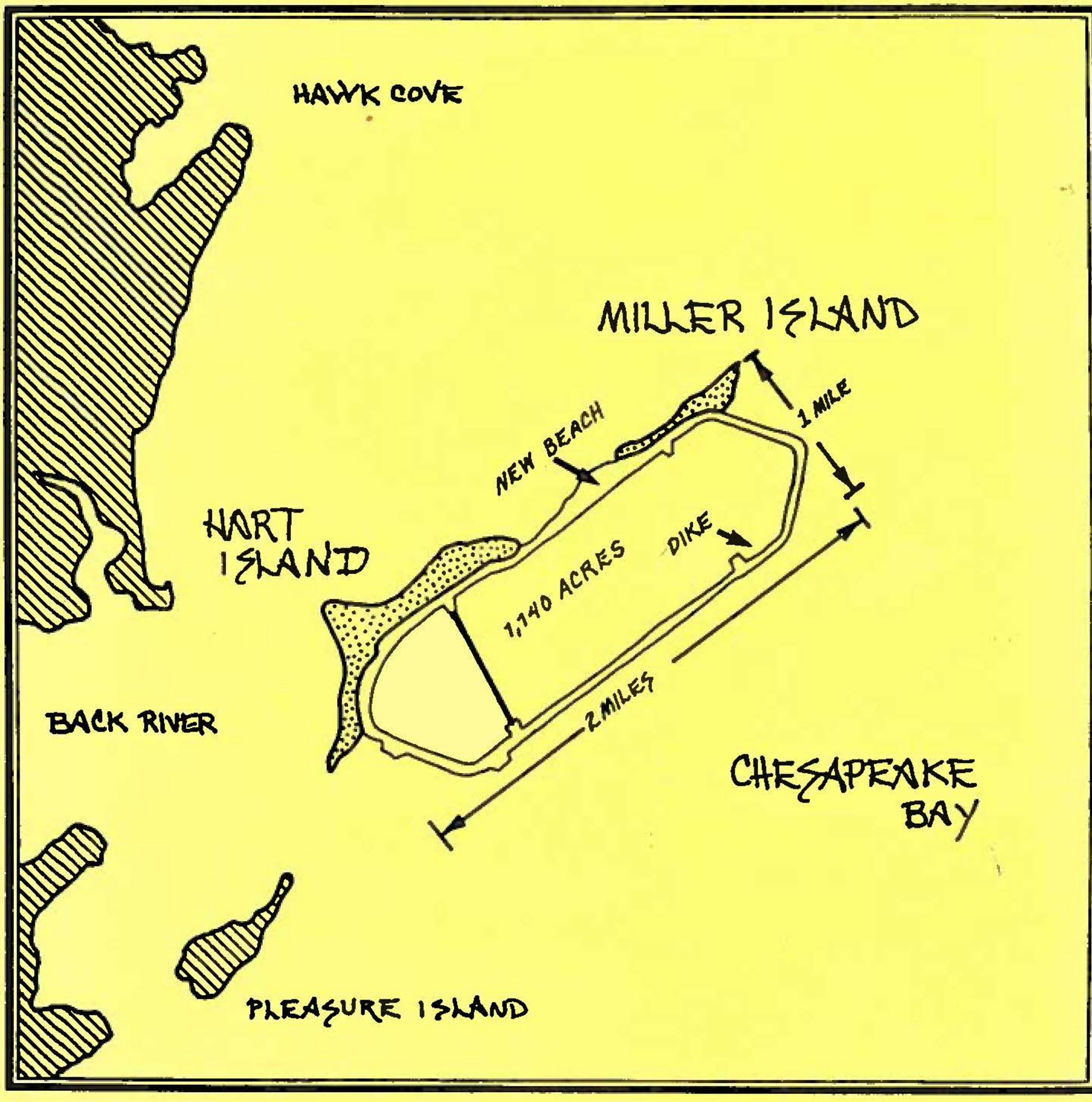
ASSESSMENT OF THE ENVIRONMENTAL IMPACTS OF THE HART AND MILLER ISLANDS CONTAINMENT FACILITY



4th. ANNUAL INTERPRETIVE REPORT
AUG.'84-AUG.'85

MARYLAND DEPARTMENT OF NATURAL RESOURCES
TIDEWATER ADMINISTRATION

FOREWORD

Maryland is rich in natural resources. Its wild game, woods, beaches, rivers, and Chesapeake Bay with its abundant aquatic resources provide a bountiful outdoor environment for our citizens. The task of the Department of Natural Resources is to manage these resources in such a way that their enhancement, conservation, use and development ensures the greatest good for the greatest number of Marylanders, now and in the future. The employees of DNR are personally and professionally committed to this task and with public understanding and support, we will achieve our goal.

Torrey C. Brown, M.D.
Secretary
Department of Natural Resources

ABSTRACT

The Hart and Miller Islands Containment Facility was designed to receive dredged material from channel dredging projects in the Baltimore Harbor and its approaches. The disposal site is located northeast of the Baltimore Harbor in the Chesapeake Bay. This report contains the results of the Department of Natural Resources fourth year monitoring effort to assess impacts to the biological and sedimentary environment exterior to the dike. Data collected from this and the previous three years of monitoring indicate there have been no significant changes in the environment other than those resulting from construction. Samples of sediments, fish and benthic populations were taken at a number of sites in the vicinity of Hart and Miller Islands during fall, 1984 and spring, 1985.

Use of the area by fish and crabs appears considerable and indicates the structure functions as an artificial reef. Changes in benthic populations have been related to seasonal and yearly variations in salinity, dredging at the rehandling pier and the 1982 fluid mud spill during construction. Species diversity was found to be low in the study area and the presence of large numbers of a few species is not uncommon in this region where low and variable salinity levels prevail. With the exception of color changes in the fluid muds deposited during construction of the dike and the reclassification of sediment types at some of the sampling stations, the physical and chemical composition of sediments has remained consistent with preconstruction samples. The color changes are attributed to biogenic activity. Difficulty in recoccupying exact sampling locations may explain the consistent shift in sediment types at specific stations.

Beach erosion monitoring was continued as part of the fourth year monitoring program. The overall configuration of the recreational beach remained similar to previous study years, however erosion from wind-generated wave attack and deposition from the transport of sediments continued during the the 1984-85 study period.

Overall, there has been no evidence of detrimental impacts related to seepage or spills of contaminants associated with operation of the facility.

Key Words: dredge spoil, monitoring, Chesapeake Bay, benthic fauna, sediments, trace metals, fish

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ACKNOWLEDGMENTS

We are grateful to the scientists who contributed to and critically reviewed this report of the fourth year monitoring. We thank the following people for their indispensible help in the completion of this report: Lenora Dennis and Lorane Bruce for their assistance in typing and Candace Marsden for editing.

Within the Maryland Department of Natural Resources, the Monitoring and Data Management Section of Tidewater Administration has prepared this report for submission to Water Resources Administration under MPA Contract 385517. The environmental monitoring of the Hart and Miller Islands is done by the Maryland Department of Natural Resources and the Chesapeake Biological Laboratory of the University of Maryland on behalf of the Maryland Port Administration. The monitoring program is part of the State of Maryland's commitment to the Chesapeake Bay.

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INTRODUCTION

The Fourth Annual Interpretive Report presents the results of environmental monitoring of the Hart and Miller Islands Diked Dredge Spoil Containment Facility conducted from September 1984 through August 1985. Final reports of fourth year monitoring efforts by each of the principal investigators are included.

The purpose of this monitoring program is to collect and analyze the data necessary to determine the impacts upon the quality of the habitat surrounding the diked facility. The monitoring program began in August 1981 to provide environmental data for comparing pre-construction and pre-operational conditions with operational conditions.

DESCRIPTION OF THE CONTAINMENT FACILITY

The State of Maryland contracted the construction of a diked area at Hart and Miller Islands during 1981-1983 to receive bottom sediments dredged from Baltimore Harbor and its approaches. The dike was completed in spring, 1983. The facility was designed to receive 53 million cubic yards of material, most of which will be produced by deepening channels to 50 feet. Its long-term use will be as a permanent wildlife and recreation area.

The containment facility is a 1,140 acre enclosure behind a dike 18 feet above mean low water constructed from sand deposits within and underlying the enclosure site. Typical side slopes are 3:1 (three horizontal to one vertical) on the exposed outside face, 5:1 on the inside and 20:1 on the Back River side. The bay side face is riprapped with stone over filter cloth. The completed dike is about 29,000 feet long and contains 5,800 cubic yards of stone.

The following list includes the quantity of dredged material deposited in the Hart and Miller Islands facility. Dredged material was deposited in the south cell, however, the quantity was not sufficient to cause a release of supernatant water from the site during 1984-1985.

LIST OF DREDGED MATERIAL DEPOSITED IN THE
HART AND MILLER ISLANDS CONTAINMENT FACILITY

Year	Source	Cut Cubic Yard Volumes
1983	Hart-Miller Personnel Pier	26,000
1984	42' Channel Maintenance (U. S. Army Corps of Engineers)	3,908,000
1984	Dundalk Marine Terminal	550,000
1984	Hart-Miller Barge Unloading Pier	180,000
	TOTAL 1984	4,638,000
1985	42' Channel Maintenance (U. S. Army Corps of Engineers)	3,145,000
1985	Bethlehem Steel	596,000
	TOTAL 1985	3,741,000

SUMMARY OF MONITORING PROGRAMS

The site is of environmental and economic significance to the State of Maryland and the Chesapeake Bay region. It offers a suitable containment area for the disposal of dredged material from channel dredging projects, thereby providing access for ships that would otherwise be unable to enter the port of Baltimore. Once the facility has reached its containment capacity, the site will be converted to a wildlife and recreational habitat. The State determined, as prescribed in authorizing permits for the facility, that there is need for "a comprehensive environmental monitoring program for the Hart and Miller Islands containment facility prior, during and following commencement of operations." The responsibility for the development and coordination of the monitoring is assigned to the Water Resources Administration.[1] The monitoring program is divided into complementary portions: (1) monitoring to assure compliance with federal and state laws and (2) monitoring for water quality. Regulation and permitting is conducted by the Office of Environmental Programs (OEP) of the Maryland Department of Health and Mental Hygiene and the Water Resources Administration (WRA) of the Department of Natural Resources. The Maryland Environmental Service is responsible for monitoring water quality within the diked area.

[1] Memorandum of Understanding on Dredging and Spoil Disposal and the Hart and Miller Islands Containment Facility between the Departments of Transportation, Natural Resources, and Health and Mental Hygiene, May 7, 1979. Approved by the Board of Public Works, June 6, 1979.

This report describes studies designed to assess impacts to the biological and sedimentary environment exterior of the dike. This assessment is performed under a separate agreement between The Maryland Department of Natural Resources and The Maryland Port Administration.

Liaison and coordination was maintained among all agencies having roles in site management, operations, monitoring, sampling and oversight programs related to the Hart and Miller Islands Facility, primarily through periodic meetings of the Technical Review Committee. Four projects were implemented during the fourth monitoring year to assess the environmental effects of construction and operation.

PROJECT I: SCIENTIFIC COORDINATION AND DATA MANAGEMENT

The Monitoring and Data Management section within the Tidewater Administration is responsible for maintaining a data base on the natural resources of Maryland, especially those within the coastal zone. Data stored include fisheries, water quality, climate, sediments and hydrography. This Section is also responsible for conducting applied scientific investigations necessary for developing information for management purposes. Studies conducted include mathematical model studies, field monitoring design, limited field operations and statistical analysis of data.

During the first four years of the Hart and Miller Islands environmental assessment program, data collected by the Department of Natural Resources and research institutions have been stored in the Tidewater Administration's "Resource Monitoring Data Storage System" (RMDSS). This data base serves both to make data readily available to interested persons, and as a permanent repository from which baseline and trend information can be retrieved at any time for comparison and evaluation. Monitoring and Data Management personnel provide overall scientific planning, review and coordination of the monitoring activities for the Hart and Miller Islands Facility. They also compile and distribute the Annual Interpretive Report and the Data Report.

PROJECT II: SEDIMENTARY ENVIRONMENT

Within the scope of its Coastal and Estuarine Geology Program, the Maryland Geological Survey has been involved in monitoring the physical and chemical behavior of the sediments around the Hart and Miller Islands Containment Facility since 1981.

Monitoring and documentation of sedimentary changes has been necessary to detect environmental changes during the operational phase of the project which began in 1983. Highly organic, fine-grained sediments from the approach channels to Baltimore Harbor are currently being placed inside the dike structure. Improper handling of these dredge spoils or leakage from the dike structure may produce changes in sand:mud ratios and physical appearances in the surrounding sediments as well as increases in the trace metals and organic contents. The data collected from four years of monitoring sediments around Hart and Miller Islands indicate there have been no major changes in the sedimentary environment.

The layer of fluid mud introduced in 1982 during construction of the dike remained evident with slight color changes attributable to biogenic activity. Benthic recolonization of the fluid mud layer was also evident in several of the cores. Radiographic analyses of sediment cores taken at given sites around the dike structure were consistent with previous years' studies. Bioturbation levels (depth of mixing) in the cores taken within the fluid mud accumulation had increased over those observed during the 1983-1984 monitoring year.

