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Reports

Mesa: Interdisciplinary Approach to Environmental Analysis of Continental Margins*

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Mesa's New York Bight Project

NOAA (National Oceanic and Atmospheric Administration) is the arm of the United States Government charged with environmental research and mapping of the continental margin. Its response to the recent and growing public concern with management of the marine environment has been the formation of the MESA (Marine Ecosystems Analysis) Program. MESA is a NOAA-wide task force. Its administrators are attached to NOAA headquarters in Washington, D.C., but its staff consists of scientists and engineers from NOAA Laboratories across the country. Participating units include at present Atlantic Oceanographic and Meteorological Laboratories, Miami; the Middle Atlantic Coastal Fisheries Center, Sandy Hood, New Jersey; Engineering Development Laboratories, Miami; the NOAA ship FERREL, and the Environmental Data Service, Washington, D.C. These in-house investigators and support personnel serve as a cadre for a larger body of academic, governmental and industrial investigators.

MESA's prototype project is an environmental study of the New York Bight, from Cape May, New Jersey, to Montauk Point, Long Island, and as far seaward over the shelf edge as environmental concerns dictate. This sector is already experiencing the environmental impact problems that most mid-latitude shelves will experience by the turn of the century. Environmental expertise developed during this prototype survey will be used by MESA in other problem areas, and techniques developed will be available to other organizations with environmental responsibilities.

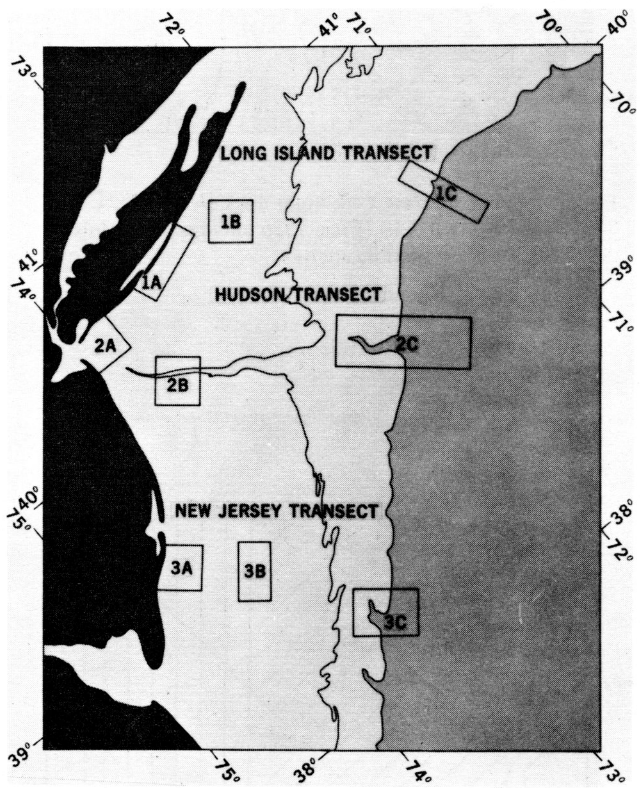

FIG. 1. Geologic study areas in the New York bight. Boundaries have been modified in the course of the program.

The New York Bight study consists of four interlocking programs of physical oceanography, geology, chemistry and biology, with technical support from the NOAA ship FERREL, the Engineering Development Laboratory, and the Environmental Data Service. A major problem in such a broad endeavour is maintaining substantive focus; without which a series of unrelated discipline-oriented papers results. Focus for the New York Bight study will be provided by the conceptual modelling committee, consisting of a commercial contractor, Water Resources Engineering, plus the principal in-house investigators. The contractor is charged with the responsibility of developing a conceptual (qualitative) model of the New York Bight Ecosystem. During the course of the study, the model will serve primarily as a management tool for the project administrators. The committee will outline the mode of attack, which then will be continuously modified by the field experience of the investigators. Toward the end of the study, however, the conceptual model will become more nearly an end than a means, and will serve as a foundation for a series of more rigorous and quantitative models that will provide substantive and predictive information for data consumers.

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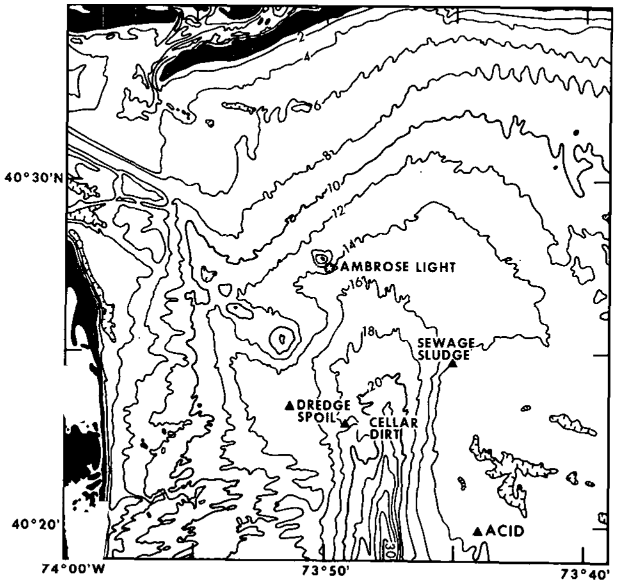

Fig. 2. Index map, New York bight apex (Area 2A). Contour interval 2 fm (From 1936 surveys). Triangles indicate nominal dumpsites.

