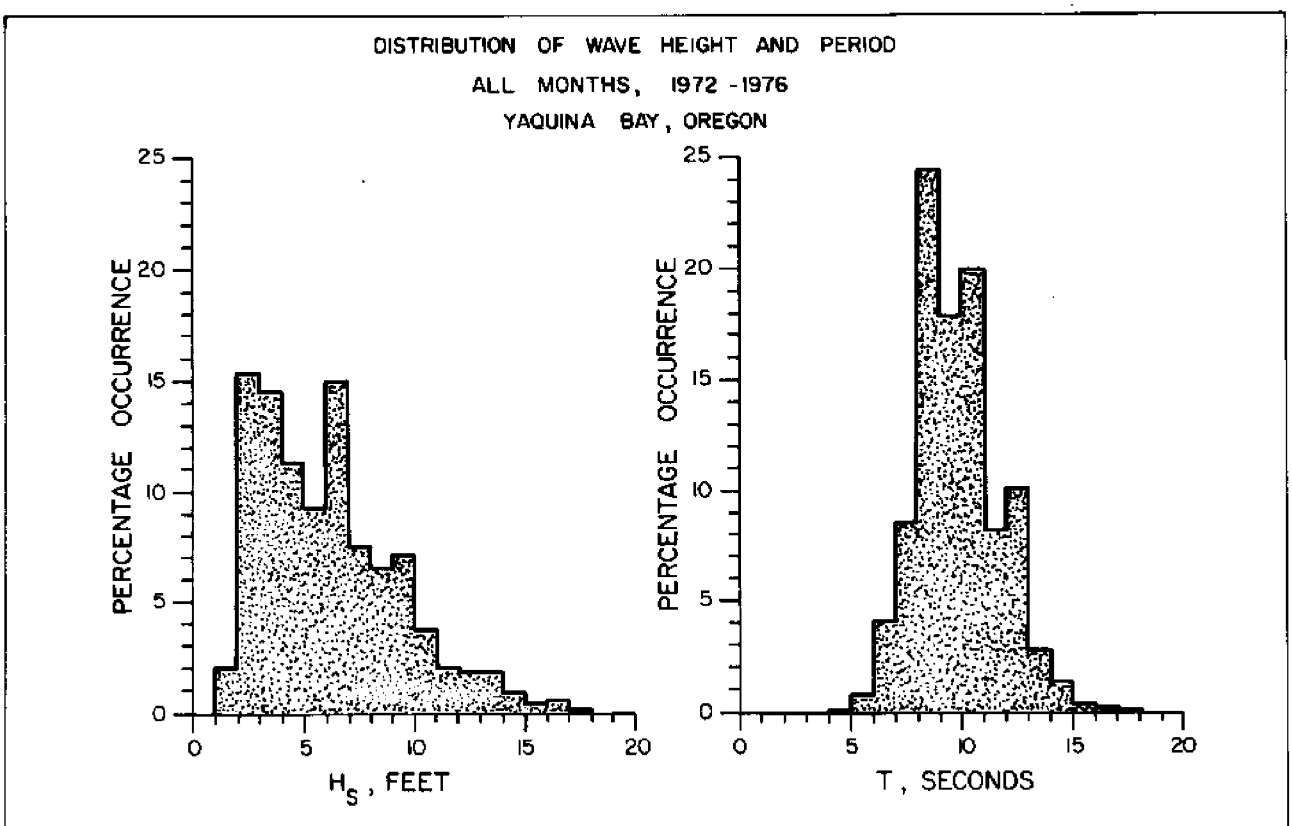

DISTRIBUTION OF WAVE HEIGHT AND PERIOD
ALL MONTHS, 1972 - 1976
YAQUINA BAY, OREGON
PERCENTAGE OCCURRENCE
25
20
15
10
5
0
0 5 10 15 20
H_S, FEET
PERCENTAGE OCCURRENCE
T, SECONDS

Fig. 7.

