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Longshore Sediment Transport Rates : A Compilation of Data

by
M. M. Das

MISCELLANEOUS PAPER NO. 1—71
SEPTEMBER 1971

U. S. ARMY, CORPS OF ENGINEERS
COASTAL ENGINEERING
RESEARCH CENTER

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ABSTRACT

This report is a compilation of data on longshore sediment transport and associated wave and sediment characteristics from six laboratory studies and four field studies. Laboratory observations include water depth, wave height, wave period, median grain size, wave generator angle with the toe of the beach, and longshore transport rate. Laboratory wave heights range from 0.035 to 0.51 foot, periods from 0.75 to 3.75 seconds, depth from 0.49 to 2.33 feet, generator angles from 10 to 50 degrees, initial beach slope from 1:5.6 to 1:33, median grain size from 0.22 mm. to 1.55 mm., and specific gravities from 1.1 to 2.69.

The maximum transport rate in studies near Anaheim Bay, California, is 2,130 cubic yards per day, north. The maximum rate near South Lake Worth Inlet, Florida, is 1,300 cubic yards per day, south. The estimated transport rate at Cape Thompson, Alaska, is 4,680 cubic yards per day. The maximum rate at Silver Strand Beach, California, is 3,400 cubic yards per day.

FOREWORD

Laboratory and field data collected by researchers from 1944 to 1970 were used in preparing this report.

M. M. Das of the Research Division prepared the report. At the time of publication, Lieutenant Colonel Don S. McCoy was Director of CERC; Thorndike Saville, Jr. was Technical Director.

Note: Comments on this publication are invited. Discussion will be published in the next issue of the CERC Bulletin.

This report is published under authority of Public Law 166, 79th Congress, approved July 31, 1945, as supplemented by Public Law 172, 88th Congress, approved November 7, 1963.

CONTENTS

ILLUSTRATIONS

Table

ILLUSTRATIONS (Continued)

ILLUSTRATIONS (Continued)

LIST OF SYMBOLS

Count	Serial number of various observations for this report.
d	Water depth in constant depth section, in feet.
e	Wave generator eccentricity in inches
E_{α}	Longshore component of wave energy flux, in ft-lbs per day per foot of beach.
H	Wave height in constant depth section, in feet.
H_o	Computed deepwater wave height, in feet.
ID	Within-test identification of observation by author and number.
I_{ℓ}	Longshore transport rate in lbs. per day.
M_d	Median grain diameter, in mm.
m	Initial beach slope.
P_{ℓ}	Longshore component of wave energy flux (power in ft/lbs per foot of beach per day).
Q	Longshore transport rate in yd^3/day.
S_r	Specific gravity of the bed material.
T	Wave period, in seconds.
V	Longshore current velocity, in feet per second.
α	Angle between wave crest and shoreline, in degrees.
α_b	Breaker crest angle, in degrees
α_o	Deepwater wave angle, in degrees.
α_g	Nominal setting of the wave generator to the beach line, in degrees.

LONGSHORE SEDIMENT TRANSPORT RATES: A COMPILATION OF DATA

by

M. M. Das

Section I. INTRODUCTION

When waves approach the shore obliquely and break, they generate a longshore current, which as a part of the nearshore current system transports sand along the shore. The principal objective of the laboratory and field studies from which data have been compiled in this report was to relate the rate of longshore transport to the longshore component of wave energy flux or the various parameters describing the energy. Lacking adequate knowledge of the hydrodynamics of the flow field in the littoral zone and of the sediment-flow interaction in an oscillatory turbulent flow, empirical predictions of longshore transport are attempted. Such attempts need either laboratory or field data on longshore transport and the associated wave and sediment characteristics.

The purpose of this report is to compile and describe the available longshore-transport data. These include six sets of laboratory measurements (Krumbein, 1944; Saville, 1950; Shay and Johnson, 1951; Sauvage and Vincent, 1954; Price and Tomlinson, 1969; and Fairchild, 1970); and four sets of field measurements (Watts, 1953; Caldwell, 1956; Moore and Cole, 1960; and Komar, 1969). For each laboratory study the longshore-transport data and the associated wave and sediment characteristics have been listed in a single table in Appendix A. For the field studies, the data are presented in the form available in published or unpublished records. This compilation forms the background for a review and evaluation of the data and a suggested relationship between longshore energy flux and longshore transport.

The compilation of the 10 studies is summarized in Tables 1, 2, 3, and 4. Table 1 summarizes the sediment characteristics of the studies, Table 2 shows a comparison of the range of important variables in the six laboratory studies, Table 3 gives a summary of the wave basin dimensions and approximate beach length in the laboratory studies, and Table 4 compares the salient features of the four field studies. These four tables follow the INTRODUCTION. The subsequent Tables (5 through 28) included in Appendix A present the available data, which consist of the actual quantities measured. Wherever a variable has been computed rather than measured, it is so mentioned in the table. Figures in Appendix B include the laboratory test setups, location maps of field studies, and longshore transport and wave measurement sites of the field studies, wherever available. Section II gives a brief description of each study; Section III contains the characteristics of the sediment in each study; and Section IV is a discussion pointing out the important aspects of the data.

TABLE 1

SUMMARY OF SEDIMENT CHARACTERISTICS OF 10 STUDIES

Study No.	Source of Data	Study Date	Publication Date	Sediment Characteristics	
				M_d (mm)	S_r
1	Laboratory (Berkeley) Krumbein	1942	1944	0.50	2.65
2	Laboratory (Berkeley) Saville	1948-49	1950	0.30	2.69
3	Laboratory (Berkeley) Shay and Johnson	1950	1951	0.30	2.69
4	Laboratory (Grenoble) Sauvage and Vincent	-	1954	0.50 1.50 1.00	2.60 1.40 1.10
5	Laboratory (CERC) Savage and Fairchild	1958-66	1962 1970	0.22	2.65
6	Laboratory (Wallingford) Price and Tomlinson	-	1969	0.80	1.35
7	Field (South Lake Worth Inlet, Florida) Watts	1952	1953	0.40 *	2.70 **
8	Field (Anaheim Bay, California) Caldwell	1948-49	1956	0.40 ***	2.65
9	Field (Cape Thompson, Alaska) Moore and Cole	1959	1960	1.0	2.65 (assumed)
10	Field a. El Moreno Beach, Baja California Komar	-	1969	0.60	2.65
	b. Silver Strand Beach, California Komar	-	1969	0.175	2.65

* Variable (Table 15), approximately average median diameter = 0.40 mm.

** Computed 72% shell S_r = 2.72, 28% quartz S_r = 2.65

*** Variable (Table 23), approximately average median diameter = 0.40 mm.

TABLE 2

COMPARISON OF VARIABLES IN SIX LABORATORY STUDIES

Authors	Period T (seconds)	Height H (feet)	Water Depth d (feet)	Wave Gen. Angle α_g (degrees)	Initial Slope	Characteristics		No. of Observations
						M_d (mm)	S_r	
1. Krumbein	.97-2.04	.073-.271	1.30	15	1:5.6 (or 10°)	0.50	2.65 (assumed)	15
2. Saville	.714-1.500	.069-.167	1.48	10	1:10	0.30	2.69 (assumed)	9
3. Shay and Johnson	.86-1.40	.080-.148	1.440-1.480	10	1:10	0.30	2.69	18
	.76-1.25	.124-.187	1.600-1.700	20	1:10	0.30	2.69	6
	.75-1.50	.052-.176	1.480-1.486	30	1:10	0.30	2.69	33
	.76-1.25	.113-.198	1.600-1.701	30	1:10	0.30	2.69	11
	.76-1.25	.104-.195	1.599-1.701	40	1:10	0.30	2.69	17
	.76-1.25	.106-.197	1.598-1.601	50	1:10	0.30	2.69	14
4. Sauvage & Vincent	.94	.105-.179	.49	15	?	0.50	2.60	3
	.94	.035-.146	.49	15	?	1.50	1.40	8
	.94	.047-.095	.49	15	?	1.00	1.10	6
(Values computed from authors' Figure 5)								
5. Fairchild	1.50-3.75*	.140-2.46	2.33	30	1:20	0.22	2.65	6
	1.25-3.75	.140-0.614	2.33	30	1:10	0.22	2.65	26
	1.50-3.00*	.176-0.192	2.33	30	Composite about 1:33	0.22	2.65	3
6. Price and Tomlinson	1.46	.183	1.0	5	1:17	0.80	1.35	2
	1.15	.208						

* Average value in variable-period tests

TABLE 3

SUMMARY OF WAVE BASIN DIMENSIONS IN LABORATORY STUDIES

Source of Data	Count	Basin Dimensions (feet)	Approximate Beach Length (feet)
1. Krumbein	1-15	58.2 x 38.7 x 2.0	38
2. Saville	16-24	122 x 66 x 2.0	60
3. Shay and Johnson	25-123	122 x 66 x 2.0	60 (Counts 25-81) 33 (Counts 82-123)
4. Sauvage and Vincent	124-140	Not available	Not available
5. Fairchild (CERC)	141-175	150 x 100 x 30 (North Sector) 200 x 150 x 30 (South Sector) *	30 - 98 (Variable)
	141-142		98
	143-		98
	144-145		30
	146-149		98

*Portions of the basin used in studies, see Figures 2b, 3 a and b.

TABLE 3 (Continued)

SUMMARY OF WAVE BASIN DIMENSIONS IN LABORATORY STUDIES

Source	Count	Basin Dimensions (feet)	Approximate Beach Length (feet)
5. Fairchild (CERC)	150-156 (150, 151 153, 155, 156)	(continued)	30 (North Sector)
	152, 154		43 (South Sector)
	157		38 (South Sector)
	158, 159		30 (North Sector)
	160		35 (North Sector)
	161-163		98 (South Sector)
	164-166		30 (North Sector)
	172-175		40 (North Sector)
6. Price and Tomlinson	176-177	190 x 75	

TABLE 4

COMPARISON OF SALIENT FEATURES OF FOUR FIELD STUDIES

Period of Study	Source of Longshore Transport Data	Depth where H, T measured
Watts 7 Mar 52 to 11 Jun 52	Sand bypassing plant located on north jetty of South Lake Worth Inlet, Florida. Transport rate measured from detention basin south of south jetty or from pumping rate during periods pump did not discharge material into the detention basin.	17 feet MSL (pressure wave recorder) 12-minute records at 4-hour intervals.
Caldwell 29 Mar 48 to 19 Aug 49	Erosion or accretion of the beach fill placed at Surfside, California, between survey ranges 3-10 (i.e., 10,000 feet). Measurements obtained from beach profile changes.	20 feet MLLW
Moore and Cole 11 Jul 59 (1:30 PM to 4:30 PM)	Plane table survey of the growth of a sand spit at outlet of Tasaychek Lagoon, 12 miles north of Cape Krusenstern, Alaska	Not mentioned in original reference
Komar	From measurement of advection rate and depth of burial of fluorescent dyed sand grains at El Moreno Beach, Mexico and Silver Strand Beach, California.	Not available in reference

TABLE 4 (Continued)

Depth where wave energy computed	Distance between wave and transport measurement sites	Distance between wave direction and transport measurement sites	Type of Transport
17 feet MSL (Southerly component of wave energy only computed)	At Palm Beach Pier 11 miles north of inlet	3½ miles north of inlet from Ambassador Hotel (Sighting bar attached to transit used)	Littoral drift intercepted by north jetty (net drift)
12 feet MLLW (Both northerly and southerly component of wave energy computed)	6 miles south of Anaheim Bay at Huntington Beach Pier	Hindcasted using synoptic charts for waves originating north of latitude 20° N for period 30 Mar 48 to 29 Mar 49	Both southerly & northerly transport past range 10
Not mentioned in original reference			Southerly transport. Longshore current of 126 feet per minute to the south
Breaker depth	Measured at same location	Measured at same location	

Section II. DESCRIPTION OF INVESTIGATIONS

The following paragraphs describe each study in the order it appears in the tables of Appendix A. The experimental setup is described and the variables measured are defined.

1. Krumbein's Laboratory Study

A laboratory study was conducted by Krumbein in 1942 at the University of California, Berkeley. The experimental setup is shown in Figure 2A. Longshore transport rate, longshore current velocity, and wave and sediment characteristics were measured. The maximum rate of removal of sand from the updrift end of the beach was determined from the rate of feed of material to a hopper. The rate was adjusted to the capability of the waves to move sand. Longshore currents were measured by using floats and confetti. The maximum velocity parallel to shore near the plunge line was measured by releasing a soaked string, and recording the movement of the end of the string over a fixed time interval. Wave heights were measured with a combination point and hook gage in which the hook could be set to the troughs of the waves and the point to the crests. The wave height was then obtained by reading the difference in gage heights on a single vernier. The mechanical analysis of the sand is given in Figure 4, and the data are presented in Table 5.

2. Saville's Laboratory Study

Saville conducted a laboratory study at the University of California, Berkeley. The test setup is shown in Figure 1A. The measurements of the wave and sediment characteristics, sand transport rate, and longshore currents are presented in Table 6. The total transport rate due to bedload and suspended load was determined by installing a weighing device at the downcoast end of the beach. The bedload rate was measured by installing hoppers on the beach. The rate of longshore transport in cubic yards per day has been computed from the author's given dry weight rate in pounds per hour using a unit weight of 105 pounds per cubic foot. Breaker angles were determined from vertical photographs. The mechanical analyses of sand are given in Figure 4.

3. Shay and Johnson's Laboratory Study

A laboratory study was conducted by Shay and Johnson at the University of California. The layout of the wave basin and the test setup are shown in Figure 1B. Wave and sediment characteristics, longshore transport rate, and maximum longshore current were measured in the tests. Tables 7 through 12 show the variables measured in the tests. Wave height variability was observed in the experiments; so many readings were taken during each run and an arithmetic average of the readings was used to characterize the wave height. Wave heights were measured with a point and hook gage as in Krumbein's tests. The bedload rate was measured by installing hoppers on the beach for small generator angles. These hoppers were removed when wave splitters were used for angles of 30 degrees or greater. The rate of longshore transport in cubic yards per day in Tables 7 to 12 are computed values using a unit weight of 105 pounds per cubic foot from authors' weight rate data in pounds per hour. The same method was used in Saville's study. Johnson has confirmed (personal communication) that the transport rate Q (lbs/hour) tabulated in the report is the dry-weight rate.

Longshore current velocities (maximum and the average) were measured by releasing fluorescein. The breaker angles were determined from vertical photographs as in Saville's study.

Equilibrium beach profiles were taken after a stable condition was reached by inserting a piece of sheet metal in the beach perpendicular to the beach contours and tracing the sand profile under water with a grease marker, with a view to study the influence of wave steepness on beach profile.

4. Sauvage and Vincent's Laboratory Study

Two series of laboratory experiments were conducted by the authors at the hydraulics laboratory at Grenoble, France. In the first series of tests, the beach was set at an angle of 15 degrees with the wave makers. In the second series, the angle was varied from 5 degrees to 70 degrees. In addition, there was a unique set of experiments in which three types of sediments with different characteristics were used. The volume of material, fed from a distributor and transported along the beach, was collected in a trap at the downdrift end. The data from the measurements of longshore transport and the wave characteristics are presented only in graphical form in the paper by Sauvage and Vincent (1954). The actual measured data are not available. Using Figure 5 *of the authors* the longshore transport rates and the wave characteristics have been obtained as shown in Table 13.

5. Savage and Fairchild's Laboratory Study

In a laboratory program on the studies of longshore transport at the former Beach Erosion Board (BEB), presently known as Coastal Engineering Research Center (CERC), several tests were conducted from 1958 to 1966. Ten of these tests were reported by Savage (1962), and all of the tests in edited form appear in Fairchild's paper (1970).

The transport studies were made in the north and south sectors of the Shore Processes Test Basin (SPTB) shown in Figures 2B, 3A, and 3B. Beach geometry and characteristics, the associated wave characteristics, and the rates of transport of beach material are presented in Tables 14 and 15. A detailed description of the SPTB, the sand transporting system, the sand traps and the sand weighing system are in BEB Technical Memorandum No. 114 (Savage 1959), and are not given here. The total quantity of longshore drift caught in the sand traps was recorded for every 5-hour interval during the test. To convert the weight rate to volume rate, a unit weight of 105 pounds per cubic foot was used for the sand tested. To establish a relationship between the longshore energy and the longshore transport rate, the transport rate between the 20th and 30th hours of test was used, whenever the test continued over 20 hours.

Due to the large variability in wave heights observed in the SPTB during the test, it was difficult to characterize each test with a particular measured incident wave height. It was decided to characterize the waves in the SPTB by a half-size Froude model in another wave flume (75 feet by 1.5 feet by 2.0 foot deep) at CERC. By varying the eccentricity and the period in the wave flume, the wave heights (before visible reflection occurred) were measured. The average of these wave heights was considered as the height of incident wave at that particular depth of water. The wave height and eccentricity corresponding to SPTB test conditions were derived from half-scale, Froude-model wave tank studies.

A family of curves was obtained for wave heights as a function of wave period with eccentricity as a parameter. These curves were used to characterize the incident waves in the SPTB (Fairchild, 1970), and these values (due to the large variability in wave heights in the measurements of wave heights in SPTB)were used to compute the wave energy in the SPTB. Fluorescein was used in most tests to measure longshore currents. Beach samples were also obtained in the tests. Water temperature measurements were made during each test at frequent intervals.

6. Price and Tomlinson's Laboratory Study

Studies were conducted at Wallingford Research Station (England) on the effect of groins on a beach stable for a particular wave condition and beach material. Longshore transport was also measured on two occasions without groins.

The wave basin is 190 feet by 75 feet equipped with a snake type wave maker, and tide and tidal-current generators. Bed material was crushed coal with specific gravity of 1.35 and mean grain size of 0.80 mm. The initial beach slope was 1 on 17 at mean tide level. The experimental conditions and variables measured are given in Tables 2 and 16.

7. Watt's Field Study

By measuring wave characteristics, longshore currents, and amount of material pumped by the bypassing plant on the north side of the north jetty at South Lake Worth Inlet, Florida, Watts (1953) attempted to relate the volume of longshore transport reaching the pump intake to the wave energy reaching adjacent shores.

