

CHAPTER 23

VISUALLY OBSERVED WAVE DATA AT PT. MUCU, CALIF.

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Abstract

A Littoral Environment Observation (LEO) Program was established along the West Coast of the United States in 1968. This program provides for visual observations of waves and surf conditions to be made systematically on a daily basis. The data addressed in this report were collected at three LEO sites (as shown in Figure 1) at Pt. Mugu California, located 50 miles northwest of Los Angeles.

In order to evaluate the reliability of wave heights and periods collected using the LEO techniques, comparisons of visual observations and measured wave gage records were made.

The study revealed that individual visual observations of breaker height can deviate significantly from measured wave heights even when the gage wave heights had been corrected for shoaling effects. On the average the LEO observations gave a fair estimate of prevailing wave heights.

LEO estimates of wave period tended to overpredict the period of maximum energy density. It is presumed that this occurred because observers often fail to count smaller waves when making this measurement. Statistics of the gage measurements of wave height and LEO wave heights are reasonably close.

Introduction

In an effort to provide low-cost coastal information for the planning, operation and maintenance of coastal structures and projects, the U.S. Army Coastal Engineering Research Center (CERC) in cooperation with coastal states and other public entities, established the Littoral Environment Observation (LEO) program. This program has been in operation since 1968, and provides a data bank of wind, wave and current statistics which have been collected on a repetitive and systematic basis by volunteer observers. (BERC, 1968)

Presently fifteen pieces of information are gathered during each observation; included are: the wave period, height, angle and type of breaker; wind speed and direction; foreshore slope; surf zone width; current and direction; and rip current and beach cusp spacings.

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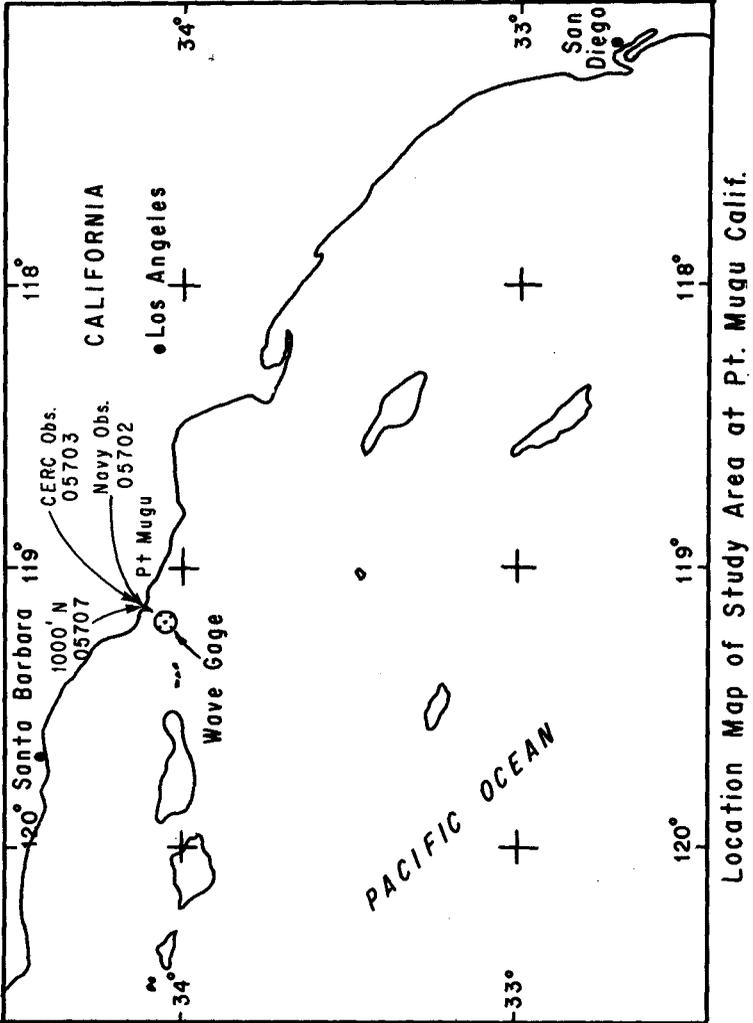


Fig. 1. Location map of study area at Pt. Mugu, California.

