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Development of a Coastal Erosion Monitoring Program for the South Shore of Long Island, New York

Proceedings of a Workshop
Held November 13–14, 1990

New York Sea Grant

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New York Sea Grant Program
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Development of a Coastal Erosion Monitoring Program for the South Shore of Long Island, New York

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INTRODUCTION

New York's ocean shoreline provides substantial economic, recreational, and environmental benefits to the state's residents. Property in the coastal flood plain along the 125-mile coastline of Long Island's south shore has a value of approximately $10 billion (NY Dept. of State, 1989). Millions of people, both residents and tourists, visit the area's beaches each year. The barrier islands and inlets found along the coast form a dynamic and interrelated system which protects the heavily-developed mainland as well as the biologically productive back bay environments.

The need for sound coastal management balancing environmental protection, public safety, and property rights is clearly evident. However, proper management requires an adequate understanding of the resource. Decisions regarding coastal regulations, resource allocation, and selection of management options must be based on credible and technically sound information. Unfortunately, a comprehensive, up-to-date coastal data base required for reliable decision-making is not presently available (Tanski et al. 1990).

Accordingly, the "Proposed Long Island South Shore Hazard Management Program" developed by the Long Island Regional Planning Board (LIRPB, 1989) for the New York State Department of State, Division of Coastal Resources, called for the development of a coastal monitoring program for the ocean shoreline. The monitoring program would be designed to improve government's ability to make timely management and regulatory decisions by providing information that would allow managers to define and quantify the erosion problem, evaluate effectiveness of adopted and proposed erosion management strategies, and develop a better understanding of the causes and effects of observed shoreline changes.

On November 13 and 14, 1990, a workshop (sponsored under a contract from the New York State Department of State) was held to identify the necessary elements and, where possible, specifications for a monitoring program for New York's open ocean coast. Representatives from New Jersey, South Carolina, Florida, and California, states that already have coastal monitoring programs in place, attended and provided overviews of their respective programs. State, Federal and local agencies having responsibilities and/or interest in coastal issues and management were invited to participate. Those agencies included the Department of Environmental Conservation, Department of Transportation, Office of Parks and Recreation, the State Geological Survey, and State Emergency Management Office at the state level; the Corps of Army Engineers, National Park Service, and the Federal Emergency Management Office at the federal level; the New York City Planning Department and the LIRPB at the local level. A list of attendees is given in Appendix I and the agenda in Appendix II. This report presents deliberations and findings of the participants.

OVERVIEW OF PROGRAMS IN OTHER STATES

A number of other states, recognizing the value and importance of their shoreline, have already developed and implemented erosion monitoring programs. Although there are certain common elements, the level of effort and type of information collected depend to a large extent on the goals and objectives of the individual programs. Obviously, an examination of what other states are doing in this area can be very beneficial in terms of applying their experiences to New York's coast. The following sections provide a brief background on the different programs as presented at the workshop. This, in turn, is followed by a more in-depth discussion and comparison of technical components that comprise each of the monitoring programs discussed.

New Jersey

In 1985 Hurricane Gloria hit the New Jersey coast and caused damages that resulted in the filing of approximately $2 million in Federal Emergency Management Administration (FEMA) insurance claims. FEMA, however, denied all municipal beach damage claims because there had been no monitoring of the shoreline to establish pre-storm conditions. In 1986, the New Jersey Department of Environmental Protection received $2 million in Federal funds for dune management, establishing dune ordinances, determining setbacks for future construction, and other coastal studies. In addition, $53,000 was used for establishing a system of beach profiles, stations which would be used as a basis for tracking long-term changes and quantifying storm damage. This information would then be used to help quantify and expedite Federal insurance claims in the future.

South Carolina

Coastal tourism is the second largest industry in South Carolina. Recognizing the importance of the state's beaches and the need for additional protection of these features, the South Carolina Coastal Council initiated the Beach Monitoring Program in 1986 to monitor the condition of the beaches in a comprehensive, on-going program. In 1988, legislation was passed calling for establishment of jurisdictional boundaries for regulatory purposes based on rates of shoreline change. Data derived from the beach monitoring program is to be used for establishing these jurisdictional boundaries. In order to obtain accurate measurements, benchmarks spaced every 1,000 to 2,000 feet along the shore are surveyed twice a year. A baseline was set along the dune crest. In areas where a dune doesn't exist, the baseline was established where it would have occurred if the beach was in its natural state. This was determined by creating an average profile for a particular stretch of coast, calculating the volume of sand contained in this typical beach and requiring that the beach in front of the baseline contain this ideal volume. A setback line was established by the expected long-term recession of the vegetation line over 40 years. Reconstruction of houses is regulated between the baseline and shoreline and new construction is regulated between the setback line and shoreline. Jurisdictional lines are to be updated every 8 to 10 years.

Florida

The Florida Department of Natural Resources has 90 people employed in the Division of Beaches and Shores. This Division includes an Office of Erosion Control, whose responsibilities include planning and managing approximately $50 million worth of beach nourishment and inlet management projects; a Bureau of Coastal Engineering and Regulation, which annually issues about 1,000 permits for coastal construction projects; and a Bureau of Coastal Data Acquisition, which is responsible for maintaining the state's beach monitoring program. The Bureau of Coastal Data Acquisition has 25 employees, including two full-time surveying crews, and an annual budget of about $3 million. This bureau maintains both a short-term and a long-term data base on coastal processes and maps of the State's jurisdictional line and the Coastal Construction Control Line, which is usually located between 300 and 500 feet from the shoreline. The jurisdictional line has been established with reference to over 3,400 survey monuments placed along the shoreline. No construction is allowed seaward of the Control Line except in unusual circumstances. The Bureau of Coastal Data Acquisition also coordinates aerial photography, wave measurements, and modeling activities associated with the state's coastal management and regulatory functions.

California

California's shoreline stretches some 1,100 miles and contains 15 harbors. During the 1982-83 winter storms, there was over $116 million of damage in the San Diego area alone. In response to the recurring erosion problem, the U.S. Congress appropriated funds to implement the Coast of California Storm and Tidal Waves Study (CCSTWS) in the early 1980s. The CCSTWS, which is managed by the Los Angeles District of the U.S. Army Corps of Engineers, is intended to provide vital information and analytical tools to coastal planners, engineers, managers, and scientists. It is a comprehensive long-term study of shoreline change and the factors that cause that change. The program was designed to provide a data base of (a) sediment characteristics, (b) past shoreline changes, and (c) models of shoreline change in a format accessible to planners and engineers as well as the public. The coast was divided into six regions based on physical characteristics but coinciding with county boundaries wherever possible. Sections were prioritized based on past erosion damage history. Two plans were developed for each section. An optimal plan included field observations and analyses while a minimal plan relied on available data whenever possible. The optimal plan has recently been completed for the San Diego area. Other sections of the coast have not been monitored but efforts are underway to institute programs in these regions. Some elements of the California programs, such as the effects of submarine canyons and river sediment inputs, are not geologically relevant to a New York application and are not included in this report.

COMPARISON OF MONITORING PROGRAM ELEMENTS AND A PROPOSED PROGRAM FOR NEW YORK

The major elements and associated characteristics of the various programs found in other states are summarized in Table 1. It should be noted that the "California" program is confined to two relatively small stretches of coast, San Diego (90 miles of shoreline) and the South Coast region (approximately 91 miles of shoreline in the Los Angeles area), and that the "South Coast" column indicates the proposed minimal plan which has not yet been implemented. The San Diego optimal plan is presently operational.

After a review of the monitoring programs implemented in other states, the workshop participants were asked to begin developing a program that would be appropriate for the south shore of Long Island. Components outlined in the table were used as a starting point to focus the group's efforts. Each component was considered and discussed by participants as to its applicability to New York. Results of these deliberations are also discussed in the following sections and summarized in the last column of Table 1.

Beach Surveys

Every monitoring program examined incorporated surveys of the beach profile and, in most cases, the nearshore zone. Such surveys were identified as essential components of the existing state programs. There were, however, differences in how the surveys were conducted in terms of their spacing, timing, extent of coverage, etc.

OTHER STATES

New Jersey. Surveys are done at 91 stations over 114 miles of coastline. At least one survey profile line had to be located in each of the FEMA-designated coastal communities for the purpose of program administration. Sites in each municipality were chosen away from the influence of any shore-perpendicular structures (groins or jetties) in areas thought to represent typical beaches. Preexisting survey sites were used wherever possible. No sites were established in Federal lands, although five of the sites were set in undeveloped lands for baseline comparisons. The benchmarks consist of an aluminum disk located on an existing fixed permanent structure (i.e., telephone pole, bulkhead, etc.). The cost of establishing these benchmarks was $53,000. In 1991, the disks are to be replaced by buried permanent aluminum monuments. The monuments will have permanent magnets in them which will allow post-storm recovery under almost any condition.

Surveys are conducted once a year over a two month period in the fall. Surveys are done within 2.5 hours of low tide to a depth of -5 to -8 feet mean low water. They are done by university staff originally using an optical theodolite, but, beginning in 1990, a Lietz Set-4 total-station surveying system was used. Each profile begins in the dunes and 20 or 30 elevations are typically measured across the profile with spacing determined by the existing topography; measurements were further apart where the beach was flat or a constant slope and closer together where the slopes changed over short distances.

New Jersey presently spends about $20,000 per year for surveys at the 91 stations, or about $220 per profile, not including the cost of establishing the monuments. An annual report is not routinely provided but data reports cost approximately $12,000 when funding allows. Proposed state legislation would provide initial funding of an additional $125,000 to increase the number of stations by 20 and to survey all 111 stations twice in the first year. Subsequent annual funding would be $90,000. If $12,000 of this $90,000 is used to produce the report, this corresponds to an average cost of $351 per profile to survey all 111 stations twice a year. The large increase in the cost for the semiannual surveying program is because the task would become a full-time occupation for three individuals. The program is currently at a level that can be done by a part-time supervisor with recent university graduates working on a part-time hourly basis. (Other contracts make up the balance of their employment.)