Trace metal analyses of sediments were performed by several laboratories using different analytical techniques which made comparisons of the trace metal data with previous years' data very difficult. To minimize these analytical differences, enrichment of zinc in the sediments has been used to show geochemical trends with respect to time and area distribution around Hart and Miller Islands. An enrichment factor (EF) is a ratio of a trace element to an element whose source can be considered solely a result of normal weathering processes. The distribution and range of zinc EF based on data collected during the fourth year were consistent with previous years. The average EF in the fluid mud zone remains lower than pre-construction levels.

The beach erosion study initiated in spring, 1984 yielded additional data which can be interpreted to define geomorphic (natural) process and anthropogenic (human) activities that shape the beach. Erosional processes are still operating and appear to be correlated with the slope, textural characteristics of the beach material, littoral drift, rainfall and wind direction. The southern end of the recreational beach became wider as a result of the longshore transport of sediments. The main agent of erosion has been wave attack on the foreshore by wind generated waves. To a lesser degree, gully erosion has affected the dike face in areas where the slope is greatest. Vegetation introduced by natural means effectively reduced erosion. To ameliorate the erosion problem, the recreational beach would have to be renourished with suitable material at the time of regrading to maintain or decrease beach gradients.

PROJECT III: BIOTA

PART 1. BENTHIC STUDIES

Benthic invertebrates surrounding Hart and Miller Islands in the Upper Chesapeake Bay have been included in the ongoing monitoring program since August 1981. The primary objectives of the benthic studies are to survey the species, abundance and distribution of benthic organisms in this area and to determine effects of construction and operation of the diked disposal facility on this fauna.

Benthic studies are part of the comprehensive environmental monitoring program for the Hart and Miller Islands Containment Facility for two reasons. First, as benthic species reach maturity, they generally become more sedentary and cannot avoid physical or chemical changes to their environment. When and if adverse conditions arise, they are directly subject to such variation. The second reason for monitoring is the highly variable physical environment in this area of the Chesapeake Bay. Sudden decreases in salinity, vast shallow areas subject to wind-induced wave action, high summer water temperatures, and ice formation in winter are some of the physical variables. As a result, benthic populations are never stable and undergo changes with species and density both seasonally and yearly.

Certain groups or species of benthic animals are better adapted to and therefore, occur in greater numbers in specific bottom sediment types. Areas investigated were nearfield silt-clay sites at the rehandling pier and sluice gate sites, the effluent shell bottom area and epibenthic fauna on pilings of piers surrounding the facility. The piling sampling replaced stone riprap sampling in the fourth sampling year. Relatively few species became established on stone riprap surfaces in 1983. By March 1984 all species had disappeared, presumably scoured from the surfaces by ice movement. Pilings are a more homogeneous environment thus permitting more reproducible samples. Deeper segments of the pilings are not impacted by ice scouring. Four farfield stations served as reference sites. Cluster analysis indicated a grouping of stations by infaunal response to bottom type. Stations where statistical analysis indicated differences in 1984-1985 could be explained on the basis of sampling station misplacement, slow recovery from 1983 dredging and influence from outside the containment.

Salinity, which is the major factor controlling benthic population densities and species occurrence in the upper Chesapeake Bay, was higher than normal during 1984-1985. This favored opportunistic dominants such as amphipods (Leptocheirus plumulosus and Corophium sp.), polychaete worms (Scolecolepides viridis) and clams (Macoma spp.). Low diversities and large numbers of a few species are expected conditions in a region of low and variable salinity such as Hart and Miller Islands. The four reference stations HM9-HM16-HM22-HM26, collectively exhibited an increase in population density similar to that at the effluent and nearfield stations during 1984-1985.

Dredging in 1983 increased the depth from 4.2m to 6.3m at one station, nearfield N5, to facilitate vessel operation at the rehandling pier. Although the bottom at adjacent N6 was not dredged, it was influenced by the dredging activity enough to cause faunal adjustments. In 1984 faunal species and numbers were reduced from the levels of earlier years. Clam populations, especially Rangia, were reduced but the motile amphipod Leptocheirus population increased. The reduction in species and number of individuals was still evident in 1985. The affected area is small and the loss is not considered important or serious to the ecosystem at Hart and Miller Islands.

The most obvious changes detected during the 1982-1985 studies related to the misplacement of material from dike construction in the summer of 1982. The fluid mud blanketed an area estimated at 460-560 acres to an average thickness of 24cm. This smothered the existing infaunal community; less than 1 percent of the number of organisms previously observed were present in August, 1982. In numbers, the animals in the fluid mud recovered about 11 percent in four months and 85 percent in ten months after the mud was deposited. In March, 1984 the ratio of species to numbers and bivalve length frequency remained about the same as the reference area, suggesting full recovery from the impact of the spill.

Infaunal and epifaunal benthic populations should be monitored no less critically during the upcoming year when effluent discharge from the containment island will probably take place. Four years of data from pre-construction through construction and early operation of the facility are a valuable baseline and will be essential for assessment of possible future benthic population changes.

PART 2. FISH AND CRAB POPULATION STUDIES

Fish and crab studies began in 1981 to describe the populations of fish and crabs in the vicinity of Hart and Miller Islands and to assess the impact of construction and operation of the containment facility on these populations.

Extensive data on the quantity and composition of the catch over the four-year period provides a detailed description and a basis for future comparisons.

Although induced currents along the south and east faces may reduce use by some desirable species, use of the area by finfish and crabs was considerable indicating the structure may function as an artificial reef. Catches of blue crabs were considerable, especially among sub-legal size (<12cm) crabs. The revetment may serve as habitat for smaller, more vulnerable life stages of crabs. Eels evidently prefer more sluggish weather-protected habitats than these found along the revetments.

During the fourth-year monitoring, the array of gear used to collect samples included fish traps, eel pots, bottom net trawls and haul seine sites. At least 21 species were caught in the water surrounding the containment facility. The majority were caught adjacent to the facility. An examination of catch abundance for adjacent inshore and offshore sites indicates that in all cases the inshore catch exceeded the offshore catch by 70 percent to 99 percent, averaging 85 percent. Species occurrence and rank abundance were similar inshore and offshore. Seasonal variations in abundance were the most apparent factor noted. These differences may have been only a response by local populations to temporary local conditions and not a result of major population fluctuations. Tissue samples of white perch and blue crabs were taken for analysis of toxic organics and heavy metals.

PROJECT IV: ANALYTIC SERVICES

The Water Resources Administration, Department of Natural Resources, in cooperation with the U. S. Environmental Protection Agency Central Regional

Laboratory in Annapolis analyzed samples of sediments, white perch and brackish-water clams for toxic organic contaminants. Low concentrations of PCB's (<3.5 ppm) were detected in sediments and perch. Very low levels of 4,4 DDE (<400 ppb) were detected in perch tissue. No other contaminants were detectable in any samples and no contaminants were detectable in clam tissue.

Data on metals in biota were received too late to be included in this report.

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SCIENTIFIC COORDINATION AND DATA MANAGEMENT

by

Stephen J. Jordan

Development and implementation of a monitoring program which is sufficiently sensitive to the environmental effects of dredge spoil containment at Hart and Miller Islands continues to be a complex and difficult undertaking. The environmental monitoring activities have evolved over the four years of the project. Ongoing studies have included physical and chemical characterization of sediments and population studies of benthic organisms and finfish. Baseline data on water column nutrients and productivity, submerged aquatic vegetation, trace metals and organic contaminants was included in the First and Second Interpretive Reports for 1981 - 1983. Bathymetric studies were completed in the first three monitoring years to identify pre- and post-construction changes in currents and erosion. A beach erosion study was initiated in spring 1984 and is included in the third and fourth year reports on the sedimentary environment.

Scientific planning, review and coordination of the monitoring activity is provided by Monitoring and Data Management personnel. Sampling procedures, data analysis, and future directions of the program were discussed with principal investigators. Descriptions of any changes in sampling methods are included in the individual investigator project reports that follow. Compilation, editing, obtaining peer reviews, and printing of the Interpretive Report are the responsibilities of the Monitoring and Data Management Section. During the first four years of the environmental assessment program, data collected by the Department of Natural Resources and research institutions were stored in the Tidewater Administration's "Resource Monitoring Data Storage System." The IBM-OS File/SAS Data Base is used for computer storage and analysis of data. Each principal investigator submits properly encoded data forms or a magnetic tape with data appropriately formatted. Permanent storage of the data in a readily accessible form provides a continuous, documented record of baselines and trends in biota, sediments and contaminant levels. Data from the 1984-1985 monitoring year are included in the Fourth Year Data Report which is compiled and printed separately from the Interpretive Report.

SEDIMENTARY ENVIRONMENT

Part 1: Sedimentary and Geochemical Environment

Edited by Darlene V. Wells and Randall Kerhin

Darlene V. Wells, Robert Conkwright, and James Hill

Part 2: Beach Erosion Study

by

Robert Cuthberston

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ABSTRACT

The Coastal and Estuarine Geology Program, Maryland Geological Survey (CEG-MGS) has been involved in monitoring the physical and chemical behavior of the sediments around the Hart and Miller Islands Containment Facility as part of Maryland's environmental assessment of the facility. Presented in this report are the results of the fourth year monitoring effort which consisted of two studies: 1) monitoring changes in the sedimentary environment and 2) measuring the degree of erosion on the recreational beach.

The data collected from the monitoring of the sediments around Hart and Miller Islands indicate that there have been no significant changes in the sedimentary environment since the start of operation. The layer of fluid mud introduced during the construction of the dike remained evident in the area east and south of the dike structure. Slight color changes seen in these fluid muds are attributable to biogenic activity. Radiographic analyses of sediment cores taken around the dike structure were consistent with the previous year's studies. Bioturbation in the cores taken within the fluid mud accumulation increased over those observed during the 1983-1984 monitoring year.

The enrichment factor for zinc remained low for the fluid muds (interpreted as an indicator of spilled construction material), consistent with the values determined during the second and third years' of monitoring.

The study of the erosion of the recreational beach on the Hart and Miller Islands Containment Facility yielded additional data which can be interpreted to define the geomorphic (natural) forces that shape the beach. During the past year, September 1984 to September 1985, the data indicate that erosional processes still are operating and appear to be correlated with the slope, textural characteristics of the beach material, littoral drift, rainfall and wind direction.

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PART 1: SEDIMENTARY ENVIRONMENT

INTRODUCTION

The areal distribution and characteristics of bottom sediments reflect the complex interaction of physical, chemical, and biological processes, acting singly or in combination. In addition to these natural processes, certain anthropogenic events such as dredging and overboard disposal may produce sudden changes in the nature of the bottom sediments. During construction of the diked structure at Hart and Miller Islands, both dredging of the nearshore bottom for suitable building material and the overboard disposal of such materials was necessary. These activities produced changes in the bottom environment.

The dike was constructed with sand mixed with some finer-grained material that was dredged from areas within the project site. During the emplacement of the sands, these finer-grained sediments were "washed out" and deposited in an area adjacent to the construction site. The introduction of these sediments was detected by changes in the sand:mud ratios, physical appearance, and trace metal content of the bottom sediments.

Monitoring and documentation of these sedimentary changes are necessary in order to detect further environmental changes during the operational phase of the project, which began in 1983. During the course of this phase, highly organic, fine-grained sediments from the approach channels to Baltimore Harbor will be placed inside the dike structure. Improper handling of the dredge spoils or leakage from the dike structure may produce changes in sand:mud ratios and physical appearances in the surrounding sediments as well as increases in the trace metals and organic contents.

PREVIOUS WORK

Changes in the sedimentary environment around the Hart and Miller Islands dike structure were documented during the first three years of the state's monitoring project and are detailed in several reports (Kerhin et al., 1982a; Wells et al., 1984 & 1985). Knowledge of the physical characteristics and areal distribution of the sediment types prior to the construction of the facility was gained from data collected by the Maryland Geological Survey in 1978 (MGS, in prep). The sediments graded from sands in the nearshore to sand-silt-clays to silt-clays just northeast of the islands. On the Hawk Cove and southern side of the complex, the sediments graded from nearshore sands to silty-clays, the latter having been described as dark-grey muds with high water contents and shells (Figure 1). Live bivalves, Rangia cuneata and Macoma balthica, were common (Kerhin et al., 1982b).

Radiographic examination of cores taken in the area around Hart and Miller Islands before the onset of construction revealed low bioturbation (depth of mixing by biota) levels in the Back River-Hawk Cove area and higher bioturbation elsewhere along the islands complex. Moreover, at several sampling locations south of the island, surface death assemblage layers (buried surfaces with empty shells) of the mactrid bivalve mollusc, R. cuneata, were found.

