NEARSHORE SEDIMENT TRANSPORT STUDY EXPERIMENTS

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INTRODUCTION

The Nearshore Sediment Transport Study (NSTS) is a multi-institutional research program with the objective of developing improved engineering predictive models for transport of sediment, both longshore and cross shore, by waves and currents. The program is sponsored by the Office of Sea Grant (OSG), an agency of the National Oceanic and Atmospheric Administration (NOAA). A general introduction to the objectives, schedule and organization of the NSTS program was presented at the 16th ICCE by Seymour and Duane (1979). Shortly after the Hamburg Conference, the first major field experiment was conducted at Torrey Pines Beach, California, in November, 1978. The second major experiment was conducted 14 months later in February, 1980 at Leadbetter Beach, in Santa Barbara, California. Each of these experiments involved levels of measurement intensity that appear to exceed by a large factor those of any similar work. Because of the large data sets obtained and the importance of these data to other investigators in coastal processes, the NSTS project is making them available promptly. In the following sections, a general description will be given for each of these experiments and information supplied on how the data may be obtained.

TORREY PINES BEACH EXPERIMENT, NOVEMBER, 1978

Torrey Pines Beach, north of the Scripps Institution of Oceanography (SIO) in La Jolla, CA, is a straight and regular beach, as shown in Figure 1. This regularity was considered a significant advantage for the initial experimental site, as was its proximity to SIO. The wave climate and beach response characteristics had been well studied and it was possible to select a month for the experiment when there would be a high probability of large waves, but prior to the extreme winter storms.

An instrumentation plan was developed by E. B. Thornton of the Naval Postgraduate School, R. T. Guza and S. S. Pawka of SIO to define the dynamics of the shoaling waves and of the surf zone. The arrangement adopted for Torrey Pines is shown in Figure 2. In this figure, the mean sea level intersection with the beach is at approximateley 90 meters offshore of the arbitrary origin, and the typical breaker line is at about 180 meters during high tide. Therefore, it can be seen that the instrumentation extended several surf zone widths seaward, but with the highest density of instruments in the breaking zone and shoreward.

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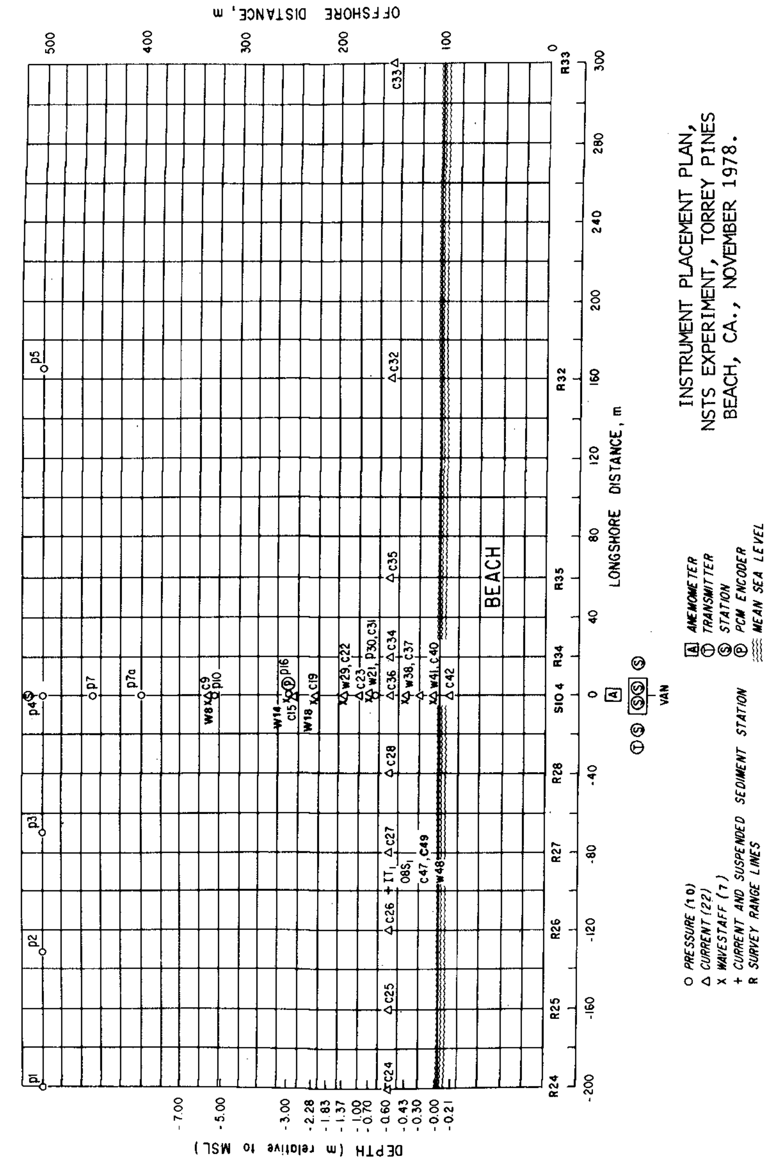
AERIAL VIEW OF TORREY PINES BEACH,
CA., SITE OF NSTS EXPERIMENT IN
NOVEMBER, 1978. SCRIPPS INSTITUTION
OF OCEANOGRAPHY PIER IN THE BACKGROUND.

