

CHAPTER 92

THE NEARSHORE SEDIMENT TRANSPORT STUDY

Richard J. Seymour*
David B. Duane**

INTRODUCTION

The models for predicting longshore transport of sediment along straight coastlines that are presently in general use were derived empirically from very sparse measurements of both the forcing function (waves and currents) and the response function (sediment motions). A detailed treatment of these data sets is contained in Greer and Madsen (1978). In addition to the generally unsatisfactory nature of the basic measurements upon which they were based, the models may be deficient because they fail to employ such potentially significant factors as wind stress, sediment size distribution, bottom slope and spatial variations in waves and currents, including the effects of rip currents. Although these models have served certain engineering needs, there is a strong measure of uncertainty in the coastal engineering community about their general applicability. Certainly, because they are empirical rather than physically reasoned models, there is no rational means for extending their usefulness to predicting transport where coastlines are not straight -- such as the case of a tidal inlet.

The economic impact of sediment transport in the nearshore regime is enormous and the need for improved predictive tools appears to be universally accepted. To be most useful, these improved models must be globally applicable. This implies very strongly that they must be based upon a thorough understanding of surf zone dynamics and the details of the response of the sediment. The surf zone flow fields are highly complex and nonlinear, implying an equally complex and difficult system of sediment responses. Characterizing the entire forcing and response functions simultaneously requires large and expensive field measurement programs that greatly exceed the present state of the art of measurement and analysis. The approach of the last two decades of single investigators working at laboratory scale or in the ocean with a few single point measurements would not appear to ever meet these needs. However, the present costs for coastal dredging and shoreline protection, which can be measured in billions of dollars on a world scale, argue for a major undertaking to develop better predictive tools.

In an attempt to satisfy these needs, an ad hoc group was formed at the Fifteenth Coastal Engineering Conference in Honolulu to plan a large scale and coordinated series of investigations leading to improved sediment transport predictive models. Less than a year later, the Nearshore Sediment Transport Study was initiated under the sponsorship of the Office of Sea Grant. The program began as a focused

*California Dept. of Navigation and Ocean Development, Scripps Institution of Oceanography, UCSD, La Jolla, California
**Office of Sea Grant, Washington, D. C.

cooperative effort among four Sea Grant universities and several government agencies. With the advent of new legislation authorizing national Sea Grant projects to meet national needs, the NSTS program has recently been designated as the first such national program.

OVERALL OBJECTIVES

The major objective of the NSTS program is to produce improved engineering models for predicting the motion of sediment along straight coastlines under the action of waves and currents in the nearshore regime. From its inception, the program has been directed towards the development of models that can be simply employed, without recourse to large computers, and which will depend upon measurements or observations that can be obtained at reasonable cost.

PROGRAM ORGANIZATION

Management of a technically complex program and the effective coordination of a large and diverse group of investigators required the creation of a management concept substantially different from existing Sea Grant programs. The program employs a two tier management structure which is shown schematically in Figure 1. The Sea Grant Director has appointed an advisory group referred to as the NSTS Review Committee. This group, all experienced in nearshore processes, reviews proposals and makes funding recommendations to the Director, formulates overall program direction and reviews the progress of the investigators. A second tier group, known as the NSTS Steering Committee, is formed of the senior investigators. The chairman of this group functions as the Project Manager and is an ex officio member of the Review Committee. The Steering Committee formulates the details of the project program, plans and executes cooperative field programs and conducts workshops to promulgate the findings of the study to the coastal engineering community.

The NSTS program will have a duration of five years and is anticipated to cost more than \$4 million. During this period, four major functional elements will be completed. These are:

1. The development of necessary instruments and measurement and analysis techniques.
2. The determination by field investigation of the parameters which are significant to nearshore sediment transport and the collection of sufficient data to allow characterization of these significant parameters.
3. The formulation of models to characterize the forcing and response functions and overall engineering models for predicting transport.
4. The verification of these models using field data obtained in this program.

These functions, although they are logically sequential, will be undertaken with a certain level of concurrence as indicated by their schedule in Figure 2.

