

PART 1

WAVE THEORY AND MEASUREMENTS

CHAPTER 1

WAVES AT CAMP PENDLETON, CALIFORNIA

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ABSTRACT

Waves were recorded for nine years at Camp Pendleton, California, and the results of an analysis of records over two years are presented in this paper.

INTRODUCTION

From 1953 to 1961, waves have been recorded at an exposed point 3000 feet west of the boat basin of Camp Pendleton, between San Diego and Los Angeles, by means of a Snodgrass Mk IX wave recorder (Snodgrass 1955) situated in a mean depth of 32ft. Records were taken at six-hourly intervals and were of 20-minutes' duration. The instrument also recorded continuously, but with a very much reduced chart speed. The distribution of wave heights for each year has been determined, and, from the nine years, two have been selected for a fuller analysis and the results have been combined to represent a typical year. One of these years, 1954, was relatively calm and the other, 1958, was relatively rough. By using this method of selection it seems unlikely that these results represent unusual conditions. The recording and analysis were done at Camp Pendleton, and the interpretation and presentation of the results were done at the National Institute of Oceanography. (The analysis does not follow the pattern recently suggested by one of the authors (Draper, 1966) as it was undertaken soon after the instrument was removed, but the interpretation and presentation are in accordance with that paper.)

PARAMETERS DERIVED FROM THE RECORDS

The methods of analysis used yield the following parameters

T_s The significant wave period. This was determined from visual inspection of the 20-minute record by selecting groups of four or more consecutive waves. The groups are selected by using two conditions:-

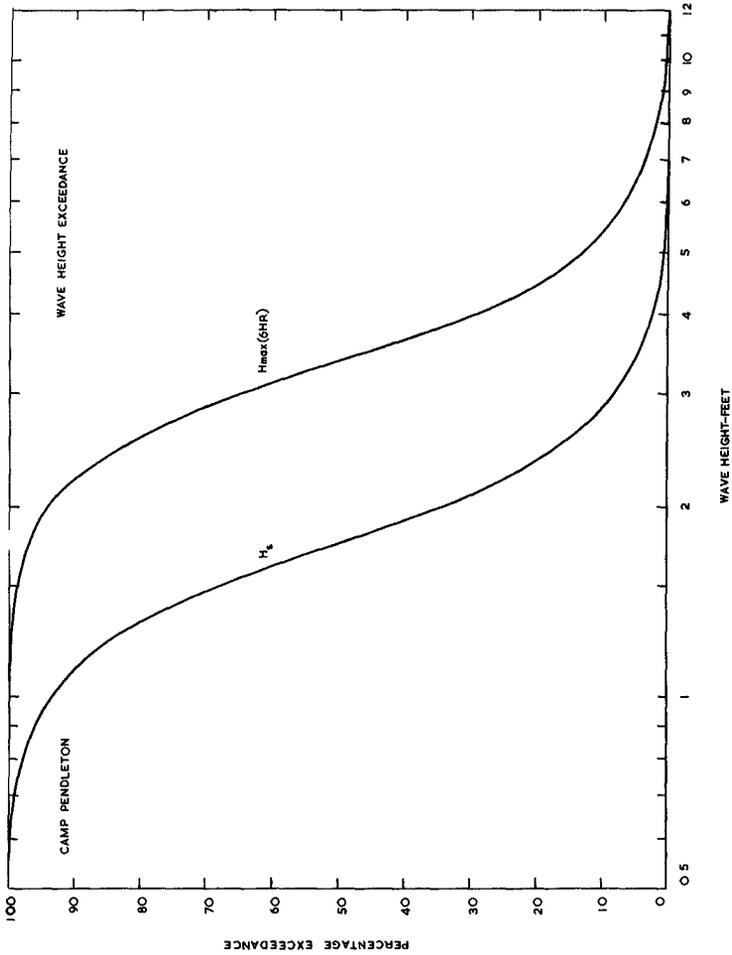


Figure 1 The cumulative distribution of significant wave height, H_s and of the most probable value of the height of the highest wave in the recording interval, H_{max} (6 hours).