FIGURE 1



INSTRUMENT PLACEMENT PLAN, NSTS EXPERIMENT, TORREY PINES BEACH, CA., NOVEMBER 1978.

FIGURE 2

The incident wave climate was measured with a 5 element linear array of pressure sensors at a depth of about 10 m. The array spacing was 2-2-2-5 with a 33 m. unit spacing. The linear array allowed the calculation of a directional spectrum so that the wave field could be refracted shoreward to any desired location. A main shore normal instrument line was established that is labelled SIO4 in Figure 2. A shore normal array of pressure sensors, wave staffs and two-axis electromagnetic current meters was installed which extended shoreward to include a resistance type runup meter in the swash zone. A second, shore parallel, array of current meters was installed at a depth of approximately 0.6 m below MSL. A total of 22 current meters was employed, 20 of them in fixed locations within the instrument grid. Two current meters were arranged in portable frames which could be installed in locations suitable for obtaining measurements of rip currents. These measurement were made by R. A. Dalrymple of the University of Delaware. Ten pressure sensors and seven wave staffs were deployed, as well as an anemometer mounted on a tower on the beach. These instruments, as well as the 20 fixed current meters and the runup meter, were installed and operated by Thornton, Guza and Pawka.

During the experiment, R. W. Sternberg of the University of Washington deployed two prototype instruments for measuring suspended sediment. One operated on the principle of changing the natural frequency of a vibrating element with changing sediment concentrations. The second unit measured concentrations by determining the number of sediment grain impacts with a small sensing whisker. A third experimental suspended sediment meter was evaluated by D. L. Inman and R. E. Flick of SIO. This instrument measured backscatter from a polarized laser.

The data gathering and recording system used at Torrey Pines was developed by the Shore Processes Laboratory (SPL) at SIO. Signals from the deep water instruments were telemetered directly to SPL using a battery powered shelf and shore station at the linear array. Other instruments were cabled to the beach and then telemetered to SIO. Data were sampled at 64 hz from all instruments and were PCM encoded. The PCM data were transmitted by telemetry link and recorded on a 7 track tape recorder at SIO. Data runs were approximately four hours in duration on each of the 20 experiment days. When the data were converted to computer compatable tapes at a later time, the sampling rate was reduced to 8 hz by block averaging 8 adjacent data values. This resulted in a data output of nearly one-half billion words.

The principal emphasis of the Torrey Pines experiment, in contrast to later field work, was on characterizing the surf zone dynamics. However, a number of sediment transport observations were made as well. D. L. Inman of SIO conducted three longshore transport experiments using dyed sand tracers which were timed to coincide with data runs. These experiments covered a variety of wave conditions. Suspended sediment measurements were made using a water column coring device. The amount of tracer in the bed, and its depth of burial, was determined from analysis of sediment cores taken using various spatial and temporal sampling schemes. Some results of this work are contained in Inman et al. (1980). Both the water column and the bed coring devices were developed by SPL.

