NOAA Technical Memorandum OMPA-23

DEPARTMENT OF COMMERCE
UNITED STATES OF AMERICA

SUMMARY RESULTS OF INSTEP PROJECT:

NEW YORK BIGHT MARINE GEOLOGY

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / Office of Marine Pollution Assessment

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ABSTRACT

Following a brief history of the INSTEP project, the data and scientific results produced by the project are summarized. In each of the three main study areas, seafloor inventory, suspended particulate measurements, and boundary layer measurements and modeling, the types of data taken and the methods used are briefly summarized. Sources from which copies of the data can be obtained are indicated. A complete bibliography of publications resulting from the INSTEP project is included.

HISTORY

By 1972, NOAA had completed plans for a long-term, multidisciplinary investigation of the New York Bight (continental shelf between Montauk Point, Long Island and Cape May, New Jersey). Administrative responsibility for the project rested with the Marine Ecosystems Analysis program (MESA program).

San Francisco Bay, Chesapeake Bay, Delaware Bay, the New York Bight and Puget Sound were all considered as possible sites for a NOAA study of Marine Environmental impact problems. However, the New York Bight was chosen as the prototype study. New York's marine environmental impact problems center around the four main waste disposal sites in the New York Bight apex; the sewage sludge dumpsite (3.7×10^6 m^3 yr^{-1}), the dredge spoil dumpsite (4.3×10^6 m^3 yr^{-1}), the acid waste dumpsite (2.0×10^6 m^3 yr^{-1}), and the dumpsite for construction and demolition debris (0.5×10^6 m^3 yr^{-1}).

The Marine Geology and Geophysics Laboratory of NOAA's Atlantic Oceanographic and Meteorological Laboratories, NOAA, Miami, was asked to develop a marine geology program for the New York Bight that would be relevant to MESA's needs. The program was to interact with similar programs in physical oceanography, chemical oceanography, and biological oceanography. The marine geology program began in the summer of 1972, six months ahead of other elements of the MESA New York Bight program. The initial work was descriptive in nature. It was agreed that some very basic geological knowledge would be needed immediately by other program elements, before any program element would be able to deliver any information to our ultimate information clients such as the regional EPA office, or municipal environmental managers. These information needs were seen as taking the following form.

I. Seafloor Inventory

A. Bathymetric maps.

B. Surficial sediment distribution.

C. Shallow stratigraphy.

D. Time and space patterns of substrate variability (SUVAR program).

II. Sediment Dynamics Studies

A. Studies of suspended sediment distribution and transport.

B. Studies of the boundary layer flow climate.

C. Studies of boundary layer sediment transport.

Because of the extreme complexity of the time and space patterns of bottom sediment distribution and sediment transport patterns, a stratified sampling plan was deemed necessary. The New York Bight was divided into several study areas. The New York Bight apex, with its four dumpsites was seen as the prime study area. Studies also took place along the New Jersey coast, along the Long Island coast, at proposed alternative dumpsites on both the New Jersey and Long Island shelves, and in the Hudson Shelf Valley.

In 1976, emphasis in the marine geology program shifted from descriptive studies of bottom sediment distribution to studies of sediment transport on the inner shelf, the Inner Shelf Sediment Transport Project (INSTEP). The ultimate goal was diagnosis of patterns of sediment and pollutant transport. However, basic knowledge concerning sediment transport mechanisms on the continental shelf was inadequate, and it was necessary to undertake studies of boundary layer transport rates and mechanisms. To this end, several boundary layer sensing systems were built in collaboration with Engineering Development

Laboratory, and deployed during both the quiescent summer period and during the stormy winter months of 1976, 1977, and 1978. The resulting data, coupled with that of the New York Bight MESA physical oceanography program, is the most massive time series of shelf sediment transport data available anywhere in the world. It has allowed our program to construct several numerical models for estimating sediment transport at the scale of the New York Bight and also at the finer scale of the dredge spoil dumpsite in the Bight apex.

