Laboratory Effects in Beach Studies

Volume III

Movable-Bed Experiments with $H_o/L_o = 0.021$ (1971)

by

Charles B. Chesnutt and Robert P. Stafford

MISCELLANEOUS REPORT NO. 77-7
NOVEMBER 1977

Approved for public release;
distribution unlimited.

U.S. ARMY, CORPS OF ENGINEERS

COASTAL ENGINEERING
RESEARCH CENTER

Kingman Building
Fort Belvoir, Va. 22060

Reprint or republication of any of this material shall give appropriate credit to the U.S. Army Coastal Engineering Research Center.

Limited free distribution within the United States of single copies of this publication has been made by this Center. Additional copies are available from:

National Technical Information Service
ATTN: Operations Division
5285 Port Royal Road
Springfield, Virginia 22151

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MR 77-7	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) LABORATORY EFFECTS IN BEACH STUDIES Volume III. Movable-Bed Experiments With H_o/L_o = 0.021 (1971)		5. TYPE OF REPORT & PERIOD COVERED Miscellaneous Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Charles B. Chesnutt Robert P. Stafford		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of the Army Coastal Engineering Research Center (CERRE-CP) Kingman Building, Fort Belvoir, Virginia 22060		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS D31192
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Army Coastal Engineering Research Center Kingman Building, Fort Belvoir, Virginia 22060		12. REPORT DATE November 1977 13. NUMBER OF PAGES 111 110p.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Breakers
Coastal engineering
Currents
Model studies
Movable-bed experiments
Wave envelopes
Wave generators
Wave height variability
Wave reflection
Wave tanks

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Two movable-bed experiments were conducted in 6- and 10-foot-wide wave tanks for 375 and 335 hours, respectively, with a wave period of 1.90 seconds and a generated wave height of 0.36 foot.

Significant lateral variations occurred in the profile development rate and profile shape in the 10-foot tank, which did not occur in the 6-foot tank, indicating that tank width can affect the study of littoral processes in movable-bed experiments.

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Wave reflection from the movable-bed profile varied considerably as the profile in both wave tanks developed from an initial planar (0.10) slope to one closer to equilibrium. The reflection coefficient, K_R, varied from 0.08 to 0.30 in the 6-foot tank and from 0.03 to 0.16 in the 10-foot tank. The variations in K_R can be related qualitatively to profile development.

Even with the fine-grained, well-sorted sediment used, a measurable sorting occurred as the finer material was eroded and deposited offshore.

PREFACE

Ten experiments were conducted at the Coastal Engineering Research Center (CERC) from 1970 to 1972 as part of an investigation of the Laboratory Effects in Beach Studies (LEBS), to relate wave height variability to wave reflection from a movable-bed profile in a wave tank. The investigation also identified the effects of other laboratory constraints. The LEBS project is directed toward the solution of problems facing the laboratory researcher or engineer in charge of a model study; ultimately, the results will be of use to field engineers in the analysis of model studies. The work was carried out under the CERC coastal processes program.

This report (Vol. III) is the third in a series of eight volumes on the LEBS experiments. Volume I describes the procedures used in the 10 LEBS experiments, and also serves as a guide for conducting realistic coastal engineering laboratory studies; Volumes II to VII are data reports covering all experiments; Volume VIII summarizes the LEBS experiments detailed in the earlier volumes.

This volume analyzes two movable-bed experiments run under nearly the same conditions as the experiments described in Volume II. As in Volume II, these repeat experiments show a slower approach to equilibrium profile than normally anticipated in movable-bed experiments, and a probable relation between tank width and profile development. These experiments indicate an even greater effect of profile change on reflection coefficient, and thus on wave height variability. However, the effect of temperature on the profile development indicated in Volume II is not supported by these experiments.

This report was prepared by Charles B. Chesnutt, principal investigator, and Robert P. Stafford, senior technician in charge of the two experiments. Dr. C.H. Everts, now Chief, Geotechnical Engineering Branch, supervised 3 months of the testing reported in this volume. Dr. C.J. Galvin, Chief, Coastal Processes Branch, provided general supervision.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

JOHN H. COUSINS
Colonel, Corps of Engineers
Commander and Director

CONTENTS

TABLES

CONTENTS

TABLES-Continued

FIGURES

CONTENTS

FIGURES-Continued

CONTENTS

FIGURES-Continued

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.8532	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.1745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: C = (5/9) (F -32).

To obtain Kelvin (K) readings, use formula: K = (5/9) (F -32) + 273.15.

LABORATORY EFFECTS IN BEACH STUDIES

Volume III. Movable-Bed Experiments With H_o/L_o = 0.021 (1971)

by

Charles B. Chesnutt and Robert P. Stafford

I. INTRODUCTION

1. Background.

Profiles in movable-bed, coastal engineering laboratory experiments and models with constant wave and sediment conditions are expected to reach an equilibrium shape after a sufficiently long time. Laboratory studies of longshore transport often depend on having an equilibrium profile to accurately determine the longshore transport rate (Savage, 1959, 1962; Fairchild,1970a). Coastal engineering models are frequently based on simulating an equilibrium profile, which implies a profile whose mean position is fixed in space for the given wave and sediment conditions, with the expectation that the actual profile at any given time will deviate from the mean profile. However, equilibrium profiles are not always easily attained (Savage, 1962; Fairchild,1970a).

The Laboratory Effects in Beach Studies (LEBS) project was initiated at the Coastal Engineering Research Center (CERC) in 1966 to investigate the causes of wave height variability and other problems associated with movable-bed coastal engineering laboratory studies. Ten movable-bed laboratory experiments were conducted from 1970 to 1972 in the CERC Shore Processes Test Basin (SPTB) to measure the variations in reflection as the profile developed toward equilibrium. The 10 experiments are described in an 8-volume series of reports; this study is Volume III of the series. An extended discussion of the contents and purposes of this series is available in Volume I (Stafford and Chesnutt, 1977).

The first two experiments discussed in Volume II (Chesnutt and Stafford, 1977) led directly to the two experiments described in this report. These two experiments were conducted primarily to relate the variation in wave height to changes in the movable-bed profile. The experiments were to continue until the profile reached equilibrium, at which point it was assumed that the wave height variability would be significantly reduced.

However, the beach had eroded to the back of the tank before the profile had reached equilibrium, and the two experiments were continued by periodically adding sand to the backshore. Even with the periodic nourishment, the profile never reached equilibrium and the wave heights remained variable.

The two experiments discussed in this study were repeats of the first two experiments with more sand added so that the initial test length (distance from the wave generator to the initial stillwater level (SWL) intercept) was shortened by 7 feet (2.1 meters) in both tanks, in hopes that the erosion would not reach the back of the tank before the profile attained equilibrium.

The two experiments covered in this study have been discussed in part in earlier reports. Chesnutt, et al. (1972) discussed the development of the profiles in four LEBS experiments, including the two in this study. Chesnutt and Galvin (1974) analyzed the relationship between reflection variability and profile development in the same four experiments discussed by Chesnutt, et al. (1972). Chesnutt (1975) analyzed other laboratory effects observed in three LEBS experiments, including one of the two in this volume.

2. Experimental Procedures.

The experimental procedures used in the LEBS experiments are described in Volume I (Stafford and Chesnutt, 1977) which provides the necessary details on the equipment, quality control, data collection, and data reduction for all 10 experiments.

The data collection and reduction procedures unique to the two experiments in this study are documented in the Appendix. The conditions of these two LEBS experiments (71Y-06 and 71Y-10) are summarized in Table 1. The table shows that the initial slope, water depth, wave period, wave height, and sand size were the same in both experiments.

Table 1. Summary of experimental conditions.

Experiment[1]	Initial test length (ft)	Initial slope	Wave period (s)	Generated wave height (ft)
71Y-06	93.0	0.10	1.90	0.36
71Y-10	54.7	0.10	1.90	0.36

[1]Refer to Volume I (Stafford and Chesnutt, 1977) for relation between these experiments and the other eight LEBS experiments.

NOTE.--The same sediment was used in both experiments; the initial d_{50} (by dry sieve analysis) was 0.23 millimeter.

Two experimental facilities were used (see Figs. 3 and 4 in Vol. I and Fig. A-1 in the App.). Each facility consisted of two side-by-side wave tanks, one with a 0.10 concrete slope and the other a sand slope. A generator was common to each pair of tanks so that each had identical wave energy input. The operation of the generators is described in Section IV and Appendix B of Volume I. The concrete slope provided a control (a bench-mark value) for the varying reflection measured in the neighboring tank with the movable bed.

The basic difference between the two facilities was the tank width. One pair of tanks, each 6 feet (1.8 meters) wide, was used for experiment 71Y-06; the other pair, each 10 feet (3.0 meters) wide, was used for experiment 71Y-10. The initial test length on the sand side was 93 feet (28.3 meters) in experiment 71Y-06 and 54.7 feet (16.7 meters) in experiment 71Y-10 (Table 1). The initial test length was 7 feet greater on the concrete side in both tanks.

The initial grading of the sand slope in experiment 71Y-06 was on 3 May 1971. The first run was on 11 May 1971, the last run was on 8 December 1971 after 380 hours, and the data collection was completed 13 December 1971. Experiment 71Y-10 began 18 June 1971, stopped on 30 November 1971 after 335 hours, and data collection completed 16 December 1971. The dates are important because the experiments were run in outdoor facilities with water temperature varying with ambient air temperature. The major events of each experiment and the cumulative time at the end of each run are summarized in Table 2.

Table 3 gives the data collection schedule within each run for 1-, 2-, and 5-hour runs. During the first 2 hours when the runs were less than 1 hour long, the same data were collected, with the schedule depending on the length of the run.

3. Subexperiment with $H_o/L_o = 0.002$.

After 375 hours in experiment 71Y-06, the beach had eroded to the end of the tank. The experiment was continued for an additional 5 hours with a much longer, lower wave, which resulted in accretion on the foreshore. The experimental conditions unique to this subexperiment are given in the Appendix.

4. Scope.

This report describes and analyzes the reduced data from LEBS experiments 71Y-06 and 71Y-10. The original data are available in an unpublished laboratory memorandum (No. 2) (Chesnutt and Leffler, 1977) filed in the CERC library (CERTI-LI).

Wave reflection, profile evolution, sediment-size distribution, breaker characteristics, and water temperature data are discussed in Section II. Section III discusses (a) profile development, including the interrelation of changes in profile shape, sediment-size distribution, breaker characteristics, and water temperature; and (b) profile reflectivity, including the interrelation of changes in profile shape, breaker characteristics, and wave reflection. Section IV discusses the results of wave height variability, profile equilibrium, and other laboratory effects.

The conclusions and recommendations (Sec. V) are directed toward the identification and solution of problems facing the laboratory researcher

Table 2. Schedule for experiments 71Y-06 and 71Y-10.

Cumulative time[1] (hr:min)	Date (1971)	Wave record No.	Survey No.	Special data collected
		Experiment 71Y-06		
0:00			1	sand samples
0:10	12 May	001	2	
0:25		002	3	
0:40		003	4	
1:00		004	5	
1:30		005	6	
2:00		006	7	
3:00		007	8	
----[2]		----[2]	----[2]	
9:00		013	14	
10:00	28 May	014	15	
12:00		015	16	
----[3]		----[2]	----[2]	
26:00	9 June	022	23	ripple photos, sand samples
----[3]		----[2]	----[2]	
52:00	14 July	035	36, 36S	profile survey, ripple photos, sand samples
----[3]		----[2]	----[2]	
98:00		058	59	
100:00	5 Aug.	059	60, 61	profile survey, ripple photos, sand samples
105:00		060	62	
----[4]		----[2]	----[2]	
200:00	10 Sept.	079	81, 82	profile survey, ripple photos, sand samples
----[4]		----[2]	----[2]	
300:00	14 Oct.	099	102, 103	profile survey, ripple photos, sand samples
----[4]		----[2]	----[2]	
370:00		113	117	
375:00	11 Nov.	114	118, 119	profile survey, ripple photos, sand samples
375:10		115	120	
375:40		116	121	
376:30		117	122	
378:00		118	123	
380:00	8 Dec.		124, 125	profile survey, ripple photos, sand samples

[1]Wave records were taken *during* run ending at cumulative time shown; surveys, sand samples, and ripple photos were taken after the run ending at the cumulative time shown (see also Table 3).

[2]Increments of 1.

[3]Increments of 2.

[4]Increments of 5.

Table 2. Schedule for experiments 71Y-06 and 71Y-10.—Continued

Cumulative time[1] (hr:min)	Date (1971)	Wave record No.	Survey No.	Special data collected
Experiment 71Y-10				
0:00			1	
0:10	18 June	001	2	
0:25		002	3	
0:40		003	4	
1:00		004	5	
1:30		005	6	
2:00		006	7	
3:00		007	8	
----------[2]		-----[2]	------------[2]	
9:00		013	14	
10:00	9 July	014	15	
12:00		015	16	
----------[3]		-----[2]	------------[2]	
24:00	16 July	021	22, 23	profile survey, ripple photos, sand samples
----------[3]		-----[2]	------------[2]	
50:00	2 Aug.	034	36, 37	profile survey, ripple photos, sand samples
----------[3]		-----[2]	------------[2]	
98:00		058	61	
100:00	30 Aug.	059	62, 63	profile survey, ripple photos, sand samples
105:00		060	64	
----------[4]		-----[2]	------------[2]	
200:00	4 Oct.	079	83, 84	profile survey, ripple photos, sand samples
----------[4]		-----[2]	------------[2]	
300:00	9 Nov.	099	104, 105	profile survey, ripple photos, sand samples
----------[4]		-----[2]	------------[2]	
335:00	30 Nov.	106	112, 113	profile survey, ripple photos, sand samples

[1]Wave records were taken *during* run ending at cumulative time shown; surveys, sand samples, and ripple photos were taken after the run ending at the cumulative time shown (see also Table 3).

[2]Increments of 1.

[3]Increments of 2.

[4]Increments of 5.

Table 3. Data collection schedule within runs for experiments 71Y-06 and 71Y-10.

Event	Time within runs (hr:min)[1]		
	1-hr runs	2-hr runs	5-hr runs
Photo at foreshore before start	before start	before start	before start
Photos of breaker and runup	0:01	0:01	0:01
Photos of breaker and runup before wave envelope	0:19	0:59	3:59
Recording of wave envelope started	0:20	1:00	4:00
Preparation of visual observation form	-------	1:50	4:50
Photos of breaker and runup; entry of breaker and runup stations in logbook	0:59	1:59	4:59
Photo of foreshore after water surface had calmed	after stop	after stop	after stop
Profile survey	after stop	after stop	after stop
Water temperature data collected in morning and afternoon of each day of testing; however, there may have been more than one run during each day.			

[1] See Table 2 for distribution of 1-, 2-, and 5-hour runs.

or engineer in charge of a model study. Field engineers should also be aware of these results when analyzing model studies for coastal engineering projects.

The data in this study (particularly the profiles) may have other uses. The researcher can use these data, after consideration of the laboratory effects, to analyze short- and long-term changes in profile shape. After an analysis of the scale and laboratory effects, the field engineer may use these data to determine generalized shoreline recession rates.

II. RESULTS

1. Wave Height Variability.

a. Incident Wave Heights.

(1) 1.90-Second Wave. Wave height measurements from the continuous recording of water surface elevation along the center range at station +25 during the first 10 minutes of each experiment are shown in Table 4. The wave heights in the movable-bed tanks varied from 0.26 to 0.52 foot (7.9 to 15.8 centimeters) in experiment 71Y-10, and from 0.20 to 0.41 foot (6.1 to 12.5 centimeters) in experiment 71Y-06. Ignoring the first group of waves, the range of wave heights within the first 10 minutes was 0.11 foot (3.4 centimeters) in experiment 71Y-10 and 0.10 foot (3.0 centimeters) in experiment 71Y-06. In the fixed-bed tanks, again ignoring the first group, the range of wave height variation was 0.12 foot (3.7 centimeters) in experiment 71Y-10 and 0.07 foot (2.1 centimeters) in experiment 71Y-06. The range of wave height variation was as great in the fixed-bed tanks as in the movable-bed tanks.

The average wave height in the movable-bed tank for each record was determined by averaging the average of the last 10 waves in the last 20-second interval for each of the 10 minutes. In experiment 71Y-10, the average wave height was 0.33 foot (10.1 centimeters) in experiment 71Y-06, the average wave height was 0.36 foot (11.0 centimeters). Because the waves were recorded at the same distance from the profile, the difference in the average wave height is likely due to the difference in the initial test length which affects the development of secondary waves or re-reflection from the wave generator. During the first 10 minutes, there was little difference in the average wave height between the movable- and fixed-bed tanks for either experiment, even though the gages in the fixed-bed tanks were 7 feet farther from the profile.

The average incident wave heights in the fixed-bed tanks from the two experiments are shown in Table 5. These heights were determined as part of the manual method for determining the reflection coefficient, K_R (see Vol. I). This variation is probably caused by generator operation variation, measurement errors, and all errors not caused by a changing profile in both movable- and fixed-bed tanks. The range of variation was 0.03 foot (0.9 centimeter) in experiment 71Y-10 and 0.04 foot (1.2 centimeters) in experiment 71Y-06.

Table 4. Wave heights (ft) during first 10 minutes for experiments 71Y-06 and 71Y-10.

Cumulative time (min:s)	Experiment 71Y-06						Experiment 71Y-10					
	Movable-bed tank			Fixed-bed tank			Movable-bed tank			Fixed-bed tank		
	(avg)	(max)	(min)	(avg)	(max)	(min)	(avg)	(max)	(min)	(avg)	(max)	(min)
0:00 to 0:20[1]	0.294	0.360	0.200	0.296	0.355	0.198	0.356	0.520	0.262	0.378	0.524	0.292
0:20 to 0:40	0.344	0.370	0.321	0.339	0.356	0.317	0.316	0.352	0.295	0.318	0.386	0.271
0:40 to 1:00	0.367	0.380	0.350	0.373	0.349	0.329	0.307	0.338	0.282	0.319	0.375	0.298
1:40 to 2:00	0.364	0.383	0.339				0.313	0.335	0.293			
2:40 to 3:00	0.339	0.351	0.326	0.339	0.355	0.321	0.348	0.372	0.332	0.319	0.342	0.298
3:40 to 4:00	0.355	0.364	0.340				0.306	0.324	0.291			
4:40 to 5:00	0.327	0.342	0.313	0.354	0.385	0.335	0.348	0.375	0.329	0.327	0.361	0.301
5:40 to 6:00	0.380	0.397	0.368				0.338	0.353	0.328			
6:40 to 7:00	0.353	0.373	0.338	0.354	0.375	0.326	0.376	0.394	0.342	0.342	0.358	0.332
7:40 to 8:00	0.375	0.406	0.344				0.335	0.361	0.313			
8:40 to 9:00	0.382	0.402	0.382				0.330	0.351	0.313			
9:40 to 10:00	0.365	0.376	0.346	0.344	0.365	0.327	0.342	0.373	0.321	0.339	0.355	0.325
Avg[2]	0.361			0.353			0.334			0.329		

[1]Waves 3 to 10; these waves were not typically shaped and the heights were erratic due to irregular angular velocity of the generator which was corrected after 20 seconds.

[2]Excludes averages for cumulative times of 0:00 to 0:20 and 0:40.

NOTE.—The wave gage was located at station 25 at the toe of the movable-bed profiles, and 7 feet from the toe of the fixed-bed profiles.

Table 5. Incident wave heights in fixed-bed tanks.

Time (hr)	Incident wave height (ft)[1]	
	Experiment 71Y-06	Experiment 71Y-10
1.5	0.38	0.35
6.0	0.39	-------[2]
7.0	-------	0.35
12.0	0.38	0.36
22.0	0.36	-------
24.0	-------	0.34
32.0	0.38	0.37
42.0	0.37	-------
44.0	-------	0.35
52.0	0.38	0.35
62.0	0.39	0.36
72.0	0.39	0.37
82.0	0.37	0.36
92.0	0.38	0.35
105.0	0.40	0.35
130.0	0.39	0.35
155.0	0.40	0.37
180.0	0.39	0.37
205.0	0.40	0.37
230.0	0.39	-------
235.0	-------	0.37
250.0	-------	0.34
255.0	0.38	-------
280.0	0.38	0.36
305.0	0.39	0.37
324.0	0.39	-------
330.0	0.38	0.36
334.0	0.38	-------
339.0	0.38	-------
344.0	0.38	-------
349.0	0.38	-------
354.0	0.38	-------
359.0	0.37	-------
364.0	0.38	-------
369.0	0.38	-------
374.0	0.37	-------
Avg.	0.38	0.36

[1]Each value is an average of wave heights at the nodes and antinodes of the wave envelope for run ending at indicated time.

[2]Data for these times were not reduced.

The average incident wave heights in the movable-bed tanks from the two experiments are shown in Table 6. These heights were determined as part of the automated method for determining K_R (see Vol. I). The range of wave heights was 0.09 foot (2.7 centimeters) in both experiments. The difference in range of variation between fixed- and movable-bed tanks is due to the changing shape and position of the profile, causing a varying re-reflection from the wave generator. The re-reflected wave superposing with the generated wave created an incident wave which varied in time. Thus, the variation due to re-reflection was 0.06 foot (1.8 centimeters) in experiment 71Y-10 and 0.05 foot (1.5 centimeters) in experiment 71Y-06.

(2) 3.75-Second Wave. Table 7 shows the wave height measurements from the continuous recording of water surface elevation during the first 10 minutes of waves with the 3.75-second wave period. A well-developed profile was created by 375 hours of 1.90-second waves. Wave heights varied from 0.09 to 0.15 foot (2.7 to 4.6 centimeters) in the movable-bed tank and from 0.09 to 0.16 foot (2.7 to 4.9 centimeters) in the fixed-bed tank. The average wave height was 0.12 foot in both movable- and fixed-bed tanks.

The average incident wave height for runs with cumulative times of 375:40, 376:30, and 378:00 were 0.15, 0.15, and 0.16 foot in the fixed-bed tank and 0.16, 0.14, and 0.14 foot (4.9, 4.3, and 4.3 centimeters) in the movable-bed tank, respectively (i.e., the incident wave height variations were small).

b. Wave Reflection. The reflection coefficient data determined by the manual method in experiments 71Y-06 and 71Y-10, are given in Table 8. K_R data determined by the automated method and a comparison of the two methods are included in the Appendix.

(1) 1.90-Second Wave. The variation in K_R from the concrete slope in experiments 71Y-06 and 71Y-10 is shown in Figure 1. The K_R varied from 0.10 to 0.16 in experiment 71Y-06 and from 0.09 to 0.12 in experiment 71Y-10. In both fixed-bed tanks, the K_R increased during the early part of the tests and then gradually decreased. The explanation is not apparent. The reason for a higher K_R in the narrower tank is unknown. The variation in K_R in the fixed-bed tank indicates the total of the measurement error in determining K_R from the changing movable-bed profile. The average K_R in the fixed-bed tanks was 0.13 in experiment 71Y-06 and 0.10 in experiment 71Y-10. Chesnutt and Galvin (1974) gave average K_R values between 0.03 and 0.07 for these experiments; however, those values were determined by the automated method which gives values lower by 0.04 to 0.05 (see App.).

The variation in K_R from the movable-bed profile in experiments 71Y-06 and 71Y-10 is shown in Figures 2 and 3. The two experiments show the same pattern of variation. The K_R during the first 10 minutes on

Table 6. Incident wave heights in movable-bed tanks.

Time (hr)	Incident wave height (ft)[1]	
	Experiment 71Y-06	Experiment 71Y-10
0.3	0.41	0.35
0.5	0.39	0.35
0.8	0.38	0.34
1.3	0.39	0.35
1.8	0.38	0.35
2.3	0.40	0.36
3.3	0.38	0.36
4.3	0.37	0.36
5.3	0.38	0.36
6.3	-------[2]	0.36
7.3	0.35	0.36
8.3	0.37	0.36
9.3	0.36	0.35
11.0	0.36	0.35
13.0	0.37	0.35
15.0	0.37	0.34
17.0	0.36	0.34
19.0	0.36	0.34
21.0	0.35	-------
23.0	0.36	0.34
25.0	0.36	0.35
27.0	0.37	0.34
29.0	0.38	0.36
31.0	0.37	0.36
33.0	0.38	0.35
35.0	0.38	0.34
37.0	0.38	0.35
39.0	0.36	0.34
41.0	0.37	-------
43.0	0.37	0.32
45.0	0.37	0.35
47.0	0.36	0.35
49.0	0.36	0.34
51.0	0.38	0.34
53.0	0.39	0.35
55.0	0.38	0.34
57.0	0.38	0.35
59.0	0.38	0.36

[1]Each value is an average of wave heights along the tank for run ending at indicated time.
[2]Data for these times were not reduced.

Table 6. Incident wave heights in movable-bed tanks.—Continued

Time (hr)	Incident wave height (ft)[1]	
	Experiment 71Y-06	Experiment 71Y-10
61.0	0.38	0.36
63.0	0.39	0.36
65.0	0.38	0.35
67.0	0.38	0.35
69.0	0.38	0.35
71.0	0.38	0.35
73.0	0.37	0.35
75.0	0.38	0.34
77.0	0.36	-------[2]
79.0	0.38	0.35
81.0	0.37	0.36
83.0	0.37	0.34
85.0	0.36	0.36
87.0	0.37	0.35
89.0	0.36	0.35
91.0	0.37	0.36
93.0	-------	0.35
95.0	0.37	0.36
97.0	0.38	0.36
99.0	0.38	0.36
104.0	0.40	0.36
109.0	0.37	0.38
114.0	0.36	0.38
119.0	0.36	0.37
124.0	0.38	0.38
129.0	0.35	0.38
134.0	0.36	0.38
139.0	0.36	0.36
144.0	0.37	0.38
149.0	0.38	0.36
154.0	0.36	0.36
159.0	0.37	0.36
164.0	0.38	0.36
169.0	0.36	0.37
174.0	0.34	0.38
179.0	0.34	0.36
184.0	0.36	0.37
189.0	0.40	0.37

[1]Each value is an average of wave heights along the tank for run ending at indicated time.
[2]Data for these times were not reduced.

Table 6. Incident wave heights in movable-bed tanks.—Continued

Time (hr)	Incident wave height (ft)[1]	
	Experiment 71Y-06	Experiment 71Y-10
194.0	0.38	0.37
199.0	0.40	0.35
204.0	0.40	0.38
209.0	0.40	0.41
214.0	0.39	0.40
219.0	0.36	0.40
224.0	0.35	0.38
229.0	0.37	0.39
234.0	0.34	0.40
239.0	0.39	0.38
244.0	0.41	0.38
249.0	0.40	0.38
254.0	0.40	0.36
259.0	0.38	0.34
264.0	0.40	0.33
269.0	0.38	0.33
274.0	0.36	0.35
279.0	0.35	0.35
284.0	0.35	0.34
289.0	0.35	0.35
294.0	0.36	0.35
299.0	0.34	0.36
304.0	0.36	0.34
309.0	0.33	0.36
314.0	-------[2]	0.36
319.0	0.36	0.36
324.0	0.38	0.36
329.0	0.40	0.38
334.0	0.40	0.36
339.0	0.38	
344.0	0.38	
349.0	0.39	
354.0	0.39	
359.0	0.38	
364.0	0.35	
369.0	0.34	
374.0	0.32	

[1]Each value is an average of wave heights along the tank for run ending at indicated time.
[2]Data for these times were not reduced.

Table 7. Wave heights during first 10 minutes of long waves near end of experiment 71Y-06.

Cumulative time	Wave height (ft)					
	Movable-bed tank			Fixed-bed tank		
(min:s)	(avg)	(max)	(min)	(avg)	(max)	(min)
0:00 to 0:35[1]	0.131	0.145	0.110	0.140	0.158	0.124
0:40 to 1:20	0.109	0.122	0.090	0.114	0.121	0.100
1:40 to 2:20	0.117	0.134	0.100			
2:40 to 3:20	0.112	0.124	0.095	0.108	0.119	0.097
3:40 to 4:20	0.112	0.126	0.093			
4:40 to 5:20	0.117	0.132	0.090	0.114	0.119	0.093
5:40 to 6:20	0.122	0.147	0.108			
6:40 to 7:20	0.126	0.143	0.102	0.114	0.128	0.098
7:40 to 8:20	0.121	0.138	0.100			
8:40 to 9:20	0.116	0.132	0.098			
9:20 to 10:00	0.115	0.133	0.094	0.112	0.128	0.094
Avg[2]	0.118			0.117		

[1]Waves 2 to 5.

[2]Excludes 0 to 0:35 measurement.

Table 8. Reflection coefficient by manual method for experiments 71Y-06 and 71Y-10.

Time (hr)	K_R in Experiment 71Y-06		K_R in Experiment 71Y-10	
	Movable bed	Fixed bed	Movable bed	Fixed bed
0.3	0.169		0.177	
0.5	0.127[1]		0.160	
0.8	0.108[1]		0.119	
1.3	0.113[1]	0.122	0.173	0.088
1.8	0.130[1]		0.134	
2.3	0.126		0.119	
3.3	0.101		0.156	
4.3	0.095		0.139	
5.3	0.098	0.138	0.104	0.107
6.3	0.132		0.099	
7.3	0.100		0.092	
8.3	0.091		0.066	
9.3	0.080		0.073	
11.0	0.097	0.142	0.070	0.110
13.0	0.106		0.059	
15.0	0.081[2]		0.067	
17.0	0.090		0.056	
19.0	0.097		0.058	
21.0	0.086	0.142	---------[3]	
23.0	0.104		0.048	0.112
25.0	0.108		0.056	
27.0	0.092		0.089	
29.0	0.098		0.095	
31.0	0.102	0.146	0.070	0.095
33.0	0.110		0.053	
35.0	0.115		0.068	
37.0	0.103		0.076	
39.0	0.088		0.080	
41.0	0.097	0.130	---------[3]	
43.0	0.094		0.063	0.099
45.0	0.099		0.065	
47.0	0.099		0.066	
49.0	0.098		0.065	
51.0	0.112	0.150	0.069	0.102
53.0	0.112		0.090	
55.0	0.112		0.069	
57.0	0.106		0.065	
59.0	0.114		---------[3]	
61.0	0.086	0.136	0.098	0.106

[1]Out only.
[2]In only.
[3]Not analyzed by this method.