During the active construction of the dike structure, which began in the fall of 1981, subtle changes in the sand-silt-clay percentages were detected in the sediments collected at established stations around the Hart-Miller Island complex. The sediments became siltier, particularly at those stations adjacent to the active construction areas. In the summer of 1982, gross changes in the physical appearance of the sediments were observed. The fine-grained sediments collected prior to the summer of 1982 were described consistently as dark grey muds. However, sediments collected in July 1982 south and adjacent to the dike wall structure were very fluid, light grey to pink muds, resembling pre-Holocene sediments that were dredged for dike construction. It was determined that a "blanket" of this fluid mud had accumulated as a result of dike construction (Wells, et al., 1984). Radiographic examination of the fluid mud accumulations revealed little or no bioturbation.

Analyses of trace metal in sediment samples were conducted, and based on zinc enrichment factors, the sediments collected before and after dike construction were similar except in the area where the light-colored fluid muds had accumulated; there the enrichment factor values for Zn dropped (see Results section for discussion of enrichment factors).

Further monitoring after the completion of the dike structure revealed little additional change in the characteristics of the sediments.

OBJECTIVES

The purpose of the fourth year study was to continue the monitoring of the vertical and areal distribution of sediments and their geochemical components. The objectives were:

1. To identify the sedimentological and geochemical conditions of the near-surface sedimentary column in the project area.
2. To provide information to assess gross environmental changes that may occur during the project life.

METHODOLOGY

FIELD METHODS

Field sampling of surficial sediments was conducted twice during the year, November 1984 and April 1985. The station locations are shown in Figure 1.

In the field, the geographical positions of the stations were determined using the Loran-C Navigational System. The Loran-C coordinates, latitude and longitude for each station are given in the fourth year data report.

The surficial sediments were collected by taking an undisturbed sample of the top 8-10 cm of the sediments with a dip-galvanized Van Veen sampler. Two grab samples were collected at each station: one for textural and trace metals analysis, a second for organic contaminant analysis. At three stations adjacent to the northeast sluice gate (#11, 21 and 24), replicate grab samples were collected. Trace metal subsamples were collected using plastic ware rinsed with distilled water. These were taken several cm into the grab, away from the sides of the sampler, and below the flocculent layer, thus avoiding any possible contamination from the sampler.

Samples for organic analyses were collected using stainless steel or aluminum sampling devices which were rinsed in pesticide-grade methylene chloride.

The sediment and trace metal samples were placed in 18oz. (0.5L) "Whirl-Pac" TM bags. The sample designated for textural analysis was stored out of direct sunlight at ambient temperature; the sample designated for trace metal analyses was refrigerated at 4°C until processed. Samples for organic contaminant analyses were placed in pre-cleaned glass and immediately frozen and delivered to the Water Resources Technical Services Laboratory in Annapolis for analysis.

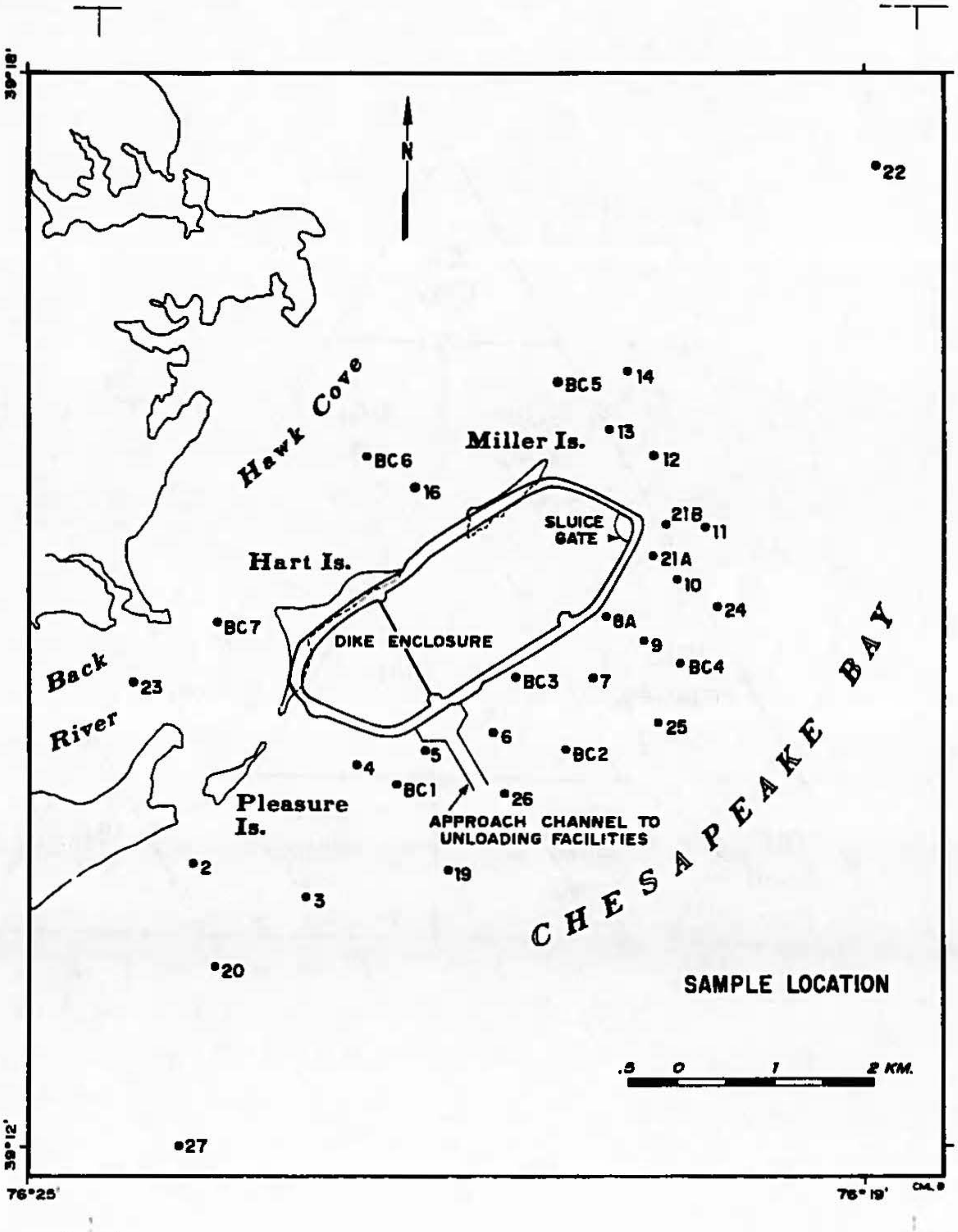


Figure 1. Map of the Hart and Miller Islands Diked Facility and vicinity, showing locations of the surficial sediment and core stations sampled during the fourth year monitoring.

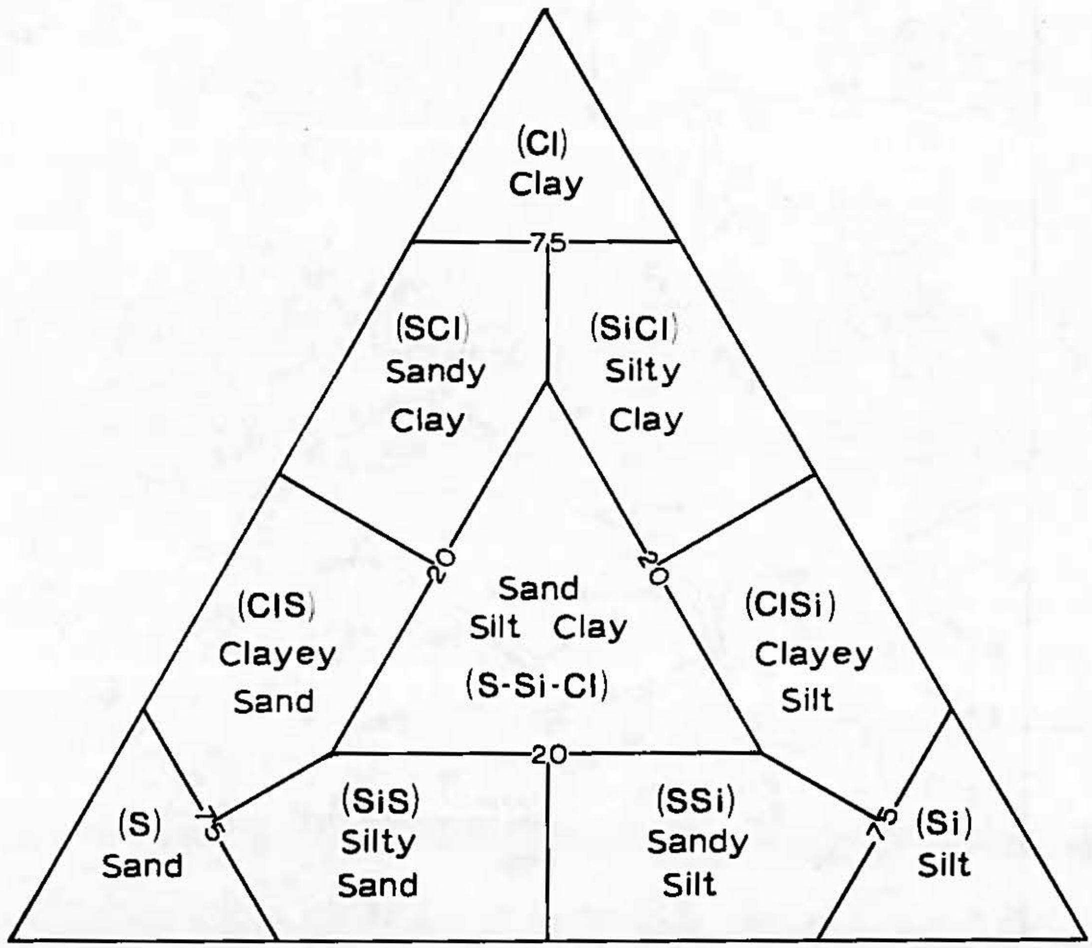


Figure 2. Ternary diagram showing the sediment classification as defined by Shepard's (1954) nomenclature.

During the April sampling period, one core was collected at each of the seven Box Core stations (Figure 1). A benthos-type gravity corer, Model #2171, with clean cellulose acetate butyrate (CAB) liners (diameter 6.3cm) was used to collect the cores. Each core was cut and capped at the original level of the sediment-water interface and refrigerated until X-rayed and processed in the lab.

LABORATORY PROCEDURES

Textural Analysis

In the laboratory, subsamples from both the surficial and gravity cores were analyzed for water content, sand, silt, and clay percentages. Water content was determined as a percentage of the weight of water in the total wet weight of the sample. The weight of water was determined by drying the sediment at 65°C, recording the dry weight, and taking the difference between total wet weight and dry weight.

The percentages of sand, silt, and clay were determined using sedimentological procedures standardized in our laboratory (Kerhin et al., 1983). The sediments were classified according to Shepard (1954) based on the percentages of sand, silt and clay (Figure 2). The total combined amount of carbonates and organics in the sediment was calculated as a percentage weight loss after digestion with hydrochloric acid and hydrogen peroxide.

Radiographic Technique

Prior to processing, each core was X-rayed at the Department of Radiography, Johns Hopkins Hospital in Baltimore, using a CTR Kv X-ray unit. A positive X-ray image of the core was obtained by xeroradiographic processing. Only the upper 60cm of each core was X-rayed. The radiographs are presented in Appendix A.

Each core was then extruded, photographed and described. Sediment samples for textural and trace metal analyses were taken at selected intervals from each core based on radiographic and visual observations.

Trace Metal Analyses

Sediment solids were analyzed for trace metals using a lithium metaborate fusion technique followed by flame atomic absorption spectrophotometry. This method is similar to that used by Sinex et al. (1980), Sinex et al (1981), and Cantillo (1982) on sediments throughout the entire Chesapeake Bay region. The method is based on the work of Suhr and Ingamells (1966) who developed the fusion technique for whole rock analysis. Details of the sample handling and preparation procedures used by the MGS laboratory follows.

1) Samples were homogenized in the "Whirl-Pac" TM bags in which they were stored (refrigerated at 4°C);
2) Approximately 10g of wet sample were drawn into a modified "Leur-Loc" TM syringe fitted with a 1.25mm polyethylene screen (used to remove shell material and large pieces of detritus);
3) Sieved samples were disaggregated in high-purity water and dried in teflon TM evaporating dishes at 110°C overnight;
4) Dried samples were then hand ground in an agate mortar and pestle, and stored in "Whirl-Pac" TM bags;
5) Samples were weighed (0.2+0.0002g) into a depression formed in $LiBO_2$ (1.00+0.01g) at the bottom of drill-point graphite crucibles (7.8 cc vol.);
6) These crucibles were placed in a highly regulated muffle furnace at 1050+5°C for 30 min.;

7) The molten beads produced were poured directly into teflon TM beakers, containing 100 ml of a solution composed of 4% HNO_3, 1000 ppm La (from $La(NO_3)$ and 2000 ppm Cs (from $CsNO_3$), and stirred for 10 min. If dissolution did not occur after 30 minutes, the solution and bead were thrown out and the sample re-fused, and;

8) The dissolved samples were transferred to CPE bottles and stored for analysis.

All surfaces which came in contact with the samples were acid washed (3 days 1:1 HNO_3; 3 days 1:1 HCl), rinsed six times in high purity water (greater than 5 mega-ohms) and stored in high purity water until use.