NSTS PROGRAM MANAGEMENT

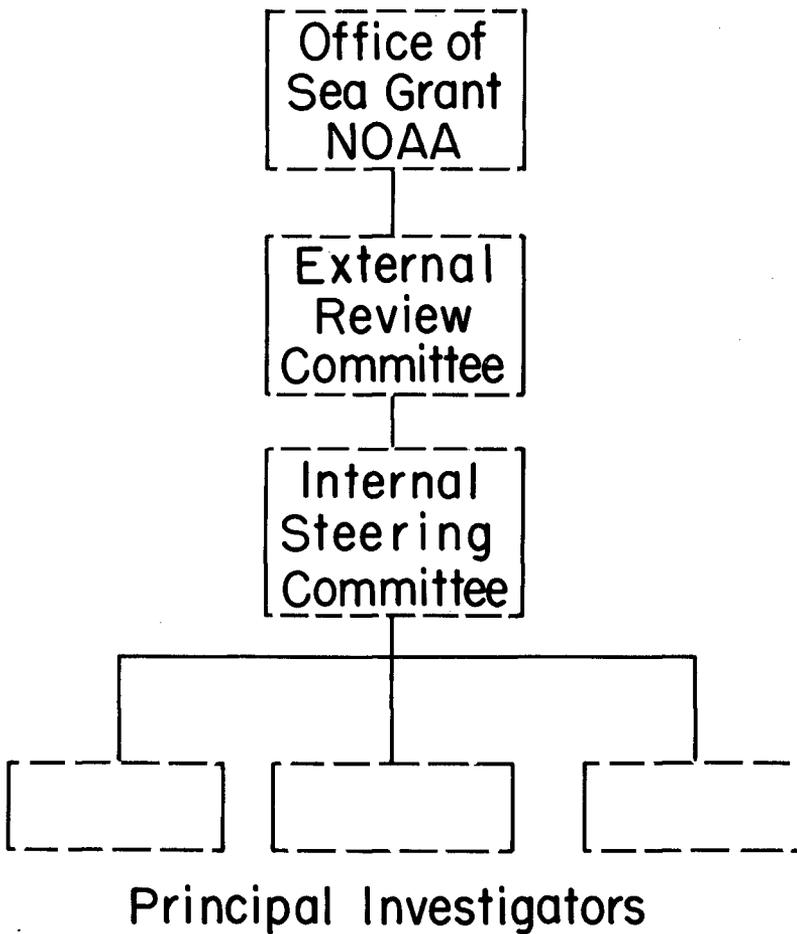


FIGURE 1

FUNCTIONAL SCHEDULE

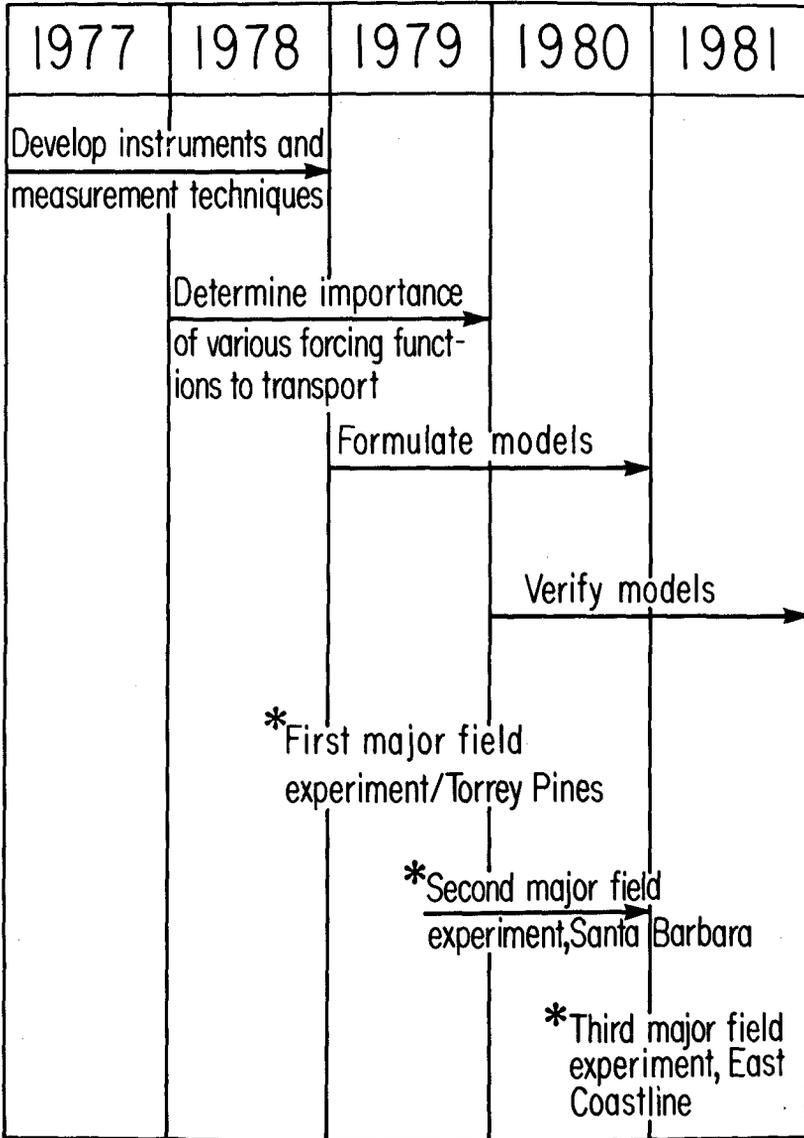


FIGURE 2

PROGRAM ATTRIBUTES

To accomplish the NSTS objectives, it was understood from the earliest planning sessions that the program must contain certain attributes which would set it apart from many prior efforts. Among the most important of these attributes are:

