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# WAVE REFRACTION AT COOS BAY, OREGON

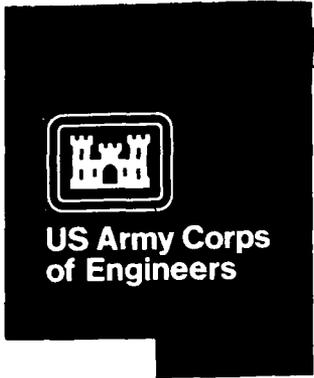
## Coastal Model Investigation

by

Ernest R. Smith

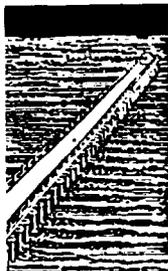
Coastal Engineering Research Center

DEPARTMENT OF THE ARMY  
Waterways Experiment Station, Corps of Engineers  
PO Box 631, Vicksburg, Mississippi 39181-0631



US Army Corps of Engineers

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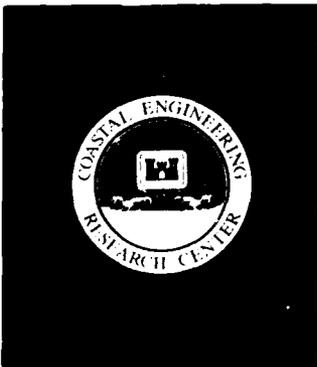


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Prepared for US Army Engineer District, Portland  
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19 ABSTRACT (Continue on reverse if necessary and identify by block number)  Coos Bay, Oregon, is protected by two rubble-mound jetties. At present, 500 ft of the north jetty has deteriorated to the extent that structural integrity is threatened. Discussed herein are efforts by the US Army Engineer District, Portland, to restore the jetty, assisted in their efforts by the Coastal Engineering Research Center which has performed a numerical water wave refraction/diffraction/shoaling analysis over the outer bathymetry at Coos Bay to determine wave characteristics.					
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PREFACE

Model investigations of Coos Bay, Oregon, were requested by the US Army Engineer District, Portland (NPP), and conducted by personnel of the US Army Engineer Waterways Experiment Station's (WES's) Coastal Engineering Research Center (CERC) during February to June 1988. The study was under general supervision of Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Chief and Assistant Chief, CERC, respectively; and under direct supervision of Messrs. C. Eugene Chatham, Jr., Chief, Wave Dynamics Division (CW), and Douglas G. Outlaw, Chief, Wave Processes Branch, CW-P, CERC.

Mr. Ernest R. Smith, Hydraulic Engineer, CW-P, CW, performed the study which involved application of a refraction/diffraction/shoaling numerical simulation model titled Regional Coastal Processes Wave Transformation Model (RCPWAVE) for water wave nearshore transformation. This model was conceived and developed by Mr. Bruce A. Ebersole, Research Hydraulic Engineer, Research Division, CERC. The assistance of Mr. Ebersole is acknowledged with appreciation. The author wishes also to acknowledge Mr. Larry R. Tolliver and Ms. Robin J. Hoban, CW-P, who digitized the grid; Ms. Lee Ann Germany, CW-P, who typed this report; and Ms. Shirley A. J. Hanshaw, Information Products Division, Information Technology Laboratory, WES, who edited this report.

Commander and Director of WES during the study was COL Dwayne G. Lee, EN. Technical Director was Dr. Robert W. Whalin.



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CONVERSION FACTORS, NON-SI TO SI (METRIC)  
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI  
(metric) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
feet	0.3048	metres
miles (US statute)	1.609347	kilometres
tons (force)	8896.444	newtons

## WAVE REFRACTION AT COOS BAY, OREGON

### PART I: INTRODUCTION

#### Background

1. Coos Bay (Figure 1) is an estuary on the Oregon coast about 200 miles\* south of the Columbia River mouth and 445 miles north of San Francisco Bay. The entrance, protected by the rubble-mound jetties, lies between Coos Head on the south and a low sandspit on the north. A 700-ft-wide, 45-ft-deep channel extends between the jetties.

2. The Port of Coos Bay is the second largest in Oregon and one of the largest shipping ports for forest products in the world, but it is not a major general cargo port because of limited ground transportation of the area. Major commodities exported include wood chips, logs, lumber, plywood, veneer, and paper products. Few commodities are imported, receipts being mostly petroleum products and gravel.

3. The north jetty was completed in 1895 and was 9,600 ft long. The outer 600 ft of the jetty subsided soon after completion and was rebuilt twice before 1900. No further repair work was done until 1923. At that time the outer 1,000 ft of the north jetty had sunk 12 to 20 ft below low water. The jetty was restored to design height from 1923 to 1929. A monolith concrete block was placed at the outer end of the jetty in 1930. To maintain the jetty, 236,342 tons of stone were placed in 1939 and 1940. Repairs were made in 1957 and 1958 to 2,870 ft of the jetty extending to the monolith. The repaired section was constructed to a crest elevation of +25 ft mean lower low water (MLLW) with a 30-ft crown width. The outer end had deteriorated to the low water level by 1970 and was repaired at that time to the 1958 dimensions. The work performed in 1970 consisted primarily of filling small, isolated cavities.

4. Currently, 500 ft of the north jetty, from station 78+00 to station 83+00, has deteriorated to the extent that structural integrity of the jetty is threatened. The most critical section has lost 18.5 ft in elevation.

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\* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.



Essentially none of the "as built" crest width remains at station 81+76. Damage is predominantly along the channel side of the jetty. Approximately 34,700 tons of stone have been misplaced. In addition, the seaward 473 ft of the jetty no longer exists.

#### Purpose

5. Since the damaged section of the jetty lies within a relatively high sediment transport zone, even under moderate wave conditions a breach of the jetty would allow sediment to move into the estuary and shoal, eventually increasing channel maintenance costs. The breach would become progressively larger, allowing waves to overtop the structure and travel into the inner harbor, making a viable year-round navigational channel difficult to maintain. Additionally, the livelihood of the communities of Coos Bay and neighboring North Bend would be seriously impacted if reliable navigation facilities could not be maintained.

6. The US Army Engineer District, Portland (NPP), has considered restoring the jetty from station 78+00 to station 83+00 to 1970 dimensions and determining if the seaward 473 ft of the jetty warrants rehabilitation. As a result, NPP has requested that the US Army Engineer Waterways Experiment Station Coastal Engineering Research Center perform a water wave refraction/diffraction/shoaling analysis at high tide elevation to determine wave characteristics at the north jetty. This report discusses the results of that analysis.

## PART II: WAVE TRANSFORMATION MODEL

### Study Conditions

7. The Regional Coastal Processes Wave Model (RCPWAVE)\* was used to transform deepwater waves over the outer Coos Bay bathymetry. The model employs an iterative, finite difference scheme with full refraction, diffraction, and shoaling effects assuming:

- a. Small bottom slopes.
- b. Linear, monochromatic, and irrotational waves.
- c. Negligible wave reflection.
- d. Insignificant energy losses due to bottom friction or wave breaking outside the surf zone.

Because of assumption a, the jetties could not be included in model simulations.