The dissolved samples were analyzed using the method of bracketing standards. The instrumental parameters used to determine the solution concentrations of Cr, Ni, Zn, and Cu were the recommended, standard F.A.A.S. conditions given in the IL 751 manual (Emmel et al., 1977). Fe and Mn were analyzed using an acetylene-nitrous oxide flame in order to eliminate interferences due to Al and Si (Butler, 1975). Blanks were run every 12 samples, and National Bureau of Standards reference Material #1646 (Estuarine Sediment; NBS-SRM #1646) was run every 24 samples (5 times).

The results of the analyses of NBS-SRM #1646 are given in Table 1, and are compared to the NBS certified values. There is an excellent agreement between the NBS certified concentrations and analytical results of the MGS lab; all of the elements, except Cr, fall within the range of the determined standard deviation. Two elements appear slightly suspect; Cr because it is 14% high and Ni because of its large relative standard deviation (50%). These discrepancies are the result of working close to the instrumental detection limit for these elements.

RESULTS

SEDIMENT DISTRIBUTION

November 1984

During the fall sampling cruise, sediment samples were collected at 25 stations and duplicate samples were collected at three of the stations. Basically, very few textural differences were seen in the sediments compared to the June 1984, sampling period. However, at several stations the classification of sediment type changed. These stations and changes are listed in Table 2.

Figure 3 is a ternary plot of the types of sediments collected in November 1984. As with the previous period (June 1984) the basic trend of the sediments passes from sand through sand-silt-clay to the silt-clay/clayey-silt boundary. Generally, the coarser sediment types were found at stations adjacent to the south and northeast perimeter of the dike (Figure 4). Finer- grained sediments were found at stations located in the Hawk Cove and east the side of the dike perimeter.

The field descriptions of the sediments indicate slight changes in physical appearances since June 1984. Material that was introduced in the area during dike construction was still evident at Station 4,5,6,7,8A and BC-3, and for the first time, at Station 26. This material was described as "steel grey, white, or pink, smooth, fluid mud." At stations 4 and BC-3, the fluid mud was overlain by darker-colored mud containing assemblages of *R. cuneata* shells. At many of the stations, surface assemblages of articulated *R. cuneata* shells were encountered. A putrid odor was associated with sediments containing shells, as well as "anoxic halos" (darker colored sediments) around many of the shells. These sediments had a high percentage of weight loss after cleaning, indicating high organic and carbonate content.

TABLE 1. Sedimentary Studies: Results of the MGS analyses of of NBS-SRM #1646 as compared to the certified values

Element Analyzed	NBS Certified* Concentrations	MGS* Results (n=5)
Cr	76+3	87+2
Cu	18+3	19+2
Fe	3.35+0.10%	3.48+0.24%
Mn	375+20	369+25
Zn	138+6	121+15
Ni	32+2	29+15

*concentration in ug/g dry weight unless otherwise noted

TABLE 2. Comparisons of sediments collected in June, 1984 November 1984 and April, 1985 at those stations showing changes in sediment type

Station Number	June 1984 Percent Sand	Silt	Clay	Class	November 1984 Percent Sand	Silt	Clay	Class	April 1985 Percent Sand	Silt	Clay	Class
3	59.00	18.85	22.16	ClS	79.00	8.92	12.08	S	30.35	30.40	39.25	SSiCl
4	0.39	46.58	53.03	SiCl	3.91	59.40	36.69	ClSi	1.56	51.87	46.56	ClSi
8A	19.84	42.58	37.58	ClSi	69.13	19.18	11.69	SiS	54.76	30.30	14.95	SiS
12	34.85	41.54	23.61	SSiCl	46.51	32.73	20.76	SSiCl	47.85	33.52	18.63	SiS
16	46.05	27.07	26.88	SSiCl	2.06	42.63	55.31	SiCl	39.76	30.32	29.92	SSiCl
*21	7.91	59.88	32.21	ClSi	29.66	38.80	31.34	SSiCl	62.74	28.15	9.11	SiS
					24.25	55.97	19.78	SSi	50.55	37.70	11.75	SiS
									24.04	63.23	12.72	SSi
22	66.35	15.05	18.60	ClS	57.97	19.80	22.23	ClS	34.51	30.72	34.78	SSiCl
23	54.32	25.47	20.21	SSiCl	1.04	49.97	49.00	ClSi	46.88	31.98	21.14	SSiCl
24	1.43	41.69	56.88	SiCl	34.44	26.40	39.17	SSiCl	78.15	8.82	13.03	S
					9.58	39.12	51.30	SiCl	56.63	17.90	25.46	ClS
									73.34	10.77	15.89	ClS

* Station 21 was relocated in April 1985.

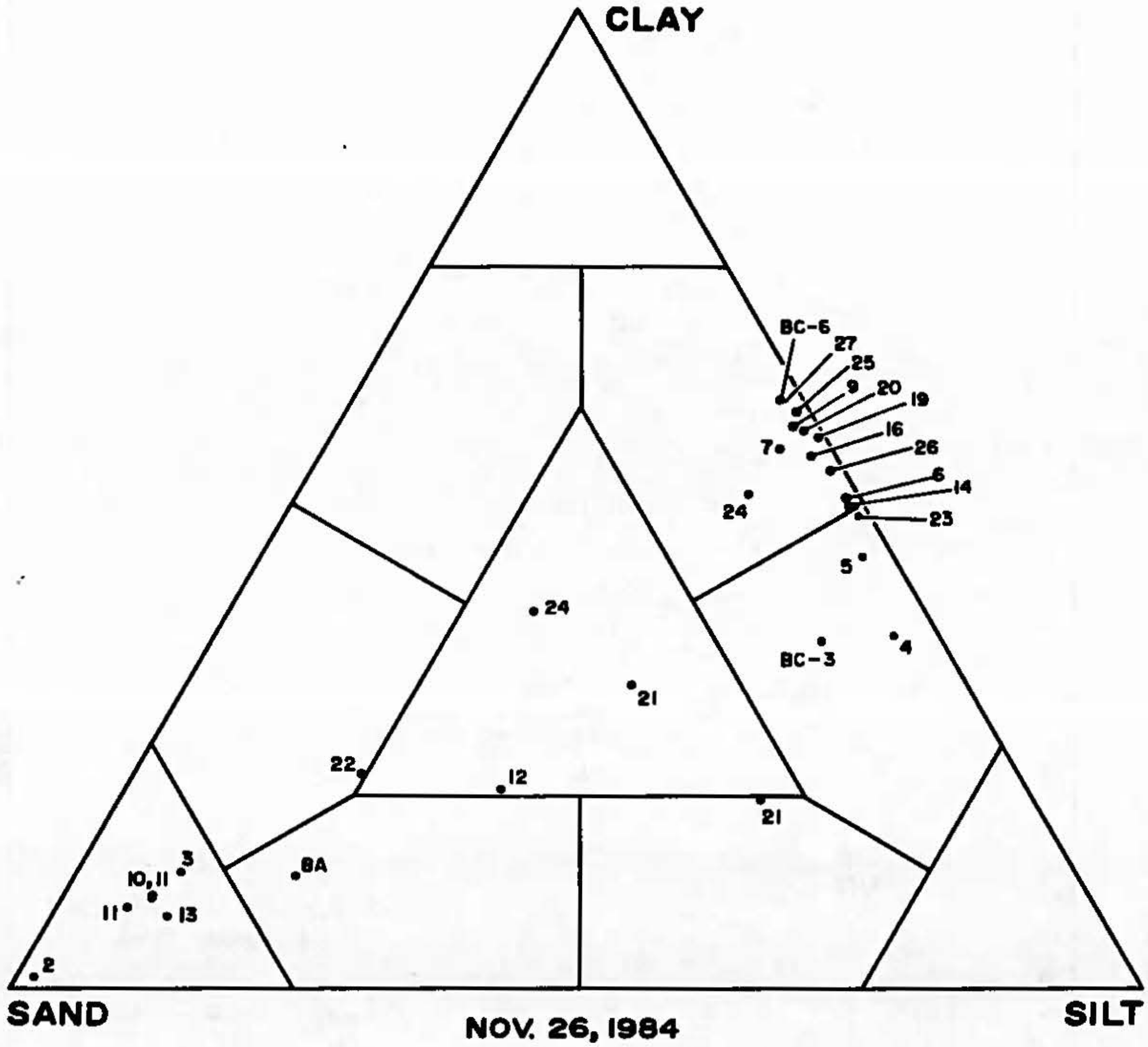


Figure 3. Ternary diagram plot of the sediment types of samples collected in November 1984.

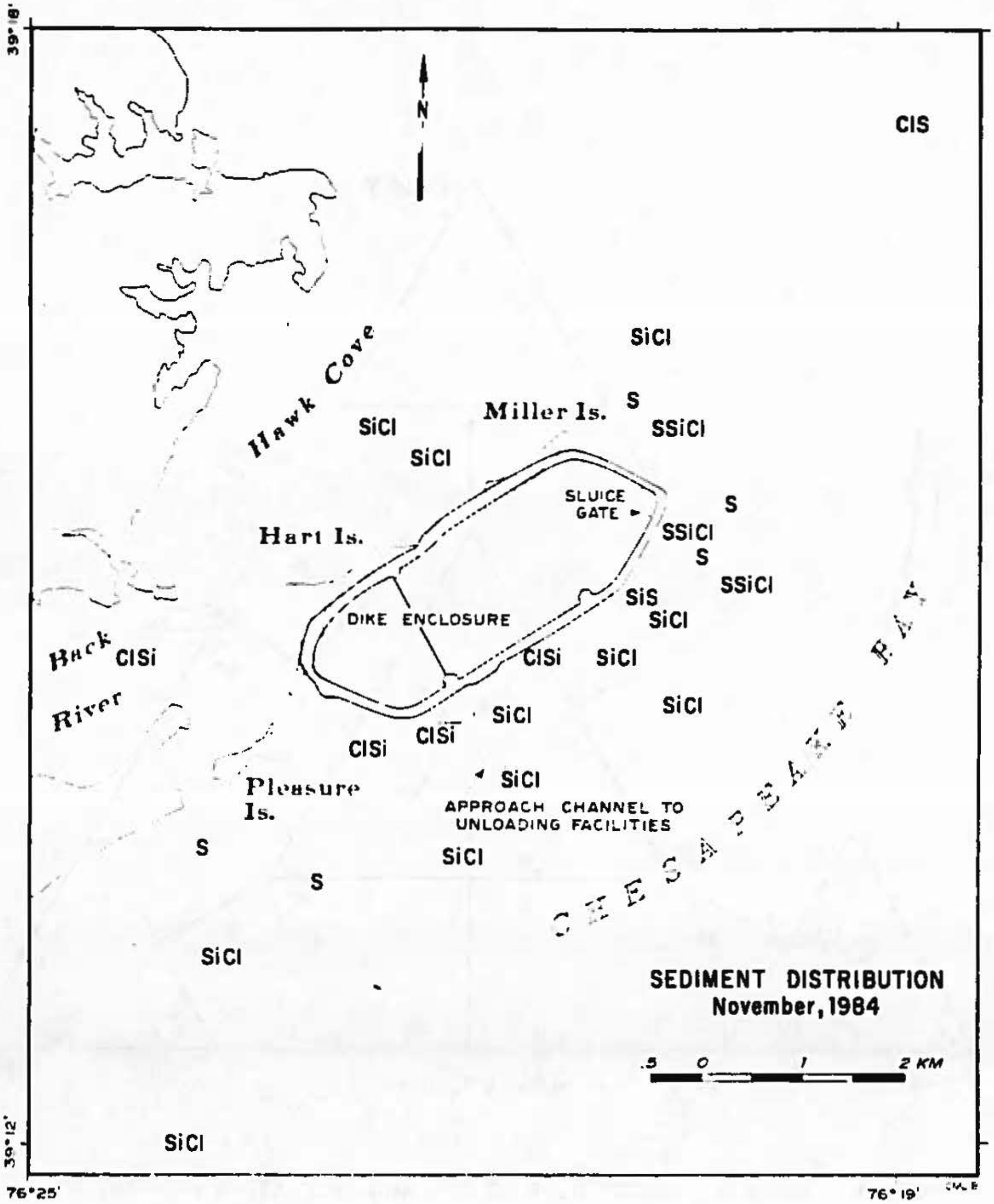


Figure 4

Distribution of sediment types on surficial sediments samples, collected on November 1984.

April 1985

Surficial sediment samples were collected at 25 stations in April, 1985. Triplicate samples were collected at three stations located near the northeast sluice gate. Generally, the sediment classification remained unchanged, except at stations that exhibited changes in November 1984 (Table 2).

A ternary plot (Figure 5) of the spring samples reveals a pattern similar to that observed in November. A discrepancy can be seen in this figure, however, it is due to the relocation of station 21B to the northeast in front of the sluice gate where silty sediments were collected (see Figure 1). Areal distribution of sediment types collected in spring show that siltier sediments were still found along the south and northeastern perimeter of the dike (Figure 6).