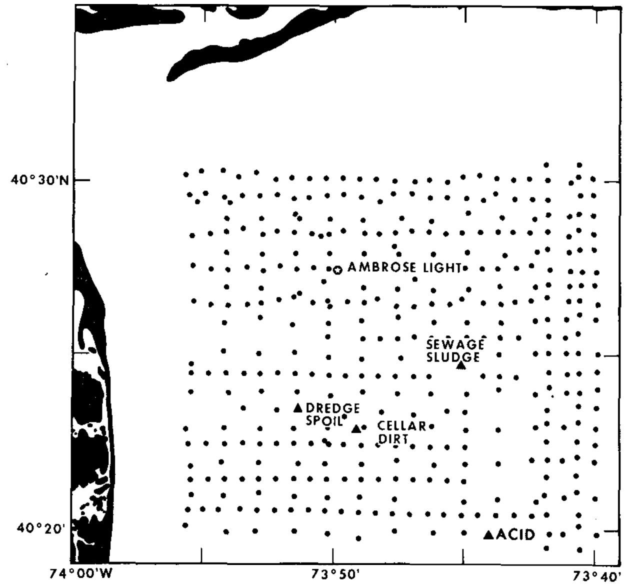

Fig. 4. Grab sample net in the New York bight apex.

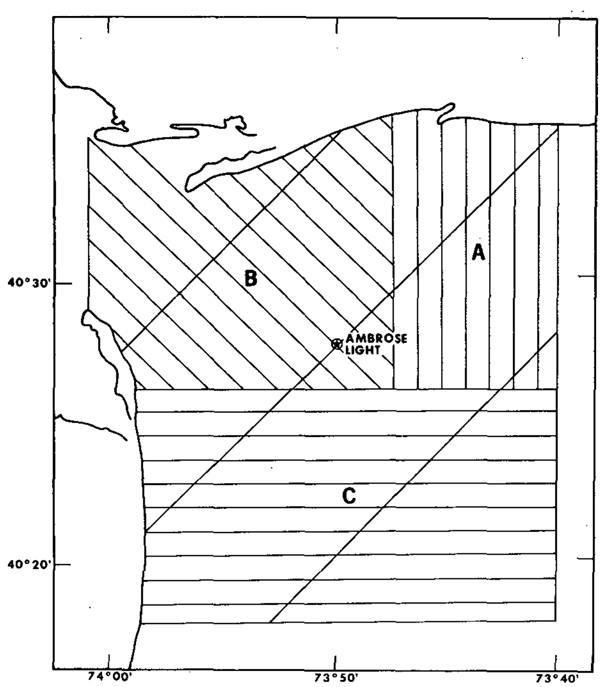

Fig. 3. Substrate inventory profiling plan for the bight apex, showing every fifth line.

Goals of MESA

The MESA project has been faced with the problem of relevance. To administrators experiencing increasingly close supervision by the Office of Management and Budget, and to the post-Apollo public, relevance means providing information of direct use to environmental managers. To MESA scientists, relevance means generating information of sufficient rigor and of a sufficiently basic nature to be acceptable to their fellow scientists. MESA's goals are defined by these two constraints; its product must be relevant to both the academic community and environmental managers. This means that MESA does not solve such specific problems as the location of a sewage sludge dumpsite or a floating atomic power plant, but if the environmental engineers and decision makers facing these problems do not have access to significant baseline data produced by MESA, then MESA has not done its job. At the same time, the unprecedented build-up of manpower, funds and equipment for a broad interdisciplinary study of the continental margin should not fail to provide new and significant insights into the basic structure of the ecosystem, and the dynamic physical systems on which it is based.

The Geological Program

The goal of the Geological Program is to resolve the sediment transport system of the New York Bight, with particular emphasis on those aspects relevant to the problem of multiple and conflicting usage of the shelf surface. The shelf surface of the New York Bight is presently (or potentially) used for:

(1) food resources (shell fish and fin fish), (2) mineral resources (beach borrow, construction aggregate, placer minerals), (3) waste dumping (sewage sludge, dredge spoil, cellar dirt, acid waste), (4) recreation (sports fishing, boating and swimming), (5) foundations (light towers; proposed floating power plants, airports, oil rigs, and deep-water tanker moorings), and (5) navigation (dredged channels). Uses (1) and (4) are obviously inhibited by the dredging, dumping and pollution associated with all others.

The geological program is fortunate in that scientific and environmental goals are easily reconciled. Intelligent decisions concerning each of the multiple uses and concerning the establishment of usage priorities require the same geological information: (1) a detailed knowledge of the physical and chemical properties of the substrate and distribution of these properties, and (2) quantitative resolution of the regional sediment budget in time and space.