The material pumped by the bypassing plant was measured by pumping it into a detention basin located on the south side of the intake. The period of pumping considered in the analysis is from February 25 to June 11 of 1952. During this period, the pumping plant bypassed almost all the littoral drift moving alongshore inside the surf zone. Therefore, it was assumed that the pumped volume would represent the total southerly longshore transport rate in the nearshore zone. The material pumped into the detention basin was periodically surveyed for measurement of the quantity. During the period the detention basin was being cleared and leveled, the material could not be pumped into the basin, but the material pumped during these intervals was estimated from the average pumping rate of 76.2 cubic yards per hour, computed from the log of pumping time between January 1949 and December 1951, furnished by the Palm Beach County Engineer. The volume of material pumped and used in the analysis is given in Table 18. Wave heights and periods were measured by a pressure gage located at Palm Beach Pier, 11 miles north of the Inlet and in about 17 feet of water below mean sea level. The recording mechanism was programmed to obtain a 12-minute record every 4 hours from 6 March to 10 June 1952. The wave data are presented in Table 17.

Wave directions were measured twice daily by the use of a sighting bar and auxiliary sights attached to an ordinary engineer transit located on the roof of the Ambassador Hotel about 3.5 miles north of the bypassing plant.

Significant wave heights and periods were computed from the wave records. Frequencies of wave heights and periods were plotted. A wave direction frequency plot indicated that 75 percent of the direction (Table 20) were from north of east. The predominant direction of longshore transport along the Florida Coast is generally from north to south. Therefore, for the data presented in the analysis, the alongshore component of wave energy was computed for each month for southerly wave directions ($\alpha \leq 90°$) from durations for each α and the corresponding recorded wave height and period data. The total monthly southerly longshore transport was evaluated from the pumped material. The data are presented in Table 19 on a monthly and daily basis. The southerly component of wave work is expressed in foot-pounds per day per foot of wave crest, and the southerly rate of littoral transport is expressed in cubic yards per day.

Longshore currents inside the breaker zone were measured twice daily by using fluorescein at four locations at distances of 1/2 mile, 2 miles, 5 miles, and 7 miles north of the bypassing plant at the same time the wave directions were measured.

Sediment samples were taken during the study. The data for sampling stations 1/2 mile north of inlet and 1,000 feet south of inlet on different dates and at high, mean, and low tide lines, and at 3-foot water depth are presented. The data for five samples taken from the inner bar and the ocean bar, and the data for the samples taken in the detention basin are also presented (see Table 21).

8. Caldwell's Field Study

From measurements of the rate of alongshore sand movement of a beach fill placed at Surfside, south of Anaheim Bay, California, and the associated wave characteristics, an attempt was made to correlate the two. The summary of computed wave energy and longshore transport rate is given in Table 26. The beach profile changes shown by seven surveys out to the 20-foot contour were used to compute the volume changes of beach fill along the shore. The volume changes are given in Tables 24 and 25.

Wave heights and periods were obtained from 8-minute wave records taken at 4-hour intervals by wave gages installed on the Huntington Beach Pier about 6 miles south of Anaheim Bay. The depth of water at the gaging station was 20 feet below mean lower low water. Utilizing meteorological data, wave forecasting techniques were used to "hindcast" significant wave heights, significant periods, and the directions of wave approach. Hindcast heights and periods were used to supplement recorded heights and periods where gaps occurred in the record. Aerial photographs of the study area were also taken. Wave direction and period were also determined from the photographs. Hindcasting and wave refraction analysis were used in combination to determine the wave direction associated with each wave observation. This analysis showed that the northerly longshore transport was caused by southerly waves reaching the 12-foot depth at an average angle of 21 degrees, and that the southerly longshore transport was due to northerly waves reaching the same depth at an average angle of 9 degrees to the beach. The wave climate near Anaheim Bay and comparison of wave data (Caldwell, 1956) are given in Tables 22 and 23, respectively.

Sand samples were taken from beaches along the different survey ranges twice during the survey period, once in March 1948 at the early part of the survey and once in August 1949 towards the end of the survey period. The average median grain sizes of the material are tabulated in the report (Table 27). The summary average given in the table shows that the median grain diameter in the beach fill area (Survey ranges 3-7A) is 0.42 mm.

9. Moore and Cole's Field Study

A transport rate of 4,680 cubic yards per day was measured near Cape Thompson, Alaska, from the growth of a sand spit during a 3-hour period. The material was deposited on the spit by waves 5 feet high with a period of 5.5 seconds and a 25-degree angle to the beach.

10. Komar's Field Study

Studies were conducted at El Moreno Beach located on the northwest shore of Gulf of California, in Baja California, Mexico, and at Silver Strand Beach near San Diego, California. The purpose was to obtain field measurements of the bedload transport rate over short periods of time and, simultaneously, to measure the waves and currents to be able to test relationships between the longshore transport rate and the wave energy flux.

The measurements of longshore transport rate of sand were made through use of natural sand colored with a thin coating of fluorescent dye. The sand advection rate was determined from the time history of the movement of the center of gravity of the sand tracer which had been introduced onto the beach. The thickness of the sand in motion was obtained from the depth of burial of the tracer sand in cores of the beach face. The product of the advection rate times the cross section of the sand in motion gave the sand transport rate. The wave direction and wave energy flux were obtained from simultaneous measurement of wave characteristics by an array of digital wave sensors placed in and near the surf zone. The wave sensors were of pressure type measuring pressure variation near the bottom. The energy density obtained from measurements of the pressure transducers was corrected for the damping effect due to overlying depth of water using the linear pressure response factor. The root-mean square wave height obtained from the energy density, and the characteristic wave period obtained from the frequency spectrum were used to compute the wave energy flux at the breaker depth.

Two models for prediction of longshore transport were tested. The first relates the immersed-weight transport rate to the longshore component of energy flux. The second is based on the concept that the waves provide the power to move and support the sand and the superimposed longshore current results in the longshore transport.

The energy flux, the volume and immersed-weight transport rate for the 14 tests, 10 at El Moreno Beach and 4 at Silver Strand Beach, are given in Table 28. The sediment and beach characteristics at the two sites are in Table 1.

Section III. SEDIMENT CHARACTERISTICS

In a discussion of Savage's (1962) paper, Manohar (1962), following the approach of Einstein (1950), showed the influence of sediment characteristics on the transport rate. Table 1 shows the median grain diameters and specific gravity of the beach material in field or laboratory studies.

1. Laboratory Studies

Krumbein's (1944) mechanical analysis of the original sand used in the tests is shown in Figure 4. The median grain diameter is 0.50 mm. The geometric mean diameter and phi standard deviation were determined graphically by Otto's (1939) method. The specific gravity of the material is not mentioned in the report, but a value of 2.65 is assumed.

Saville (1950) presented the mechanical analysis data of the sand used in his tests (Figure 4). The M_d of the sand used is 0.30 mm and the specific gravity is 2.69.

Shay and Johnson's (1951) mechanical analysis of the sand used in the studies is given in Figure 4. The M_d is nearly 0.30 mm and the specific gravity of the quartz sand is 2.69.

In the studies by Sauvage and Vincent (1954), the mean grain sizes of the three materials used were 0.5 mm, 1.5 mm, and 1.0 mm, and their respective specific gravities were given as 2.60, 1.40 and 1.1.

A size distribution of the sediment used in BEB studies (1958-1966) is shown on Figure 4. The M_d is 0.22 mm and the specific gravity is assumed as 2.65 for the quartz sand. The mean grain size and the specific gravity of crushed coal used in Price and Tomlinson's studies (1969) are 0.80 mm and 1.35 respectively.

2. Field Studies

Sand size analysis of samples obtained during the study at South Lake Worth Inlet, Florida, (Watts, 1953) are shown in Table 21. The size distributions were done by an Emery Settling Velocity Tube.

Considering the samples taken at 1/2 mile north of the Inlet to be representative of material in movement in the littoral zone in the area, a mean grain size of 0.41 mm, or 0.40 mm as suggested by Caldwell (1956), may be accepted for this study. The average shell content of the samples at 1/2 mile north of the Inlet is 72 percent (Watts, 1953). Most of the remaining 28 percent is presumably quartz. Considering this shell to be calcite with specific gravity of 2.72 and the quartz of specific gravity of 2.65, the average specific gravity of the material would be 2.70.

Summary of beach sand size analysis of the Anaheim data (Caldwell, 1956) is given in Table 27. The summary includes materials at several survey locations. An average value of the grain size of the material between survey ranges 3 and 10 would be 0.40 mm. A specific gravity of 2.65 may be assumed for the beach fill material moving in the survey area.

The sand size analyses for Silver Strand Beach and El Moreno Beach samples (Komar, 1969) are shown on Figure 4. The median diameters of the samples are 0.175 mm and 0.60 mm, respectively. The specific gravity is 2.65. The median grain size of the beach material in Moore and Coles' (1960) study was 1.0 mm.

Section IV. DISCUSSION OF DATA

The data in the tables and the foregoing descriptions show the main differences and points in common among the sets of data. Some of the important aspects of the data are brought out here.

1. Laboratory Data

The same wave basin (122 feet by 66 feet by 2 feet deep) was used in both the studies of Saville, and Shay and Johnson. The wave tank used by Krumbein was smaller in dimensions (58.2 feet by 38.7 feet by 2.0 feet deep). The size and layout of the test setup used by Sauvage and Vincent are not available. The wave basin used in Price and Tomlinson's studies was 190 feet long and 75 feet wide. The SPTB, used in BEB studies (Savage and Fairchild's) is shown in Figures 2B, 3A, and 3B.

The water depths in the model studies were: 1.30 feet (Krumbein), 1.48 feet (Saville), 1.400 - 1.701 feet (Shay and Johnson), 0.49 feet (Sauvage and Vincent), 2.33 feet (BEB) and 1.0 feet (Price and Tomlinson).

The median grain sizes of the material used were 0.50 mm (Krumbein), 0.30 mm (Saville, Shay and Johnson), 0.22 mm (BEB). Sauvage and Vincent used three types of beach material with specific gravities of 2.6, 1.4, and 1.1 and the mean grain sizes of 0.5 mm, 1.5 mm, and 1.0 mm, respectively. Price and Tomlinson used crushed coal with specific gravity of 1.35 and mean grain size of 0.80 mm.

The angles α_g, defined as the nominal setting of the wave generator to the beach, were 15 degrees (Krumbein), 10 degrees (Saville), 30 degrees (BEB), and 5 degrees (Price and Tomlinson). Shay and Johnson varied the angle from 10 degrees to 50 degrees at 10-degree intervals. Sauvage and Vincent, in the first series of tests, maintained this angle at 15 degrees. In the second series, while studying the influence of angle of wave approach on longshore transport, they varied the angle from 5 degrees to 70 degrees. The data presented were obtained from their Figure 5 (Sauvage and Vincent, 1954), but their other results of the first series conducted on the study of the effects of wave height, wave length and wave steepness as well as data of the second series of tests have not been compiled.

The lengths of laboratory beaches were about 38 feet (Krumbein), 60 feet (Saville), 60 feet (Shay and Johnson for α_g = 10, 20, and 30 degrees with long beach), and 33 feet(Shay and Johnson for α_g = 30 with short beach, 40 and 50 degrees). In three series of tests with α_g of 10, 20 and 30 degrees, Shay and Johnson used sediment traps both in the midsection of the beach and at the downbeach end to determine both bedload and total load, respectively. Similar arrangement was also used by Saville. In the tests of Shay and Johnson with α_g of 30, 40 and 50 degrees, a wave splitter was used in the beach to reduce the spreading out of the beach to the wave generator as shown on Figure 3. This reduced the beach length to 33 feet. No information is available on the beach length or size of basin used in the study of Sauvage and Vincent. The length of beach at stillwater line for the SPTB at BEB was varied from 30 feet to 98 feet as shown in Table 3.

The initial beach slopes used in the studies were 1:5.6 or 10 degrees (Krumbein), 1:10 (Saville), 1:10 (Shay and Johnson), 1:10, 1:20 and composite of about 1:33 (BEB). There is no information available on the initial beach slope used in the study of Sauvage and Vincent.

Except in most of the studies conducted at BEB, no training walls were placed in the wave basin to conform to the wave orthogonal for uniform distribution of energy in the beach. The BEB study also differs from other studies in such aspects as basin geometry, beach slope, wave height and period variability, and sand feeder height with respect to stillwater level.

Krumbein determined the transport rate from the sand-feeding rate necessary for the waves to move it along the beach. Therefore, this transport rate differs from rates in the other laboratory studies which were determined from the quantity moved along the beach and collected in downbeach hoppers. Because Shay and Johnson noticed wave height variability, they took several records during each test to determine an average height. Saville used the energy setting to compute the wave height and also at frequent intervals during the test period he measured the wave heights by point gages located at crest and trough of the wave and he also used the averaging procedure to take into account the wave height variability. No information is available on the apparatus used by Sauvage and Vincent to measure the wave heights. Due to large variation of wave heights in the BEB tests, it was difficult to determine the incident wave heights from measurements in the test basin. Therefore, the wave heights were determined from a half-scale Froude model in another wave tank. A parallel-wire resistance-type wave gage was used to measure wave heights in the model wave tank at BEB.

2. Field Data

At South Lake Worth Inlet, Florida, Watts used a pressure-type wave gage. This was located on the ocean bottom in 17 feet of water below mean sea level, near Palm Beach Pier, 11 miles north of the Inlet. Records 12 minutes long were taken at 4-hour intervals. Significant wave heights and periods were computed from these records. Wave directions were measured visually from the Ambassador Hotel, 3 1/2 miles north of the Inlet.

In the studies at Anaheim Bay, California (Caldwell, 1956) wave heights and periods were obtained from measurements with a step-resistance wave gage and a float type wave gage, installed on the seaward end of the Huntington Beach Pier, about 6 miles south of Anaheim Bay. The depth of water at the gage was 20 feet below mean lower low water. The step-resistance gage provided 8-minute records at 4-hour intervals. The float gage provided continuous records of wave heights, but no periods. When the wave data could not be obtained from the gages, wave forecasting techniques were used to "hindcast" the significant height, period, and wave direction. No measurement of wave direction was made in this study. The wave direction associated with each wave observation was obtained by hindcasting using synoptic charts.

In the South Lake Worth Inlet region of the Florida coast, net longshore transport is from north to south. The material intercepted by the north jetty of the Inlet was bypassed from the north side to the south shore of the south jetty to prevent shoaling inside the Inlet and to nourish the south beach. The southerly component of longshore transport near the Inlet was measured from a detention basin, which was prepared for this study. The sand was pumped into this basin. During the period sand could not be pumped into the basin, the pumping rate of the plant was used to compute the material pumped.

At Anaheim Bay, the longshore transport passing survey range 10, located about 2 miles south of the Bay, was computed from beach profile changes between survey ranges 3 and 10, south of Surfside, where beach fill material was placed 2 months prior to the start of the study. Both the south and north transport rates were computed.

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APPENDIX A

Tables 5 through 28

TABLE 5

LABORATORY DATA (KRUMBEIN)

$m = 10°$ $\alpha_g = 15°$ $M_d = 0.50$ mm. $S_r = 2.65$ $d = 1.3$ ft.

ID	Count	T (sec)	H_o (ft)	H (ft)*	V (ft/sec)	Transport Rate** Quantity ft^3/sec $q \times 10^3$	Transport Rate** Q yd^3/day (comp)
17	1	1.14	0.206	0.187	0.47	1.39	4.45
18	2	1.38	0.145	0.131	0.36	0.72	2.30
19	3	1.44	0.115	0.104	0.35	0.67	2.14
20	4	1.80	0.097	0.090	0.21	0.30	0.96
21	5	1.69	0.100	0.092	-	0.28	0.90
22	6	1.94	0.077	0.073	0.17	0.22	0.70
23	7	2.04	0.084	0.080	0.17	0.25	0.80
24	-	2.00	0.095	0.090	0.20	-	-
25	8	1.84	0.079	0.073	0.24	0.30	0.96
26	9	1.56	0.099	0.090	0.29	0.36	1.15
27	10	1.49	0.130	0.118	0.32	0.47	1.50
28	11	1.65	0.104	0.096	0.25	0.30	0.96
29	12	1.40	0.151	0.137	0.35	0.72	2.30
30	13	1.10	0.237	0.217	0.55	1.91	6.10
31	14	0.97	0.290	0.271	0.74	2.08	6.66
32	15	1.25	0.195	0.176	0.42	1.00	3.20

* H is computed from the value of H_o computed and tabulated by the author.

** Measured from rate of feeding into a hopper to maintain a maximum rate of removal by the wave action.

TABLE 6

LABORATORY DATA (SAVILLE)

ID	Count	T (sec)	H (ft)	H_0 (ft)*	V (ft/sec)	Transport Rate ** Quantity Dry wt. lbs/hr	Transport Rate ** Q yd^3/day
6	16	0.714	0.146	0.145	0.319	23.3	.20
7	17	0.846	0.129	0.126	0.270	40.2	.34
4	18	0.937	0.116	0.111	0.254	62.6	.53
55	19	0.996	0.110	0.102	0.205	56.8	.48
9	20	0.744	0.169	0.167	0.398	29.9	.25
8	21	0.845	0.147	0.144	0.322	48.7	.41
10	22	0.990	0.126	0.117	0.241	88.2	.75
11	23	1.170	0.106	0.096	0.066	85.0	.72
12	24	1.500	0.082	0.069	-	18.2	.15

Assumptions: Solids - 60%; unit wt. = 0.6 x 2.69 x 62.4 = 101 lbs/ft^3

* H is computed from the value of H_0 computed and tabulated by the author.