Table 8. Reflection coefficient by manual method for experiments 71Y-06 and 71Y-10.—Continued

Time (hr)	K_R in Experiment 71Y-06		K_R in Experiment 71Y-10	
	Movable bed	Fixed bed	Movable bed	Fixed bed
63.0	0.114		0.108	
65.0	0.108		0.087	
67.0	0.102		0.103	
69.0	0.117		0.104	
71.0	0.112	0.130	0.088	0.119
73.0	0.108		0.100	
75.0	0.126		0.099	
77.0	0.102		---------[3]	
79.0	0.108		0.085	
81.0	0.090	0.120	0.067	0.102
83.0	0.096		0.053	
85.0	0.100		0.095	
87.0	0.101		0.078	
89.0	0.092		0.105	
91.0	0.101	0.137	0.097	0.121
93.0	---------[3]		0.093	
95.0	0.094		0.101	
97.0	0.111		0.090	
99.0	0.143		0.089	
104.0	0.126	0.142	0.075	0.106
109.0	0.103		0.119	
114.0	0.100		0.071	
119.0	0.113		0.078	
124.0	0.087		0.094	
129.0	0.126	0.156	0.085	0.109
134.0	0.113		0.086	
139.0	0.128		0.033	
144.0	0.112		0.098	
149.0	0.122		0.102	
154.0	0.145	0.126	---------[3]	0.099
159.0	0.140		0.064	
164.0	0.134		0.080	
169.0	0.144		0.067	
174.0	0.139		0.099	
179.0	0.195	0.144	0.074	0.092
184.0	0.146		0.102	
189.0	0.135		0.114	
194.0	0.145		0.093	
199.0	0.168		0.093	

[3]Not analyzed by this method.

Table 8. Reflection coefficient by manual method for experiments 71Y-06 and 71Y-10.—Continued

Time (hr)	K_R in Experiment 71Y-06		K_R in Experiment 71Y-10	
	Movable bed	Fixed bed	Movable bed	Fixed bed
204.0	0.150	0.150	0.102	
209.0	0.161		0.131	
214.0	0.157		0.129	
219.0	0.156		0.123	
224.0	0.215		0.136	
229.0	0.192	0.147	0.136	
234.0	0.245		0.138	0.098
239.0	0.231		0.131	
244.0	0.140		0.135	
249.0	0.154		0.152	
254.0	0.162	0.137	0.153	0.116
259.0	0.169		0.131	
264.0	0.169		0.159	
269.0	0.137		0.141	
274.0	0.143		0.112	
279.0	0.178	0.130	0.122	0.106
284.0	0.171		0.110	
289.0	0.177		0.095	
294.0	0.186		0.147	
299.0	0.174		0.156	
304.0	0.179	0.126	0.137	0.104
309.0	0.229		0.108	
314.0	0.246		0.099	
319.0	0.271		0.060	
324.0	0.234	0.137	0.080	
329.0	0.132	0.122	0.089	0.093
334.0	0.128	0.127	0.110	
339.0	0.109	0.124		
344.0	0.107	0.125		
349.0	0.141	0.125		
354.0	0.143	0.127		
359.0	0.257	0.121		
364.0	0.184	0.113		
369.0	0.232	0.109		
374.0	0.296	0.099		
375.3[4]	0.285	0.338		
376.2[4]	0.360	0.311		
377.3[4]	0.271	0.354		

[4]Wave period is 3.75 seconds; wave period is 1.90 seconds for all other times.

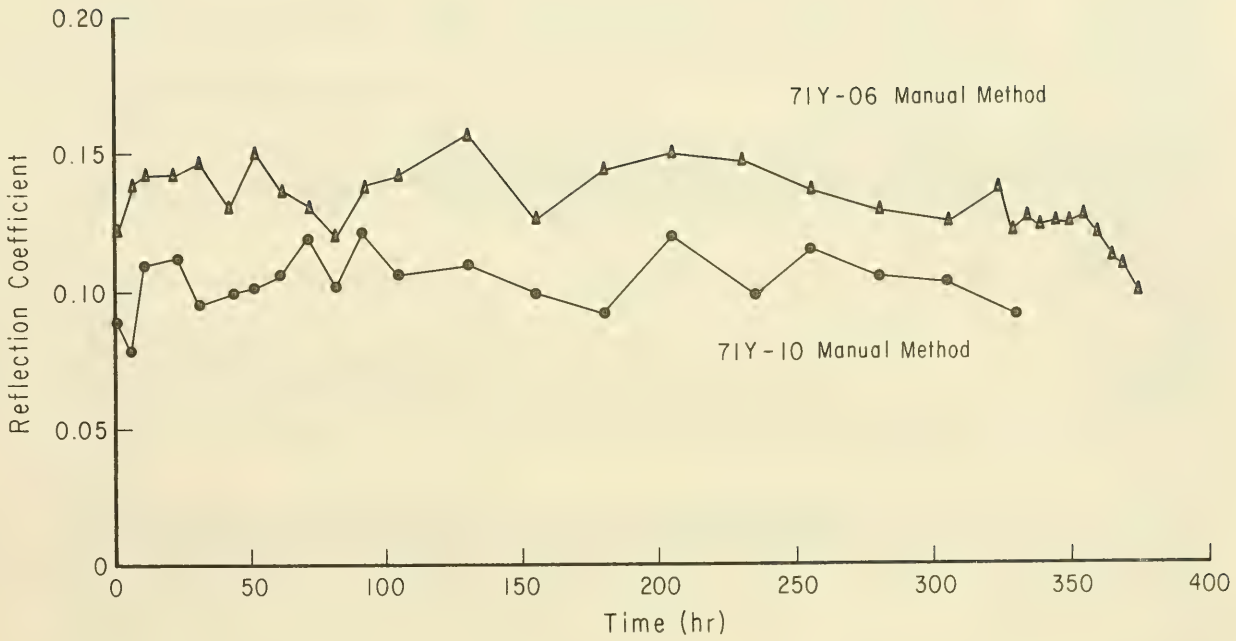


Figure 1. Reflection variability in fixed-bed tanks.

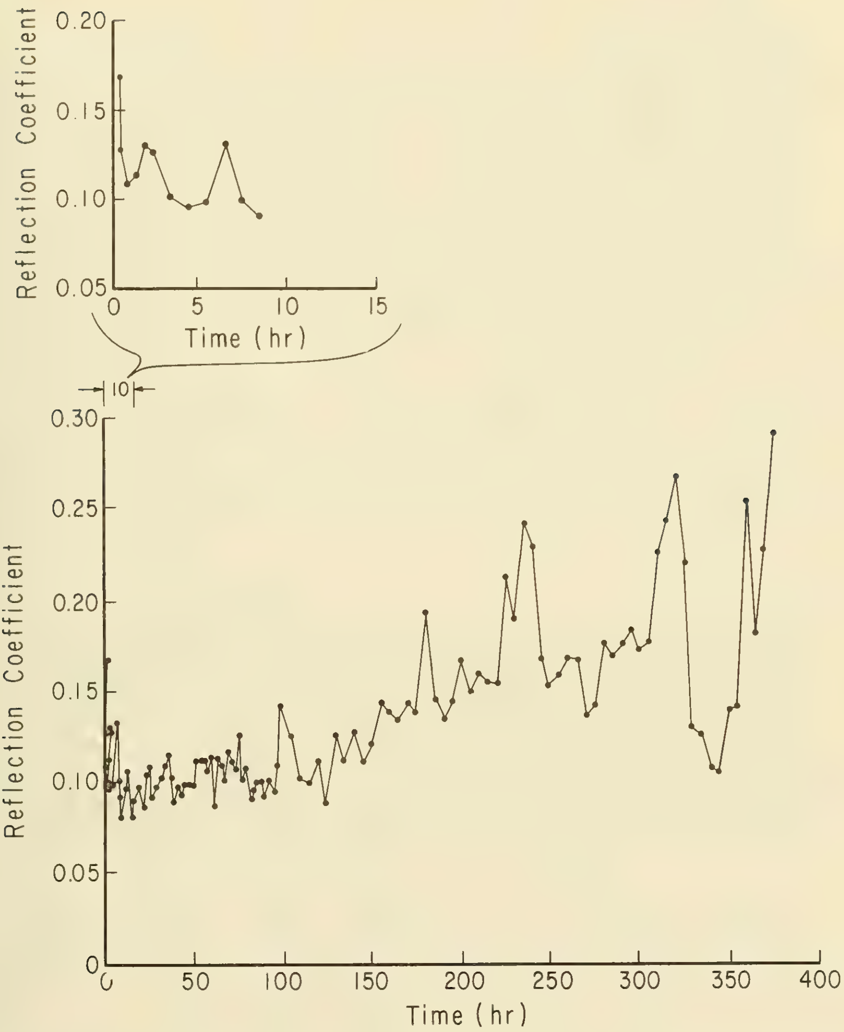


Figure 2. Reflection variability in movable-bed tank of experiment 71Y-06.

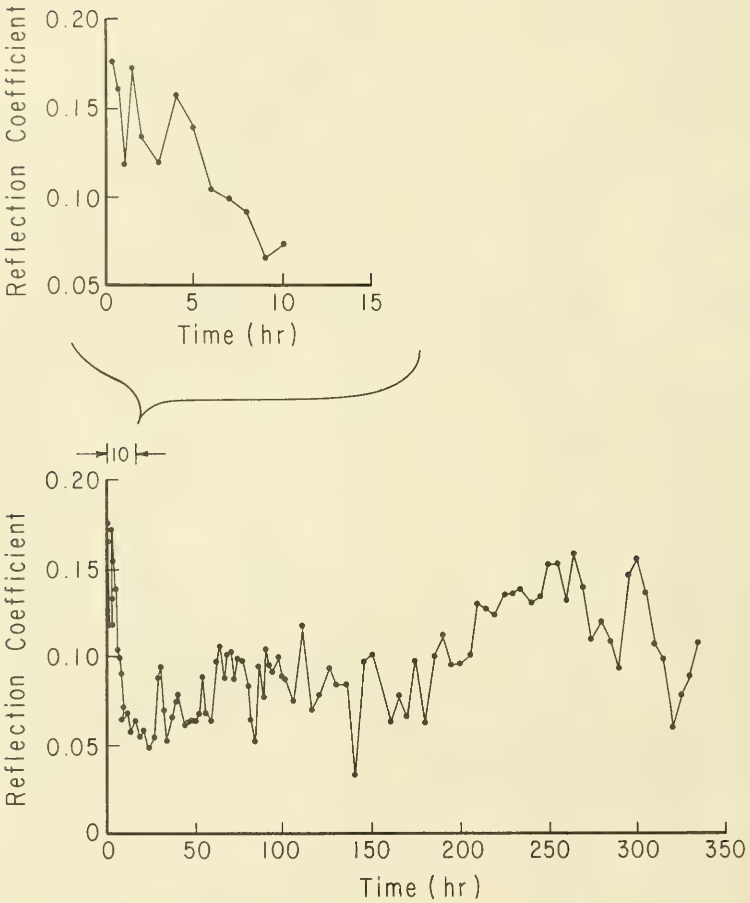


Figure 3. Reflection variability in movable-bed tank of experiment 71Y-10.

the movable-bed side is assumed to be about the same as the average K_R values in the fixed-bed tanks; i.e., 0.13 in the 6-foot tank and 0.10 in the 10-foot tank. The first measured values of K_R from the movable-bed profile (recorded between 12 and 20 minutes) increased to 0.17 in the 6-foot tank and 0.18 in the 10-foot tank. These are significant increases, but not as great as inferred in Chesnutt and Galvin (1974). After the initial high values and for the first 10 hours, K_R varied from 0.07 to 0.17. For an extended period of time, the K_R was relatively small ($K_R \leq 0.14$ for 148 hours in the 6-foot tank and ≤ 0.13 for 210 hours in the 10-foot tank). For the remainder of each experiment, the K_R increased in mean value and variability, varying from 0.11 to 0.30 in experiment 71Y-06 and from 0.06 to 0.16 in experiment 71Y-10.

In general, the reflection coefficient varied from 0.03 to 0.30, which is a large variation considering the generated wave conditions were held constant.

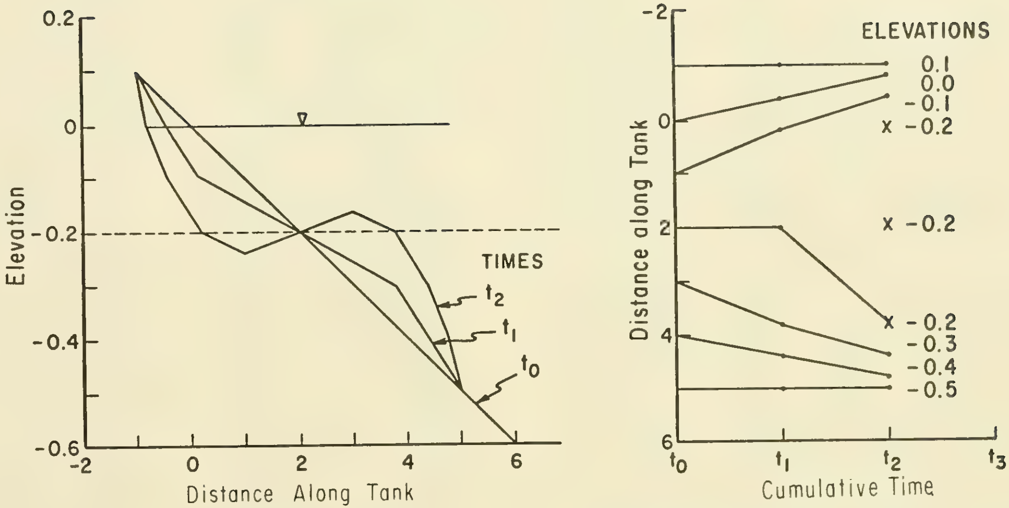
(2) <u>3.75-Second Wave</u>. During the 5 hours of experiment 71Y-06 when the wave period was 3.75 seconds, the K_R at cumulative times of 375:20, 376:10, and 377:20 was 0.29, 0.36, and 0.27 in the movable-bed tank and 0.34, 0.31, and 0.35 in the fixed-bed tank. Reflection from the movable bed was slightly lower on the average, but the values varied over a greater range.

2. <u>Profile Surveys</u>.

a. <u>Interpretation of Contour Movement Plots</u>. The profile surveys (discussed in Vol. I) measured the three space variables of onshore-offshore distance (station), alongshore distance (range), and elevation at fixed times (Table 2) during the experiment. The CONPLT method (see Vol. I) for presenting the data involves fixing the alongshore distance by selecting data from a given range and analyzing the surveys along that range. The surveyed distance-elevation pairs along that range are used to obtain the interpolated position of equally spaced depths; e.g., -0.1, -0.2, and -0.3 on the hypothetical profile in Figure 4(a). These contour positions from each survey are then plotted against time (Fig. 4,b).

A horizontal line in Figure 4(b) represents no change in contour position. An upward-sloping line indicates landward movement of contour position (i.e., erosion); a downward-sloping line indicates deposition. The slope of a line indicates the horizontal rate of erosion or deposition at that elevation. The three x's at time t_2 (Fig. 4,b) indicate multiple contour positions at elevation -0.2 which is shown by the intersection of the dashline with profile t_2 in Figure 4(a).

Three types of contour movement plots included in this study are: (a) The seawardmost intercepts along one range for specified depths; (b) the seawardmost intercepts for one selected depth along all ranges; and (c) all contour intercepts including multiple intercepts along one



a. Profile Line

b. Movement of Contour Position

Figure 4. Interpretation of contour movement plots.

range, for up to 12 selected depths. The coordinate system used for the contour movement plots is shown in Figure 5.

The following elevations are referred to in the discussion that follows: 0.2 foot (6.1 centimeters), 0.3 foot (9.1 centimeters), 0.4 foot (12.2 centimeters), 0.5 foot (15.2 centimeters), 0.6 foot (18.3 centimeters), 0.7 foot (21.3 centimeters), 0.8 foot (24.4 centimeters), 0.9 foot (27.4 centimeters), 1.2 feet (36.6 centimeters), 1.4 feet (42.7 centimeters), and 2.1 feet (64.0 centimeters).

b. Profile Zones. Definitions of coastal engineering terms used in LEBS reports conform to Allen (1972) and the Shore Protection Manual (SPM) (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1975). For the profile zones in this study, the boundary between the foreshore and inshore zones is defined at elevation -0.2 foot.

The seaward edge of the inshore zone is defined as extending through the breaker zone. The boundary between the inshore and offshore zones for these experiments is at elevation -0.8 foot.

A definition sketch of the profile zones is shown in Figure 6. The profile in each experiment developed in a similar sequence. Early profiles (broken line in Fig. 6) had a steep foreshore, a short inshore zone with a longshore bar, and a gently sloping offshore zone. Later profiles (dashline in Fig. 6) also had a steep foreshore zone, but the inshore zone widened to a long, flat shelf which terminated in a relatively steep offshore zone. This development is shown by contour movement plots (Figs. 7 to 14) of the seawardmost contour intercepts for elevations at 0.1-foot-depth increments from +0.2 to -2.1 feet. Figures 7, 8, and 9 are for ranges 1, 3, and 5 in experiment 71Y-06; Figures 10 to 14 are for ranges 1, 3, 5, 7, and 9 in experiment 71Y-10. The heavier lines for the -0.2- and -0.8-foot contours distinguish the three profile zones in the figures. In the foreshore and offshore zones the contour lines are close together indicating steeper slopes; in the inshore zone the lines are spaced farther apart indicating flatter slopes.

(1) Foreshore Zone. Within the first hour of each experiment, the foreshore developed the basic shape which it maintained throughout experiment 71Y-10 and until the wave period was changed in experiment 71Y-06, as shown in the contour movement plots of the foreshore zone for the first 10 hours of experiments 71Y-06 (Fig. 15) and 71Y-10 (Fig. 16). The foreshore maintained basically the same shape (see Figs. 7 to 14) but retreated as material was eroded from the foreshore and backshore (upward-sloping lines in the figures).

Although the contour lines of the foreshore moved together, the lines were not always parallel, indicating a variation in foreshore slope with time at each range (Figs. 7 to 14). Table 9 gives slope values at the SWL intercept for the regularly surveyed profiles in experiments 71Y-06 and 71Y-10. The steepest slope was about 0.56, and the flattest slope was 0.08; the average slope was about 0.20.

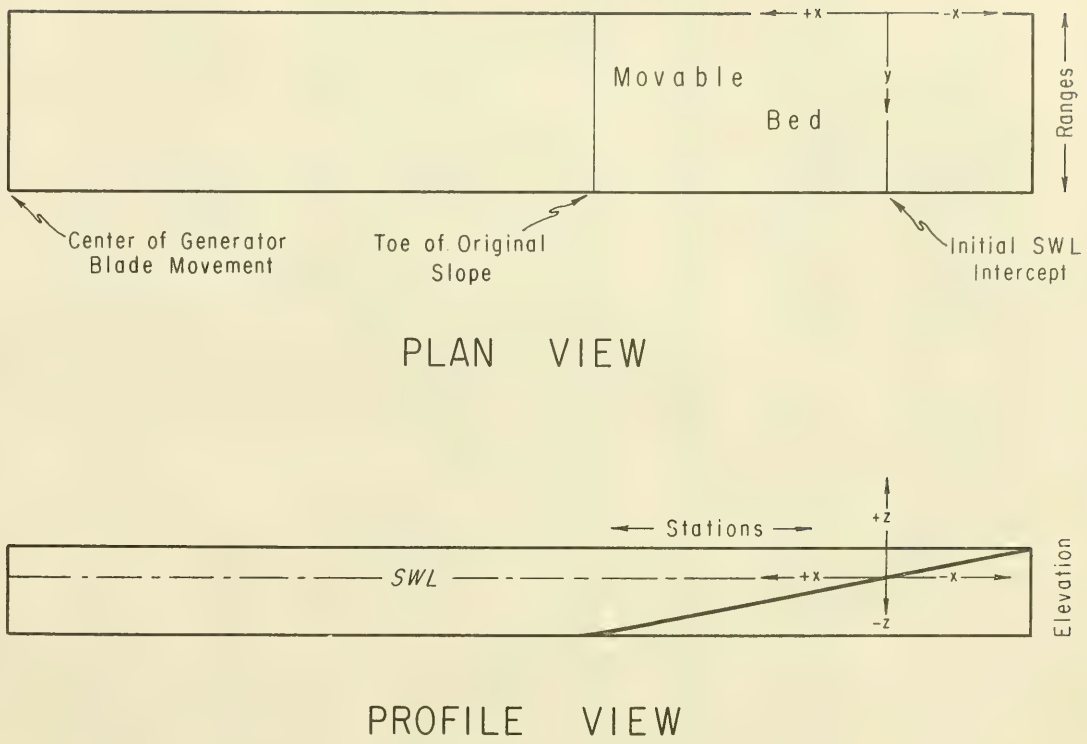


Figure 5. Definition of coordinate system.

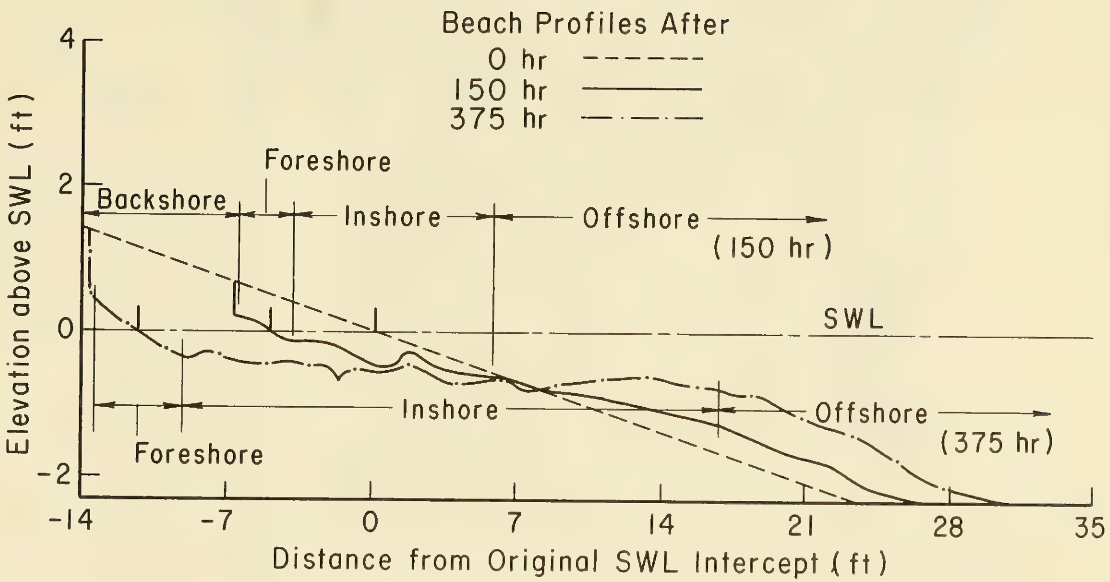


Figure 6. Definition sketch of profile zones (experiment 71Y-06).

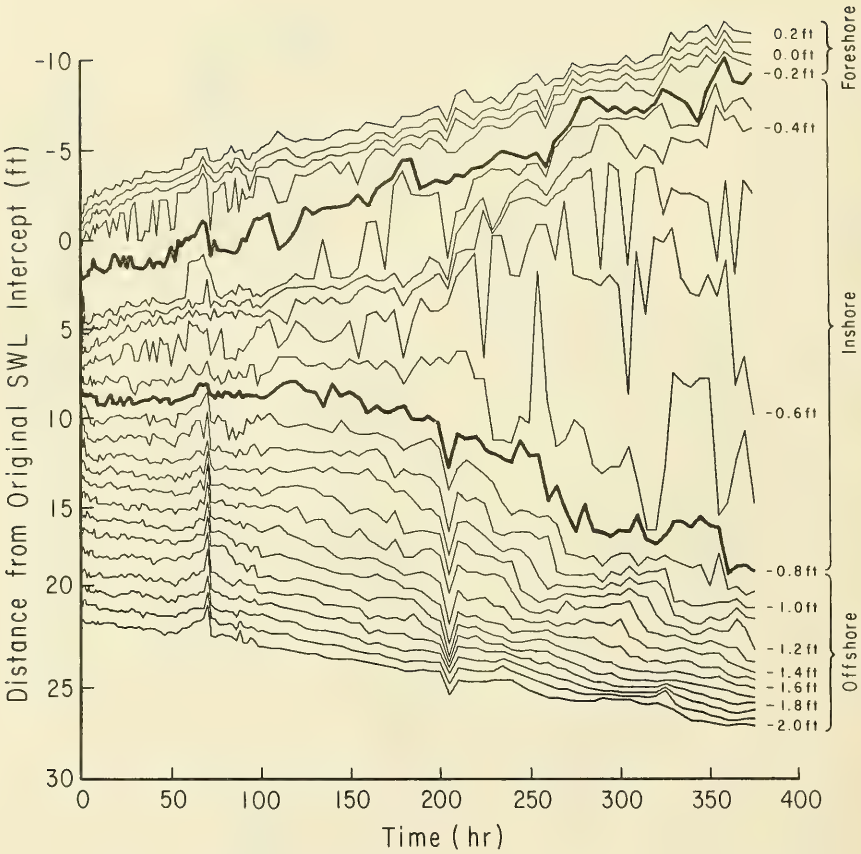


Figure 7. Profile changes along range 1, experiment 71Y-06.

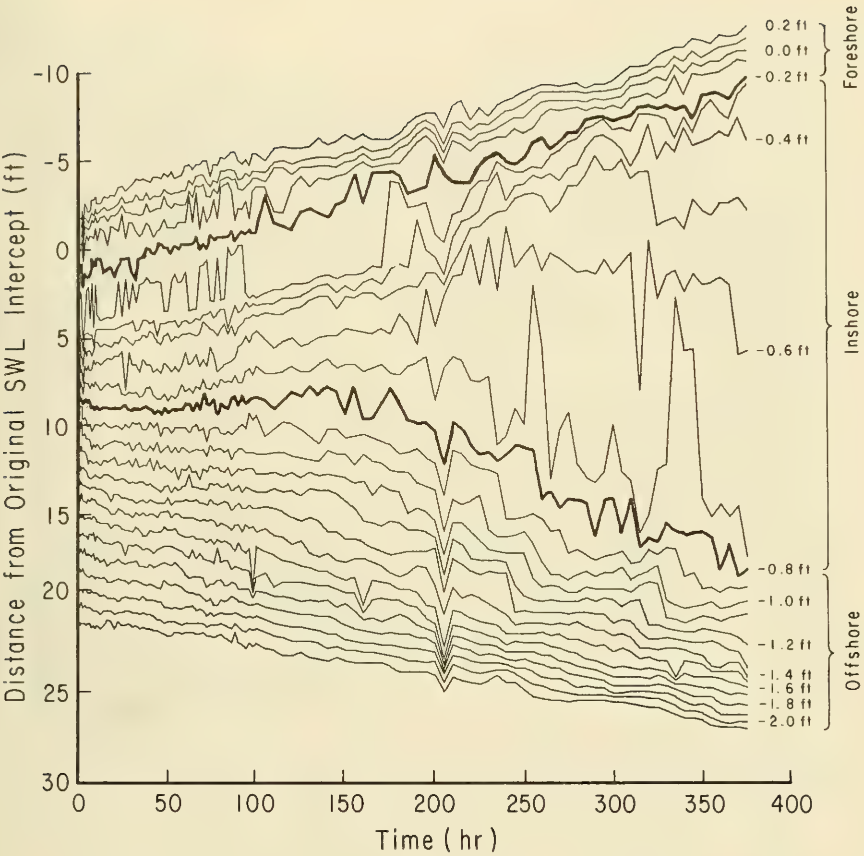


Figure 8. Profile changes along range 3, experiment 71Y-06.

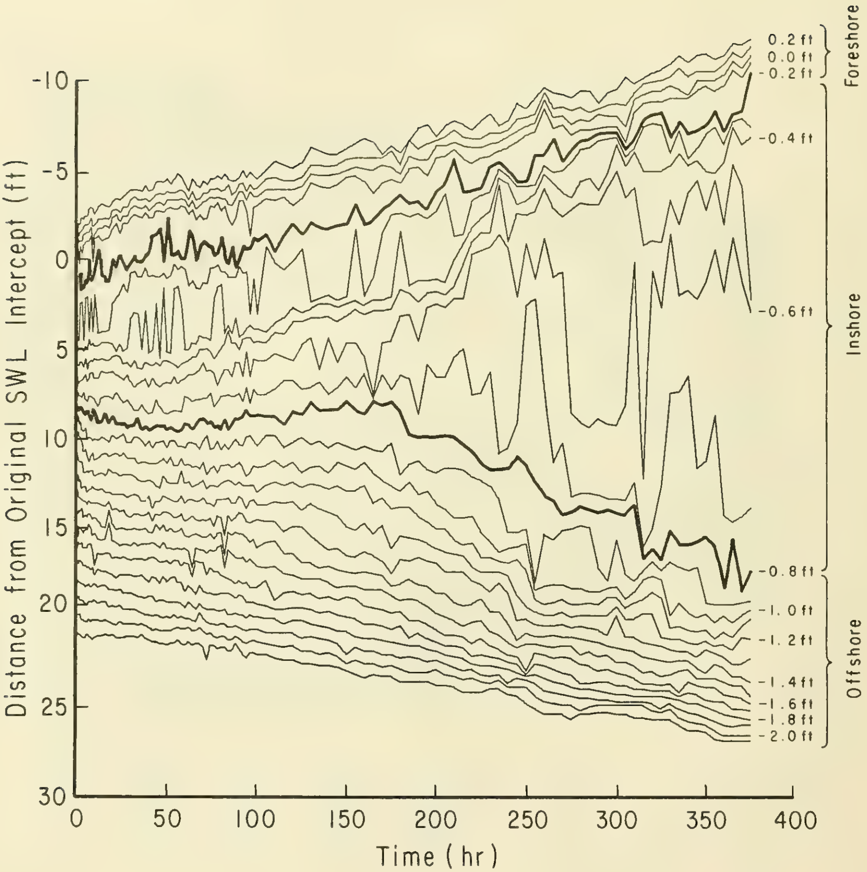


Figure 9. Profile changes along range 5, experiment 71Y-06.