1. NSTS is a broad-based program with many investigators from a large number of institutions. It is an attempt to bring together many experienced practitioners to plan and execute a series of major experiments which would vastly exceed the capabilities of a single investigator.
2. NSTS is a field-oriented program. Laboratory or numerical modeling are not foreseen as significant elements of the project.
3. The NSTS field experiments will attempt to measure, simultaneously, the details of both the velocity field within the surf zone and the sediment response to these velocities. This is in recognition of the fact that there are significant spatial variations in sediment transport within the nearshore regime and that the ability to understand and predict these variations is a prerequisite to developing a universally applicable engineering model.
4. The NSTS measurement program will encompass a large number of parameters that are potentially significant to a predictive model.
5. The NSTS predictive model is intended to be two-dimensional. That is, it will predict on-offshore movement as well as longshore movement of sediment.

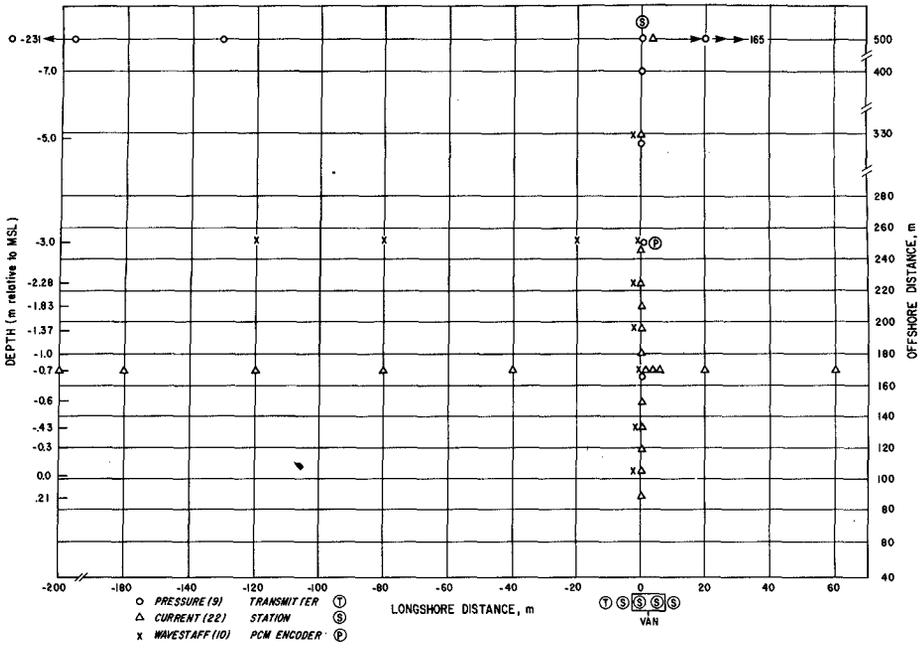
TASK ORGANIZATION

The overall NSTS program is composed of a large number of tasks, each one of which addresses a major element in the project and which is under the direction of one or more principal investigators. In the following sections, the tasks which were funded in 1977 and 1978 will be described followed by those which are anticipated to be funded in 1979 and subsequent years.

TASKS PRESENTLY FUNDED

.....Field Investigation of Currents and Surface Elevation Within the Surf Zone. This task is under the joint direction of R. T. Guza of Scripps Institution of Oceanography and E. B. Thornton of the Naval Postgraduate School. Guza and Thornton (1978) describes the type of measurements and analyses undertaken in this task. A typical instrumentation plan is shown in Figure 3. The major objective of this task is to characterize the three-dimensional velocity field within the surf zone and to relate this to the observed incident wave climate.

.....Field Investigation of Rip Currents, under the direction of R. A. Dalrymple of the University of Delaware. This task is concerned with the measurement and characterization of rip currents, determination of



TYPICAL PLAN FOR INSTRUMENT PLACEMENT IN A LARGE FIELD
 EXPERIMENT TO DEFINE SURF ZONE DYNAMICS
 FIGURE 3

the mechanism for their formation and their correlations with the incident wave climate. A general treatment of the approach is contained in Dalrymple (1978).