** Measured, weighing the sand in a submerged hopper located at the down-beach end.

TABLE 7

LABORATORY DATA (SHAY AND JOHNSON)

$m = 1:10\ (5.75°)$ $\alpha_g = 10°$ $M_d = 0.30$ mm. $S_r = 2.69$

								Transport Rate**		
ID	Count	T (sec)	H_o (ft)	H (ft)	d (ft)	α_b (degrees)	V (ft/sec)	Quantity dry wt.* lbs/hr	Q yd^3/day	Water Temp. (deg. F)
10-4	25	1.40	0.089	0.080	1.442	-	Not measured	29.5	.25	Not measured
10-6	26	1.38	0.093	0.083	1.442	6.2		36.2	.31	
10-7	27	1.09	0.119	0.109	1.442	-		67.6	.57	
10-8	28	1.08	0.094	0.086	1.442	4.3		68.0	.57	
10-11	29	1.14	0.102	0.093	1.440	-		67.0	.57	
10-12	30	1.14	0.107	0.098	1.442	-		96.7	.82	
10-13	31	1.13	0.101	0.093	1.442	-		88.4	.75	
10-14	32	1.12	0.093	0.085	1.442	2.0		87.9	.74	
10-15	33	1.07	0.119	0.110	1.442	-		58.8	.50	
10-16	34	1.08	0.101	0.093	1.442	-		74.7	.63	
10-17	35	1.08	0.115	0.106	1.442	-		62.4	.53	
10-18	36	1.08	0.116	0.107	1.442	8.0		72.9	.62	
10-19	37	1.00	0.125	0.117	1.480	6.2		76.0	.64	
10-20	38	1.00	0.123	0.115	1.480	-		73.3	.62	
10-21	39	1.00	0.112	0.105	1.480	-		72.0	.61	
10-22	40	0.86	0.154	0.148	1.480	-		38.8	.33	
10-23	41	0.86	0.148	0.144	1.480	-		39.1	.33	
10-24	42	0.86	0.154	0.148	1.480	-		36.5	.31	

*Dry Weight - personal communication with Professor Johnson

** Weighing the sand caught in down-beach hoppers.

NOTE: Volume rate yd^3/day has been computed from weight rate lbs/hr with the assumption of 60% solids Unit weight = 0.6 x 2.69 x 62.4 = 101 lbs/ft^3.

TABLE 8

LABORATORY DATA (SHAY AND JOHNSON)

m = 1:10 (5.75°) $\alpha_g = 20°$ $M_d = 0.30$ mm. $S_r = 2.69$

								Transport Rate**		Water
ID	Count	T (sec)	H_o (ft)	H (ft)	d (ft)	α_b (degrees)	V (ft/sec)	Quantity lbs/hr.	Q yds3/day	Temp. Degrees F
20-1	43	0.76	.186	.185	1.700	Not measured	.86	78.4	.67	71.3
20-2	44	0.86	.191	.187	1.700		1.08	123.0	1.04	68.8
20-4	45	1.15	.149	.138	1.699		.60	165.0	1.40	74.9
20-5	46	1.25	.135	.124	1.700		.42	97.0	.82	74.5
20-6	47	1.05	.147	.139	1.700		.84	210.0	1.78	69.9
20-7	48	1.05	.146	.139	1.600		.68	179.0	1.52	72.4

* Measured, weighing the sand caught in down-beach hoppers.

TABLE 9

LABORATORY DATA (SHAY AND JOHNSON)

$m = 1:10$ (5.75°) $\alpha_g = 30°$ $M_d = 0.30$ mm. $S_r = 2.69$

ID	Count	T (sec)	H_o (ft)	H (ft)	d (ft)	α_b (degrees)	V (ft/sec)	Transport Rate* Quantity lbs/hr	Transport Rate* Q yds^3/day	Water Temp. (degrees F)
30-1	49	0.88	0.153	0.145	1.486	-	-	162.2	1.38	57.5
30-2	50	0.88	0.164	0.155	1.486	-	-	89.2	.76	54.0
30-3	51	0.88	0.177	0.167	1.486	-	-	64.9	.55	-
30-4	52	0.88	0.147	0.139	1.480	-	0.55	55.4	.47	-
30-5	53	0.88	0.152	0.143	1.483	-	0.49	49.0	.42	45.0
30-6	54	0.88	0.156	0.148	1.483	-	0.51	69.7	.59	47.0
30-7	55	0.88	0.146	0.138	1.485	-	0.47	63.8	.54	50.0
30-8	56	0.88	0.147	0.139	1.418	15.1	-	31.0	.26	50.0
30-9	57	0.88	0.154	0.146	1.485	16.7	0.53	68.5	.58	48.0
30-10	58	0.88	0.162	0.153	1.485	15.2	0.40	44.5	.38	45.0
30-11	59	0.88	0.162	0.153	1.485	15.9	0.40	47.4	.40	45.0
30-12	60	0.75	0.178	0.175	1.484	21.2	0.41	16.1	.14	47.0
30-13	61	0.75	0.179	0.176	1.483	18.0	0.46	27.5	.23	46.0
30-14	62	0.75	0.173	0.170	1.483	19.5	0.46	25.8	.22	47.0
30-15	63	1.00	0.133	0.122	1.483	-	0.37	63.2	.54	43.0
30-16	64	1.00	0.156	0.143	1.484	17.5	0.38	93.9	.80	42.0
30-17	65	1.00	0.170	0.156	1.483	-	-	93.1	.79	43.0
30-18	66	1.50	0.065	0.056	1.486	-	0.08	18.8	.16	48.0
30-19	67	1.50	0.087	0.075	1.486	12.4	-	36.1	.31	43.0
30-20	68	1.50	0.060	0.052	1.486	11.7	0.03	39.8	.34	55.0

* Measured, weighing the sand caught in down-drift hoppers.

TABLE 9 (Continued)

LABORATORY DATA (SHAY AND JOHNSON)

$m = 1{:}10\ (5.75°)$ $\alpha_g = 30°$ $M_d = 0.30$ mm. $S_r = 2.69$

ID	Count	T (sec)	H_o (ft)	H (ft)	d (ft)	α_b (degrees)	V (ft/sec)	Transport Rate*		Water Temp. (degrees F)
								Quantity lbs/hr	Q yds^3/day	
30-21	69	1.50	0.073	0.063	1.486	10.4	-	46.1	.39	54.0
30-22	70	1.25	0.112	0.099	1.486	20.5	.11	72.5	.62	51.0
30-24	71	1.25	0.101	0.089	1.486	8.4	-	90.3	.77	48.0
30-25	72	1.25	0.092	0.081	1.484	10.8	.13	152.	1.29	40.0
30-26	73	1.25	0.096	0.084	1.484	9.0	.12	114.	.97	51.0
30-27	74	1.25	0.104	0.092	1.486	7.0	.12	89.9	.76	49.0
30-28	75	1.10	0.136	0.112	1.484	16.5	.56	69.1	.59	54.0
30-29	76	1.10	0.127	0.114	1.488	12.5	.53	126.1	1.07	54.0
30-30	77	1.10	0.121	0.109	1.486	9.0	.70	76.6	.65	56.0
30-31	78	1.10	0.124	0.112	1.486	7.7	.38	107.8	.92	57.0
30-32	79	1.37	0.082	0.071	1.486	-	.33	17.5	.15	56.0
30-33	80	1.37	0.071	0.062	1.486	13.4	.15	35.	.30	60.0
30-34	81	1.37	0.070	0.061	1.486	13.8	.09	32.5	.28	61.0

* Measured, weighing the sand caught in down-drift hoppers.

TABLE 10

LABORATORY DATA (SHAY AND JOHNSON)

m = 1:10 (5.75°) α_g = 30° M_d = 0.30 mm. S_r = 2.69 SHORT BEACH

ID	Count	T (sec)	H_o (ft)	H (ft)	d (ft)	α_b (degrees)	V (ft/sec)	Transport Rate* Quantity lbs/hr	Transport Rate* Q yds^3/day	Water Temp. (degrees F)
30-1	82	0.76	0.192	0.191	1.700	8.5	1.10	72.9	.62	69.0
30-2	83	0.76	0.194	0.192	1.600	10.2	1.06	60.4	.51	75.0
30-3	84	0.86	0.178	0.173	1.601	14.5	1.22	142.0	1.21	72.0
30-4	85	0.86	0.202	0.196	1.600	10.0	1.14	190.0	1.61	78.5
30-5	86	0.86	0.204	0.198	1.600	-	1.26	165.0	1.40	70.5
30-7	87	1.00	0.178	0.168	1.700	12.5	1.38	377.0	3.20	69.5
30-8	88	1.00	0.197	0.186	1.699	19.0	1.19	315.0	2.68	68.5
30-10	89	1.15	0.148	0.135	1.700	11.0	0.71	218.0	1.85	76.0
30-12	90	1.15	0.162	0.147	1.701	16.0	0.94	300.0	2.55	67.0
30-11	91	1.25	0.140	0.125	1.700	10.5	0.60	187.0	1.59	70.0
30-13	92	1.25	0.127	0.113	1.700	7.0	0.61	195.0	1.66	69.5

* Measured, weighing the sand caught in down-drift hoppers.

TABLE 11

LABORATORY DATA (SHAY AND JOHNSON)

m = 1:10 (5.75°) $\alpha_g = 40°$ $M_d = 0.30$ mm. $S_r = 2.69$

								Transport Rate*		
								Quantity	Q	
ID	Count	T (sec)	H_o (ft)	H (ft)	d (ft)	α_b (degrees)	V (ft/sec)	lbs/hr	yds^3/day	Water Temp. (degrees F)
40-1	93	0.76	0.189	0.186	1.600	21.5	1.07	112	.95	74.0
40-2	94	0.76	0.188	0.185	1.599	20.5	1.12	102	.87	65.5
40-3	95	0.76	0.189	0.186	1.601	14.0	1.19	130	1.10	71.5
40-4	96	0.86	0.173	0.168	1.600	18.0	1.14	202	1.72	66.0
40-6	97	0.86	0.202	0.195	1.600	-	1.29	155	1.32	68.0
40-7	98	0.86	0.176	0.171	1.599	25.0	1.37	120	1.02	76.0
40-8	99	0.86	0.189	0.184	1.600	20.5	1.22	154	1.31	69.0
40-14	100	0.93	0.176	0.168	1.700	12.5	1.39	243	2.06	74.0
40-9	101	1.00	0.178	0.165	1.600	-	1.07	166	1.41	75.0
40-10	102	1.00	0.196	0.183	1.699	19.5	1.52	278	2.36	72.0
40-11	103	1.00	0.197	0.184	1.701	14.5	1.34	241	2.05	78.5
40-12	104	1.05	0.166	0.152	1.700	18.0	1.32	197	1.67	75.5
40-13	105	1.05	0.168	0.155	1.701	18.0	1.34	206	1.75	80.5
40-15	106	1.15	0.165	0.148	1.700	-	1.09	201	1.71	73.5
40-16	107	1.15	0.149	0.133	1.700	26.5	1.17	205	1.75	78.5
40-17	108	1.25	0.126	0.111	1.700	-	0.74	137	1.16	72.0
40-18	109	1.25	0.119	0.104	1.699	-	0.67	144	1.22	76.5

* Measured, weighing the sand caught in down-drift hopper.

TABLE 12

LABORATORY DATA (SHAY AND JOHNSON)

$m = 1{:}10\ (5.75°)$ $\alpha_g = 50°$ $M_d = 0.30$ mm. $S_r = 2.69$

ID	Count	T (sec)	H_o (ft)	H (ft)	d (ft)	α_b (degrees)	V (ft/sec)	Transport Rate* Quantity lbs/hr	Transport Rate* Q yds^3/day	Water Temp. (degrees F)
50-3	110	0.76	0.200	0.197	1.600	35.0	0.85	67.3	.57	70.5
50-11	111	0.76	0.199	0.196	1.601	-	0.94	48.6	.41	59.0
50-12	112	0.76	0.189	0.185	1.601	26.5	0.88	56.8	.48	63.0
50-4	113	0.86	0.199	0.192	1.600	-	1.15	86.5	.73	65.5
50-5	114	0.86	0.177	0.170	1.600	-	1.14	134.0	1.14	70.0
50-13	115	0.86	0.180	0.173	1.600	24.0	1.16	113.0	.96	67.0
50-15	116	0.86	0.190	0.183	1.599	31.0	1.24	141.0	1.20	68.5
50-7	117	1.00	0.173	0.159	1.600	30.0	0.82	142.0	1.20	60.5
50-8	118	1.00	0.165	0.151	1.599	25.5	0.76	148.0	1.26	61.5
50-9	119	1.00	0.168	0.155	1.600	26.5	0.92	177.0	1.50	59.5
50-10	120	1.14	0.134	0.115	1.600	15.5	0.64	72.0	.61	61.5
50-14	121	1.14	0.138	0.119	1.600	-	0.78	127.5	1.08	73.5
50-16	122	1.25	0.131	0.110	1.598	15.8	0.51	91.0	.77	-
50-17	123	1.25	0.171	0.106	1.600	20.0	0.54	90.0	.76	71.5

* Measured, weighing the sand caught in down-drift hopper.

TABLE 13

LABORATORY DATA (SAUVAGE AND VINCENT)

$d = 0.49$ ft. $\alpha_g = 15°$ $\beta = 10°$ (assumed)

ID	Count	T (sec) computed	H_o (ft.)	M_d (mm)	S_r	Transport Rate* Quantity litre/min	 Q yds^3/day
1	124	0.94	0.047	1.0	1.1	1.05	1.98
2	125	0.94	0.054	1.0	1.1	1.35	2.52
3	126	0.94	0.073	1.0	1.1	2.35	4.35
4	127	0.94	0.076	1.0	1.1	3.10	5.76
5	128	0.94	0.091	1.0	1.1	3.60	6.66
6	129	0.94	0.095	1.0	1.1	4.50	8.31
7	130	0.94	0.035	1.5	1.4	0.31	0.576
8	131	0.94	0.074	1.5	1.4	1.45	2.69
9	132	0.94	0.088	1.5	1.4	1.70	3.14
10	133	0.94	0.088	1.5	1.4	2.10	3.90
11	134	0.94	0.105	1.5	1.4	2.80	5.18
12	135	0.94	0.110	1.5	1.4	3.10	5.76
13	136	0.94	0.113	1.5	1.4	3.80	7.05
14	137	0.94	0.146	1.5	1.4	5.40	10.0
15	138	0.94	0.105	0.5	2.6	0.30	0.576
16	139	0.94	0.152	0.5	2.6	0.65	1.22
17	140	0.94	0.179	0.5	2.6	0.90	1.70

* Measured, collecting material at the down-beach end.
Quantities derived from Figure 5 in Sauvage and Vincent (1954)

TABLE 14

LABORATORY DATA (SAVAGE AND FAIRCHILD)

Variable Period Tests $\alpha_g = 30°$ $d = 2/33$ $S_r = 2/65$

							Transport Rate		
ID	Count	T (sec)	e_c (in)	H (ft)	m	V (ft/sec)	Q yds^3/day	Duration of test (hrs)	Special setup changes
1-58	141	1.30 1.50 1.75	1.00	.216 .176 .141	.05	.73 .55, .61 .46	2.65	60	No groin; no sand fed on feeder beach after 35 hours. T changed at 15-minute intervals. Beach length 95 feet at SWL
2.58	142	1.30 1.50 1.76	1.00	.216 .176 .141	.05	.74 .56,.64 .46	2.09	70	No groin; feeder beach maintained entire test. Same beach length as in 1-58.
2a-59	143	2.50 3.00 3.75	2.35	.246 .192 .140	.10	.71 .25,.27 .17	13.20	80	Upbeach training wall curved for wave refraction, T = 3.0 seconds, beach length 98 feet at SWL.
3a-59	144	2.50 3.00 3.75	2.35	.246 .192 .140	.10	.86 .44,.42 .29	13.54	50	Beach length reduced to 30 feet along SWL, other conditions same as 2a-59.
4a-59	145	1.94 2.18 2.50	1.75	.240 .210 .180	.10	1.14 .89,.89 .60	18.38	50	Updrift training wall recurved for wave refraction, T = 2.18 seconds, other conditions same as 3a-59
1-59	146	1.30 1.50 1.76	1.00	.216 .176 .141	Comp. Slope ≈ 0.03	.76 .57,.67 .46	1.93	25	Portion of downbeach training wall from carriage rail to toe of slope at its downdrift limit removed beach length 98 feet at SWL.

TABLE 14 (Continued)

							Transport Rate		
ID	Count	T (sec)	e_c (in)	H (ft)	m	V (ft/sec)	Q yds^3/day	Duration of test (hrs)	Special Setup Changes
2-59 Ph. I	147	1.30 1.50 1.76	1.00	.216 .176 .141	Comp. Slope 0.03	.71 .50,58 .50	2.45	32	Downdrift training wall completely removed. Same beach length as in 1-59.
2-59 Ph. II	148	2.50 3.00 3.75	2.35	.246 .192 .140	Slope at end of Ph. I	.54 .38,.45 .26	3.59	80	No downdrift training wall as in Phase I. Same beach length as 2-59.
3-59	149	2.50 3.00 3.75	2.35	.246 .192 .140	.05	.69 .41,.42 .20	13.20	75	Updrift training wall curved for wave refraction. T=3.0 sec. No downdrift training wall. Same beach length as in 2-59.
1-60	150	1.94 2.18 2.50	1.75	.240 .210 .180	.10	.94 .73,.95 .48	19.92	50	Downdrift training wall installed and curved for more refraction. T=2.18 sec. Beach length 30 feet at SWL.
2-60	151	1.94 2.18 2.50	3.50	.490 .420 .365	.10	1.62 1.28,1.15 1.03	56.20	26	No change from test 1-60 except wave height.
3-60	152	2.50 3.00 3.75	2.35	.246 .192 .140	.10	.82 .52,.46 .45	17.20	27	Additional second sand trap 11 feet downdrift of primary trap. Beach length 43 feet at SWL.
4-60	153	1.94 2.18 2.50	5.00	.750 .614 .530	.10	2.01 1.89,1.83 1.59	80.03	25	Test run at maximum wave height for generators for period as shown. Beach length 30 feet at SWL

TABLE 14 (Continued)

ID	Count	T (sec)	e_c (in)	H (ft)	m	V (ft/sec)	Transport Rate Q yds^3/day	Duration of test (hrs)	Special Setup Changes
5-60	154	2.50 3.00 3.75	4.70	.495 .422 .342	.10	1.71 1.54,1.68 1.58	132.80	26	Conditions same as in 3-60 except for increased wave height.
6-60	155	1.94 2.18 2.50	2.50	.344 .300 .250	.10	Rejected	39.83	50	To test intermediate wave height between 1-60 and 2-60. Beach length 30 feet at SWL.
7-60	156	1.25 1.36 1.50	1.50	.341 .320 .290		2.33 3.14,2.53 3.27	8.11	50	Test at maximum wave height and minimum period for generators. Beach length 30 feet at SWL.
1-61	157	2.50 3.00 3.75	2.35	.246 .192 .140	.10	.83 .50,.49 .48	18.63	50	Period changed at 5-minute instead of 15-minute intervals. Cycle length 20 minutes. Beach length 38 feet at SWL.
2-61	158	2.50 3.00 3.75	2.35	.246 .192 .140	.10	.59 .42,.42 .41	19.56	50	Period changed at 1-minute intervals. Cycle length 4 minutes. Beach length 30 feet at SWL.
5-61	159	3.75 2.00 2.50	2.35	.140 .192 .246	.10	Rejected	19.70	50	Continuously variable wave period. Cycle length 1 min. Beach length 30 ft. at SWL.
8-62	160	1.30 1.50 1.76	0.94	.202 .172 .140	.10	1.06 .76,.83 .60	6.08	30	Feasibility test of radioactive sand tracer. Fluorescent tracer also used.