These are the same goals that preoccupy marine sedimentologists. The petrology and stratigraphy of the continental margin has long been the topic of classic shelf studies. The second goal, shelf dynamics from a systems analysis point of view, is certainly the scientific frontier.

These considerations have lead to the following program of geological investigation in the New York Bight.

I. Substrate Inventory. Resolution of the physical and chemical properties of the substrate in three dimensions by all classic means including electronic profiling, coring and grab sampling.

II. Substrate Monitoring. Analysis of the variation of these properties with time. Selected Phase I observations will be repeated along monitoring transects through time. The physical oceanography program will provide a history of the velocity field from current meter arrays, wave hindcasting and tidal analysis. Sediment transport will be monitored directly by means of tracers.

III. Numerical Analysis of the Sediment Transport System. Numerical models of the shelf velocity field will be modified so as to resolve bottom shear stress. Data input will consist of current meter data, wave and tide data, bottom sediment distribution and concentration of suspended sediment in the water column. Estimates of sediment trans ort rules and directions will be subject to verification by tracer experiments.

The project was started in Fiscal Year 1973 and will continue until Fiscal Year 1978. Phases I and II will be completed by then; Phase III is hardly state of the art, and its schedule cannot be predicted.

In designing its Phase I sampling plan, the geological program had to avoid duplication of work already done by the Woods Hole - U.S. Geological Survey study of the Atlantic Continental Shelf. It soon became apparent that the problem was one of resolution; the latter study encompassed a much larger area. Its 10-km basic sample spacing did not sufficiently resolve the fine structure of sediment distribution, which requires a maximum 0.5-km spacing.

The result of these considerations was a nested sampling plan in which the Bight Apex was divided into three cross-shelf transects of three study areas each; an inshore tier of study areas, a mid-shelf tier, and a shelf-edge tier (Fig. 1).

The Bight Apex (2A) is of obvious significance (Fig. 2). It contains the four main dumpsites of metropolitan New York: a major harbour entrance, recreational beaches, sites for a proposed floating airport and a deep water tanker terminal and commercial and sports fishing grounds.

The Substrate Inventory Profiling program (Phase I) in the bight apex is under the supervision of Dr. George Freeland, NOAA, Atlantic Oceanographic and Meteorological Laboratories, Miami. This will examine the bight floor by electronic means. Bathymetry of the bight apex has been mapped on a 1000-foot line spacing under a contract to the New York District Corps of Engineers (Fig. 3). Side scan sonar and 3.5 kH seismic profiling was done on a 2000-foot line spacing by Freeland with the help of Dr. A.E. Cok of Adelphi University.

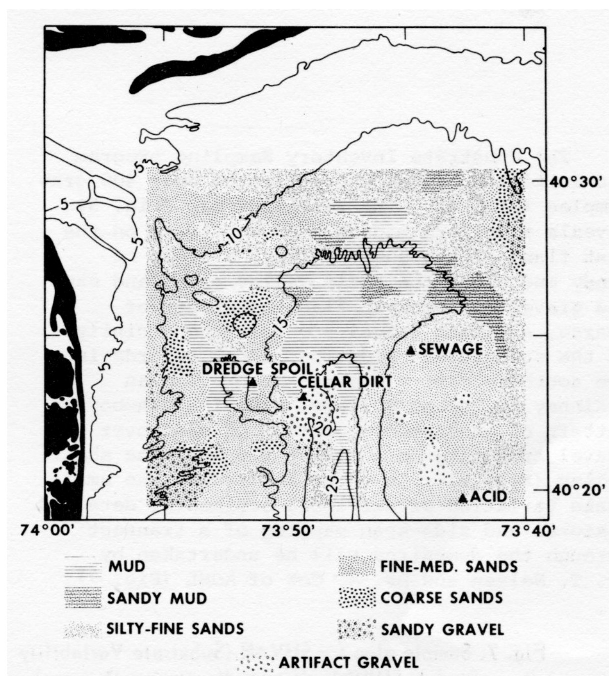

Fig. 5. Grain size facies of the New York bight apex (Cok)