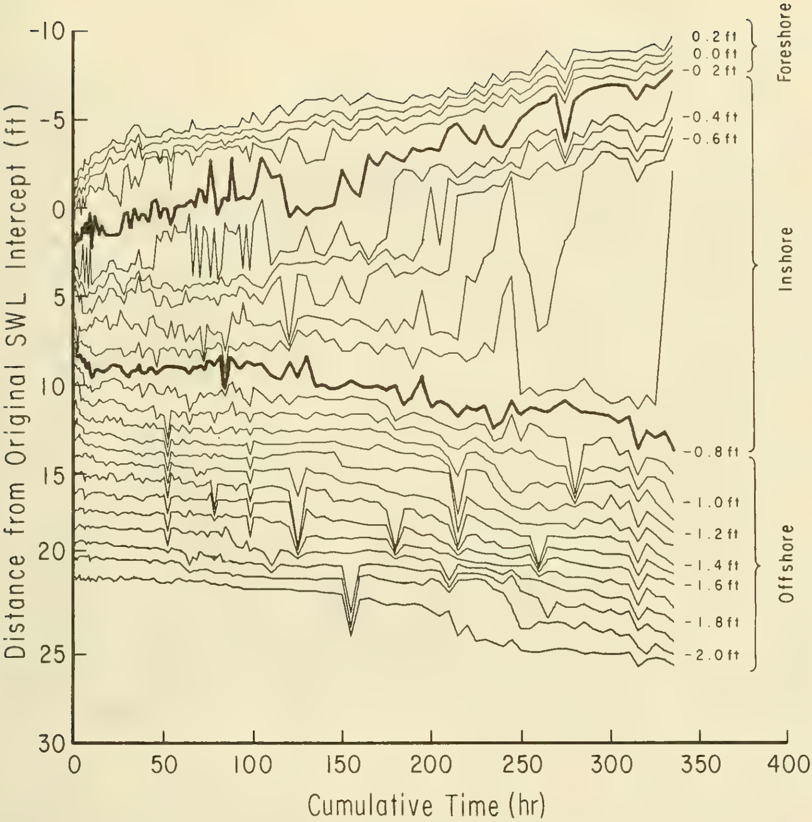


Figure 10. Profile changes along range 1, experiment 71Y-10.

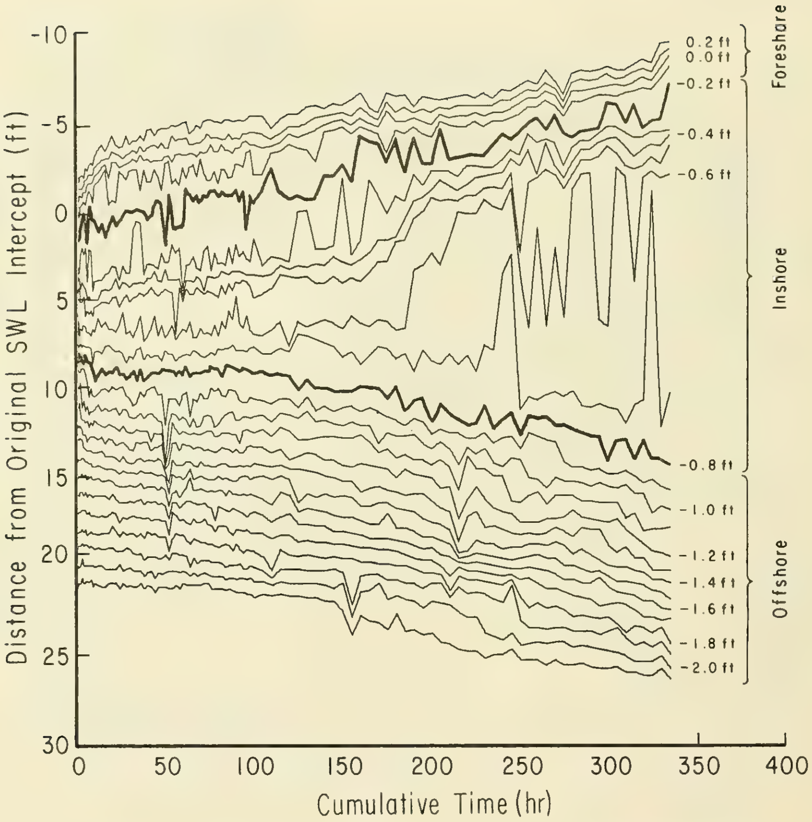


Figure 11. Profile changes along range 3, experiment 71Y-10.

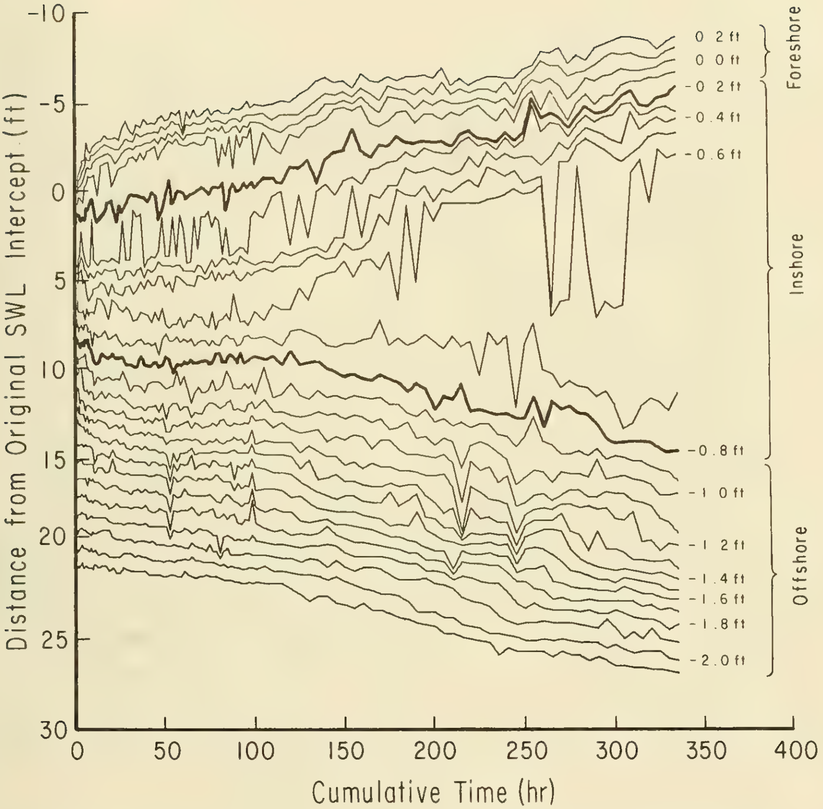


Figure 12. Profile changes along range 5, experiment 71Y-10.

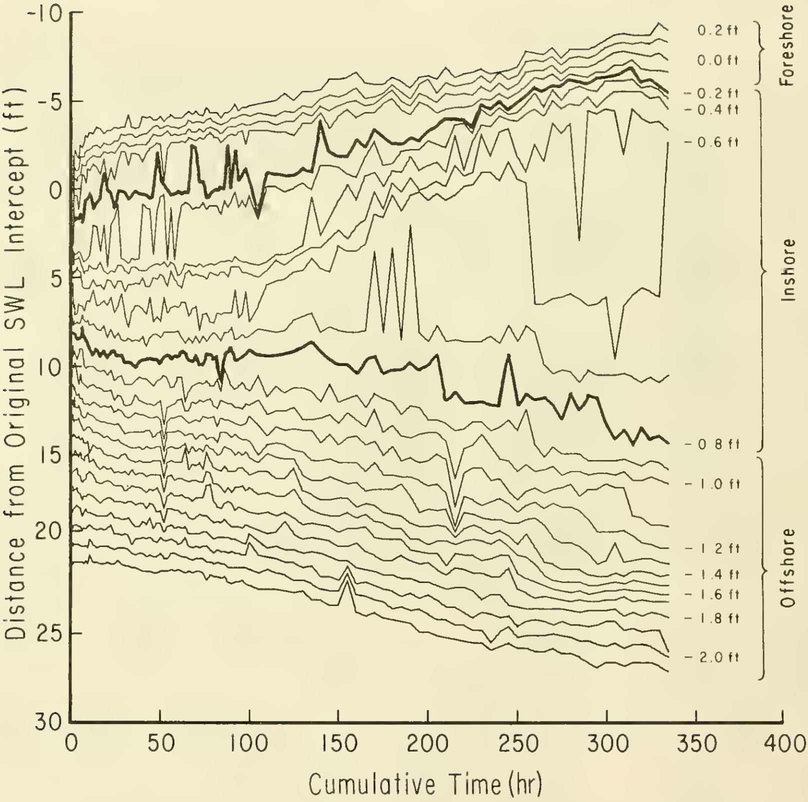


Figure 13. Profile changes along range 7, experiment 71Y-10.

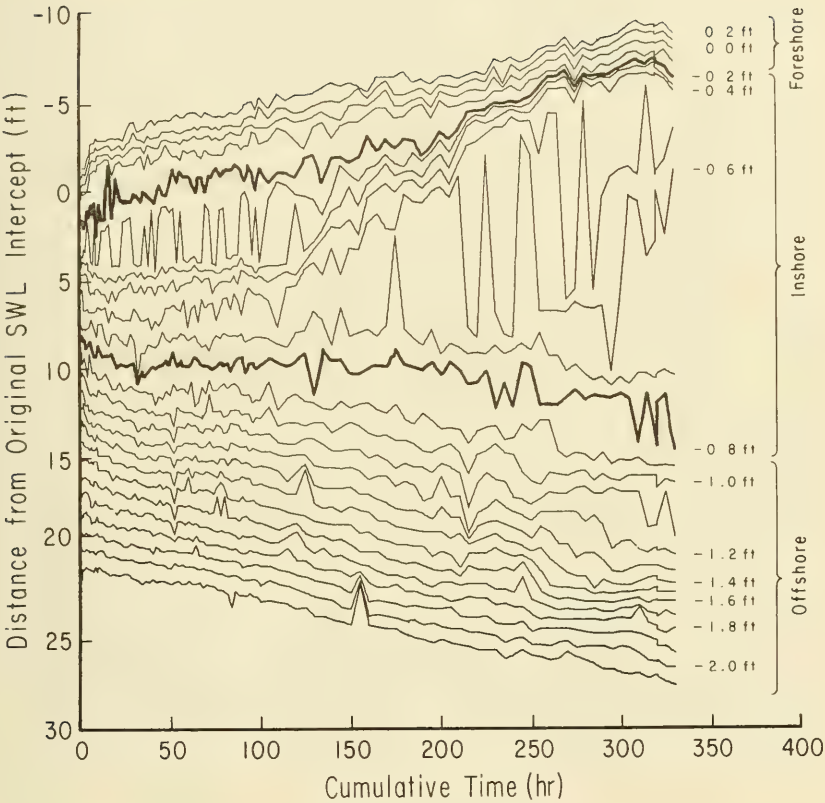


Figure 14. Profile changes along range 9, experiment 71Y-10.

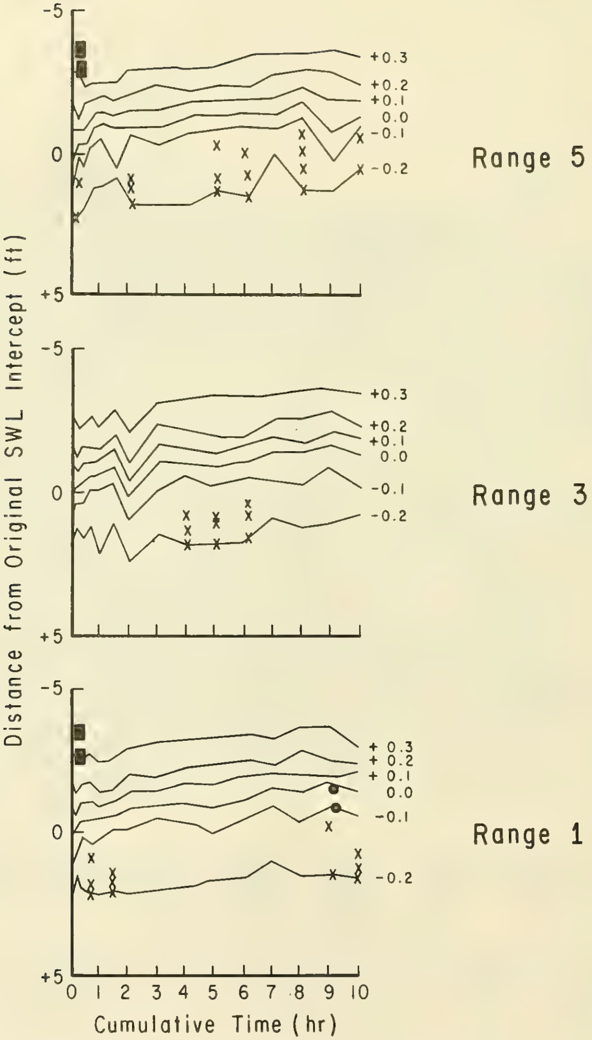


Figure 15. Comparison of initial contour movement on the foreshore zone in experiment 71Y-06.

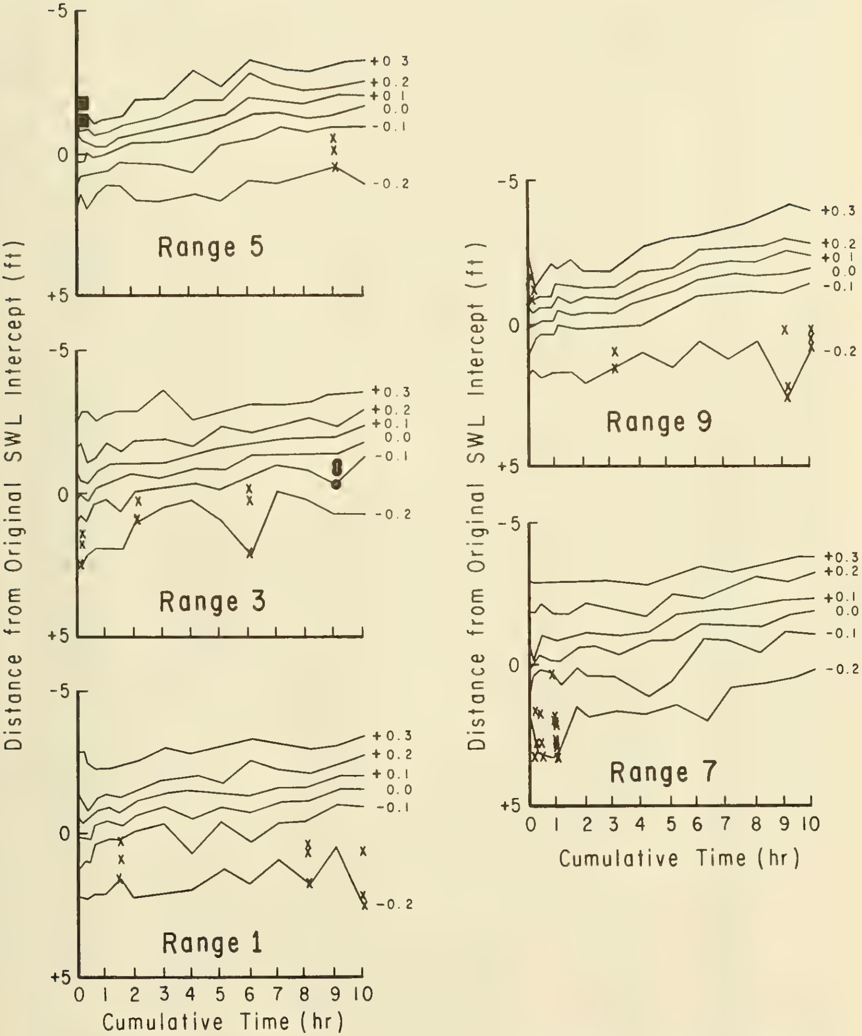


Figure 16. Comparison of initial contour movement on the foreshore zone in experiment 71Y-10.

Table 9. Slope of the beach face at the SWL intercept in experiments 71Y-06 and 71Y-10.

Cumulative time (hr)	Tangent of the slope							
	Range 1		Range 3		Range 5		Range 7	Range 9
	71Y-06	71Y-10	71Y-06	71Y-10	76Y-06	71Y-10	71Y-10	71Y-10
0:00	0.12	0.08	0.08	0.10	0.10	0.06	0.08	0.08
0:10	0.20	0.20	0.18	0.20	0.22	0.20	0.44	0.18
0:25	0.24	0.20	0.12	0.18	0.20	0.18	0.12	0.18
0:40	0.22	0.20	0.20	0.20	0.20	0.24	0.18	0.18
1:00	0.24	0.20	0.22	0.22	0.20	0.20	0.22	0.18
1:30	0.16	0.20	0.16	0.18	0.20	0.22	0.24	0.20
2:00	0.16	0.22	0.22	0.24	0.20	0.18	0.14	0.18
3:00	0.24	0.20	0.22	0.22	0.18	0.14	0.14	0.20
4:00	0.18	0.14	0.20	0.22	0.18	0.18	0.20	0.18
5:00	0.12	0.20	0.22	0.16	0.18	0.22	0.14	0.16
6:00	0.20	0.14	0.22	0.20	0.24	0.16	0.24	0.18
7:00	0.24	0.20	0.24	0.24	0.20	0.22	0.20	0.20
8:00	0.14	0.20	0.22	0.20	0.20	0.20	0.16	0.18
9:00	0.44	0.16	0.24	0.24	-------[1]	0.14	0.18	0.12
10:00	0.14	0.20	0.16	0.20	0.34	0.20	0.20	0.22
12:00	0.20	0.18	0.24	0.20	0.22	0.26	0.22	0.26
14:00	0.20	0.18	0.20	0.26	0.20	0.20	0.14	0.20
16:00	0.14	0.14	0.14	0.32	0.20	0.16	0.22	0.16
18:00	0.22	0.20	0.26	0.10	0.18	0.20	0.20	0.18
20:00	0.10	0.22	0.20	0.16	0.18	0.22	0.22	0.26
22:00	0.22	0.20	0.22	0.18	0.24	0.14	0.24	0.22
24:00	0.16	0.20	0.24	0.48	0.20	0.16	0.14	0.22
26:00	0.28	0.22	0.14	0.20	0.24	0.20	0.20	0.20
28:00	0.20	0.22	0.14	0.20	0.26	0.18	0.20	0.16
30:00	0.28	0.14	0.12	0.18	0.20	0.20	0.20	0.10
32:00	0.14	0.18	0.14	0.18	0.20	0.26	0.12	0.18
34:00	0.18	0.14	0.14	0.22	0.22	0.20	0.26	0.26
36:00	0.16	0.28	0.12	0.20	0.22	0.20	0.24	0.16
38:00	0.20	0.18	0.16	0.20	0.26	0.22	0.24	0.20
40:00	0.20	0.32	0.12	0.16	0.20	0.20	0.18	0.26
42:00	0.30	0.28	0.12	0.14	0.16	0.26	0.18	0.16
44:00	0.18	0.20	0.22	0.14	0.24	0.30	0.20	0.18
46:00	0.18	0.22	0.14	0.18	0.20	0.18	0.26	0.20
48:00	0.18	0.54	0.24	0.12	0.18	0.14	0.30	0.36
50:00	0.28	0.22	0.08	0.24	0.18	0.32	0.24	0.20
52:00	0.22	0.26	0.12	0.24	0.28	0.26	0.26	0.10
54:00	0.24	0.20	0.16	0.10	0.18	0.16	0.28	0.18
56:00	0.20	0.20	0.12	0.14	0.18	0.30	0.36	0.16
58:00	0.20	0.26	0.16	0.16	0.24	0.18	0.26	0.22
60:00	0.20	0.12	0.12	0.12	0.26	0.32	0.28	0.22
62:00	0.16	0.32	0.18	0.12	0.24	0.18	0.28	0.16

[1]Suspect data.

Table 9. Slope of the beach face at the SWL intercept in experiments 71Y-06 and 71Y-10.—Continued

Cumulative time (hr)	Tangent of the slope							
	Range 1		Range 3		Range 5		Range 7	Range 9
	71Y-06	71Y-10	71Y-06	71Y-10	71Y-06	71Y-10	71Y-10	71Y-10
64:00	0.24	0.26	0.12	0.18	0.12	0.22	0.22	0.20
66:00	0.22	0.16	0.24	0.22	0.18	0.20	0.20	0.16
68:00	0.24	0.46	0.22	0.12	0.24	0.24	0.16	0.18
70:00	0.24	0.18	0.22	0.20	0.24	0.14	0.16	0.18
72:00	0.18	0.26	0.14	0.14	0.20	0.12	0.20	0.20
74:00	0.18	0.20	0.18	0.12	0.24	0.18	0.20	0.16
76:00	0.20	0.26	0.20	0.28	0.20	0.26	0.26	0.18
78:00	0.26	0.26	0.14	0.14	0.22	0.24	0.18	0.14
80:00	0.20	0.26	0.26	0.12	0.16	0.18	0.22	0.24
82:00	0.16	0.18	0.26	0.38	0.24	0.44	0.20	0.18
84:00	0.52	0.50	0.30	0.12	0.40	0.16	0.22	0.20
86:00	0.20	0.24	0.14	0.12	0.16	0.42	0.22	0.24
88:00	0.32	0.34	0.30	0.10	0.20	0.18	0.22	0.18
90:00	0.20	0.24	0.20	0.14	0.24	0.22	0.22	0.20
92:00	0.20	0.26	0.14	0.16	0.18	0.16	0.20	0.24
94:00	0.36	0.18	0.10	0.22	0.24	0.20	0.18	0.20
96:00	0.16	0.22	0.26	0.14	0.32	0.14	0.12	0.18
98:00	0.28	0.20	0.22	0.16	0.28	0.28	0.16	0.22
100:00	0.22	0.28	0.26	0.16	0.18	0.36	0.22	0.18
105:00	0.14	0.16	0.22	0.14	0.22	0.22	0.14	0.20
110:00	0.22	0.22	0.20	0.24	0.18	0.22	0.24	0.28
115:00	0.32	0.10	0.30	0.20	0.26	0.10	0.20	0.18
120:00	0.18	0.20	0.20	0.24	0.20	0.18	0.20	0.20
125:00	0.22	0.24	0.24	0.16	0.20	0.16	0.24	0.20
130:00	0.20	0.22	0.14	0.20	0.22	0.18	0.22	0.16
135:00	0.24	0.24	0.24	0.14	0.20	0.12	0.24	0.20
140:00	0.20	0.14	0.20	0.20	0.18	0.14	0.20	0.10
145:00	0.20	0.16	0.20	0.20	0.22	0.38	0.38	0.32
150:00	0.22	0.12	0.20	0.26	0.18	0.20	0.24	0.22
155:00	0.18	0.20	0.22	0.20	0.20	0.26	0.24	0.08
160:00	0.20	0.20	0.20	0.18	0.18	0.18	0.14	0.24
165:00	0.24	0.18	0.18	0.26	0.14	0.12	0.24	0.16
170:00	0.24	0.22	0.24	0.24	0.12	0.14	0.24	0.18
175:00	0.18	0.18	0.24	0.22	0.28	0.18	0.44	0.20
180:00	0.20	0.20	0.28	0.16	0.18	0.16	0.32	0.16
185:00	0.16	0.22	0.20	0.14	0.12	0.14	0.20	0.18
190:00	0.18	0.22	0.22	0.32	0.18	0.14	0.20	0.22
195:00	0.18	0.24	0.20	0.18	0.10	0.14	0.20	0.14
200:00	0.14	0.16	0.12	0.18	0.14	0.20	0.56	0.24
205:00	0.22	0.24	0.20	0.20	0.20	0.14	0.18	0.14
210:00	0.18	0.22	0.18	0.22	0.10	0.22	0.12	0.18

Table 9. Slope of the beach face at the SWL intercept in experiments 71Y-06 and 71Y-10.—Continued

Cumulative time (hr)	Tangent of the slope							
	Range 1		Range 3		Range 5		Range 7	Range 9
	71Y-06	71Y-10	71Y-06	71Y-10	71Y-06	71Y-10	71Y-10	71Y-10
215:00	0.14	0.22	0.16	0.14	0.18	0.16	0.14	0.22
220:00	0.22	0.20	0.16	0.20	0.18	0.24	0.14	0.16
225:00	0.20	0.18	0.16	0.22	0.18	0.18	0.16	0.22
230:00	0.20	0.20	0.18	0.16	0.18	0.18	0.16	0.12
235:00	0.20	0.18	0.18	0.20	0.18	0.12	0.20	0.56
240:00	0.18	0.06	0.14	0.18	0.20	0.20	0.18	0.20
245:00	0.14	0.18	0.20	0.18	0.14	0.14	0.16	0.20
250:00	0.22	0.18	0.16	0.16	0.22	0.16	0.22	0.34
255:00	0.16	0.28	------[1]	0.18	0.16	0.20	0.16	0.18
260:00	0.18	0.20	0.12	0.18	0.28	0.10	0.20	0.18
265:00	0.22	0.16	0.16	0.20	0.22	0.18	0.18	------[1]
270:00	0.18	0.18	0.16	0.16	0.16	0.10	0.18	0.20
275:00	0.18	0.18	0.16	0.24	0.14	0.08	0.18	0.14
280:00	0.20	0.20	0.20	0.18	0.18	0.08	0.24	0.24
285:00	0.14	0.20	0.22	0.14	0.16	0.20	0.12	0.18
290:00	0.20	0.20	0.24	0.22	0.44	0.10	0.20	0.20
295:00	0.14	0.22	0.18	0.24	0.18	0.10	0.20	0.20
300:00	0.18	0.16	0.30	0.18	0.18	0.10	0.10	0.18
305:00	0.18	0.16	0.16	0.30	0.08	0.16	0.16	0.18
310:00	0.16	0.16	0.20	0.24	0.26	0.14	0.18	0.16
315:00	0.14	0.22	0.18	0.14	0.16	0.16	0.24	0.14
320:00	0.16	0.22	0.12	0.20	0.20	0.16	0.14	0.14
325:00	0.16	0.14	0.16	0.18	0.18	0.16	0.12	0.18
330:00	0.16	0.26	0.16	0.16	0.14	0.20	0.14	0.18
335:00	0.16	0.26	0.16	0.28	0.08	0.16	0.16	0.20
340:00	0.16		0.16		0.40			
345:00	0.14		0.16		0.18			
350:00	0.18		0.22		0.22			
355:00	0.18		0.16		0.20			
360:00	0.16		0.18		0.18			
365:00	0.26		0.16		0.18			
370:00	------[1]		0.24		0.18			
375:00	0.14		0.16		0.20			
375:10	0.26		0.10		0.18			
375:40	0.12		0.14		0.16			
376:30	0.12		0.18		0.18			
378:00	0.12		0.12		0.18			
380:00	0.28		0.10		0.16			
Avg	0.20	0.21	0.18	0.19	0.20	0.19	0.21	0.19
Overall avg		0.20						

[1]Suspect data.

The lateral variation in the slope of the foreshore developed as a result of concentrations of backwash, which created gullies or flatter slopes. The flow of the wave uprush and backrush for the same wave conditions that shaped the foreshore is discussed in Volume II (Chesnutt and Stafford, 1977).

Near the end of experiment 71Y-10, the changes in the foreshore zone became more complex (Fig. 17). Erosion of the backshore was greatest along the outside ranges. A large concentration of backwash occurred along the center of the tank and at various times was skewed toward different sides of the tank. The steepest slopes were not perpendicular to the wave approach. A greater lateral variation occurred in the foreshore zone of the 10-foot tank than in the 6-foot tank.

The shoreline (0 contour) movement along the several ranges of the two experiments is compared in Figure 18. The slope of the 0 contour indicates the shoreline recession rate. Because the slope of the backshore was 0.10 (and not flat), the volume rate of erosion was not constant and increased at a rate proportional to the square of the shoreline recession rate. The lateral variations discussed previously are also shown in the top set of curves in Figure 18 for experiment 71Y-10. The rate of shoreline recession increased along the sides of the tank, as indicated by the widening of the family of curves, with range 5 on the bottom and ranges 1, 7, and 9 on the top.

During the first 15 hours the shoreline retreated 1.7 feet (0.52 meter) in experiment 71Y-06 and 2 feet (0.61 meter) in experiment 71Y-10. The average erosion rate in experiment 71Y-06 between 15 and 375 hours was 0.025 foot (0.76 centimeter) per hour. The rate along range 5 in experiment 71Y-10 between 15 and 335 hours was 0.016 foot (0.49 centimeter) per hour. At 205 hours the erosion rate along the outside ranges increased from 0.016 to 0.025 foot per hour.

(2) Inshore Zone. Within the first hour of each experiment, a longshore bar developed at the shoreward end of the inshore zone between elevations -0.2 and -0.5 foot. Later, but at different times, the bar disappeared, and the area between elevations -0.2 and -0.5 foot steepened, and a long, flat shelf developed between elevations -0.5 and -0.8 foot. The shelf continued to grow in length for the remainder of the experiments. Changes in the inshore zone are divided into an inner region (between elevations -0.2 and -0.5 foot) and an outer region (between -0.5 and -0.8 foot).

(a) Inner Region (Experiment 71Y-06). The movement of all contour intercepts in the inshore zone along the three ranges for experiment 71Y-06 is shown in Figures 19, 20, and 21; the movement of selected individual contours along the three ranges is compared in Figure 22.

During the first 10 minutes of testing a longshore bar formed at station +4. For the first 200 hours the bar crest elevation varied between -0.3 and -0.4 foot, and the bar moved in the shoreward direction at an

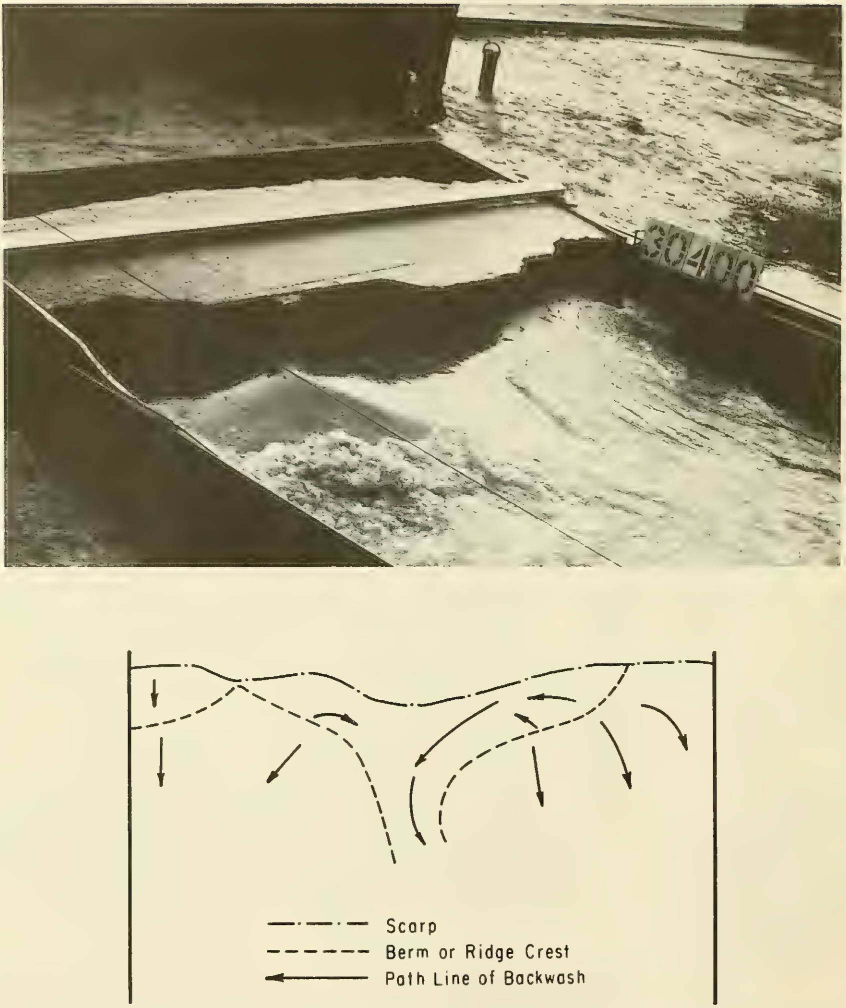


Figure 17. Shape of foreshore zone near end of experiment 71Y-10.