TABLE 15

LABORATORY DATA (SAVAGE AND FAIRCHILD)

Constant Period Test

ID	Count	T (sec)	e_c (in)	H (ft)	m	V (ft/sec)	Transport Rate Q yds^3/day	Duration of test (hrs)	Special setup changes
4-59	161	3.00	2.35	.192	0.05	.28	9.52	50	Updrift training wall curved for refraction. Beach length at SWL, 98 feet (South Sector)
5-59	162	3.75	2.35	.140	.05	.23	6.15	50	Same as 4-59
6-59	163	2.50	2.35	.246	.05	.72	7.62	50	Same as 4-59
3-61	164	3.00	2.35	.192	.10	.15	8.03	50	Comparison with 4-59. Beach length 30 feet (North Sector)
6-61	165	2.50	2.35	.246	.10	.59	27.94	50	Comparison with 6-59. Beach length 30 feet (North Sector)
7-61	166	3.75	2.35	.140	.10	.33	2.26	50	Comparison with 5-59. Beach length 30 feet (North Sector)
1-62	167	3.75	2.35	.140	.10	.91	5.99	50	Test of effect of sand feeder elevation on sand feeding rate. Feeder mouth tangent to, landward of, and 0.2 feet above SWL. Beach length 35 feet (North Sector)
2-62	168	3.75	2.35	.140	.10	1.31	5.12	25	Same as 1-62, except feeder elevation was 0.1 foot above SWL. Beach length 35 feet (North Sector)

TABLE 15 (Continued)

ID	Count	T (sec)	e_c (in)	H (ft)	m	V (ft/sec)	Transport Rate Q Yds^3/day	Transport Rate Duration of test (hrs)	Special setup changes
3-62	169	3.75	2.35	.140	.10	.88	4.77	25	Same as 1-62 except feeder was at SWL. Beach length 35 feet (North Sector)
4-62	170	3.75	2.35	.140	.10	.59	2.88	25	To investigate effects of extraneous (may be transverse) wave effects on wave height variability and other test results. Beach length 35 feet (North Sector)
6-62	171	1.50	.94	.172	.10	.84	7.23	48	Feasibility test of radioactive tracer; also fluorescent tracer. Beach length 35 feet (North Sector)
1-64	172	3.75	2.35	.140	.10	.59	5.43	50	Space between updrift and downdrift training walls divided into 8 flumes, each 5 feet wide, to test effect on wave-height variability and littoral transport rate. Beach length 40 feet (No. Sector)
1-65	173	3.75	2.35	.140	.10	.38	5.49	40	All training walls and splitter walls removed. Rubble absorber placed around test area.

TABLE 15 (Continued)

ID	Count	T (sec)	e_c (in)	H (ft)	m	V (ft/sec)	Transport Rate: Q Yds^3/day	Transport Rate: Duration of test (hrs)	Special setup changes
2-66	174	2.18	2.35	.288	.10	1.09	39.94	25	Same as 1-65; to compare diffraction effects for shorter periods to those observed in 1-65; to continue real and temporal measurements and observations of wave-height variability; and to compare general results (including littoral transport and sand feed) in "open basin test area" to similar wave condition results in previous tests where training and/or splitter walls and baffles were used. Test 1-66 and 2-66 are practically one test, namely, test 2-66. The only difference is that the sand feeder, as initially positioned for test 1-66 was moved updrift about 4.8 feet at the end of test 1-66 and before starting test 2-66. Beach length 40 feet at SWL.

TABLE 15 (Continued)

							Transport Rate		
	Count	T (sec)	e_c (in)	H (ft)	m	V (ft/sec)	Q Yds^3/day	Duration of test (hrs)	Special setup changes
3-66	175	1.25	2.00	.480	.10	1.41	9.18	50	Only major changes were in wave period and height; readout quantities of sand pumped by eductor in test operation wave made on a radiation-sensing-mass flow-device for comparison to mass quantities of sand pumped and measured independently using the standard test method of weighing submerged with a dynamometer type scale. Beach length 40 feet at SWL.

TABLE 16

LABORATORY DATA (PRICE AND TOMLINSON)

Initial Beach Slope 1:17 M_d = 0.80 mm. S_r = 1.35 Crushed Coal

ID	Count	T (sec)	H (ft)	H_o (ft) computed	d (ft)	α_g (degrees)	Transport Rate* Q yd^3/day
PRT	176	1.146	0.188	0.194	1.0	5	6.95
PRT	177	1.15	0.208	0.228	1.0	5	7.8

* Measured in traps at downdrift end of wave tank.

TABLE 17

WAVE DATA, PALM BEACH PIER, SOUTH LAKE WORTH INLET, FLORIDA (WATTS)

Date	Time of Start	T (sec)	H (ft)	α (degrees)
Mar 7	0000	18.2	0.6	S 13.8
	0400	16.0	0.7	S 13.8
	0800	17.3	0.7	S 13.8
	1200	16.7	0.9	S 9.7
	1600	18.0	1.0	S 9.7
	2000	5.0	1.2	S 13
Mar 8	0000	5.6	1.5	S 16
	0400	6.5	1.0	S 19
	0800	8.0	1.1	S 19
	1200	8.7	1.0	S 19
	1600	6.5	1.5	S 19
	2000	9.4	1.7	S 15
Mar 9	0000	9.4	1.9	S 11
	0400	9.4	1.7	S 7
	0800	- - - - - - CALM - - - - - -		
	1200	12.8	1.4	S 21
	1600	15.0	1.3	S 21
	2000	12.0	1.6	S 11
Mar 10	0000	12.5	1.8	S 1
	0400	11.4	2.0	N 9
	0800	12.8	1.5	N 9
	1200	6.0	2.5	N 12
	1600	6.9	2.2	N 15
	2000	7.0	1.9	N 18
Mar 11	0000	11.0	1.6	N 22
	0400	8.1	1.6	N 26
	0800	6.8	2.0	N 26
	1200	6.7	1.6	N 18
	1600	6.4	0.9	N 18
	2000	6.1	0.6	N 16
Mar 12	0000	7.0	0.7	N 16
	0400	6.4	0.5	N 14
	0800	6.2	0.6	N 14
	1200	6.0	0.5	N 12
	1600	10.2	0.4	N 12
	2000	9.3	0.4	N 15
Mar 13	0000	12.0	0.4	N 18
	0400	12.0	0.4	N 21
	0800	12.0	0.4	N 21
	1200	5.0	0.8	N 21
	1600	4.5	0.9	N 21
	2000	4.5	0.5	N 21
Mar 14	0000	3.5	0.3	N 21
	0400	8.2	0.3	N 21
	0800	-	-	N 21
	1200	3.5	-	N 19
	1600	3.8	-	N 19
	2000	6.2	0.6	N 18

TABLE 17 (Continued)

Date	Time of Start	T (sec)	H (ft)	α (degrees)	Date	Time of Start	T (sec)	H (ft)	α (degrees)
Mar 15	0000	5.9	0.6	N 17	Mar 19	0000	5.1	1.4	N 12
	0400	6.9	0.3	N 17		0400	5.4	1.4	N 15
	0800	3.7	-	N 17		0800	4.4	0.9	N 15
	1200	4.0	0.4	N 10		1200	5.9	1.1	N 20
	1600	4.0	0.6	0		1600	5.4	0.7	N 20
	2000	10.5	0.3	S 10		2000	5.5	0.5	N 19
Mar 16	0000	10.6	0.3	S 20	Mar 20	0000	9.9	0.3	N 18
	0400	5.8	0.4	S 27		0400	4.8	0.5	N 17
	0800	8.5	0.6	S 27		0800	8.2	0.3	N 16
	1200	9.2	0.7	S 23		1200	6.0	-	N 15
	1600	7.6	1.1	S 23		1600	8.7	-	N 15
	2000	9.7	0.6	S 30		2000	7.5	-	N 15
Mar 17	0000	10.3	1.1	S 37	Mar 21	0000	4.0	1.0	N 14
	0400	10.3	0.4	S 45		0400	4.6	1.0	N 14
	0800	10.3	0.9	S 45		0800	4.3	1.4	N 14
	1200	7.0	0.6	S 41		1200	4.4	1.1	N 19
	1600	9.7	0.7	S 41		1600	12.6	0.7	N 19
	2000	9.5	0.8	S 26		2000	5.5	1.8	N 19
Mar 18	0000	8.6	0.6	S 11	Mar 22	0000	5.1	1.6	N 22
	0400	9.7	0.9	N 3		0400	5.1	2.0	N 22
	0800	10.7	0.9	N 3		0800	5.1	1.5	N 22
	1200	10.7	1.6	N 6		1200	4.3	1.4	N 23
	1600	5.0	1.7	N 6		1600	4.2	0.9	N 23
	2000	11.1	1.1	N 19		2000	4.4	1.0	N 23

TABLE 17 (Continued)

Date	Time of Start	T (sec)	H (ft)	α (degrees)
Mar 23	0000	4.2	0.9	N 24
	0400	5.3	0.9	N 24
	0800	4.3	1.0	N 30
	1200	4.5	1.3	N 26
	1600	4.5	1.1	N 26
	2000	4.4	0.9	N 23
Mar 24	0000	4.4	0.8	N 20
	0400	4.4	1.1	N 16
	0800	4.7	1.1	N 33
	1200	5.2	1.0	N 27
	1600	7.3	0.5	N 21
	2000	5.8	0.6	N 20
Mar 25	0000	6.6	0.4	N 18
	0400	-	-	N 16
	0800	11.2	0.6	N 16
	1200	6.9	0.7	N 18
	1600	7.7	0.5	N 18
	2000	8.5	0.5	N 22
Mar 26	0000	10.0	0.7	N 26
	0400	9.2	0.8	N 19
	0800	9.0	0.9	N 19
	1200	9.4	0.6	N 16
	1600	5.9	1.0	N 16
	2000	9.6	1.4	N 14
Mar 27	0000	9.1	1.5	N 12
	0400	9.5	1.1	N 11
	0800	10.0	0.8	N 11
	1200	9.3	0.8	N 4
	1600	9.0	0.8	N 4
	2000	9.4	0.8	-
Mar 28	0000	7.7	0.6	-
	0400	10.1	0.6	S 4
	0800	8.2	0.7	S 4
	1200	7.5	0.8	S 8
	1600	7.2	0.9	S 8
	2000	9.0	0.7	S 12
Mar 29	0000	8.0	0.5	S 12
	0400	10.0	0.6	S 17
	0800	10.0	0.9	S 17
	1200	12.3	1.0	S 16
	1600	14.0	1.1	S 16
	2000	10.4	1.0	S 10
Mar 30	0000	10.0	0.8	S 4
	0400	-	-	N 3
	0800	5.7	1.8	N 3
	1200	7.0	1.4	S 10
	1600	7.0	1.4	S 10
	2000	7.3	1.7	S 6

TABLE 17 (Continued)

Date	Time of Start	T (sec)	H (ft)	α (degrees)
Mar 31	0000	10.2	1.2	S 2
	0400	5.9	2.1	N 3
	0800	16.6	1.2	N 3
	1200	-	-	N 2
	1600	-	-	N 2
	2000	-	-	N 5
Apr 1	0000	-	-	N 8
	0400	-	-	N 11
	0800	-	-	N 11
	1200	-	-	N 14
	1600	-	-	N 14
	2000	-	-	N 11
Apr 2	0000	-	-	N 8
	0400	-	-	N 5
	0800	16.0	0.7	N 5
	1200	15.0	0.4	N 7
	1600	16.0	0.7	N 7
	2000	16.0	0.4	N 9
Apr 3	0000	16.5	0.5	N 9
	0400	16.0	0.5	N 11
	0800	15.0	0.8	N 11
	1200	15.0	0.8	N 14
	1600	16.5	0.4	N 14
	2000	15.0	0.5	N 17
Apr 4	0000	15.0	0.7	N 17
	0400	16.0	0.6	N 21
	0800	3.9	0.9	N 21
	1200	15.0	0.7	N 21
	1600	4.5	0.5	N 21
	2000	4.1	0.5	N 17
Apr 5	0000	13.5	0.5	N 13
	0400	14.5	0.3	N 9
	0800	14.5	0.3	N 5
	1200	14.5	0.2	N 1
	1600	13.5	0.2	S 3
	2000	14.0	0.2	S 7
Apr 6	0000	6.8	0.3	S 11
	0400	6.7	0.5	S 14
	0800	7.0	0.6	S 14
	1200	8.1	0.6	S 19
	1600	8.3	0.6	S 19
	2000	8.0	0.5	S 19
Apr 7	0000	7.7	0.4	S 19
	0400	-	-	S 20
	0800	7.7	0.5	S 20
	1200	8.5	0.5	S 20
	1600	7.8	0.5	S 20
	2000	7.2	0.8	S 12

TABLE 17 (Continued)

Date	Time of Start	T (sec)	H (ft)	α (degrees)
Apr 8	0000	8.2	0.5	S 12
	0400	10.2	0.4	S 3
	0800	10.5	0.7	S 3
	1200	7.4	0.9	S 10
	1600	6.9	0.6	S 10
	2000	10.5	0.7	0
Apr 9	0000	17.5	0.6	0
	0400	18.5	0.5	N 9
	0800	4.9	0.8	N 9
	1200	6.5	0.6	N 10
	1600	6.2	0.7	N 10
	2000	5.2	1.3	N 10
Apr 10	0000	5.5	1.3	N 10
	0400	5.6	1.2	N 10
	0800	5.8	1.1	N 10
	1200	5.1	1.0	N 10
	1600	4.7	1.3	N 10
	2000	5.4	2.0	N 9
Apr 11	0000	6.9	1.4	N 7
	0400	6.1	2.0	N 5
	0800	5.4	1.9	N 5
	1200	5.3	1.1	N 4
	1600	8.2	0.8	N 4
	2000	4.9	2.1	N 6
Apr 12	0000	5.0	1.5	N 9
	0400	5.0	2.0	N 12
	0800	5.8	1.5	N 12
	1200	6.4	1.3	N 4
	1600	6.5	0.9	N 4
	2000	5.0	1.3	N 11
Apr 13	0000	5.6	2.1	N 18
	0400	6.4	1.6	N 26
	0800	4.9	1.7	N 26
	1200	5.2	1.2	N 19
	1600	4.9	0.9	N 19
	2000	4.6	1.1	N 22
Apr 14	0000	4.9	1.5	N 25
	0400	5.3	1.5	N 29
	0800	5.2	1.0	N 29
	1200	5.5	0.6	N 28
	1600	6.0	0.4	N 28
	2000	6.1	0.2	N 21
Apr 15	0000	6.4	0.2	N 14
	0400	7.0	0.3	N 7
	0800	7.0	0.5	-
	1200	-	-	S 8
	1600	-	-	S 8
	2000	-	-	S 14

TABLE 17 (Continued

Date	Time of Start	T (sec)	H (ft)	α (degrees)
Apr 16	0000	-	-	S 21
	0400	6.8	0.4	S 28
	0800	8.0	0.4	S 28
	1200	8.1	1.0	S 28
	1600	7.7	1.0	S 28
	2000	7.0	0.7	S 29
Apr 17	0000	8.0	0.9	S 29
	0400	8.9	0.6	S 29
	0800	7.6	0.9	S 29
	1200	9.2	1.2	S 31
	1600	8.5	1.1	S 31
	2000	9.3	1.1	S 29
Apr 18	0000	8.0	1.1	S 29
	0400	9.0	1.3	S 26
	0800	10.0	1.0	S 26
	1200	8.8	1.1	S 21
	1600	5.0	0.8	S 21
	2000	4.8	0.9	S 17
Apr 19	0000	8.4	0.7	S 13
	0400	9.6	0.7	S 10
	0800	8.2	0.4	S 10
	1200	4.2	1.0	N 1
	1600	4.3	0.8	N 1
	2000	4.3	0.9	N 1
Apr 20	0000	4.2	0.9	N 1
	0400	4.1	0.9	-
	0800	4.3	0.8	-
	1200	4.5	0.7	N 1
	1600	4.7	1.0	N 1
	2000	4.5	1.3	-
Apr 21	0000	5.0	1.1	-
	0400	4.8	1.4	S 1
	0800	4.1	0.9	S 1
	1200	4.2	0.7	N 4
	1600	4.1	0.9	N 4
	2000	5.3	1.5	N 4
Apr 22	0000	5.0	1.3	N 4
	0400	5.1	1.7	N 4
	0800	5.3	1.6	N 4
	1200	5.1	0.9	N 5
	1600	5.3	1.4	N 5
	2000	-	-	N 8
Apr 23	0000	-	-	N 8
	0400	-	-	N 11
	0800	-	-	N 11
	1200	-	-	N 10
	1600	-	-	N 10
	2000	-	-	N 14

TABLE 17 (Continued)

Date	Time of Start	T (sec)	H (ft)	α (degrees)	Date	Time of Start	T (sec)	H (ft)	α (degrees)
Apr 24	0000	5.0	1.1	N 14	Apr 28	0000	6.0	-	N 6
	0400	4.4	1.0	N 17		0400	7.0	0.3	N 3
	0800	8.7	0.8	N 17		0800	6.5	-	-
	1200	-	-	N 5		1200	7.3	-	S 3
	1600	-	-	N 5		1600	8.5	-	S 6
	2000	-	-	N 2		2000	7.8	0.5	S 10
Apr 25	0000	-	-	N 2	Apr 29	0000	8.5	0.4	S 14
	0400	-	-	S 2		0400	8.9	0.4	S 18
	0800	-	-	S 2		0800	7.3	0.4	S 18
	1200	-	-	N 2		1200	7.8	0.4	S 22
	1600	-	-	N 2		1600	9.0	-	S 22
	2000	-	-	N 10		2000	7.8	0.4	S 26
Apr 26	0000	-	-	N 18	Apr 30	0000	6.8	-	S 26
	0400	-	-	N 27		0400	7.0	-	S 30
	0800	-	-	N 27		0800	6.6	0.5	S 30
	1200	-	-	N 30		1200	6.7	0.8	S 33
	1600	-	-	N 30		1600	6.6	0.8	S 33
	2000	-	-	N 27		2000	8.5	0.6	S 31
Apr 27	0000	-	-	N 24	May 1	0000	7.1	0.8	S 31
	0400	-	-	N 21		0400	8.2	0.8	S 29
	0800	10.5	-	N 18		0800	7.8	0.8	S 29
	1200	7.0	-	N 15		1200	8.5	0.6	S 27
	1600	10.0	-	N 12		1600	8.1	0.7	S 27
	2000	6.0	-	N 9		2000	8.7	0.7	S 20