South Carolina. Four hundred and thirty profile monuments are spaced an average of 2,000 feet apart along the 120 miles of South Carolina's shoreline. In heavily developed, or critical areas, the spacing may be less than 1,000 feet while undeveloped areas, such as a wildlife refuge, may have none. Two monuments (stamped aluminum disks set in concrete on a fiberglas post) were set at each station. One was near the active part of the beach or immediately behind any shore parallel structures. The other was set farther back behind the dune to insure that it would not be lost during periods of severe erosion. After Hurricane Hugo, however, some of these were buried in overwashed sand and difficult to locate. The cost of setting each monument and establishing horizontal and vertical control was estimated to be between $300 and $500. If we assume an average cost of $400 per monument, total cost of establishing the monuments would have been $172,000. Surveys are usually done only over the active part of the profile. Witness posts are also set for each station to facilitate recovery. Horizontal and vertical control was not available for all stations initially; an arbitrary elevation of +100 feet was assumed for stations lacking vertical control so that data from these points could be distinguished easily from accurately leveled stations. This was a temporary condition, however, and the elevation of all stations have been accurately known since 1986. Surveys are done twice a year, in the fall and spring. The initial survey at each station was done from the landward benchmark. Subsequent surveys were done from the seaward benchmark over the active part of the beach only. Surveys were done initially to wading depth, nominally -5 feet MSL, using a rod and level.

Surveys done by students cost the state about $30 apiece. When university-based surveyors are not available, profiles are sometimes done by state agencies or private professional surveyors at a cost of $50 and $100 per profile respectively. In addition, $30,000 is allowed for an annual report, bringing the total cost to approximately $55,800 per year for surveying. This figure does not include the cost to establish monuments.

(Since the meeting was held, South Carolina has begun planning for the surveying to be done by university personnel with profiles out to a depth of at least 20 feet on every fourth station; the method had not yet been decided but fathometers would probably be used because obstructions prohibit the use of towed sleds. The anticipated cost is $300,000.)

Florida. Fixed concrete monuments were set approximately every 1,000 feet along the shore. A second set of concrete benchmarks was also established 500 feet behind the dune to insure recovery of survey stations after storms. Surveys are done sequentially with crews visiting each site every 3 to 5 years. Normally about 600 stations are done per year but arrangements are also made to do critical areas after major storms. The State's goal, however, is to have each of the 3,587 locations (State of Florida, 1989) surveyed twice a year.

Profile lines are surveyed to a depth of -5 feet MSL with every third station surveyed to a depth of 30 feet MSL or a distance 3,000 feet offshore, whichever is reached first. Offshore surveys are conducted with a boat and fathometer and are run three times to check precision. The State maintains two full-time professional survey crews to do this work.

Although exact figures are not available, the offshore surveys done by a professional crew have been estimated to cost between $1,000 and $2,000 per profile. Since approximately one-third, or 200, of the annual surveys were offshore profiles, this corresponds to annual costs of $200,000 to $400,000 for the offshore surveys alone. The total cost would include approximately 400 subaerial profiles but the estimated cost of these profiles was not available so a total annual cost could not be calculated.

California. Regional and intensive beach profile surveys were specified for both the South Coast and San Diego sections, but only the total number of regional monuments are given in Table 1. More intensive surveys are done in areas of particular interest. For example, in the South Coast minimal plan, 20 additional stations would be spaced 1,500 feet apart and surveys done to a depth of -40 MLW twice a year and to wading depth bimonthly in one area. These profiles will be in addition to the 18 regional profile locations which are surveyed twice a year. Wherever possible, existing benchmarks were used as regional profile locations.

Regional surveys are done at each location twice a year = once in September or October and once in March or April = to measure seasonal changes in the beach profile. Provisions are also made to have profiles done immediately after major storms to quantify storm damage and recovery. It normally takes 12 days to complete the surveys at the 57 locations in the San Diego region. At some locations it has been recommended that local authorities make measurements only of the beach width on a monthly basis. As mentioned, at several locations intensive surveying of beach profiles is done on a bimonthly basis.

Surveys are conducted to the depth of closure or -40 feet MLLW, to measure the seasonal envelope of beach variation. The offshore component was initially done with a sled but because of technical problems at some sites, this method was abandoned and replaced by boat surveys using a standard fathometer. Professional surveyors do the beach and offshore profiles.

During 1985, 1986, 1987, and 1988, $550,000 was allotted for regional-scale beach and nearshore bathymetric surveys or an average of $137,500/year (U.S. Army Corps of Engineers, 1987, p. A25). This does not include the cost of establishing monuments. If surveys are done at 57 monuments twice a year, cost per survey would be $1,200. $18,000/year is allotted for the preparation of a report. For regional surveys in the proposed minimum plan for the South Coast section, $100,000 was committed to establish benchmarks where needed and conduct the surveys. In subsequent years, the cost of surveys was estimated to be $75,000 per year, implying that the cost of the benchmarks was $25,000 (U.S. Army Corps of Engineers, 1987, p. B48). The cost per survey for the minimal plan would be $2,080. The differences are apparently due to economies of scale.

PROPOSED FOR NEW YORK

For the New York program, the group recommended establishing benchmarks over the 125 miles of shoreline from Coney Island to Montauk Point. The spacing would not be uniform. Stations might be spaced closer than 1,000 feet in highly developed, unstable areas and around inlets and near groin fields, and up to 5,000 feet apart on undeveloped land. If the measurements are to be used for regulatory purposes, the monuments should be no more than 2,000 feet apart. In no case should the distance between monuments exceed 1 mile. Where it is appropriate to space benchmarks more closely, the distance might be chosen so that the stations adequately represent curvature of the shoreline. This spacing is recommended so that regulations enforced at any particular location can be supported by direct measurements at a station within one-half mile of the location. In most cases, this will be close enough to insure that conditions at the location are adequately documented, but in heavily developed areas, or where trend of the shoreline changes sharply, more closely spaced stations would be needed to insure that the measurements at the station are representative of conditions between stations.

Preexisting benchmarks, such as the "Strock" ranges, which were established by the Corps and surveyed in 1979, should be reoccupied where possible. (See Appendix III for relative shoreline coverage provided by existing profile lines.) Two markers should be set at each station, one in the upland behind any existing dune that would be in little danger of being lost even during severe storms and one on or in front of the dune to facilitate access.

Surveys should be conducted twice a year = once in the fall and once in the spring. Two surveys per year are required to document the seasonal variability characterized by erosion due to winter storms and rebuilding of the summer beach. Those responsible for conducting surveys must be capable of performing extra surveys on short notice to insure that additional profiles are done before and after major storms. (The definition of a "major storm" would have to be based on the best professional judgment of the agency responsible for the management of the overall program.) They must have the personnel to assign this task a high priority when needed and be assured of the resources to cover the additional expense. Some stations should also be sampled more frequently, say every four to six weeks, to better document short-term variations. These latter two types of surveys may be incorporated in and supported by studies independent of the overall monitoring program. There must be a long-term commitment to carrying out biannual beach profile surveys both to document long-term shoreline trends and to properly evaluate the effects of storms with different recurrence intervals. This information is essential to developing effective, defensible regulations and management plans.

Two classes of surveys were recommended. Every third station, or one station approximately every mile (whichever is fewer) would be done to the depth of closure or approximately -30 feet MSL. This would be done by professional surveyors with a rod and transit onshore, and a boat and fathometer, or sled, offshore. The remaining stations would be done within 2.5 hours of low tide to the water level, or nominally to -2 feet MSL. These surveys could be done by trained university students under faculty supervision to reduce costs. Surveys done to closure depth would provide data for a sediment budget which could be used to assess overall behavior of the system and evaluate the effects of management decisions. Offshore profiles need to be done at least every 5 years except in areas of major engineering projects or in areas subject to the annual loss of property due to chronic erosion. The information provided by offshore profiles is critical to improving our understanding of the sand budget and to the success of predictive modeling efforts. As a result, offshore surveys should be done semiannually at as many locations as possible if funds are available.

For New York the cost of subaerial surveys was assumed to be $200 per profile. This is comparable to the cost in New Jersey. Costs for New York may be slightly higher because access to many stations on the New York shoreline would be more difficult, especially those on Fire Island. A cost of $2,000 per profile was assumed for profiles to a depth of -30 feet MSL. This cost is comparable to other programs but relatively high again because overland access to many stations on Fire Island would be difficult. When both subaerial and offshore profiles are done, 110 stations would be surveyed to -30 feet MSL twice in that year at a cost of $440,000 plus $88,000 for the 220 subaerial surveys that year. If offshore profiles are only done every 5 years for economic reasons, during the other 4 years the cost of subaerial surveys would be $132,000 per year. In this case, total survey cost for a 5-year period would be $1,056,000, for an average cost of $211,200 per year, as indicated in Table 1. To this, an annual cost of $25,000 would be added for reducing and analyzing data and preparing a report.

Aerial Photographs

OTHER STATES

New Jersey. In New Jersey, annual aerial photographs of the shoreline are usually taken in late summer or early fall under other state programs. In 1986, rectified aerial photographs were taken of the entire coast for the Historical Shoreline study. The shoreline was digitized for comparison with 1836, 1870, 1899, 1932, 1952, 1971, and 1977 shorelines digitized from maps and aerial photos. Beginning in 1991 the entire shoreline will be flown every 5 years as part of a freshwater wetlands mapping project. High water shorelines will be digitized from these photo sets and the data entered into a geographical information system (GIS, specifically ARC/INFO in this case) so that a planner could construct shoreline-change maps. The cost for aerial photographs covering 114 miles of coast was estimated to be $15,000, or $130/mile/flight, but this does not include digitization or costs associated with processing or storing resulting data.

South Carolina. One set of aerial photographs was flown to construct a set of orthophoto maps to be used for regulatory purposes. In order to provide the best estimate of the state's jurisdictional control lines, maps were produced at a scale of 1 inch = 100 feet with an accuracy of 2.5 feet. Total cost was $300,000. The jurisdictional line is to be updated every 8 to 10 years. These updates will require new aerial photographs to be taken. Initially, the Coastal Council, which runs the monitoring program, planned to have aerial photographs updated on an annual basis with additional overflights done within 3 days of any major storm (Lennon, 1987).

Florida. The Florida Department of Natural Resources has controlled stereoscopic aerial photographs of the shoreline done in conjunction with their coastal construction control line studies. As a result, the entire coast is flown every 3 to 5 years. The photographs are used to provide detailed working photomaps at a scale of 1 inch = 100 feet. Survey monuments are targeted before the flights and plotted directly on the photomaps. Photogrammetrically-generated contours (at 2-foot intervals) delineating beach and dune details are also plotted. Positions of the shoreline, dune, and other features on the photographs are digitized by Florida State University for use in evaluating shoreline changes.