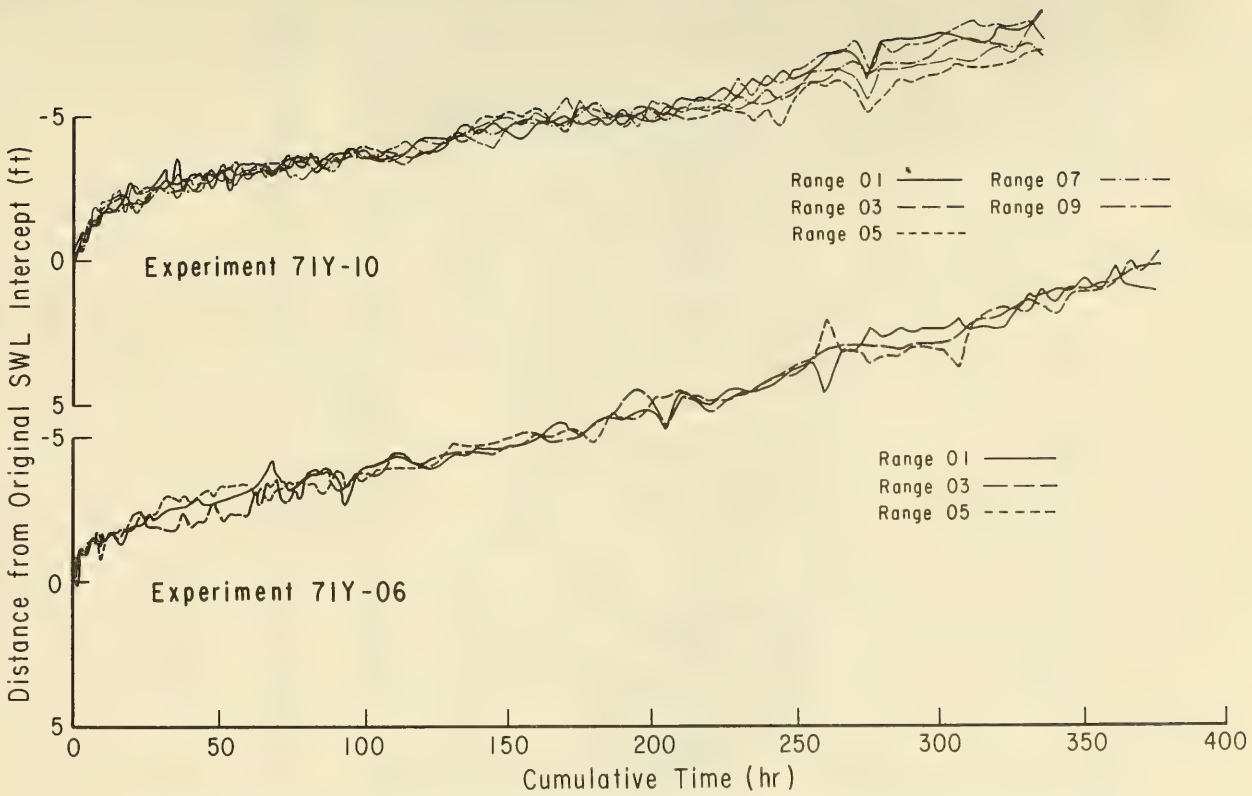


Figure 18. Comparison of the shoreline (0 contour) movement in experiments 71Y-06 and 71Y-10.

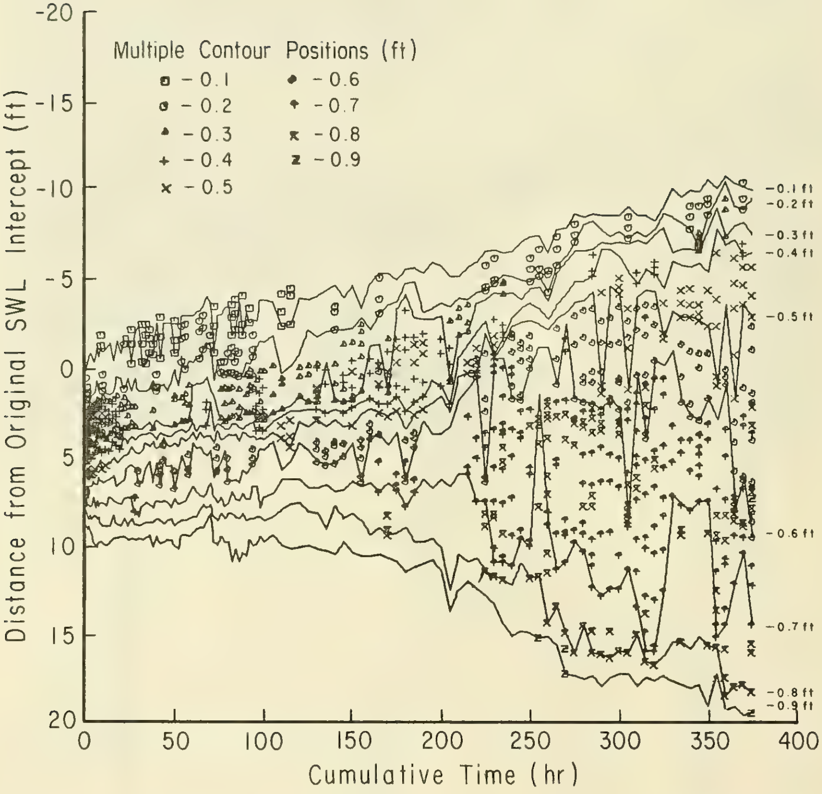


Figure 19. Changes in the inshore zone along range 1, experiment 71Y-06.

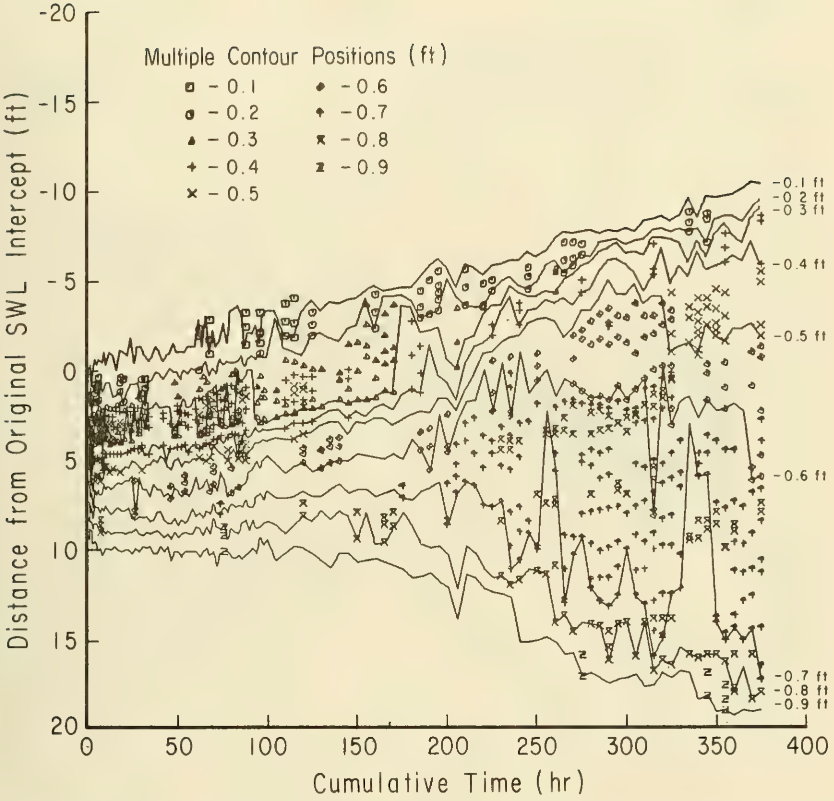


Figure 20. Changes in the inshore zone along range 3, experiment 71Y-06.

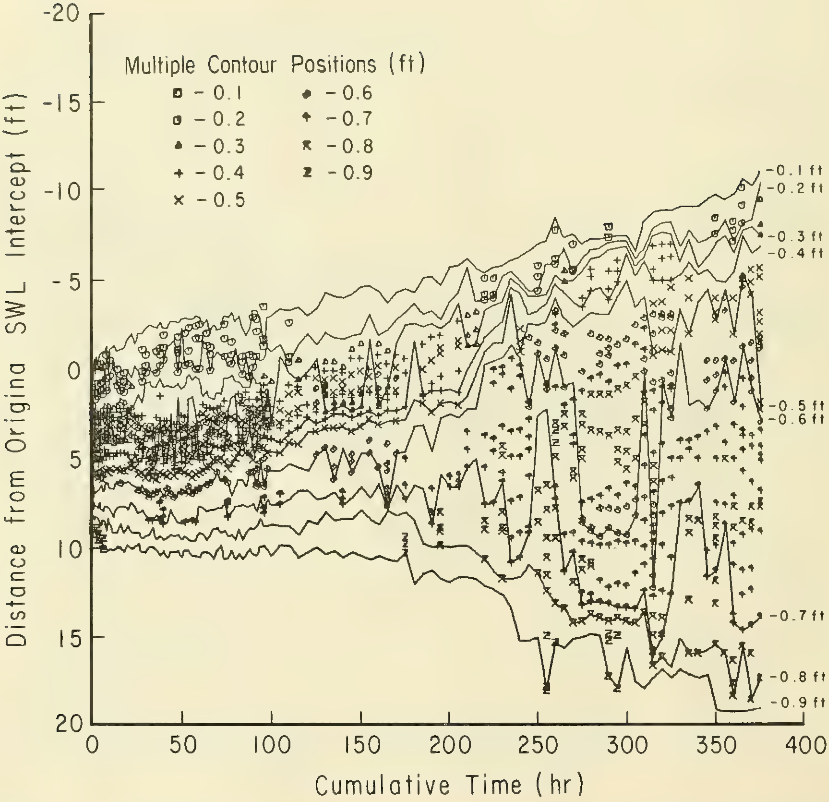


Figure 21. Changes in the inshore zone along range 5, experiment 71Y-06.

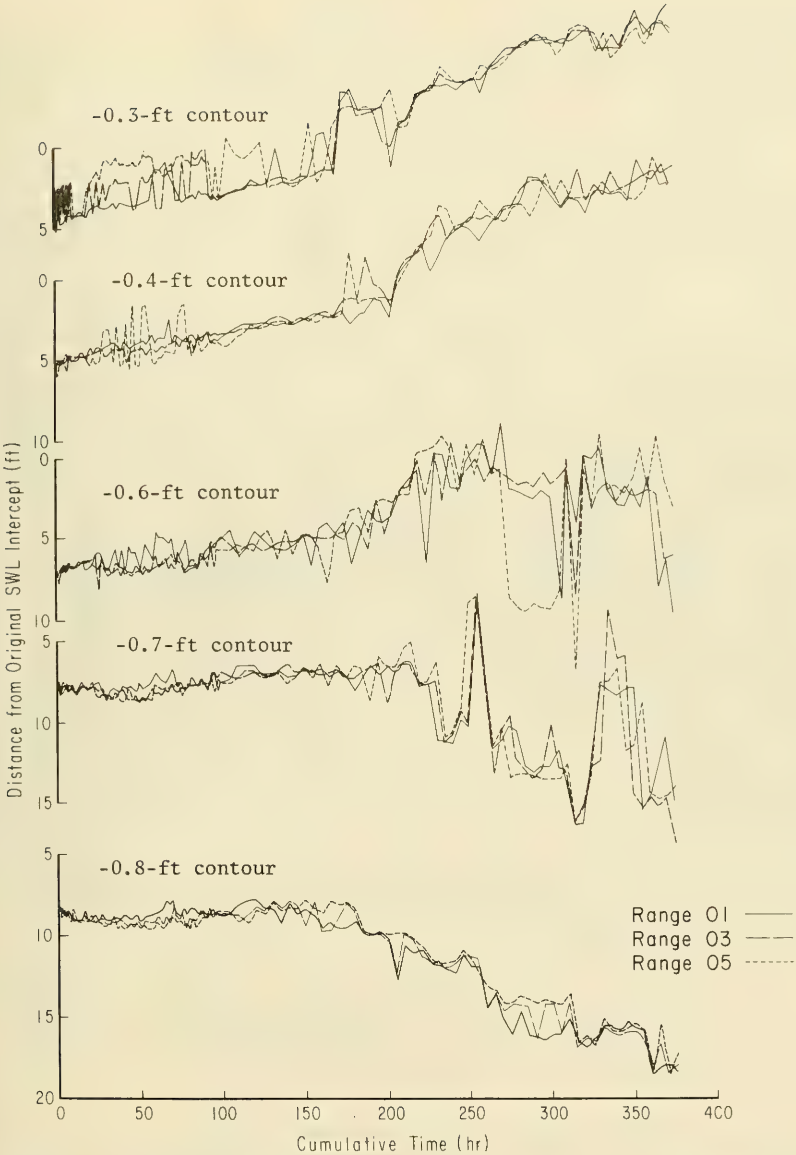


Figure 22. Comparison of the -0.3-, -0.4-, -0.6-, -0.7-, and -0.8-foot contour movements in experiment 71Y-06.

average rate of 0.018 foot (0.55 centimeter) per hour. After 205 hours the bar was eroded, as indicated by the shoreward movement of the -0.3-, -0.4-, and -0.5-foot contours in Figures 19, 20, and 21. The inner region maintained a fairly steep slope from 220 to 375 hours (shown by the close spacing of the -0.2-, -0.3-, -0.4-, and -0.5-foot contours in Figs. 19, 20, and 21).

The movements of the -0.3- and -0.4-foot contours along the three ranges are compared in Figure 22. No lateral variation apparently occurred in the changes of the inner region, other than minor differences in the bar crest elevation between 0 and 200 hours (see the different positions of the -0.3-foot contour in Fig. 22).

(b) Outer Region (Experiment 71Y-06). Although some deposition occurred during the first 2 hours which moved the -0.6-, -0.7-, and -0.8-foot contours 1 foot in the seaward direction, the outer region remained unchanged for 175 hours. After 175 hours the -0.7- and -0.8-foot contours began moving in the seaward direction as material was deposited at the seaward edge of the inshore zone, and the -0.6-foot contour began moving in the shoreward direction as erosion of the bar began in the inner region. After 200 hours the outer region became a long, relatively flat shelf, as shown by the divergence of the -0.8- and -0.5-foot contours. The several intercepts of the -0.6- and -0.7-foot contours indicate several small bars and troughs. Figure 23 shows the appropriate contour intercepts connected and the bars and troughs indicated by shaded areas.

The length of the shelf continued to increase as material eroded from the foreshore and was deposited offshore. The largest fluctuations in contour position were two temporary shifts of about 10 and 12 feet in the -0.7-foot contour position (Figs. 19, 20, and 21). The same shifts occurred simultaneously at all three surveyed ranges (Fig. 22), showing that this change was two-dimensional, and suggesting that significant net sand transport occurred across the inshore zone during these periods. The large shifts in the -0.7-foot contour represent an increase in the depth over the inshore zone.

The -0.6-, -0.7-, and -0.8-foot contours indicate no significant lateral variations (Fig. 22). The variations in the -0.6-foot contour show that the bar crest elevation reached -0.6 foot at different times along the different ranges.

(c) Inner Region (Experiment 71Y-10). Contour movement in the inshore zone along the five ranges for experiment 71Y-10 is shown in Figures 24 to 28. Movements of the seawardmost intercepts along ranges 1, 3, 5, 7, and 9 are compared at depths of -0.3, -0.4, -0.6, -0.7, and -0.8 foot in Figure 29.

Within the first 10 minutes a longshore bar formed at station +4. The bar remained stationary for the first 100 hours, while the crest elevation varied between -0.3 and -0.4 foot, as shown by the movement of the -0.3-foot contour in Figure 29. Erosion of the longshore bar began first along

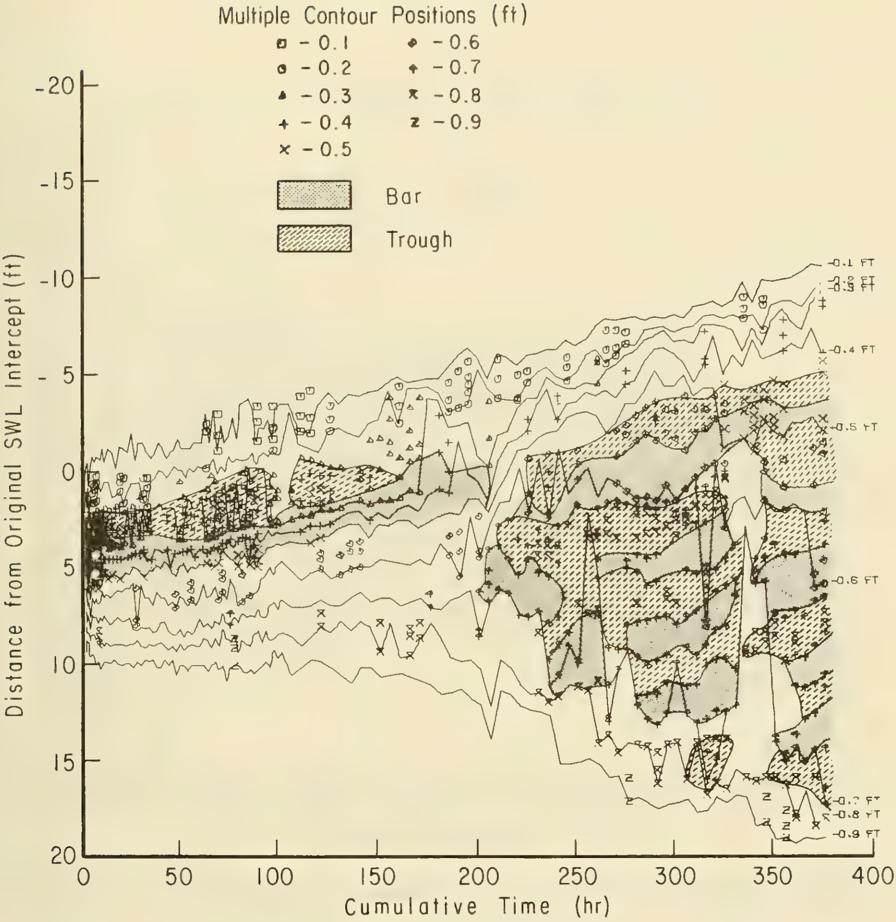


Figure 23. Movement of bars and troughs along range 3 in experiment 71Y-06.

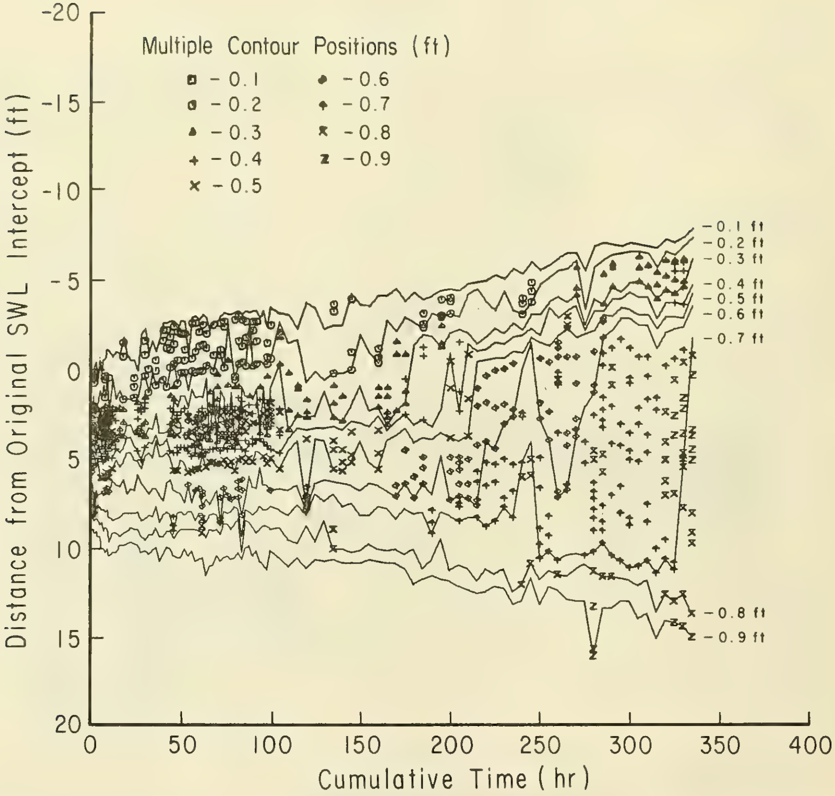


Figure 24. Changes in the inshore zone along range 1, experiment 71Y-10.

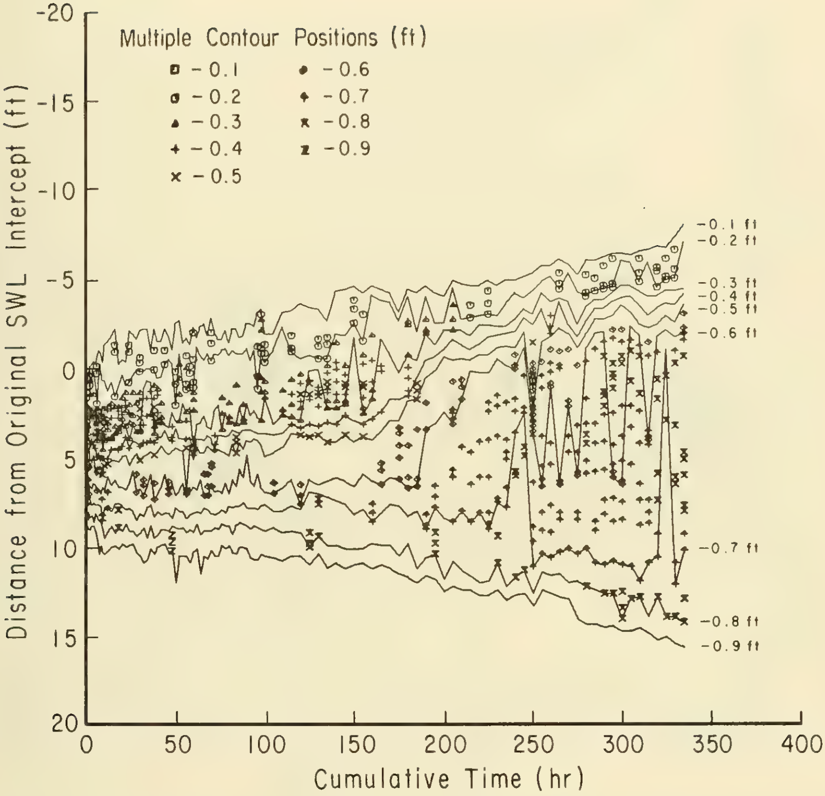


Figure 25. Changes in the inshore zone along range 3, experiment 71Y-10.

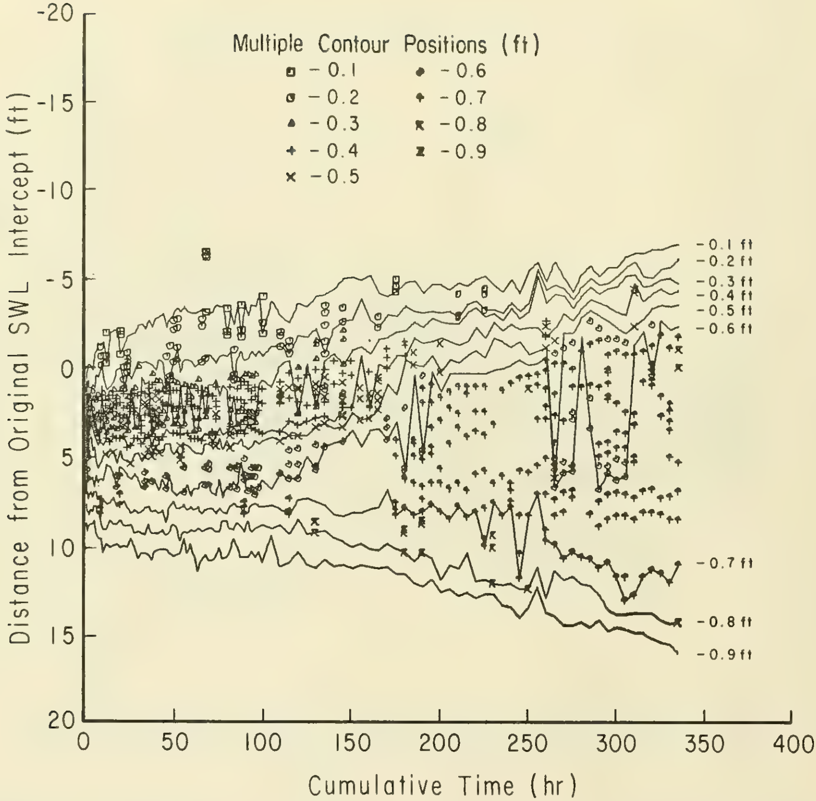


Figure 26. Changes in the inshore zone along range 5, experiment 71Y-10.

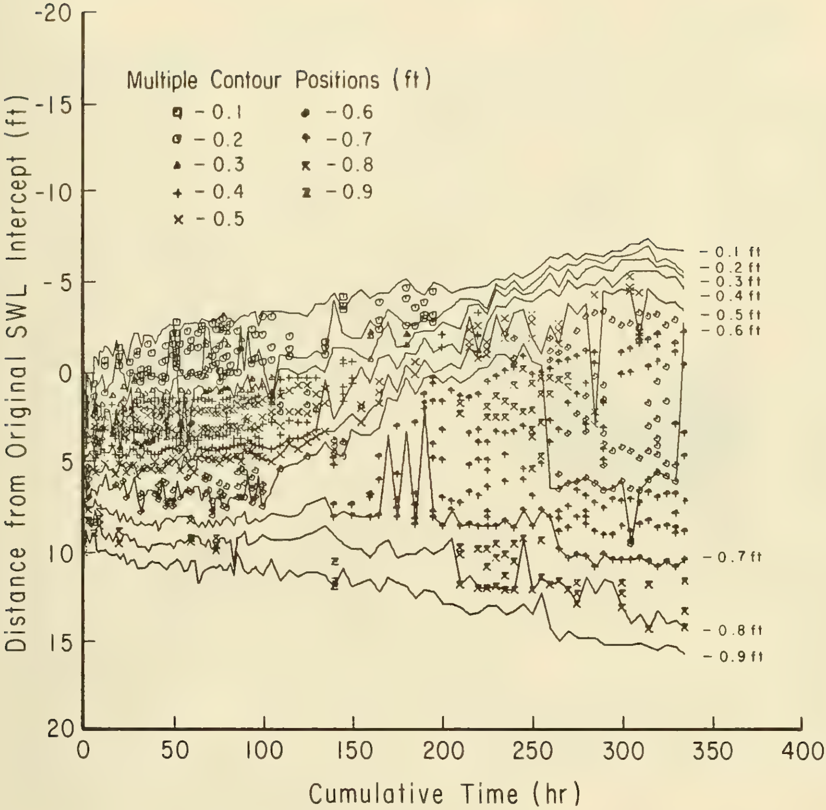


Figure 27. Changes in the inshore zone along range 7, experiment 71Y-10.

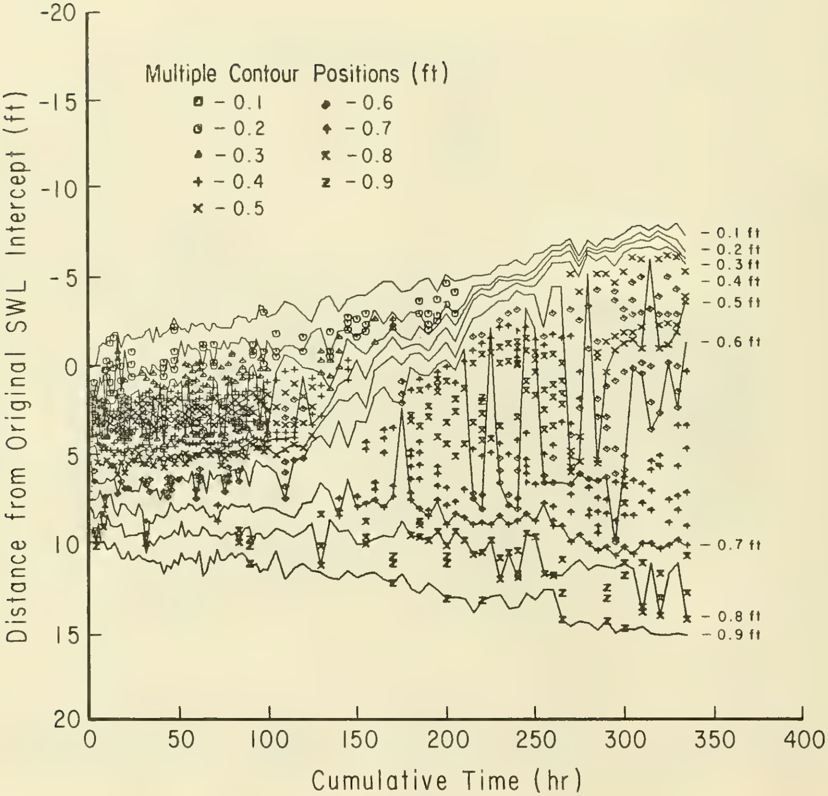


Figure 28. Changes in the inshore zone along range 9, experiment 71Y-10.