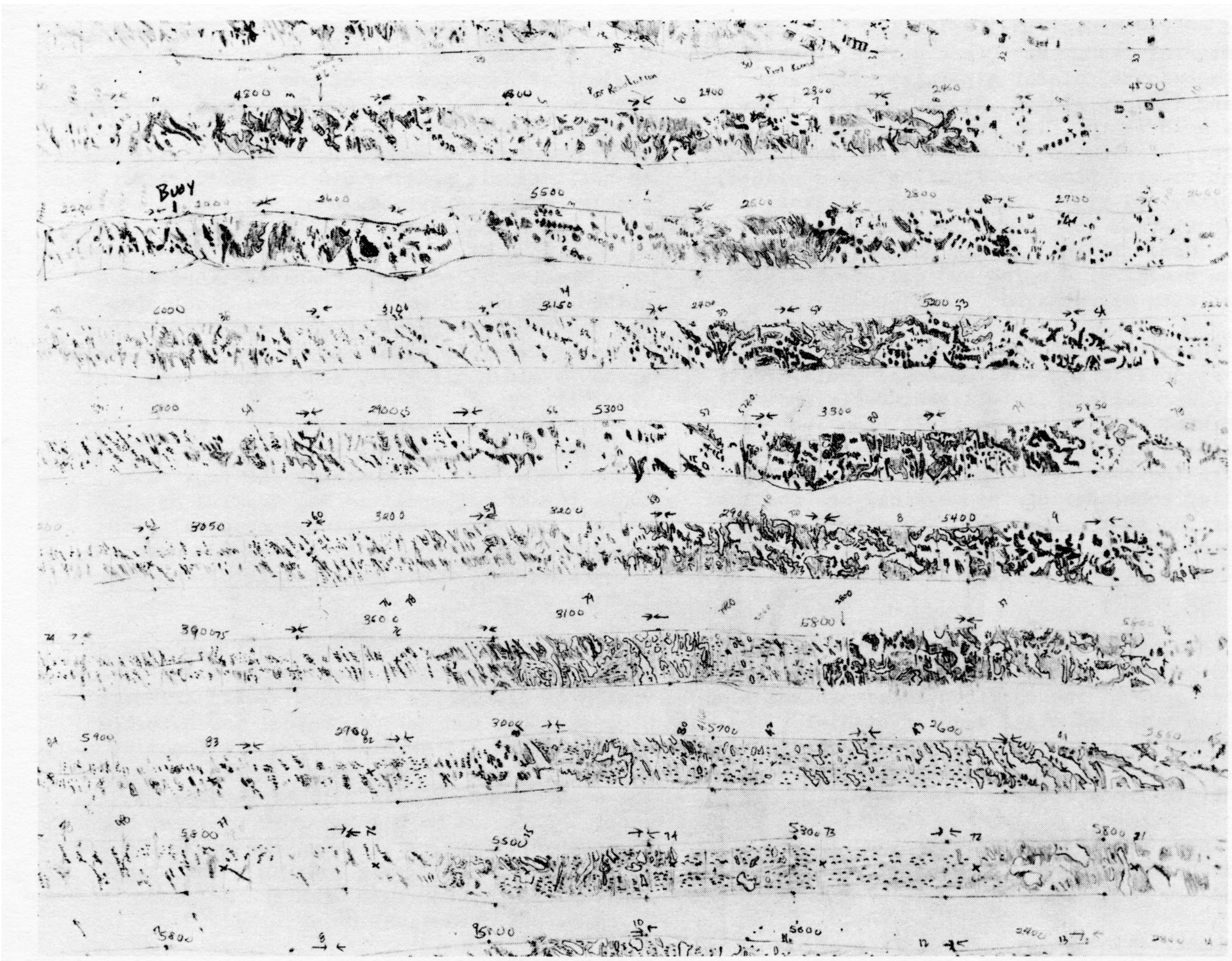

Fig. 6. Mosaic of side-scan sonar imagery from a portion of Fig. 3 (McKinney).

The Substrate Inventory Sampling program was initiated by Cok who collected over 400 grab samples (Fig. 4). The resulting map (Fig. 5) reveals a uniform medium sand substrate on the east flank of the shelf valley, a strip of sandy mud along the shelf valley axis, and sand and gravel on the west flank. Patches of coarse, artifact gravel occur in the vicinity of the dumpsites. Side-scan sonar records in the southern part processed by Dr. Thomas McKinney of Vassar College, reveal a flamboyant pattern of anastomosing strips of sand over a gravel substrate on the west flank of the shelf valley (Fig. 6). In order to resolve the small scale variation of surficial sediments, detailed textural and side-scan mapping of a transect through the dumpsites will be undertaken by Mr. T. Nelsen and Dr. A. Cok of AOML (Fig. 7).

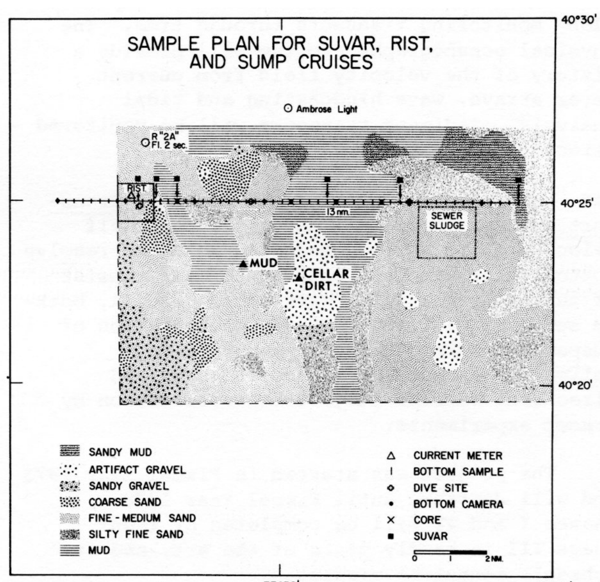

Fig. 7. Sample plan for SUVAR (Substrate Variability Study), SUMP (substrate Monitoring Program), and RIST (Radioisotope Tracer Study).