8. A stretched rectangular grid of 60 by 55 cells covering an area 60,000 ft by 38,000 ft was applied to the offshore Coos Bay bathymetry with fine resolution in the nearshore region and coarse resolution offshore for the five interior incident wave angles. Grid spacing in the nearshore region was 500 ft in the x-direction. In the offshore region, grid spacing varied somewhat, stretching from 500 to 2,000 ft beginning at 19,000 to 38,000 ft in the x-direction. Spacing in the y-direction was 1,000 ft throughout the grid. A rectangular grid of 60 by 74 cells covering approximately the same area as the stretched grid was used for the extreme incident wave angles (north and southwest). Grid spacing was 1,000 ft in the alongshore direction and 500 ft in the offshore direction. Both grids were oriented so that the tip of the north jetty was located at alongshore cell number 24 and offshore cell number 24, and the maximum incident wave angle was  $\pm 67.5$  deg. The y-direction was approximately parallel to the shoreline of North Spit, and the x-direction was parallel to the jetties.

9. Seven wave directions (north (N), north-northwest (NNW), northwest (NW), west-northwest (WNW), west, west-southwest (WSW), and southwest (SW))

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\* B. A. Ebersole, M. A. Cialone, and M. D. Prater, 1985, "Regional Coastal Processes Numerical Modeling System; Report 1: RCPWAVE--A Linear Wave Propagation Model for Engineering Use," Technical Report CERC-86-4, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

and six wave periods (7, 9, 11, 13, 15, and 17 sec) were chosen as test conditions based on Pacific coast hindcast, Phase II data from the Wave Information Studies.

### Study Results

10. Wave height coefficients (wave height at a grid cell divided by deepwater wave height  $H/H_0$ ) were determined over an alongshore distance of 20,000 ft and an offshore distance of approximately 37,000 ft in the vicinity of the jetties. Maximum  $H/H_0$  at the toe was 1.05 for a 17-sec period from the west-northwest. Minimum  $H/H_0$  was 0.66 for 13- and 17-sec periods from the southwest. Table 1 lists  $H/H_0$  at the north jetty toe, one grid cell (500 ft) inshore of the toe, and two grid cells (1,000 ft) inshore of the toe for each direction and period.  $H/H_0$  at the three points listed above are plotted versus period for each direction in Plates 1-7.

11. Example vector plots of  $H/H_0$  and direction over the area near the jetty, for selected periods from each direction, are included in Plates 8-14. The entire data set of vector plots and test results is available upon request.

PART III: CONCLUSION

12. Wave height coefficient analysis results indicate that:
  - a. Maximum wave heights along the seaward end of the north Coos Bay jetty are a maximum for waves from the west-northwest at a period of 17 sec.
  - b. Little variation in the wave height coefficient calculated for each wave period and direction occurs along the damaged section of the existing breakwater.

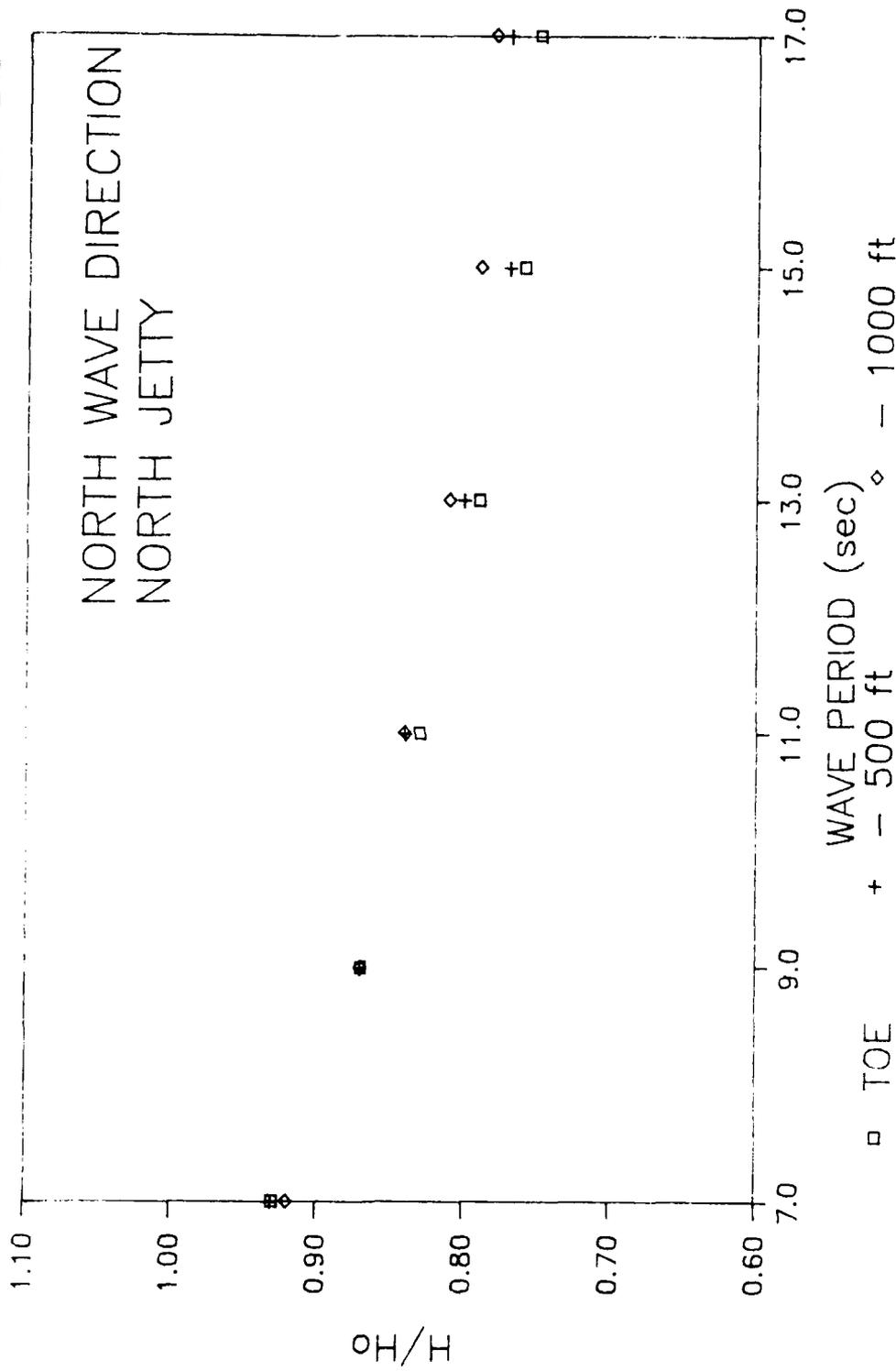
Analysis results can be combined with hindcast data to estimate recurrence intervals for storm wave conditions along the outer section of the breakwater.

Table 1  
Coos Bay Wave Height Coefficients

<u>Direction</u>	<u>Period</u>	<u>H/H<sub>o</sub></u>		
		<u>Toe</u>	<u>-500 ft</u>	<u>-1,000 ft</u>
North	7.0	0.93	0.93	0.92
	9.0	0.87	0.87	0.87
	11.0	0.83	0.84	0.84
	13.0	0.79	0.80	0.81
	15.0	0.76	0.77	0.79
	17.0	0.75	0.77	0.78
NNW	7.0	0.93	0.93	0.93
	9.0	0.89	0.90	0.91
	11.0	0.88	0.89	0.90
	13.0	0.89	0.90	0.91
	15.0	0.91	0.92	0.93
	17.0	0.93	0.94	0.95
NW	7.0	0.93	0.93	0.93
	9.0	0.91	0.91	0.91
	11.0	0.92	0.92	0.92
	13.0	0.94	0.95	0.95
	15.0	0.98	0.98	0.99
	17.0	1.02	1.02	1.03
WNW	7.0	0.93	0.93	0.93
	9.0	0.91	0.91	0.91
	11.0	0.93	0.93	0.93
	13.0	0.96	0.97	0.97
	15.0	1.01	1.01	1.01
	17.0	1.05	1.06	1.06
West	7.0	0.92	0.92	0.92
	9.0	0.89	0.90	0.91
	11.0	0.90	0.91	0.91
	13.0	0.93	0.94	0.94
	15.0	0.97	0.98	0.98
	17.0	1.02	1.03	1.03
WSW	7.0	0.90	0.90	0.90
	9.0	0.84	0.84	0.84
	11.0	0.83	0.83	0.84
	13.0	0.83	0.84	0.84
	15.0	0.85	0.85	0.86
	17.0	0.87	0.88	0.88
SW	7.0	0.80	0.79	0.77
	9.0	0.71	0.72	0.72
	11.0	0.68	0.68	0.69
	13.0	0.66	0.67	0.67
	15.0	0.67	0.68	0.68
	17.0	0.66	0.67	0.68