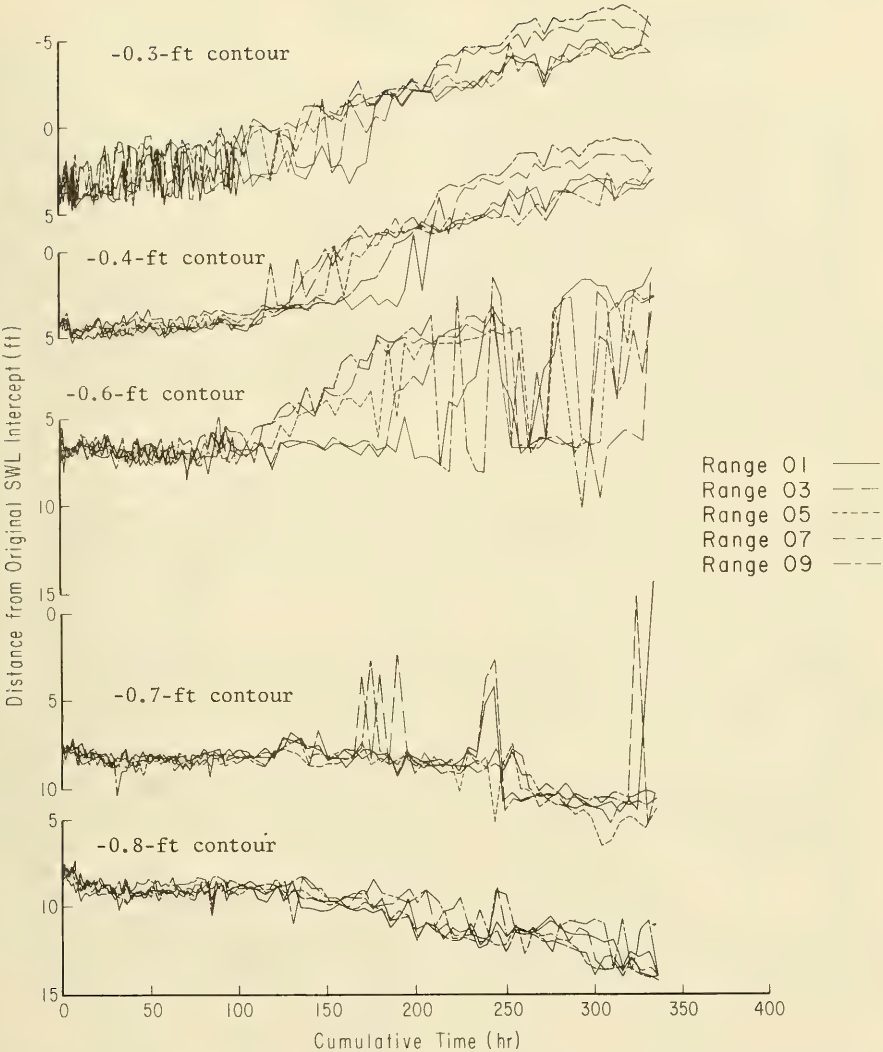


Figure 29. Comparison of the -0.3-, -0.4-, -0.6-, -0.7-, and 0.8-foot contour movements in experiment 71Y-10.

range 9 at 115 hours, advanced across the tank, and began along range 1 at 190 hours (shown by movement of the several -0.4-foot contours in Fig. 29). After the bar eroded, the inner region maintained a fairly steep slope for the duration of the experiment.

(d) Outer Region (Experiment 71Y-10). Although some deposition occurred during the first 5 hours which moved the -0.6-, -0.7-, and -0.8-foot contours 2 feet in the seaward direction, the outer region remained unchanged until after 100 hours. The development of the flat shelf in the outer region followed erosion of the longshore bar in the inner region, as indicated by the movement of the -0.6-foot contour along the five ranges in Figure 29. The shelf began developing first along range 9 at 115 hours and along range 1 at 215 hours. The shelf widened as material was eroded from the foreshore and deposited in the offshore. At different times along the five ranges, the seawardmost -0.7-foot contour made significant shifts, first along ranges 7 and 9 and later along ranges 1, 3, and 5. These shifts correlate with the progressive development of the shelf across the tank from range 9 to range 1 and indicate a net movement of sediment across the inshore zone.

(3) Offshore Zone.

(a) Experiment 71Y-06. The movement of contours in the offshore zone is shown in Figures 7, 8, and 9 for ranges 1, 3, and 5. The offshore zone developed from the initial 0.10 slope to a relatively steep slope as a result of the deposition of material seaward of the breaker.

During the first 10 hours, more deposition occurred at the higher elevations, but after that time, all the contour movements were parallel in the offshore zone until 200 hours. Between 200 and 250 hours and between 315 and 340 hours, significant deposition occurred again at the higher elevations, increasing the offshore zone slope.

The movement of contours at the three ranges for elevations of -0.9, -1.2, and -2.1 feet is compared in Figure 30. No lateral variations occurred in the movements of the -1.2- and -2.1-foot contours, and only minor variations in the movement of the -0.9-foot contour.

(b) Experiment 71Y-10. Figures 10 to 14 show the contour movements in the offshore zone for the five ranges in experiment 71Y-10. During the first 10 hours sediment was deposited between depths of 0.9 and 1.4 feet. After 10 hours the contours along a given range were parallel (indicating uniform deposition at all depths), but there was variation from one range to the next. Along range 9 the contours moved seaward at an average rate of 0.025 foot per hour. Along range 5 the offshore remained essentially stationary for the next 100 hours (until 110 hours) and then began prograding seaward at an average rate of 0.024 foot (0.73 centimeter) per hour; along range 1, the offshore remained stable until 170 hours and then prograded seaward at a rate of 0.019 foot (0.58 centimeter) per hour.

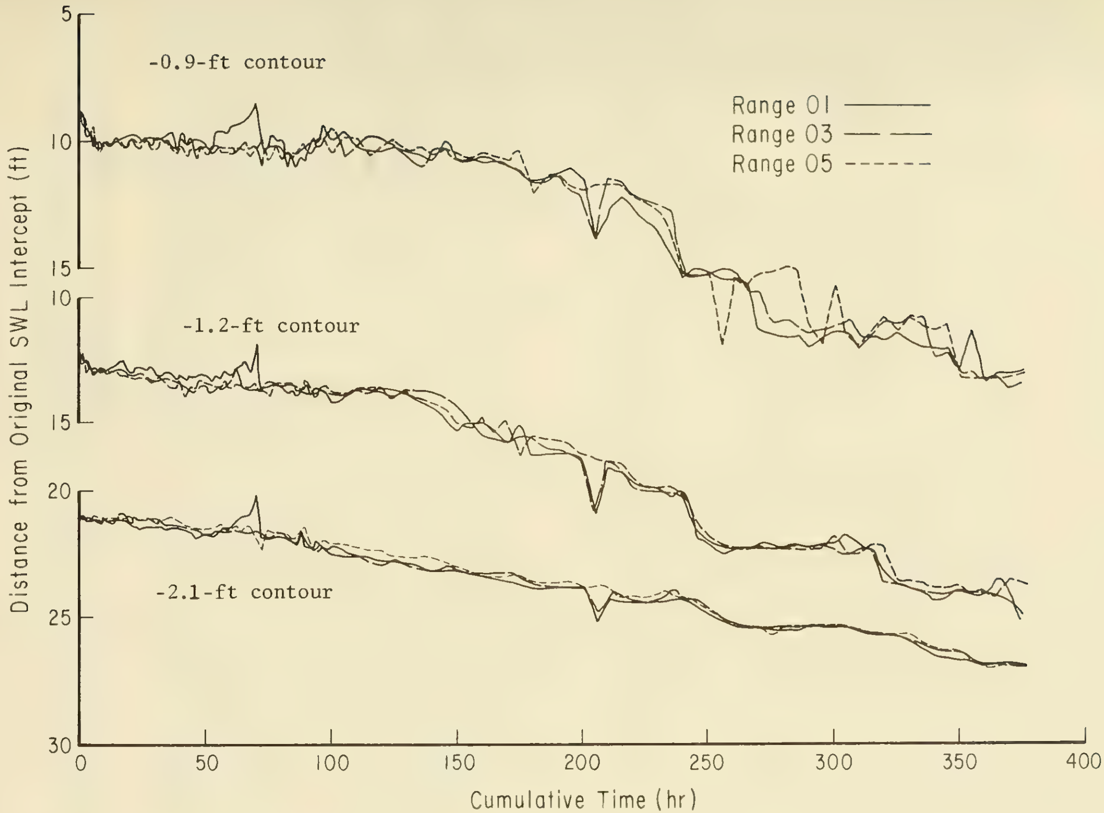


Figure 30. Comparison of the -0.9-, -1.2-, and -2.1-foot contour movements in experiment 71Y-06.

The movement of contours at the five ranges for elevations of -0.9, -1.2, and -2.1 feet is compared in Figure 31. The lateral variation in the movement of the offshore zone is quite noticeable at -1.2 and -2.1 feet; e.g., the positions of the -2.1-foot contour at 335 hours are stations 25.6, 26.3, 27.0, 27.2, and 27.5 feet along ranges 1, 3, 5, 7, and 9, respectively.

The offshore slope, measured between the -0.9- and -2.1-foot contours, varied from 0.113 along range 1 to 0.098 along range 9.

c. Profile Adjustment Under 3.75-Second Wave. For 375 hours, the profile in experiment 71Y-06 was attacked by a fairly steep (H_o/L_o = 0.021) wave. Then, for the next 5 hours, the profile was subjected to a low (H_o/L_o = 0.002) wave. As expected, this low wave moved sediment back toward the shoreline and onto the foreshore. The profiles along range 3 at the beginning and the end of this subexperiment are compared in Figure 32. The low wave flattened out the many small bars and troughs within the inshore zone and deposited material on the foreshore. Movement of the seawardmost contour intercepts during the 5-hour period is plotted in Figures 33, 34, and 35. These plots indicate deposition at elevations 0.2, 0.1, 0, -0.1, -0.2, and -0.5 foot, and erosion at elevations -0.3, -0.4, -0.6, -0.7, and -0.8 foot. A photo in Figure 36 shows deposition on the foreshore zone at 380 hours. After the experiment was stopped, a trench was dug along the middle of the test area. The light-toned sediment on top in the photo is the deposition during the 5 hours of long-period waves.

3. Sediment-Size Distribution.

The sand for these experiments was the same sand used by Savage (1959, 1962) and Fairchild (1970a, 1970b). Because the samples collected in this study were surface samples, and therefore subject to winnowing action, the median grain size may have been slightly less when Savage and Fairchild performed their tests. The data reported here are the Rapid Sediment Analyzer (RSA) values, which were generally 0.04 millimeter greater than that determined by the dry sieve method (see Vol. I). The RSA values are used here only because all the data were reduced by this method.

Tables 10 and 11 give the sediment-size analysis results from experiments 71Y-06 and 71Y-10. Sediment samples were collected along the profile before the beginning of experiment 71Y-06, and the results of the size analysis are given in Table 10. The average median grain size was 0.27 millimeter, which is assumed to represent the median grain size, d_{50}, for the unsorted sediment in both experiments.

a. Experiment 71Y-06. A summary of the median grain sizes for experiment 71Y-06, including the mean of the medians, range of values, and the number of samples within each profile zone for each time, is given in Table 12. The median grain size on the foreshore remained above 0.27 millimeter (with one exception). This value of 0.27 was the same as the mean of the medians of all samples from the beach at 0 hours. The increase

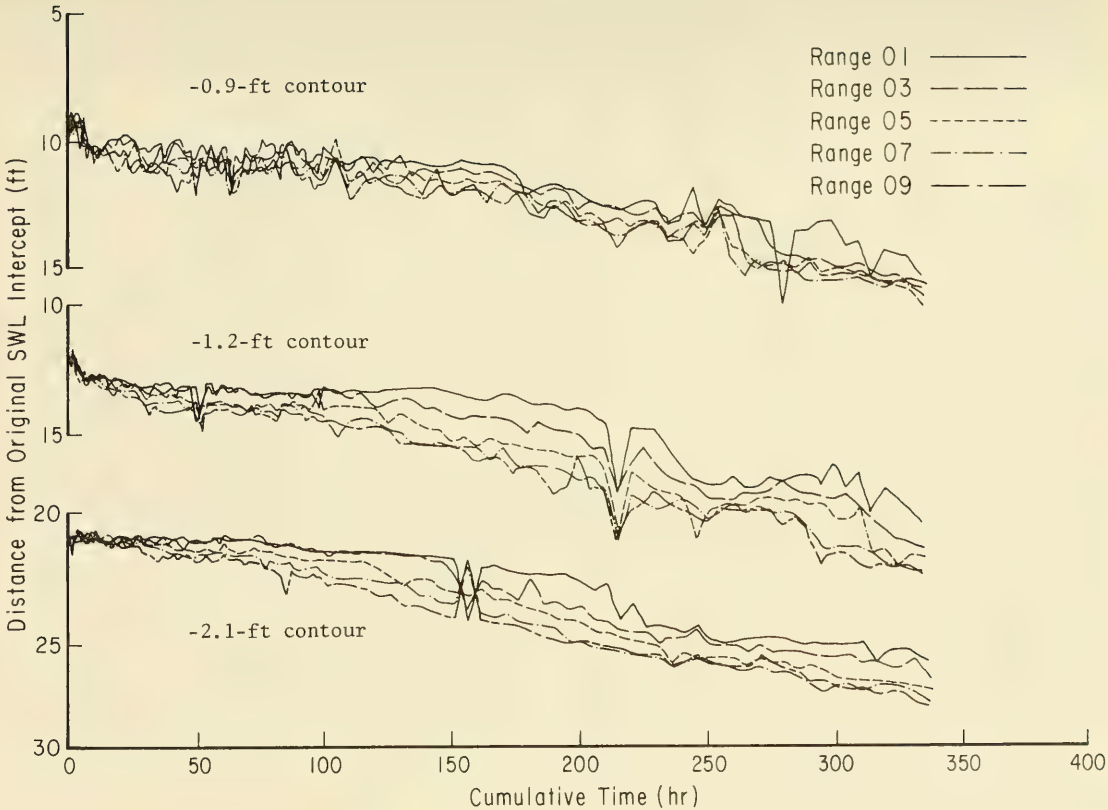


Figure 31. Comparison of the -0.9-, -1.2-, and -2.1-foot contour movements in experiment 71Y-10.

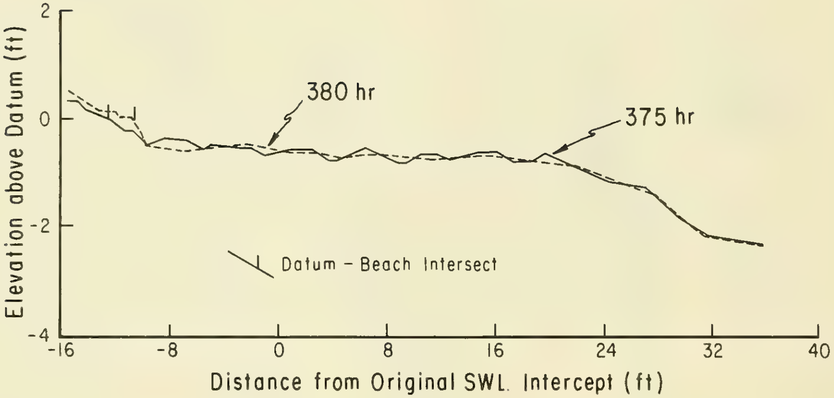


Figure 32. Comparison of profiles along range 3 at 375 and 380 hours in experiment 71Y-06.

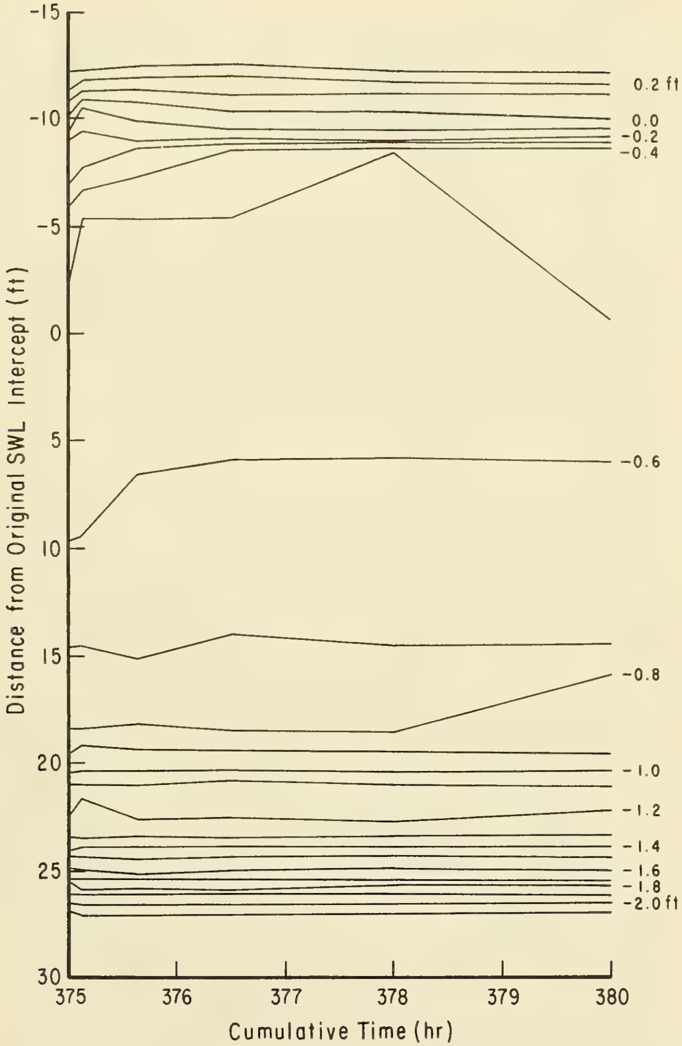


Figure 33. Profile changes along range 1 in experiment 71Y-06 between 375 and 380 hours.

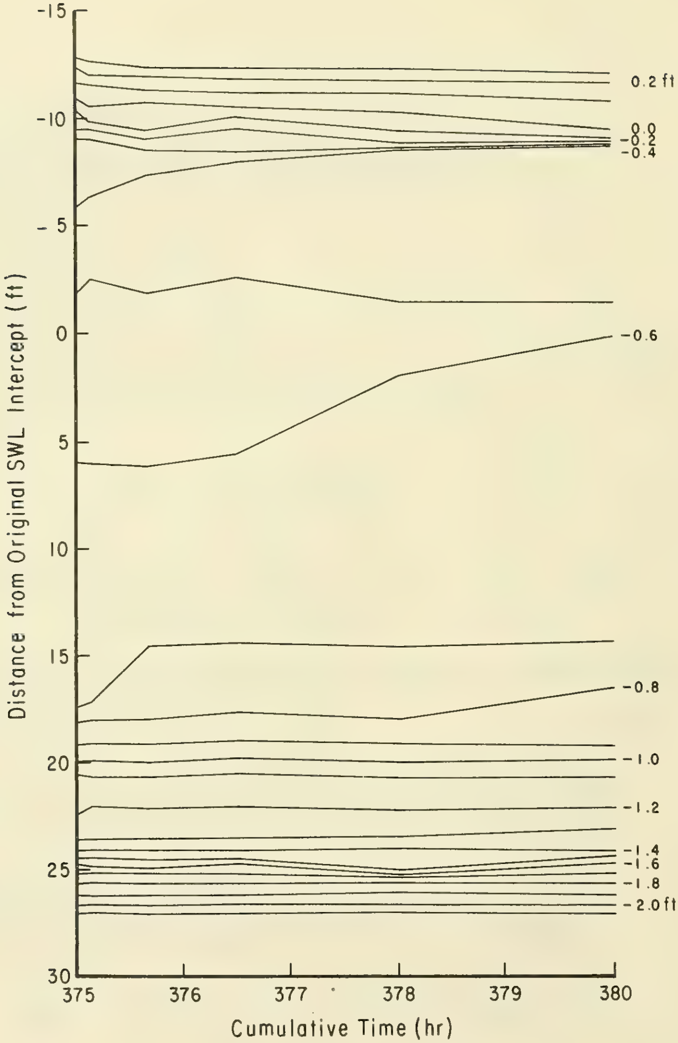


Figure 34. Profile changes along range 3 in experiment 71Y-06 between 375 and 380 hours.

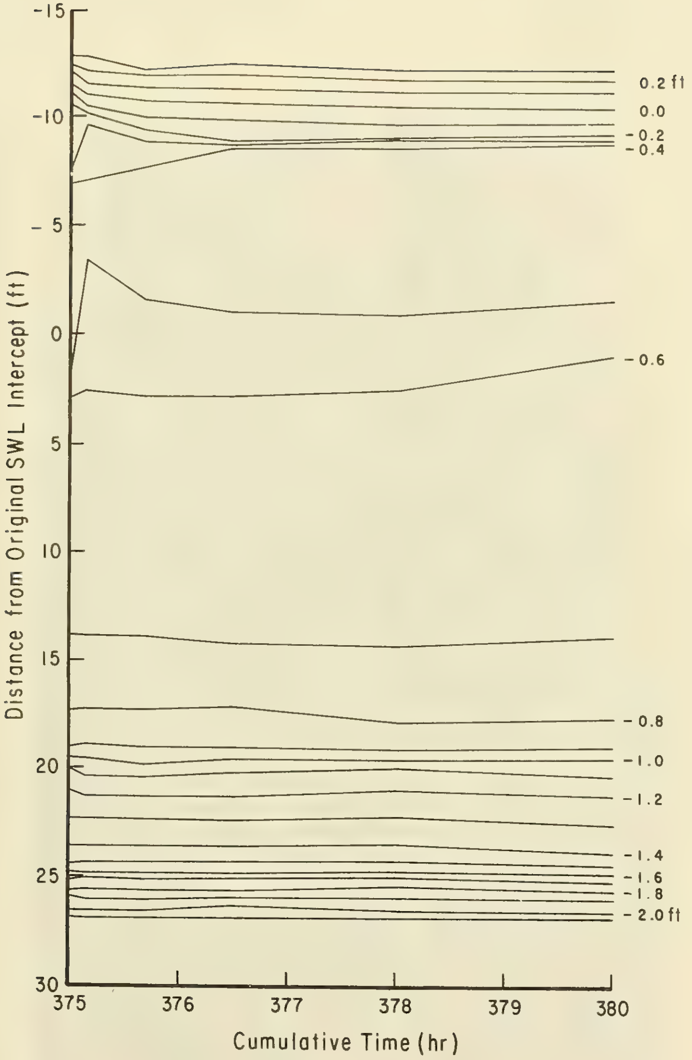


Figure 35. Profile changes along range 5 in experiment 71Y-06 between 375 and 380 hours.

Figure 36. Long wave deposition on foreshore between 375 and 380 hours in experiment 71Y-06.

Table 10. Sediment-size analysis at various hours for experiment 71Y-06.

Station	Range 2			Range 4		
	Elevation (ft)	Median (mm)	Median (phi)	Elevation (ft)	Median (mm)	Median (phi)
0 Hr						
–6	0.30	0.28	1.84	0.30	0.27	1.87
–4	0.30	0.26	1.99	0.30	0.26	1.93
–2	0.20	0.26	1.96	0.20	0.28	1.84
0	–0.10	0.26	1.94	–0.10	0.26	1.95
2	–0.20	0.26	1.92	–0.20	0.26	1.93
4	–0.30	0.25	1.99	–0.30	0.27	1.92
6	–0.45	0.26	1.94	–0.45	0.25	2.03
8	–0.70	0.26	1.93	–0.70	0.27	1.90
10	–1.00	0.27	1.92	–1.00	0.28	1.83
12	–1.15	0.26	1.97	–1.15	0.26	1.95
14	–1.30	0.27	1.87	–1.30	0.26	1.94
16	–1.60	0.26	1.97	–1.60	0.28	1.91
18	–1.75	0.26	1.94	–1.75	0.28	1.90
20	–2.00	0.27	1.87	–2.00	0.28	1.84
22	–2.33	0.26	1.94	–2.33	0.28	1.82
26 Hr						
–6	0.30	0.28	1.84	0.30	0.24	2.08
–4	0.30	0.29	1.76	0.30	0.28	1.86
–2	0.00	0.31	1.71	0.05	0.32	1.67
0	–0.20	0.29	1.77	–0.10	0.31	1.71
2	–0.28	0.28	1.83	–0.32	0.27	1.88
4	-0.40	0.30	1.73	–0.60	0.30	1.75
6	–0.60	0.27	1.91	–0.50	0.29	1.81
8	–0.75	0.26	1.95	–0.70	0.28	1.86
10	–0.90	0.25	2.02	–0.90	0.25	2.00
12	–1.15	0.24	2.07	–1.08	0.25	1.99
14	–1.40	0.24	2.07	---------[1]	-------	-------
16	–1.60	0.24	2.05	–1.50	0.23	2.10
18	–1.75	0.24	2.08	–1.75	0.24	2.05
20	–2.00	0.24	2.05	–1.95	0.23	2.11
22	–2.33	0.25	2.02	–2.33	0.26	1.93
24	–2.33	0.30	1.75	–2.33	0.27	1.90

[1] Samples not collected at these stations.

Table 10. Sediment-size analysis at various hours for experiment 71Y-06.—Continued

Station	Range 2			Range 4		
	Elevation (ft)	Median (mm)	Median (phi)	Elevation (ft)	Median (mm)	Median (phi)
			50 Hr			
–7	0.30	0.27	1.87	0.30	0.26	1.92
–5	0.30	0.26	1.97	0.30	0.35	1.54
–3	0.10	0.28	1.83	0.00	0.31	1.69
–1	–0.10	0.31	1.69	–0.10	0.31	1.71
1	–0.15	0.30	1.75	–0.30	0.30	1.73
3	–0.30	0.29	1.79	–0.50	0.30	1.76
5	–0.55	0.28	1.85	–0.50	0.29	1.77
7	–0.60	0.28	1.85	–0.65	0.29	1.77
9	–0.85	0.26	1.96	–0.75	0.29	1.80
11	–0.95	0.25	1.98	–0.95	0.27	1.90
13	–1.18	0.25	2.00	–1.15	0.24	2.08
15	–1.40	0.24	2.04	–1.37	0.26	1.97
17	–1.65	0.23	2.12	–1.60	0.24	2.07
19	–1.80	0.23	2.11	–1.80	0.24	2.06
21	–2.00	0.24	2.05	–2.04	0.23	2.09
23	–2.33	0.25	2.01	–2.33	0.26	1.96
			100 Hr			
–7	0.30	0.27	1.88	0.30	0.30	1.76
–5	0.20	0.25	2.00	0.25	0.28	1.84
–3	---------[1]	-------	-------	–0.10	0.35	1.51
–1	–0.23	0.30	1.75	–0.20	0.31	1.70
1	–0.40	0.31	1.70	–0.30	0.33	1.61
3	–0.40	0.32	1.62	---------	-------	-------
5	–0.61	0.28	1.83	–0.52	0.29	1.80
7	–0.66	0.28	1.83	–0.66	0.28	1.85
9	–0.85	0.26	1.93	–0.82	0.27	1.91
11	–0.95	0.26	1.96	–0.95	0.26	1.96
13	–1.12	0.25	2.02	–1.10	0.24	2.03
15	–1.32	0.24	2.07	–1.32	0.25	2.01
17	–1.47	0.25	2.00	–1.47	0.26	1.96
19	–1.65	0.25	2.00	---------	-------	-------

[1] Samples not collected at these stations.

NOTE.—At 100 hours, one sediment sample was taken on range 1 at station 19; median grain size, 0.25 millimeter (1.99 phi), elevation –1.65 feet.

Table 10. Sediment-size analysis at various hours for experiment 71Y-06.—Continued

Station	Range 2			Range 4		
	Elevation (ft)	Median (mm)	Median (phi)	Elevation (ft)	Median (mm)	Median (phi)
200 Hr						
–9	0.30	0.28	1.85	0.30	0.27	1.91
–7	0.20	0.28	1.85	0.30	0.27	1.92
–5	–0.12	0.31	1.67	–0.12	0.28	1.85
–3	–0.20	0.32	1.67	–0.25	0.31	1.67
–1	–0.40	0.34	1.56	–0.50	0.34	1.57
–1	--------[1]	------	------	–0.40	0.31	1.67
3	--------	------	------	–0.62	0.31	1.69
5	--------	------	------	–0.66	0.31	1.71
7	--------	------	------	–0.70	0.29	1.76
9	–0.77	0.30	1.76	–0.80	0.29	1.77
11	–0.90	0.28	1.86	–0.85	0.28	1.86
13	–0.98	0.27	1.87	–0.95	0.28	1.85
15	–1.08	0.26	1.95	–1.10	0.27	1.89
17	–1.30	0.26	1.94	–1.30	0.27	1.90
19	–1.40	0.26	1.95	–1.45	0.26	1.93
21	–1.60	0.24	2.09	–1.65	0.26	1.93
300 Hr						
–13	0.30	0.27	1.90	0.30	0.28	1.82
–11	0.30	0.34	1.58	0.30	0.34	1.56
–9	0.05	0.35	1.50	0.15	0.33	1.59
–7	–0.20	0.34	1.55	–0.10	0.41	1.29
–5	–0.45	0.32	1.66	–0.48	0.30	1.73
–3	–0.50	0.27	1.91	–0.52	0.25	1.99
–1	–0.60	0.29	1.80	–0.65	0.28	1.82
1	–0.60	0.28	1.84	–0.80	0.31	1.71
3	–0.80	0.28	1.86	–0.80	0.28	1.83
5	–0.70	0.29	1.80	–0.80	0.27	1.89
7	–0.70	0.27	1.92	–0.82	0.28	1.82
9	–0.70	0.28	1.82	–0.60	0.29	1.80
11	–0.70	0.28	1.84	–0.70	0.27	1.88
13	–0.70	0.30	1.76	–0.70	0.29	1.78
15	–0.80	0.28	1.85	–0.84	0.26	1.95
17	–0.85	0.26	1.94	–0.92	0.28	1.83
19	–1.10	0.25	2.00	–1.10	0.28	1.86
21	–1.35	0.24	2.04	–1.35	0.25	1.99

[1] Samples not collected at these stations.