California. Both of the California monitoring programs call for aerial photographs of the entire shoreline to be taken twice a year at a scale of 1 inch = 1,000 feet to aid in the analyses and interpretation of other shoreline change data. The program managers and other professionals who use these data have found the photographs very useful. Arrangements to fly additional photographs after major storms were also incorporated into the plans. Routine flights were scheduled to coincide with ground surveys in the fall and spring but often conditions would not allow the two activities to be coordinated. Shorelines on the photos were not digitized but the aerials were used to provide qualitative assessment of shoreline conditions between stations where ground surveys were conducted, determine the seasonal envelope of beach changes and construct a sediment budget for cliff erosion. Because they are used for a variety of other purposes, half of the cost of the aerial photographs was paid by another department. Total cost of $25,000 given in Table 1 is the estimated cost for both flights each year.

PROPOSED FOR NEW YORK

In New York, aerial photographs of the south shore should be taken twice a year. The timing should coincide with ground surveys when possible. These photos would be used to supplement the profile data, interpolate beach changes between monuments, resolve discrepancies in ground surveys and provide a qualitative indication of shoreline conditions between the survey stations. For regulatory purposes, this insures that the measurements made on the ground at the survey stations will be

applicable to any location between stations. After 5 years the utility of the semi-annual aerial photographs should be reassessed to see if the interval between flights should be changed. Digitization of the shoreline to look for long-term trends is not necessary every year. However, the shoreline and dune crest in both seasons should be digitized at 10-year intervals. This information could be used in conjunction with the sediment budget developed by Research Planning Institute, Inc. (1985) to provide more accurate estimates of the regional sediment budget. To help identify long-term trends, the vegetation line should also be digitized; this parameter is used in Florida to record extreme storm erosion between surveys. The cost of digitizing only the shoreline on one complete set of aerial photographs is estimated to be between $30,000 and $50,000 (or between $240 and $400 per mile). This does not include set-up costs for the necessary hardware or software; such a facility must be available to the responsible agency. Overflights will cost about $32,800 for both flights every year.

Historical Analysis

OTHER STATES

Historical analysis refers primarily to collection, summarization, and analysis of certain data sets that existed before the monitoring program was initiated. The objective is to cast those measurements in terms comparable to those collected by the monitoring program so that longer term trends can be identified more quickly. Archived beach profiles on recorded shoreline positions would be examples of such data. In addition, there may be data available on parameters that are not being measured under the auspices of the monitoring program but which may be relevant to its management objectives. Inlet bathymetry is an important example of such data.

Inlets are important for navigation and critical modulators of the coastal budget of sand. The littoral drift of sand is interrupted by inlets and substantial volumes of sand can be stored for greater or lesser periods of time in shoals, channels, and submerged deltas that form around inlets. Management of inlets will be essential to maintaining littoral sand transport along the New York coast. Some historical inlet bathymetry is available for analysis but future surveys are also expected to be conducted by the Corps of Engineers in the course of their operation. We have chosen to discuss inlet bathymetry in this section on historical analysis because the implementation of bathymetric surveys will not be part of the proposed program for New York, but bathymetric information would be helpful. Only the program in Florida conducts their own bathymetric surveys; other states rely on the analysis of data collected by the Corps of Engineers during their normal operations.

New Jersey. In New Jersey, $250,000 was spent for an historical analysis of changes in shoreline position between 1836, 1870, 1899, 1932, 1952, 1971, 1977, and 1986. The shoreline data was incorporated into the New Jersey Department of Environmental Protection's ARC/INFO GIS as a series of 1:2400 maps of the ocean coastline compatible with the existing New Jersey tidelands maps. Maps are available to allow the analysis needed to establish setback lines for projects planned on the New Jersey coastline. A comprehensive review of existing profiles was done, but no additional analyses of historic water levels were made. A computer-based bibliography of reports and articles on coastal erosion and processes for the New Jersey shoreline was compiled for the Philadelphia District of the COE by a private consulting firm. There is no program in New Jersey for routine collection and analysis of inlet bathymetry data. However, as part of the historical shoreline change study, bathymetry data from Corps of Engineers' surveys were digitized for some inlets. These data have not been analyzed for the State program.

South Carolina. The regulatory jurisdictional lines were based in part on an analysis of historical shoreline change. This was determined by an analysis of available aerial photographs using position of the vegetation line as an indication of long-term change. Historical beach profiles were also examined but water level data were not reanalyzed under this program. Inlet management zones have been established in South Carolina but the monitoring program does not include the taking of routine bathymetry measurements at inlets at this time.

Florida. The State has established a setback for coastal construction based on a 30-year projection of the shore position. Long-term shoreline change rates used to make this projection were measured from historical profiles, charts, and photographs dating back to 1850. Specific procedures for obtaining acceptable data, analysis of data for determining rates, and establishment of a data base have been established. This work is usually contracted out by the state on a county-by-county basis and comprehensive costs were not available.

Historical water levels in terms of storm tide elevations and return period have been analyzed for most of the state's coastline as part of the shoreline modeling efforts conducted by Florida State University under contract with the State. An extensive beach nourishment program has helped restore the condition of beaches and the State is now focusing on sand management at inlets. Dredging projects must incorporate provisions for insuring that 100 percent of the longshore drift at all inlets is bypassed. The State requires that detailed management plans, which contain bathymetric data, be developed for any inlet dredging projects.

California. Historical shorelines were mapped, long-term shoreline changes calculated, existing beach profiles were compiled, and past water level changes were catalogued and analyzed from available records. Results of these studies, which cost $315,000, were used to supplement new, more complete data generated by the monitoring efforts (U.S. Army Corps of Engineers, 1987, p. A39, A40). For the minimal plan, inlet bathymetry was not done, and the level of detail of the other elements was reduced (U.S. Army Corps of Engineers, 1987, p. B54, B55). The optimal plan for the San Diego region allows $30,000 for analysis of existing bathymetry data at six inlets or harbor entrances (U.S. Army Corps of Engineers, 1987, p. A37). This data is often collected by the Corps of Engineers for those areas containing federally maintained channels.

PROPOSED FOR NEW YORK

For the New York program, the analysis of historic shoreline positions done by Leatherman and Allen (1985) is a good beginning. However, that work was only done for the coast east of Fire Island Inlet, with the last shoreline examined in 1979. The stretch east of Fire Island Inlet should be updated with a more recent shoreline, and the stretch from Fire Island Inlet to Coney Island should be done by comparable techniques over the same time period. If digitized shoreline data are available, it is estimated this additional analysis would cost $60,000.

There have been numerous beach profile surveys conducted along the south shore. Most cover only short sections of the coast for brief time periods, but more comprehensive sets of surveys are available. Although a complete reanalysis of this data may not be necessary at this time, provisions should be made to catalogue the available surveys and assess their potential quality and utility.

There are no tide gages for the open ocean south of Long Island, but long-term tide gage records have been analyzed from the Battery in New York City and New London, Connecticut. In addition, storm surge water level information has been developed by the Corps using historical data and numerical computer models. The available information will probably be adequate for immediate management needs, but the program should reassess the need for an offshore tide gage after 5 years.

Efforts to examine inlets in New York should first focus on identifying, compiling and, if feasible, analyzing the bathymetry data that were, and will be, collected by the Corps of Engineers in association with their inlet dredging programs. Some of the Corps' surveys in these areas have already been digitized. This information would be used to estimate the volumes of sand being stored or diverted at inlets for incorporation into inlet management plans. The estimated, one-time cost of compiling and making a preliminary analysis of these data would be $30,000.

Total costs for analysis of New York's historical data, estimated at $140,000, may be distributed over three years and would probably be a one-time cost, although the results may indicate that additional work (and expense) is necessary, particularly in the continued analysis of inlet bathymetry that may be collected by the Corps of Engineers in the course of their operations.

Wave Data

Waves are the single most important force shaping the shoreline. An adequate understanding of the wave climate in an area is necessary for proper coastal planning, management, and design. However, the cost and technical complexity associated with taking wave measurements make this one of the most difficult monitoring program elements to implement. As a result, these important measurements are sometimes omitted from monitoring programs due to technical and monetary constraints.

OTHER STATES

New Jersey. New Jersey's State program does not collect wave data.

South Carolina. South Carolina does not collect wave data on a routine basis at the state level.

Florida. Florida operates a network of 13 wave gages around the coast as a cooperative program between the state, Corps of Engineers, Navy, and University of Florida. Some gages are not permanent but associated with specific coastal projects. Four of the gages are directional. All but four gages are hard-wired to shore to provide real time data, and have a "storm mode" which will allow them to run on internal batteries if the cable is severed so data will not be lost in the event of a storm. Although the system requires continuous maintenance, data return has been very good. Data from this program is stored in a dedicated data base maintained by the University of Florida's Coastal Engineering Archives. This data base is accessible by personal computers through telephone lines and is used by Federal, State, and local governmental agencies, private companies, and others. The wave data network costs approximately $500,000 per year to maintain.

California. Three nearshore gages were funded and installed as part of the optimal monitoring program for the San Diego region, although the program incorporates results from five directional nearshore wave gages (slope arrays) and two deepwater directional buoys for a 90-mile stretch of coast. In addition, temporary arrays of wave gages were clustered at different locations within the 40-mile study area. Plans for the 91-mile south coast region's minimal monitoring program call for installation of three directional gages (one offshore buoy and two nearshore slope arrays). The system would be operated for a period of at least 3 years. Installation and operational costs include the preparation of monthly data summaries. Funding for the wave gages in the California program is complicated by cost-sharing and loaning of equipment between projects or programs. Based on discussion with the Corps of Engineers, $60,000 per year per gage appears to be a reasonable estimate of the annual cost of installing and operating a wave gage. For the optimal plan in San Diego total cost was $545,000. This apparently provided for data collected over a 4-year period corresponding to an annual cost of $181,700 for the gages. In the minimal plan, $325,000 was budgeted for three wave gages to be operated over a 3-year period for an average cost of $108,300 per year. This seems to be the cost to operate two gages while the third is to be run by another agency; it is not clear from available information how the costs and responsibilities actually would be shared if this plan was implemented.