Based on the visual appearances of the sediments, light colored fluid muds, introduced during dike construction, were found at Stations 4,5,6,8A,21B,26 and BC-3. Surface shell layers, mainly *R. cuneata* were found at many stations south of the dike structure. Several sediment samples with a surface shell layer also contained "anoxic halos" around some shells; in these cases a putrid odor was present.

RADIOGRAPHIC STUDIES

Cores were collected at each of the seven "BC" stations (Figure 1) in the spring of 1985. These cores provided information on the vertical distribution of the sediments (i.e. depositional history), and physical and biogenic sedimentary structures. Detailed description of the cores based on radiographic and visual observations are presented in the fourth year Data Report along with textural and trace metal data of sediment subsamples taken from the cores.

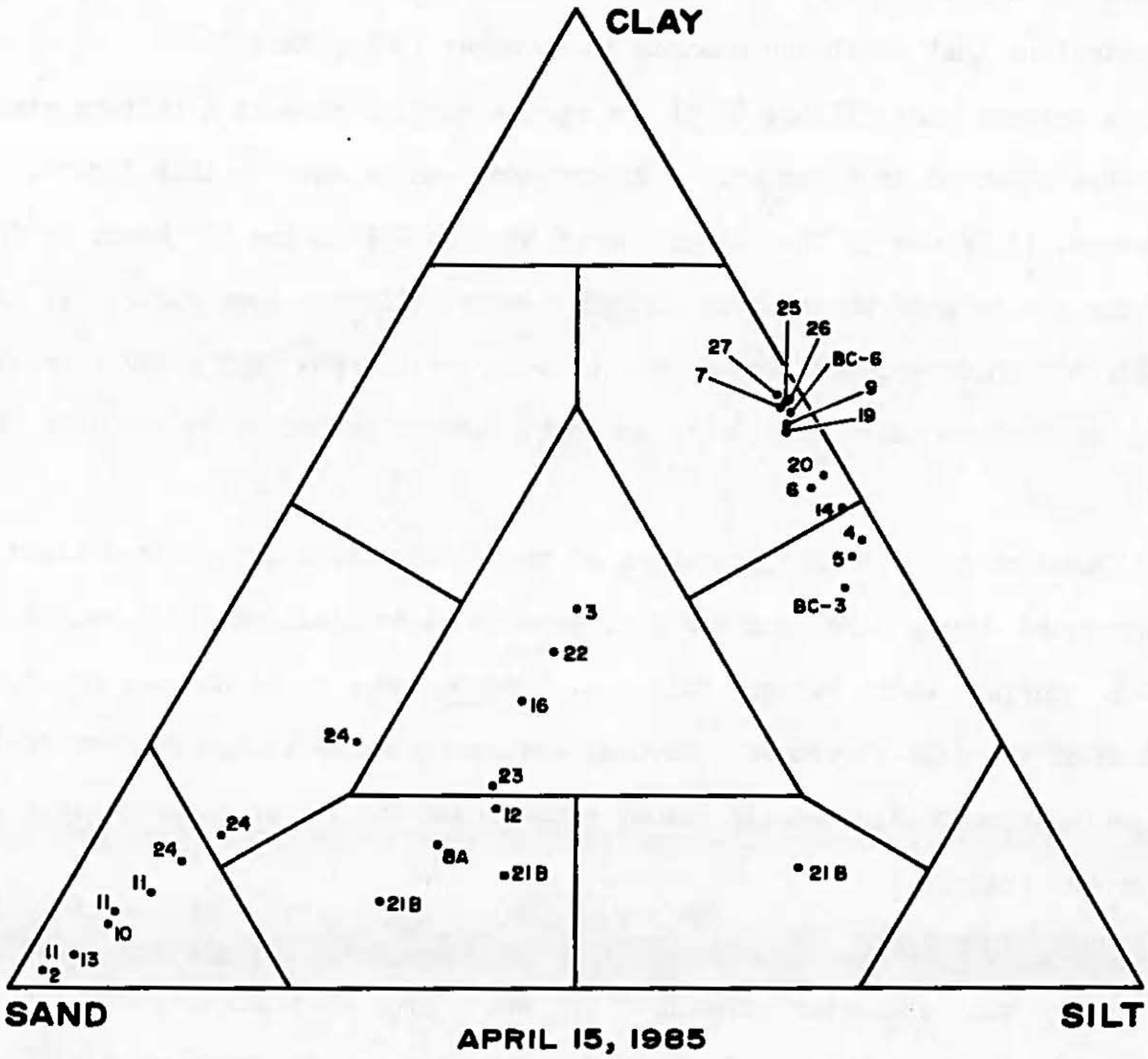


Figure 5. Ternary diagram plot of the sediment types of samples collected in April 1985.

TABLE 3. Sedimentary Studies: Average enrichment factors of the elements analyzed during the Hart-Miller Island Facility Monitoring (surficial sediment only)

Ef	University of Md 8/81	5/83	WRA/EPA 11/83	6/84	MGS 11/84	4/85
Volatile						
Cd	0.98 ± 0.32	2.96 ± 1.23	BDL	NA	NA	NA
Pb	2.02 ± 0.69	2.08 ± 0.87	2.65 ± 0.69	NA	NA	NA
Hg	0.34 ± 0.17	0.65 ± 0.88	1.77 ± 1.19	NA	NA	NA
As	0.44 ± 0.19	0.19 ± 0.16	2.42 ± 0.75	NA	NA	NA
Se	0.26 ± 0.25	NA	NA	NA	NA	NA
Sn	0.57 ± 0.50	NA	NA	NA	NA	NA
Non-Volatile						
Cr	0.67 ± 0.14	0.36 ± 0.17	0.55 ± 0.19	2.09 ± 1.44	1.56 ± 0.63	2.24 ± 0.73
Ni	2.17 ± 0.91	1.22 ± 0.31	1.69 ± 1.19	0.88 ± 0.58	1.12 ± 0.71	1.16 ± 0.80
Zn	3.83 ± 1.27	3.50 ± 1.62	4.11 ± 1.81	3.28 ± 1.28	3.25 ± 0.85	3.81 ± 1.69
Cu	0.90 ± 0.31	0.92 ± 0.39	1.17 ± 0.30	2.26 ± 1.96	2.07 ± 2.07	1.66 ± 0.82
Mn	9.31 ± 6.47	2.91 ± 1.62	6.06 ± 6.09	4.75 ± 5.03	3.89 ± 1.79	3.51 ± 1.63

NA - not analyzed
BDL - Below detection limit

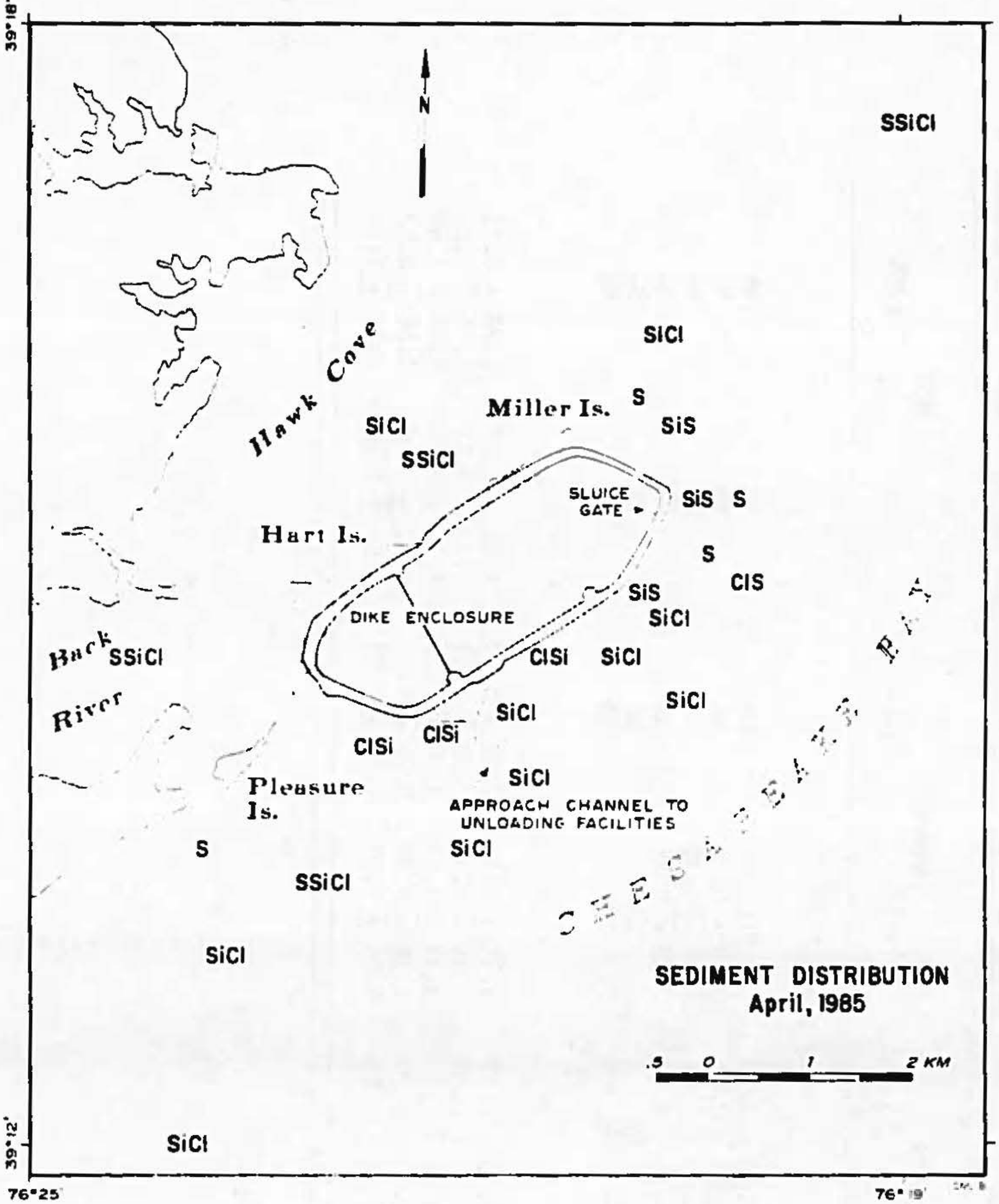


Figure 6

Distribution of sediment types based on surficial sed. samples colected Apr. 1985

Below is a summary of the core data with references to radiographs presented in Appendix A.

Station BC-1 (Figure A-1)

This station is located on the south side of the dike facility. Two cores were collected at this site. The first core was taken in April 1985. Radiography was performed prior to extrusion. However, sampling for trace metals was precluded by disruption of the core when it was extruded from its liner. A second core was collected in July 1985. Based on radiographs taken, both cores were very similar.

The depth of penetration of the core taken July 1985 was 82cm. The top 20cm consisted of steel grey to brown mud. Laminae were seen between 11 and 20cm. In the 0-11cm interval the laminae were obscured by a reticulated network of burrows. The sediment was slightly darker in the top few centimeters, gradually becoming lighter in color with depth. At 20.5cm, the sediment changed to a dark grey to black, cohesive mud. At 27 to 35cm, there was a shell layer of R. cuneata, with both articulated and disarticulated shells. Below this depth, there was steel grey, cohesive mud, uniform in texture and structure.

Textural analyses of sediments taken at selected intervals from this core (see Table 9 in 4th year Data Report) revealed that the sediment type throughout the core was silty-clay, although the top segment (0-20cm) was siltier than the down-core sediments. The sediments associated with the shell layer (28-32cm) had a large (40%) weight loss on digestion indicating higher carbonate and organics content.

Station BC-2 (Figure A-2)

The core collected at this station contained a surface layer of shells, comprised mainly of the bivalve R. cuneata. The upper portion of the core consisted of dark grey, almost black mud, with a network of oxidized burrows that extended down to approximately 10cm. The sediment gradually became lighter in color and increasingly more cohesive down-core. Textural analyses revealed that the sediments were silty-clays. The top 4cm of sediments had a high percentage of weight loss (40%) on digestion.

Station BC-3 (Figure A-3)

This station is located near the dike wall on the bay side of the facility. The core penetrated to a depth of 82cm. The core was composed of a surface layer of shells (R. cuneata) overlying a series of layers of grey, grey-brown and reddish-brown smooth muds, to a depth of 16cm. A network of burrows were found in the top 6cm. A series of shell layers were seen at 16 to 26cm. The rest of the core was grey cohesive mud.

Based on textural analyses, the lighter muds at the top of this core consisted of clayey-silts; the underlying darker muds were silty-clays. Again, a large weight loss (>20%) after cleaning was found in the sediments associated with the shell layers (16-20cm interval).

Station BC-4 (Figure A-4)

The core collected at this station penetrated to a depth of 88cm. The dark-grey mud at the surface was slightly sandier than down-core. A surface layer of R. cuneata and various crustaceans was present. Burrows were evident throughout the core as seen in the radiograph.

Textural analyses showed that the sediments were silty-clays. Slightly sandier sediment was found at the top (0-4cm), in addition to a high percentage of (>40%) weight loss.

Station BC-5 (Figure A-5)

The core collected here was 90cm in length, composed of dark grey, cohesive mud containing a series of shells. The surface layer of shells consisted of live R. cuneata. Burrowing was evident throughout the core but most prominent in the top 15cm.