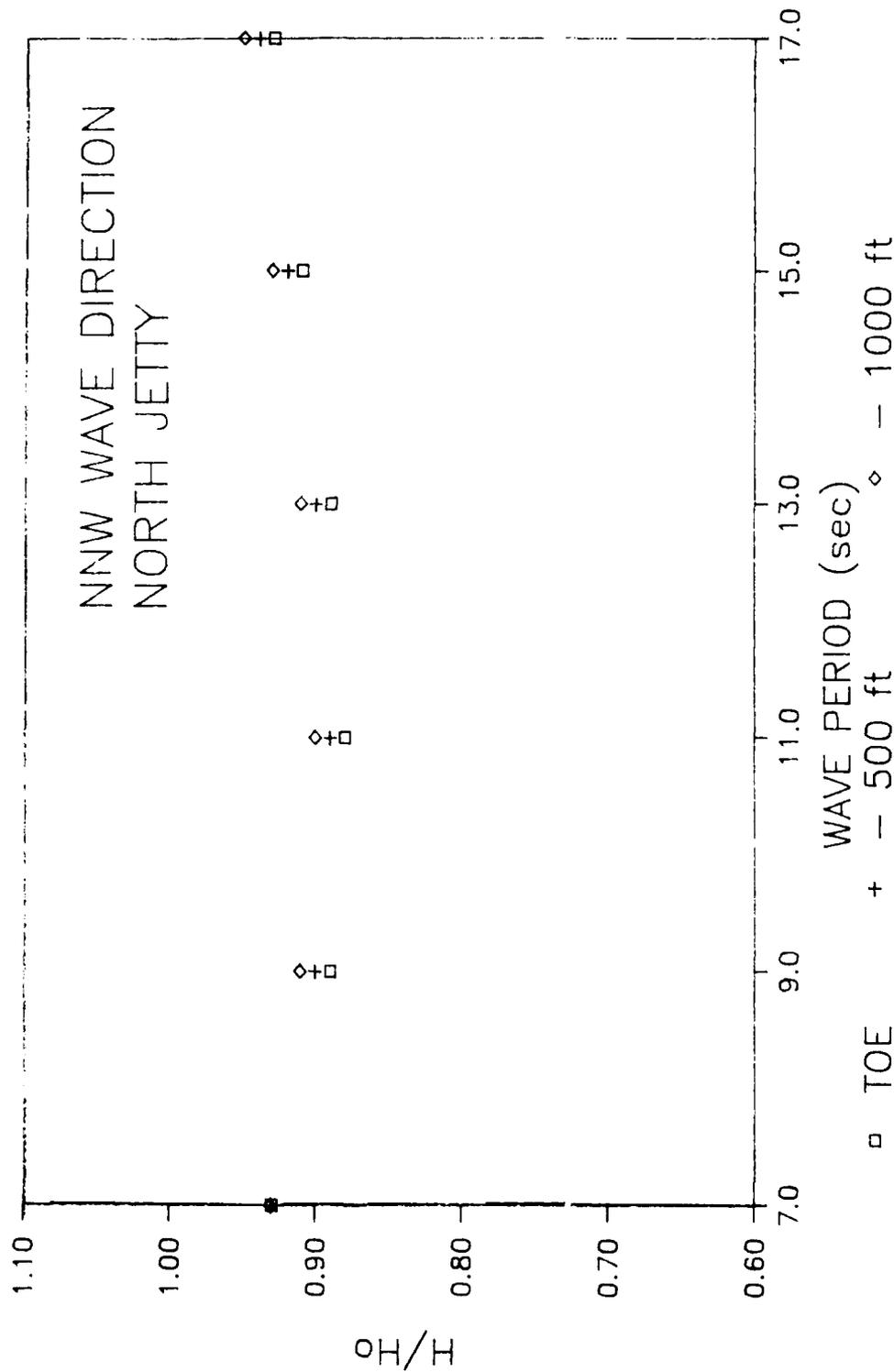
# COOS BAY WAVE HEIGHT COEFFICIENTS

NORTH WAVE DIRECTION  
NORTH JETTY



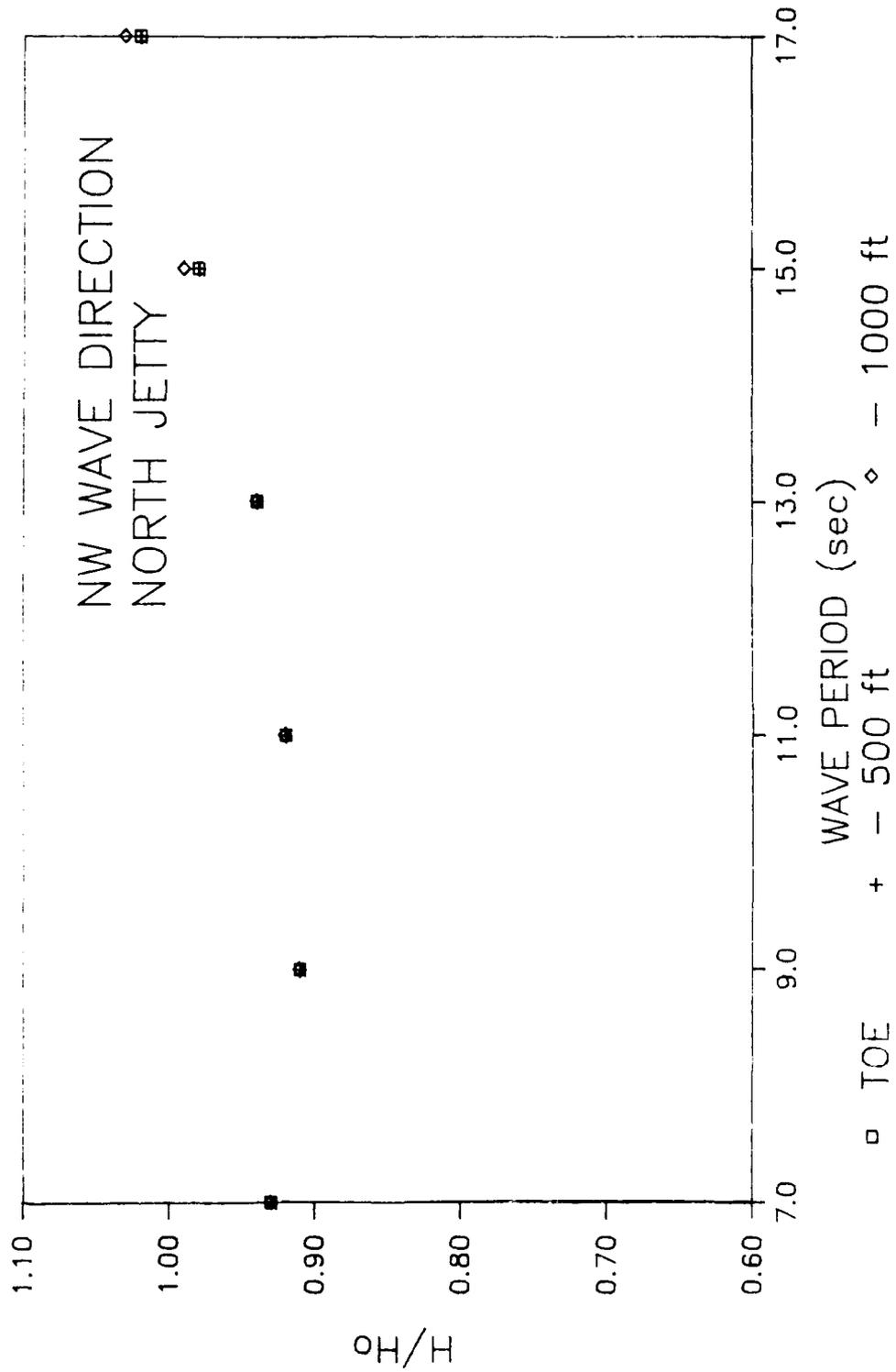
# COOS BAY WAVE HEIGHT COEFFICIENTS

NNW WAVE DIRECTION  