In addition to monthly data reports from the contractors, both programs in California would spend approximately $15,000 per year for annual reports that summarize and synthesize collected wave data in a form readily usable for coastal engineering and planning. This analysis includes a comparison of collected data with historic and hindcast wave data.

PROPOSED FOR NEW YORK

For New York, the group's consensus was that at least four directional wave gages should be established. (Directional information is needed for calculations of longshore transport.) The general shoreline is relatively straight, so that changes in regional wave climate are likely to be fairly gradual and due primarily to the sheltering effect provided by the New Jersey coast. Four gages should be adequate to characterize this trend as well as to provide redundancy in case of gage failure. The specific locations of gages would require a siting study. Such a study would also provide guidance as to the most suitable type of gage (buoy, slope array, etc.) for the particular location and application. If possible, the gages should be equipped to provide real time data for other uses. The gages should be provided with an internal mechanism to record data in case the cables are damaged during storms, and precautions should also be taken to minimize the potential damage from commercial fishing activity, especially draggers. The Corps' Coastal Engineering Research Center (CERC) has developed dragger-resistant bottom-resting wave gages. Use of these instruments in conjunction with educational programs for commercial fishermen should be considered to minimize losses. CERC manages a Field Wave Gaging (FWG) program as part of the U.S. Army Corps of Engineers coastal field data collection program. Recently, CERC has been given the authority to enter into cost-sharing agreements with individual states to set up cooperative wave gaging programs. These cooperative networks have been implemented in California and Florida. (Since the workshop was held, the Corps and the State have met to discuss the possibility of implementing a FWG program. It was suggested that two permanent deepwater gages and several nearshore gages that could be periodically relocated might provide adequate coverage. One gage had been installed this year as part of a Corps construction project offshore of Fire Island Inlet.)

Estimated annual costs for individual gages range between $50,000 to $100,000 per year depending on the options used and number of gages deployed. The tabulated cost was based on an assumed annual cost of $60,000/gage. Because considerable savings can be realized through a collaborative effort, the State should pursue the feasibility of entering into a cooperative agreement with CERC to form a gage network under the FWG program. Because of its importance in planning and design decisions, wave data collected by the networks should be compiled and stored in a data base easily accessible to a variety of user groups. Florida's program uses a data base accessible by modem open to the public. Results of the wave gage system should be assessed after the first year to determine if coverage is adequate or whether it needs to be expanded or reduced.

Computerized Data Base

To maximize usefulness of data and information developed by a monitoring program, this data base must be a functional data base, not just storage of data in some electronic media, and it must be accessible to people other than those collecting the data.

OTHER STATES

New Jersey. Profile data and digitized historic shoreline positions are maintained in a data base on an IBM Compatible 386-based computer. Profile data is stored in a format that is compatible with both commercially available spreadsheet programs and the Corps' Interactive Survey Reduction Program (ISRP) format. The ISRP data base is available on disk only to ISRP program users.

The historical shoreline positions have been transferred to the statewide geographic information system (ARC/INFO) to make this data accessible to other agencies as 1:2400 scale New Jersey tidelands maps or as overlays on New Jersey tidelands photo-quads. The cost of this processing was $47,500. In addition, a computerized bibliography of relevant reports and articles was compiled for the Philadelphia District of the U.S. Army Corps of Engineers by a Florida consulting firm; the cost of this bibliography was not available.

South Carolina. The State stores beach profile data in a computerized data base developed by an outside contractor. In addition, historic shoreline change data is entered into a commercial, GIS (ARC/INFO) to produce maps of shoreline movements, jurisdictional lines and structures for coastal planners and managers. This work is done in-house. Presently, none of the data bases have provisions for open access by outside user groups.

Florida. The State maintains or provides funding for a number of different data bases related to its shoreline monitoring program. The Division of Shore and Beaches stores beach profiles and long-term and short-term shoreline position change data in computerized data bases accessible by modem and personal computer from remote locations. With funding from the State, the University of Florida's Coastal and Oceanographic Engineering Department operates the Coastal Engineering Archives, which collects and organizes a comprehensive library of materials relating to coastal processes and engineering including reports, data, charts, and aerial photos. These materials are made available to individuals and agencies. As mentioned previously, wave data from the gage network is also available through the Archives via telephone modem from remote locations. In addition to being used by State and other government officials to set jurisdictional lines, develop regulations, make management decisions, etc., information stored in the data bases is also used extensively by consultants, engineers, and other members of the public for a variety of coastal projects because it is so easily accessible.

California. The Corps of Engineers maintains a data base of all the data collected under the San Diego region monitoring program. These data are available to the public. The data base includes a computerized bibliography of previous reports and articles on the area's coast, as well as program-generated materials. The most widely used data are those from the beach profile surveys. These data are provided to interested parties free of charge in both a format compatible with a widely used commercial spreadsheet and in the Corps' developed ISRP format. The data base is run by the district corps office. For the 6-year program, they estimated start up costs of $80,000 in the first year and a total of $90,000 over the subsequent 5 years.

PROPOSED FOR NEW YORK

New York's monitoring program should maintain a data base at a central location. Initially, the data base should contain the profile, wave, historical, and shoreline position information collected by the program. In addition, a computerized bibliography of available reports, articles, etc. for the region should be developed. Eventually, the results of other studies should be incorporated in the data base. To maximize utility, the data base must be updated continually and should be staffed by professionals who can handle queries and assist users in accessing the data. Remote accessibility through a personal computer, modem, and phone line should also be incorporated into the system to enhance its utility and availability to the widest possible audience. The data-basing system presently used in Florida could serve as a model. Recent advances in commercial data base software development may make it possible to utilize commercially available systems for the New York program. Use of off-the-shelf software could provide substantial savings over custom configurations. Although incorporation of a computerized GIS may be premature in the initial stages of development of a monitoring program, care should be taken to insure that the resulting data is compiled and stored in a data base format compatible for possible

incorporation into a GIS at a later date. The cost indicated in Table 1 is based on the assumption that the hardware, software, and partial manpower requirements would be available in an existing entity. The total figure given is similar to data base management costs given for the California optimal plan.

Modeling

The objective of coastal modeling is to develop predictive tools that would allow planners, managers, and other decision-makers to forecast response of the shoreline or beach to a variety of environmental conditions or to implementation of various erosion management options. The use of models could help managers in making decisions based on sound scientific principles and data.

OTHER STATES

New Jersey. In New Jersey, numerical modeling using several different computer models has been done for some small coastal sections by the Corps of Engineers as part of specific construction projects, but no modeling is done under the State monitoring program. SBEACH (Storm induced BEAch CHange model, developed at CERC) and other models are in the process of being used in the New York Bight as part of the New Jersey water quality program.

South Carolina. No computer modeling is done under the South Carolina Program at the present time.

Florida. Florida's Division of Natural Resources employs a number of coastal models utilizing their monitoring data. The results of these models are actually used to set jurisdictional and regulatory boundaries under State law. Computer models are used to predict storm tide elevations of 10-year to 500-year storm events at different locations, expected rates of dune and beach erosion in response to extreme storms, and maximum inland penetration of storm waves on a county-by-county basis. These models were developed and are run for the State primarily by university researchers and outside contractors.

California. In California the U.S. Army Corps of Engineers' "optimal" plan for the San Diego region incorporates a number of state-of-the-art mathematical coastal models used for a variety of different purposes. Long-term, wide scale shoreline changes were simulated with GENESIS (GENEralized Model for SImulating Shoreline Change). This model, developed at CERC, was adapted for use in PC's for the California program. The SBEACH model was used to estimate shorter-term storm impacts on the cross-shore beach profile at different locations. In addition to shoreline changes, models were also developed and applied to evaluate and assess sediment transport and the sheltering effect of offshore islands on the nearshore wave climate. The purpose of these modeling efforts is to allow managers, planners, and engineers to quickly investigate the potential effect of various management decisions or actions; for example, the response of the shoreline to installation of a structure. Since accurate data are needed to run the models and calibration can be difficult, the utility of some shoreline change models is subject to differing opinions. Although shoreline change models should not be considered engineering design tools at this time, they can provide information extremely useful for planning and management purposes. In California's optimal plan, a total of approximately $750,000 over a 6-year period was allotted for modeling work along the 90-mile coastline.

For the proposed "minimal plan" for the South Coast, modeling will be limited to a simplified, qualitive sediment-budget, box model installed on a spreadsheet program. The estimated cost for developing and implementing this model is $160,000.

PROPOSED FOR NEW YORK

In New York, modeling efforts would help cast the results and data from the monitoring program in a form that would make it easier for coastal planners, managers, and engineers to use in the decision-making process. Models can provide a technically sound basis for risk assessment for management decisions. Modeling efforts associated with the proposed monitoring program must be compatible and adaptable to the level and type of data available. The higher the quality and quantity of data, the more sophisticated the models used can be. Where (or when) data are few a conceptual model may be the most appropriate alternative. A diagnostic model or box model may be appropriate when adequate observations are available, and dynamic numerical models of processes and shoreline response used when physical forcing is adequately described. Because of rapid advances being made in shoreline change mathematical modeling, today's state-of-the-art model might soon be dated. Therefore, no single model was identified as the most appropriate. Rather, the consensus of the group was to follow a phased plan where monitoring data would be used to develop conceptual models of shoreline response initially and then expand to empirical and numerical models as the data base increased. Care should be taken to insure that the data collection format, techniques, etc. will be compatible with modeling efforts in the future. The proposed management plan for the south shore (Long Island Regional Planning Board, 1989) estimated costs to be $300,000 for establishing appropriate models and $60,000 per year for their maintenance and use.

REQUIREMENTS FOR ELEMENTS OF NEW YORK'S PROPOSED MONITORING PROGRAM

Although the administration and management of the overall monitoring program were not specifically addressed at the workshop, technical capabilities and resources needed to implement a coastal monitoring program in New York and potential areas of coordination among agencies were briefly discussed by participants. Results of these deliberations are summarized in this section.

Although there is no shorewide monitoring program in place in New York, the

Corps of Engineers, the National Park Service, and the New York State Department of Environmental Conservation are involved with coastal projects at various locations, some of which could be integrated into a comprehensive monitoring plan. The Corps' existing and proposed programs along the south shore are the most extensive and described briefly in Appendix IV.