LEO data have been collected primarily at sites where little or no wave data existed or where resources are not available for installation of wave recording instruments. This report presents comparisons between LEO observations of wave characteristics and gage measured characteristics made for the period from March to December 1972 at Pt. Mugu, California where a 5-gage array and several LEO Sites were operated simultaneously. At the Pt. Mugu site, LEO observations were obtained by two separate observers, a CERC observer and a Navy observer. In addition, CERC observations were made at two adjacent locations 1000 ft. upcoast (northwest) and 1000 ft. downcoast (southeast) from the primary site. The primary site was located at a pier constructed across the surf zone and thus the observers at this location were not constrained to make observations from the beach. All of the Navy observations were made from the deck of the pier while most of the CERC observations were made from the beach. At the adjacent sites, the CERC observer made estimates of breaker height, surf zone width, breaker period, etc. from the beach. It is thus possible to look at differences between two independent observers at a given site and to look at spatial variations introduced by a single observer making observations at three sites spaced 1000 ft. apart. Only data from the pier site and the upcoast were analysed for this study and thus only results from these two sites are presented herein. For observations made by a single observer at two separated sites, it is not known how much influence the observation at one site has on the same observer's estimate of wave conditions 1000 ft. away. Presumably, the observations are independent and describe real spatial variations; however, it seems reasonable to assume that observations made at one site may have some influence on what the observer reports from an adjacent site.

DATA ANALYSIS

Comparisons were made of wave heights obtained visually at three LEO stations (two sites) with the significant wave heights obtained from a pressure wave gage located in about 30 ft of water. The gage was about 2.5 feet above the bottom and pressure readings were corrected to obtain water surface elevations including the effect of tide. Additionally, comparisons were made of wave periods obtained by timing the passage of 11 breaker crests and the period of maximum energy density obtained from the wave spectrum. The comparison was made for the gage observations taken closest to the time the LEO observation was made. Since gage measurements were taken every six hours the greatest time between gage measurement and corresponding LEO observation was 3 hours.

Figure 2, shows scatter plots of the LEO estimated wave heights for both the Navy observer and CERC observer at the pier and 1000 ft upcoast, respectively, and how they compare with the significant wave heights measured in 30 ft of water.

No corrections for refraction and shoaling between the gage and breaking were applied to the gage data for these plots. The lines shown on the plots are (a) the line of equality, (b) a least-squares best-fit straight line and (c) a least-squares-best-fit straight line constrained to pass through the origin. Comparing this latter line for the three sets of observations, it appears that the Navy observations

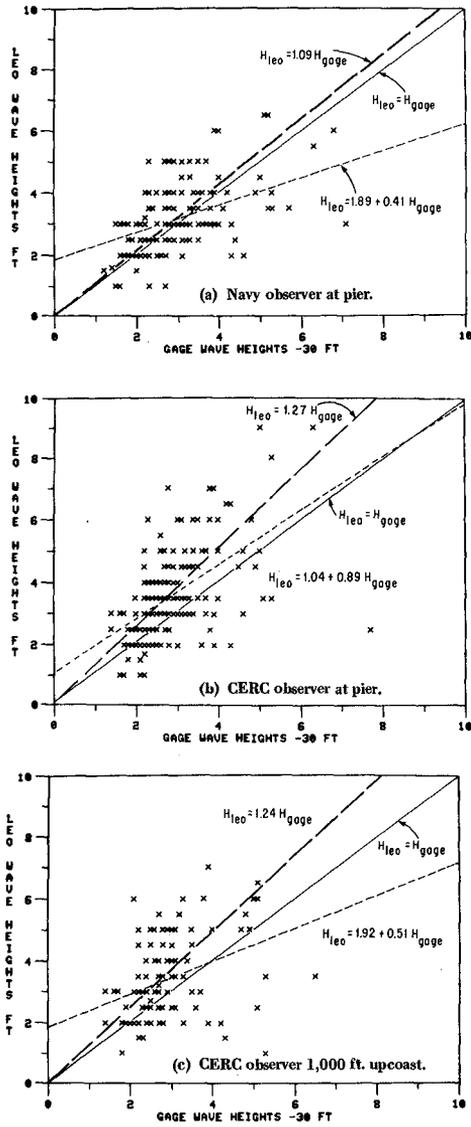


Figure 2. LEO observations of breaker height versus uncorrected wave gage heights, 1972.

of breaker height most closely approximate the gage values while the CERC observations at both the pier and 1000 feet upcoast are generally greater than the significant wave height as recorded at the gage. The least-squares best-fit line suggests that there is a tendency for both observers to overestimate the height of smaller waves and underestimate the height of larger waves. Obviously, the effects of shoaling and refraction between the gage and breaker line need to be considered.