Phase II operations in the bight apex include quarterly textural and side-scan monitoring of the dumpsite transect (LCDR W. Stubblefield of AOML); detailed mapping of the dumpsites (Dr. J. Dowling, University of Connecticut); one month quarterly deployment of Aandaraa current meter arrays (Mr. R. Charnell, AOML - see Fig. 8); modification of the RIST (Radioisotope Sand Tracer) system for deployment in the bight apex (Mr. N. Case, Oak Ridge National Laboratories); analysis of wave refraction patterns in the Middle Atlantic Bight (Dr. W. Pierson, New York University); analysis of the bottom boundary layer (Dr. R. Miller, University of Chicago); and periodic sampling of suspended sediment and other chemical and physical properties of the water column (Dr. David Drake, Pat Hatcher and Terry Nelsen, AOML - see Fig. 9).

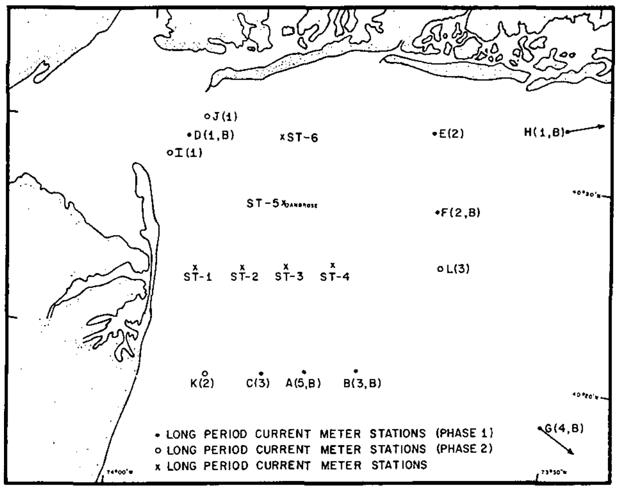

Fig. 8. Planned current meter array for New York bight apex.

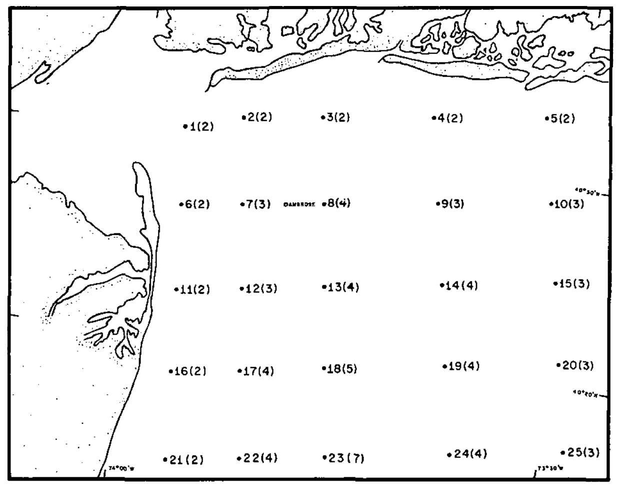

Fig. 9. Suspended sediment sampling stations, New York bight apex.

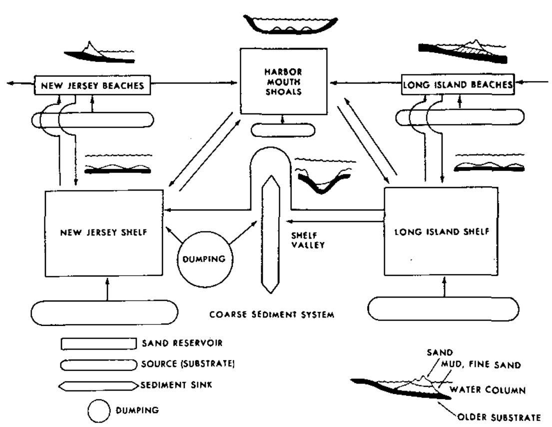

Fig. 10. Hypothetical scheme for coarse sediment transport system, Area 2A.

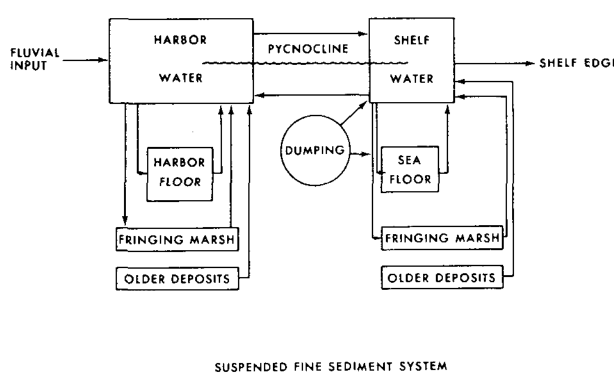

Fig. 11. Hypothetical scheme for fine sediment transport system, Area 2A.