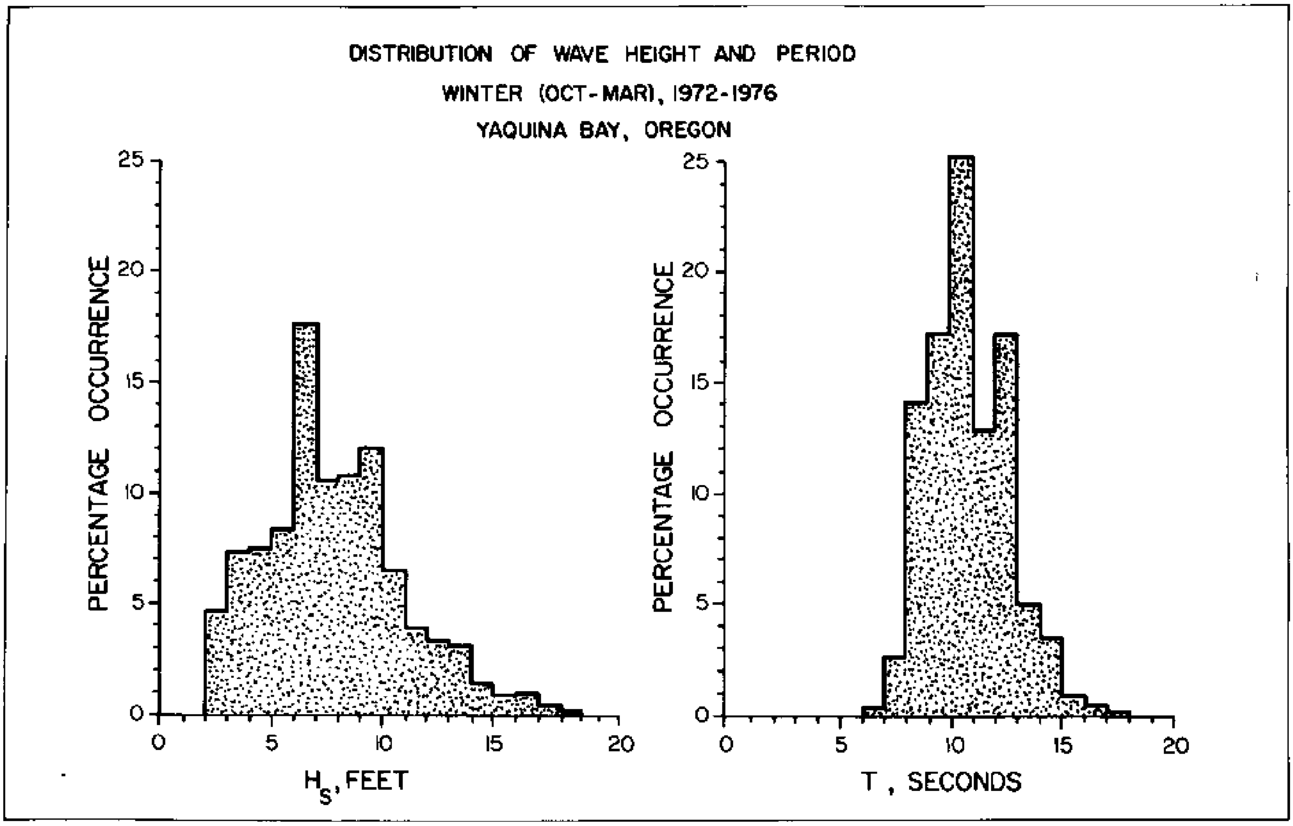

DISTRIBUTION OF WAVE HEIGHT AND PERIOD
WINTER (OCT-MAR), 1972-1976
YAQUINA BAY, OREGON
PERCENTAGE OCCURRENCE
25
20
15
10
5
0
0
5
10
15
20
H_S, FEET
T, SECONDS

Fig. 8.