- 1 The waves should be well formed.
- 2 The period within each group should appear to be consistent. The periods of the groups do not have to be consistent from one group to the other but in most cases they vary by only one or two seconds.

The total number of waves in all the selected groups is then divided into the total duration, in seconds, of those groups, to yield T_s .

H_{\max} (20-minutes) The height of the highest individual wave in the record.

H_s The significant wave height, the average height of the highest one third of all the waves on the record.

This is calculated in the following manner. The length of record, in seconds, is divided by the significant period to yield the effective number of waves in the record. The effective number of waves is divided by three, and this latter number of the higher waves (starting with the highest) is averaged to yield the significant wave height.

These heights have been corrected for instrumental response and the attenuation of wave motion with depth, this latter correction is the theoretical hydrodynamic one, unmodified by any experimental technique.

H_{\max} (6 hours) The most probable value of the height of the highest wave in the recording interval (Draper, 1963).

PRESENTATION OF RESULTS

There appeared to be no consistent seasonal distribution of wave heights or periods, so the results are presented on a yearly basis, and are as follows:

Fig. I The cumulative distribution of significant wave height, H_s and of the most probable value of the height of the highest wave in the recording interval, H_{\max} (6 hours).

Fig. II The distribution of wave periods.

Fig. III A scatter diagram relating significant wave height to significant wave period.

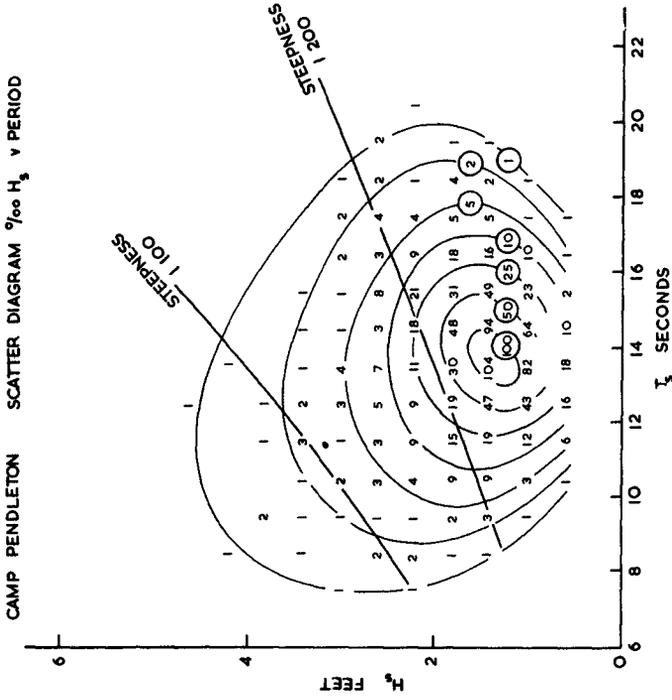


Figure III A scatter diagram relating significant wave height to significant wave period

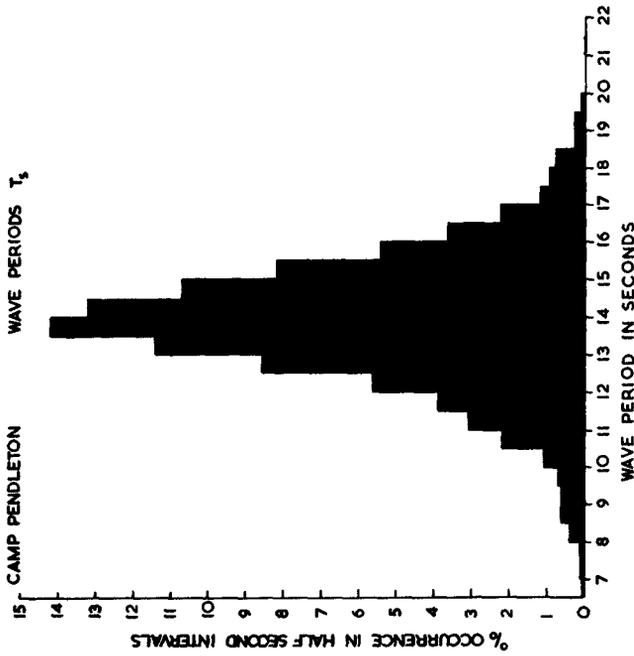


Figure II The distribution of significant wave periods

Fig IV A cumulative persistence diagram for waves of various significant heights

Fig V 'Lifetime' wave prediction

Discussion of results

From Fig I may be determined the proportion of time for which H_S or H_{max} (6 hours) exceeded any given height. For example, the significant height exceeded two feet for 34 per cent of the time.