NORTH JETTY



# COOS BAY WAVE HEIGHT COEFFICIENTS

NW WAVE DIRECTION  
NORTH JETTY



# COOS BAY WAVE HEIGHT COEFFICIENTS

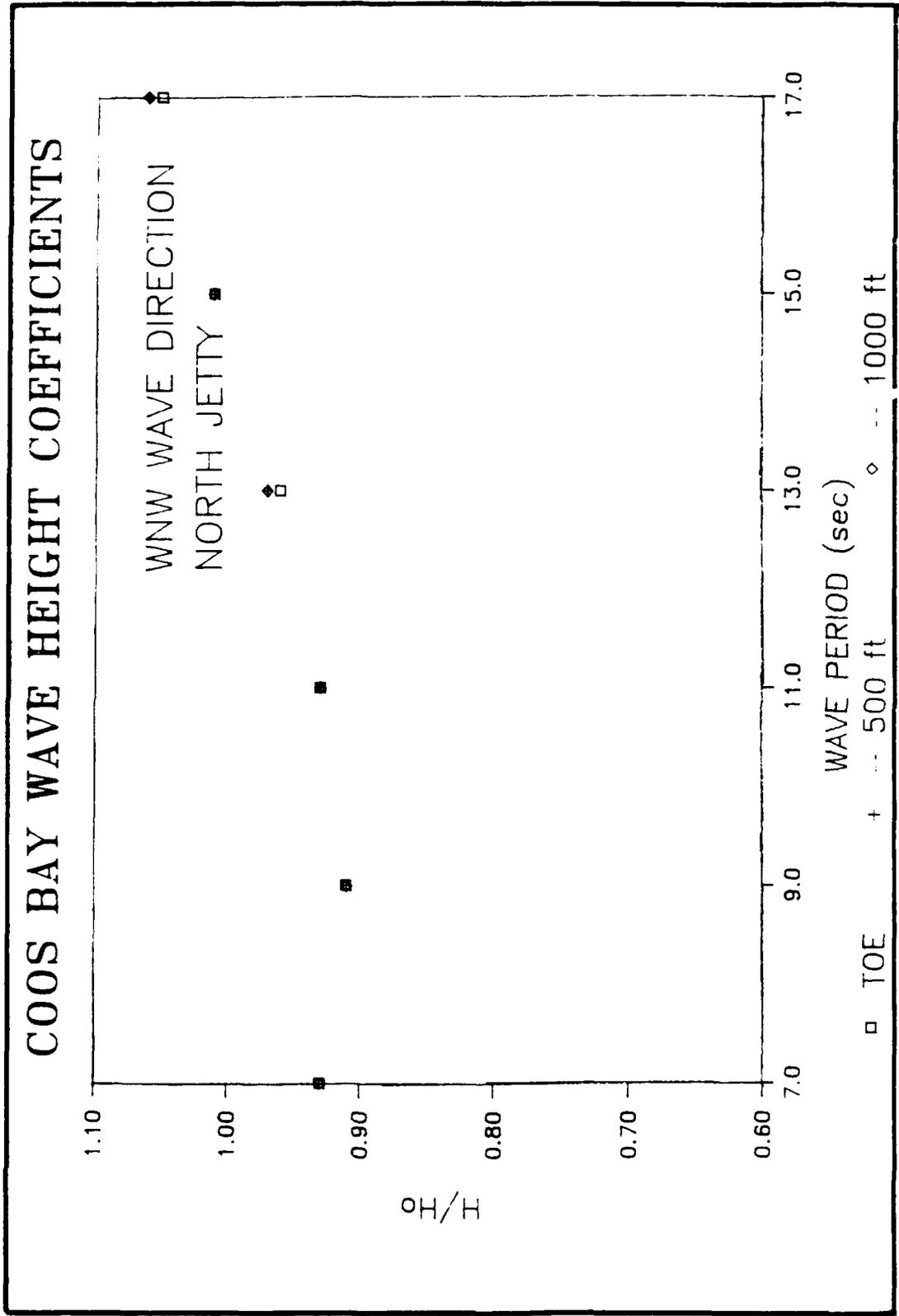
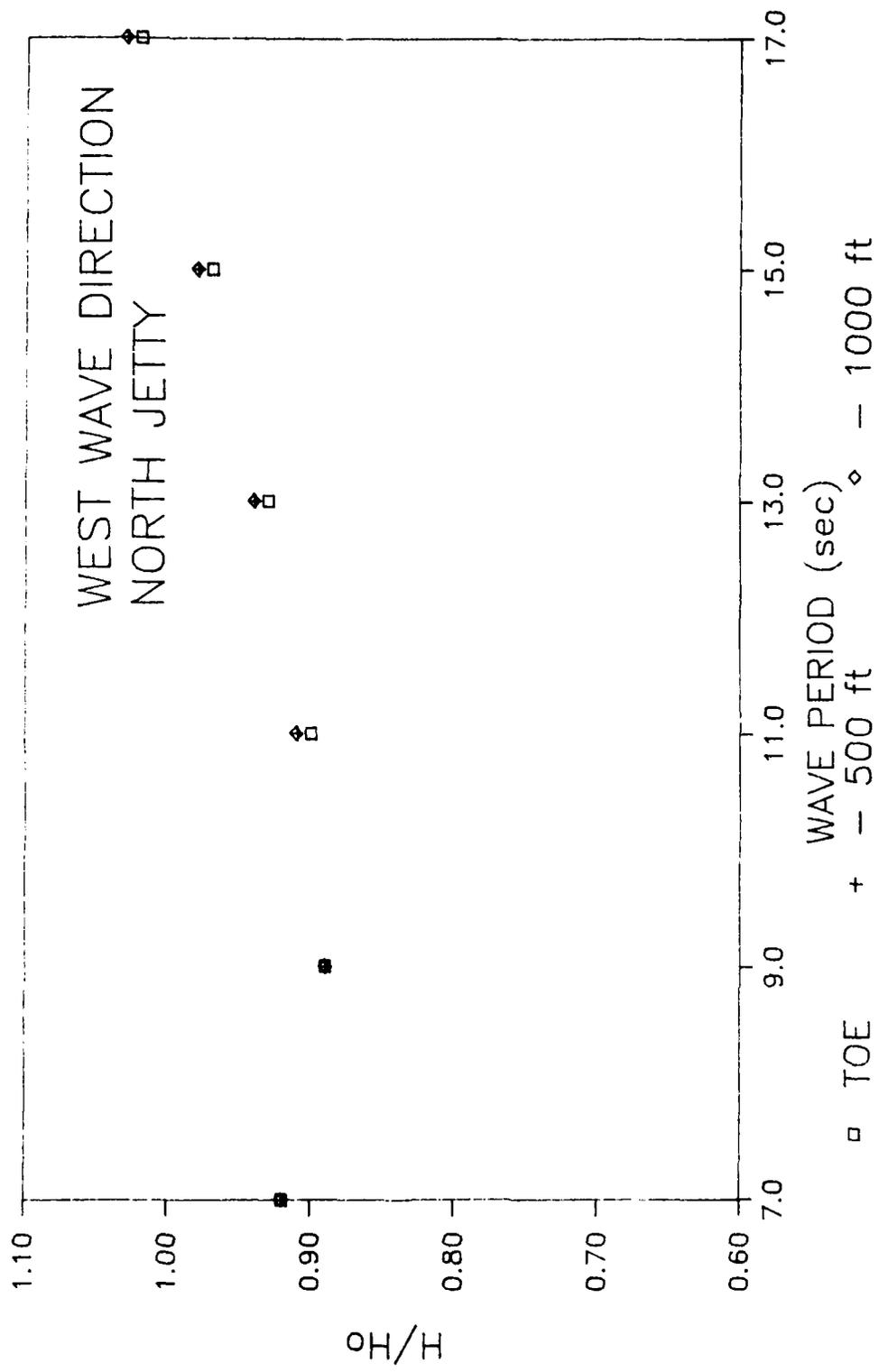