Surveys. Development of the beach survey monument network should be closely coordinated between State, Federal, and local interests. To provide the longest period of record in the most cost-effective manner, existing survey benchmarks or monuments should be reoccupied whenever possible. Beach monitoring stations that would be established by the state may also be used for pre-project and post-project surveys at both Shinnecock and Moriches inlets as well as at Coney Island and Long Beach (Appendix IV). Although the objective of the Corps' monitoring (to assess project performance) limits the extent of observations, at least methods could be standardized to insure compatibility with any State program, with cost-sharing also a possibility. The National Park Service has conducted occasional studies in the National Seashore and may be interested in insuring that some comparable survey data is available on parkland.

Beach surveys require two types of capability. The subaerial surveys require the ability to mobilize several, moderately well-trained crews under the supervision of an experienced professional to field check quality of the data. Use of university students and personnel would meet this requirement, but it may equally be met by any authority or agency that maintains a large field crew and/or professional surveyors such as the Department of Transportation.

The second type of survey requires a professional survey crew with the ability to conduct offshore surveys. The Corps maintains two survey parties who operate at a cost of $2,400 per party per day; they can complete two to five long surveys per day. The cost of private contractors would be higher. The COE also has open-ended contracts with private firms to do surveys when they cannot be done in-house. Alternatively, a crew could be established at a local university or within the Department of Transportation, perhaps with help from the National Park Service. Regardless of who is chosen to do the work, survey crews must have the ability to respond quickly to monitor the subaerial beach immediately after storms.

However the surveys are implemented, one or a few experienced professionals must be available to check the data, reduce the measurements, and prepare an annual report to the lead agency.

Aerial Photographs. For the New York coastal monitoring program, the schedule and arrangements for overflights should be coordinated with other programs to reduce costs. The New York State Department of Environmental Conservation uses aerial photographs to establish the State's jurisdictional lines under the Coastal Erosion Hazard Area Program in New York. This line is to be revised every 10 years. In addition, aerial photographs are also used for mapping wetlands. It may be possible to coordinate these activities with the recommended digitizing of two sets of aerial photographs (summer and winter) every decade. All aerial photography for New York State is done by private contractors. An agency convenient to the south shore should be enlisted to archive the photographs and to have them accessible to users. Digitization of shoreline features might be contracted out as several states have done, but it could be done at any facility with (a) experience in interpreting shoreline photographs, (b) hardware and software for digitizing large images, and (c) available, skilled operators.

Historical Analysis. Upgrading historical shorelines would require expertise to digitize aerial photographs and maps. The search and assessment of historical beach profiles and inlet bathymetry would require a coastal technical specialist with experience in analyzing coastal survey data and assessing the Corps' records.

Wave Data. The agency responsible for implementing the wave monitoring program must have access to individuals with both practical experience and the technical and theoretical background for operation of wave gages and analysis of wave data.

They must be able to deploy equipment at sea either with their own resources or under contract, and to secure the necessary computer hardware and software to process, reduce, and analyze data. They must also be willing and able to disseminate the collected wave information to a wide range of users in a timely manner.

The state should pursue the possibility of entering into a cooperative data collection agreement with the U.S. Army Corps of Engineers under their FWG Program for construction projects through the New York District. Both California and Alaska have used such agreements to conduct coastal processes data programs, and similar agreements are presently being reviewed for South Carolina, Virginia, and Florida. An arrangement between the State and the Corps could provide considerable cost savings for both. Other possibilities for cooperation are afforded by the New York Bight study or the Philadelphia Corps District's study of the New Jersey coast. Florida has installed wave gages as part of a Federal reconnaissance study. (A Federal reconnaissance study can be initiated with the proper local support as long as a problem is identified. This leads to a feasibility study to identify the benefits and finally to a General Design Memorandum in which a project is defined in engineering terms. With the proper local support it may be possible to have a congressional resolution passed for a reconnaissance study of the coast of Long Island with cost-sharing between the Federal and State governments.)

Data Base. The facilities required to operate and maintain a coastal processes data base as described do not presently exist in the region. Such a facility would require computers with data basing software and technical specialists both in computer information management systems and in coastal processes. Provisions must also be made to make the data accessible to outside users through printed and electronic media. Several such facilities have been or are being established in other states (e.g., Florida). For parts of the New Jersey coast a reconnaissance report was done which, among other things, set up a data base; this was funded by the Federal Government at a level of $400,000 over 18 months as part of a program to reduce water pollution and beach litter. Another data base is planned at the State University of New York for regional environmental data on Long Island Sound with support from the Environmental Protection Agency (EPA).

The EPA has investigated the needs of potential users of a marine data base and recommends the following functional requirements (Copeland, 1990):

- The system should be able to store the types of data used by the majority of the user community.
- Sufficient quality assurance/quality control (QA/QC) steps should be taken for on-line data.
- The data should be easily transferred from the system into software packages used by the majority of . . . users. These include:
    - DBM's — Dbase III and SAS.
    - Spreadsheets — Lotus 1-2-3.
    - Word Processors — Word Perfect/Word Star.
    - Data Analysis Systems — SAS.
    - Telecommunication Systems — CrossTalk, Kermit, and Procomm.
- The system should be accessible with IBM compatible personal computers.
- There should be a variety of data analysis tools available on the system.
- The system should have the following capabilities:
    - A central index which identifies what data are available, where the data are located, and who should be contacted to access the data.
    - Retrieval of on-line data.
    - Access to a geographical information system (GIS). This could range from actual user access to a GIS to creation of hard copy GIS outputs for users.
- The system should be easy to use. The majority of the individuals

involved in the [EPA study] . . . identified themselves as beginning computer users. If a system is too difficult to use it will be useless to a large portion of the [potential audience].

- The system should have extensive documentation. It is important for users of all levels of expertise to have access to documentation and user support.
- The costs involved with the system should be reasonable. This includes the costs of data storage, data access, data QA/QC, telecommunication, and hardware.
- The costs of training individuals to use the system should be reasonable.

Modeling. Development of modeling capabilities would, in large part, depend on implementation of the data collection under the monitoring program. Several classes of shoreline change and coastal processes models exist and most run on PC's, but none are commercially available. The skill and professional judgment of an experienced coastal expert would be required to choose suitable models and exercise them.

Two general classes of models must be available (Wood et al., 1990). One class is a longshore transport, or one-line model that basically uses information on the wave climate to predict longshore transport of sand and changes in shoreline position. Analytical longshore transport models may be readily applicable to some situations (e.g., Pelnard-Considere, 1956; LeMehante and Soldate, 1978; and Larson et al., 1987). Numerical models often require detailed site specific information and more computational power than is available in a PC, but they are applicable to the full range of conditions in the study area. An example of a numerical model is GENESIS that was developed and is used by the U.S. Army Corps of Engineers (Hanson and Kraus, 1989).

The second class of models are cross-shore models which predict changes in beach profile especially in response to storm conditions. Some models are based only on geometry of the shoreline like that used by FEMA (Hallermeier and Rhodes, 1988) or

Bruun's Rule (Bruun, 1962), but other models specifically take into account the response of sand transport to time varying conditions (e.g., Vellinga, 1983; Kriebel and Dean, 1985; and Larson et al., 1988). The later models require detailed, site specific data for their use. Combinations of cross-shore and longshore models are currently being developed and, since this is an expanding area of coastal research, any modeling effort must be flexible to accommodate improvements in our ability to model beach processes.

Management. All components of the program must be under the overall coordination of a lead agency whose first tasks would be to finalize details of the monitoring plan and secure funding, as well as to coordinate with other agencies. This agency would then select appropriate groups to implement various elements of the program, set the objectives of each group, synthesize annual results, and reassess the direction and data needs of the program.

This agency must not only have the administrative resources to secure and disburse the required budgets but also must have the services of a program manager with the appropriate technical expertise. The manager should solicit the advice of other professionals, but he or she would be ultimately responsible for the selection of competent contractors, approval of the work plans and budgets, and quality of the data. The program manager must be able to periodically review and synthesize data from diverse sources to decide if certain observations must be redone, if improvements in the techniques must be made, when exceptional surveys must be made, and whether or not results are conforming to expectations.

Costs. Estimates of the total annual costs of various State programs discussed here range from $55,800 to $3,000,000 (Table 1). The great disparity in the levels of effort among various programs and lack of fiscal information for specific individual program components makes comparison of total costs difficult. As a result, cost of the overall program proposed for New York is difficult to estimate based on information from other states. For the most part, the New York program proposed here is similar in scope to the minimum plan proposed for the south coast of California. The sum of the cost estimates for the various elements of the proposed New York program amounts to $609,000/year distributed as follows:

Surveys	$236,200/yr
Aerial photographs	32,800/yr
Wave data	255,000/yr
Data base	25,000/yr
Models	60,000/yr
TOTAL	$609,000/yr

It is reasonable to allow about 20 percent additional, or about $121,800, for program administration and supervision. This would bring the total annual cost for the New York program to $730,000/year plus any overhead charges that might be required by contractors, and fixed costs of about $585,000 for installing monuments ($125,000), studying inlet bathymetry and compiling historical data ($140,000), siting of wave gages ($20,000), and establishing suitable computerized models ($300,000). As discussed earlier, these costs can be shared among State and Federal agencies with coastal responsibilities.