SEAFLOOR INVENTORY STUDIES

Seafloor inventory studies began in 1972 and have continued through the INSTEP program. As MESA began a broad spectrum of marine environmental studies in the New York Bight, there was an urgent need to provide very basic information on seafloor bathymetry and the character and distribution of marine sediments. This information was needed by biologists and chemists working on MESA projects, and also by environmental managers and engineers in Long Island and New Jersey municipalities (to make decisions on sewage outfalls), in the Corps of Engineers, and in Environmental Protection Agency district office, and port authority (decisions on dumping). Studies took place in the New York Bight apex, on the New Jersey shelf, at the proposed offshore dumpsites, in the Hudson Shelf Valley, and on the Long Island coast.

Side scan sonar records, bottom grab samples, and bottom photographs were collected along two transects in the New York Bight apex, on a quarterly basis for six quarters as part of the Substrate Monitoring Project (SUMP). The sampling started in the fall of 1974 and continued through mid-winter of 1976. The sampling was designed to determine the natural variability of bottom deposits in time and space, and the effect of ocean dumping on these natural patterns.

Two sampling lines were used on each of the cruises; a 14 nm long east-west line and a 12 nm long north-south line. Side scan sonar records were collected continuously along each of the lines. Bottom grab samples were collected at quarter mile intervals with a Shipek grab sampler. During each cruise 56 grab samples were collected on the east-west line and 48 samples on the north-south line for a total of 104 sample per cruise. The bottom photographs were generally taken every mile along both lines. Due to turbidity in the bottom nepheloid layer during most of the year the bottom photographs were generally very poor.

On each cruise Raydist navigation was used. This system affords an accuracy of ± 10 m. This accuracy was confirmed by a sunken ship on the east-west transect which plotted in the same geographical position on successive cruises. For the six cruises, five different research vessels were used. Consequently, navigation on each ship had to be compensated for the varying sizes and the winch positions. These variables were reduced to a common datum.

Grab sample aliquots from each bottom grab sample were processed for grain size distribution. The sand fraction (- 1.0 ϕ to 4.0 ϕ) was analyzed by an Automated Rapid Sediment Analyzer (ARSA) which measures the fall time of the sand through 132 cm of water (Nelsen, 1976). An assumption was made that the material was of uniform density, that of quartz (2.65). The fine fraction (greater than 4.0 ϕ) was examined by the pipette technique. Data from both the ARSA and pipette technique were used to compute mean grain size, standard deviation, skewness, and kurtosis, by using moment parameters.

The distribution of grain sizes and bedform patterns are stable over time in the area sampled in the New York Bight apex. This indicates that the bottom is in a state of textural near-equilibrium with the hydraulic climate. The effects of the prolonged ocean dumping are most obvious in the vicinity of the dredge spoil dumpsite. This area has shoaled 15 m within the last thirty years (Freeland and Merrill, 1977). Here an aureole of anomalously fine sediment is spreading over a bottom composed of anthropogenic rubble. Cholera Bank, the area where the highly mobile sewage sludge is dumped, is floored by sand; no permanent sludge deposits were detected from our data set. Apparently, the sewage sludge is so mobile that it is widely diffused through the entire Bight apex. Even though it is reasonable to suppose that the fine muddy sands of the Christianensen Basin may be contaminated with sewage sludge, the resolution of such contamination is beyond the primary physical observations undertaken during the SUMP program.

SIDE SCAN SONAR STUDIES

The side scan sonar offers a continuous 75 m record of the bottom, both in terms of bedforms and to some degree grain size. The intensity of the signal return is a function of the properties of the bottom material. Coarse grained material results in a darker or stronger return signal. By calibrating the side scan sonar record with a known grain size by means of the bottom grab samples, an approximation of the grain size along the complete sampling transect is possible. This continuous record of grain size is in many respects more revealing than the grain size data adjacent to the transect available from isolated bottom grab samples.