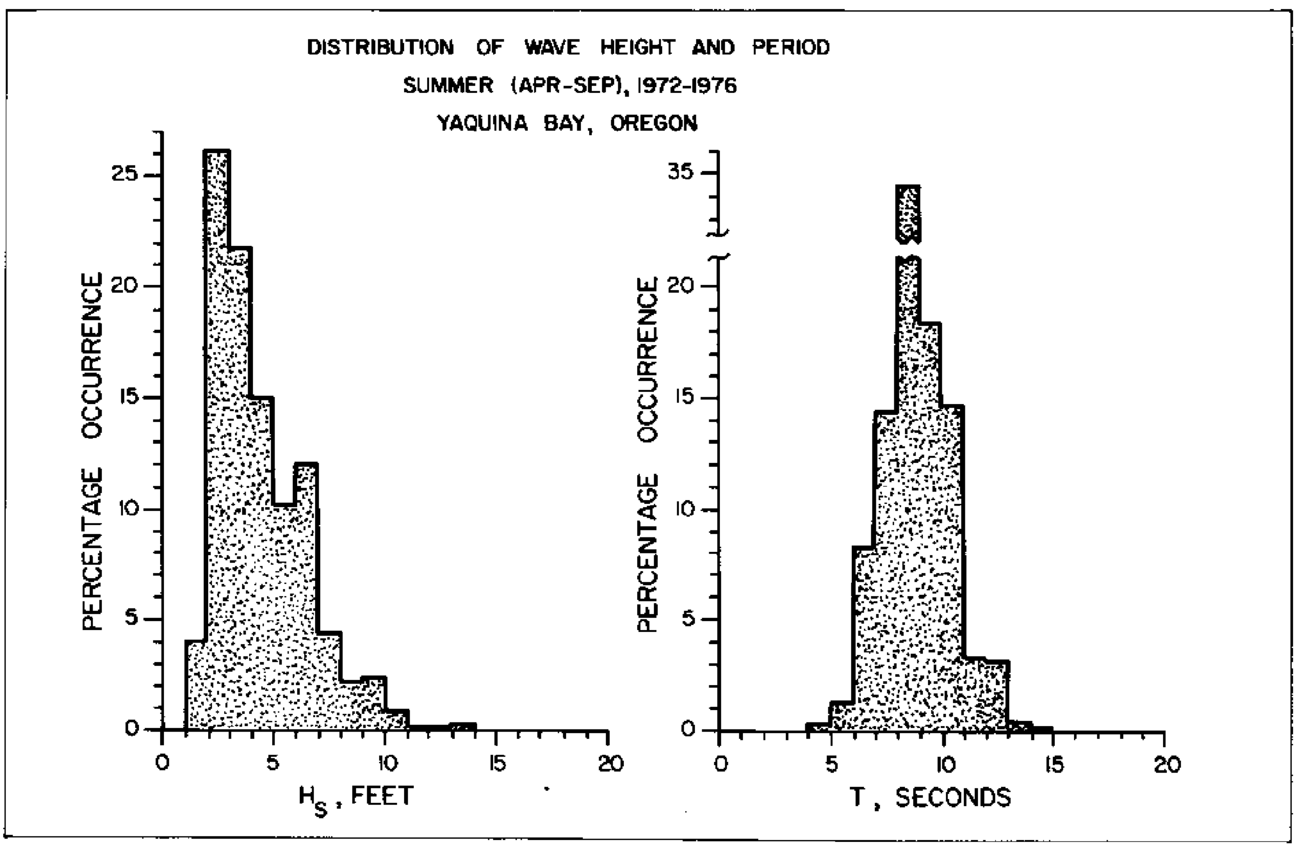

DISTRIBUTION OF WAVE HEIGHT AND PERIOD
SUMMER (APR-SEP), 1972-1976
YAQUINA BAY, OREGON
PERCENTAGE OCCURRENCE
35
25
20
15
10
5
0
0
5
10
15
20
H_S, FEET
T, SECONDS

Fig. 9.

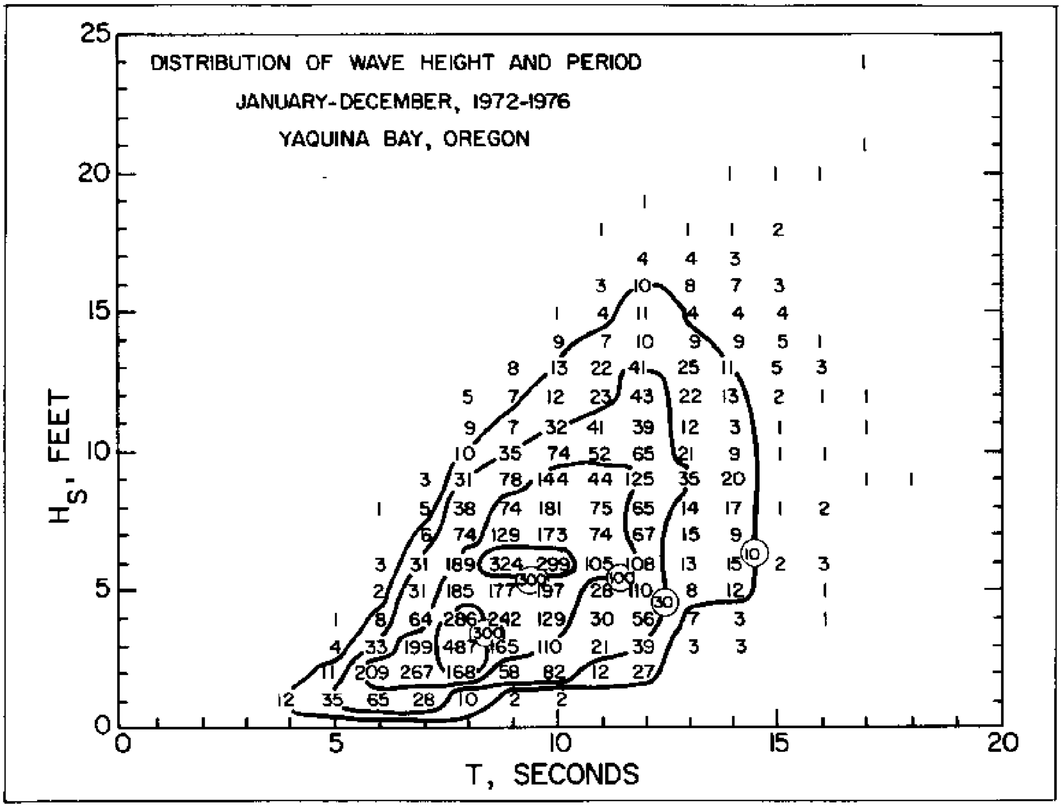

DISTRIBUTION OF WAVE HEIGHT AND PERIOD
JANUARY-DECEMBER, 1972-1976
YAQUINA BAY, OREGON
H$_S$, FEET
T, SECONDS

Fig. 10.