TABLE 17 (Continued)

Date	Time of Start	T (sec)	H (ft)	α (degrees)	Date	Time of Start	T (sec)	H (ft)	α (degrees)
May 2	0000	8.5	0.4	S 13	May 6	0000	9.3	-	N 19
	0400	8.4	0.5	S 6		0400	9.3	-	N 22
	0800	3.8	0.7	S 6		0800	8.7	-	N 22
	1200	3.6	0.8	N 6		1200	8.3	-	N 21
	1600	9.1	0.4	N 6		1600	9.7	-	N 21
	2000	8.4	0.3	N 3		2000	8.7	-	N 21
May 3	0000	8.5	0.3	N 3	May 7	0000	9.3	-	N 22
	0400	9.4	0.4	-		0400	8.7	-	N 33
	0800	6.6	-	-		0800	10.0	-	N 33
	1200	7.4	-	N 4		1200	10.0	-	N 40
	1600	8.8	-	N 4		1600	3.0	-	N 40
	2000	9.2	-	N 6		2000	8.7	-	N 39
May 4	0000	9.0	-	N 6	May 8	0000	11.0	-	N 39
	0400	10.0	-	N 8		0400	10.0	-	N 38
	0800	9.6	-	N 8		0800	10.0	-	N 38
	1200	9.2	-	N 10		1200	10.1	-	N 36
	1600	7.4	-	N 10		1600	3.7	-	N 36
	2000	8.5	-	N 12		2000	4.0	0.9	N 35
May 5	0000	8.8	-	N 12	May 9	0000	12.0	0.3	N 35
	0400	9.0	-	N 14		0400	10.0	-	N 33
	0800	8.5	-	N 14		0800	12.0	0.3	N 33
	1200	8.7	-	N 16		1200	12.0	-	N 32
	1600	9.0	-	N 16		1600	10.7	0.3	N 32
	2000	9.0	-	N 19		2000	10.0	0.4	N 32

TABLE 17 (Continued)

Date	Time of Start	T (sec)	H (ft)	α (degrees)
May 10	0000	10.5	0.3	N 32
	0400	9.0	0.3	N 32
	0800	9.3	-	N 32
	1200	3.6	0.7	N 32
	1600	3.5	-	N 32
	2000	3.3	-	N 29
May 11	0000	3.6	-	N 26
	0400	3.1	-	N 23
	0800	3.9	-	N 23
	1200	3.6	-	N 32
	1600	4.8	0.6	N 32
	2000	4.3	0.5	N 5
May 12	0000	5.4	0.4	S 22
	0400	5.0	0.5	S 49
	0800	7.2	0.6	S 49
	1200	7.0	0.9	S 45
	1600	7.0	1.0	S 45
	2000	5.7	0.8	S 42
May 13	0000	4.5	0.6	S 42
	0400	5.0	0.5	S 39
	0800	5.4	0.6	S 39
	1200	6.2	0.6	S 33
	1600	5.2	0.6	S 33
	2000	4.9	0.5	S 30
May 14	0000	4.8	0.6	S 27
	0400	5.6	0.6	S 24
	0800	6.0	0.8	S 24
	1200	6.3	1.0	S 5
	1600	5.1	1.0	S 5
	2000	5.3	1.0	S 4
May 15	0000	4.6	1.0	S 4
	0400	8.3	0.9	S 2
	0800	4.6	0.9	S 2
	1200	5.2	1.1	S 1
	1600	7.3	0.6	S 1
	2000	7.7	0.5	S 1
May 16	0000	7.8	0.5	S 1
	0400	6.7	0.6	S 2
	0800	4.3	0.8	S 2
	1200	4.3	0.9	0
	1600	3.9	1.1	0
	2000	4.1	1.2	N 3
May 17	0000	4.5	0.7	N 3
	0400	4.8	1.0	N 6
	0800	4.4	1.1	N 6
	1200	4.1	1.0	N 6
	1600	3.7	0.7	N 6
	2000	3.8	0.7	N 7

TABLE 17 (Continued)

Date	Time of Start	T (sec)	H (ft)	α (degrees)
May 18	0000	3.5	0.6	N 8
	0400	3.8	0.9	N 9
	0800	4.1	0.7	N 9
	1200	3.8	0.7	N 2
	1600	4.1	0.7	N 2
	2000	3.8	0.4	N 7
May 19	0000	3.7	0.7	N 12
	0400	4.2	0.6	N 18
	0800	4.3	0.6	N 18
	1200	4.5	0.5	N 21
	1600	4.4	0.6	N 21
	2000	3.6	0.7	N 17
May 20	0000	4.5	1.0	N 17
	0400	5.0	0.8	N 13
	0800	5.2	0.8	N 13
	1200	4.8	0.7	N 21
	1600	13.0	0.5	N 21
	2000	12.0	0.4	N 19
May 21	0000	14.0	0.4	N 19
	0400	14.0	0.5	N 16
	0800	14.0	-	N 16
	1200	14.0	-	N 14
	1600	14.5	0.5	N 14
	2000	12.5	0.4	N 10
May 22	0000	12.0	0.4	N 10
	0400	12.0	-	N 5
	0800	4.1	-	N 5
	1200	12.0	0.3	N 16
	1600	12.5	0.3	N 16
	2000	14.0	0.5	N 14
May 23	0000	8.0	-	N 14
	0400	4.0	-	N 11
	0800	4.4	0.6	N 11
	1200	13.0	0.5	N 8
	1600	12.7	0.5	N 8
	2000	12.5	0.5	N 7
May 24	0000	4.3	0.7	N 7
	0400	4.2	1.0	N 6
	0800	5.3	0.5	N 6
	1200	4.2	0.8	N 2
	1600	4.6	0.5	N 2
	2000	4.0	0.8	N 4
May 25	0000	4.8	1.4	N 4
	0400	5.1	1.0	N 6
	0800	5.2	0.7	N 6
	1200	5.0	0.7	N 10
	1600	4.7	0.8	N 10
	2000	5.4	0.9	N 8

TABLE 17 (Continued)

Date	Time of Start	T (sec)	H (ft)	α (degrees)
May 26	0000	5.6	1.2	N 8
	0400	6.6	0.8	N 6
	0800	5.0	0.9	N 6
	1200	5.9	0.9	N 14
	1600	5.4	0.8	N 14
	2000	4.9	0.6	N 10
May 27	0000	5.0	-	N 10
	0400	6.0	-	N 6
	0800	7.3	0.4	N 6
	1200	5.6	0.8	N 2
	1600	4.6	0.8	N 2
	2000	4.7	0.7	S 5
May 28	0000	5.0	0.7	S 5
	0400	10.0	0.4	S 12
	0800	8.7	-	S 12
	1200	4.2	-	S 19
	1600	5.0	0.7	S 19
	2000	5.7	0.6	S 19
May 29	0000	4.8	-	-
	0400	5.0	-	-
	0800	3.8	-	-
	1200	4.0	-	-
	1600	8.7	0.3	S 20
	2000	8.8	0.3	S 20
May 30	0000	9.0	0.3	S 20
	0400	9.0	-	-
	0800	9.5	-	-
	1200	9.5	-	-
	1600	9.0	-	-
	2000	9.8	-	-
May 31	0000	9.0	-	-
	0400	7.7	-	-
	0800	9.0	-	-
	1200	8.3	-	-
	1600	9.0	-	-
	2000	9.0	-	-
Jun 1	0000	10.0	-	-
	0400	9.5	-	-
	0800	9.0	-	-
	1200	9.0	-	-
	1600	4.8	-	-
	2000	9.5	-	-
Jun 2	0000	8.4	0.3	S 20
	0400	8.8	0.3	S 20
	0800	8.4	0.3	S 20
	1200	8.3	0.3	S 20
	1600	5.0	0.8	S 20
	2000	7.6	0.4	S 20

TABLE 17 (Continued)

Date	Time of Start	T (sec)	H (ft)	α (degrees)
Jun 3	0000	6.7	0.5	S 14
	0400	8.3	0.5	S 14
	0800	6.7	-	S 14
	1200	6.0	-	S 14
	1600	5.5	0.8	S 14
	2000	6.5	0.5	S 12
Jun 4	0000	4.6	-	S 12
	0400	5.0	0.6	S 11
	0800	8.2	0.4	S 11
	1200	7.5	0.4	S 8
	1600	3.3	-	S 8
	2000	8.0	0.5	S 4
Jun 5	0000	10.0	0.4	S 4
	0400	8.3	0.7	N 1
	0800	8.0	-	N 1
	1200	8.7	0.4	N 1
	1600	8.5	0.3	N 1
	2000	9.5	0.3	N 1
Jun 7	0000	9.0	0.4	N 1
	0400	8.0	0.5	N 1
	0800	8.0	-	N 1
	1200	8.1	-	N 12
	1600	8.3	-	N 12
	2000	10.0	-	N 12
June 8	0000	10.0	-	N 12
	0400	9.5	-	N 12
	0800	10.6	-	N 12
	1200	5.0	-	N 12
	1600	8.0	-	N 12
	2000	8.3	-	N 13
June 9	0000	9.0	-	N 13
	0400	10.7	-	N 14
	0800	9.0	-	N 14
	1200	7.0	-	N 15
	1600	9.0		N 15
	2000	9.0	-	N 11
June 10	0000	3.5	-	N 11
	0400	8.0	-	N 7
	0800	3.3	-	N 7
	1200	3.0	-	N 2
	1600	3.4	-	N 2
	2000	6.5	-	N 6

TABLE 18 - VOLUME OF MATERIAL PUMPED

South Lake Worth Inlet (Watts, 1953)

Date 1952	Time	Pumping Time (Hours)	Pumping Times into Basin (Hours)	Volume Pumped in Cubic Yards Computed	Estimated*
Feb 25	0900-1500	6	6	443	
26	0700-0900	2			152
27	0700-1300	6	6	491	
28	0700-1200	5			
29	0700-1330	6.5	11.5	948	
Mar 1	0700-1000	3	3	256	
3	0700-1030	3.5			267
4	0700-0900	2	2	141	
6	0700-1000	3			
7	0700-0900	2	5	373	
7	1000-1400	4			
8	0700-1100	4	8	615	
8	1200-1900	7			
9	0700-0900	2	9	785	
9	0900-1600	7			533
10	0700-1430	7.5			572
11	0700-1400	7			533
12	0700-1000	3			229
13	0700-0800	1			
14	0700-0800	1			
16	0700-0800	1			
17	0700-1000	3	6	476	
17	1030-1330	3			
18	0700-0900	2	5	353	
19	0700-1000	3			
21	0700-0900	2	5	328	
22	0700-0900	2			
24	0700-0800	1			
25	0700-0800	1			
27	0700-0800	1			
29	0830-0930	1			
30	0700-1300	6	12	1182	
30	1330-1800	4.5			343
31	0700-1530	8.5			648
Apr 6	0700-1100	4			305
7	0700-0830	1.5			114
7	1500-1630	1.5			
8	0700-0800	1			
8	1500-1630	1.5			
9	0930-1230	3	7	534	
9	1530-1700	1.5			
10	0630-1330	7	8.5	731	
10	1445-1615	1.5			
11	0630-1230	6	7.5	669	
12	0730-1030	3			
17	0930-1300	3.5			
17	1530-1800	2.5	9	608	
18	1200-1800	6			
19	0600-1000	4	10	757	
19	1400-1500	1			
20	0700-1030	3.5			
20	1300-1500	2			
21	0700-1000	3	9.5	660	
22	0730-1200	4.5	4.5	366	
23	0700-1100	4			305
30	0800-1000	2			
30	1500-1700	2			
May 1	0500-0730	2.5			
1	1400-1530	1.5	8	534	
2	1000-1100	1			
3	1100-1200	1			
6	0800-0900	1			
9	0930-1030	1	4	230	
12	0730-0800	0.5			
12	1530-1730	2			
13	0700-1000	3	5.5	306	
13	1500-1630	1.5			
14	0800-1100	3	4.5	258	
14	1300-1730	4	4	270	
15	1200-1700	5			
16	0730-1030	3	8	540	
20	1300-1500	2			
21	1730-1830	1			
24	0800-0900	1	4	376	
28	0730-0830	1			
29	0800-0900	1			
Jun 3	0730-0900	1.5			
4	0700-1000	3	6.5	444	
5	0700-0830	1.5			
10	11-1230	1.5			
11	0700-0800	1	4	234	
Totals		235.5	183	13,958	4,001
				Total	17,959

* Estimated volume based on average rate of pumping, computed from pumping time and measured volume as 76.2 cubic yards per hour.

TABLE 19 - WAVE ENERGY AND LITTORAL DRIFT
South Lake Worth Inlet (Watts, 1953)

Dates 1952	Net Time (Days)	Wave Energy Ft-lbs./ft. of Wave Crest for Periods Indicated x10^6	Energy (E_T) ft-lbs/day/ft of Wave Crest x 10^3	Material Pumped for Periods Indicated (Cu. Yds.)	Nearshore Littoral Drift (Q) (Cu.Yds./Day)
Computations Based on Monthly Data					
Mar 7 to 31	24.23	25.26	1040	6600	272
Apr 5 to 30	25.17	19.67	780	5400	215
May 1 to 31	30.83	10.90	350	2360	76.5
June 2 to 11	9.17	1.70	185	526	57
Computations Based on Daily (0.3 to 4 days) Data					
Mar 7 to 9	2.17	7.87	3620	1550	715
16 to 18	2	7.13	3560	657	328
28 to 30	2.17	3.94	1820	874	402
30 to 31	0.5	2.25	4500	648	1296
Apr 7 to 8	1.33	1.48	1110	380	285
16 to 19	3.17	14.45	4560	1290	406
Apr 30 - May 2	2	5.07	2535	686	343
May 12 to 16	4.17	6.76	1620	1374	330
27 to 28	0.5	0.22	440	76	152
28 to 28	0.33	0.48	1440	76	228
29 to 30	0.5	0.20	400	114	228
June 2 to 3	1.66	1.40	840	228	137

TABLE 20

WAVE DIRECTION FREQUENCIES

6 March - 10 June 1952

South Lake Worth Inlet (Watts, 1953)

Period (sec)	0.0 2.9	3.0 3.9	4.0 4.9	5.0 5.9	6.0 6.9	7.0 7.9	8.0 8.9	9.0 9.9	10.0 10.9	11.0 11.9	12.0 12.9	13.0 13.9	14.0 14.9	15.0 16.9	16.0 16.9	17.0 17.9	18.0 18.9	Total Percent	Cumulative Percent
Direction (azimuth)																			
0°-39°																			
40°-59°	2.4		0.2	0.9	0.6	0.9	0.3	0.3	0.5									6.1	6.1
60°-79°	2.4		0.7	1.7	2.4	2.6	5.3	1.9	0.9		0.5		0.2	0.2	0.2	0.2	0.2	19.4	25.5
80°-99°	2.4	2.1	6.6	4.3	2.4	3.3	2.9	2.2	2.1	0.3	0.9	0.3	0.7	0.2	1.1	0.2	0.3	32.3	57.8
100°-119°	2.4	2.1	6.4	6.2	3.6	1.4	3.1	3.6	1.6	0.3	1.6	0.3	1.1	0.9	0.7			35.3	93.1
120°-139°	2.4	0.9	0.7				0.3	0.2	1.6	0.2	0.5							6.9	100.0
140°-179°																			

TABLE 21 - SAND SAMPLE ANALYSES

South Lake Worth Inlet,
Florida (Watts, 1953)

Dates 1952	H.T.L. Md_o (mm)	H.T.L. S_o	M.T.L. Md_o (mm)	M.T.L. S_o	L.T.L. Md_o (mm)	L.T.L. S_o	3-ft. Water Depth Md_o (mm)	3-ft. Water Depth S_o	
			0.5 Mile North of Inlet						
3-7			0.37	1.24					
3-21			0.31	1.18					
4-16	0.38	1.31	0.47	1.29					
4-22	0.34	1.18			0.48	1.44	0.54	1.41	
4-29			0.57	1.45			0.45	1.69	
5-5	0.36	1.25	0.34	1.25	0.64	1.50	0.42	1.41	
5-8	0.31	1.15	0.32	1.17	0.58	1.45	0.34	1.30	
5-15	0.32	1.16	0.38	1.19	0.38	1.18	0.63	1.33	
5-22	0.34	1.41	0.37	1.23	0.33	1.20			
6-10	0.29	1.18	0.36	1.29	0.53	1.55	0.33	1.29	
Mean	0.33		0.39		0.49		0.45		Average 0.41 mm.
			1,000 feet South of Inlet						
3-7			0.68	1.23					
3-21			0.80	1.29					
4-16			0.57	1.44					
4-22			0.43	1.23					
4-29			0.71	1.27	0.47	1.31	0.90	1.24	
5-5	0.50	1.17	0.61	1.28	0.63	1.09	0.77	1.34	
5-8	0.48	1.29	0.52	1.25	0.74	1.25	0.88	1.16	
5-15	0.53	1.22	0.40	1.14	0.48	1.36	0.54	1.38	
5-22	0.45	1.23	0.58	1.23	0.86	1.18	1.01	1.12	
6-10	0.50	1.25	0.66	1.32	1.02	1.15	0.92	1.29	

	Sample No. 1 Md_o	Sample No. 1 S_o	Sample No. 2 Md_o	Sample No. 2 S_o	Sample No. 3 Md_o	Sample No. 3 S_o	Sample No. 4 Md_o	Sample No. 4 S_o	Sample No. 5 Md_o	Sample No. 5 S_o
			Inner Bar							
3-7	0.33	1.36								
3-21	0.52	1.50								
4-22	0.47	1.81								
4-29	0.40	1.38	0.50	1.30	0.44	1.67	0.58	1.43	0.70	1.36
5-5	0.47	1.64	0.50	1.57	0.48	1.35	0.44	1.47	0.53	1.39
5-15	0.54	1.26	0.96	1.38	1.03	1.21	0.76	1.51	0.70	1.33
5-22	0.50	1.78	0.41	1.42	0.54	1.35	0.50	1.36	0.50	1.24
6-10	0.65	1.48	0.90	1.36	0.78	1.33	0.92	1.33	0.52	1.34
			Ocean Bar							
3-7	0.60	1.39								
3-21	0.60	1.28								
4-16	0.66	1.62								
4-22	0.68	1.45	0.82	1.41	0.64	1.43				
4-29	0.76	1.61	0.84	1.46	0.68	1.35	0.69	1.41	0.76	1.73
5-5	0.76	1.66	0.66	1.54	0.81	1.45	0.76	1.47	0.82	1.42
5-15	0.75	1.44	0.87	1.46	0.77	1.46	0.93	1.37	0.94	1.33
5-22	0.77	1.46	0.76	1.32	0.75	1.60	0.80	1.65	0.74	1.48
6-10	0.89	1.43	0.86	1.46	0.78	1.57	0.76	1.50	0.89	1.42

Detention Basin

	Md_o	S_o
3-21	0.64	1.52
4-16	0.87	1.50
4-22	1.07	1.29
5-15	1.08	1.35
5-22	0.64	1.48
6-10	0.48	1.24

H.T.L. - High Tide Line M.T.L. - Mean Tide Line L.T.L. - Low Tide Line Md_o - Median diameter (mm)
S_o - Sorting Coefficient

TABLE 22

WAVE CLIMATE NEAR AHAHEIM BAY, CALIFORNIA

(From Caldwell, 1956)

Deepwater Direction from North (Degrees)	Wave Period (Seconds)						
	Calm	4½-7½	7½-10½	10½-13½	13½-16½	16½-19½	Total
	Percent Occurrence*						
	6						6
160-180		0	1	1	0	0	2
230-250		0	0	0	0	0	0
250-260		0	0	3	0	0	3
260-270		0	2	2	1	1	6
270-280		0	3	7	6	7	23
280-290		0	3	10	12	6	31
290-300		0	0	7	9	0	16
300-310		0	0	7	5	0	12
310-320		0	0	0	1	0	1
Total	6	0	9	37	34	14	100

* Developed by hindcasts of waves originating north of latitude 20° north for period March 30, 1948 to March 29, 1949.