Table 10. Sediment-size analysis at various hours for experiment 71Y-06.—Continued

Station	Range 2			Range 4		
	Elevation (ft)	Median (mm)	Median (phi)	Elevation (ft)	Median (mm)	Median (phi)
			375 Hr			
–13	0.30	0.34	1.54	0.30	0.29	1.78
–11	0.10	0.34	1.56	0.10	0.41	1.28
–9	–0.20	0.27	1.89	–0.20	0.28	1.85
–7	–0.35	0.27	1.88	–0.30	0.26	1.93
–5	–0.50	0.26	1.95	–0.50	0.31	1.71
–3	–0.50	0.26	1.93	–0.50	0.27	1.88
–1	–0.55	0.27	1.89	–0.50	0.30	1.75
1	–0.59	0.24	2.04	–0.60	0.30	1.76
3	–0.70	0.26	1.96	–0.60	0.26	1.94
5	–0.75	0.28	1.86	–0.70	0.29	1.77
7	–0.70	0.26	1.92	–0.70	0.26	1.92
9	–0.80	0.28	1.82	–0.70	0.29	1.77
11	–0.70	0.25	2.01	–0.70	0.25	2.02
13	–0.70	0.31	1.71	–0.70	0.31	1.69
15	–0.72	0.26	1.96	–0.72	0.26	1.96
17	–0.78	0.30	1.73	–0.76	0.29	1.80
19	–0.85	0.27	1.90	–0.90	0.26	1.94
21	–1.10	0.25	2.01	–1.18	0.25	2.03
23	–1.30	0.28	1.86	–1.33	0.25	2.00
25	–1.60	0.27	1.90	–1.60	0.26	1.93
			380 Hr			
–13	0.30	0.29	1.79	---------[1]	-------	-------
–11	0.10	0.25	1.99	0.10	0.28	1.85
–9	–0.20	0.29	1.78	–0.20	0.28	1.82
–7	–0.35	0.26	1.95	–0.30	0.23	2.11
–5	---------	-------	-------	–0.50	0.29	1.77
–3	---------	-------	-------	–0.50	0.24	2.04
–1	–0.55	0.30	1.72	–0.50	0.30	1.75
1	–0.59	0.27	1.90	–0.60	0.26	1.92
3	–0.70	0.26	1.93	---------	-------	-------
7	–0.70	0.26	1.95	---------	-------	-------
11	–0.70	0.28	1.84	–0.70	0.26	1.95
13	–0.70	0.32	1.66	–0.70	0.30	1.75
15	–0.72	0.29	1.81	---------	-------	-------
17	–0.78	0.29	1.81	–0.76	0.29	1.78
21	–1.10	0.26	1.97	–1.18	-------	-------
23	–1.30	0.26	1.93	–1.33	0.26	1.93
25	–1.60	0.26	1.92	–1.60	0.26	1.95

[1] Samples not collected at these stations.

Table 11. Sediment-size analysis at various hours for experiment 71Y-10.

Station	Range 4 Elevation (ft)	Range 4 Median (mm)	Range 4 Median (phi)	Range 6 Elevation (ft)	Range 6 Median (mm)	Range 6 Median (phi)
			24 Hr			
–6	0.30	0.26	1.93	0.30	0.26	1.93
–4	0.25	0.28	1.86	0.25	0.30	1.74
–2	–0.10	0.28	1.85	0.00	0.34	1.57
0	–0.15	0.29	1.77	–0.20	0.31	1.70
2	–0.30	0.30	1.72	–0.50	0.30	1.74
4	–0.40	0.32	1.66	–0.40	0.30	1.73
6	–0.56	0.28	1.85	–0.55	0.29	1.81
8	–0.70	0.26	1.93	–0.65	0.27	1.88
10	–0.90	0.25	2.00	–0.85	0.26	1.97
12	–1.10	0.24	2.06	–1.00	0.25	2.02
			50 Hr			
–6	0.30	0.26	1.95	0.30	0.27	1.91
–4	0.20	0.25	1.99	0.20	0.28	1.85
–2	–0.10	0.30	1.72	–0.20	0.33	1.62
0	–0.20	0.32	1.66	–0.20	0.31	1.69
2	–0.20	0.33	1.61	–0.30	0.30	1.76
4	–0.45	0.36	1.47	–0.40	0.29	1.78
6	–0.55	0.26	1.95	–0.52	0.29	1.79
8	–0.70	0.24	2.05	–0.70	0.30	1.75
10	–0.90	0.26	1.97	–0.81	0.27	1.88
12	–1.00	0.25	2.01	–1.00	0.26	1.96
14	–1.20	0.26	1.97	–1.25	0.25	2.00
16	–1.40	0.23	2.15	–1.45	0.25	2.00
18	–1.70	0.24	2.06	–1.70	0.25	2.00
20	–1.95	0.24	2.08	–1.92	0.25	2.03

Table 11. Sediment-size analysis at various hours for experiment 71Y-10.—Continued

Station	Range 4			Range 6		
	Elevation (ft)	Median (mm)	Median (phi)	Elevation (ft)	Median (mm)	Median (phi)
100 Hr						
−6	0.30	0.29	1.81	0.30	0.28	1.85
−4	0.10	0.26	1.99	0.15	0.28	1.83
−2	−0.10	0.32	1.66	−0.20	0.33	1.61
0	−0.22	0.32	1.66	−0.24	0.30	1.74
2	−0.30	0.32	1.63	−0.50	0.30	1.76
4	−0.45	0.28	1.82	−0.40	0.31	1.67
6	−0.55	0.26	1.93	−0.58	0.29	1.77
8	−0.73	0.26	1.93	−0.70	0.29	1.80
10	−0.85	0.27	1.88	−0.83	0.28	1.84
12	−1.05	0.25	1.98	−1.00	0.27	1.89
14	−1.28	0.26	1.97	−1.18	0.26	1.96
16	−1.60	0.24	2.05	−1.38	0.25	1.99
18	−1.70	0.24	2.05	−1.60	0.26	1.93
20	−1.89	0.25	2.00	−1.89	0.25	2.01
200 Hr						
−8	0.30	0.30	1.72	0.30	0.37	1.44
−6	0.15	0.34	1.56	0.10	0.34	1.56
−4	−0.10	0.37	1.43	−0.15	0.39	1.37
−2	−0.32	0.34	1.54	−0.40	0.34	1.54
0	−0.51	0.30	1.74	−0.52	0.31	1.71
2	−0.58	0.32	1.63	−0.70	0.29	1.78
4	−0.65	0.28	1.82	−0.70	0.29	1.81
6	−0.70	0.27	1.90	−0.70	0.30	1.75
8	−0.70	0.29	1.78	−0.70	0.28	1.82
10	−0.80	0.29	1.80	−0.80	0.27	1.88
12	−0.80	0.29	1.77	−0.86	0.28	1.82
14	−1.10	0.26	1.93	−1.00	0.27	1.90
16	−1.27	0.26	1.95	−1.15	0.27	1.91
18	−1.45	0.27	1.90	−1.30	0.26	1.97
20	−1.72	0.27	1.91	−1.50	0.28	1.85
22	−1.95	0.26	1.96	−1.75	0.25	2.01
24	−2.10	0.28	1.83	−2.00	0.26	1.92

NOTE.—At 200 hours, one sediment sample was taken on range 8 at station—4; median grain size 0.78 millimeter (0.37 phi).

Table 11. Sediment-size analysis at various hours for experiment 71Y-10.—Continued

Station	Range 4			Range 6		
	Elevation (ft)	Median (mm)	Median (phi)	Elevation (ft)	Median (mm)	Median (phi)
300 Hr						
−10	0.30	0.41	1.28	0.30	0.29	1.79
−8	0.30	0.33	1.58	0.20	0.40	1.34
−6	−0.20	0.47	1.08	−0.02	0.42	1.26
−4	−0.40	0.34	1.58	−0.54	0.34	1.57
−2	−0.60	0.34	1.55	−0.65	0.30	1.72
0	−0.80	0.30	1.76	−0.70	0.35	1.51
2	−0.75	0.30	1.73	−0.66	0.25	2.02
4	−0.70	0.23	2.12	−0.60	0.23	2.13
6	−0.65	0.29	1.79	−0.60	0.31	1.70
8	−0.70	0.27	1.91	−0.70	0.29	1.81
10	−0.70	0.29	1.79	−0.70	0.30	1.74
12	−0.75	0.26	1.93	−0.80	0.27	1.89
14	−0.80	0.25	2.01	−0.83	0.28	1.82
16	−1.04	0.25	2.01	−1.00	0.28	1.83
18	−1.22	0.24	2.04	−1.15	0.27	1.90
20	−1.29	0.27	1.89	−1.25	0.28	1.85
22	−1.62	0.28	1.86	−1.50	0.27	1.91
24	−1.94	0.26	1.93	−1.80	0.25	2.03
335 Hr						
−10	0.30	0.29	1.80	0.30	0.40	1.33
−8	−0.10	0.31	1.70	0.10	0.31	1.67
−6	−0.24	0.35	1.53	−0.15	0.36	1.46
−4	−0.40	0.37	1.43	−0.42	0.33	1.62
−2	−0.60	0.29	1.80	−0.70	0.30	1.73
0	−0.80	0.32	1.65	−0.70	0.30	1.74
2	−0.80	0.33	1.60	−0.70	0.28	1.86
4	−0.80	0.26	1.93	−0.70	0.21	2.26
6	−0.80	0.25	2.02	−0.70	0.25	1.99
8	−0.80	0.26	1.95	−0.70	0.21	2.24
10	−0.70	0.31	1.70	−0.70	0.29	1.79
12	−0.75	0.26	1.96	−0.75	0.26	1.97
14	−0.80	0.27	1.88	−0.80	0.27	1.88
16	−0.92	0.27	1.89	−0.90	0.26	1.95
18	−1.12	0.25	1.98	−1.05	0.25	2.00
20	−1.27	0.27	1.90	−1.18	0.27	1.90
22	−1.50	0.26	1.95	−1.40	0.27	1.92
24	−1.78	0.25	2.03	−1.80	0.26	1.94

Table 12. Summary of median grain-size values within profile zones for experiments 71Y-06 and 71Y-10.

Cumulative time (hr)	Profile zones								
	Foreshore[1]			Inshore			Offshore		
	Mean (mm)	Range (mm)	No.	Mean (mm)	Range (mm)	No.	Mean (mm)	Range (mm)	No.
Experiment 71Y-06									
26	0.31	0.31 to 0.32	3	0.28	0.27 to 0.30	9	0.25	0.23 to 0.30	15
50	0.30	0.28 to 0.31	5	0.29	0.28 to 0.30	8	0.25	0.23 to 0.29	15
100	0.29	0.25 to 0.35	3	0.30	0.28 to 0.31	9	0.25	0.24 to 0.27	11
200	0.29	0.28 to 0.31	3	0.31	0.29 to 0.34	10	0.27	0.24 to 0.30	12
300	0.36	0.33 to 0.41	3	0.29	0.27 to 0.34	22	0.26	0.24 to 0.31	7
375	0.38	0.34 to 0.41	2	0.28	0.24 to 0.31	28	0.26	0.25 to 0.30	8
380	0.27	0.23 to 0.29	6	0.28	0.24 to 0.32	15	0.26	0.26	5
All times (except 380)	0.32	0.25 to 0.41	19	0.29	0.24 to 0.34	86	0.26	0.23 to 0.31	68
Experiment 71Y-10									
24	030	0.28 to 0.34	5	0.29	0.26 to 0.31	9	0.25	0.24 to 0.26	4
50	0.28	0.25 to 0.30	3	0.30	0.24 to 0.32	12	0.25	0.23 to 0.27	11
100	0.29	0.26 to 0.32	3	0.30	0.26 to 0.33	11	0.26	0.24 to 0.28	12
200	0.36	0.34 to 0.39	4	0.30	0.28 to 0.34	15	0.27	0.25 to 0.29	13
300	0.41	0.29 to 0.41	2	0.30	0.23 to 0.35	21	0.27	0.24 to 0.28	10
335	0.33	0.29 to 0.40	3	0.28	0.21 to 0.37	21	0.26	0.25 to 0.27	10
All times	0.32	0.26 to 0.41	20	0.29	0.21 to 0.37	89	0.26	0.24 to 0.29	60

[1]Samples collected on the backshore not included.

NOTE.—The mean of the median sizes at 0 hour was 0.27 millimeter.

in the mean median size on the foreshore at 300 and 375 hours could have been the result of the profile eroding into the relict profile from 1970, which had coarser material. The median grain size in the inshore zone was 0.27 millimeter or greater for the first 300 hours and at 375 hours a few samples had a d_{50} lower than 0.27 millimeter; the median grain size in the offshore zone was as low as 0.23 millimeter. As expected, more of the finer material eroded from the foreshore (raising the d_{50} in that zone) and deposited in the offshore (lowering the d_{50} in that zone). The material deposited on the foreshore by the long-period wave was finer material, thus significantly lowering the d_{50} on the foreshore at 380 hours.

b. Experiment 71Y-10. A similar summary of median grain-size data for experiment 71Y-10 is given in Table 12. The same trend in median grain-size changes occurred, but was even more distinct. With one exception, the median grain size in the foreshore zone remained above 0.27 millimeter. The increase in the mean median size in the foreshore zone could have been the erosion into the relict profile. In the offshore, d_{50} varied only between 0.24 and 0.29 millimeter.

4. Breaker Characteristics.

a. Experiment 71Y-06. Breaker position superimposed on contour movement along range 3 is shown in Figure 37 for experiment 71Y-06. During the first 180 hours the wave broke mostly at a depth of 0.6 foot, breaking by plunging for the first 105 hours and by plunging and spilling for the next 75 hours. After 180 hours the breaker position coincided with the general seaward movement of the -0.7-foot contour, and the breaker type was primarily spilling. Between 220 and 315 hours the wave broke twice--by spilling at a depth of 0.7 foot and by plunging at the toe of the foreshore.

Between 375 and 380 hours the 3.75-second wave was a surging-type breaker on the foreshore.

b. Experiment 71Y-10. Breaker position superimposed on contour movement along range 5 is shown in Figure 38 for experiment 71Y-10. The wave broke by plunging at a depth of 0.6 foot for the first 125 hours with no lateral variation in the breaker position. From 125 to 265 hours the wave type varied between plunging and spilling, and the breaker position varied from stations 8 to 10 along range 9 (breaker depth about 0.7 foot), and from stations 5 to 7 along range 1 (breaker depth about 0.6 foot).

From 265 to 280 hours the breaker type was spilling and the breaker position along range 9 remained at about station 9. Along range 1, the breaker position moved to station +2 at 270 hours and -2 at 275 and 280 hours.

The most significant change occurred between 280 and 285 hours. Between range 10 (station 8) and range 3 (station 2) the wave broke by spilling; between range 3 and range 0 the wave broke by plunging at station -2

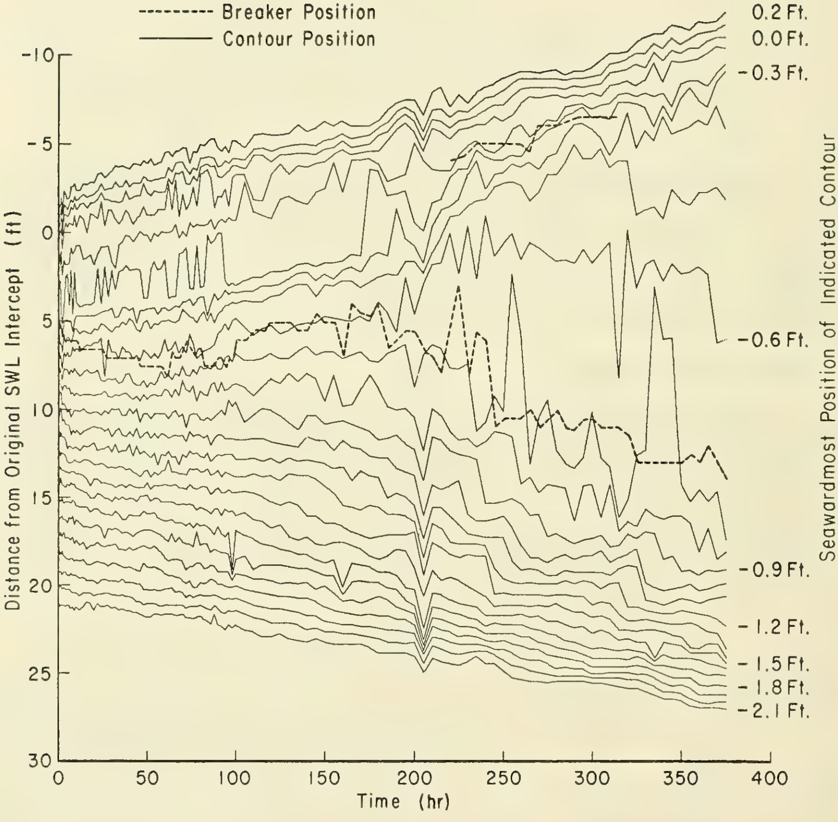


Figure 37. Movement of breaker position in experiment 71Y-06.

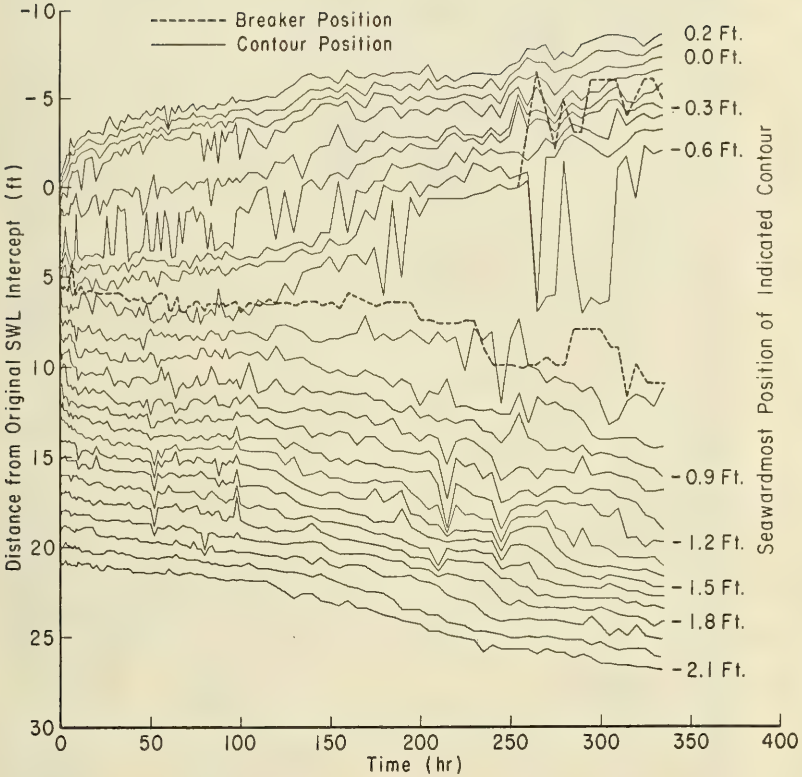


Figure 38. Movement of breaker position in experiment 71Y-10.

(Fig. 39). This pattern was maintained for the remainder of the experiment. During the last 10 hours of this experiment, a strong seaward current was observed in the inshore zone between ranges 0 and 2, in the region where the wave did not break until reaching the toe of the foreshore.

Contour maps in Figure 40 show the profile at 135 and 335 hours. Figure 41 shows ripple formations between ranges 0 and 2 and stations +2 to +5, where large ripples are oriented in the seaward direction. A plausible explanation for the breaking pattern and current development is that: (a) As the wave broke first along range 9, energy moved along the wave crest toward this range; (b) this loss of energy along the lower ranges decreased the wave height along the lower ranges causing the waves to break even farther inshore so that eventually the waves along range 2 lost enough height (energy) to not break until the waves had traveled farther up the profile; and (c) the flow of energy along the wave crest toward range 9 increased the shoreward mass transport along that side of the tank, and the seaward return flow of mass transport chose the path of least resistance--along range 1.

5. Water Temperature.

Figure 42 gives data on daily average water temperature versus both cumulative test time and dates for experiments 71Y-06 and 71Y-10.

III. PROFILE DEVELOPMENT AND REFLECTIVITY

Results are analyzed by: (a) Profile development, in which the interdependence of the changes in the profile shape, sediment-size distribution, breaker characteristics, and water temperature is analyzed; and (b) profile reflectivity, in which changes in profile shape and breaker characteristics are related to the variability of the reflection coefficient. Profile development is discussed first to provide an introduction to profile reflectivity.

1. Profile Development.

a. Experiment 71Y-06. The important changes in the foreshore, inshore, and offshore zones, the breaker conditions, median grain size, and water temperature during experiment 71Y-06 are summarized and tabulated as a function of time in Table 13.

During the first hour the foreshore zone developed the basic shape which was maintained throughout the remainder of the experiment, and a longshore bar was formed by the plunging breaker in the inner inshore region. The eroded material during this early development was deposited at elevations -0.6 to -1.2 feet in the first 2 hours. As the foreshore retreated at 0.113 foot (3.44 centimeters) per hour for the first 15 hours and the bar moved shoreward at 0.018 foot per hour, the eroded material was deposited mostly at elevation -0.9 to -1.2 feet up to 10 hours and uniformly at all depths in the offshore zone after 10 hours (see Figs. 7, 8, and 9). After 15 hours the shoreline recession rate dropped to 0.025 foot per hour.

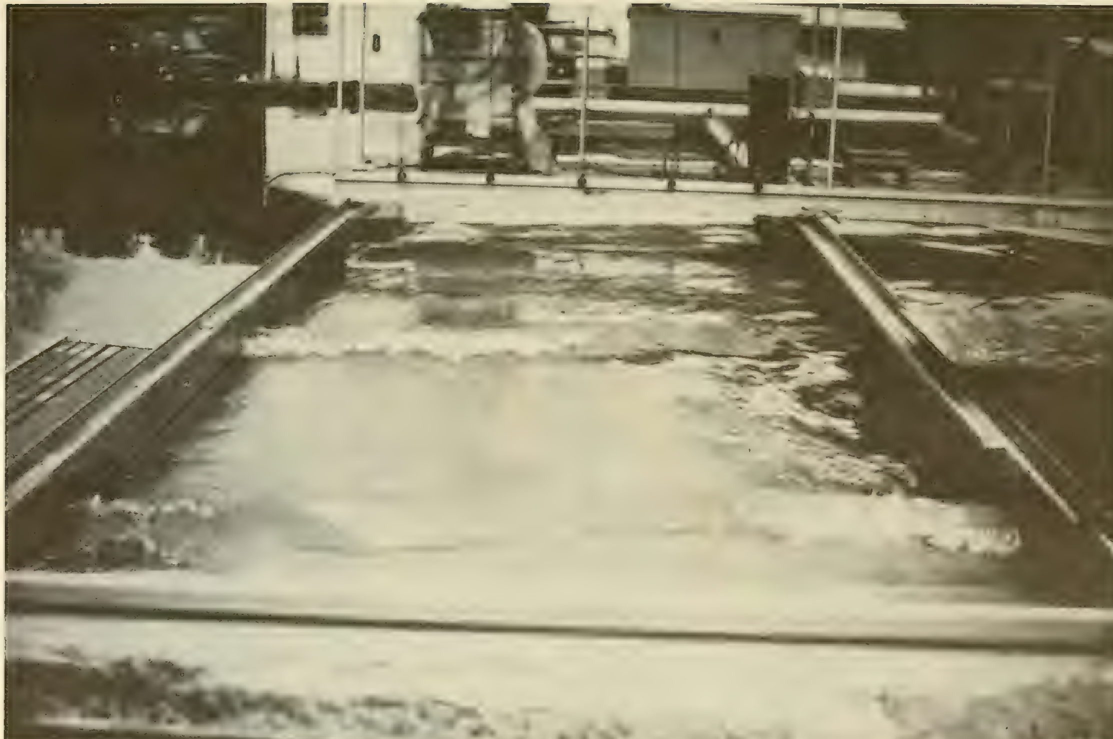


Figure 39. View of breakers from backshore at 330 hours in experiment 71Y-10.

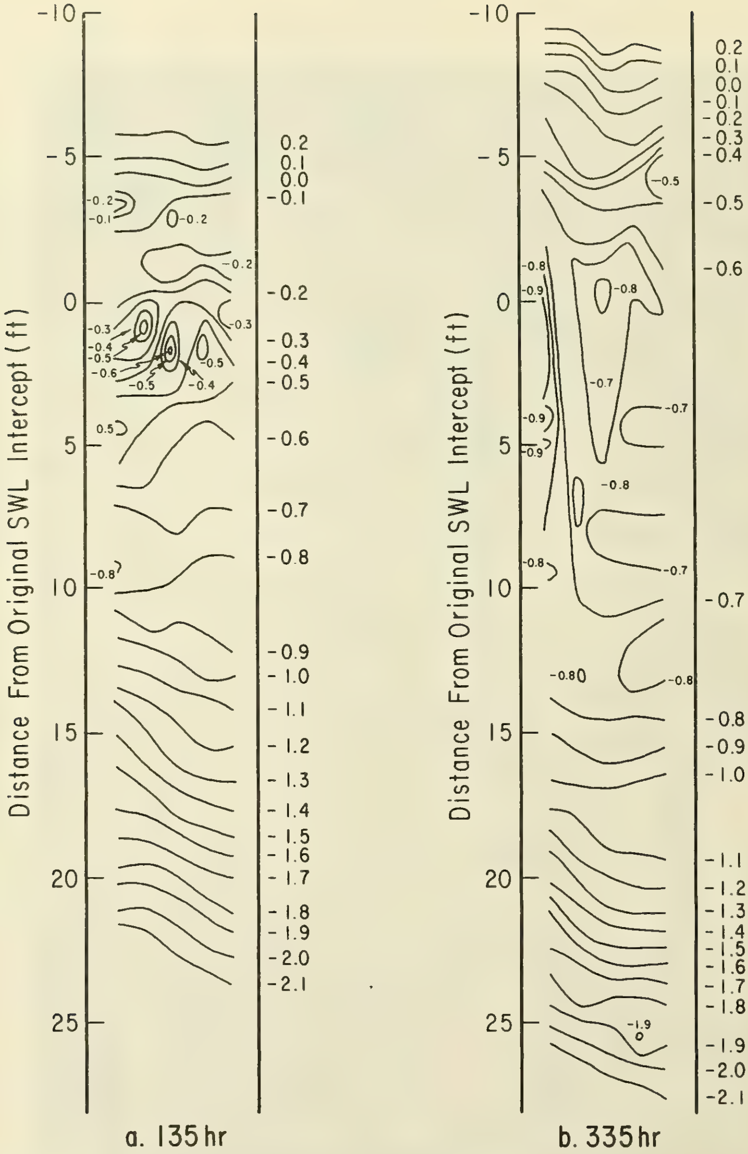


Figure 40. Contour maps of experiment 71Y-10 at 135 and 335 hours.

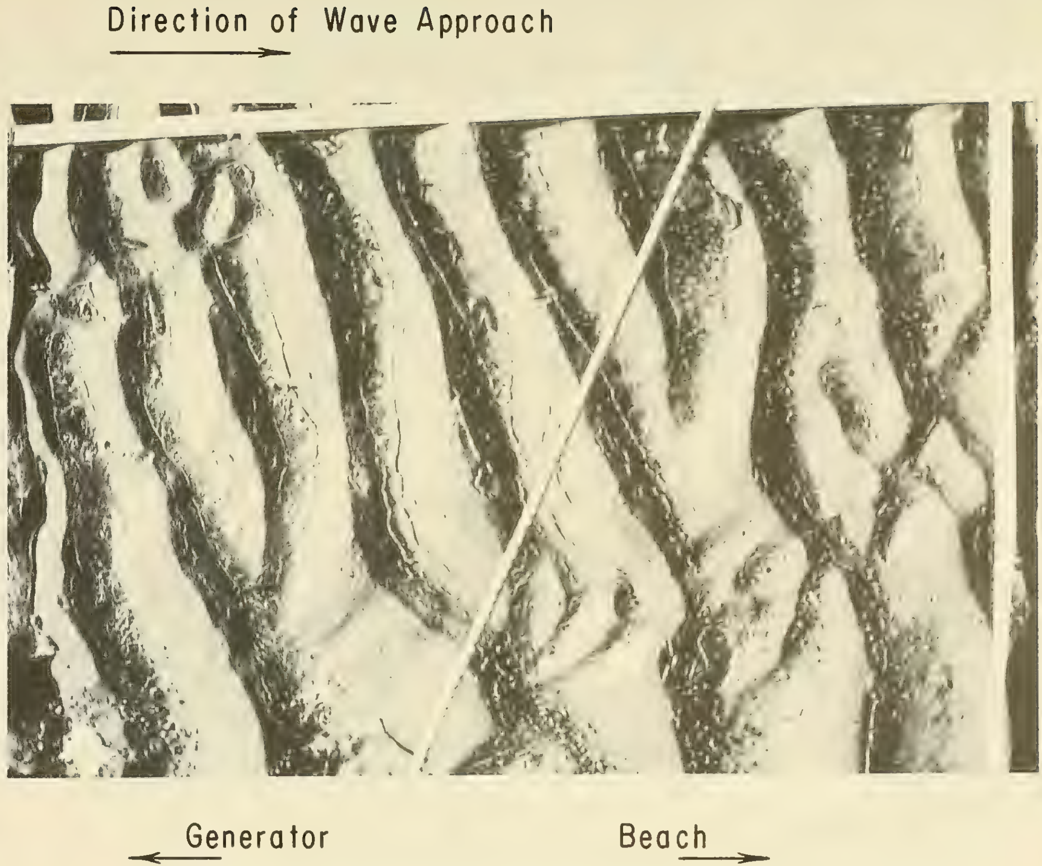
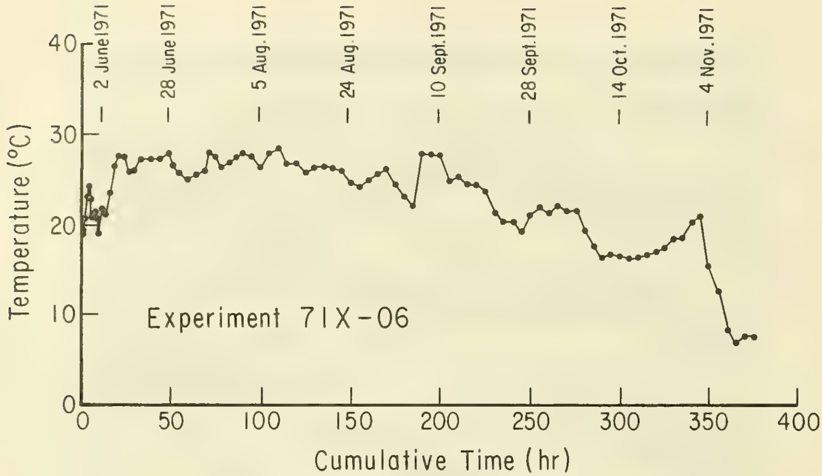


Figure 41. Seaward directed ripples on the inshore along range 1 in experiment 71Y-10.



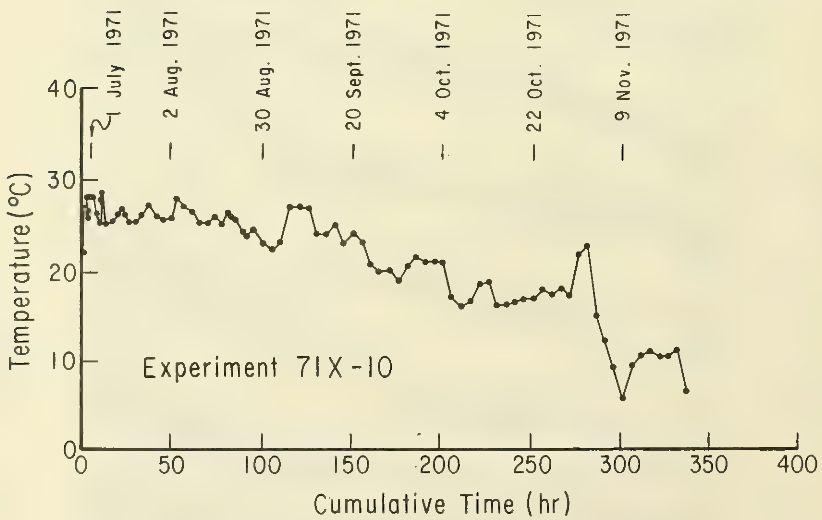


Figure 42. Water temperature data from experiments 71Y-06 and 71Y-10.