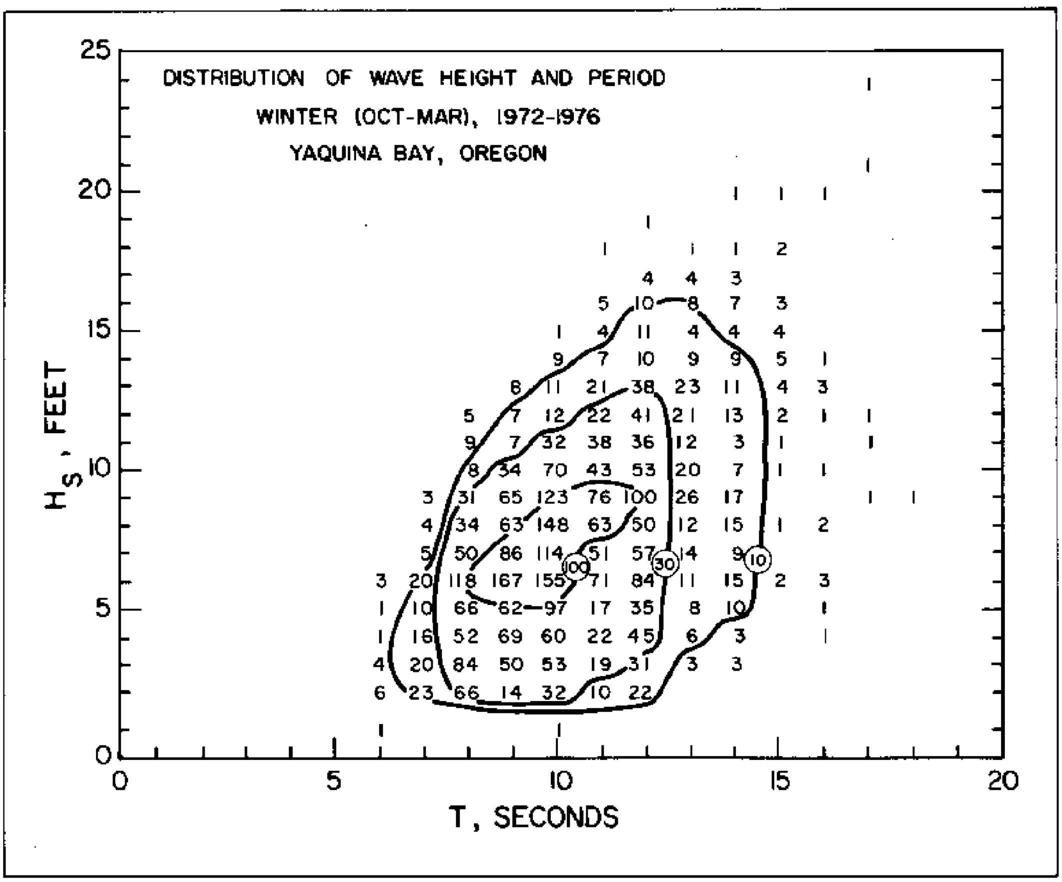
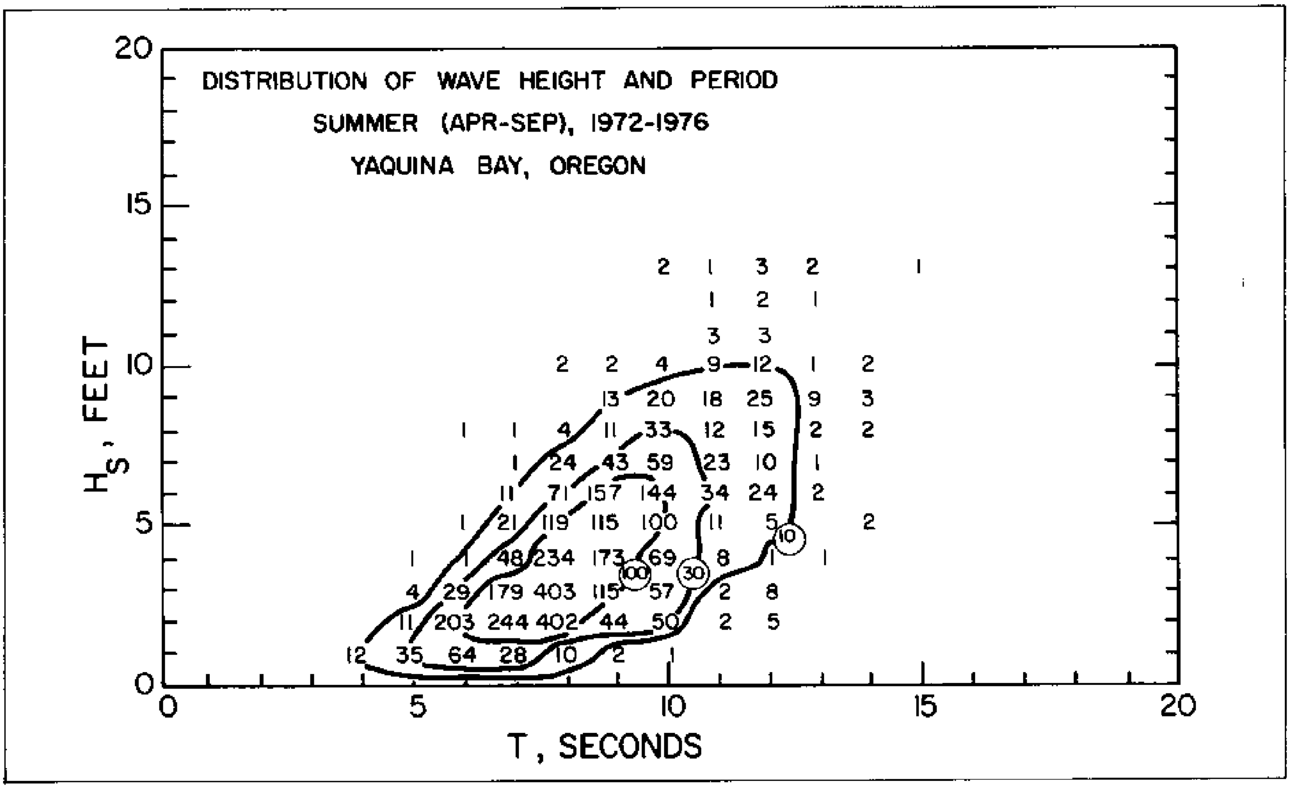