Beach morphology changes were measured by R. J. Seymour of SIO. The ten ranges shown on Figure 2 were surveyed to wading depth every second day. The main range (SIO4) was surveyed daily. In addition, these ranges were extended to a depth of 10 m twice during the experiment using a boat mounted fathometer with electronic navigation. All of the beach profile and bathymetric data were digitized and recorded on magneteic tape. The beach changes included a number of erosional and accretional events associated with variations in the incident wave climate. These provide a data set on cross shore transport which can be correlated with the forcing functions obtained from the surf zone dynamics measurements.

Drift kelp was a major problem in this experiment. Particularly after an event of large waves, the mats of kelp could exceed 100 kg in weight and were capable of damaging or destroying any of the surf zone instrumentation. Guza and Thornton developed a breakaway mount for the current meters which allowed them to survive the kelp onslaughts and also devised a scheme for rapidly reinstalling and realigning the meters after the kelp was removed. Precise alignment of the two axis meters was critical in shallow water since wave approach angles are quite small, approaching the directional resolution of the meter. A storm midway through the experiment carried away all of the wave staffs and they were not replaced. However, all of the current meters were returned to service.

THE TORREY PINES DATA

One of the guiding policies of the NSTS program is that the experimental data be made available to the public promptly. The investigators are allowed 18 months after the completion of an experiment to analyze their data and to publish their findings. A large fraction of this time is spent in sorting out the records and editing the raw data. In July, 1979, NSTS sponsored a workshop at La Jolla in which the preliminary results of the Torrey Pines experiment were presented. In December, 1979, a comprehensive experiment report was published (Gable

[1979]). This report contained complete descriptions of the experiment site, the environmental conditions, the instrument locations, types and calibrations, and sufficient information to allow other investigators to extract meaningful data from the data tapes. In March, 1980, an announcement was made at the 17th ICCE that the data tapes were available to the general public. This was accomplished on schedule, 18 months after the experiment. The data require eight 2400 foot 9-track magnetic tapes. They include the profile data and the suspended sediment data from Sternberg's instruments as well as all of the surf zone dynamics measurements. The data from Inman's tracer studies, which could not be readily presented on tape, are included as an appendix to the experiment report.

Investigators wishing to acquire the Gable report or copies of the tapes should contact

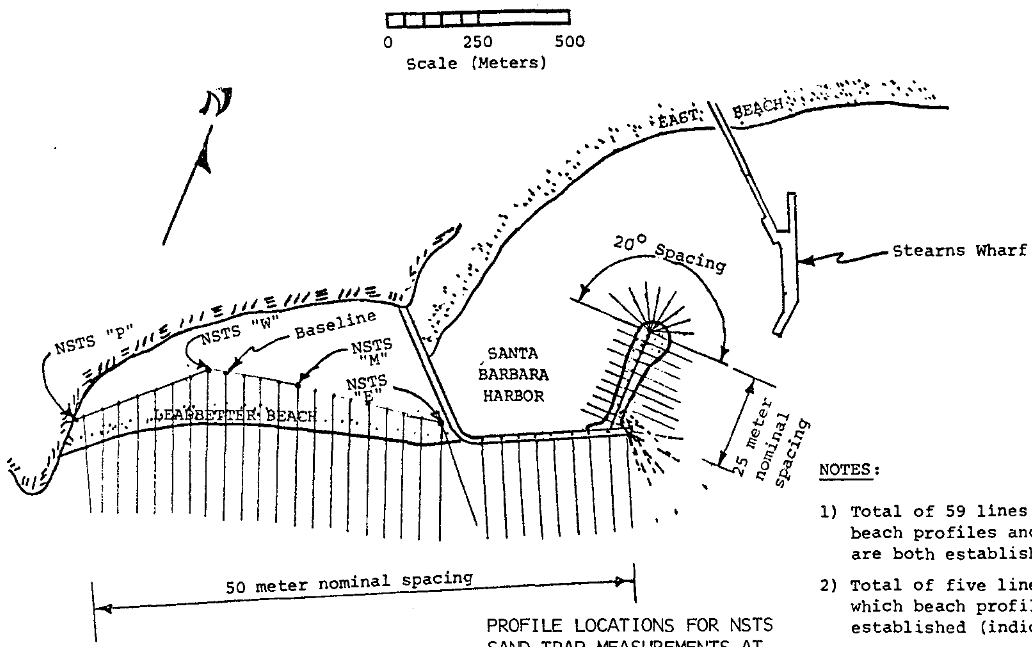
National Oceanographic Data Center
Code D781
2001 Wisconsin Avenue, N.W.
Washington, D.C. 20235