PLATE 4

# COOS BAY WAVE HEIGHT COEFFICIENTS

WEST WAVE DIRECTION  
NORTH JETTY



# COOS BAY WAVE HEIGHT COEFFICIENTS

WSW WAVE DIRECTION  
NORTH JETTY

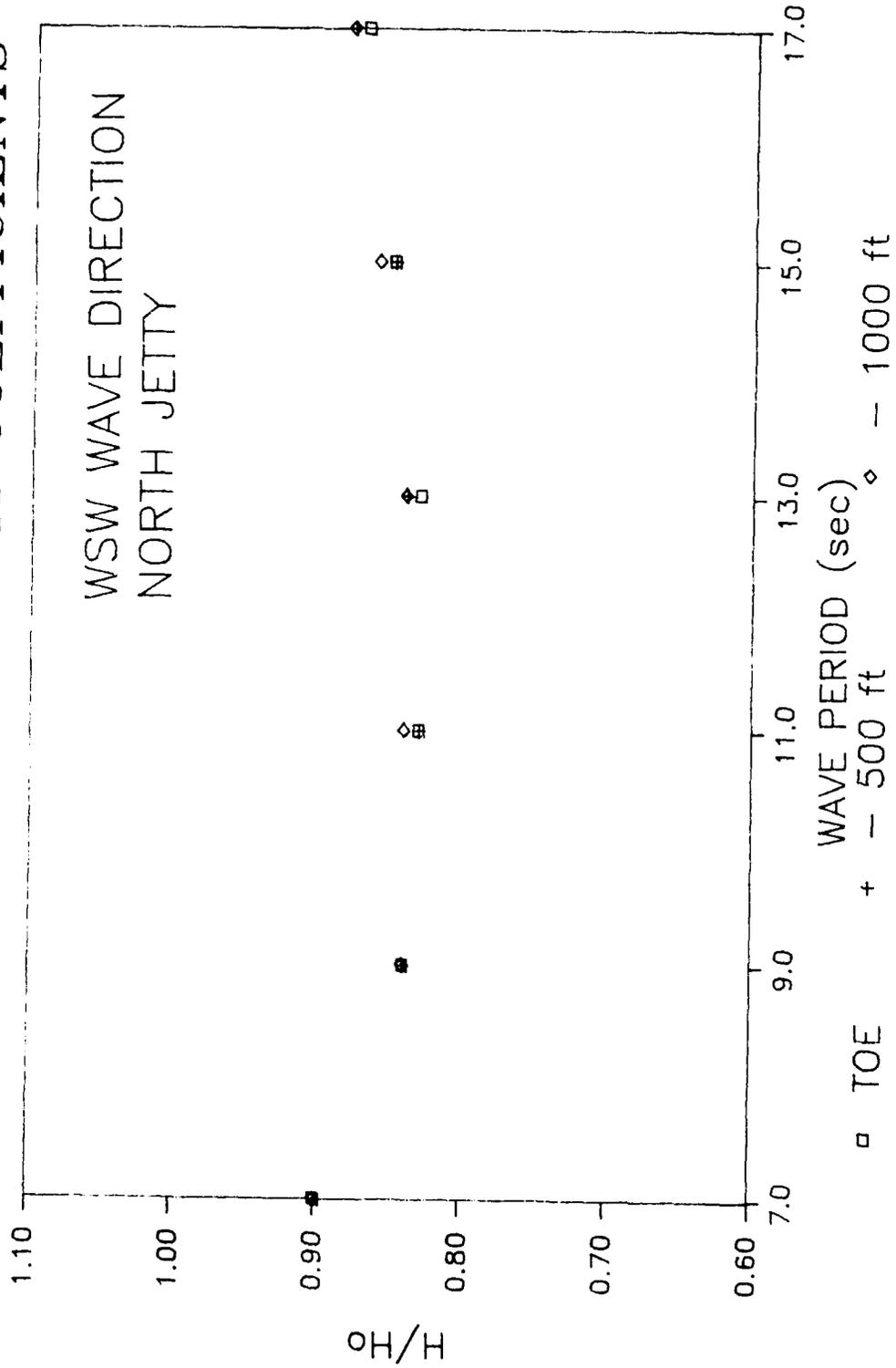
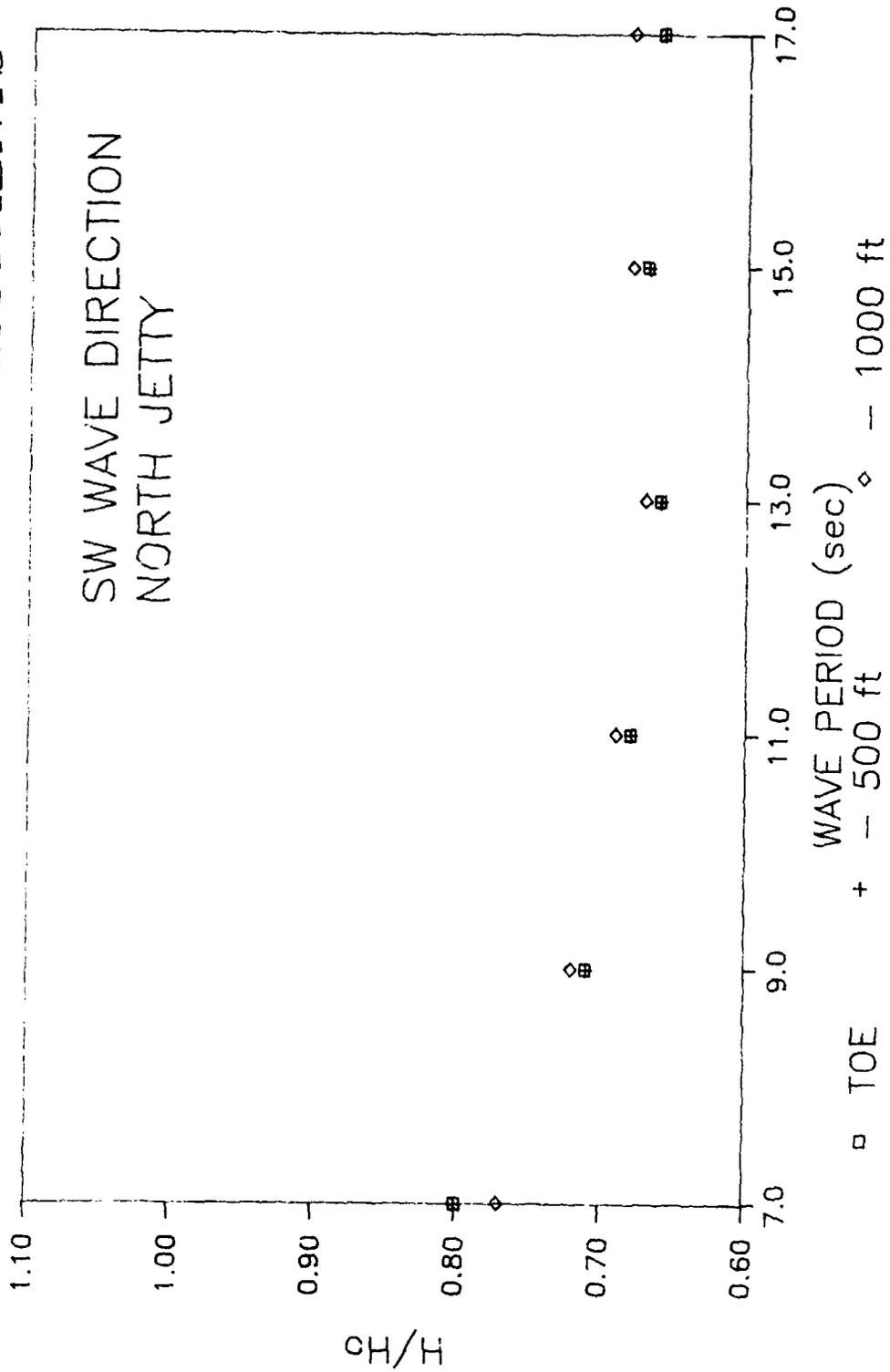