TABLE 23

COMPARISON OF WAVE DATA NEAR ANAHEIM BAY, CALIFORNIA
OBTAINED BY VARIOUS METHODS
(From Caldwell, 1956)

	Deepwater Waves			Shallow-Water Waves (20-foot depth near Huntington Beach Pier)		
	Direction (deg)	Period (sec)	Height (ft)	Direction (deg)	Period (sec)	Height (ft)
10/30/48						
Photo Data	165* (Southern Swell)	13.5*	-	180	13.5	-
Wave Gage	-	-	-	-	13.7	3.6
Hindcast	290 ±10	14.6	2.7	225**	14.6	1.4**
11/23/48						
Photo Data	286*	14.5*	-	223½	14.5	-
Hindcast	290 ±10	16.0	2.0	220**	16.0	1.0**
1/31/49						
Photo Data	273*	12.5-13.5*	-	223-235	12.5-13.5	-
Wave Gage	-	-	-	-	14.5	0.5
Hindcast	280 ±10	17.2	3.1	220**	17.2	1.5**
3/8/49						
Photo Data	288*	17.0-18.0*	-	219-232	17-18	-
Wave Gage	-	-	-	-	15.5	2.0
Hindcast	280 ±10	17.0 ±1	3.0-3.5	220**	17.0	1.5-1-8**
4/4/49						
Photo Data	275*	11.5-12.5*	-	227-223	11.5-12.5	-
	172* (Southern Swell)	15.0*		189	15.0	-
Wave Gage	-	-	-	-	13.0	1.1
Hindcast	280 ±10	17.2	3.1	220**	17.2	1.5**

* Developed from reverse orthogonals
** Developed through refraction diagrams

TABLE 24

VOLUMES OF EROSION AND ACCRETION IN ANAHEIM STUDY AREA BETWEEN SURVEYS

(+ = accretion to beach; - = erosion of beach)

Range Number	Distance From R-0	Distance Range Interval	Mar 29-Jun 1 Change in Vol. (cu. yds.)	Cumulative Change in Vol. (cu. yds.)	Jun 1-Aug 6 Change in Vol. (cu. yds.)	Cumulative Change in Vol. (cu. yds.)	Aug 6-Nov 9 Change in Vol. (cu. yds)	Cumulative Change in Vol. (cu. yds.)
			65 Days		66 Days		95 Days	
0	0							
		900						
1	900							
		500						
2	1,400							
		500	- 8,700	- 8,700	+ 9,800	+ 9,800	-14,800	-14,800
3	1,900							
		500	-13,000	-21,700	+ 5,600	+15,400	-18,500	-33,300
4	2,400							
		500	-10,200	-31,900	-11,100	+ 4,300	+ 8,300	-25,000
5	2,900							
		500	- 7,400	-39,300	-10,200	- 5,900	+17,600	-7,400
6	3,400							
		500	+ 2,800	-36,500	- 3,700	- 9,600	+ 900	- 6,500
6AA	3,900							
		500	+ 2,800	-33,700	- 3,700	-13,300	+ 6,500	00
6A	4,400							
		500	+12,900	-20,800	+ 8,300	- 5,000	+11,000	+11,000
6B	4,900							
		500	+13,000	- 7,800	+ 8,400	+ 3,400	+ 1,900	+12,900
7	5,400							
		500	+11,100	+ 3,300	+17,600	+21,000	+ 1,900	+14,800
7AA	5,900							
		500	+11,100	+14,400	+17,600	+38,600	+ 4,600	+19,400
7A	6,400							
		500	- 2,800	+11,600	+ 6,500	+45,100	- 4,600	+14,800
7B	6,900							
		500	- 2,800	+ 8,800	+ 6,500	+51,600	+ 900	+15,700
8	7,400							
		500	-12,900	- 4,100	+ 6,500	+58,100	00	+15,700
8A	7,900							
		500	-12,900	-17,000	+ 6,400	+64,500	00	+15,700
8B	8,400							
		500	-12,900	-29,900	+ 6,500	+71,000	00	+15,700
8C	8,900							
		500	-12,900	-42,800	+ 6,500	+77,500	00	+15,700
9	9,400							
		500	- 8,300	-51,100	+15,700	+93,200	-11,100	+ 4,600
9A	9,900							
		500	- 8,300	-59,400	+15,700	+108,900	-11,100	- 6,500
9B	10,400							
		500	- 8,300	-67,700	+15,800	+124,700	-11,100	-17,600
9C	10,900							
		500	- 8,400	-76,100	+15,800	+140,500	-11,200	-28,800
10	11,400							

TABLE 24

(Continued)

Range Number	Distance From R-0	Distance Range Interval	Nov 9-Jan 25 Change in Vol. (cu. yds.)	Cumulative Change in Vol. (cu. yds.)	Jan 25-Apr 8 Change in Vol. (cu. yds.)	Cumulative Change in Vol. (cu. yds.)	Apr 8-Aug 19 Change in Vol. (cu. yds.)	Cumulative Change in Vol. (cu. yds.)
			77 Days		73 Days		123 Days	
0	0							
		900						
1	900							
		500						
2	1,400							
		500	-32,800	-32,800	-41,200	-41,200	+42,600	+42,600
3	1,900							
		500	-33,300	-66,100	-28,800	-70,100	+ 9,300	+51,900
4	2,400							
		500	-25,900	-92,000	-47,200	-117,300	- 2,800	+49,100
5	2,900							
		500	-25,900	-117,900	- 4,700	-122,000	-43,400	+ 5,700
6	3,400							
		500	- 7,400	-125,300	-11,100	-133,100	-23,200	-17,500
6AA	3,900							
		500	00	-125,300	00	-133,100	-22,200	-39,700
6A	4,400							
		500	- 3,700	-129,000	- 300	-134,000	-12,000	-51,700
6B	4,900							
		500	+ 7,400	-121,600	- 1,900	-135,900	-10,200	-61,900
7	5,400							
		500	+12,000	-109,600	-15,700	-151,600	+ 8,400	-53,500
7AA	5,900							
		500	+ 6,600	-103,000	- 8,500	-160,100	+ 4,600	-48,900
7A	6,400							
		500	+ 6,500	-96,500	+ 5,600	-154,500	- 5,600	-54,500
7B	6,900							
		500	+ 4,600	-91,900	+ 4,600	-149,900	- 5,500	-60,000
8	7,400							
		500	+ 4,600	-87,300	+ 3,700	-146,200	- 7,400	-67,400
8A	7,900							
		500	+ 9,300	-78,000	+ 7,400	-138,800	-12,000	-79,400
8B	8,400							
		500	+ 3,700	-74,300	- 1,200	-140,000	+ 7,400	-72,000
8C	8,900							
		500	+ 3,700	-70,600	+ 6,700	-133,300	+ 2,800	-69,200
9	9,400							
		500	+13,900	-56,700	+ 3,700	-129,600	-11,100	-80,300
9A	9,900							
		500	+ 7,400	-49,300	+12,000	-117,600	-24,100	-104,400
9B	10,400							
		500	+ 3,700	-45,600	- 3,800	-121,400	- 2,700	-107,100
9C	10,900							
		500	- 1,900	-47,500	- 1,800	-123,200	+ 2,700	-104,400
10	11,400							

TABLE 25

SUMMARY OF VOLUME CHANGES
(from Caldwell, 1956)

Volume changes in Cubic yards.

(+ = accretion; - = erosion)

Survey Interval	Method of Presentation	Ranges 2 to 6A (3,000 feet)	Ranges 2 to 7A (5,000 feet)	Ranges 2 to 10 (10,000 feet)
		(cu. yds.)	(cu. yds.)	(cu. yds.)
3/29 to 6/1/1948 (65 Days)	Change between surveys (1)	-33,700	+14,400	-76,100
	Average change per day	- 518	+ 211	- 1,170
	Cumulative change (2)	-33,700	+14,400	-76,100
	Change in sector (3)	-33,700 (4)	+48,100 (5)	-90,500 (6)
6/1 to 8/6/1948 (66 Days)	Change between surveys (1)	-13,300	+38,600	+140,500
	Average change per day	- 202	+ 585	+ 2,130
	Cumulative change (2)	-47,000	+53,000	+ 64,400
	Change in sector (3)	-47,000 (4)	+100,000 (5)	+ 11,400 (6)
8/6 to 11/9/1948 (95 Days)	Change between surveys (1)	0	+19,400	-28,800
	Average change per day	0	+ 205	- 303
	Cumulative change (2)	-47,000	+72,400	+35,600
	Change in sector (3)	-47,000 (4)	+119,400 (5)	-36,800 (6)
11/9/48 to 1/25/1949 (77 Days)	Change between surveys (1)	-125,300	-103,000	-47,500
	Average change per day	- 1,630	- 1.340	- 618
	Cumulative change (2)	-172,300	- 30,600	-11,900
	Change in sector (3)	-172,300 (4)	+141,700 (5)	+18,700 (6)
1/25 to 4/8/1949 (73 Days)	Change between surveys (1)	-133,100	-160,100	-123,200
	Average change per day	- 1,820	- 2,200	- 1,680
	Cumulative change (2)	-305,400	-190,700	-135,100
	Change in sector (3)	-305,400 (4)	+114.700 (5)	+ 55,600 (6)
4/8 to 8/19/1949 (123 Days)	Change between surveys (1)	- 39,700	- 48,900	-104,400
	Average change per day	- 323	- 398	- 845
	Cumulative change (2)	-345,100	-239,600	-239,500
	Change in sector (3)	-345,100 (4)	+105,500 (5)	+ 100 (6)

(1) Volume change between range 2 and stated range between indicated surveys
(2) Cumulative change between range 2 and stated range from 29 March 1948 to indicated terminal survey
(3) Cumulative change in Sectors indicated in footnotes (4), (5), and (6).
(4) Cumulative changes in Sector 2 - 6A
(5) Cumulative changes in Sector 6A - 7A
(6) Cumulative changes in Sector 7A - 10

TABLE 26

SUMMARY OF WAVE ENERGY AND SAND MOVEMENT

Average north angle = 9°   sinØ cosØ = 0.154
Average south angle = 21°   sinØ cosØ = 0.334
(Energy expressed in million foot-pounds)
(from Caldwell, 1956)

Date of Survey	Interval in Days	Total energy per ft. of crest at 12-foot depth		Total alongshore energy per foot of beach		Net alongshore energy per foot of beach	Avg. daily alongshore energy per foot of beach	Sand movement past Range 10* (cu. yds. per Day)
		from North	from South	from North	from South			
3/29/48								
	65	2610	0	402	0	402N	6.2N	-1170
6/1/48								
	66	3844	5295	592	1765	1173S	17.8S	+2130
8/6/48								
	95	5572	1889	859	630	229N	2.4N	- 303
11/9/48								
	77	7901	780	1220	260	960N	12.5N	- 618
1/25/49								
	73	6336	595	975	199	776N	10.6N	-1680
4/8/49								
	123	3926	2522	604	844	204S	1.7S	- 845
8/19/49								

* Figures on sand movement are taken from Table 26. A plus (+) indicates a movement north past Range 10 into the study area. A minus sign (-) indicates a movement south past Range 10.

TABLE 27

SUMMARY OF BEACH SAND ANALYSIS, ANAHEIM STUDY AREA
(from Caldwell, 1956)

Range	Average median grain size in mm. of all Beach Samples* taken near the time of the March 1948 Survey	August 1949 Survey
3	0.47 (7)**	0.35 (15)
4	0.43 (7)	0.31 (14)
5	0.53 (6)	0.34 (12)
6 - 6A	0.51 (14)	0.48 (3)
7 - 7A	0.44 (8)	0.60 (2)
8	0.33 (4)	0.60 (1)
9	0.29 (4)	0.39 (1)
10	0.26 (4)	0.30 (2)
11	0.31 (3)	0.34 (1)
12 - 24 ***	0.20 (3)	0.33 (12)
	Summary from above compilation:	
3 - 7A	0.48	0.36
8 - 11	0.30	0.39

* Beach samples are those taken from the surface of the beach between the mean lower low water contour and the survey base line.

** The numbers in parentheses indicate the number of beach samples collected and averaged in obtaining the stated median diameter.

*** Ranges 11 (sic) through 24 are spaced at 3,000-foot intervals along the beach.

TABLE 28

KOMAR'S FIELD DATA

Study Number	Date	Volume transport rate cm^3/sec	Q yd^3/day (Computed)	Energy Flux P_ℓ erg/cm sec ($x\ 10^5$)	E_a ft-lbs/ft-day (Computed) ($x\ 10^4$)	Immersed weight transport I_ℓ dynes/sec ($x\ 10^5$)	I_ℓ lbs/day (Computed) ($x\ 10^4$)
1 EMB*	4 May 66	4490	508	43	83.5	45.1	87.5
2	5 May 66	8350	948	104	202.0	84.4	164.0
3	11 Oct 66	2560	290	30	58.0	25.7	49.7
4	13 Oct 66	981	107	15	29.0	9.9	19.2
5	22 May 67	1450	164	20	39.0	14.6	28.3
6	22 May 67	4260	481	38	74.0	42.8	83.0
7	23 May 67	604	68	6	12.0	6.1	11.8
8	23 May 67	881	100	18	35.0	8.9	17.2
9	28 Jan 68	292	33	6	12.0	2.9	5.6
10	11 May 68	2060	232	18	35.0	20.8	40.4
11 SSB**	14 Nov 67	1270	144	15	29.0	12.8	24.8
12	22 Nov 67	30100	3400	380	740.0	302.0	585.0
13	4 Sep 68	4680	530	91	177.0	47.1	91.0
14	5 Sep 68	3760	425	41	79.0	37.9	73.5

* El Moreno, Beach, Mexico

** Silver Strand Beach, California, USA

APPENDIX B

Figures 1A through 10

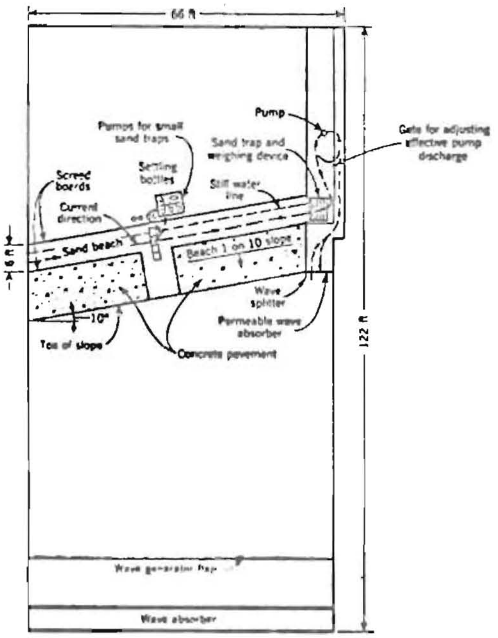


Figure 1-A. Saville's Test Setup (1950)