Side scan sonar records were taken in several areas of the New York Bight during the period 1973 to 1977. Records were taken to study the bottom microtopography for the purpose of determining features indicative of the direction of bottom sediment transport. These features include ripples, sand waves and sand ridges. In the Bight apex, side scan records also delineated areas of dredged material dumping. Figure 1 shows the detailed tracklines of side scan sonar taken within the Apex region of the New York Bight. Figure 2 shows at larger scale the locations of side scan sonar tracklines within the New York Bight region as a whole (see also Table 1).

The results of the SUMP program grain size analyses are available from the National Geophysical, Solar and Terrestrial Data Center in Boulder, Colorado. The original side scan records can be obtained from the national archives. In addition, the results of these programs are summarized in publications cited in the Bibliography.

SUSPENDED MATERIAL MEASUREMENTS

Since 1973, MESA has conducted various multi-disciplinary investigations of the New York Bight in an attempt to assess man's impact on this area. As part of that program, the NOAA Atlantic Oceanographic and Meteorological Laboratories have studied suspended particulate matter (SPM) concentration, distribution, and composition in the New York Bight apex (Figure 1). This report covers SPM data for the period 1973 1979.

Suspended particulate matter in the New York Bight apex can be broadly classified as natural and anthropogenic. Natural sources include the mineral and biological components of river runoff, plankton,