The program for numerical modelling of sediment transport in the New York Bight Apex is under the supervision of Dr. W. Lavelle of AOML. Two systems are of concern. The coarse sediment transport system is hypothesized to consist of bottom sands which are put into suspensive or tractive transport during storms. The sediment source is probably the Pleistocene substrate which appears in windows on the shoreface and on the shelf flow. The overlying, discontinuous, Holocene sand sheet is activated during storms and is patterned into arrays of meso-scale and large-scale bedforms such as sand ribbons. The system may be quiescent during normal periods except in the surf and the tidal entrance to New York Harbour. The sense of transport is not highly directional as in the case of a river; instead it is probably a complex pattern of exchange between reservoir areas of the Holocene sand sheet as indicated in Figure 10. The modelling effort will start with attempts to determine bottom shear stress from $\bar{U}_{100}$ values (velocity 100 cm. off the bottom) obtained by bottom-mounted current meters, and by calculating sediment discharge from relationships such as the quadratic stress law. Results will be compared with estimates obtained from tracer dispersal patterns.

The fine sediment transport system consists of silt and clay-sized material that travels as suspended agglomerates with fair-weather water drift as during high energy events. It is probably more nearly a case of flux through a box; however, traffic on feedback loops internal to the system may be one or more orders of magnitude greater than throughput. Dumping is more significant than natural throughput, but is possibly less significant than internal recirculation in the natural system. Modelling efforts will focus on quantification of the hypothetical scheme presented in Figure 11.

Study areas peripheral to the New York Bight apex are undergoing Phase I studies (Substrate inventory).

Areas 2B and 2C comprise the Hudson Shelf Valley - Hudson Canyon system (Fig. 12, 13). It is not clear whether this topographic complex is merely a sink for suspended fine sediment and organic detritus or if it is an active conduit. It is under study by Dr. G. Keller of AOML, by means of grab sampling, coring, electronic profiling and submersible observations (ALVIN).

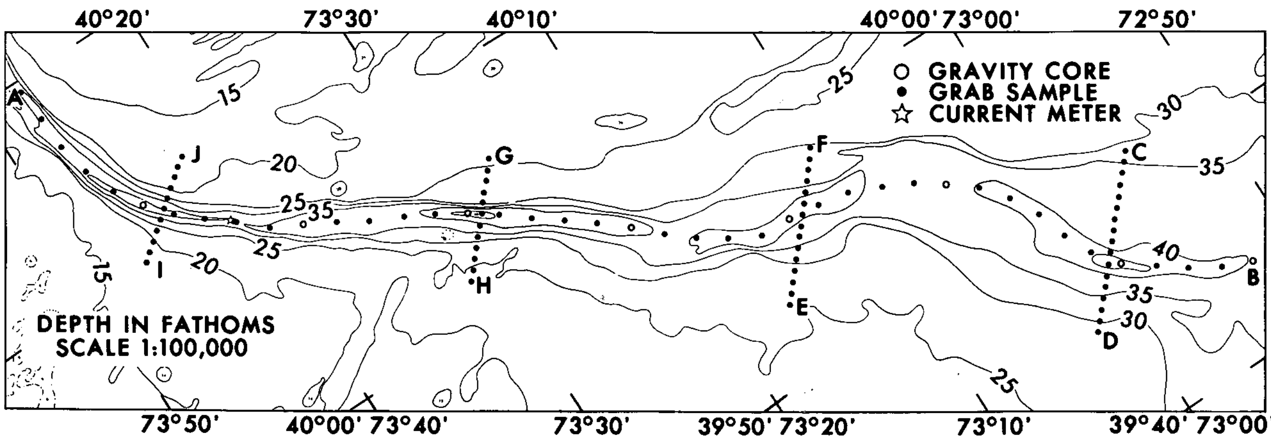

Fig. 12. Sampling plan for Area 2B (Hudson Shelf Valley) from PEIRCE cruise, August, 1973.

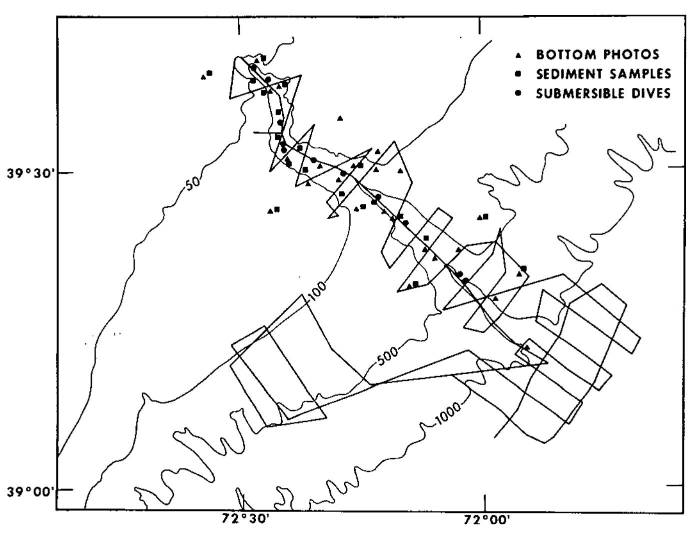

Fig. 13. Sampling plan for Area 2C (Hudson Canyon head), ALVIN-LULU-ANNANDALE cruise, July, 1972.