Because of the difficulty of differentiating on the low-speed record between waves and any spurious electrical pulse, H_{max} (6 hours) has been calculated from H_{max} (20 minutes). However, although the calculated 6-hour maximum waves are, on average, 28 per cent higher than the 20-minute maximum, the average measured value of H_{max} (6 hours) is only 2.3 per cent higher than the calculated value.

The highest wave of all which occurred during a 20-minute record in the two years which were studied was 11.5 feet high. The calculated height of the highest wave of all during the nine years was 14.5 feet (in 1955).

The scatter diagram of Fig III relates the significant wave height to significant wave period. The numbers of occurrences are expressed in parts per thousand. For example, the most common situation with a significant wave height of about 1.5 feet and a period of between 13 and 14 seconds, occurred for 104 thousandths, or 10.4 per cent, of the time.

A parameter which is sometimes of interest is the wave steepness, defined as the ratio of wave height to wavelength, it may also be expressed as a decimal number. It should be noted that the steepness of a wave is not the same as the maximum slope of the water surface during the passage of a wave. Lines of constant steepness of 1:100 and 1:200 are drawn on Fig III (in this case, steepness relates to the significant wave height:significant wave length). Because the waves are predominantly swell, the steepness is much lower than can occur in an area where waves are generated, where the significant-height steepness can exceed 1:20. There is a theoretical limit to steepness of an individual wave of 1:7, and such a steepness is known to be approached occasionally during storms in an area such as the North Atlantic, (Draper and Squire, 1967) and is almost certainly approached on any ocean during a severe storm.

Because of the depth of installation of the instrument, waves of periods shorter than about five seconds are not recorded adequately. It seems unlikely that this is the primary cause of the cut-off in measured

