Part 1
BASIC INFORMATION FOR COASTAL INVESTIGATIONS

REVISED WAVE FORECASTING RELATIONSHIPS

C. L. Bretschneider*
Institute of Engineering Research
University of California
Berkeley, California

INTRODUCTION

Data on the generation and decay of wind-generated gravity waves have been collected for several years by the University of California. These data together with the original data by Sverdrup and Munk have been analyzed, and the results were presented in dimensionless graphs suitable for use in wave forecasting (Bretschneider, 1951). No analysis was made of the effect of following or opposing winds.

The dimensionless parameters presented by Sverdrup and Munk (1947) (C/U, gH/U^2, gF/U^2, gt/U, and tU/F) are suitable; however, new curves have been constructed which include the new data recently available (Figure 1). In order that the data on the decay of waves could be presented in a logical manner, a concept, based on the following observations was introduced: (a) Individual waves do not maintain their identity in deep water, (b) a spectrum of lengths and heights is present in both the fetch and decay areas, (c) at any particular decay distance the significant period decreases with time, (d) the significant period increases with decay distance in a manner different than that assumed by Sverdrup and Munk for their decay relationships, (e) the travel time depends upon the group velocity associated with the period at the end of the decay distance.

It is found that the wave height and period at the end of the decay distance depend upon the length of the fetch and the height and period at the end of the fetch as well as upon the decay distance. Using D/F as a dimensionless parameter, decay graphs, D/gT_F^2 versus D/gT_D^2 and D/H_F versus D/H_D, were constructed representing the increase of period and the decrease in height, respectively. These curves give a unique solution for each combination of period and height at the end of the fetch; whereas, the decay relationships proposed by Sverdrup and Munk (1947) gave a unique solution for the increase of wave period regardless of the wave height at the end of the fetch.

*Now Research Engineer with Texas A & M Research Foundation, College Station, Texas

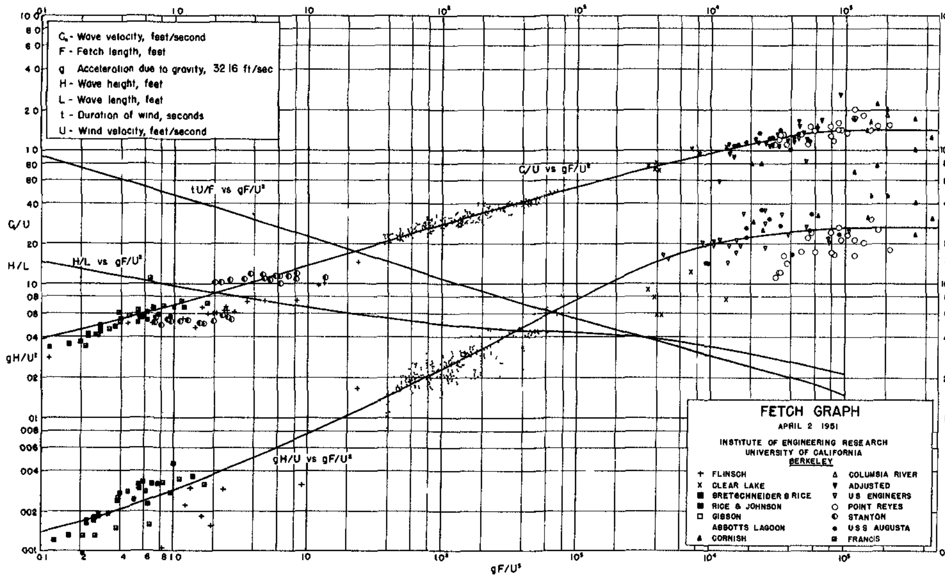

Figure 1 Fetch Graph - Relationship between Wind Speed, Wind Duration, Fetch, Wave Height, and Wave Velocity.