Two shoaling models were applied to the gage data to estimate breaker heights that could be compared with LEO breaker height observations. Recognizing that the transformation of a wave spectrum across the nearshore area is a complex phenomenon, a crude approximation to the shoaling process was made by characterizing the spectrum as monochromatic waves having height and period equal to the significant height and the period of maximum energy density. No correction for refraction was applied. The first shoaling model used linear wave theory with the assumption that the group velocity and phase velocity were the same at breaking. From linear theory,

$$\frac{H_{bl}}{H_{gage}} = \sqrt{\frac{(C_g)_{gage}}{(C_g)_b}} = \sqrt{\frac{(nC)_{gage}}{(C_g)_b}} \quad (1)$$

$$\text{where } (C_g)_b \approx \sqrt{g(d_b + H_{bl})} \quad (2)$$

$$\text{and } d_b = 1.28 H_{bl} \quad (3)$$

where H_{bl} is the breaker height

H_{gage} is the gage wave height in 30 ft of water

$(C_g)_{gage}$ is the wave group velocity at the gage

$(C_g)_b$ is the wave group velocity at breaking, and

n = ratio of wave group velocity to phase velocity

Combining these expressions gives, for H_{bl} as a function of H_{gage} , the explicit relationship

$$H_{bl} = \left\{ H_{gage} \sqrt{n \frac{L_{gage}}{T}} (0.1167) \right\}^{4/5} \quad (4)$$

where L_{gage} is the wave length at the gage of a wave with period T equal to the period of maximum energy density. Applying this shoaling adjustment to the gage data results in the scatter plots of figure 3 for the Navy observer, the CERC observer at the pier and the CERC observer 1000 feet upcoast of the pier, respectively. The approximate shoaling correction results in higher gage wave heights and better comparison with the LEO observations. Comparing the least-squares-best-fit lines passing through the origin, the Navy observations now generally underpredict the corrected gage heights while the CERC

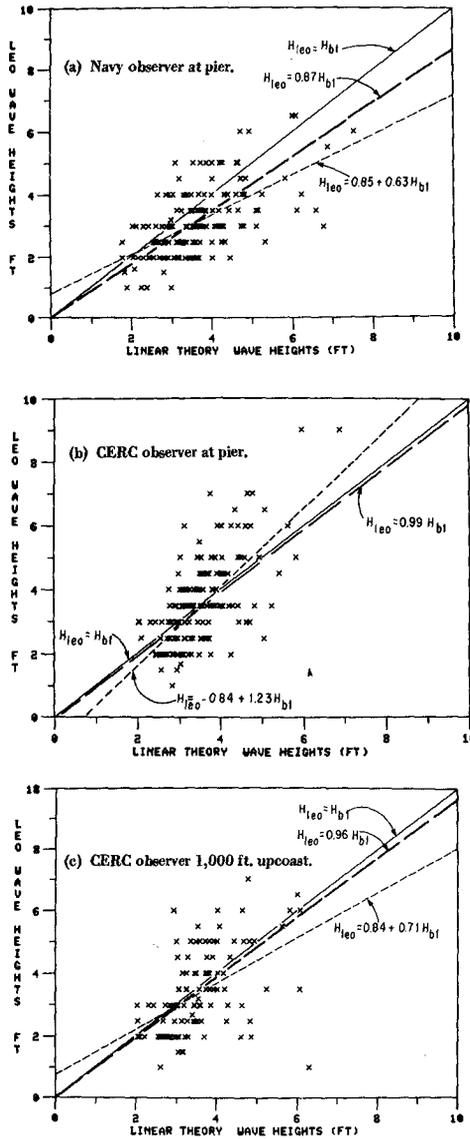


Figure 3. LEO observations of breaker height versus wave gage heights corrected for shoaling (shoaling model 1).

observations at both the pier and 1000 ft. upcoast, on the average, predict the measured values rather well.