Table 13. Summary of profile development for experiment 71Y-06.

Time (hr)	Foreshore	Inner inshore	Outer inshore	Offshore	Breaker conditions		Water temperature
					Depth (ft)	Type[1]	(°C)
0 to 1	Characteristic shape developed	Longshore bar formed	Deposition at elevations –0.6, –0.7, and –0.8 ft	Deposition mostly at elevations –0.9 to –1.2 ft	0.6	P	19
1 to 2	Average rate of erosion 0.113 ft/hr	Crest elevation of bar varied between –0.3 and –0.4 ft; bar moved shoreward at rate of 0.018 ft/hr					21
2 to 10							19 to 24
10 to 15				Deposition uniformly at all depths			22 to 24
15 to 105	Average rate of erosion 0.025 ft/hr						24 to 29
105 to 175					0.6	PS	24 to 29
175 to 180			Erosion at –0.6 ft, deposition at –0.7 and –0.8 ft				23
180 to 200					0.7	S	22 to 28
200 to 220		Bar eroded	Shelf developed	Deposition mostly at elevations –0.9 to –1.3 ft			25 to 26
220 to 250		Maintained fairly steep slope	Shelf grew in length in both directions		0.7	S	19 to 24
250 to 315				Deposition uniformly at all depths	0.3	P	17 to 22
315 to 340				Deposition mostly at elevations –0.9 to –1.2 ft	0.7	S	17 to 21
340 to 375				Deposition at all depths			7 to 21

[1]P = plunging; S = spilling.

At 105 hours the breaker type became mixed between plunging and spilling, indicating that the flatter slope in the offshore had begun to affect the waves. At 175 hours, erosion at elevation -0.6 foot and deposition at -0.7 and -0.8 foot caused the breaker at 180 hours to become consistently spilling and to move seaward with the -0.7-foot contour. After 200 hours, with the wave no longer breaking near the bar, the bar eroded and a shelf developed (erosion at -0.5 and -0.6 foot, and deposition at -0.7 and -0.8 foot; see Fig. 37). Deposition mostly at elevations -0.9 to -1.3 feet in the offshore zone steepened the offshore slope and caused a farther seaward extension of the inshore zone (Figs. 7, 8, and 9).

From 220 to 315 hours the wave broke a second time (in the inner inshore), further eroding and steepening that region. Continuous erosion of the foreshore and inner inshore, and deposition in the offshore caused the flat shelf in the outer inshore to grow in both directions (Fig. 37).

More finer material eroded from the foreshore and inner inshore zones leaving the sediment-size distribution coarser in those areas and decreasing the median grain size in the offshore zone where it was deposited (Table 12).

The daily mean water temperature with shoreline position is compared in Figure 43. For the first 15 hours the shoreline recession rate was 0.113 foot per hour; after 15 hours the shoreline recession rate was an average 0.025 foot per hour. Because the backshore slope was 0.10 and not flat, the volume rate of erosion was continually increasing. The water temperature was increasing for the first 25 hours and then fairly high and constant until 200 hours. From 200 hours to 345 hours the temperature gradually dropped; from 345 to 365 hours the temperature dropped sharply. The drops in temperature, particularly the sharp drop, were not accompanied by an increase in the shoreline recession rate.

b. Experiment 71Y-10. The major events of the profile development in experiment 71Y-10 are summarized in Table 14. During the first hour the foreshore developed a characteristic shape, and a longshore bar was formed in the inner inshore by the plunging breaker. This material was deposited at depths of 0.6 to 1.4 feet. As the shoreline retreated at a rate of 0.133 foot (4.05 centimeters) per hour (for the first 15 hours), the eroded material was deposited along all ranges at depths from 0.6 to 1.4 feet until 5 hours, and along all ranges at depths from 0.9 to 1.4 feet until 10 hours (Figs. 10 to 14).

After 10 hours the lateral variations became significant. The erosion rate dropped to 0.016 foot per hour after 15 hours. For an unknown reason, all the material was deposited in the offshore zone along the range 9 side of the tank, while the erosion from the foreshore and inner inshore was uniform across the tank. This situation continued for 100 hours when the offshore along the center of the tank (range 5) began to prograde at the same rate. However, by this time the offshore zone along range 9 was already 2 feet farther offshore (Fig. 31).

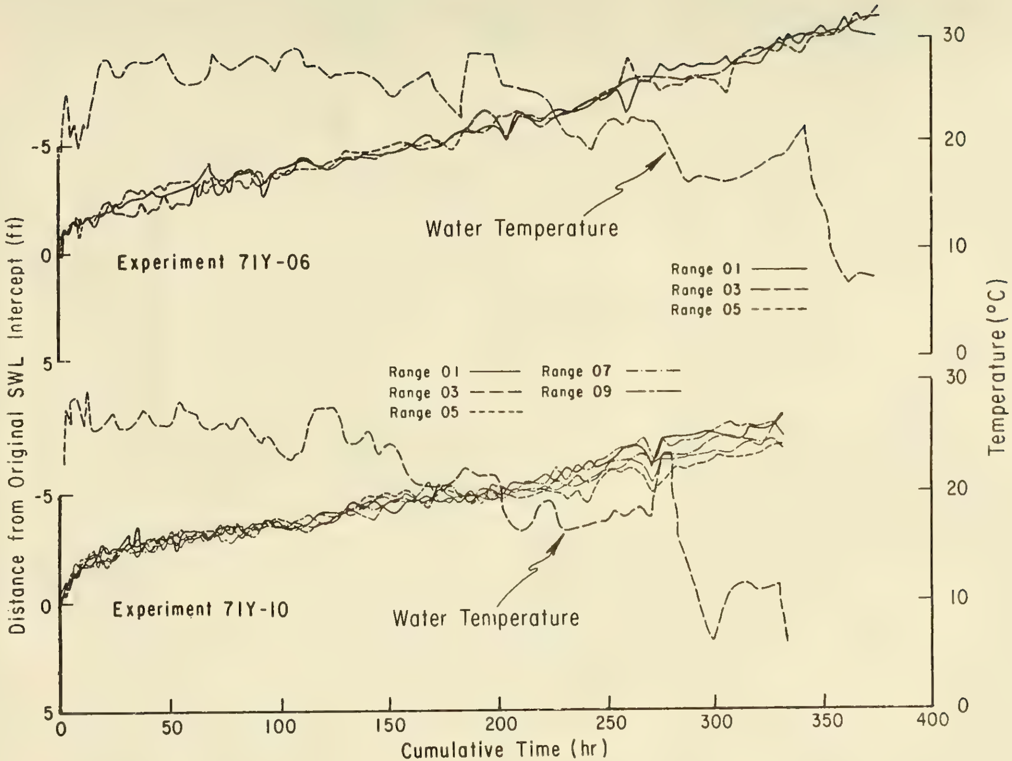


Figure 43. Comparison of water temperature and shoreline position in experiments 71Y-06 and 71Y-10.

Table 14. Summary of profile development for experiment 71Y-10.

Time (hr)	Foreshore	Inner inshore	Outer inshore	Offshore	Breaker conditions			Water temperature
					Depth (ft)	Position	Type[1]	(°C)
0 to 1	Characteristic shape developed	Longshore bar formed	Deposition at elevations –0.6, –0.7, and –0.8 ft	Deposition between elevations –0.9 and –14 ft	0.6		P	23 to 27
1 to 5	Shoreline recession uniform across tank at 0.133 ft/hr	Bar stationary; crest elevation varied from –0.4 to –0.3 ft						26 to 29
5 to 10			No change					26 to 29
10 to 15				Deposition along range 9 at 0.02 ft/hr; along ranges 1 and 5, offshore stationary				25 to 26
15 to 110	Shoreline recession uniform across tank at 0.016 ft/hr			Deposition along ranges 5 and 9 at 0.02 ft/hr; along range 1, offshore stationary				23 to 28
110 to 115								28
115 to 125		Erosion of bar began along range 9 at 115 hours and along range 1 at 190 hours	Shelf development progressed across tank beginning along range 9 at 115 hours and ending along range 1 at 215 hours					28
125 to 170					0.6 0.7	R 1 R 9	PS	20 to 26
170 to 205				Deposition along all ranges at 0.02 ft/hr				18 to 22
205 to 215	Shoreline recession varied across tank; range 5 at 0.016 ft/per hr; range 1 and 9 at 0.025 ft/hr							17
215 to 265		Maintained fairly steep slope	Shelf grew in length in both directions					17 to 19
265 to 280						R 9 stationary; R 1 moving inshore	S	18 to 21
280 to 335						R 0 to R 2 inner inshore; R 8, S 10 to R 2, S 3	P S	6 to 16

[1]P = plunging; S = spilling.

At 115 hours along range 9 the bar in the inner inshore began to erode and a flat shelf began to develop. This pattern continued progressively across the tank: progradation of the offshore zone, erosion of the longshore bar, and development of the flat shelf in the outer inshore region.

With the profile along range 9 closer to the generator, the waves began to refract and break first along the range 9 side of the tank, draining energy along the wave crests toward range 9 (see Fig. 41,a at 135 hours).

Deposition in the offshore along range 1 began at 170 hours. Erosion of the bar and development of the shelf were completed by 215 hours. Deposition in the offshore zone along the other ranges continued, thus maintaining the refraction pattern and the skewed breaker position. By 265 hours the refraction had decreased the wave energy (and wave height) along range 1 so that the breaker position was even farther inshore at a shallower depth where the smaller wave would break. At 280 hours the waves along range 1 did not break as part of the continuous breaker line between ranges 0 and 2, but broke separately at the base of the foreshore (Fig. 39). The refraction increased the mass transport along the range 9 side and the return flow was concentrated along range 1 where the incident wave energy was least.

The concentration of energy along range 9 due to refraction also accounts for the increased shoreline recession along the range. The increased shoreline recession along range 1 may have been the result of the wave breaking closer to the foreshore, thereby increasing the turbulence at the foreshore (Fig. 18).

Water temperature and shoreline position for experiment 71Y-10 are compared in Figure 43. For the first 15 hours the shoreline recession rate was 0.133 foot per hour; from 15 to 205 hours the rate was 0.016 foot per hour. At 205 to 335 hours the shoreline recession rate varied across the tank, from 0.016 foot per hour along the center to 0.025 foot per hour along the outside ranges of the tank. The water temperature rose sharply during the first 2 hours and then remained fairly high and constant until 125 hours. The temperature dropped gradually between 125 and 280 hours, then dropped sharply between 280 and 300 hours. The increase in the recession rate along the outside ranges occurred during a period when the temperature was gradually dropping, but the sharp drop in temperature at 280 hours was not accompanied by an increase in recession rate.

c. Comparison of the Two Experiments. The general shape of the profiles and the sequence of events during the development of the profiles appeared to be similar in the two experiments, and neither experiment reached equilibrium. Significant lateral variations in the rate of profile development, which occurred in the wider tank, did not occur in the narrower tank.

(1) Shoreline Recession Rate. In experiment 71Y-06 the shoreline retreated at a uniform (across the tank) rate of 0.025 foot per hour after 15 hours. In experiment 71Y-10 the shoreline recession rate was lower (0.016 foot per hour) and more uniform across the tank between 15 and 205

hours. After 205 hours in experiment 71Y-10 the recession rate increased to 0.025 foot per hour along the sides of the 10-foot tank while remaining at 0.016 foot per hour in the center. Figure 44 compares the shoreline movement along the center ranges of the two tanks and shows that the erosion rate was slightly greater in the 6-foot tank.

(2) Inshore and Offshore Zones. In both experiments along a given range, the sequence of events in profile development was the same: development of a longshore bar, deposition in the offshore zone, seaward movement of the breaker, erosion of the bar, and development of the shelf. In the narrower tank, this development occurred along all ranges almost simultaneously; in the wider tank, it occurred first along range 9 and then progressed slowly across the tank. This unusual development caused significant lateral variations in breaker depth, breaker type, and littoral currents. The slower development is further amplified by the fact that the center range in the 6-foot tank (solid line in Fig. 44) was representative of all three ranges; whereas, the dashline in Figure 44 was the mean value of contour position in the 10-foot tank and this mean was more representative of changes along range 1 where the development was slower than the mean.

2. Profile Reflectivity.

The basic profile shapes which evolved during the profile development are shown in Figure 6. Early profiles (solid line in Fig. 6) had a steep foreshore, a short inshore with a longshore bar formed by the plunging breaker, and a gently sloping offshore zone. Later profiles (dashline in Fig. 6) also had a steep foreshore, but the inshore widened to a long, flat shelf which terminated in a relatively steep offshore zone.

Chesnutt and Galvin (1974) discussed the processes which reflect wave energy from movable beds in these experiments. The processes include the conversion of potential energy stored in runup on the foreshore into a seaward-traveling wave, the seaward radiation of energy from a plunging breaker, and reflection of the incident wave from the movable bed, particularly where the depth over the movable bed changes significantly. Depth changes are significant if the depth difference is an appreciable fraction of the average depth over a horizontal distance less than a wavelength. For conditions of these experiments, the wavelength is 14.3 feet (4.36 meters) in the section seaward of the movable bed and approximately 9 feet (2.74 meters) over the inshore zone.

a. Reflection From the Foreshore. The foreshore zone developed within the first hour of testing, well before the other elements of the movable-bed profile had become prominent. The developed foreshore had a slope of about 0.20, considerably steeper than the original 0.10 slope. The initial high values of K_R are probably the result of reflection from the foreshore of waves which dissipated little energy until almost at the foreshore. Reflection from the foreshore is a function of the height of the wave reaching the foreshore, and this height would diminish due to increased bottom friction as the inshore and offshore segments of the profile (Fig. 6) became prominent.

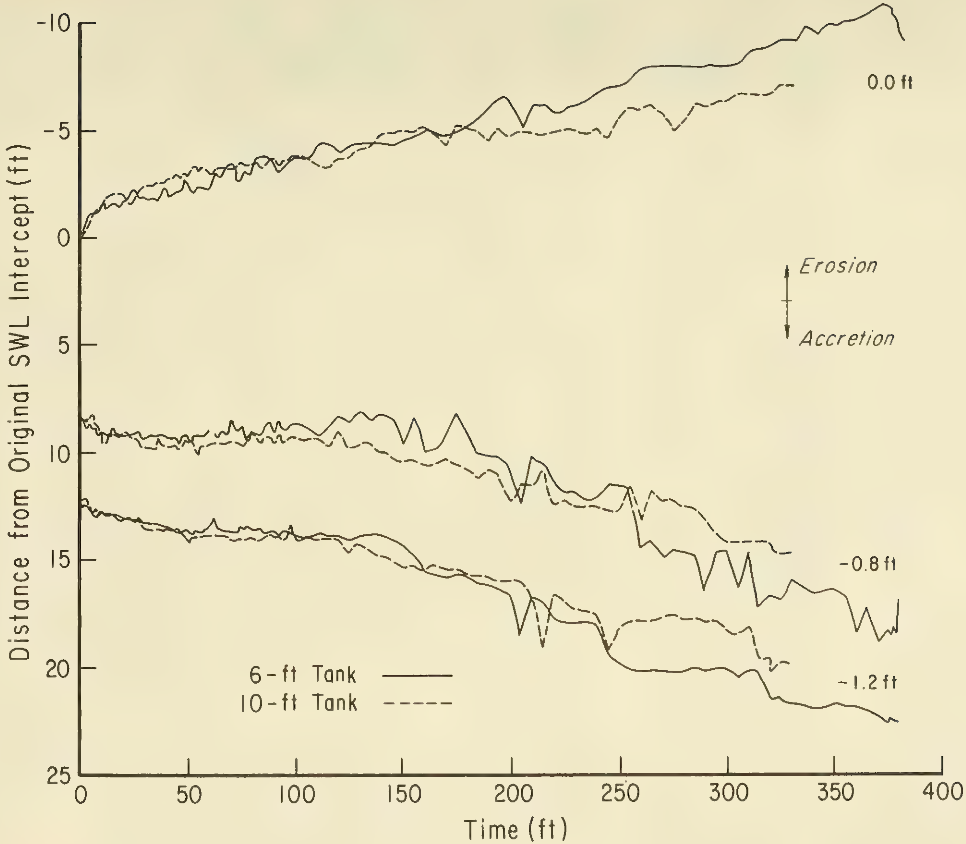


Figure 44. Erosion and accretion in 6- and 10-foot tanks.

b. Reflection as a Result of Wave Breaking. On the concrete slab the wave broke as a plunging breaker and on the movable-bed profile, the wave was initially a less well-developed plunger and evolved to a spilling breaker. The reflection from the concrete slab was an average 0.12 for both experiments, where the plunger is assumed to contribute more significantly to the total reflection. The lowest values of reflection in the movable-bed tanks were slightly lower than the K_R for the fixed bed and occurred during the period when the wave broke by plunging. The reflection from the spilling breaker later in the experiments is assumed to be negligible.

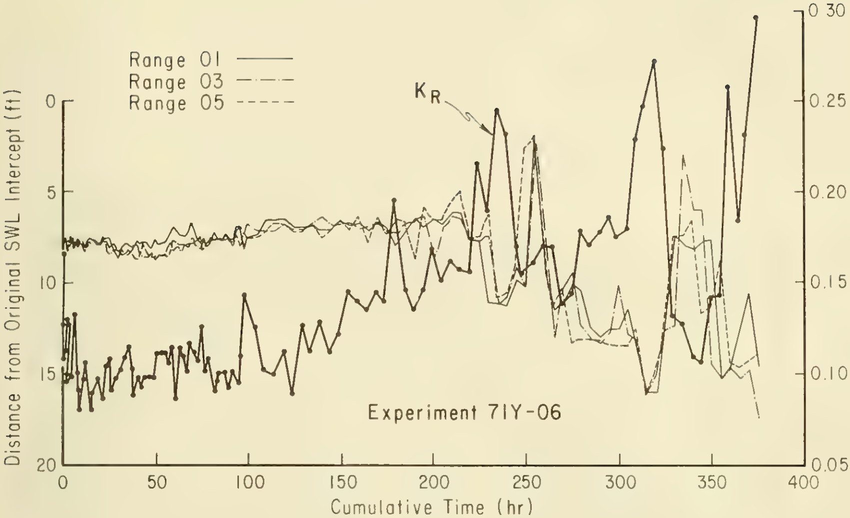
c. Effect of Inshore and Offshore. As the experiments proceeded, the inshore widened and flattened and the offshore steepened. At first, the widening of the inshore dominated; the lowering of the reflection after the high initial values (Figs. 2 and 3) is attributed to the greater energy dissipation in the inshore. The later steepening of the offshore correlates well with the trend toward higher K_R later in the experiments (compare the offshore contour positions in Figs. 8 and 12 with the appropriate reflection values in Figs. 2 and 3).

With the development of the two reflecting zones (foreshore and offshore) separated by a relatively flat inshore zone, the measured reflected wave was composed of two reflected waves. A change in phase or amplitude of either reflected wave would change the phase and amplitude of the measured wave. Part of the long-term K_R variability can be attributed to the change in phase difference between these two reflected waves as the foreshore retreated landward and the offshore built seaward.

Chesnutt and Galvin (1974) examined results from experiment 71Y-06 and pointed out an apparent correlation between the movement of the -0.7-foot contour and the variability of the reflection coefficient, and suggested that the reflection is very sensitive to small changes in the depth near the seaward edge of the inshore zone. These depth changes would cause variability in the reflection of the incident wave from the offshore slope and variability in the amount of energy trapped on the inshore shelf.

The position of the -0.7-foot contour and the reflection coefficient versus time for the two experiments are compared in Figure 45. The seaward (downward) movement of the -0.7-foot contour in the figure is an indication of the development of the steeper offshore slope. Both experiments show a general increase in the reflection coefficient as the -0.7-foot contour moved seaward (and the offshore slope increased).

In experiment 71Y-06, the K_R values are highest at 320, 360, and 375 hours when the -0.7-foot contour is at the seawardmost position; the K_R values are low at 225 and 335 hours when the -0.7-foot contour is at the landwardmost position. The same relationship exists at other times (275, 290, and 300 hours), but the variation is not as great. A scatter plot (Fig. 46) of K_R versus position of the seawardmost -0.7-foot contour for all times after 220 hours indicate the correlation.



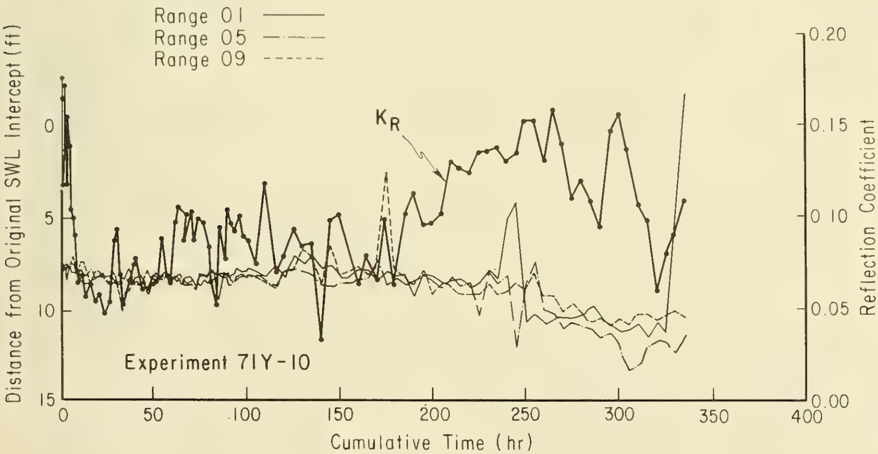


Figure 45. Comparison of the -0.7-foot contour position and K_R in experiments 71Y-06 and 71Y-10.

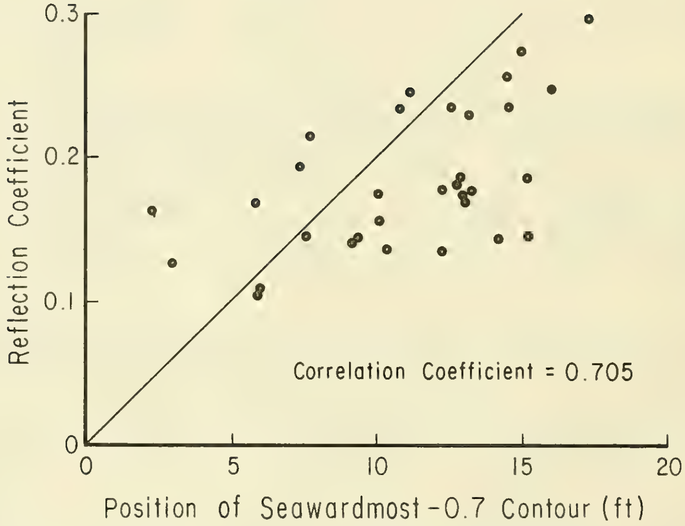


Figure 46. Correlation of the -0.7-foot contour position and K_R in experiment 71Y-06.

In experiment 71Y-10 the -0.7-foot contour varied in position, but not uniformly across the tank. The K_R in this experiment did not fluctuate in response to any particular contour movements; however, with the complex profile development, a lack of correlation is expected. These lateral variations in profile development certainly contributed to a complex wave reflection pattern, which appeared simple and less variable when only recorded along the center of the tank.

IV. DISCUSSION OF RESULTS

1. Wave Height Variability.

Three probable causes of wave height variability in the two experiments are: (a) Wave reflection from the changing profile, (b) re-reflection from the wave generator, and (c) secondary waves. These experiments were designed primarily to quantify the amount of variability due to reflection.

a. Wave Reflection From the Profile. The K_R in the fixed-bed tanks increased during the early hours of the experiments and decreased in the later hours. In the narrower fixed-bed tank, the K_R was always higher. The K_R in the movable-bed tanks varied from 0.08 to 0.30 in experiment 71Y-06 and from 0.03 to 0.18 in experiment 71Y-10 (Figs. 2 and 3). K_R values during the development of the foreshore were relatively high, then decreased as the remainder of the profile began to adjust. Later, after the profile had developed a relatively steep offshore slope, the K_R increased and the variation in K_R increased. The variations appear to have been caused by small changes in depth near the seaward edge of the inshore zone (the top of the offshore reflecting surface) and by the gradual separation of the two reflecting surfaces as the offshore slope prograded seaward (see Fig. 45, and Chesnutt and Galvin, 1974).

b. Re-Reflection From the Generator. The reflected wave advanced to the generator and was reflected. As the height of the reflected wave varied, the height of the re-reflected wave varied; as the phase difference between the reflected wave and the generator motion varied with changes in the profile, the height and phase of the re-reflected wave varied. The height of the wave incident to the profile, which was the average of wave heights along the full tank length and was composed of the generated wave and the re-reflected wave, varied from 0.32 to 0.41 foot (9.8 to 12.5 centimeters) in experiments 71Y-06 and 71Y-10 (Tables 6 and 7). Part of that variation (0.04 foot in experiment 71Y-06 and 0.03 foot in experiment 71Y-10) could be attributed to measurement errors, variations in the generated wave, and all other errors not caused by a changing profile. The remainder of the variation (0.05 and 0.06 foot) is likely due to varying re-reflection.

c. Secondary Waves. Along the length of the tank. between the generator and the toe of the profile, wave heights on a given recording varied as the result of secondary waves. Galvin (1972) and Hulsbergen (1974) described secondary waves (called solitons by Galvin) and their effects. Although secondary waves were observed on the wave records, these waves were not analyzed in this study; wave height variations due to secondary waves did not affect the wave height data presented here.

2. Profile Equilibrium.

The experiments were extended over several hundred hours in hopes of defining the equilibrium profile for the given wave and sediment conditions. At the end, there was no indication that either experiment was close to equilibrium (see Figs. 7 to 14). In experiment 71Y-10 the profile had great lateral variation, which seemed to be getting continually more complex.

The decreasing water temperature at the end of the experiments, increasing the viscosity and presumably the sediment-carrying capacity (Chesnutt, 1975; Chesnutt and Stafford, 1977), may have contributed to the continuing erosion and lack of equilibrium. However, the lack of an increase in recession rate at the times of the sharpest temperature drop seems to discount this explanation. The continually changing distances between the wave generator and parts of the profile (foreshore and offshore) causing variations in re-reflection and secondary waves may also have prevented the profile from reaching equilibrium.

To further complicate the question of profile equilibrium, Collins and Chesnutt (1975, 1976) showed that, even with constant water temperature, the final, unchanging profile for the same wave and sediment conditions was not always repeatable.

A constant rate of volume erosion might be an acceptable alternative to profile equilibrium for defining steady-state conditions in some coastal engineering experiments, but that may also be affected by water temperature and other variables.

3. Other Laboratory Effects.

The differences in test conditions (tank width, initial test length, and the uncontrolled water temperature) provide possible explanations for the differences in rate of profile development discussed in Section III,1,c, but also prevent a rigorous proof of the effect of any one of these differences as definite causes. Chesnutt (1975) discussed the effects of initial test length and water temperature.

a. Water Temperature. The water temperature varied from 29° to 7° Celsius for the experiments which began in May and June and continued into early December. The dynamic viscosity varied from 1.7×10^{-5} to 3.0×10^{-5} pounds-second per square foot (7.98×10^{-3} to 14.30×10^{-3} grams-second per square centimeter). The existence of a temperature effect seems to be disproven by the data presented in this study. However, the possibility of a temperature effect prevents the drawing of strong conclusions about profile equilibrium and other laboratory effects.

b. Initial Test Length. Two possible phenomena are affected by varying tank length, re-reflection and secondary waves. Chesnutt (1975) and Chesnutt and Stafford (1977) discussed these phenomena and the possible effects on the rate of profile development.

c. Tank Width. Experiments 71Y-06 and 71Y-10 probably serve their greatest purpose by pointing out the effect of tank width. This study (Sec. III,1) discussed the significant lateral variations in the wider tank, which must have resulted from a minor perturbation in profile development. Lateral variations in profile shape occur on natural beaches, and variations on a wide laboratory beach would not be unexpected. In the 6-foot tank, the profile was essentially two-dimensional; in the 10-foot tank, the natural lateral variations were most likely distorted by the tank walls.

V. CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions.

(a) In two experiments with a water depth of 2.33 feet (0.71 meter) a wave period of 1.90 seconds, and a generator stroke of 0.39 foot (11.9 centimeters), the average incident wave height was 0.38 foot (11.3 centimeters) in experiment 71Y-06 and 0.36 foot in experiment 71Y-10. Reflection measurements in the control tanks with a fixed-bed profile varied from 0.10 to 0.16 in experiment 71Y-06 and from 0.09 to 0.12 in experiment 71Y-10, indicating that the wave generators were operating uniformly and that the error in determining reflection from the changing profile was about ±0.03 for experiment 71Y-06 and ±0.015 in experiment 71Y-10. The lower K_R in the wider tank is probably due to an unknown width effect (Tables 6 and 8).

(b) K_R varied from 0.08 to 0.30 in experiment 71Y-06 and from 0.03 to 0.16 in experiment 71Y-10. The variation in K_R correlates with profile changes. K_R was high during the development of the foreshore and decreased as the inshore widened. Later increases in K_R occurred when the offshore slope steepened. Large fluctuations in K_R occurred at times of large shifts in contour position on the flat inshore zone, suggesting that reflection is quite sensitive to small changes in depth at the shoreward edge of the submerged reflecting surface (Figs. 3, 4, 45, and 46).

(c) Profiles along given ranges in the two experiments developed in the same sequence, but did not reach equilibrium. In the wider tank, the development of the flat shelf in the inshore zone began along one side of the tank and the development progressed slowly across the tank, causing significant differences in breaker type and depth across the tank and a strong seaward current along one side of the tank. This development suggests that tank width can significantly affect laboratory studies of coastal processes (Figs. 7 to 14).

(d) The shoreline recession rate was a constant 0.025 foot per hour uniformly across the tank after 15 hours in experiment 71Y-06. In experiment 71Y-10, the shoreline recession rate was a constant, uniform 0.016 foot per hour between 15 and 205 hours; for the last 130 hours, the rate along the outside ranges of the tank increased to 0.025 foot per hour (Fig. 18).