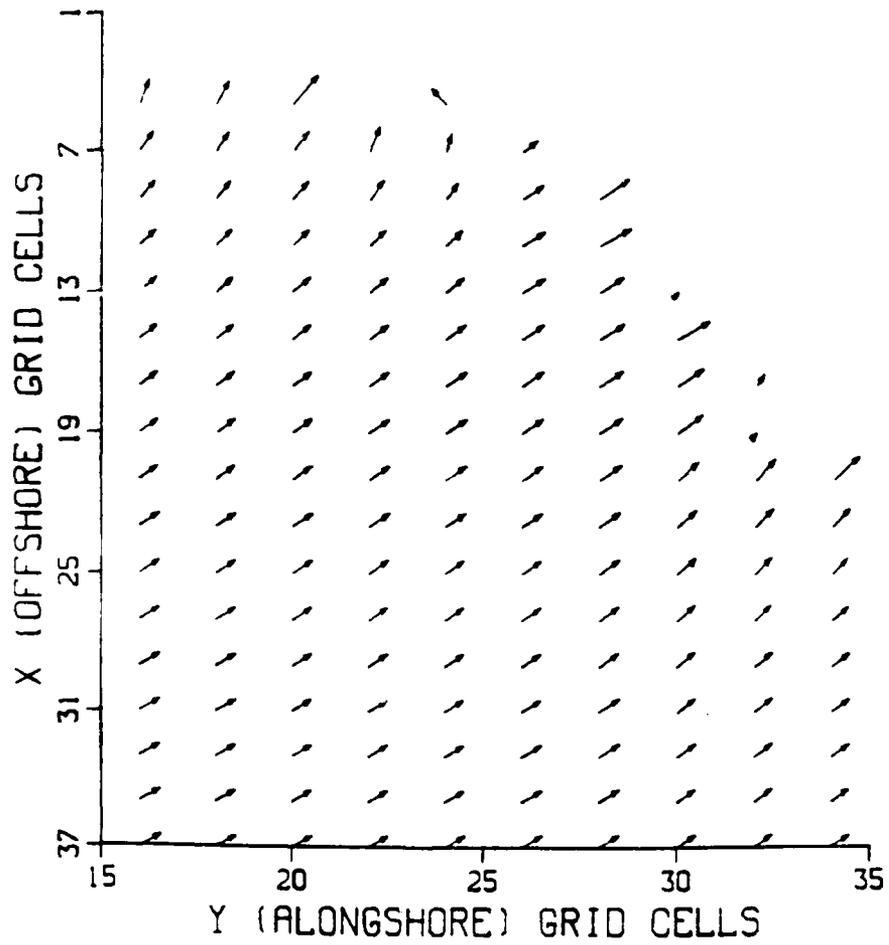
PLATE 6

# COOS BAY WAVE HEIGHT COEFFICIENTS

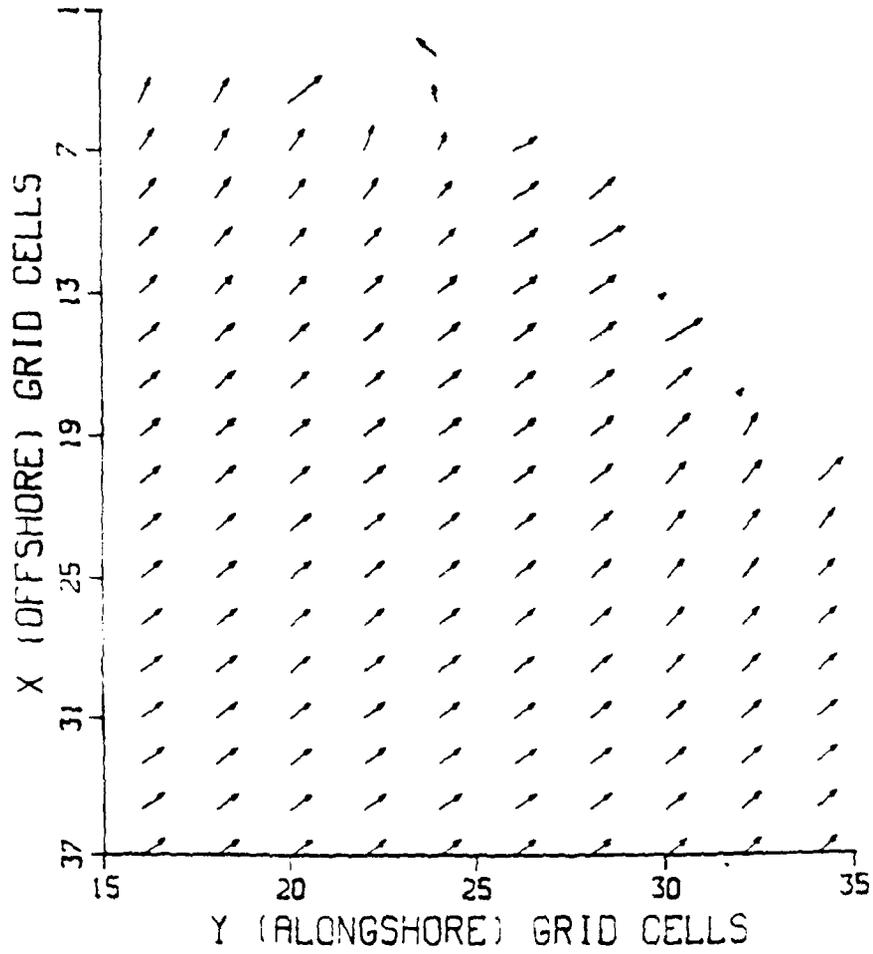
SW WAVE DIRECTION  
NORTH JETTY



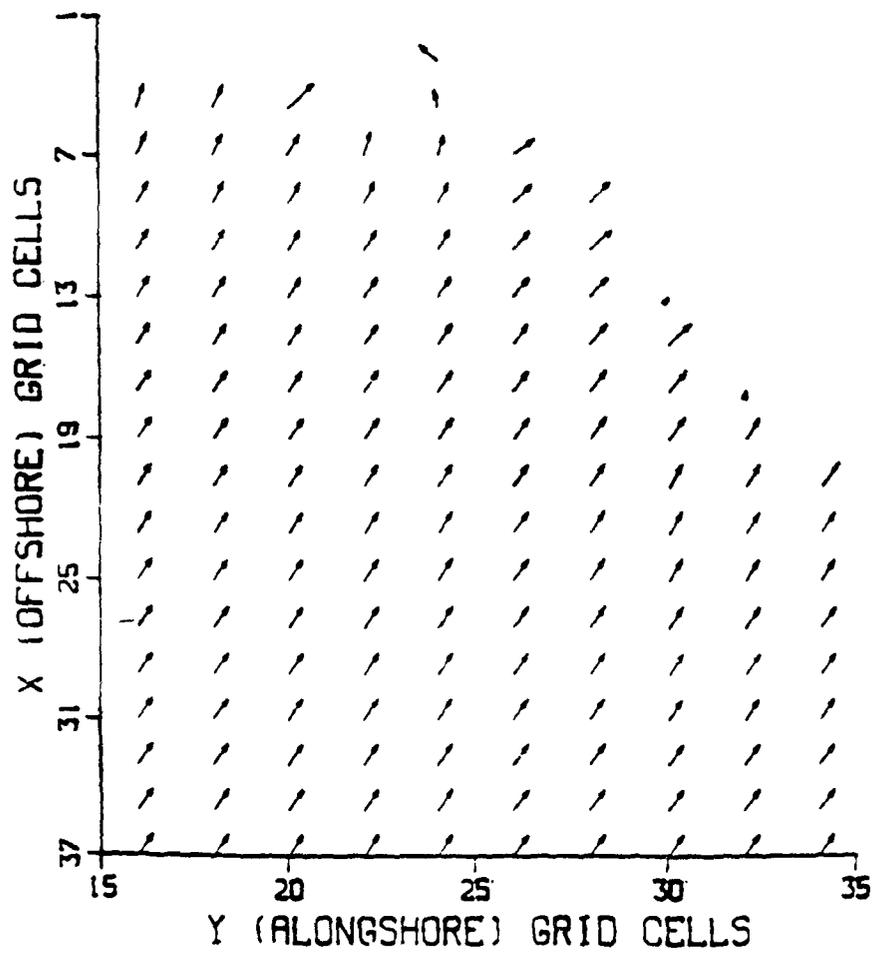
COOS BAY WAVE HEIGHTS AND DIRECTIONS  
PERIOD = 15 s  
NORTH WAVE DIRECTION



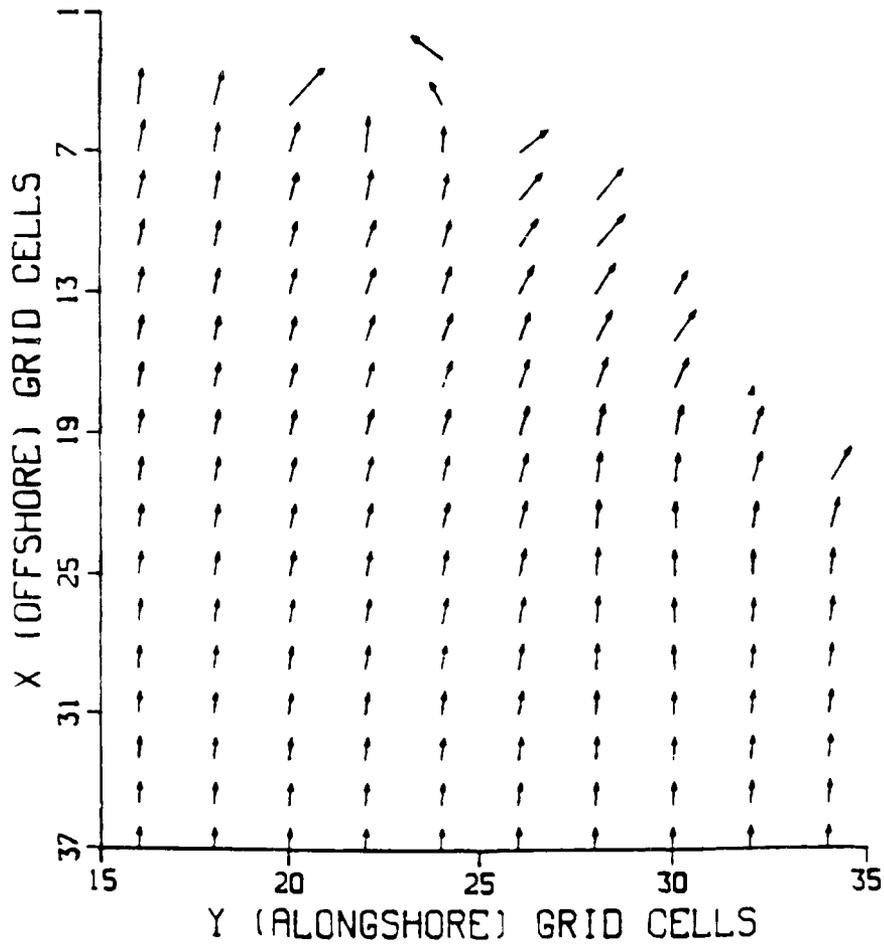