Area 3A includes the Fire Island System of shoreface-connected ridges, probably a major reservoir in the coarse sediment transport system. It is under study by Dr. A.E. Cok of Adelphi University and students (Fig. 14).

Area 3B has been proposed by EPA (Environmental Protection Agency) as a potential alternate site for waste dumping. Cok and students are supplementing EPA studies.

Area 3C is a shelf edge site not subject to significant canyon activity. Studies there have not yet been initiated.

Area 1A, the Atlantic City, New Jersey resort area, contains the Brigantine system of shoreface-connected ridges which, like the Fire Island system off Long Island, is a probable major reservoir in the sand transport system (Fig. 15). It also contains the Beach Haven site, where a floating atomic power plant will be constructed. It is the subject of a Master's thesis by Mr. Michael Dicken of Queens College.

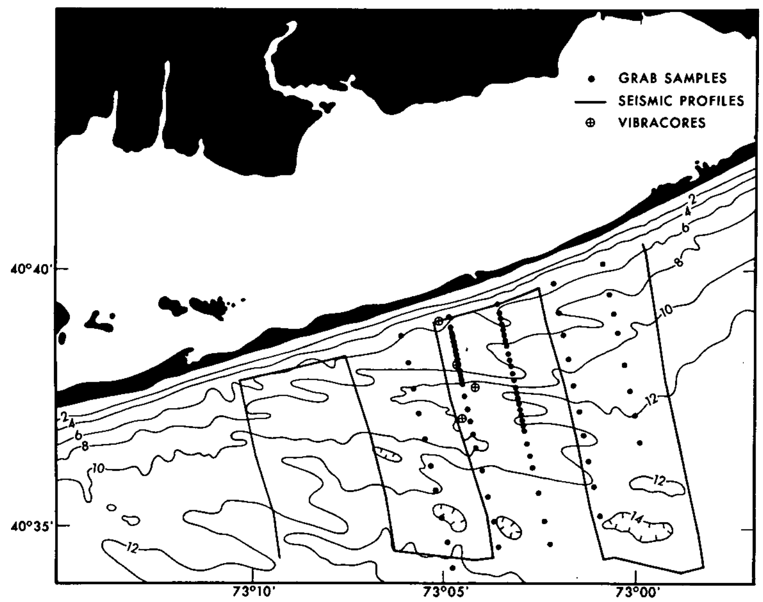

Fig. 14. Sampling plan for Area 3A (Fire Island sector), from VENTURE cruise, July, 1972.

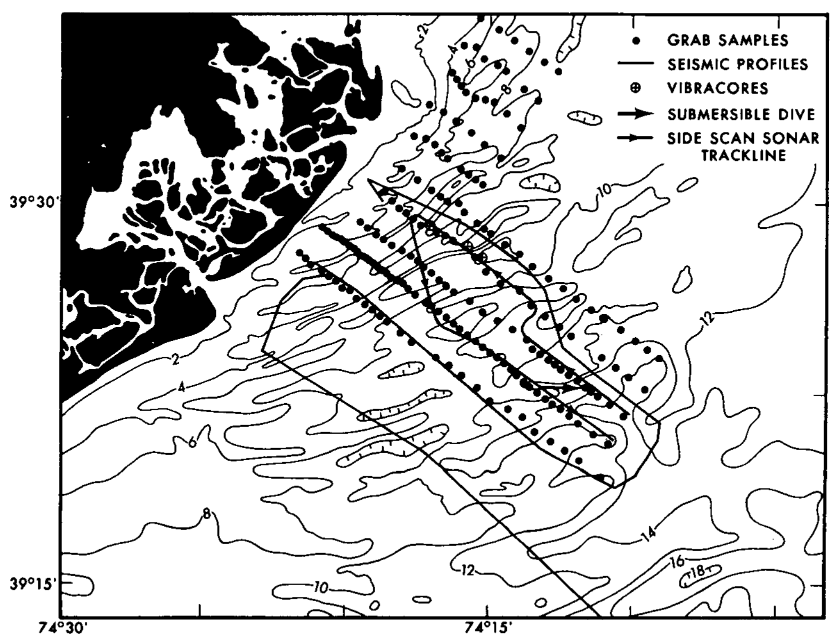

Fig. 15. Sampling plan for Area 1A (Brigantine sector) from VENTURE cruise, July, 1972.

Area 1B, the central New Jersey sector, is sited on the Great Egg Shoal-retreat Massif, the retreat path during the Holocene transgression of an estuary mouth shoal associated with the Ancestral Delaware-Schuylkill River (Fig. 16). Post-transgression dissection of the massif by south-trending storm currents has resulted in some of the most complex ridge and swale topography of the Atlantic shelf (Fig. 17). The petrography and geophysical records of this area is under study by LCDR. W. Stubblefield of AOML.