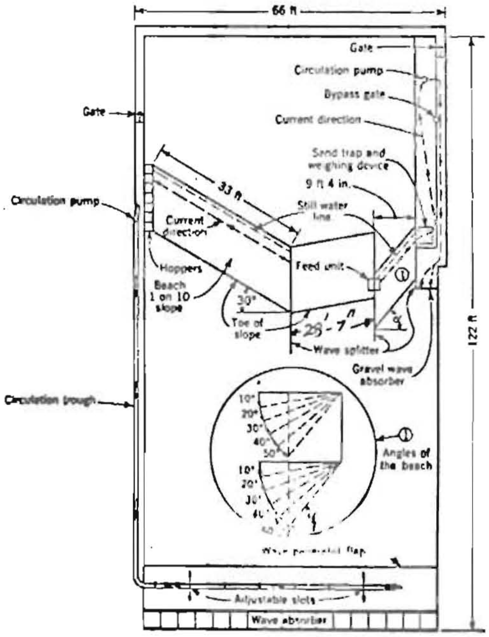


Figure 1-B. Shay and Johnson's Test Setup (1951) for α_g = 30 degrees or greater

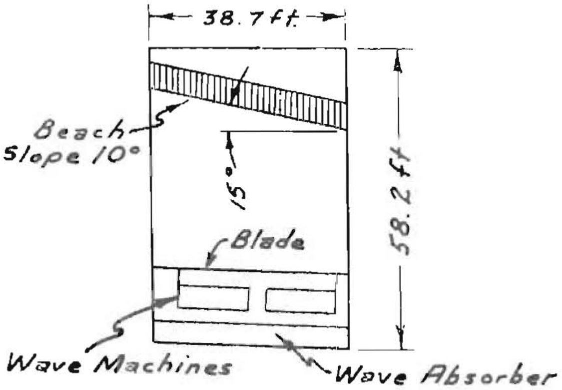
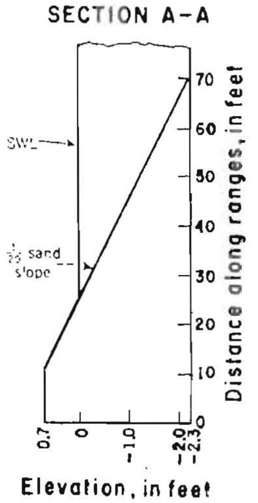


Figure 2-A Krumbein's Test Setup (1942)



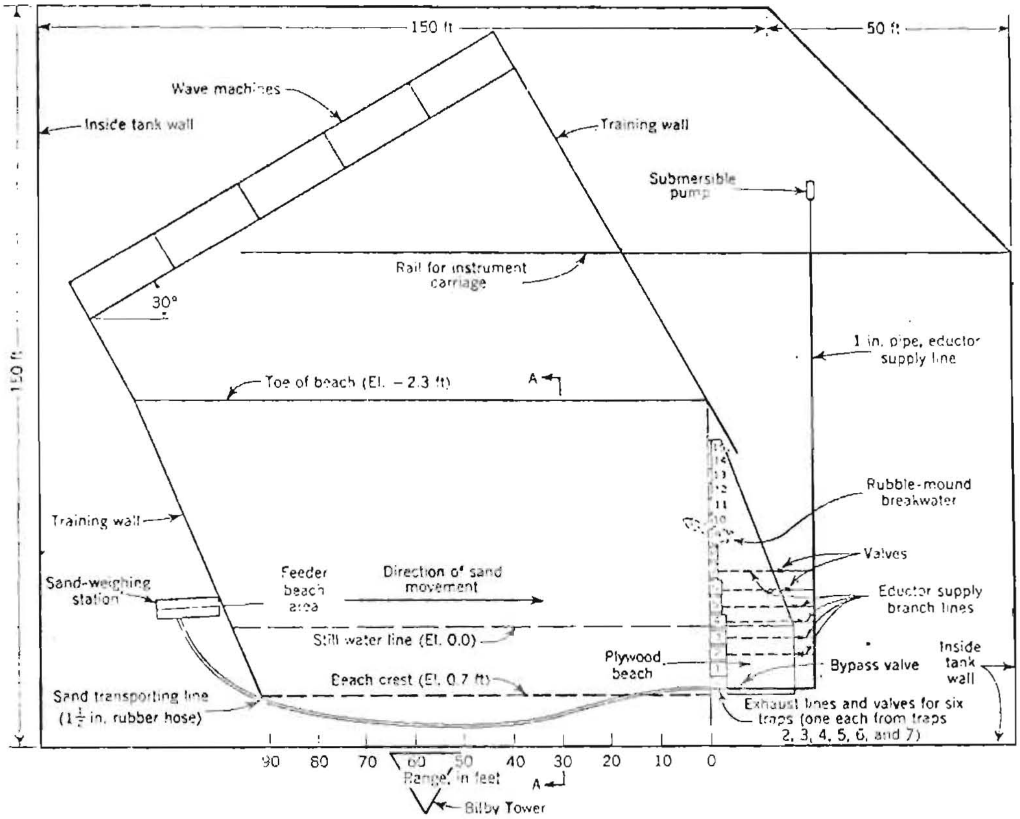


Figure 2-B. Layout of Shore Processes Test Basin, BEB (from Savage, 1962)

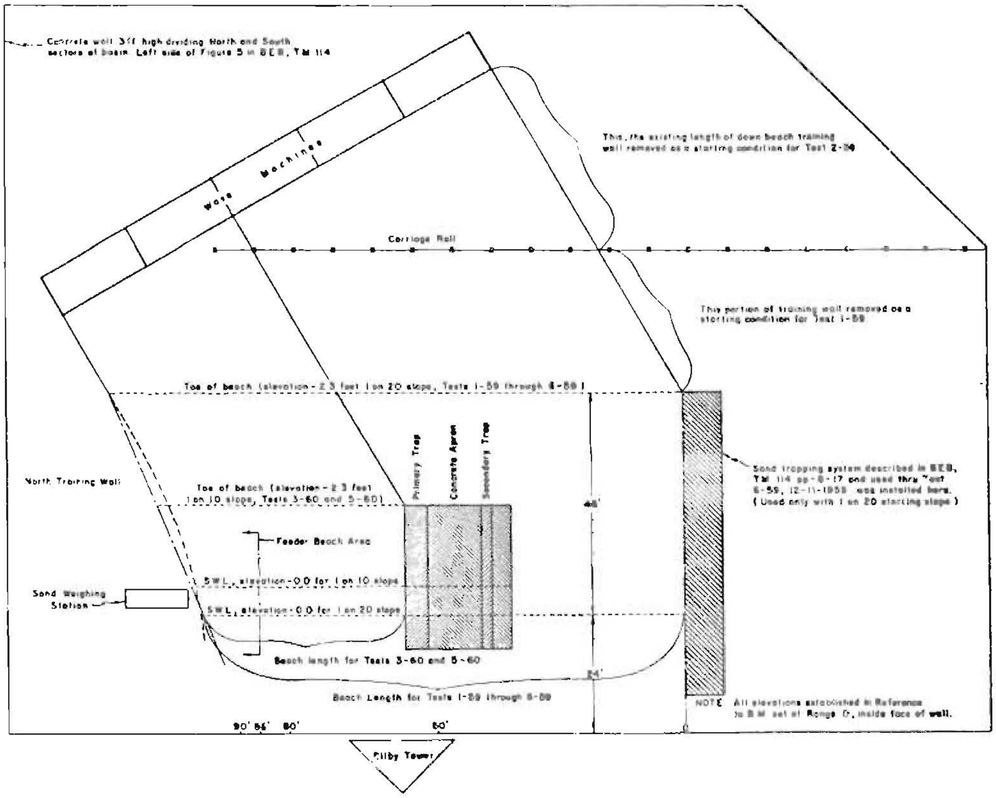


Figure 3-A. Layout of Shore Processes Test Basin, South Sector BEB (from Fairchild, 1960-61)

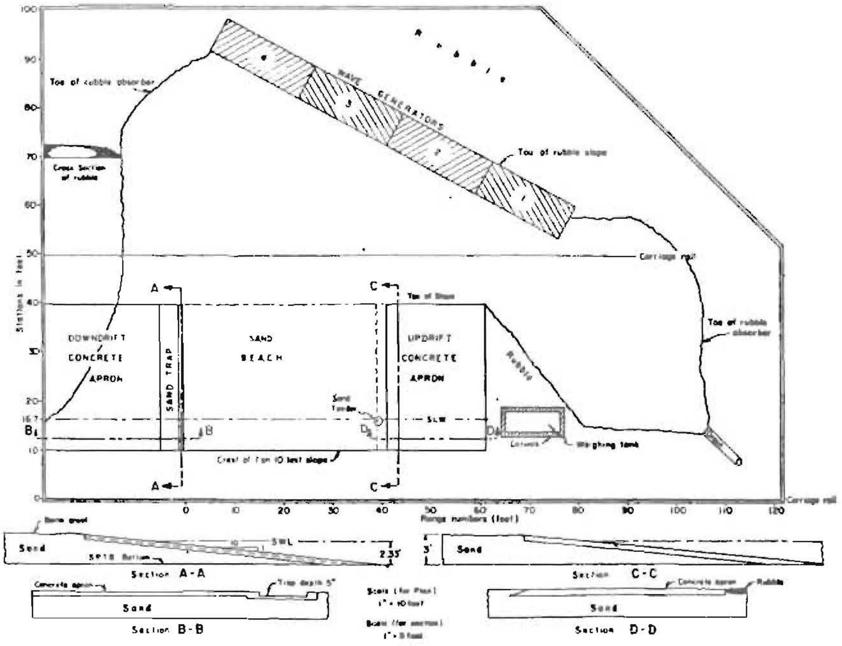


Figure 3-B. Layout of Shore Processes Test Basin, North Sector CERC (from Fairchild, 1965 - 1968)

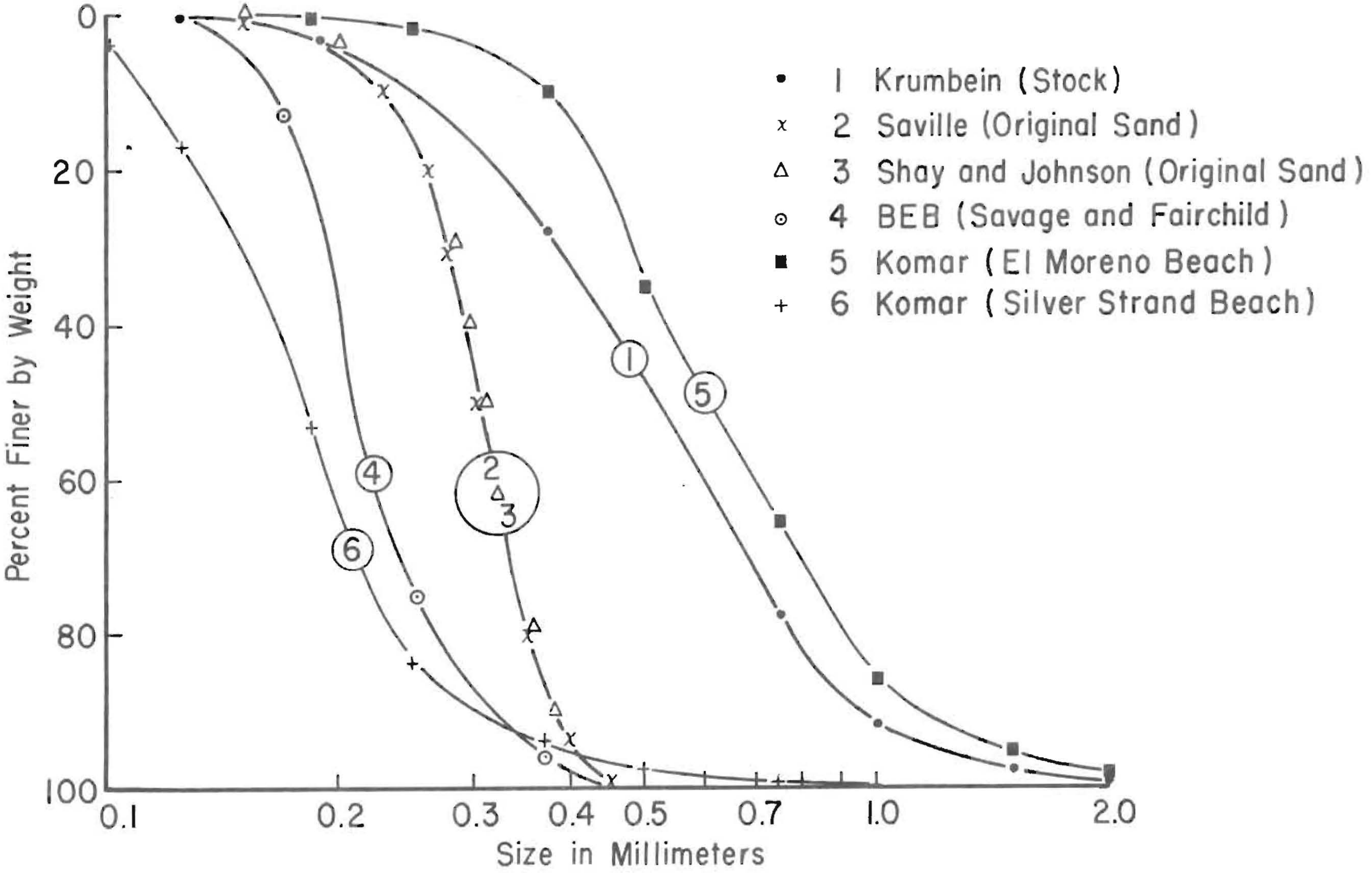


Figure 4. Mechanical Analyses of Sands

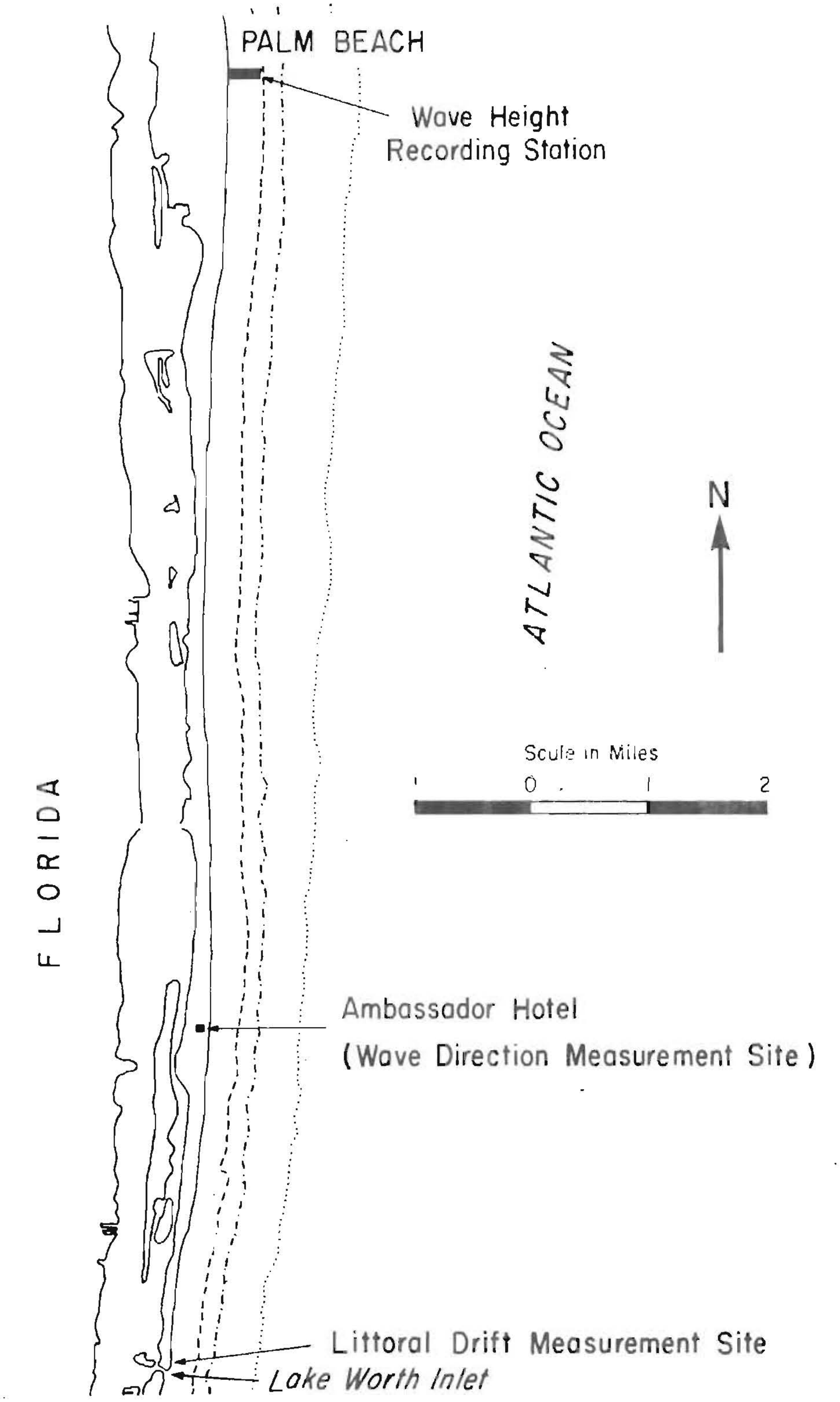


Figure 5. Location Map, Study at South Lake Worth Inlet, Florida (from Watts, 1953)