COOS BAY WAVE HEIGHTS AND DIRECTIONS  
PERIOD = 11 s  
NNW WAVE DIRECTION



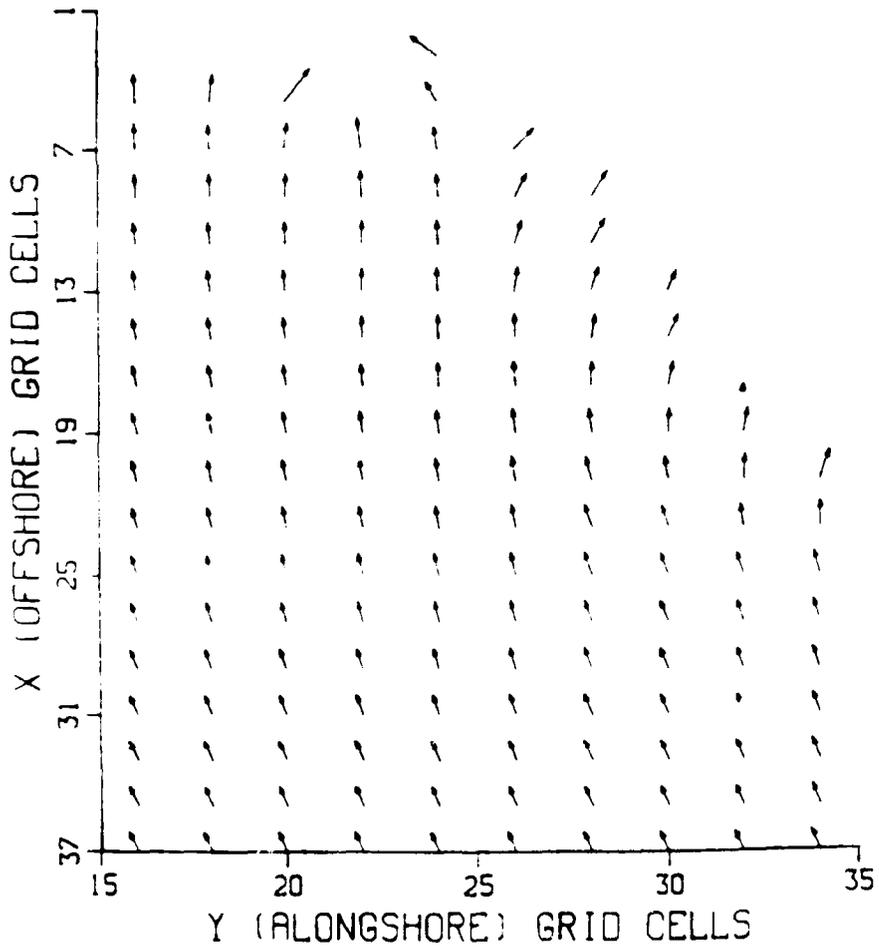
COOS BAY WAVE HEIGHTS AND DIRECTIONS  
PERIOD - 7 s  
NW WAVE DIRECTION



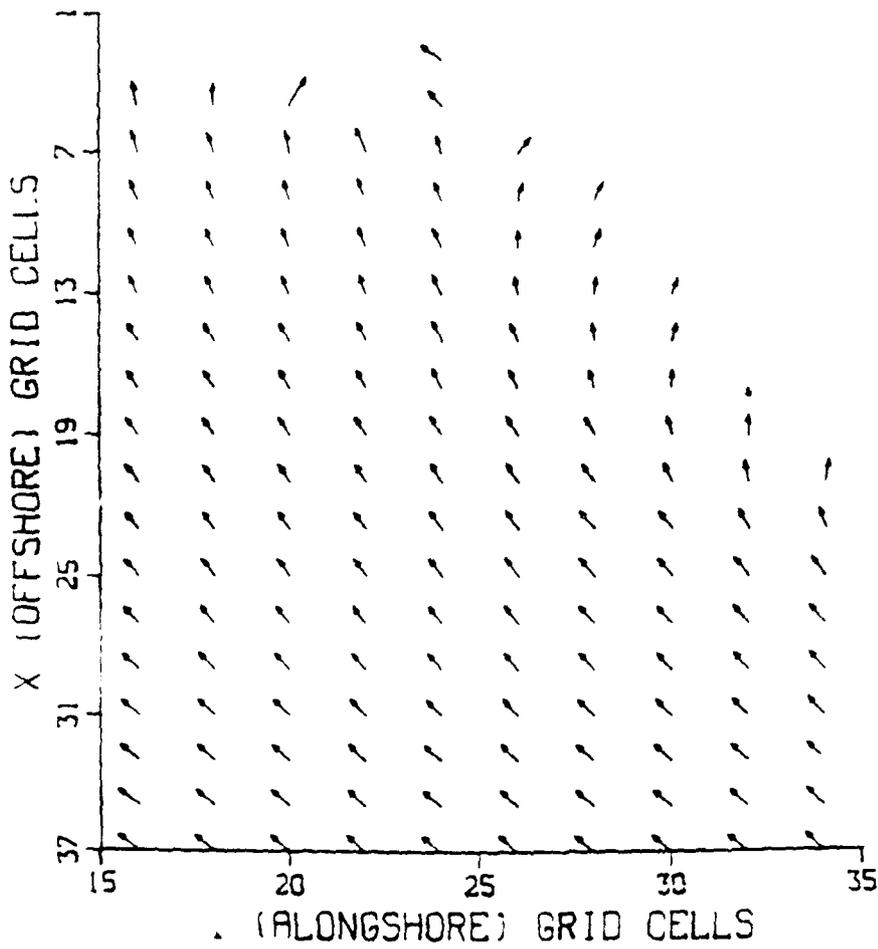
COOS BAY WAVE HEIGHTS AND DIRECTIONS  
PERIOD - 17 s  