The second shoaling model used was an iterative solution to the linear shoaling relationship and the breaker height to water depth ratio (equation 3.) This implicit scheme makes no a priori assumptions about the relationship between the wave group velocity and phase velocity at breaking, nor does it require that the shallow water approximation be made to determine the wave phase velocity. This second shoaling model resulted in higher breaker heights than the first model (figure 4.) As a result, the LEO observations by both the Navy and CERC observer are quite a bit lower than the transformed significant wave height obtained from the gage. If the root-mean-square wave height is used instead of the significant height (assuming that $H_{rms} = 0.71 H_S$) the equations on figure 4 become,

$$H_{leo} = 0.86 (H_{b2})_{rms} \quad (\text{Navy Observer, pier})$$

$$H_{leo} = 0.96 (H_{b2})_{rms} \quad (\text{CERC Observer, pier})$$

$$H_{leo} = 0.92 (H_{b2})_{rms} \quad (\text{CERC Observer, 1000 ft upcoast})$$

where H_{b2} is now the breaker height determined from the second shoaling model using the rms wave height measured at the gage.

The statistical distribution of wave heights was estimated for the LEO observations at the three sites and compared with the distribution of heights obtained from the gage and from the gage as corrected by the two shoaling models. Comparisons between the LEO observations and the wave gage heights are shown on figure 5 plotted on a log-normal probability scale. Probabilities were estimated by ranking the individual observations and using the plotting position formula,

$$P(X \geq x) \approx \frac{m}{N+1} \quad (5)$$

where m is the rank of the observation (m=1 for the largest) and N is the number of observations in the sample. The distribution of gage heights shown on figures 5a, 5b, and 5c are essentially identical; any small differences are due to a slightly different sample size. These differences are most apparent at the extreme ends of the distribution (near the largest and smallest observations.) The Navy observations (5a) compare favorably with the uncorrected gage heights whereas the CERC observations at both sites overestimate the significant wave height at the gage.

Figure 6 shows the probability distribution of the gage wave heights transformed by the two shoaling models. In both cases the curve is shifted upward for shoaling-corrected wave heights. Shoaling model 1 applied to the significant wave height gives the best comparison with the LEO observations. If the H_{rms} wave height is assumed to characterize the wave spectrum at the gage, the second shoaling model and the

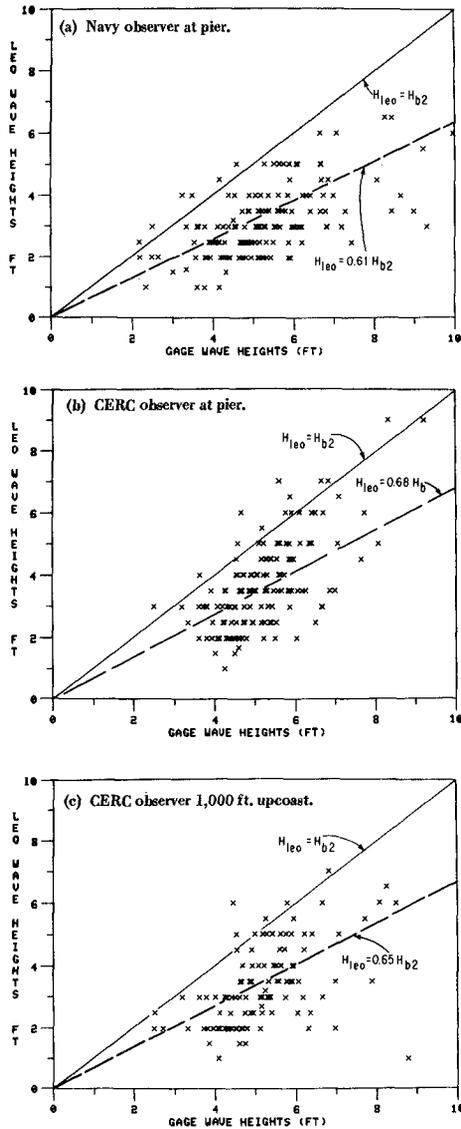


Figure 4. LEO observations of breaker height versus wave gage heights corrected for shoaling (shoaling model 2).