THE SANTA BARBARA EXPERIMENT

A site selection study, conducted by R.G. Dean of the University of Delaware, recommended that the second NSTS experiment be conducted at Leadbetter Beach in Santa Barbara, CA. The second experiment was to place heavier emphasis on the measurement of sediment transport than the first, and Santa Barbara was selected principally because of the very satisfactory sediment trap provided by the harbor. As shown in Figure 3, Leadbetter Beach is a feeder beach for the sandspit formed in the shadow of the breakwater. The accumulation of sediment within the harbor is bypassed by intermittent dredging. The Santa Barbara experiment began in September, 1979 with the initiation of a year long trap study. The intensive experiment period, comparable to the Torrey Pines experiment, was conducted during the month of February, 1980. The experiment was directed by R.G. Dean, for the sediment transport measurements and by R.J. Seymour for the wave climate measurements. The accumulation of sediment was measured at approximately six week intervals with profiles extending from the dry beach to a depth of approximately 10 m. These profiles were run at 50 m spacing along the feeder beach, the breakwater and the sandspit, as shown in Figure 4. Wading surveys were made on the shallow end of the profiles with the deep water portion conducted by fathometer surveys using an electronic location system on the boat. The incident wave climate was measured at least every six hours for the one year period of the experiment. Two slope arrays of the type described in Seymour et al. (1980) were

AERIAL VIEW OF SANTA BARBARA, CA., LEADBETTER BEACH, SITE OF NSTS EXPERIMENT IN FEBRUARY 1980 AS SHOWN ABOVE THE HARBOR.

FIGURE 3



PROFILE LOCATIONS FOR NSTS SAND TRAP MEASUREMENTS AT SANTA BARBARA, CA., 1979-80.

FIGURE 4

NOTES:

1) Total of 59 lines for which beach profiles and soundings are both established.

2) Total of five lines along which beach profiles only are established (indicated ——).

3) Total of three lines along which soundings only are established (indicated ----).

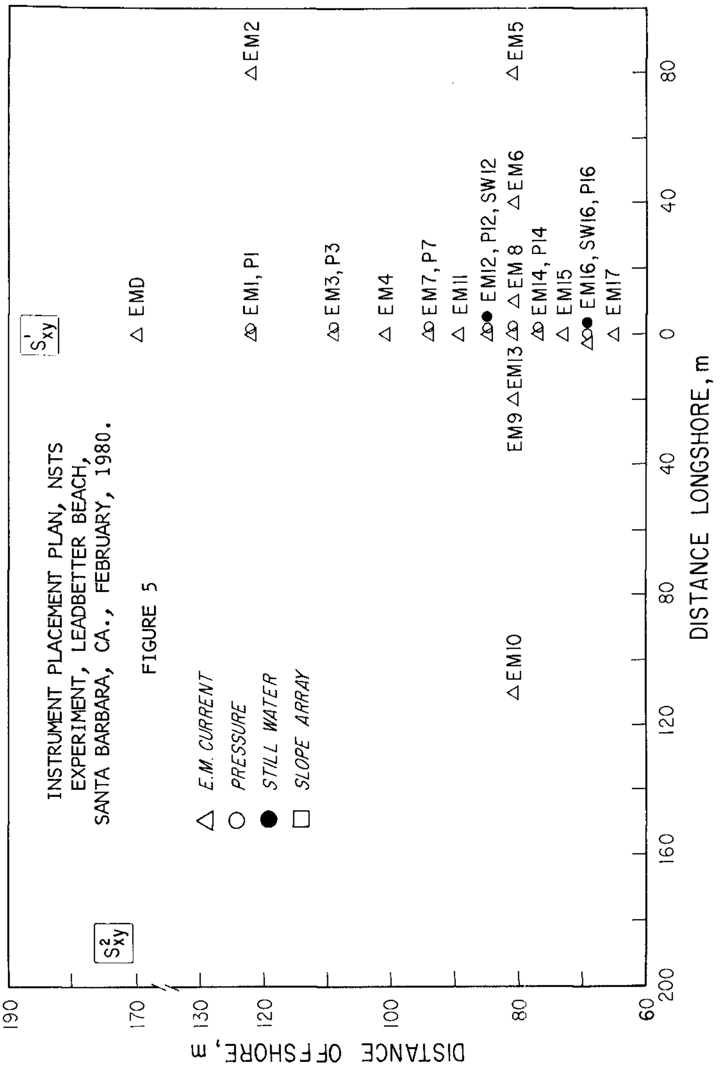
installed. These directional arrays provide a moderately well defined directional spectrum and well defined estimates of the longshore radiation stress. The wave data is collected automatically over telephone lines using the system described in Seymour and Sessions (1976) and is recorded at La Jolla.