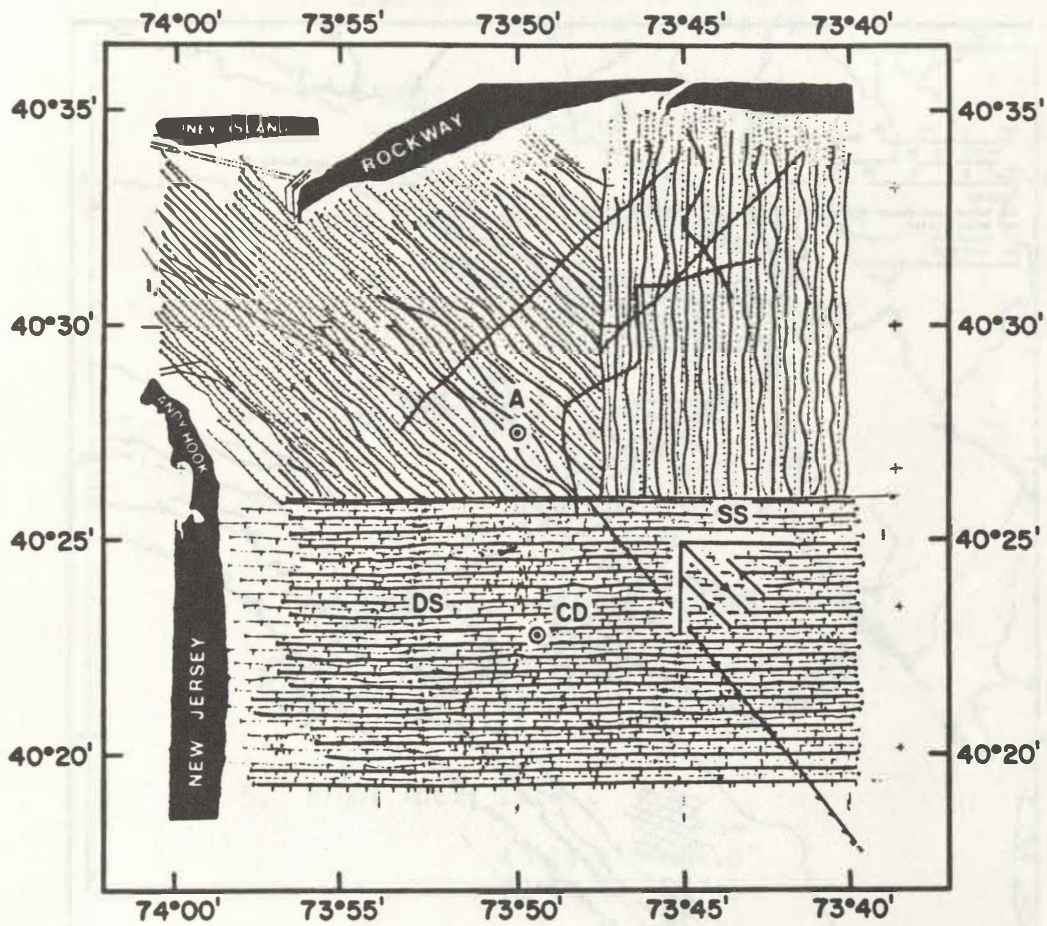

Figure 1. New York Bight apex tracklines. Dark lines indicate side scan sonar tracklines. A: Ambrose Light Tower. SS: Sewage sludge dumpsite. CD: Cellar dirt (construction rubble) dumpsite. DS: Dredged material dumpsite.