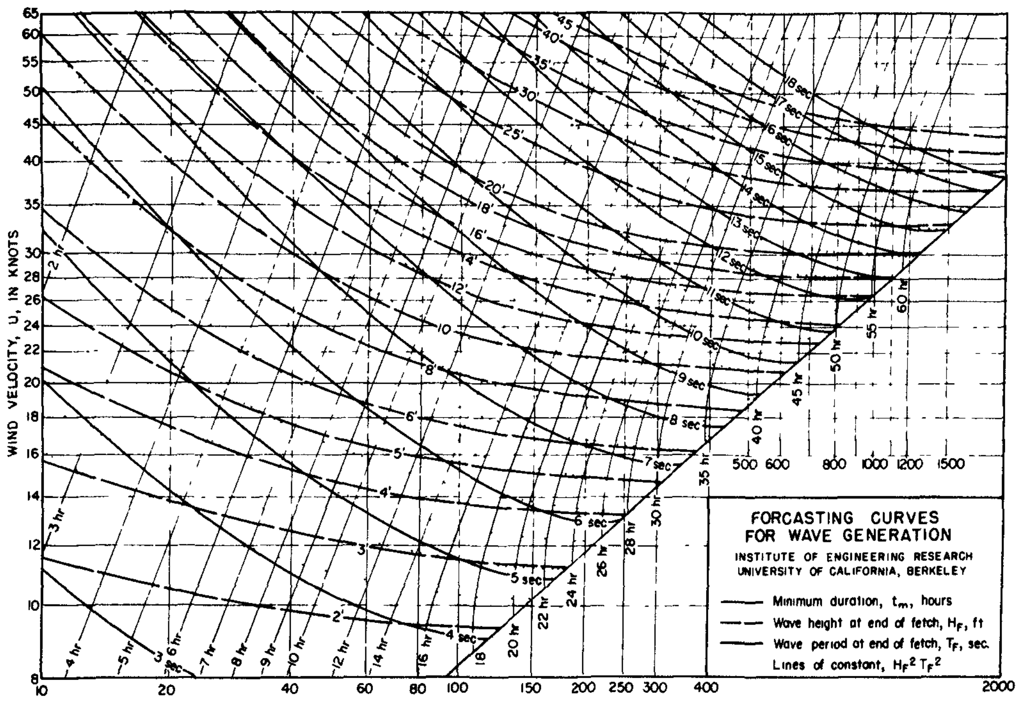

Figure 2 Forcasting Curves for Wave Generation