During the February intensive experiment the instrument location plan followed the Torrey Pines scheme as shown in Figure 5. R. T. Guza and E. B. Thornton were again responsible for the surf zone dynamics measurements with R. A. Dalrymple making the rip current measurements. Twelve current meters were installed in the main cross shore range line and five meters were used in the longshore line. One other current meter was permanently installed, two were moveable for rip current measurements, and three were used for swash zone measurements. In addition to the eight pressure sensors in the slope arrays shown in Figure 5, there were seven additional pressure sensors in the cross shore main range line. Two still water level reference gauges were also installed in this line to measure setup.

In the Santa Barbara experiment, particular emphasis was placed on measurements in the inner third of the surf zone. Special portable space frames were developed to support instruments in very shallow water. These frames are shown in Figure 6. Typically, one frame would mount a two- axis current meter, a resistance type wave height probe, and two types of sediment concentration meters developed by R. W. Sternberg. The first of these was a refinement of the impact whisker type deployed at Torrey Pines. The second was a new miniaturized optical backscatter instrument with five sensors mounted at various heights off the bottom.

Measurements of integrated longshore current were obtained by R. E. Flick using a conventional metallic conductor GEK system and also a prototype seawater conductor unit. D. L. Inman and R. L. Lowe of Scripps Institution of Oceanography deployed a prototype bedlaod sensor employing three downward looking sonars. One sonar senses the bed thickness by discriminating the horizons at the sand surface and at the bottom of the moving bed. The other two, which look at the bottom at an angle, detect bedload speed components by Doppler shift. In addition to the swash zone instruments described earlier, R. W. Sternberg deployed two stacked 5 element suspended sediment meters of the backscatter type in deeper water.

Beach profile changes were measured by R. J. Seymour and by D. G. Aubrey of Woods Hole Oceanographic Institution. Five ranges were surveyed at least daily using wading survey techniques. In addition, an automatic profiling tractor was deployed to obtain continuous surveys to depths of 6 m. This vehicle is described in Seymour, et al. (1979).


INSTRUMENT PLACEMENT PLAN, NSTS
EXPERIMENT, LEADBETTER BEACH,
SANTA BARBARA, CA., FEBRUARY, 1980.
FIGURE 5
E.M. CURRENT
PRESSURE
STILL WATER
SLOPE ARRAY
S^2_{xy}
S'_{xy}
EMD
EM1, P1
EM2
EM3, P3
EM4
EM7, P7
EM11
EM12, P12, SW12
EM9
EM13
EM 8
EM6
EM5
EM10
EM14, P14
EM15
EM16, SW16, P16
EM17
DISTANCE LONGSHORE, m
DISTANCE OFFSHORE, m
190
170
130
120
100
80
60
200
160
120
80
40
0
40
80

SWASH ZONE INSTRUMENTATION
AT NSTS SANTA BARBARA
EXPERIMENT, FEBRUARY, 1980.