.....Development of a Model Characterizing Surf Zone Dynamics. This task, under the direction of O. S. Madsen of Massachusetts Institute of Technology, will undertake the synthesis of a simplified model for predicting the surf zone velocity field from known incident wave and wind characteristics. This model will then be verified using the data sets from Guza and Thornton, and Dalrymple.

.....Field Investigation of Longshore Sediment Transport, under the direction of D. L. Inman of Scripps Institution of Oceanography. This task has as its major objective the characterization of longshore transport using fluorescent tracers, point samplers of suspended concentrations and continuous measurement of bedload transport with monitoring instruments.

.....Field Investigation of Suspended Sediment, under the direction of R. W. Sternberg at the University of Washington. This is a complementary project to the Inman task and is concerned with the development and deployment of monitoring instruments to obtain continuous measurements of suspended sediment concentrations.

.....Field Investigation of On-Offshore Transport, under the direction of R. J. Seymour of Scripps Institution of Oceanography. This task is concerned with the characterization of on-offshore transport by means of precision profiling. Seymour, Higgins and Bothman (1978) describes a remotely controlled profiling tractor developed in this task.

.....Evaluation of Candidate Experimental Sites, under the direction of R. G. Dean of the University of Delaware. This task is concerned with identifying and ranking potential sites along the United States coastlines for large scale field experiments.

1978 FIELD EXPERIMENT

The first major experiment under the NSTS program is scheduled for October - November 1978 at Torrey Pines Beach in Southern California. All of the field investigations described above will be undertaken jointly in this one-month-long effort. Approximately 90 channels of data will be sampled at 16 Hz for at least four hours each day for the 30-day period.

TASKS TO BE FUNDED IN 1979 AND SUBSEQUENT YEARS

.....Field Investigation of Tidal Currents. In this task, long-term (on the order of months) measurements of longshore current will be made at locations through the surf zone and correlated with surface tides. The objective is to determine if tidal current is a significant factor within the surf zone.

.....Field Investigation of the Effect of Winds. In this task, the wind stress on the surf zone will be characterized and correlated with the surface elevation and velocity fields measured in other tasks. The objective is to determine under what conditions the wind is a significant parameter in nearshore transport.

.....Field Investigation of the Interactions with Periodic Planform Changes. In this task, rhythmical changes in beach contour in the longshore direction will be measured and correlated with changes in the velocity field measured by others. The objective is to determine if these planform shapes must be accounted for in the transport model.

.....Field Investigation of Three-Dimensional Velocity Structure. This task is a continuation of the present effort associated with characterizing the nearshore velocity field.

.....Field Investigation of the Incident Directional Wave Field. In this task, directional arrays will be employed to characterize the incident wave field. These data will form the basis for models that predict velocity or transport rates from known wave data.

.....Field Investigations of Longshore Transport. This task is a continuation of the two present programs on longshore transport with increased emphasis on the use of continuously monitoring instruments.

.....Field Investigation of On-Offshore Transport. This is a continuation of the present program using beach profile data with emphasis on rapid offshore movement under storm waves.

.....Develop an Improved Engineering Model for Nearshore Sediment Transport. This is the task in which all of the other findings of the program are synthesized into a single model.

FUTURE FIELD EXPERIMENTS

The major field experiment for 1979 will occur at Leadbetter Beach, west of the harbor at Santa Barbara, California. The experiment sites for 1980 and beyond are presently under study. However, it is planned that one East Coast site will be selected.

AVAILABILITY OF DATA

Under the NSTS management plan, data are exchanged freely between investigators. The investigator collecting the data has proprietary publishing rights for a period of one year. After that time, all data becomes available to the public. In addition to the normal papers, texts and reports, all of the raw data will be archived through the National Oceanographic Data Center and will be available on magnetic tape.

REFERENCES

- Dalrymple, R. A.: 1978. "Rip Currents and Their Genesis." Proc., 16th Int'l. Conf. on Coastal Engr., Hamburg, September 1978.
- Greer, M. N. and O. S. Madsen: 1978. "Longshore Sediment Transport Data: A Review." Proc., 16th Int'l. Conf. on Coastal Engr., Hamburg, September 1978.
- Guza, R. T. and E. B. Thornton: 1978. "Longshore Current Variability." Proc., 16th Int'l. Conf. on Coastal Engr., Hamburg, September 1978.
- Seymour, R. J., A. L. Higgins and D. P. Bothman: 1978. "Tracked Vehicle for Continuous Nearshore Profiles." Proc., 16th Int'l. Conf. on Coastal Engr., Hamburg, September 1978.