SUMMARY TABLE

PROGRAM ELEMENTS	CHARACTERISTICS	NEW JERSEY	S. CAROLINA	FLORIDA	CALIFORNIA South Coast (Minimal Plan)	CALIFORNIA San Diego (Optimal Plan)	PROPOSED FOR NEW YORK
SURVEYS							
	spatial distance	91 monuments/ 114 miles	430 monuments/ 120 miles	3587 monuments/ 682 miles	18 monuments/ 91 miles	57 monuments/ 90 miles	330 monuments/ 125 miles
	monument cost	$53,000	$172,000	NA	$25,000	NA	$125,000
	frequency	1/yr goal 2/yr	2/yr	1/3-5 yrs goal-2/yr	2/yr	2/yr	2/yr
	timing	Fall	fall/spring	continuous	fall/spring	fall/spring	fall/spring
	depth of survey	-6ft MSL	-5ft MSL	-5ft MSL (-30ft or 3000ft offshore whichever is less, every 3rd station)	-40 ft MLLW	-40 ft MLLW	-5ft MSL (-30ft MSL every 3rd station,every 5 years)
	who does it?	university	university	state	undecided	company/university	various options (see text)
	average cost/profile	$220	$30 - 100	$1,000-2,000	$2,080	$1,200	$320
	analysis/report	$12,000 (when done)	$30,000	NA	$14,000	$18,000	$25,000
	annual total cost	$30,000/yr	$55,800/yr	NA	$89,000/yr	$156,800/yr	$236,200/yr
	proposed expansion	$35,000 fixed + $80,000/yr	$300,000/yr				
AERIAL PHOTOS							
	frequency	1/5yrs	once only	1/3-6 yrs	2/yr	2/yr	2/yr
	timing	spring	-	-	fall/spring	fall/spring	fall/spring
	scale	1"=1000'	1"=100'	1"=100'	1"=1000'	1"=1000'	1" = 500'
	digitized features	waterline	none	waterline, dunes, structures	none	none	waterline, dune crest vegetation line, every 10 yrs
	unit cost	$130/mile/flight (photos only)	$2000/mile/flight (orthomaps)	$200/mile/flight (digitizing only)	$140/mile/flight (photos only)	$140/mile/flight (photos only)	$131/mile/flight (photos only)
	total cost	$15,000/yr	one time cost of $300,000	NA	$25,000/yr	$25,000/yr	$32,800/year ($62,800-82,800 every 10yrs)

NA = Not available

Please see notes following table and text for more detailed information on headings.

SUMMARY TABLE (*continued*)

PROGRAM ELEMENTS	CHARACTERISTICS	NEW JERSEY	S. CAROLINA	FLORIDA	CALIFORNIA South Coast (Minimal Plan)	CALIFORNIA San Diego (Optimal Plan)	PROPOSED FOR NEW YORK
HISTORIC ANALYSIS							
	shoreline change analysis	yes	yes	yes	yes	yes	yes
	historic beach profiles	yes (no analysis)	yes	yes	yes	yes	yes
	sea level changes	no	no	yes	yes	yes	no
	inlet bathymetry	yes	no	yes	no	yes	yes
	total cost	$250,000	$30,000	NA	$170,000	$345,000	$140,000
WAVE DATA							
	is it collected?	no	no	yes	yes	yes	yes
	siting analysis	-	-	NA	$10,000	$20,000	$20,000
	# gages	-	-	13	3	3	4
	directional?	-	-	3	3	3	4
	record length	-	-	indefinite	3 yrs	4 yrs	at least 3-5 years
	install/operate	-	-	$380,000/yr	$108,300/yr	$181,700/yr	$240,000/yr
	who does it?	-	-	university/COE	undecided	COE/NOAA/Univ.	various options (see text)
	analysis/report	-	-	NA	$15,000/yr	$15,000/yr	$15,000/yr
	annual total cost	-	-	$500,000/yr	$123,300/yr	$196,700/yr	$255,000/yr

NA = Not available

Please see notes following table and text for more detailed information on headings.

SUMMARY TABLE (*continued*)

PROGRAM ELEMENTS	CHARACTERISTICS	NEW JERSEY	S. CAROLINA	FLORIDA	CALIFORNIA South Coast (Minimal Plan)	CALIFORNIA San Diego (Optimal Plan)	PROPOSED FOR NEW YORK
COMPUTERIZED DATA BASE	is there one?	yes	yes	yes	yes	yes	yes
	data stored	profiles, shoreline position	profiles, shoreline position	profiles, shoreline position, waves	sediments, waves tides, storm surge, profiles, etc.	sediments, waves tides, storm surge, profiles, etc	profiles, waves, shoreline position
	other studies incorporated?	yes	yes	yes	yes	yes	yes
	bibliography?	yes	no	yes	yes	yes	yes
	who maintains?	university/COE	state SCCC	state/university/COE	COE	COE	various options (see text)
	database management	$14,000/yr (for profiles only)	$5,000/yr	NA	$16,000/yr	$28,000/yr	>$25,000/yr
MODELING	is it done?	no	no	yes	no	yes	yes
	what is input?	-	-	wave, meterological, profile, water level data	sediment budget data	bathymetry, sediment budget, sediment transport, wave, water level data	bathymetry, sediment budget, sediment transport, wave, water level data
	model type(s)	-	-	storm surge and dune erosion, numerical models	qualitative spreadsheet	several numerical coastal processes and response models used	progression from conceptual to numerical coastal response models (longshore and cross-shore) appropriate to data
	who does it?	-	-	university	undecided	COE	various options (see text)
	cost	-	-	$200,000/yr	$160,000	$750,000	$300,000 fixed + $80,000/yr
	lead agency	Dept Env Prot. Div Coastal Resources	S. Carolina Coastal Council	Dept Natural Resources/Div Beaches & Shores	COE	COE	various options (see text)
TOTAL COST excluding administrative costs		$59,000/yr (+$303,000 fixed)	>$55,800/yr (+472,000 fixed)	$3,000,000/yr (total program)	$263,000/yr (+$355,000 fixed)	$405,200/yr (+$1,085,000 fixed)	$600,000/yr (+$585,000 fixed)

NA = Not available

Please see notes following table and text for more detailed information on headings.

EXPLANATION AND ADDITIONAL NOTES FOR TABLE*

Surveys. These are periodic measurements of the beach profile.

1. Spatial distance. The spacing of the monuments from which the surveys are made is not necessarily uniform but specifying the total number of monuments over the total length of shoreline characterizes both the size of the program and the density of sampling stations. **The Long Island ocean shoreline is 125 miles long from Montauk Point to the western end of Coney Island including an overlap at Fire Island Inlet.**

2. Monument costs. These are fixed costs for constructing the monuments in place and determining their exact position and elevation. **The New York program will also have to insure that the monuments are maintained and lost monuments replaced. There may be some cost savings if some previously used monuments are still in place and adequate for the surveys.**

3. Frequency. This is the number of times per year that a survey is done at each monument.

4. Timing. This indicates when during the year the surveys are done. Fall surveys are intended to represent the maximum beach conditions for the year after the summer episode of accretion, while spring surveys are intended to represent minimum beach conditions for the year after the impact of repeated winter storms.

5. Depth. This is the depth of water that defines the seaward limit of the profile measurements. Subaerial beach profiles are usually done to "wading depth" at low tide. As a result, the actual depth for a particular profile is dependent not only on the tidal range at the time of the survey but also on the meteorological tide, the wave set-up and wave conditions that may hamper measurements. Offshore surveys are intended to be done to the depth of closure, i.e., that depth beyond which the bathymetry is not altered by waves.

6. Who does it? Some surveys are done by professional surveyors and some by universities using staff and students. Some of the California surveys are done by the Scripps Oceanographic Institute, but it is unclear whether they use staff or students; presumably staff would be more highly trained. The surveys in South Carolina were done by students.

7. Average cost/survey. This is the annual total cost. Except for New Jersey, it does not include the cost of establishing or maintaining the monuments. Stations

* Specific references to the New York program are written in boldface in the text.

profiled to "wading" depth would be less expensive than stations profiled to depths of -30 or -40 feet offshore.

8. Analysis/report. This represents the annual cost for summarizing the data and preparing a synthesis report on the results of the surveys.

9. Total cost. This is the annual expense for doing the actual surveys and preparing a report.

10. Proposed expansion. Several states are preparing to expand their program. This indicates the scope of that expansion.

Aerial photographs. These should provide complete coverage of the shoreline. Since they can also be used by other programs or agencies such as wetland delineation or updating land-use maps, the cost may be shared between agencies or programs.

1. Frequency. This is the number of complete shoreline overflights per year. "Once only" means that the aerial photography was not intended to be repeated.

2. Timing. This is when the photographs are taken during the year. The aerial photographs are intended to be taken when the surveys are done but the experience in other states has shown that this is often impossible because of logistical problems. **For the New York program, they should be taken as near to the time of the surveys as possible, certainly in the same season.**

3. Scale. **The products of the New York overflight would be scaled, reproducible mylars (1:6000) and rectified to allow for accurate quantitative measurements from digitized features.**

4. Digitized features. This indicates whether or not certain features were digitized so that their location and their change in location between overflights can be analyzed by computer. The specific features that are digitized, if any, are also indicated. **For the New York program, digitization is recommended only every 10 years, since historically the rates of change of these features in most areas is relatively small. In 10 years, however, shifts may be large enough to be accurately measured.**

5. Unit cost. This is each program's cost per flight per mile of shoreline. In some cases, it is the cost of the photos only. In others, the photographs are produced under another program and only the cost of digitizing needs to be incurred. The

cost is high for the South Carolina program even though shoreline features were not digitized because the photos were used to produce accurate base maps.

6. Total cost. **For the New York program, the cost of digitizing shoreline features was estimated to be between $30,000 and $50,000 for both overflights in a given year. This does not include the set-up cost of hardware and software to complete the digitization; the responsible agency or company was assumed to have the necessary facilities available.**

Historical Changes. This element involves the collection of shoreline and process data previously acquired under other programs and casting it in a form that facilitates comparison with the data being collected under the present program.

1. Shoreline changes. In some cases, former shorelines have already been digitized and shoreline changes calculated. In other cases, aerial photographs may be available for particular time periods or sections of the shoreline but the shoreline position has not been determined.

2. Historical beach profiles. This element would involve the documentation and analysis, if necessary, of any beach profiles that may have been collected by other, earlier studies. The results would need to be cast in the same terms that are used by the monitoring program.

3. Sea level changes. An analysis of available tide gage records could be done to determine multi-year changes in sea level, if this has not been done already. **For the New York program, the long-term trends have already been analyzed for the tide gages at the Battery and New London at least until sometime within the last two decades. It is probably not necessary to update those analyses at this time. There are no water-level measurements on the south shore that could be analyzed as part of an historical study, although the general tidal characteristics have been calculated.**

4. Inlet bathymetry. This element is anticipated to involve identification and analysis of surveys taken by the U.S. Army Corps of Engineers. The cost would probably not be incurred annually but on a schedule determined by the rate of shoaling, hence the frequency of dredging, of the inlet.

5. Total cost. This represents a one-time cost although it could be spread out over several years.

Wave Data. This element involves the direct, ongoing measurement of waves in the study area.