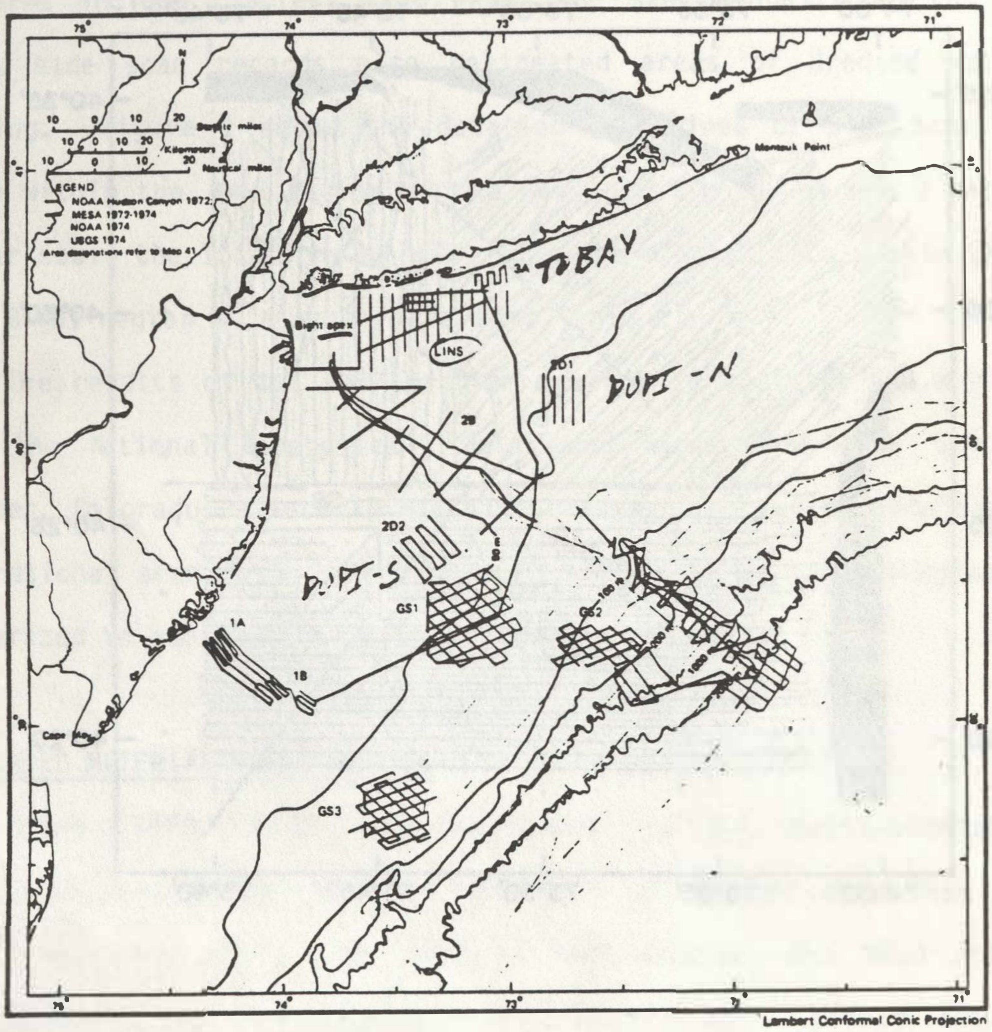

Figure 2. New York Bight side scan sonar tracklines. Tracklines within bight apex are shown in Figure 1.

Table 1. Side Scan Sonar Areas for the New York Bight

1. Alternative Dumping Sites (DUPI), 1975		
	N area:	40°06'39" - 16'48"N 72°39'30" - 50'43"W
	S area:	39°31'22" - 45'23" 73°13'13" - 31'35"
2. Long Island Nearshore LINS, 10/1974		
		40°17'09" - 48'57"N 72°59'12" -73°40'54"W
3. Tobay Beach, New York, 11/74		
		40°22.1' - 34.5'N 73°18.0' - 30.8'W
4. Tobay Beach, New York, 12/76 and 6/77		
		40°35.3' - 37.0'N 73°20.0' - 25.2'
5. Bight Apex, 1973		
		40°19.5' - 34.0' 73°40.0' - 57.5'

eolian sources, resuspended bottom sediments, and material advected into the apex by continental shelf currents. To this natural particulate matrix man introduces a complex mixture of particles derived from dredged materials, construction debris, sewage sludge, and industrial acid waste material. The approximate locations of these dumpsites in the New York Bight apex are shown in Figure 3.

During the period 1974-1975, samples were obtained on cruises separated by approximately one month and designated as Water Column Characterization (WCC) cruises, and were sequentially numbered from six to fourteen. On a seasonal basis, two cruises occurred in the spring, three in summer, two in fall, and two during the winter of 1974-1975 (Table 2). Each of these cruises was timed to coincide with an Earth Resources Technology Satellite (ERTS) overpass for examining the potential utility of correlating remotely-sensed observations to ongoing studies of the New York Bight.

For continuity with prior NOAA sampling (Drake, 1974), the previously established 25-station Bight apex grid (Figure 3) was maintained. For each cruise, precision navigation was supplied by a Hastings-Raydist navigation system used in the range-range mode. Although the system is capable of greater precision over distances covered in the apex, a value of ± 10 meters is valid for station location precision from cruise to cruise.

Results of analyzing this data are described in Nelsen (1979) and Gadd <u>et al.</u> (1978). The data obtained from the WCC suspended sediment measurement program are available from the National Ocean Data Center (NODC) in Washington, D.C.