Based on textural analyses of samples taken from this core, the sediments were silty-clay.

Station BC-6 (Figure A-6)

The core taken at this station penetrated to a depth of 80cm and consisted of a steel grey stiff mud, overlain by a 20cm layer of darker grey watery mud. An assemblage of fairly large R. cuneata was encountered at the top. The textural class of the sediments was silty-clay.

Station BC-7 (Figure A-7)

The length of the core collected at this station was 80cm and the sample was composed of grey cohesive muds. These ranged from clayey-silt (0-4cm) to silty-clay (56-60cm), increasing in clay content down-core.

TRACE METALS

Sediment solids from the area surrounding the Hart-Miller Island Containment Facilities were analyzed for Cr, Mn, Fe, Ni, Cu, and Zn, and included surficial samples collected during the last three sampling periods: June 1984, November 1984 and April 1985. Trace metal analyses also were performed on sediments taken from gravity cores collected in April 1985. The results for both surficial sediments and core samples are presented in the fourth year Data Report. For comparison with previous data, the trace metal results are given in terms of enrichment factors.

Enrichment Factors

The most fundamental problem encountered when examining and comparing data from several sources is the comparability of sampling and analytical techniques. Generally, these techniques are not given with the data, and when they are, there are considerable differences between the methods employed. Another problem encountered in using raw concentration data is the association of trace elements with specific components in the sediment. Trace elements are generally associated with fine-grained sediments and organic material.

Variations in bulk sediment analyses may simply reflect fundamental variations in the physical environment and may not reflect any influence due to man or changes in the chemical environments. The use of enrichment factors circumvents these problems by removing the influences of sediment grain-size and organic matter (Zoller et al., 1974; Sinex and Helz, 1981). The ratios also minimize differences due to variation in analytical methods.

An enrichment factor (EF) is a ratio of a trace element to an element whose source can be considered solely a result of normal weathering processes. This ratio is in turn normalized to the same ratio calculated from a standard material. The elements on which enrichment factors are generally based are iron (Fe) and aluminum (Al). The standards used for normalization are generally either the average crustal abundance of the elements or the average composition of shale. In this report the enrichment factors are based on Fe and are normalized to an average shale (Turekian and Wedepohl, 1961). Thus, the enrichment factors are calculated as:

$$EFFe(X)shale = \frac{(X/Fe)sample}{(X/Fe)shale}$$

where: X is the element of interest;

(X/Fe)sample is the analytically determined ratio of X's concentration to Fe concentration (both expressed as dry weight of sample);

(X/Fe)shale is the ratio of X to Fe in the average shale of Turekian and Wedepohl (1961).

An enrichment factor of 1.0 indicates no enrichment over average shale values. Values which differ from 1.0 may be explained by a variety of hypotheses, but the more important aspect of the values is that they are a relative indicator referenced to a known material. This eliminates artificial variations in the data due to sediment type. This approach is particularly useful in examining spatial distribution of elements in the sediment.

Comparisons of analytical methods

Differences in analytical methodology can be seen by comparing enrichment factors within a relatively small region. This comparison is useful as a check on the internal consistency of the data. Since the start of the Hart and Miller monitoring effort, three laboratories, each using a different analytical method, have been used to analyze the sediment solids. Table 3 shows the average enrichment factors for the elements analyzed during each sampling period. The table is divided into two groups of elements, the volatile and non-volatile elements. Several features within this table show the variation of results as a consequence of differences in the analytical methods used. These differences are:

I. Volatile elements

a. the high-temperature fusion method used by MGS is not capable of measuring the volatile elements, which are lost during sample preparation.

b. Selenium and Sn were not analyzed after the first sampling period, due either to extremely low levels (University of Maryland - UM) or analytical difficulties (EPA).

c. The average EF of Hg, As, Se, and Sn were much lower than 1.0 in the UM data. This suggests that these elements either were volatilized during samples preparation or not totally recovered from the samples. Samples analyzed by UM were prepared by:

a) digesting the samples with HNO_3 at $80^{\circ}C$;

b) allowing the sample plus solution to evaporate to near dryness;

c) the extract was diluted with 4% HNO_3, filtered, then analyzed (Wright, pers. comm.).

d) The EF for Hg and As were significantly larger (nearer expected levels) in the EPA data than in the UM data. The standard EPA procedure is to digest the sediment in an HNO_3-HCl acid mixture heated in flasks capped with relux columns. This procedure is more vigorous than that used by UM, and probably extracts a larger proportion of the total metals. However, the increase in EF is more likely due to trapping of volatile elements by the reflux columns.

2. Non-volatile elements: In this group of metals there is only one significant variation in the data which can be attributed to differences in analytical methodology. This difference can be found in the mean EF for Chromium. Chromium is found, to a large extent, in heavy minerals and lattice sites in clays. Acid digestion of solids does not extract Cr from the more tightly bound lattice sites. A major benefit of fusing the sediment solids is that the entire sample is rendered soluble. Consequently, the average EF for Cr in the MGS data set are greater than those for the other methods.

DISCUSSION

SEDIMENTARY ENVIRONMENT

During the fourth year monitoring, some changes were seen in the sedimentary environment around the Hart-Miller Containment Facility. Shifts in the sediment classification were seen at basically the same stations both in the fall and spring sampling (Table 2). These changes, however, may not reflect a trend in the sedimentary environment, but rather difficulties in reoccupying exact station locations.

In the beginning of 1984, Maryland Geological Survey began to use the Loran-C radionavigation system when the State of Maryland eliminated the Teledyne Hastings-Raydist system. The Loran-C system has proven to be a more reliable, but less accurate system than the Raydist. Failure to reoccupy locations exactly could result in the collection of a totally different sediment type, particularly at those stations located at boundaries or transitional zones between coarser nearshore sands and deep water silty-clays, e.g. Stations 3,4,12,16,21 and 24.

Other changes observed during the fourth year monitoring were color changes in the top 20cm of the sediments. During both the fall and spring sampling periods, "steel grey, red and white, smooth fluid muds" were encountered at stations along the south and southeast perimeter of the dike structure (Stations 4,5,6 BC-3,7,8A and 26). The fluid muds which were introduced during dike construction, blanketed the surface sediments (Wells et al., 1984). However, during the November 1984 and April 1985 sampling cruises, these "fluid mud" stations contained surface layers of shells or dark brown to grey muds, or both, with thicknesses ranging from several cm to 20cm. This layer of darker mud and/or shells may be, in part, a typical flocculent layer which has been found throughout the Bay (Kerhin et al., 1983). The flocculent layer has been described as a highly mobile, organic-rich layer, periodically resuspended by tidal and/or current action.

Beneath the floccuent layer a zone of biogenic activity was found. Within this zone, benthic organisms introduce organic material into the relatively organic-free fluid muds (Wells et al., 1984). As the organic material decays, available oxygen in the muds is depleted and anoxic conditions soon develop. The sediments turn from light grey and tan to dark grey, brown or black muds resembling those muds originally found in this area before dike construction.

Field descriptions of the fall and spring sediment samples indicate that many of the R. cuneata were found in "life" positions but were dead. A putrid odor was associated with these sediments containing shells. Periodic mortality of the bivalve mollusc, R. cuneata is not unusual for the Upper Chesapeake Bay. Rangia cuneata is an opportunistic species preferring warmer, brackish water, and is capable of relatively rapid population growth. Increases in salinity, low water temperature or periodic anoxia can contribute to seasonal kills of this species.

Benthic recolonization of the fluid mud layer was also evident in several of the gravity cores collected in April. Core stations BC-1 and BC-3 lie within the extent of the fluid mud layer. Radiographic examinations showed a reticulated network of burrows extending down 7 to 11cm into the core (Figures A-1 and A-3), all but erasing the distinct laminae associated with the fluid mud layer (Wells et al., 1984).

GEOCHEMICAL CHARACTERISTICS OF SEDIMENT

The general behavior of the non-volatile elements (Cr, Cu, Fe, Mn, Ni, and Zn) is strongly correlated (Table 4). There are three features to note about the linear relation of these elements. These are:

1. All of these elements are significantly related to one another;

2. The poorest correlation is found between Mn and all of the other elements. Manganese is thought to be readily mobilized from the sediment under anoxic conditions (Eaton, 1979), and is found primarily as grain coating in the form of of the oxyhydroxide (Cantillo, 1982). Consequently, its behavior should be less related to the more sediment-bound elements, and;

3. In the MGS data, the correlations between Cr and the other elements were lower than the correlation coefficients from the UM or EPA data. This is because of the complete digestion of the sample with the fusion technique, which liberates elements bound in the more refactory, heavy mineral fraction of the sediment. These refractory minerals, such as chromite, would only be partially accounted for by acid-digestion methods.

As a consequence of the strong correlation of the elements to one another, one element can be chosen as an indicator. Zinc has been used because:

1. It generally has the strongest correlation to the other elements;

2. It is a non-volatile element, results for which do not appear to be influenced by the analytical procedure;

3. Within the surface sediments of the Bay the EF for Zn shows a wide, systematic variation regionally (Sinex & Helz, 1981). This variation is potentially useful in showing contrasts due to importation of sediment from other areas in the Bay, and;

TABLE 4. **Sedimentary Studies: Correlation matrices of the non-volatile elements measured between August 1981 and April 1985**

Variable		UM		WRA/EPA		MGS	
1	2	8/81	5/83	11/83	6/84	11/84	4/85
Zn	Cr	0.98	0.88	0.95	0.78	0.85	0.86
	Cu	0.96	0.81	0.97	0.87	0.87	0.91
	Fe	0.94	0.84	0.86	0.86	0.91	0.76
	Mn	0.70	0.90	0.77	0.88	0.74	0.74
	Ni	0.90	0.91	0.96	0.90	0.83	0.89
Cr	Cu	0.97	0.79	0.98	0.80	0.80	0.89
	Fe	0.95	0.83	0.88	0.85	0.88	0.81
	Mn	0.65	0.81	0.67	0.55	0.63	0.68
	Ni	0.90	0.86	0.91	0.82	0.77	0.77
Cu	Fe	0.89	0.75	0.90	0.77	0.90	0.80
	Mn	0.61	0.74	0.68	0.77	0.74	0.75
	Ni	0.90	0.82	0.94	0.87	0.77	0.88
Fe	Mn	0.60	0.70	0.66	0.67	0.74	0.71
	Ni	0.87	0.91	0.92	0.88	0.80	0.74
Mn	Ni	0.71	0.86	0.78	0.74	0.71	0.70
Number of Analyses		20	21	28	28	31	31

Note: The 90% significance level for n=20 is r=0.38.

4. Zn is one of the few elements, to date, which are considered to be strongly influenced by anthropogenic inputs to the Bay (Cantillo, 1982; Sinex & Helz 1981).

Figure 7 shows the average EF for Zn over a nine-year period in the area of Hart and Miller Islands. Although the figure indicates that some influence due to Hurricane Eloise may be present, there was little change during the monitoring period between 1981 to 1985. However, Figure 7 shows only the regional average, not local variations around the containment facility.

Figure 8 shows Zn EF contours for each of the sampling period (August 1981 to April 1985). Although there was some fluctuation over time, the general patterns were similar. Particularly consistent was the distribution and range of EF found on the western side of the Hart Miller Island complex.

Variations in the general pattern, possibly due to dredging and the operation and construction of the facility, can be seen. The most obvious variations in the general pattern are anomalous areas of either unusually high or low EF. These can be seen in the contour maps for August 1981 (pre-construction), June 1983 and November 1983. These areas are thought to be anthropogenic in nature (Wells et al., 1984).

Other variations are less dramatic, but reflect the longer-term influences of dike operation. As mentioned in previous reports, the average EF in the fluid mud zone decreased compared to pre-construction levels. This reflects the inputs of pre-Holocene sediment used in dike construction. Another feature can be seen in the channel area leading to the unloading facility. The channel was dredged between the November 1983 and the June 1984 sample periods. This can be seen in the EF contours. Prior to June 1984, the contours are nearly parallel to the dike. After dredging there is a pronounced deflection.