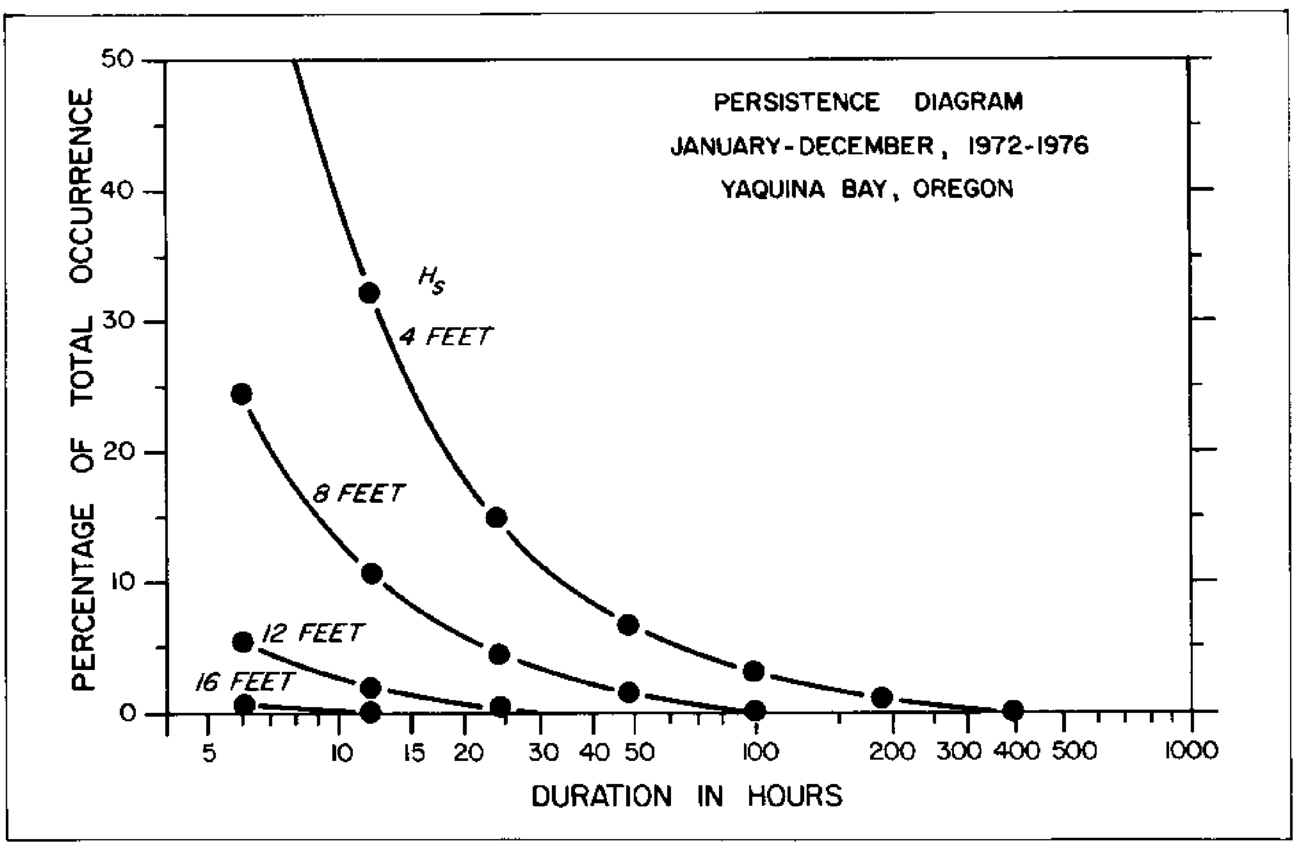