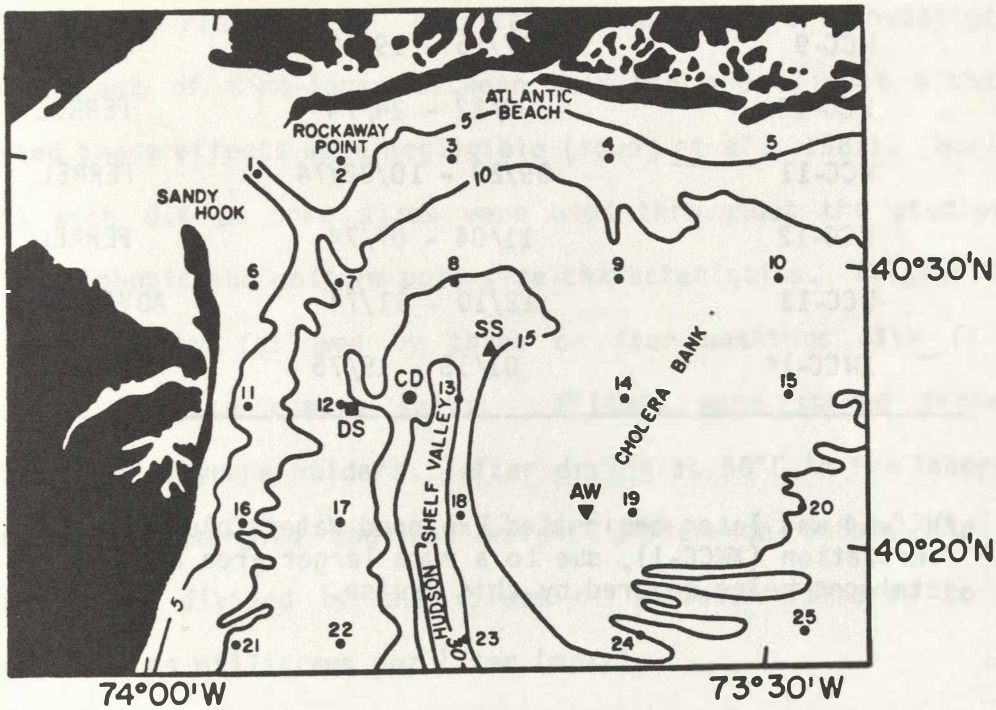

Figure 3. The 25-station sample grid and the four-dump sites.

Table 2. WCC Cruises

Cruise Designator	Dates	Ship
WCC-6	04/16 - 20/74	FERREL
WCC-7	05/06 - 09/74	FERREL
WCC-8	06/10 - 13/74	FERREL
WCC-9	07/16 - 19/74	FERREL
WCC-10	08/22 - 24/74	FERREL
WCC-11	09/29 - 10/02/74	FERREL
WCC-12	11/04 - 07/74	FERREL
WCC-13	12/10 - 11/74	ADVANCE II
XWCC-1*	01/15 - 19/75	ADVANCE II

*WCC-14 was later designated Expanded Water Column Characterization (XWCC-1), due to a much larger area and more stations being covered by this cruise.

Suspended matter sampling for INSTEP during the period 1976-1979 was accomplished by filtering water samples obtained as part of spatial and temporal variance studies (Young et al., 1981; Young and Hillard, in preparation). Sampling frequency and other statistics are given in Table 3.

Methods are described in Mann (1981) and consisted of filtering measured 0.3 to 1.0 liter aliquots of seawater drawn from five to ten liter Niskin Go-Flo bottles. Replicate measurements and investigations of the effect of time-lapse between sampling and aliquot withdrawal indicated these effects were negligible (Young et al., 1981). Nuclepore filters with 0.4 μm pore sizes were used throughout the studies for their hydrophobic and uniform pore size characteristics. Filtration was done under vacuum followed by three or four washings with filtered distilled water to remove salts. Filters were stored frozen in individual polystyrene holders. After drying at 50°C in the laboratory, filters were reweighed and the weight difference before and after filtration was divided by the volume of seawater filtered to yield concentration as milligrams per liter (mg/ℓ).

Data for samples taken from 1976-1978 are found in Young et al. (1981). Data for the 1979 samples are in Mann (1981). Vertical light scattering profiles and long time series at a single depth at several stations were obtained as shown in Table 3. The instrument used was a modified Monitek 360 dual source and dual detector instrument. Light sources were incandescent broad spectrum bulbs. Output was passed through a red filter (6300 Å) and directed through a 10 cm water path toward two detectors, one sensing the direct beam and the other the beam scattered from 145° to 178° in the forward direction. Sources and