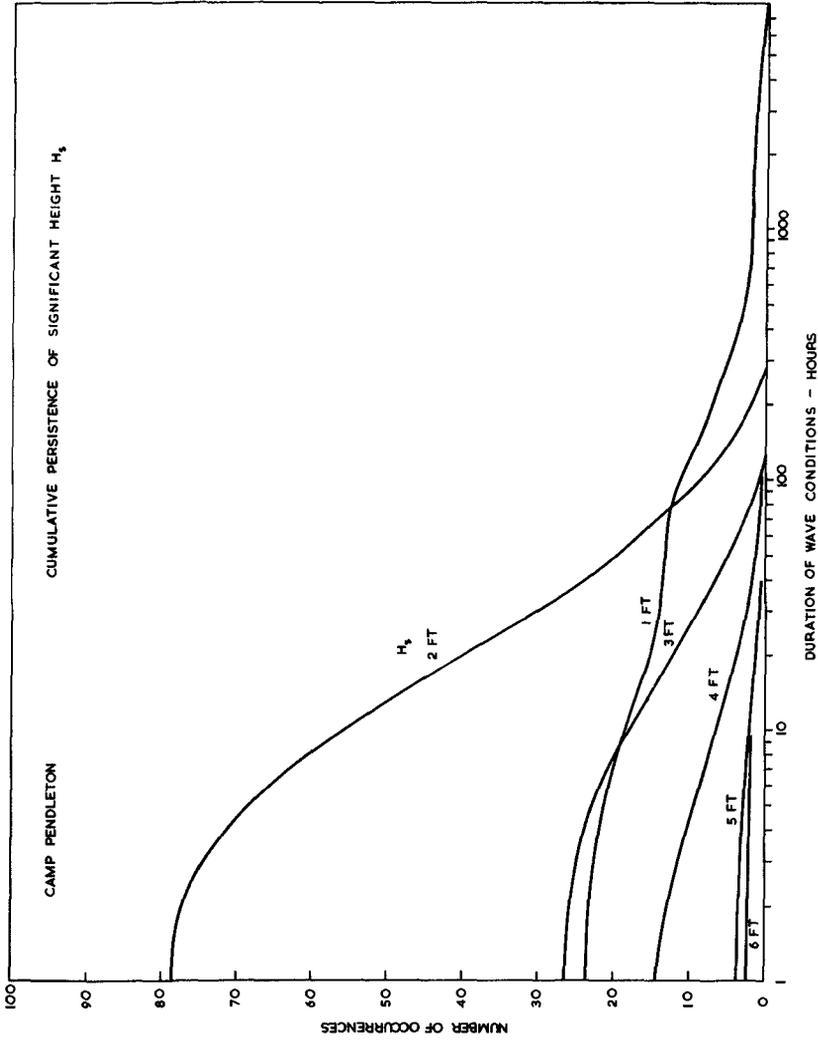


Figure IV A cumulative persistence diagram for waves of various significant heights.

wave period below about seven seconds, so that it is therefore reasonable to conclude that locally generated waves rarely predominate over the swell

Fig. IV From this diagram may be deduced the number and duration of the occasions in one year on which waves will be likely to persist at or above a given height. For example, if the limit for a particular operation of a vessel is a significant height of three feet, it will be unable to operate for spells in excess of ten hours on 18 occasions or spells in excess of 60 hours on four occasions.

Fig. V From this diagram it can be inferred that the most probable value of the height of the highest wave in, say, 50 years, is likely to be about 19 feet (Draper 1963). The parameter used in the preparation of this figure is H_{\max} (6 hours).

It is hoped that an analysis of the variability of wave conditions from year to year will be published later.

Other publications on waves in this area are given in the references.

Acknowledgment

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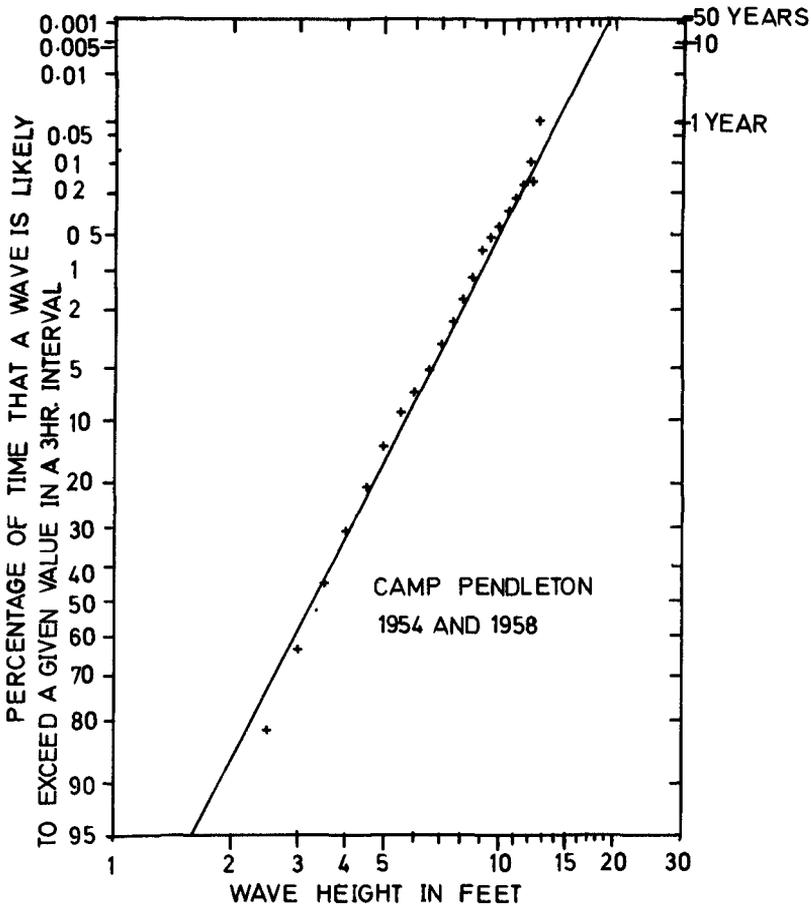


Figure V Prediction of a 'Lifetime' Wave