DISTRIBUTION OF WAVE HEIGHT AND PERIOD
WINTER (OCT-MAR), 1972-1976
YAQUINA BAY, OREGON
H$_S$, FEET
T, SECONDS

Fig. 11.



DISTRIBUTION OF WAVE HEIGHT AND PERIOD
SUMMER (APR-SEP), 1972-1976
YAQUINA BAY, OREGON
H_S, FEET
T, SECONDS

Fig. 12.



PERSISTENCE DIAGRAM
JANUARY-DECEMBER, 1972-1976
YAQUINA BAY, OREGON
H_s
4 FEET
8 FEET
12 FEET
16 FEET
PERCENTAGE OF TOTAL OCCURRENCE
DURATION IN HOURS

Fig. 13.

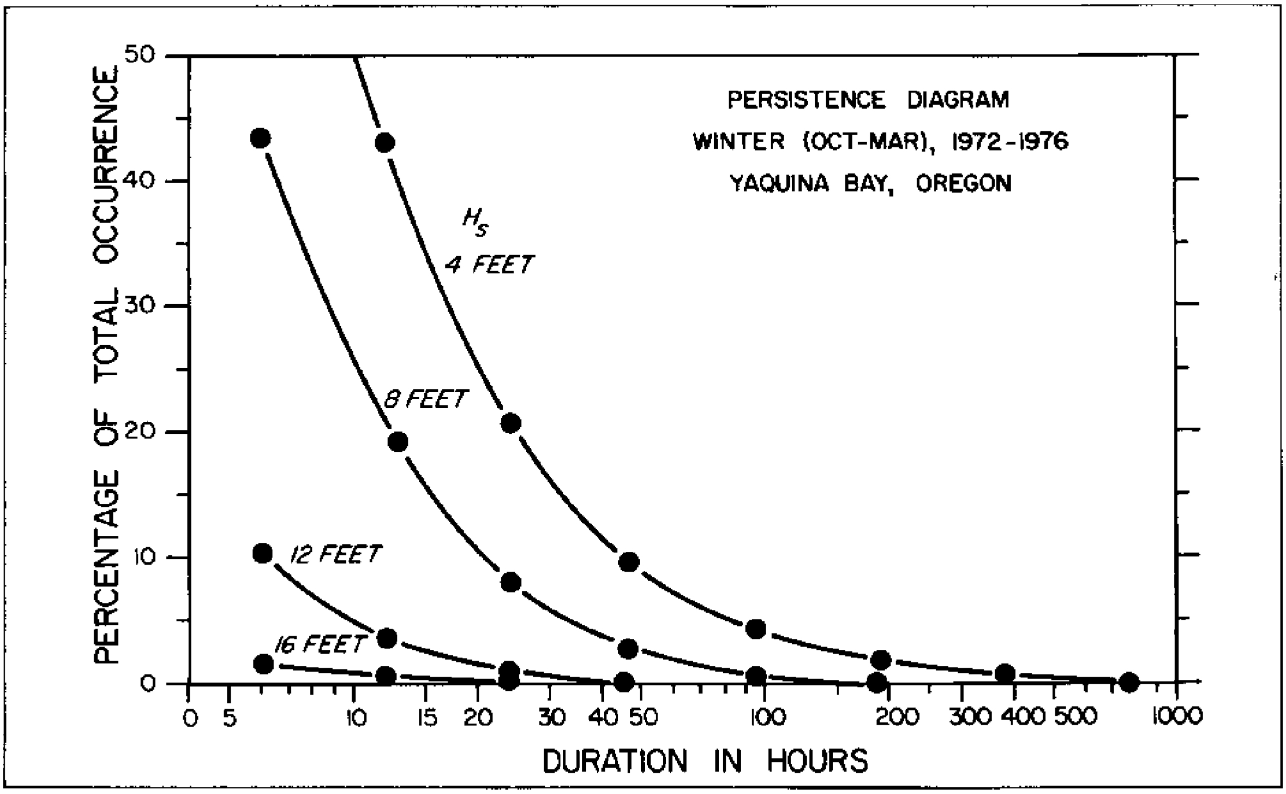

PERSISTENCE DIAGRAM
WINTER (OCT-MAR), 1972-1976
YAQUINA BAY, OREGON
H_s
4 FEET
8 FEET
12 FEET
16 FEET
PERCENTAGE OF TOTAL OCCURRENCE
0
10
20
30
40
50
0 5 10 15 20 30 40 50 100 200 300 400 500 1000
DURATION IN HOURS

Fig. 14.