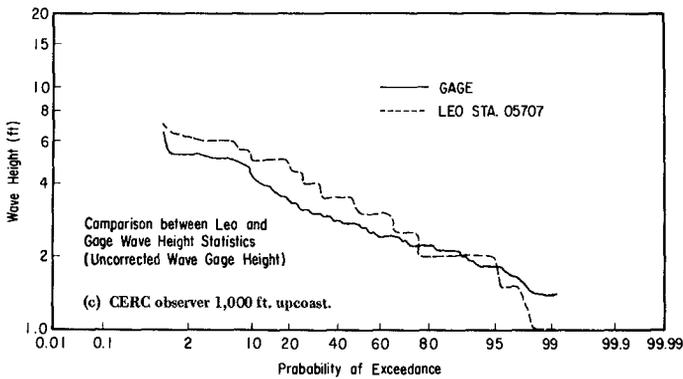
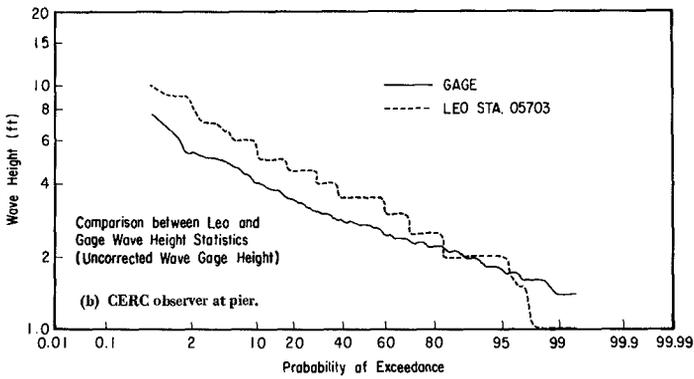
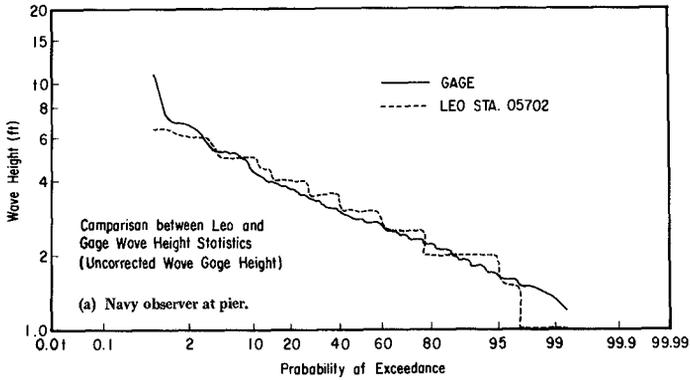


Figure 5. Probability a given wave height is exceeded, LEO breaker heights compared with uncorrected wave gage heights.

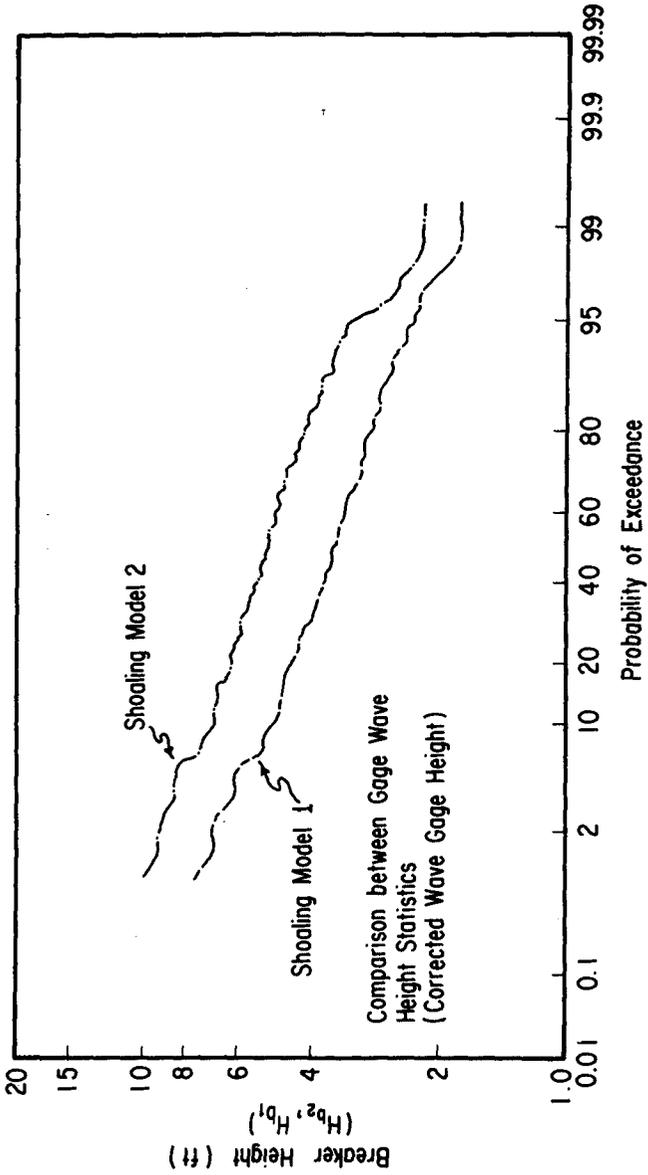


Figure 6. Probability a given wave height is exceeded, wave gage data corrected using shoaling models 1 and 2.