Dr. Thomas McKinney of Vassar College is analyzing side-scan sonar records. Preliminary results reveal active sediment transport in the form of ribbon-like sand streams over a coarser substrate in the troughs between ridges (Fig. 18).

Area 1C comprises the Wilmington Submarine Canyon. It is under study by Dr. Daniel Stanley of the Smithsonian Institution.

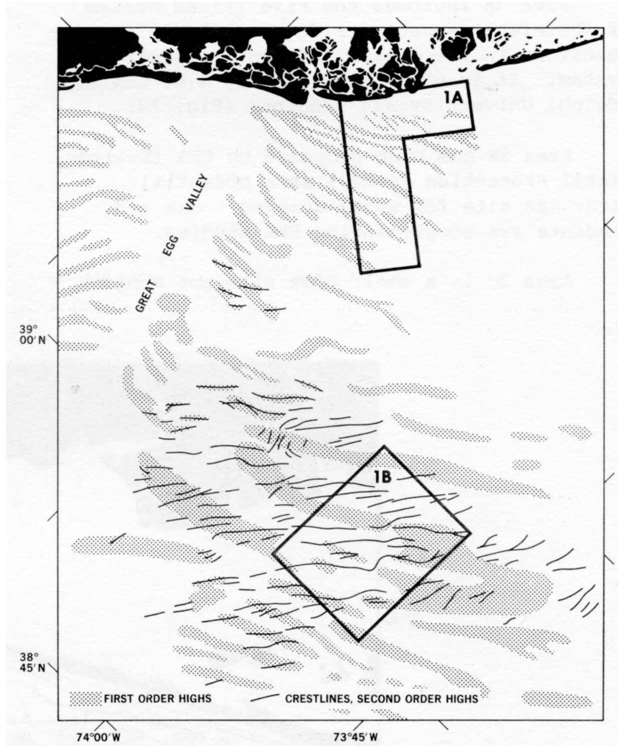

Fig. 16. Study Area 1A and 1B in relation to regional bathymetry (McKinney and others, in press).

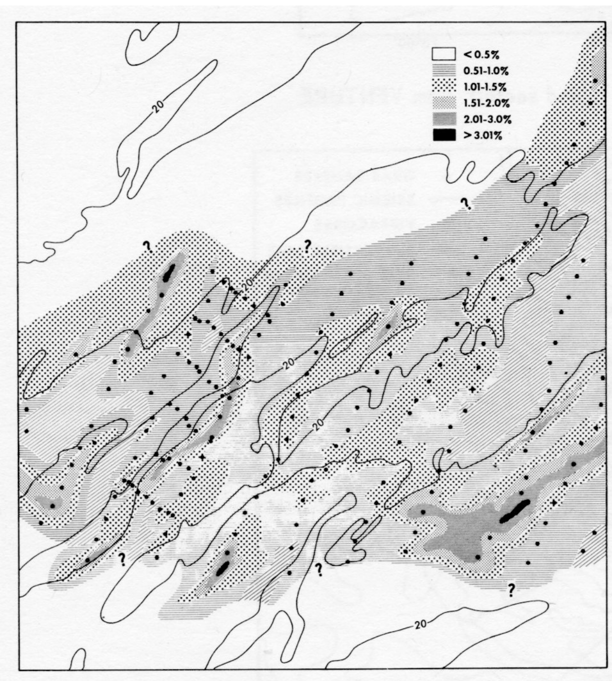

Fig. 17. Percent silt and clay in area 1B (Stubblefield and others, in press).

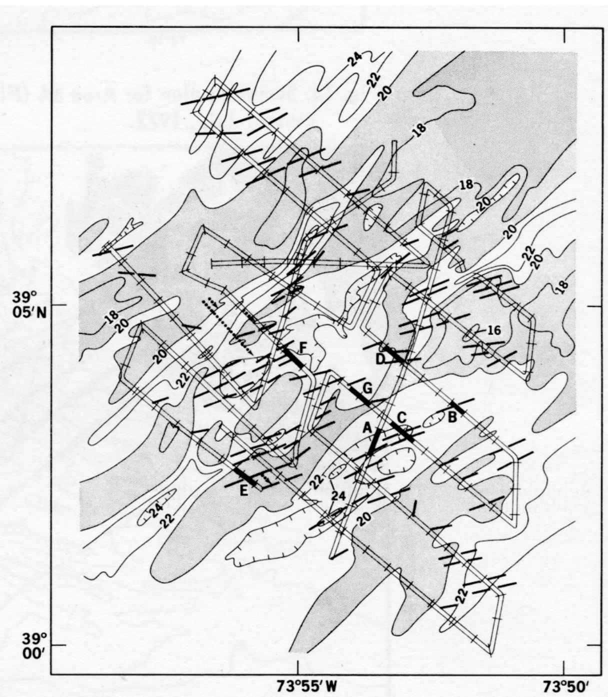

Fig. 18. Side-scan sonar tracklines and orientations of large scale current lineations (sand ribbon-like features) in Area 1B (McKinney, in press).