FIGURE 6

The first two weeks of the month long experiment were characterized by moderate to low waves with high angles of incidence so that the longshore currents tended to be strong at all times. Midway in the experiment a storm of very unusual intensity attacked the site for about one week, resulting in severe erosion to the beach as shown by the profiles in Figure 7. During the high wave episode, which was also marked by exceptionally strong longshore currents, drift kelp necessitated the removal of all but the deepest instruments. The wave measurement system continued to function throughout the experiment.

D. L. Inman and R. E. Flick conducted seven tracer studies during this experiment. Four were before the storm and three were in the week following the storm when the beach had been flattened and narrowed considerably. These studies followed the methodology utilized at Torrey Pines.

At Santa Barbara, the data were all cabled directly to the recording system which was housed in a trailer adjacent to the beach. Because of increase in the number of channels of instrumentation and because of longer data runs, almost a billion words of data were recorded -- roughly twice that at Torrey Pines.

SANTA BARBARA DATA

An experiment report and copies of the raw data tapes are expected to be available through the National Oceanographic Data Center in August 1981 for this experiment.

FUTURE EXPERIMENTS

The NSTS program plans one more major field experiment, patterned on the one at Santa Barbara, but on the eastern coast of the United States. The intensive portion of this experiment is tentatively scheduled for the fall of 1981. This third major experiment is expected to add a valuable data set on a barred coastline with steeper waves.

ACKNOWLEDGMENTS

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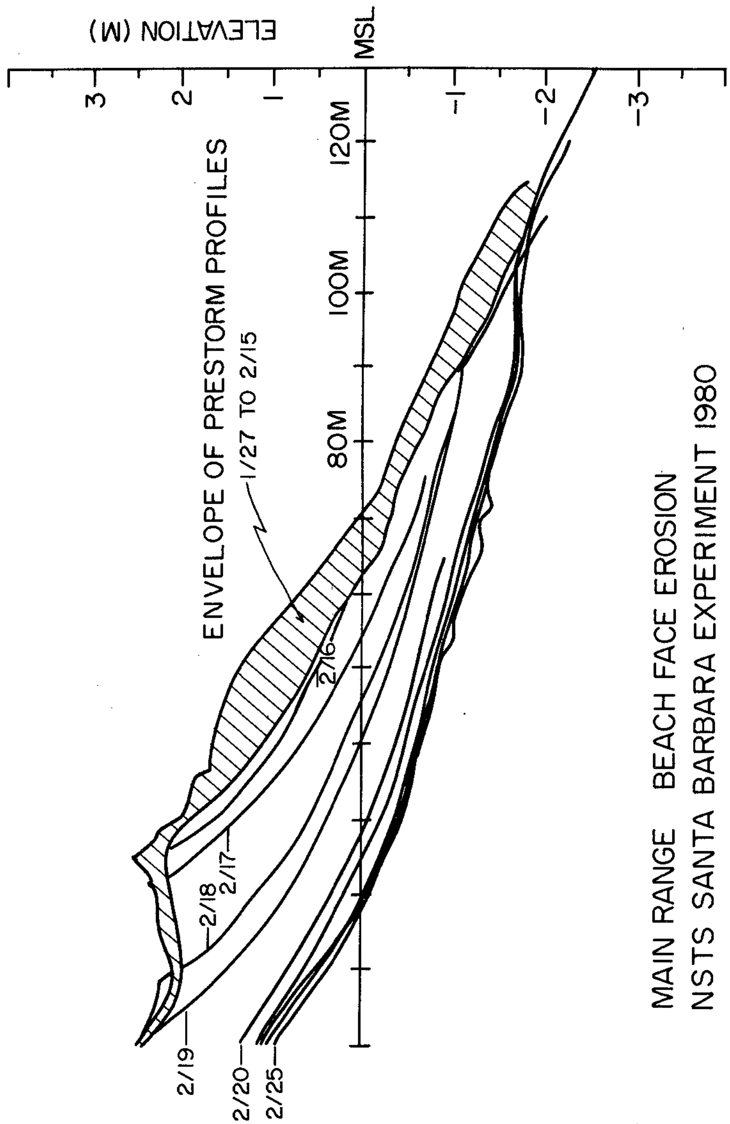

MAIN RANGE BEACH FACE EROSION
NSTS SANTA BARBARA EXPERIMENT 1980

FIGURE 7

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