LEO observations are comparable. No firm conclusions can be reached regarding which wave of the spectrum an observer sees when he estimates the breaker height. It appears to be some wave between the root-mean-square height and the significant height; however, the scatter of individual observations about the line of best fit indicates that any individual visual observation may be in significant error. Statistically, however, the data appear to give comparable results. Data on observed wave periods and the measured period of maximum energy density are compared on figure 7 for each of the three data sets. In each case the tendency is for the observer to overestimate the wave period especially for lower wave periods. For larger periods there is some tendency for the LEO observer to underestimate the period. This apparent bias is presumably due to the observer's failure to count the smaller waves that pass a given point when timing the passage of 10 waves. This leads to a bias toward recording longer wave periods. Also, during times when there is a local sea which may dominate the wave energy spectrum, long period waves may continue to dominate in the breaker zone.

Table 1 compares the coefficients (ratio of LEO observation to gage measurement) of the best-fit line through the origin for (a) uncorrected gage heights, (b) the two shoaling models and (c) for wave period. All gage heights are significant heights or transformed significant heights. The gage period is again the period of maximum energy density in the spectrum and the LEO period is the time for 11 wave crests (10 wave lengths) to pass a fixed point in the surf zone.

TABLE 1: COMPARISON OF COEFFICIENTS OF BEST FIT LINE THROUGH ORIGIN

STA	OBSERVER	LOCATION	H_{LEO}/H_{GAGE}	H_{LEO}/H_{b1}	H_{LEO}/H_{b2}	T_{LEO}/T_{GAGE}
05702	(NAVY)	AT PIER	1.09	0.87	0.61	1.38
05703	(CERC)	AT PIER	1.27	0.99	0.68	1.18
05707	(CERC)	1000' N of PIER	1.24	0.96	0.65	1.21

Conclusions

When using the LEO method to collect wave data, the breaker height can deviate from measured heights, even after models had been applied to correct the information for shoaling effects. On the average, the LEO observations are a fair estimate of prevailing breaker heights.

Again the LEO estimates of breaker period tend to overpredict the period of maximum energy density, presumably because of the observer's failure to count smaller waves.

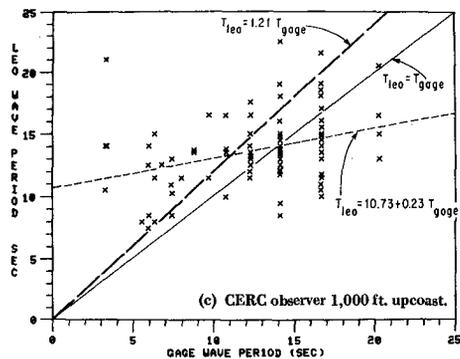
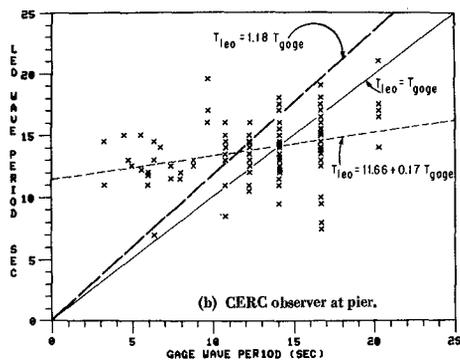
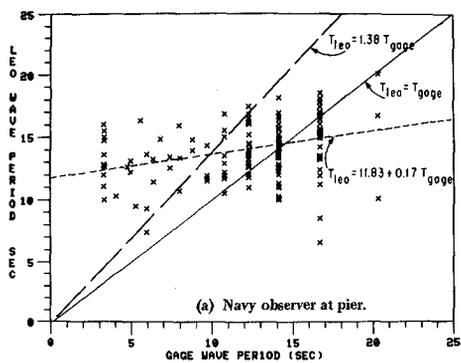


Figure 7. LEO observations of wave period versus period of maximum energy density from wave gage.

These conclusions are not general, as the capability of each observer is a real factor. Periodic visits and checks of observers are needed to insure data are collected conscientiously. Recognizing the shortcomings of visual observations, they still represent a useful and inexpensive source of coastal information, but data that must be used carefully with full recognition of its limitations.

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REFERENCES

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