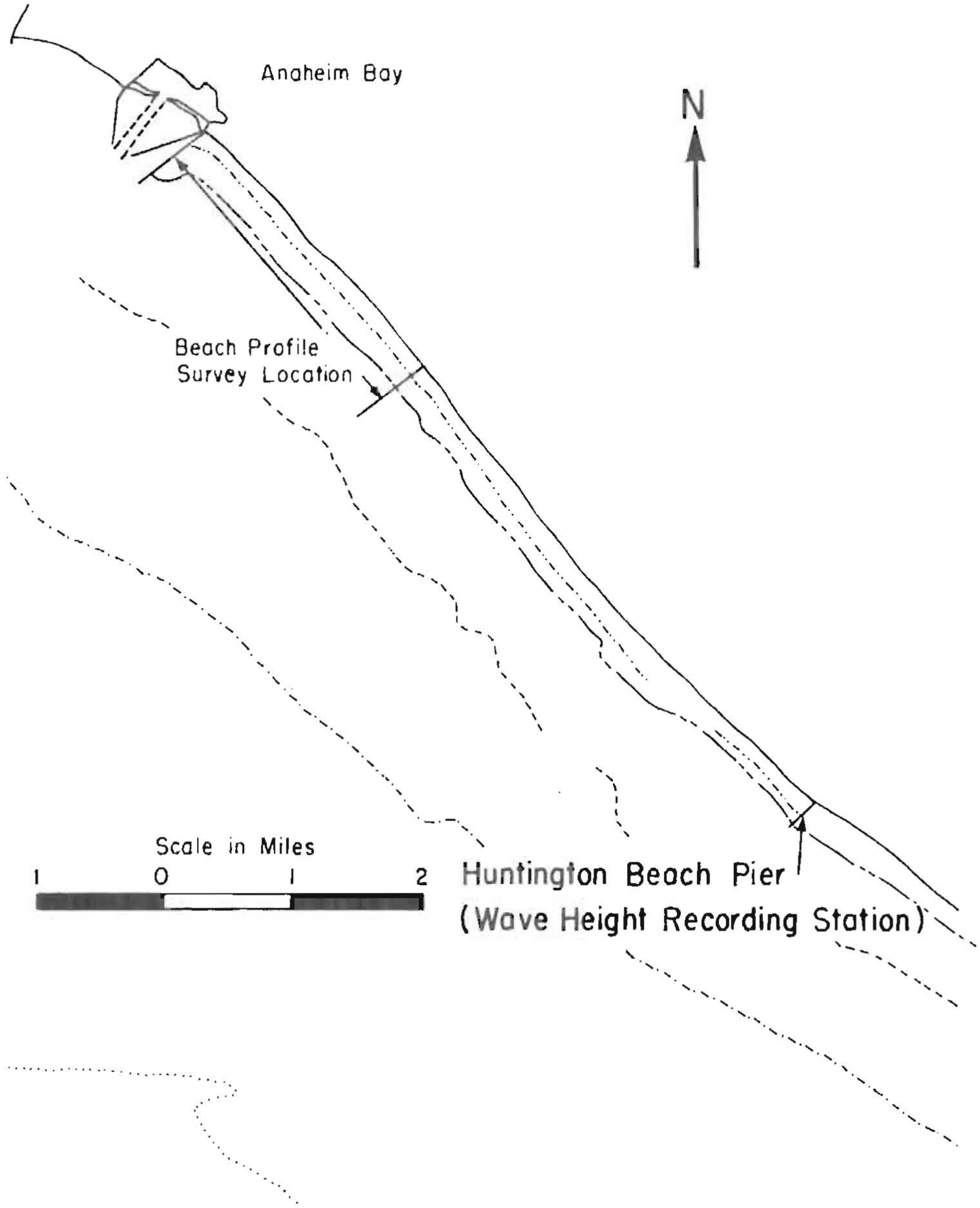


Figure 6. Location Map, Study at Anaheim Bay, California (from Caldwell, 1956)

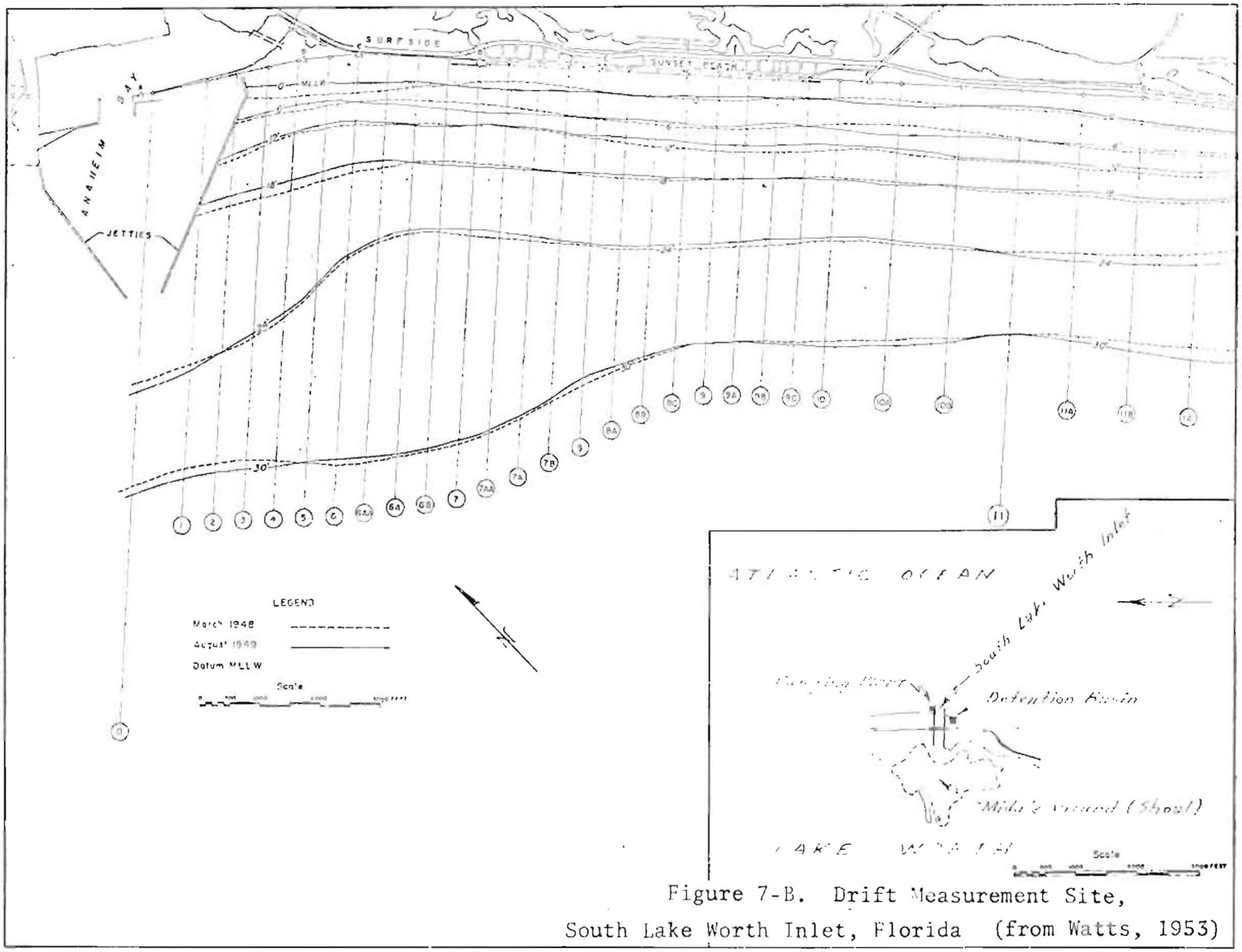


Figure 7-B. Drift Measurement Site, South Lake Worth Inlet, Florida (from Watts, 1953)

Figure 7-A. Survey Data and Range Location, Anaheim Bay, California (from Caldwell, 1956)

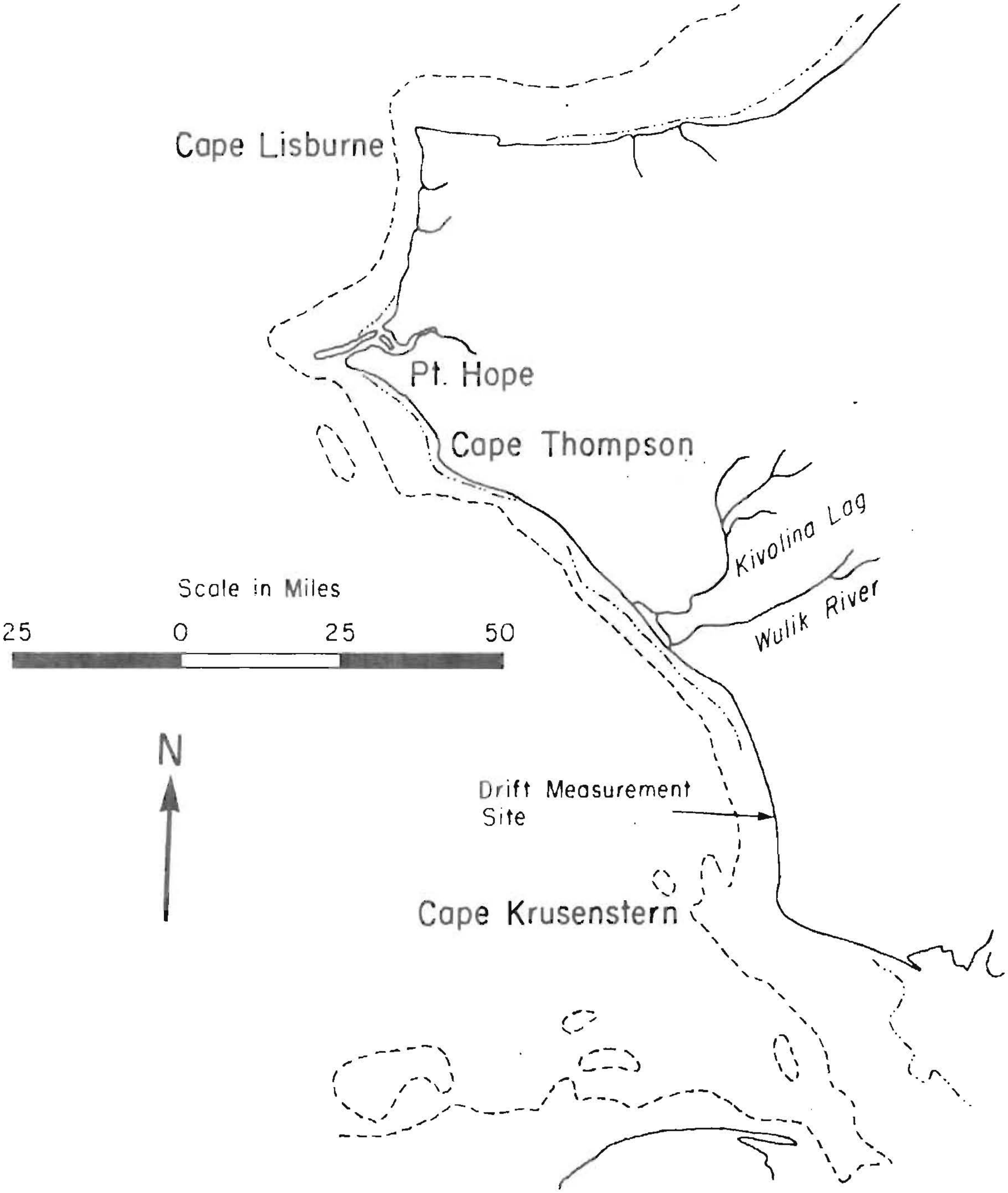


Figure 8. Location Map, Study at Cape Thompson, Alaska (from Moore and Cole, 1960)

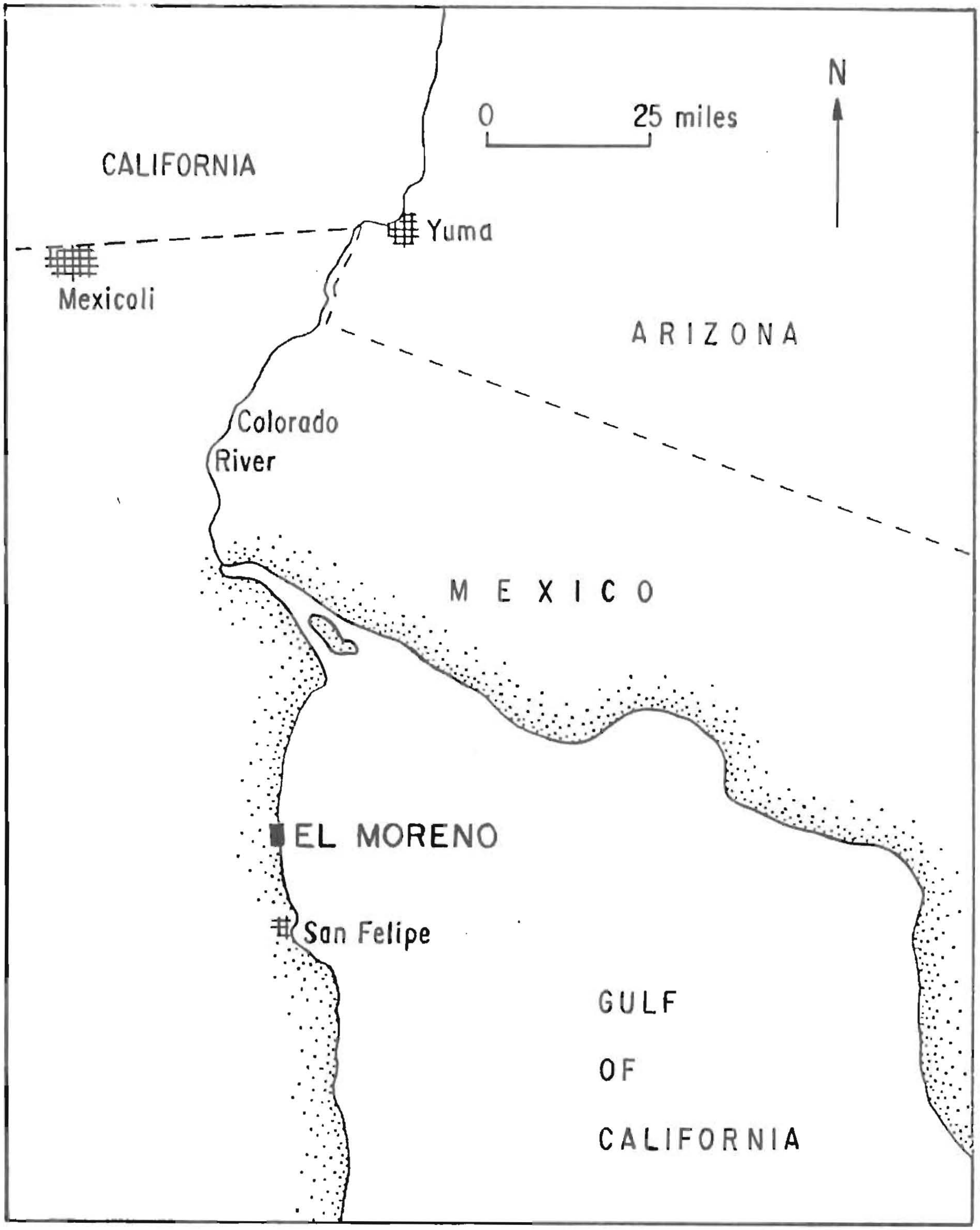


Figure 9. Location Map, El Moreno Beach, Baja California, Mexico

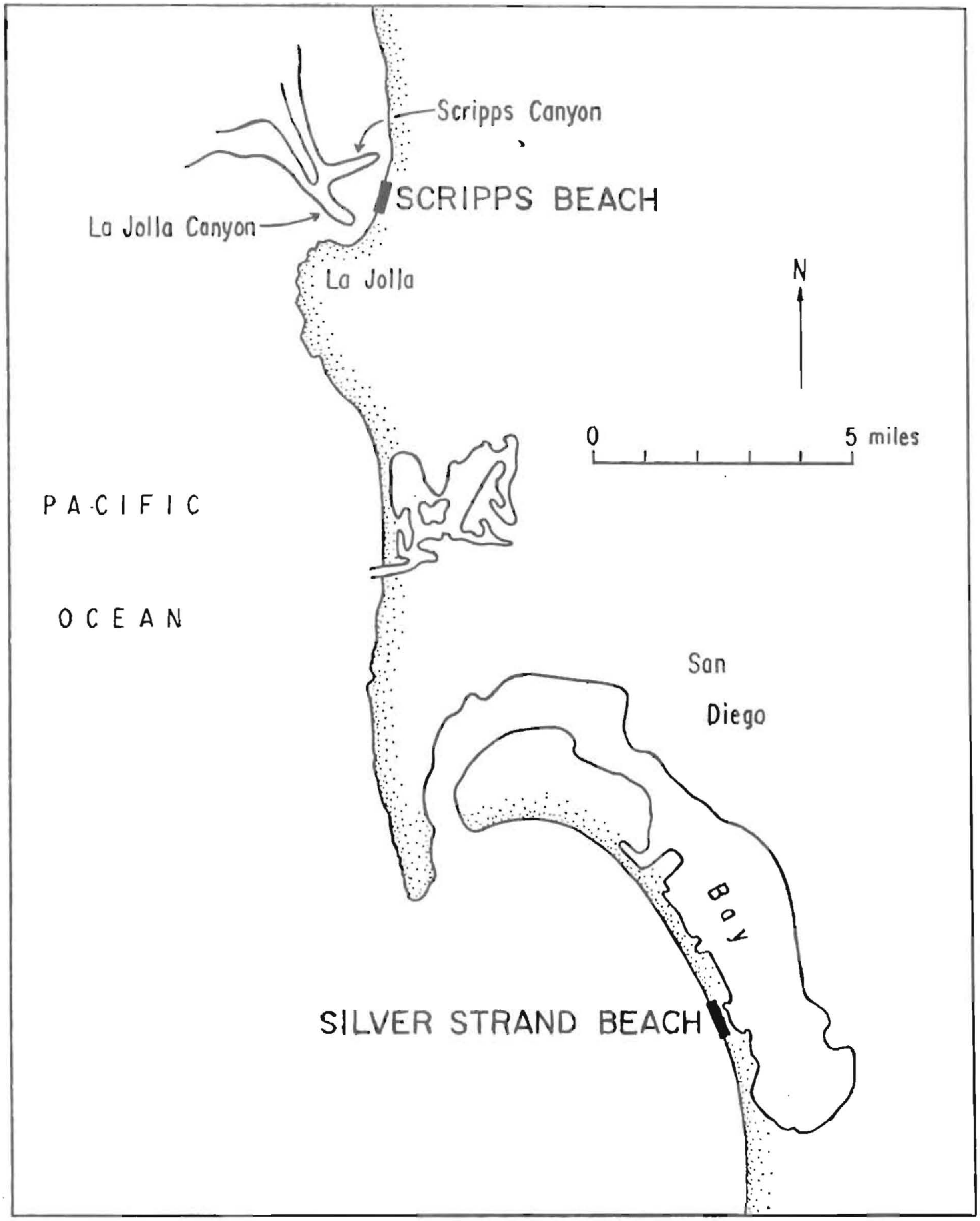


Figure 10. Location Map, Silver Strand Beach near San Diego, California

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The report is a compilation of data on longshore sediment transport and associated wave and sediment characteristics from six laboratory studies and four field studies. Laboratory observations include water depth, wave height, wave period, sand size, wave generator angle with toe of the beach, and longshore transport rate. Laboratory wave heights range from 0.035 to 0.51 foot, periods from 0.75 to 3.75 seconds, depth from 0.49 to 2.33 feet, generator angles from 10 to 50 degrees, initial beach slope from 1:5.6 to 1:33, median grain size from 0.22 mm. to 1.55 mm., and specific gravities from 1.1 to 2.69. The maximum transport rate near Anaheim Bay, California, is 2,130 cubic yards per day, north; near South Lake Worth Inlet, Florida, is 1,300 cubic yards per day, south. The estimated transport rate at Cape Thompson, Alaska, is 4,680 cubic yards per day; the rate at Silver Strand Beach, California, is 3,400 cubic yards per day.

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