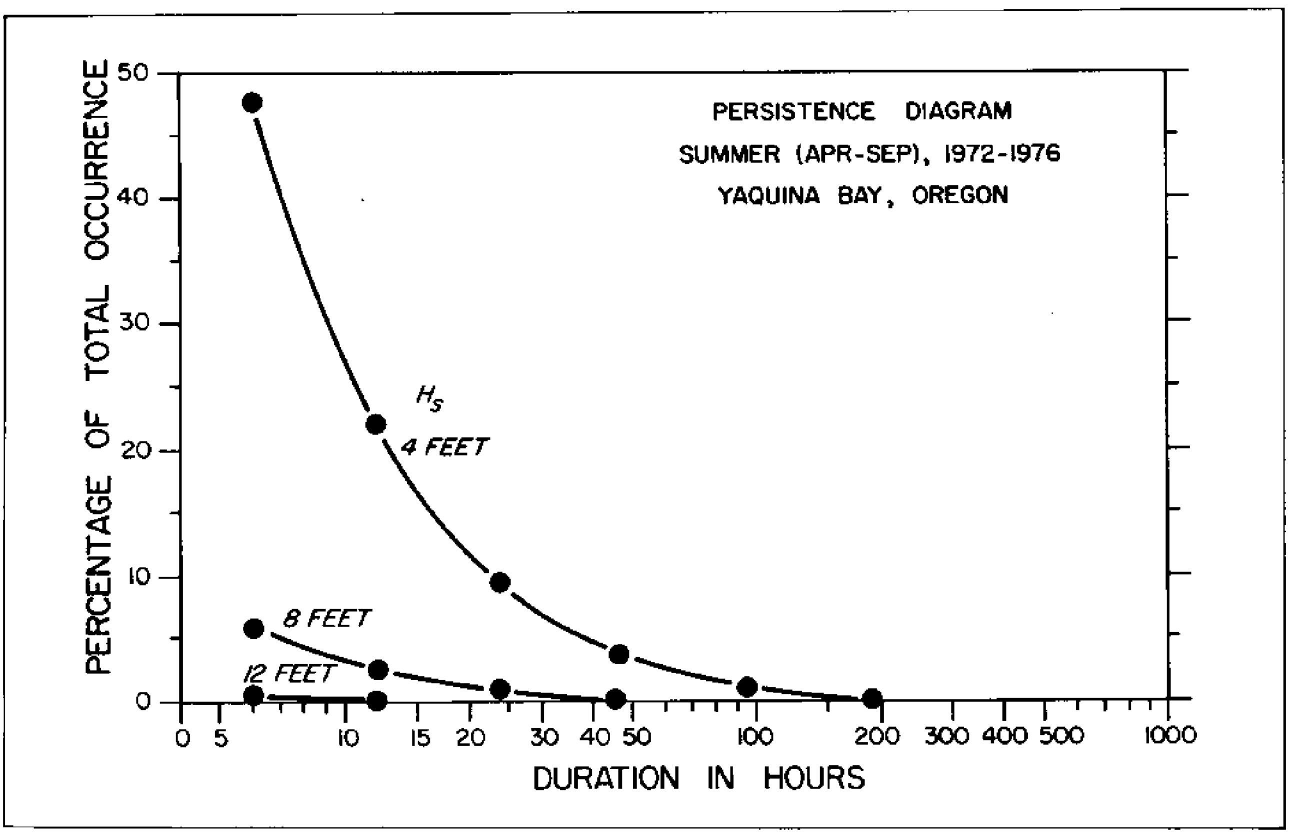

PERSISTENCE DIAGRAM
SUMMER (APR-SEP), 1972-1976
YAQUINA BAY, OREGON
H_s
4 FEET
8 FEET
12 FEET
PERCENTAGE OF TOTAL OCCURRENCE
0
10
20
30
40
50
0 5 10 15 20 30 40 50 100 200 300 400 500 1000
DURATION IN HOURS

Fig. 15.