Table 3. Summary of Sampling Locations, Methods and Dates

Dates	Site/Depth	Method	Rate (No. samples/ unit time)	Interval
10/20/76	Tobay/10 m	water bottles	1/5 min	1 hr
11/15/76	Tobay/10 m	water bottles	2/5 min	1 hr
11/16/76	Tobay/10 m	water bottles	2/5 min	1 hr
02/23/77	Tiana/10 m	water bottles	5/5 min	1 hr
03/21/77	Tiana/10 m	water bottles	5/5 min	1 hr
07/11/77	Tiana/10 m	water bottles	5/5 min	1 hr
07/12/77	Tiana/10 m	water bottles	5/5 min	1 hr
03/1-2/78	Tiana/10 m	water bottles	5/5 min	1 hr
10/19/76-11/02/76	Tobay/10 m	CV probe	0.5 Hz for 5 min per hr	1 hr
11/04/76-11/16/76	Tiana/10 m	CV probe	0.5 Hz for 5 min per hr	1 hr
08/18/77-08/29/77	Tiana/10 m	CV probe	0.5 Hz for 5 min per hr	1 hr
03/01/78-03/29/78	Tiana/10 m	CV probe	0.5 Hz for 7 min per hr	3 hr
02/28/78-03/29/78	Tiana Transect	light-scattering profiler	2 samples per meter	Daily
03/13-15/79	Inner Bight	water bottles/ light-scattering profiler	32 stations	2 days
04/4-5/79	Inner Bight	water bottles/ light-scattering profiler	34 stations	2 days
05/21-23/79	Inner Bight	water bottles/ light-scattering profiler	33 stations	2 days
06/10-11/79	Inner Bight	water bottles/ light-scattering profiler	34 stations	2 days
06/29-30/79	Inner Bight	water bottles light-scattering profiler	37 stations	2 days
08/1-2/79	Inner Bight	water bottles light-scattering profiler	37 stations	2 days
09/5-7/79	Inner Bight	water bottles light-scattering profiler	39 stations	2 days

detectors were arranged opposite each other such that when one source was activated one detector sensed the direct beam while the other sensed the scattered beam. Sources were activated alternately and the signals from the detectors were switched to correspond to their direct or scattered beam processing or recording channels.

Ideally, the use of dual sources and detectors allows the scattering losses due to suspended particles in the beam path to be calculated nearly independently of temporal changes in source intensity, biologic window fouling or other electronic or biofouling problems. In practice, the short path length of the instrument, recorder problems, and electronic noise reduced measurement accuracy below that desired, but still yielded reasonable semiquantitative estimates of suspended matter concentrations.

The relationship between light scattering and suspended matter concentration depends mainly on particle size and composition (index of refraction). Sizes and composition of particles in the ocean vary with time and location, and it is therefore necessary to empirically determine the correlation between scattering and concentration for each local area, and for each cruise. This was accomplished for the 1976-1978 measurements for the light scattering sensor on the CV probe boundary layer system by enclosing the 10 cm long space between sources and detectors on the Monitek and filling with suspensions of various concentrations using the fine-grained (< 62 μm) fraction of bottom sediments from the CV probe deployment areas.

For the 1978 and 1979 measurements, when the Monitek was used to make vertical profiles of scattering, water samples taken at the surface and near-bottom were filtered as above and correlated with the scattering measurements. Both calibration methods yielded correlation coefficients of 0.85 or greater indicating that the scattering measurements are good quantitative indicators for the concentration of suspended fine sediments.

The data obtained using the Monitek were not considered of high enough quality to send to a data center for archiving. The suspended material measurements obtained by filtration are completely reported in the scientific literature (Young et al., 1981). Additional references in the bibliography give examples of the scientific implications of both the Monitek and the filtration data.

BOUNDARY LAYER PROBE MEASUREMENTS AND MODELS

While not strictly a boundary layer measuring system, the use of radioactively labelled sand in the Radio Isotope Sand Tracer (RIST) experiment has provided valuable information on the pattern and functional relationships of sand transport on the continental shelf. Data from the RIST experiment is available from the National Ocean Data Center (NODC) in Washington and complete scientific details of the experiment can be found in Lavelle et al. (1979).