(e) The slower development of the inshore shelf across the full width of the tank and slightly slower shoreline recession rate in the wider tank indicate that even wider beaches (closer to an infinitely long beach) would develop more slowly. Until tank width effects can be quantified, engineers should be careful in extrapolating shoreline recession rates from two-dimensional laboratory tests to field problems (Fig. 44).

(f) Changes in the sediment-size distribution along a laboratory profile appear to be measurable, even for fine, well-sorted sand. The median size along the initial profile was 0.27 millimeter. At the end of the experiments the mean median was 0.32 millimeter in the foreshore zone, 0.29 millimeter in the inshore zone, and 0.26 millimeter in the offshore zone (Tables 10 and 11). (Sand sizes are RSA values which tend to average 0.04 millimeter higher than sieve analyses of the same sample.)

(g) The long, low wave run near the end of experiment 71Y-06 on the steep wave profile quickly began the natural healing process of the beach, which occurs after storms in nature (Figs. 33, 34, and 35).

2. Recommendations.

(a) Because of varying reflectivity of the profiles, incident wave measurements to characterize a three-dimensional coastal engineering experiment should be based on calibration of the wave generator rather than isolated wave measurements during the experiment.

(b) Experimenters should be cautious in defining equilibrium profile conditions and should consider the possibility of using other means for characterizing steady-state conditions in coastal processes experiments and models.

(c) In conducting two-dimensional studies of profile development, the tank width should not be too great, probably less than half the incident wavelength. But extrapolation of narrow tank results should assume variability in profile development in the longshore direction.

3. Further Analysis.

These experiments were essentially the same as the experiments discussed in Volume II except for the 7-foot difference in initial test length. These results will be compared with results from Volume II in Volume VIII.

LITERATURE CITED

ALLEN, R.H., "A Glossary of Coastal Engineering Terms," MP 2-72, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Washington, D.C., Apr. 1972.

CHESNUTT, C.B., "Laboratory Effects in Coastal Movable-Bed Models," *Proceedings of the Symposium on Modeling Techniques*, 1975, pp. 945-961.

CHESNUTT, C.B., and LEFFLER, M.W., "Reduced Data from the Laboratory Effects in Beach Studies (LEBS) Experiments 71Y-07 and 71Y-10," Laboratory Memorandum No. 2, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., unpublished, Oct. 1977.

CHESNUTT, C.B., and GALVIN, C.J., Jr., "Lab Profile and Reflection Changes for H_o/L_o = 0.02," *Proceedings of the 14th Conference on Coastal Engineering*, 1974, pp. 958-977.

CHESNUTT, C.B., and STAFFORD, R.P., "Movable-Bed Experiments with H_o/L_o = 0.021 (1970)," Vol. II, MR 77-7, *Laboratory Effects in Beach Studies*, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Aug. 1977.

CHESNUTT, C.B., et al., "Beach Profile Development on an Initial 1:10 Slope of 0.2 millimeter Sand," *Transactions of the American Geophysical Union*, Vol. 53, 1972, p. 411.

COLLINS, J.I., and CHESNUTT, C.B., "Tests on the Equilibrium Profiles of Model Beaches and the Effects of Grain Shape and Size Distribution," *Proceedings of the Symposium on Modeling Techniques*, 1975, pp. 907-926.

COLLINS, J.I., and CHESNUTT, C.B., "Grain Shape and Size Distribution Effects in Coastal Models," TP 76-11, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., July 1976.

FAIRCHILD, J.C., "Laboratory Tests of Longshore Transport," *Proceedings of the 12th Conference on Coastal Engineering*, 1970a, pp. 867-889.

FAIRCHILD, J.C., "Wave Diffraction in a Laboratory Movable-Bed Set-up," *Bulletin and Summary of Research Progress Fiscal Years 1967-69*, Vol. III, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Washington, D.C., 1970b, pp. 29-40.

GALVIN, C.J., Jr., "Finite-Amplitude, Shallow Water-Waves of Periodically Recurring form," *Proceedings of the Sumposium on long Waves*, 1972, pp. 1-32.

HULSBERGEN, C.H., "Origin, Effect, and Suppression of Secondary Waves," *Proceedings of the 14th Conference on Coastal Engineering*, 1974, pp. 392-411.

SAVAGE, R.P., "Laboratory Study of the Effect of Groins on the Rate of Littoral Transport: Equipment Development and Initial Tests," TM-114, U.S. Army, Corps of Engineers, Beach Erosion Board, Washington, D.C., June 1959.

SAVAGE, R.P., "Laboratory Determination of Littoral-Transport Rates," *Journal of the Waterways and Harbors Division*, Vol. 88, No. WW2, May 1962, pp. 69-92.

STAFFORD, R.P., and CHESNUTT, C.B., "Procedures Used in 10 Movable-Bed Experiments," Vol. I, MR 77-7, *Laboratory Effects in Beach Studies*, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., June 1977.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, Vols. I, II, and III, 2d ed., Stock No. 008-022-00077-1, U.S. Government Printing Office, Washington, D.C., 1975, 1,160 pp.

APPENDIX

EXPERIMENTAL PROCEDURES FOR 71Y-06 and 71Y-10

This appendix documents those aspects of the experimental procedures unique to experiments 71Y-06 and 71Y-10. The procedures common to all experiments are documented in Volume I (Stafford and Chesnutt, 1977).

1. Experimental Layout.

At the beginning of the 1971 experiments, the movable-bed profiles were constructed with sufficient sand to move the initial SWL intercept 7 feet closer to the generator. Because the initial SWL intercept on the movable bed is the standard reference point, the tapes along the center of each pair of tanks were moved to establish the new origin 7 feet seaward of the origin used in experiments 70Y-06 and 70-10 (Chesnutt and Stafford, 1977). This resulted in a 7-foot offset of the origin in the fixed-bed tanks. Figure A-1 shows the position of the initial profiles within each pair of tanks and the adjusted x-axis.

2. Data Collection.

a. Regular Data.

(1) Wave Height Variability. During the first 10-minute run of each experiment and from 375 to 375:10 hours in experiment 71Y-06, a continuous water surface elevation was recorded at station 25 near the toe of the movable-bed slope (Fig. A-1). Wave envelopes in all subsequent runs were recorded with wave gages moving toward and away from the generators along the center of each tank from station +15 to +85 in experiment 71Y-06 and +15 to +50 in experiment 71Y-10 with the instrument carriage moving at a near-constant speed of 10 feet per minute. Wave records 002 to 006 from experiment 71Y-06 contain only one envelope because the runs were too short to permit recording of two envelopes.

(2) Breakers. Table 3 indicates the times during runs when breaker data were collected, which included taking 35-millimeter slides of the breakers three times during each run, recording the breaker position in the logbook just before the end of each run, and preparing the visual observation form near the end of each run. The first two procedures were used throughout the two experiments and the use of the visual observation form was initiated 18 August 1971, at 78 hours in experiment 71Y-10 and 140 hours in experiment 71Y-06.

Unlike the two experiments in 1970, the carriage and camera locations were not maintained at the same positions throughout the tests; therefore, the slides were not useful for determining breaker position. Since the breaker station recorded in the logbook was the position along the centerline of the tank, lateral variations in breaker positions were not recorded. The visual observation form was used to sketch the breaker position

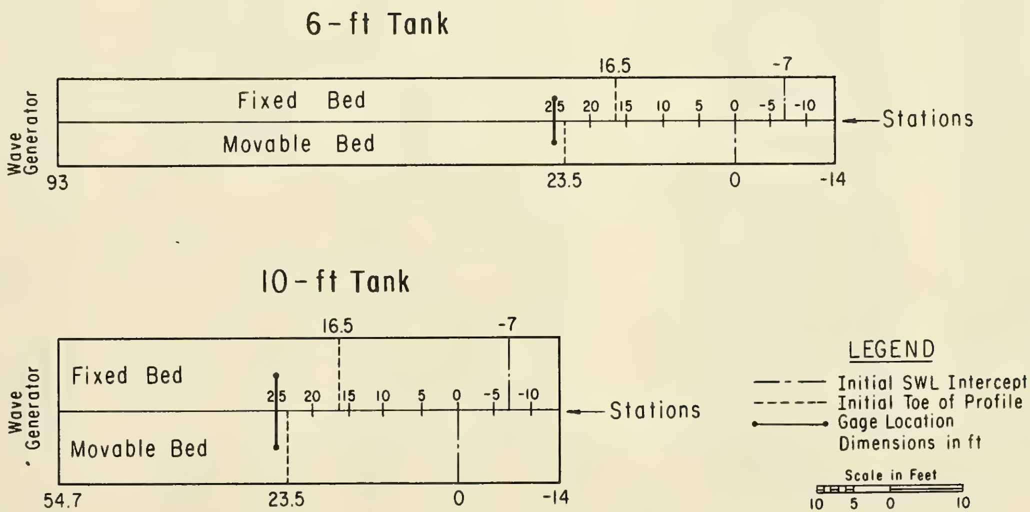


Figure A-1. Experimental setup.

and type, allowing technicians to record lateral variations in breaker position, and the positions of profile features, such as the shoreline and the scarp on a plan view drawing of the wave tank.

b. Special Data. Three types of special data were collected at less frequent intervals, and Table A-1 indicates the times when each type of data was collected.

3. Data Reduction.

a. Wave Height Variability. All wave reflection data collected from the movable-bed profiles in the two experiments were reduced by both the manual and automated methods. Table A-2 presents the K_R data determined by the automated method. Plots of K_R versus time (Figs. A-2 and A-3) compare results from the two methods for experiments 71Y-06 and 71Y-10. Figures A-4 and A-5 are plots of manual K_R values versus automated K_R values. These plots show that the automated method gave consistently lower results and that the difference is not a function of the magnitude of K_R.

b. Sand-Size Distribution Data. All samples were analyzed in the CERC Petrology Laboratory using the RSA. Approximately 5 percent of the samples were analyzed by project personnel using the dry sieve method as a quality control measure.

c. Breaker Data. Breaker type was determined from slides and, after 84 hours in experiment 71Y-10 and 140 hours in experiment 71Y-06, from the visual observation forms. Breaker position data were determined from the logbooks and the visual observation forms.

Table A-1. Summary of special data collection.

Time (hr)	Limits (ft)		
	Profile survey[1]	Photo survey	Sand sample[2]
Experiment 71Y-06			
0	Not taken	Not taken	–6 to +22
26	Not taken	–7 to +23	–6 to +24
52	–6.5 to +19.0	–7 to +23	–5 to +23
100	–6.5 to +19.0	–7 to +25	–7 to +19
200	–5.0 to +20.0	–9 to +25	–9 to +21
300	–11.0 to +21.0	–13 to +31	–9 to +21
375	–13.5 to +21.0	–14 to +31	–13 to +25
380	–13.5 to +21.0	–14 to +31	–13 to +25
Experiment 71Y-10			
0	Not taken	Not taken	Not taken
24	–6.5 to +12.0	–7 to +26	–6 to +20
50	–6.5 to +14.5	–7 to +26	–6 to +20
100	–6.5 to +14.5	–7 to +26	–6 to +20
200	–7.5 to +20.0	–10 to +29	–8 to +24
300	–10.5 to +21.0	–13 to +29	–8 to +24
335	–10.5 to +21.0	–13 to +29	–10 to +24

[1]Elevation measurements at 0.5-foot intervals between the given stations along ranges 0.5 foot apart.

[2]Samples collected at 2-foot intervals between given limits along ranges 1 foot either side of centerline.

Table A-2. Reflection coefficients by automated method for experiments 71Y-06 and 71Y-10.

Time (hr)	Movable bed	Fixed bed	Movable bed	Time (hr)	Movable bed	Fixed bed	Movable bed
	Experiment 71Y-06		Experiment 71Y-10[1]		Experiment 71Y-06		Experiment 71Y-10
00.3	0.102	--------[2]	0.079	104.0	0.060	--------	0.056
00.5	0.075	--------	0.059	109.0	0.012	--------	0.059
00.8	0.039	--------	0.077	114.0	0.022	--------	0.046
01.3	0.077	--------	0.084	119.0	0.033	--------	0.050
01.8	0.079	--------	0.089	124.0	0.011	--------	0.065
02.3	0.066	--------	0.090	129.0	0.049	--------	0.065
03.3	0.045	--------	0.106	134.0	0.042	--------	0.070
04.3	0.026	--------	0.099	139.0	0.053	--------	0.014
05.3	0.034	--------	0.088	144.0	0.045	--------	0.074
06.3	--------	--------	0.061	149.0	0.058	--------	0.063
07.3	0.033	--------	0.055	154.0	0.083	--------	0.042
08.3	0.019	--------	0.049	159.0	0.086	--------	0.040
09.3	0.007	--------	0.045	164.0	0.082	--------	0.051
11.0	0.024	--------	0.026	169.0	0.074	--------	0.036
13.0	0.024	--------	0.045	174.0	0.064	--------	0.074
15.0	0.005	--------	0.020	179.0	0.121	--------	0.056
17.0	0.024	--------	0.018	184.0	0.078	--------	0.044
19.0	0.030	--------	0.020	189.0	0.064	--------	0.073
21.0	0.020	0.057	--------	194.0	0.049	--------	0.068
23.0	0.035	0.054	0.020	199.0	0.087	--------	0.040
25.0	0.050	0.040	0.006	204.0	0.064	--------	0.066
27.0	0.038	0.044	0.038	209.0	0.078	--------	0.087
29.0	0.043	0.048	0.049	214.0	0.083	--------	0.104
31.0	0.050	0.058	0.023	219.0	0.083	--------	0.103
33.0	0.055	0.059	0.009	224.0	0.145	--------	0.105
35.0	0.053	0.032	0.029	229.0	0.137	--------	0.100
37.0	0.049	0.048	--------	234.0	0.189	--------	0.112
39.0	0.033	0.045	0.036	239.0	0.173	--------	0.104
41.0	0.046	0.058	--------	244.0	0.104	--------	0.110
43.0	0.048	0.054	0.048	249.0	0.072	--------	0.126
45.0	0.060	0.054	--------	254.0	0.091	--------	0.134
47.0	0.049	0.045	0.031	259.0	0.107	--------	0.115
49.0	0.049	0.060	0.052	264.0	0.104	--------	0.129
51.0	0.047	0.058	0.058	269.0	0.044	--------	0.120
53.0	0.044	0.059	0.065	274.0	0.053	--------	0.076
55.0	0.048	0.051	0.046	279.0	0.094	--------	0.082
57.0	0.053	0.047	0.040	284.0	0.112	--------	0.091
59.0	0.058	0.054	0.038	289.0	0.092	--------	0.077
61.0	0.046	--------	0.060	294.0	0.107	--------	0.110
63.0	0.050	--------	0.065	299.0	0.089	--------	0.127
65.0	0.056	--------	0.048	304.0	0.111	--------	0.106
67.0	0.048	--------	0.062	309.0	0.151	--------	0.079
69.0	0.057	--------	0.067	314.0	--------	0.035	0.073
71.0	0.055	--------	0.056	319.0	0.214	--------	0.070
73.0	0.045	--------	0.072	324.0	0.176	--------	0.053
75.0	0.055	--------	0.078	329.0	0.067	--------	0.051
77.0	0.044	--------	--------	334.0	0.068	--------	0.089
79.0	0.039	--------	0.059	339.0	0.045	--------	
81.0	0.020	--------	0.040	344.0	0.051	--------	
83.0	0.032	--------	0.025	349.0	0.062	--------	
85.0	0.033	--------	0.057	354.0	0.083	--------	
87.0	0.040	--------	0.053	359.0	0.178	--------	
89.0	0.008	--------	--------	364.0	0.118	--------	
91.0	0.033	--------	0.071	369.0	0.159	--------	
93.0	--------	--------	0.069	374.0	0.225	--------	
95.0	0.031	--------	0.076	375.7[3]	0.207	--------	
97.0	0.050	--------	0.071	376.5[3]	0.240	--------	
99.0	0.071	--------	0.071	378.0[3]	0.243	--------	

[1]Fixed bed in experiment 71Y-10 not analyzed by this method.

[2]Not analyzed by this method.

[3]Standing wavelength 15.70 feet; standing wavelength was 7.0 feet at all other times.

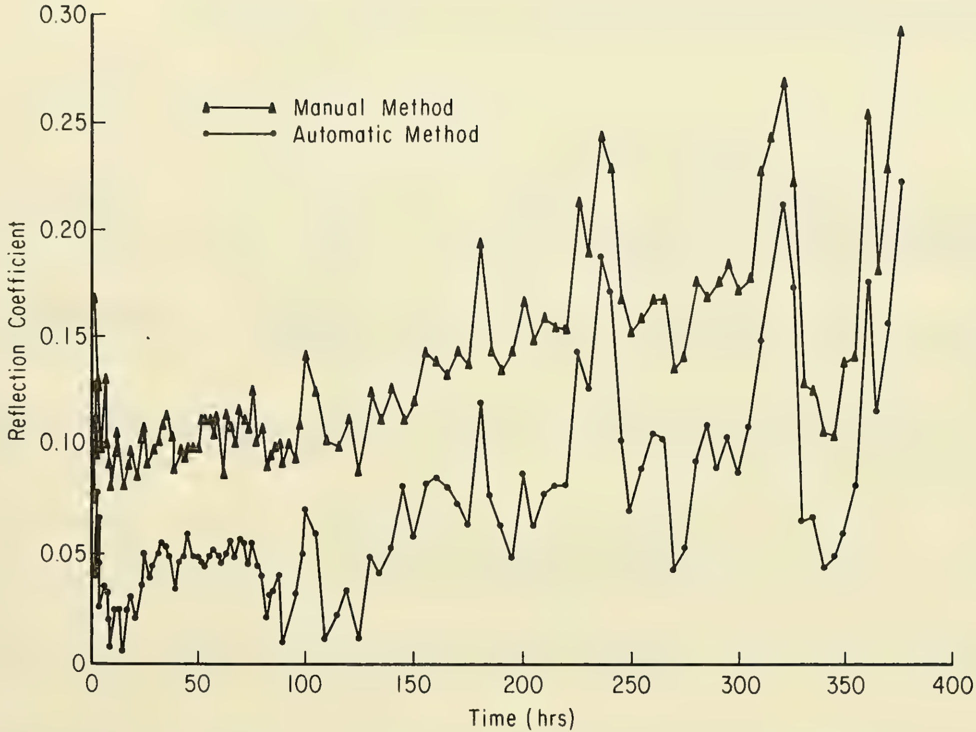


Figure A-2. Comparison of manual and automated reflection coefficients, experiment 71Y-06.

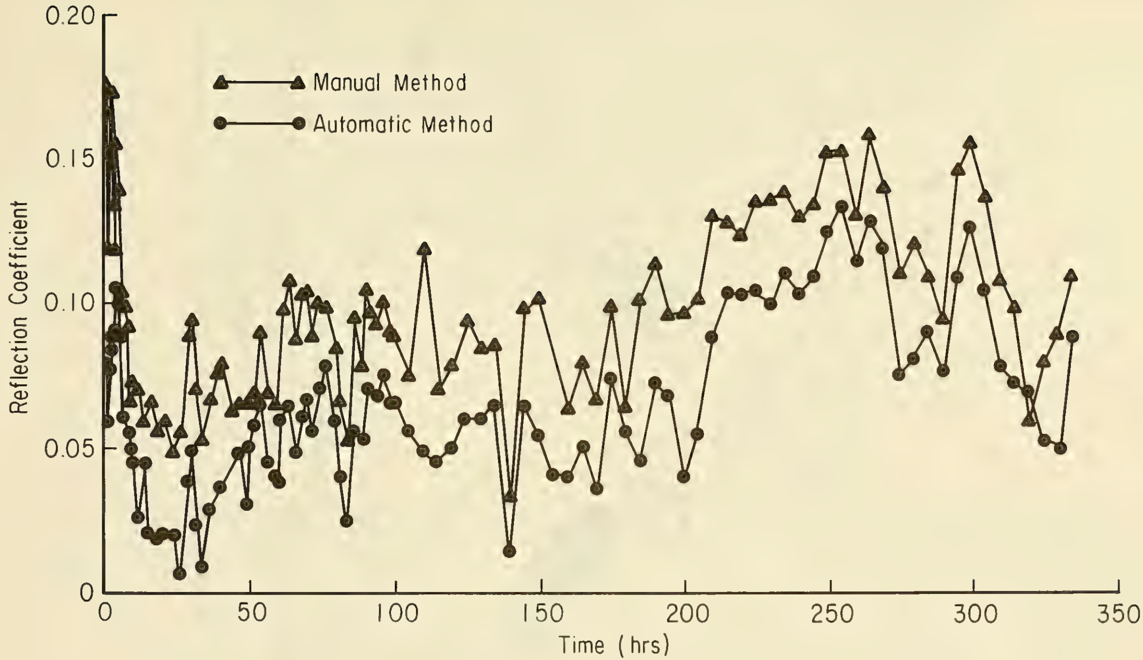


Figure A-3. Comparison of manual and automated reflection coefficients, experiment 71Y-10.

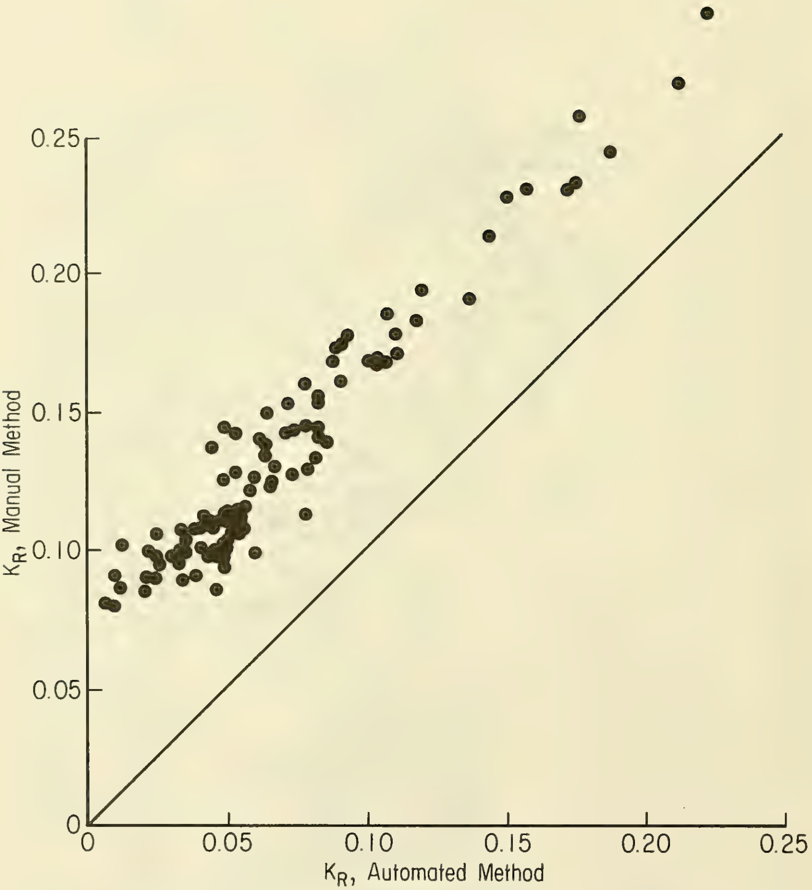


Figure A-4. Correlation of manual and automated K_R's, experiment 71Y-06.

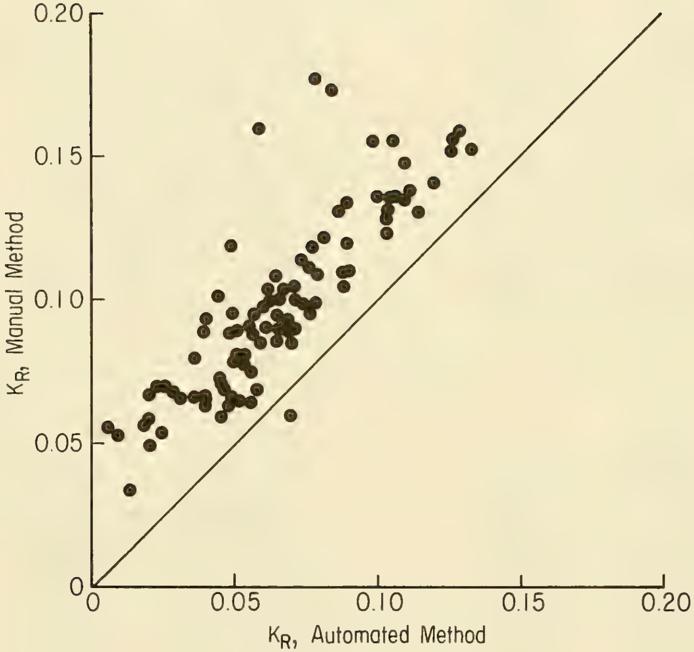


Figure A-5. Correlation of manual and automated K_R's, experiment 71Y-10.

Chesnutt, Charles B.
Laboratory effects in beach studies. Volume III. Movable-bed experiments with H_0/L_0 = 0.021 (1971) / by Charles B. Chesnutt and Robert P. Stafford. – Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1977.
111. p. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; no. 77-7)
Bibliography: p. 101.
Movable-bed experiments conducted in 6- and 10-foot-wide wave tanks, with waves directed normal to the initial shoreline, showed that tank width can affect littoral processes studies. Reflection coefficient variations were significant and qualitatively related to profile development.
1. Coastal engineering. 2. Breakers. 3. Currents. 4. Movable beds. 5. Wave generators. 6. Wave reflection. 7. Wave tanks. I. Title. II. Stafford, Robert P., joint author. III. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-7.

TC203 .U581mr no. 77-7 627

Chesnutt, Charles B.
Laboratory effects in beach studies. Volume III. Movable-bed experiments with H_0/L_0 = 0.021 (1971) / by Charles B. Chesnutt and Robert P. Stafford. – Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1977.
111. p. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; no. 77-7)
Bibliography: p. 101.
Movable-bed experiments conducted in 6- and 10-foot-wide wave tanks, with waves directed normal to the initial shoreline, showed that tank width can affect littoral processes studies. Reflection coefficient variations were significant and qualitatively related to profile development.
1. Coastal engineering. 2. Breakers. 3. Currents. 4. Movable beds. 5. Wave generators. 6. Wave reflection. 7. Wave tanks. I. Title. II. Stafford, Robert P., joint author. III. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-7.

TC203 .U581mr no. 77-7 627

Chesnutt, Charles B.
Laboratory effects in beach studies. Volume III. Movable-bed experiments with H_0/L_0 = 0.021 (1971) / by Charles B. Chesnutt and Robert P. Stafford. – Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1977.
111. p. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; no. 77-7)
Bibliography: p. 101.
Movable-bed experiments conducted in 6- and 10-foot-wide wave tanks, with waves directed normal to the initial shoreline, showed that tank width can affect littoral processes studies. Reflection coefficient variations were significant and qualitatively related to profile development.
1. Coastal engineering. 2. Breakers. 3. Currents. 4. Movable beds. 5. Wave generators. 6. Wave reflection. 7. Wave tanks. I. Title. II. Stafford, Robert P., joint author. III. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-7.

TC203 .U581mr no. 77-7 627

Chesnutt, Charles B.
Laboratory effects in beach studies. Volume III. Movable-bed experiments with H_0/L_0 = 0.021 (1971) / by Charles B. Chesnutt and Robert P. Stafford. – Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1977.
111. p. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; no. 77-7)
Bibliography: p. 101.
Movable-bed experiments conducted in 6- and 10-foot-wide wave tanks, with waves directed normal to the initial shoreline, showed that tank width can affect littoral processes studies. Reflection coefficient variations were significant and qualitatively related to profile development.
1. Coastal engineering. 2. Breakers. 3. Currents. 4. Movable beds. 5. Wave generators. 6. Wave reflection. 7. Wave tanks. I. Title. II. Stafford, Robert P., joint author. III. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-7.

TC203 .U581mr no. 77-7 627

Chesnutt, Charles B.
Laboratory effects in beach studies. Volume III. Movable-bed experiments with H_0/L_0 = 0.021 (1971) / by Charles B. Chesnutt and Robert P. Stafford. – Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1977.
111. p. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; no. 77-7)
Bibliography: p. 101.
Movable-bed experiments conducted in 6- and 10-foot-wide wave tanks, with waves directed normal to the initial shoreline, showed that tank width can affect littoral processes studies. Reflection coefficient variations were significant and qualitatively related to profile development.
1. Coastal engineering. 2. Breakers. 3. Currents. 4. Movable beds. 5. Wave generators. 6. Wave reflection. 7. Wave tanks. I. Title. II. Stafford, Robert P., joint author. III. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-7.

TC203 .U581mr no. 77-7 627

Chesnutt, Charles B.
Laboratory effects in beach studies. Volume III. Movable-bed experiments with H_0/L_0 = 0.021 (1971) / by Charles B. Chesnutt and Robert P. Stafford. – Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1977.
111. p. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; no. 77-7)
Bibliography: p. 101.
Movable-bed experiments conducted in 6- and 10-foot-wide wave tanks, with waves directed normal to the initial shoreline, showed that tank width can affect littoral processes studies. Reflection coefficient variations were significant and qualitatively related to profile development.
1. Coastal engineering. 2. Breakers. 3. Currents. 4. Movable beds. 5. Wave generators. 6. Wave reflection. 7. Wave tanks. I. Title. II. Stafford, Robert P., joint author. III. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-7.

TC203 .U581mr no. 77-7 627

Chesnutt, Charles B.
Laboratory effects in beach studies. Volume III. Movable-bed experiments with H_0/L_0 = 0.021 (1971) / by Charles B. Chesnutt and Robert P. Stafford. – Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1977.
111. p. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; no. 77-7)
Bibliography: p. 101.
Movable-bed experiments conducted in 6- and 10-foot-wide wave tanks, with waves directed normal to the initial shoreline, showed that tank width can affect littoral processes studies. Reflection coefficient variations were significant and qualitatively related to profile development.
1. Coastal engineering. 2. Breakers. 3. Currents. 4. Movable beds. 5. Wave generators. 6. Wave reflection. 7. Wave tanks. I. Title. II. Stafford, Robert P., joint author. III. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-7.

TC203 .U581mr no. 77-7 627

Chesnutt, Charles B.
Laboratory effects in beach studies. Volume III. Movable-bed experiments with H_0/L_0 = 0.021 (1971) / by Charles B. Chesnutt and Robert P. Stafford. – Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1977.
111. p. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; no. 77-7)
Bibliography: p. 101.
Movable-bed experiments conducted in 6- and 10-foot-wide wave tanks, with waves directed normal to the initial shoreline, showed that tank width can affect littoral processes studies. Reflection coefficient variations were significant and qualitatively related to profile development.
1. Coastal engineering. 2. Breakers. 3. Currents. 4. Movable beds. 5. Wave generators. 6. Wave reflection. 7. Wave tanks. I. Title. II. Stafford, Robert P., joint author. III. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-7.

TC203 .U581mr no. 77-7 627