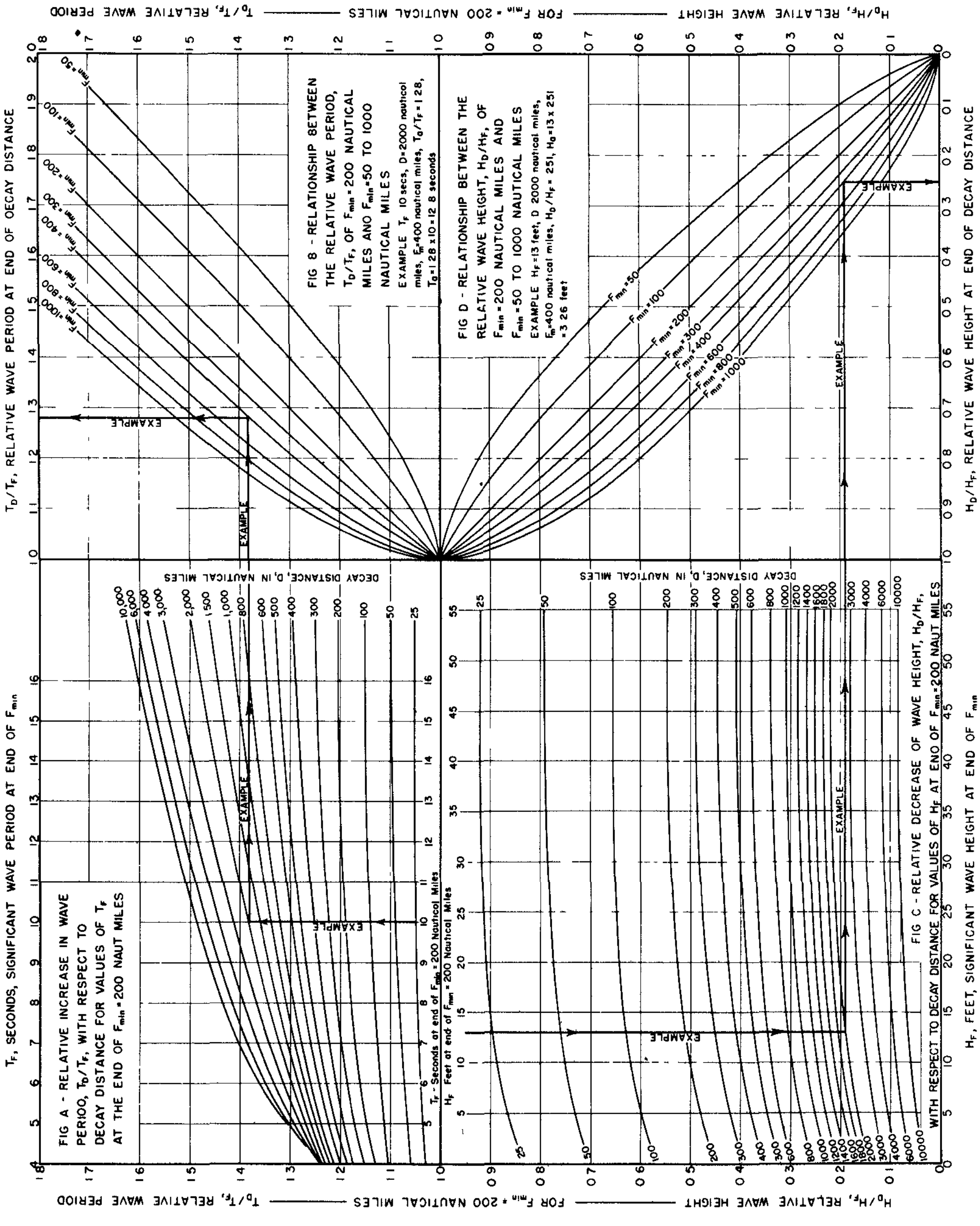

Fig. 3 Forecasting curves for wave decay.