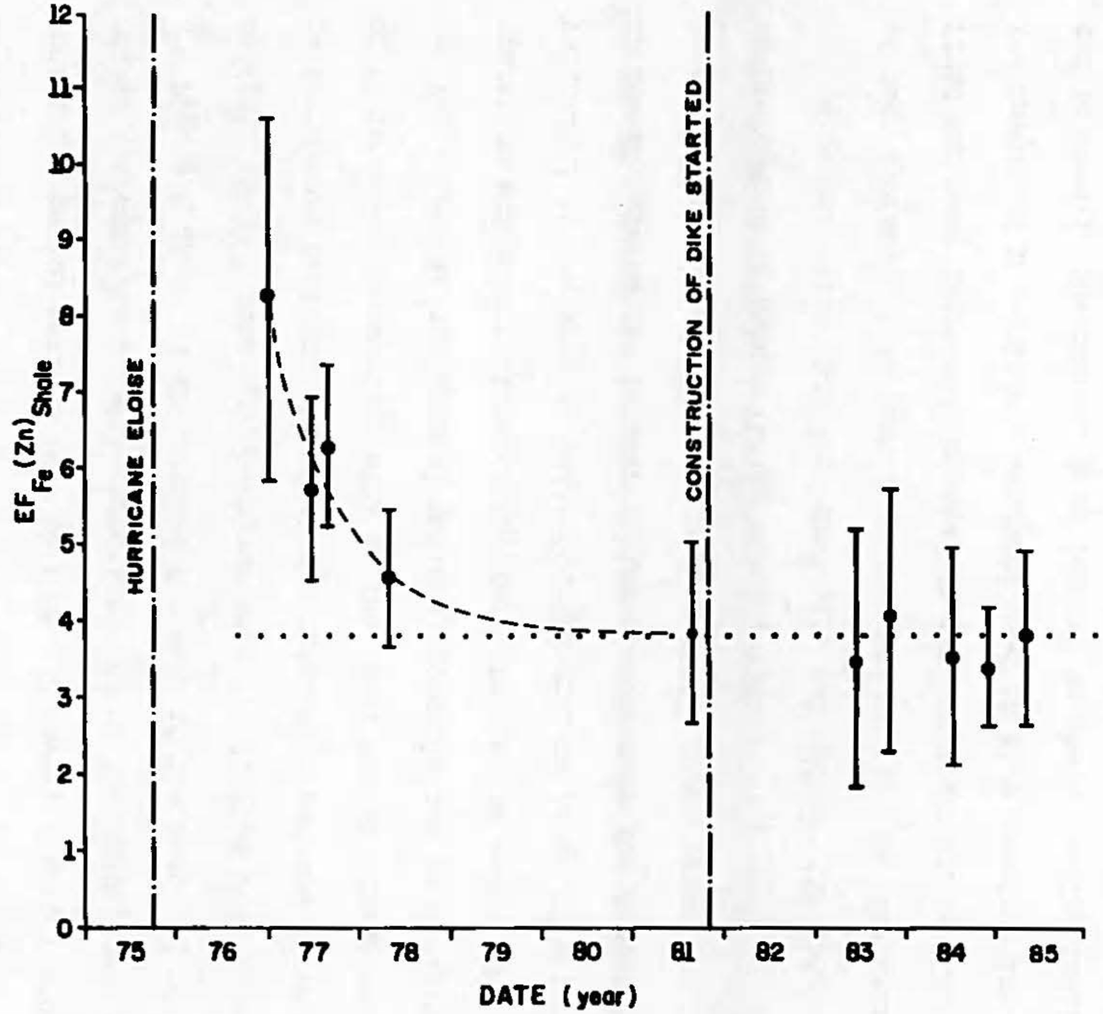


Figure 7. Graph of the average enrichment factors for Zn over a nine year period in the area of Hart-Miller Island.

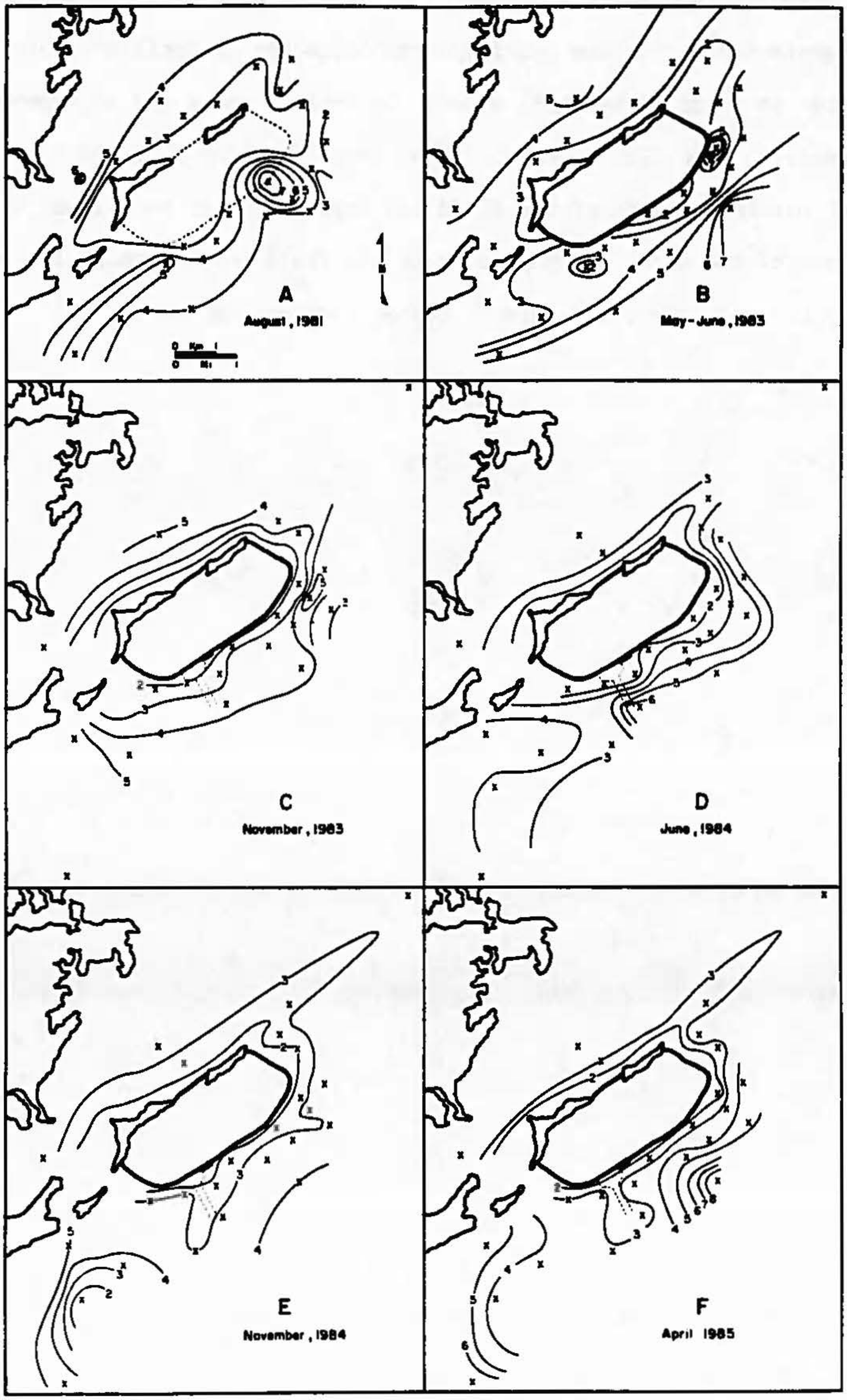


Figure 8. Contour of enrichment factors for Zn around Hart and Miller Islands Facility for each of the sampling periods between August, 1981 and April, 1985. Sample locations are indicated by "x's".

Trends in the vertical behavior of zinc EF were also noted. Zinc EF of the sediments taken from the gravity cores collected in April and July 1985 were similar to those in May 1983 cores. Generally, there was an expected down-core decrease in zinc EF. However, in two cores (Station BC-1 and BC-3) which were taken within the area of the fluid mud layer, zinc EF were lower in the top portion of the core, corresponding to the fluid mud. Zinc EF increased below the fluid mud layer, and then decreased further down-core.

CONCLUSIONS

During the fourth year study, slight changes were observed in the sedimentary environment around Hart and Miller Island Containment Facility. However, these changes did not appear to be a result of the operational phase of the Hart-Miller Island Facility.

The blanket of fluid mud deposited as a result of dike construction was still detected in areas south and east of the dike structure. Subtle changes in the color of these sediments have been observed and are attributed to the effects of biogenic activity. Radiographic study of cores collected within the fluid mud area revealed an increase in bioturbation levels compared to the previous year.

Because the trace metal analyses were performed by several laboratories using different analytical techniques, comparisons of the trace metal data with data of previous years were very difficult. To minimize these analytical differences, enrichment of zinc in the sediments has been used as a relative measure of geochemical trends with respect to time and areal distribution around Hart and Miller Islands. The distribution and range of zinc EF based on data collected during the fourth year were consistent with previous years. The average EF for zinc in the fluid mud zone remains lower than pre-construction levels, apparently as a result of a spill of pre-Holocene construction material. Low EF for Zn reflects lower relative Zn concentrations than expected from more recent sediments. Low Zn enrichments factor have persistent in this area since construction.

PART 2: BEACH EROSION STUDY

INTRODUCTION

An immediate benefit of the Hart and Miller Islands Containment Facility was the creation of a recreational beach during the early stages of dike construction. Because the beach afforded immediate access to the public, management and maintenance of the beach were placed under the auspices of the Department of Natural Resources, Forest Park and Wildlife Services. As part of the management program, the Maryland Geological Survey was enlisted to monitor the beach and to document certain changes in the beach. These changes began shortly after its creation, and were erosional in nature, particularly in the form of sheet-wash from the dike face and the formation of a wave-cut escarpment along the foreshore of the beach.

The beach study was initiated late in the spring of 1984. The results of the first year are detailed in Wells et al. (1985). Based on changes in the beach profile over a period of four months, it was determined that two distinct morphological processes were acting on the beach and dike face. The beach face changes were a result of wave and storm-related processes and the changes in the dike face were controlled by pluvial and aeolian processess (rain and wind).

OBJECTIVES

This continuing study has focused on the erosional patterns of the recreational beach constructed between Hart and Miller Islands. The problems observed in the first survey (Well, et al. 1985) are reviewed and expanded upon in this report, which covers the period from September 1984 to September 1985.

The study had three objectives:

1. To analyze the beach configuration and relate it to the natural beach configuration for the area;
2. To evaluate the erosional-depositional processes acting on the beach, and;
3. To determine the time scales of erosional responses and readjustment cycles to known geomorphic and anthropogenic processes in the area.

METHODOLOGY

FIELD METHODS

Ten profile lines were surveyed along the recreational beach area between Hart and Miller Islands. The locations of these profiles were established during the previous year's study (Wells, et al. 1985) and are shown in Figure 9. A benchmark located 20 feet from the centerline of the dike roadway at Station 30+00 was the starting point for profiling. All of the profile origins were located along the centerline of the dike roadway, with elevations transferred from the 30+00 benchmark. Each profile was measured down the dike face past the level of low tide.

Profile measurements were made using standard surveying techniques. The beach profiles were surveyed five times during the second year of the beach study (Table 5). During the June 1985 survey, sediments were collected at changes in slope and/or every fifty feet along each profile line. These distance and elevation data are presented in the Fourth Year Data Report.

Aerial photographs were taken three times (December 1984, May and September 1985) to provide an overview of the recreational beach. Any special features or observations were also documented photographically.

LABORATORY METHODS

Sediment samples were analyzed in the laboratory for grain size according to Maryland Geological Survey standard techniques as outlined in Kerhin, et al., 1983.

TABLE 5. Dates on which beach profiles were surveyed

Profile Location	1st Survey	2nd Survey	3rd Survey	4th Survey	5th Survey
22+00	9-24-84	12-10-84	3-20-85	6-20-85	9-17-85
24+00	9-24-84	12-10-84	3-20-85	6-20-85	9-17-85
30+00	9-24-84	12-10-84	3-20-85	6-20-85	9-17-85
32+00	9-24-84	12-10-84	3-20-85	6-20-85	9-17-85
36+00	9-24-84	12-11-84	3-22-85	6-20-85	9-17-85
40+00	9-25-84	12-11-84	3-22-85	6-21-85	9-18-85
44+00	9-25-84	12-11-84	3-22-85	6-21-85	9-18-85
48+00	9-25-84	12-11-84	3-22-85	6-21-85	9-18-85
49+00	9-25-84	12-11-84	3-22-85	6-21-85	9-18-85