1. Is it collected? That is, does the monitoring program continually maintain wave gages and process the data. In some cases in which the monitoring program does

not assume this task, wave gages may still be operated and data analyzed by other agencies or programs. **In New York, one directional wave gage is currently in place offshore of Fire Island Inlet.**

2. Siting analysis. This includes the cost of studies required to choose the best location for the instruments, the exact number of instruments needed, the type of instrument used, and the logistics of maintenance, but it does not include the price of the instrument or the actual cost of installation.

3. Number of gages. This is the number of locations at which measurements are made even though some sites may have several instruments linked in an array to obtain directional wave data.

4. Directional? This is the number of sites at which wave direction is measured as well as wave height and period.

5. Record length. Wave data not only provides a statistical description of the wave climate but also a continuing quantitative record of the type of events affecting the coast. Data adequate for the former purpose might be collected in a few years, that is, over a time period long enough to contain rare but extreme events. The latter goal requires continued monitoring. **For the New York program, a multiyear but limited commitment would be made to assess both uses of wave data and the adequacy of existing sites. The program would then be re-evaluated. It is expected that measurements would continue to be made at some locations.**

6. Install/operate. This is the annual cost to install and maintain the wave gages but not the cost to process the data. A rule-of-thumb provided by the experience of the U.S. Army Corps of Engineers is $60,000/gage/year.

7. Who does it? Wave gages require trained and experienced technical support. In many cases, this is provided as a joint effort between Federal, particularly the U.S. Army Corps of Engineers (COE), and State agencies.

8. Analysis and report. The raw data must be processed, summarized, and reported in terms useful to coastal managers. These costs are approximate since the number of operating gages and, thus, the amount of data may vary from year to year.

9. Annual cost. This is the total annual commitment for installing and operating the equipment and preparing the data report.

Computerized Data Base. This refers to a functional data base that is accessible to people other than those collecting the data; it is not merely the storage of data on electronic media.

1. Is there one? All programs have a data base as part of their development.

2. Data stored. This entry represents the type of data in the data base. Beach profiles provided by the surveys are stored in all programs but other relevant parameters may be only available in reports or stored electronically by other programs.

3. Other studies incorporated? All programs also assume the responsibility for including relevant measurements made by other programs in the data base. These could be historical data or relevant continuing observations.

4. Bibliography? Except for South Carolina, bibliographies of reports and articles relevant to the monitoring program, as well as an index of the available data, are available for the other states. These are developed and maintained by either State or Federal agencies, depending on the program.

5. Who maintains? Data basing requires a long-term commitment as well as adequate hardware and software and an experienced staff.

6. Data base management. This is an estimated cost for maintaining the data base and does not include the set-up costs or the cost of facilities or equipment.

Modeling. This element refers to the use of numerical computer models to describe and predict wave condition changes in the beach and/or longshore transport caused by physical processes.

1. Is it done? Models could include models for waves, longshore transport, changes in shoreline position, and beach profile response.

2. Input? What basic data are required to use the models?

3. Model type? Models may range from qualitative models that are essentially a balance sheet for sand volumes to complex process response models. **For the New York program, the complexity of the models used should be appropriate to the quality and quantity of the data. It is anticipated that more sophisticated process-response models will be incorporated into the program as the other monitoring elements provide the necessary data.**

4. Who does it? Modeling requires both adequate computer facilities, well-trained operators, and experienced researchers to interpret the results.

5. Cost? This is an estimate of the annual cost excluding the initial cost of establishing a proper facility. **For the New York program, it is assumed that a core facility already exists within the state system, as, for example, in a university.**

6. Lead Agency? The lead agency is expected to provide direction to the modelers and to assess the quality and utility of the results.

Total Costs. These are compilations of the costs for comparable elements of the various state programs. In the case of Florida, although the individual costs of some elements were not available, the total cost was $3 million/yr. Presumably this includes administrative costs. The California Optimal Plan contains large fixed costs primarily because the modeling costs ($750,000) were treated as fixed; if these were distributed over five years, the annual cost for the California Optimal Plan would be $555,200 per year with fixed costs of $315,000. This figure is more comparable to the proposed program for New York, but somewhat lower due to the fact that the California program covers a smaller stretch of coast than the south shore of Long Island.

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APPENDIX I

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APPENDIX II

LONG ISLAND SOUTH SHORE EROSION MONITORING PROGRAM WORKSHOP AGENDA

November 13–14, 1990

Tuesday, November 13

10:30 AM Welcome/Introduction/Background

10:45 Monitoring Programs in Other States

New Jersey
Beth Sullivan
Coastal Research Center
Stockton State College

South Carolina Beach Monitoring Program
William Eiser
South Carolina Coastal Commission

Florida Beach Monitoring and Coastal Data Network
Robert Dean
Coastal and Oceanographic EngineeringLaboratory
University of Florida

12:15 PM Lunch

1:00 California Storm and Tidal Wave Study
Pam Castens
U.S. Army Corps of Engineers,
L.A. District

1:30 Identification and Discussion of Characteristics of New York Program

3:30 Break

3:45 Discussion of New York Program Continues

6:00 Adjourn

Wednesday, November 14

8:00 AM	Coffee and Danish
8:15	Review/Summarize New York Program
9:00	Planning Initiatives for Long Island's South Shore Lynn Marie Bocamazo U.S. Army Corps of Engineers N.Y. District Planning Div.
10:00	Break
10:15	Options for Implementation and Coordination
12:15 PM	Review and Wrap Up
12:30	Adjourn

APPENDIX III

EXISTING BENCHMARKS AND PROFILE LINES ON LONG ISLAND'S SOUTH SHORE

Whenever possible, the beach survey stations of the monitoring program should reoccupy stations or benchmarks that have been surveyed in the past to take advantage of historical data sets. Beach profiles have been measured at one time or another at numerous locations along the south shore. While identifying and locating all the stations at which surveys have been made in the past is beyond the scope of this report, the accompanying map indicates a number of locations where beach profiles have been measured and provides a preliminary idea of the extent of coverage provided by existing benchmarks. It is not complete, however, and when stations are established for the monitoring program, authorities with local responsibility should be contacted to aid in recovering existing benchmarks, and in identifying the most suitable and useful locations for new or continuing stations.

Over 135 beach profiles have been measured between Montauk Point and Fire Island Inlet under the auspices of the Corps of Engineers. The locations of many of these are indicated by arrows on the map. However, physical monuments are not necessarily present at each of these locations. A detailed description of the available data and the surveying efforts undertaken in this area is given in a sediment budget prepared for the Corps by the Research Planning Institute, Inc. (1985) as cited in this report. Other surveys, associated with diverse projects, have been done by the Corps but are not indicated on the map. These were often clustered in the vicinity of inlets or groins. On Jones Island, the Corps had established 15 stations and surveyed the beach at each station between 1969 and 1972 (Morton, R.W., W.F. Bohlen, and D.G. Aubrey. 1986. Beach changes at Jones Beach, Long Island, NY 1962-1974. Miscellaneous Paper CERC-86-1. U.S. Army Corps of Engineers, Coastal Engineering Research Center, Washington, D.C., 96 pp.). Subaerial beach profiles have been done at 20 other locations by the NY State Office of Parks and Recreation that are not indicated here. On Long Beach, Rockaway, and Coney Island, the Corps has established many stations in conjunction with existing or proposed public works' projects in these areas. The stations are too numerous to indicate individually on the map, but the number of stations in each area is given. On Coney Island 93 profiles are being done at stations about 200 feet apart. Along the Rockaway shore 97 stations were established, in some places less than 200 feet apart; and at Long Beach, at least 34 stations have been profiled.

FIGURE 1.