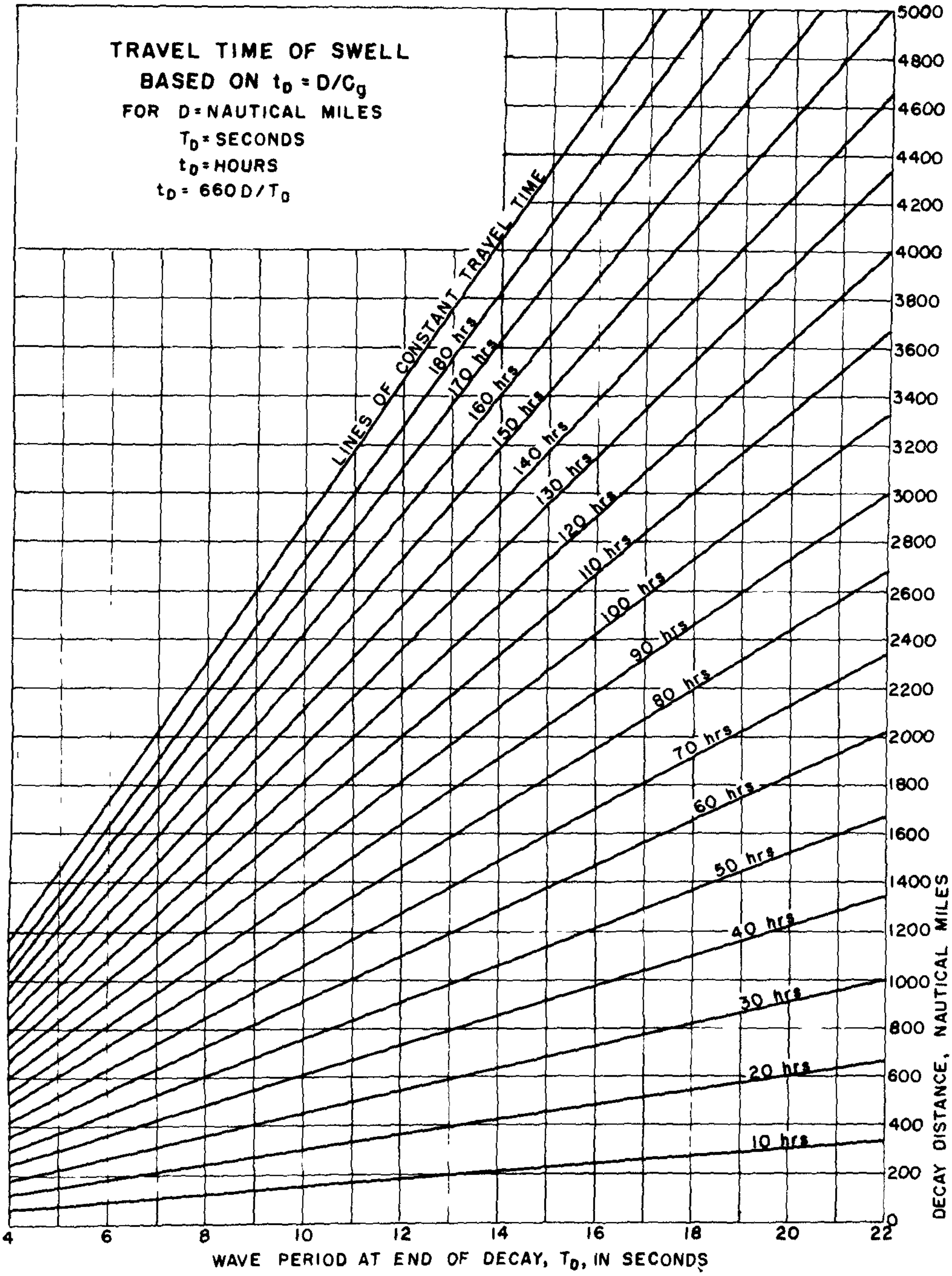

Fig. 4
Travel time of swell - Relationship between travel time, decay distance and wave period at end of decay.

Forecasting Curves: Figure 2, forecasting curves for the generation of waves, is prepared from Figure 1. Figure 3, forecasting curves for the decay of waves, is prepared from published decay curves (Bretschneider, 1951). Since Figures 2 and 3 are based on much wave data, they may be used to make reliable wave forecasts.

The travel time of the swell is based on the average group velocity of the significant waves at the end of decay and is given in Figure 4.

Example of the use of Figures 2 and 3

Given: U = 23.5 knots (as determined from weather map)

F = 600 nautical miles (as measured from weather map)

t_d = 33 hours (as determined from weather map or maps)

D = 2000 nautical miles (measured from weather maps)

Enter Figure 2 at the left on U = 23.5 knots and proceed until either t_m = 33 hours or F = 600 nautical miles is first reached, and read H_F = 13 feet, T_F = 10 seconds, t_m = 33 hours and F = 400 nautical miles (this is F_{min}*)

Enter Figure 3-A at T_F = 10 seconds, and proceed to decay, D = 2000 nautical miles (this gives T_D/T_F at D = 2000 nautical miles for a significant wave period at the end of fetch (minimum fetch) of 200 nautical miles). Proceed horizontally to Figure 3-B to F_m = 400 nautical miles and read T_D/T_F = 1.28; T_D = 10 x 1.28 = 12.8 sec.

To determine the wave height, H_D at the end of the decay curves, use Figure 3-C and D, and read H_D/H_F = 0.25; H_D = 3.3 feet.

From Figure 4, the travel time of the swell is t_D = 103 hours.

References

Bretschneider, C.L. (1951). The Generation and Decay of Wind Generated Gravity Waves: Tras. Amer. Geophys. Union (In press)

Sverdrup, H. U. and Munk, W. H. (1947). Wind, sea, and swell; Theory of relation for forecasting: Hydrographic Office, U. S. Navy, Publ. No. 601.

*For a given wind velocity the fetch length behind which a steady state is reached depends only upon the wind duration. For a given duration of wind this steady state fetch depends on the wind velocity and is shorter for weak winds than strong winds. This fetch length is called minimum fetch, F_{min}.