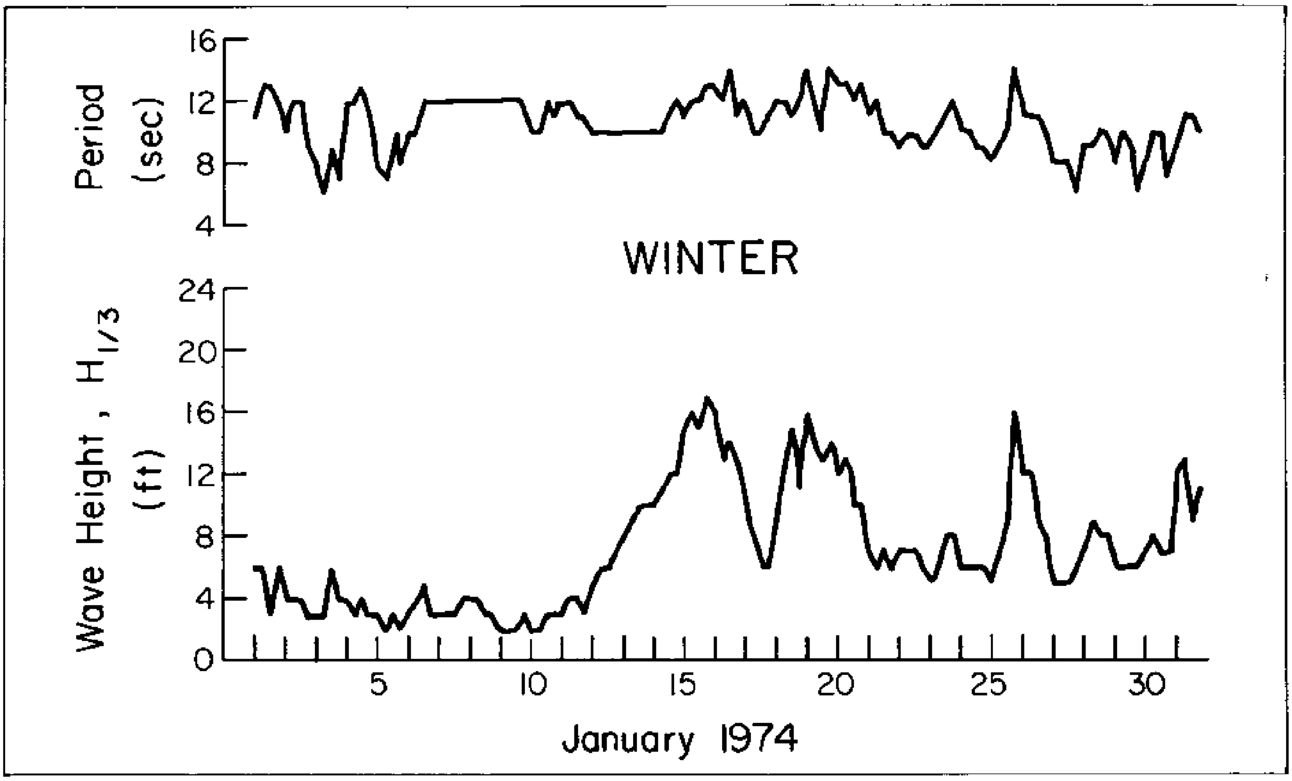

WINTER
Period (sec)
16
12
8
4
Wave Height, $H_{1/3}$ (ft)
24
20
16
12
8
4
0
5
10
15
20
25
30
January 1974

Fig. 16.

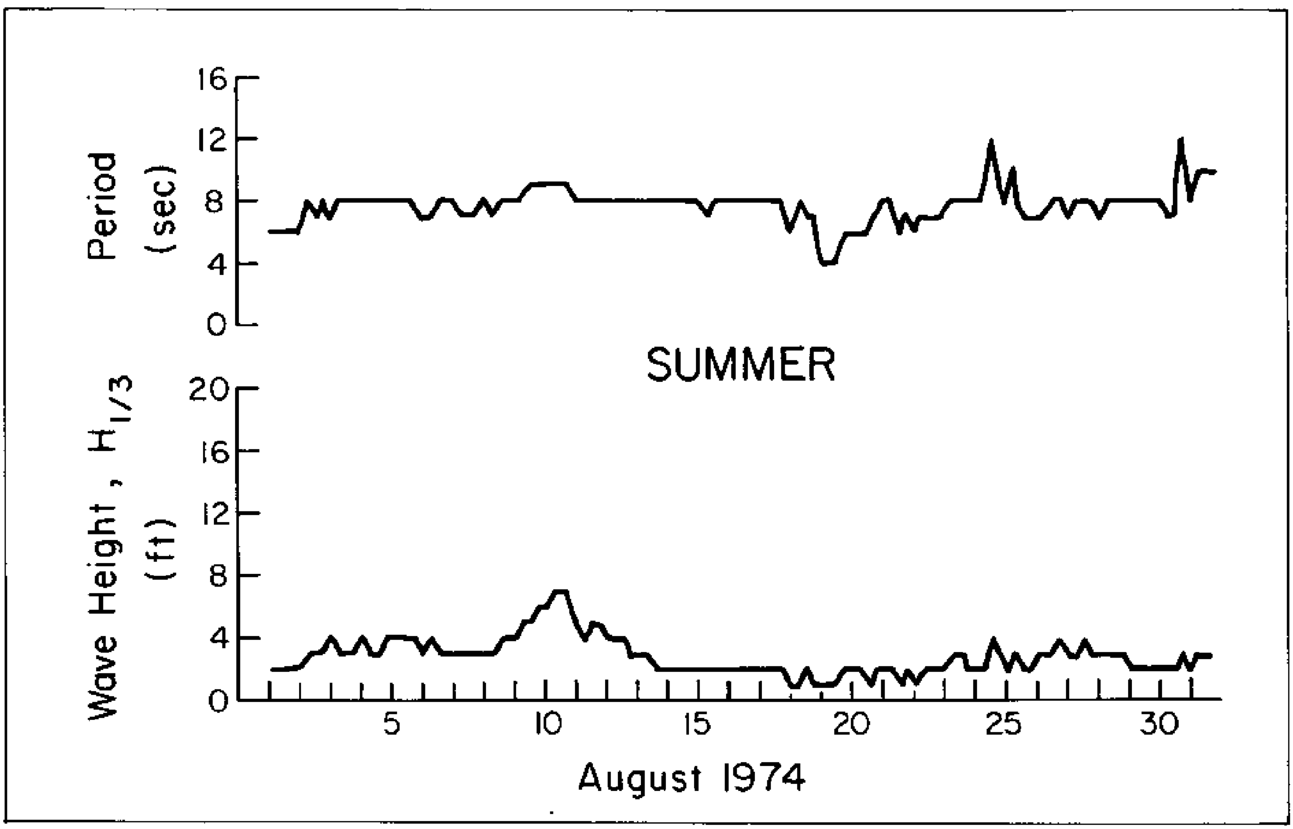

SUMMER
Period (sec)
16
12
8
4
0
Wave Height, $H_{1/3}$ (ft)
20
16
12
8
4
0
5
10
15
20
25
30
August 1974

Fig. 17.

TABLE 2
PERCENT POSSIBLE TIME PER MONTH
DAILY MAXIMUM WAVE HEIGHT EXCEEDS GIVEN VALUE
YAQUINA BAY, OREGON
1972-1976

	MONTH											
H_s (ft)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
4	90	93	87	87	58	47	32	19	40	73	94	94
8	58	50	42	20	16	3	0	0	3	27	58	65
12	19	14	10	3	3	0	0	0	0	3	20	13
16	3	0	0	0	0	0	0	0	0	0	3	3

Table 2.