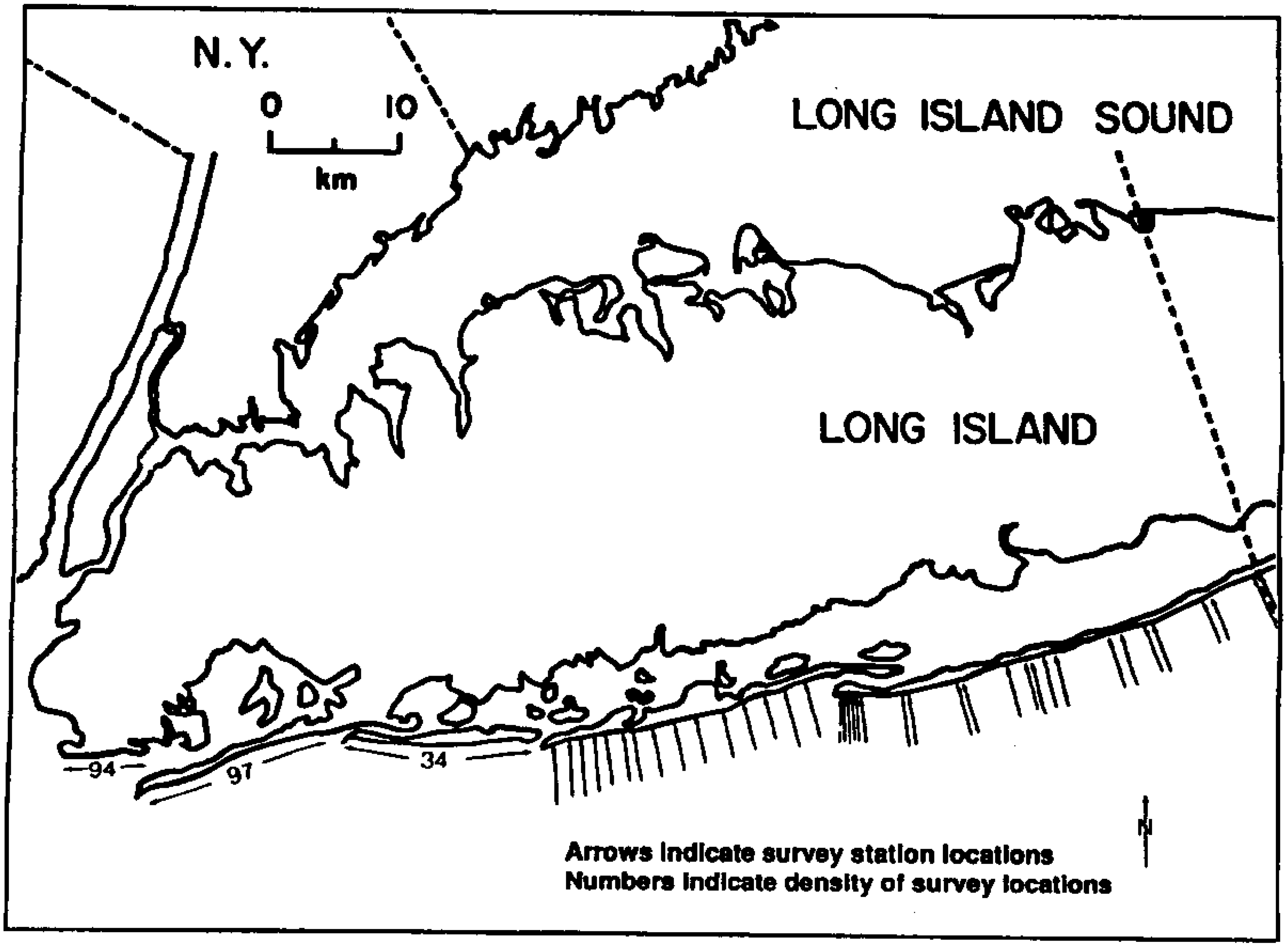
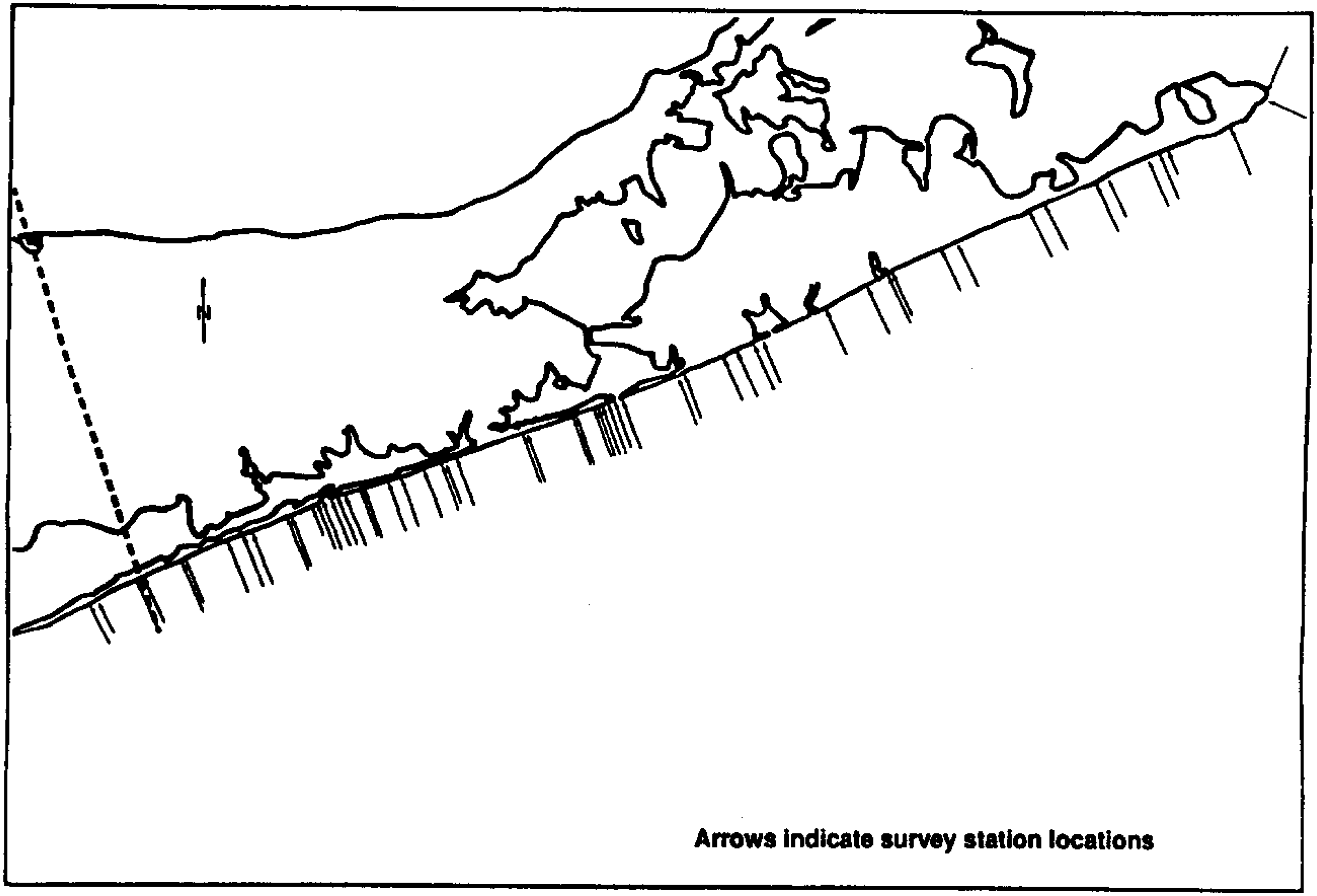

N.Y.
0
10
km
LONG ISLAND SOUND
LONG ISLAND
94
97
34
N
Arrows indicate survey station locations
Numbers indicate density of survey locations

FIGURE 1. (CONTINUED)



APPENDIX IV

MONITORING ACTIVITY OF THE U.S. ARMY CORPS OF ENGINEERS

The New York District of the Corps has beach erosion control and storm damage prevention studies on Coney Island, Long Beach, Rockaway Beach, and Sea Bright, New Jersey. The Corps also has ongoing dredging and navigation projects in Jones, Fire Island, Moriches, and Shinnecock inlets.

Coney Island is to receive beach renourishment as part of a program to reduce storm damage which, if approved, will begin in 1992. A reconnaissance survey was done at Long Beach in 1989; a feasibility study, initiated in 1991, and scheduled to be completed in 1995, may lead to the construction of dunes and beach filling. Erosion control at Rockaway Beach was done in the late 70s, renourished in the 1980s and monitoring of the project has now been completed. A study is underway to extend the period of nourishment in the project area.

Of the inlets, Fire Island Inlet has recently been dredged. The dredged sand is supplied to Gilgo Beach. Dredging of the inlet and bypassing of sand is to be done every 2 years. Jones' Inlet has also recently been dredged and the sand placed on the beach to the west; it is dredged every 2 to 3 years. Shinnecock Inlet was dredged in the summer of 1990. Jetty reconstruction plans and specifications have been prepared. Moriches Inlet jetty stabilization has been constructed, except for a small section. Dredging of the inlet and deposition basin has not yet been started.

In conjunction with these works, the Corps develops monitoring programs designed to assess project performance. The proposed monitoring of the beach renourishment project in Sea Bright, New Jersey exemplifies a Corps' monitoring program. A 12-mile section of beach is to be restored from the base of Sandy Hook south to Asbury Park. The northern end is armored with an existing stone seawall. The project is designed to create a beach with a 100-foot-wide berm at elevation +10 ft. MLW with an onshore slope of 10:1 and an offshore slope of 35:1. Seventeen million cubic yards will be placed along a 12-mile stretch of coast. Three-and-a-half million cubic yards is designated for advanced nourishment. The beach will be monitored for 6 years, after which time it will be renourished, as necessary.

The monitoring of the Sea Bright project has been coordinated with the U.S. Fish and Wildlife Service, The National Marine Fisheries Service, and the New Jersey Department of Environmental Preservation. The Corps' Waterway Experiment Station (Vicksburg, Mississippi) also participated in the development of the program. Beach profiles are to be done at 12 sites, approximately 1 mile apart. The sites correspond to stations used previously to collect survey data, originally located in 1954. In addition, two sites on Sandy Hook and one site south of Asbury Park, on undisturbed beaches, will be surveyed as control sites. The elements of the monitoring program include beach and offshore surveys, aerial photography, collection of wave data, and both sediment and biological sampling. Surveys are to be done twice a year and after major storms to a depth of -30 feet. Seven sediment samples will be taken along each transect. Short cores will be taken on five profiles, at three locations. Aerial photographs are to be taken twice a year along the 15-mile stretch of beach on the survey dates at a scale of 1" = 500' in order to document the behavior of the fill between survey stations. A "PUV" meter (a combined pressure and current meter used to record wave data) will be set in the center of the project area with LEO (a system of making visual estimates of wave characteristics) being used as back-up data. This was to be funded at a level of $2 million for 6 years with an additional $500,000 for biological sampling.

The erosion control project at Rockaway extends along 6.2 miles of the shore. This stretch had been renourished every 2 years during the 1980s. One hundred and five long ranges were surveyed over a 10-mile stretch of beach between 1976 and 1986. In addition, aerial photographs, a pressure gage, LEO observations, and sediment samples have also been taken. The last measurements were made in 1986, and CERC is drafting a final report on the monitoring.

Fire Island Inlet is dredged about every 2 years. About one million cubic yards of sand is removed over a 6 month period and usually placed downdrift on Gilgo Beach. Bathymetric condition surveys and interim surveys of the inlet are done in conjunction with this project. Beach profiles are surveyed after placement of the dredged sand on the beach. The jetty was rehabilitated about 3 years ago as a maintenance activity. There is still concern over the channel orientation and the effect of the "sore thumb," but a system-wide study is needed.

A hydrographic survey of Jones Inlet is done annually and the inlet is dredged every 1 to 3 years. The dredged sand is disposed offshore or placed on Point Lookout and/or Town of Hempstead beaches. Beach profiles are usually surveyed after the placement of sand.

The jetties at Moriches Inlet were rehabilitated between 1987 and 1989, but the head of the west jetty is still unfinished. Hydrographic surveys and side scan sonar surveys of the jetty and adjacent scour holes were done in 1989. At present there are no plans (or funds) for long-term project monitoring. The Corps is awaiting funds to dredge the inlet.

Shinnecock Inlet is used by a small, commercial fishing fleet and connects to the Intercoastal Waterway. The jetties are to be rehabilitated and there will be a revetment on the east bay shore. The design includes bypassing with the use of a deposition basin. The draft monitoring plan at Shinnecock includes surveys at 15 long ranges spaced at 1,000-foot intervals, hydrographic surveys, additional beach surveys at the fill site, sediment samples in the deposition basin, aerial photographs coinciding with the ground survey and, perhaps, a wave gage in the disposal area. The monitoring is to continue for 4 or 5 years including several maintenance cycles, and is estimated to cost between $500,000 and $1 million.