WNW WAVE DIRECTION



COOS BAY WAVE HEIGHTS AND DIRECTIONS  
PERIOD = 13s  
WEST WAVE DIRECTION



COOS BAY WAVE HEIGHTS AND DIRECTIONS  
PERIOD = 11 s  
WSW WAVE DIRECTION



COOS BAY WAVE HEIGHTS AND DIRECTIONS  
PERIOD = 13s  
SW WAVE DIRECTION

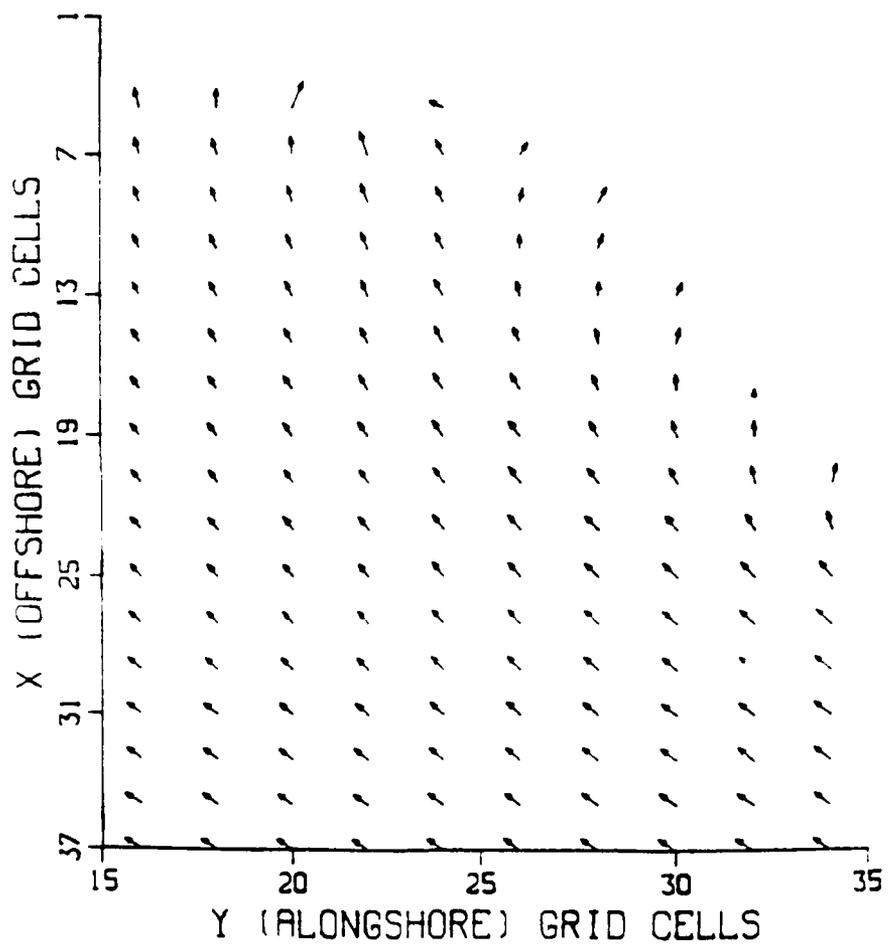


PLATE 14