Four different types of boundary layer probes have been employed during the INSTEP project. The concentration-velocity (CV) probe is described in Lavelle et al. (1978). It consists of an electromagnetic current meter and a nephelometer-transmissometer mounted 100 cm off the seafloor. A profiling concentration-velocity (PCV) probe uses an acoustic transducer and four electromagnetic current meters to profile concentration and velocity from zero to 100 cm off the seafloor. The PCV probe is described more fully in Huff et al. (1980) and in Young et al. (1982). In addition, a standard Marsh McBirney model 585 current meter (MMB) was used during 1979. A fourth system, the Boundary Layer Instrument Package (BLIP), used an array of propeller current meters and one transmissometer. It is described in Lesht et al. (1976).

The results of the deployments of these instruments are chiefly summarized in Lavelle et al. (1978), Lesht et al. (1980), Clarke et al. (1982), Young et al. (1981), Vincent et al. (1981), and Vincent et al. (submitted 1982). Not all deployments resulted in data that was uniformly good. Data that was of good quality was sent to National Ocean Data Center (NODC) for archival, while data which was poorly calibrated or with other problems was not. The situation is summarized in Table 4.

SUMMARY

Geological studies in the New York Bight sponsored by the Marine Ecosystems Analysis program began in 1972 with maps of sediment distribution, bathymetry and bedform distribution. With the advent of INSTEP, geological studies were focused in sediment transport, in order to help assess the dispersal of pollutants.

Initial studies dealt with seafloor inventory in order to provide information on bathymetry and sediment characters in the New York Bight Hudson Shelf Valley, and proposed offshore dumpsites. Subsequent studies were concerned with mechanisms of sediment deposition and erosion, and with measuring the flux of suspended fine sediments. A sophisticated array of boundary layer sensing systems were developed for this purpose. Data taken by these systems provided the information needed to develop a numerical modeling capability for fine sediment, and hence pollutant, transport.

Table 4. INSTEP Probe Deployments

Place	Date	Instrument	Status
Tobay Beach	19 Oct 76 - 02 Nov 76	CV Probe	Submitted NODC
Tobay Beach	05 Nov 76 - 17 Nov 76	CV Probe	Submitted NODC
Tiana Beach	10 Aug 77 - 18 Aug 77	CV Probe	Submitted NODC
Tiana Beach	02 Mar 78 - 29 Mar 78	CV Probe	Submitted NODC
Tiana Beach	18 Apr 78 - 25 May 78	PCV Probe	Uncalibrated
Tiana Beach	18 Apr 78 - 25 May 78	CV Probe	Submitted NODC
Tiana Beach	22 Aug 78 - 03 Oct 78	BLIP Probe	Flooded, no data
Tiana Beach	22 Aug 78 - 03 Oct 78	CV Probe	Failed
Tiana Beach	22 Aug 78 - 03 Oct 78	PCV Probe	Uncalibrated
Manasquan	14 Jul 79 - 08 Aug 79	PCV Probe	Uncalibrated
Tobay Beach	04 Apr 79 - 23 May 79	MMB	Unreadable
Manasquan	24 Apr 79 - 10 Jun 79	MMB	Submitted NODC
Tobay Beach	23 May 79 - 10 Jul 79	MMB	Transcription errors
Manasquan	10 Jun 79 - 30 Jul 79	MMB	Transcription errors
Atlantic Beach	10 Jul 79 - 07 Sep 79	MMB	Submitted NODC
Tobay Beach	10 Jul 79 - 07 Sep 79	MMB	Transcription errors
Long Branch	30 Jul 79 - 05 Sep 79	MMB	Submitted NODC
Manasquan	30 Jul 79 - 06 Sep 79	MMB	Submitted NODC

All data from the INSTEP project that were of sufficiently high quality have been submitted to either the National Ocean Data Center (NODC) or the National Geophysical Solar and Terrestrial Data Center (NGSDC). These data should have a long second life in which they are used both by scientists undertaking basic research, and by scientists and environmental managers attempting to deal with specific problems.

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