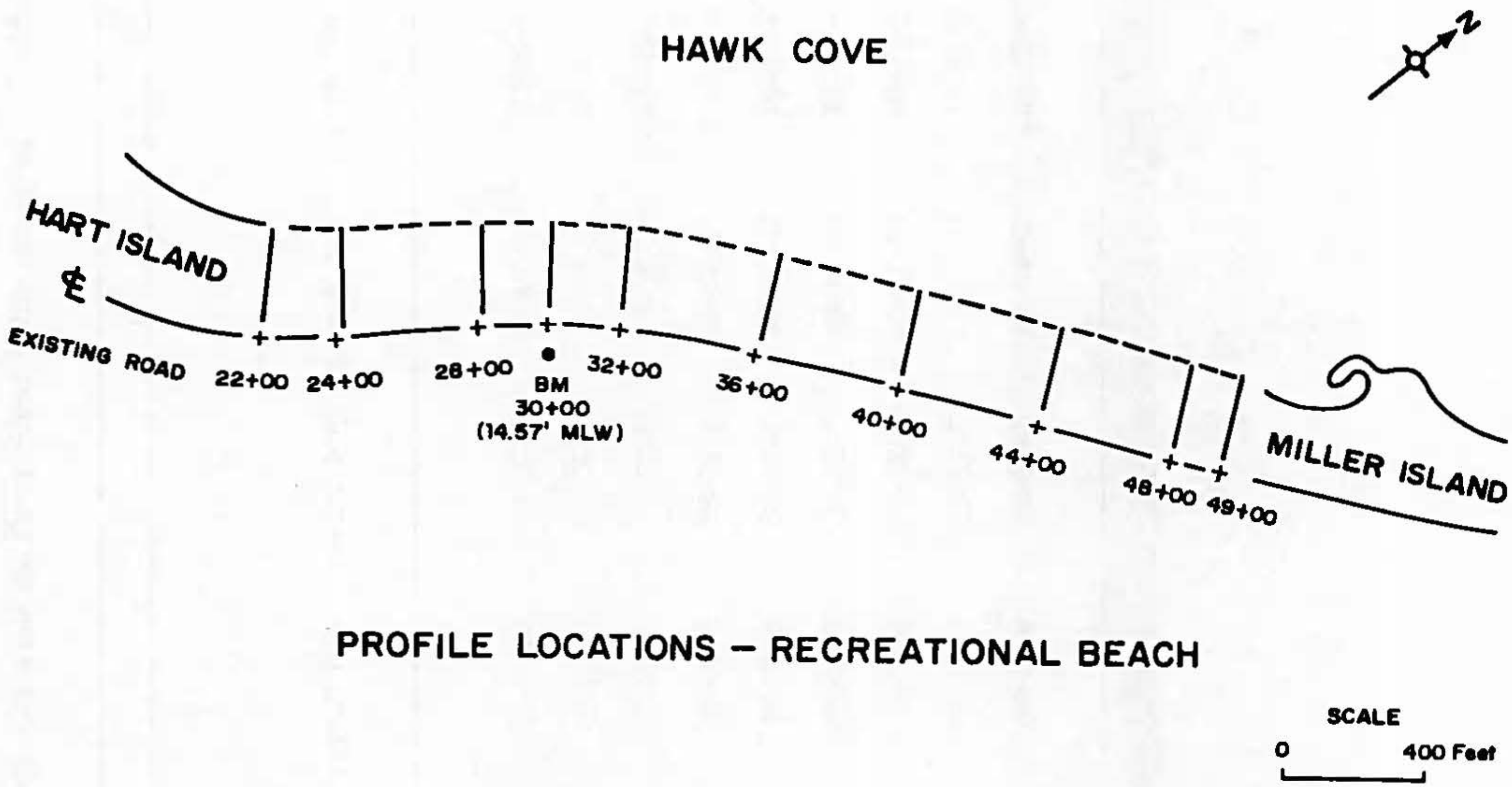


Figure 9. Recreational beach on Hart and Miller Islands dike structure, showing locations of the profile lines.

RESULTS AND DISCUSSION

RECREATIONAL BEACH

The recreational beach between Hart and Miller Islands was created during the early stages of construction of the diked disposal facility. Over 500,000 yd^3 (382,000 m^3) of material were pumped between the islands following the linear configuration of the dike. A roadway runs along the crest of the recreational beach which is at +18.00 feet (5.44m) mean low water (mlw). The recreational beach slopes gently (1:30) down to the water's edge. The width of the beach is approximately 250 feet (75m).

To facilitate the discussion of the findings in this report the recreational beach has been divided into three zones (Figure 10). The outer dike face or dike face is defined as that part of the beach from the roadway to high water mark (which is usually identified as an escarpment in this study). The zone between the high water mark and mean low water (0 feet mlw) is termed the foreshore. Nearshore refers to the zone beyond mlw.

CHANGES IN BEACH-PROFILE CONFIGURATION

Contour maps and cross-sectional profiles were constructed from the survey data, to document changes along the recreational beach.Both the cross-sectional profiles and contour maps are presented in Appendix B (Figures B-1 through B-15). The changes indicated in both the profiles and maps are similar to those observed in the previous study (Wells et al., 1985).

The contour maps reveal subtle changes on the beach. The overall configuration of the recreational beach remained the same for the September, December and March contour maps (Figures B-11 through B-13). However, a comparison of the March 1985 contour map with the June 1985 map shows a smoothing or straightening of the contours along the lower portion of the beach. This change is attributed to an anthropogenic process; the beach was

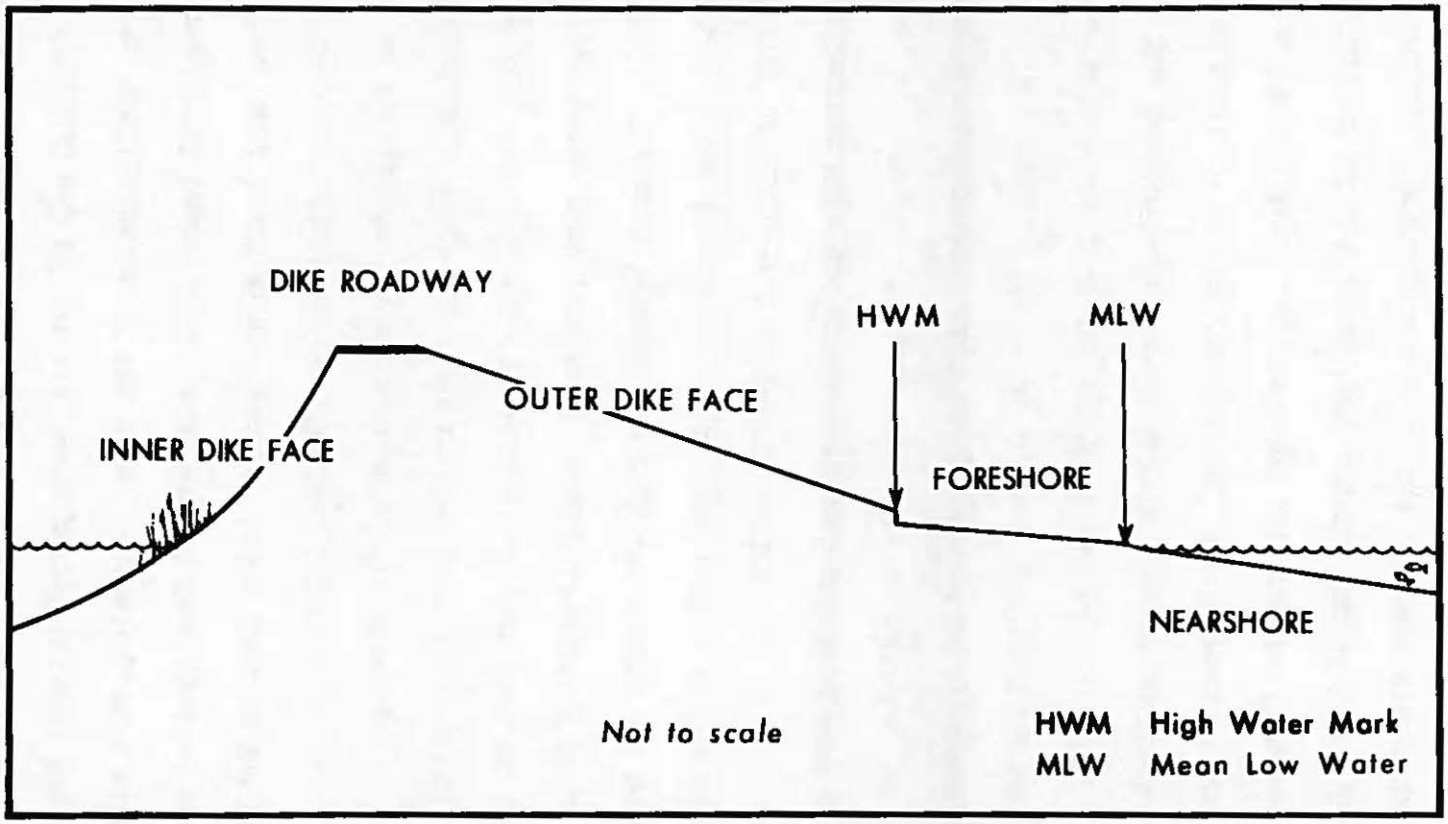


Figure 10. Schematic cross-section of the dike illustrating the terminology used in this report referring to specific areas along the dike and beach profile. (See text for explanation)

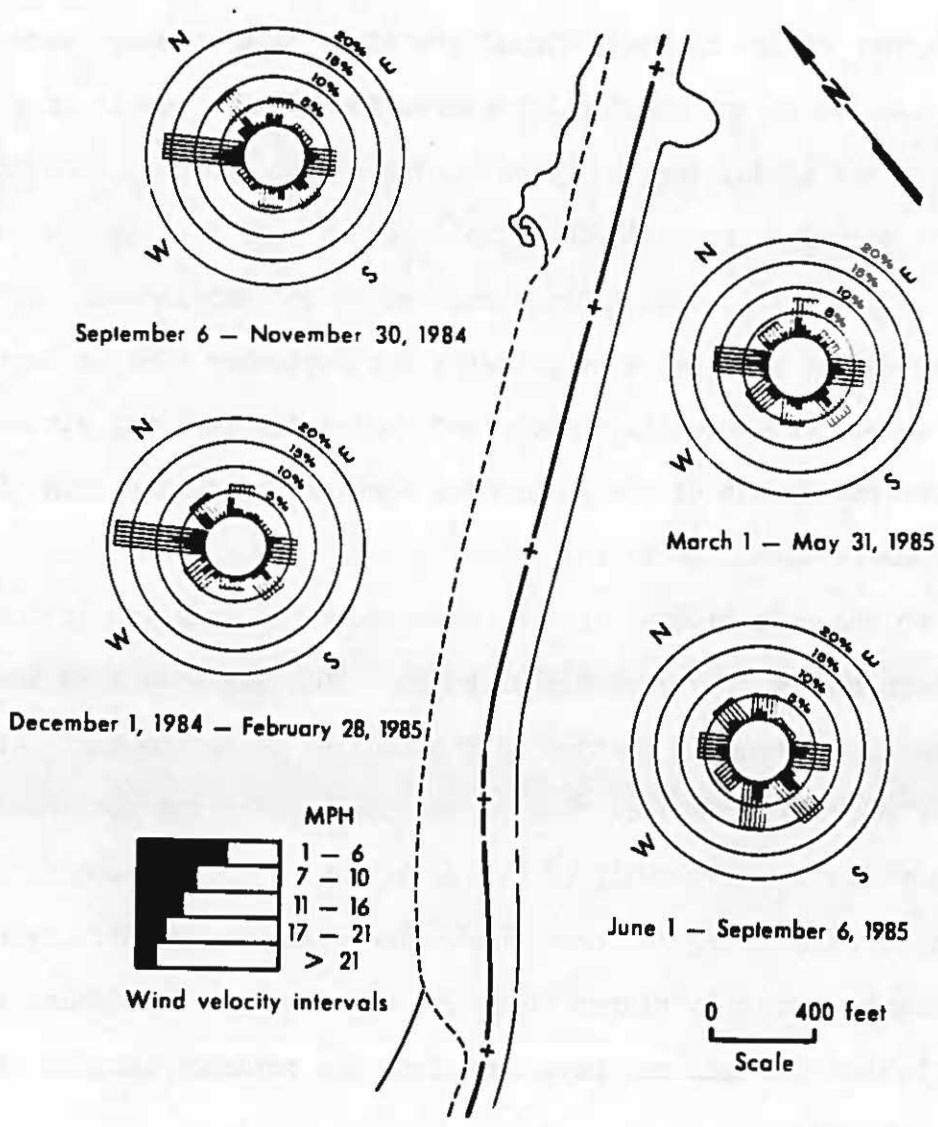
regraded (bulldozed) in April 1985. By September 1985, the contours were almost identical to those of September 1984 (Figures B-11 and B-15).

The cross-sectional profiles show the changes in the recreational beach in greater detail than the contour maps. The cross-sectional profiles reveal that relatively little erosion took place on the upper dike face during the study period. On the foreshore and nearshore, however, erosional and, to a lesser extent, depositional processes are evident. The most noticeable feature, common to many of the cross-sectional profiles, is a wave-cut escarpment.

The escarpments are erosional features formed as a result of wind-generated waves assaulting the beach. Severe wave conditions occur here with winds from the north or northeast, the directions of greatest fetch. In Figure 11, wind roses developed from data supplied by the Maryland Environmental Service summarize seasonal wind patterns for September 1984 to September 1985. The most severe wave conditions occurred during the fall and winter. The development and growth of the escarpment accelerated during this time as seen in the cross-sectional profiles.

Another change indicated in the cross-sectional profiles is the widening of the southern end of the recreational beach. This suggests that the direction of the dominant longshore current is from Miller Island to Hart Island. The sourtherly sediment transport is also responsible for the continued growth of a small recurved spit on the tip of Miller Island. The area behind the spit continued to fill during the past year. The spit has essentially welded to Miller Island, with only higher tides and storm surges inundating it. Some material behind the spit may have come from the northern portion of the recreational beach.

Another erosional feature observed on the recreational beach was a series of gullies (Figure 12). The gullies are not readily apparent in the cross-



WIND CLIMATE: HART-MILLER ISLAND VICINITY

Figure 11. Wind rose diagrams for the Hart and Miller Island vicinity based on wind data collected by MES for the period between September 1984 and September 1985.

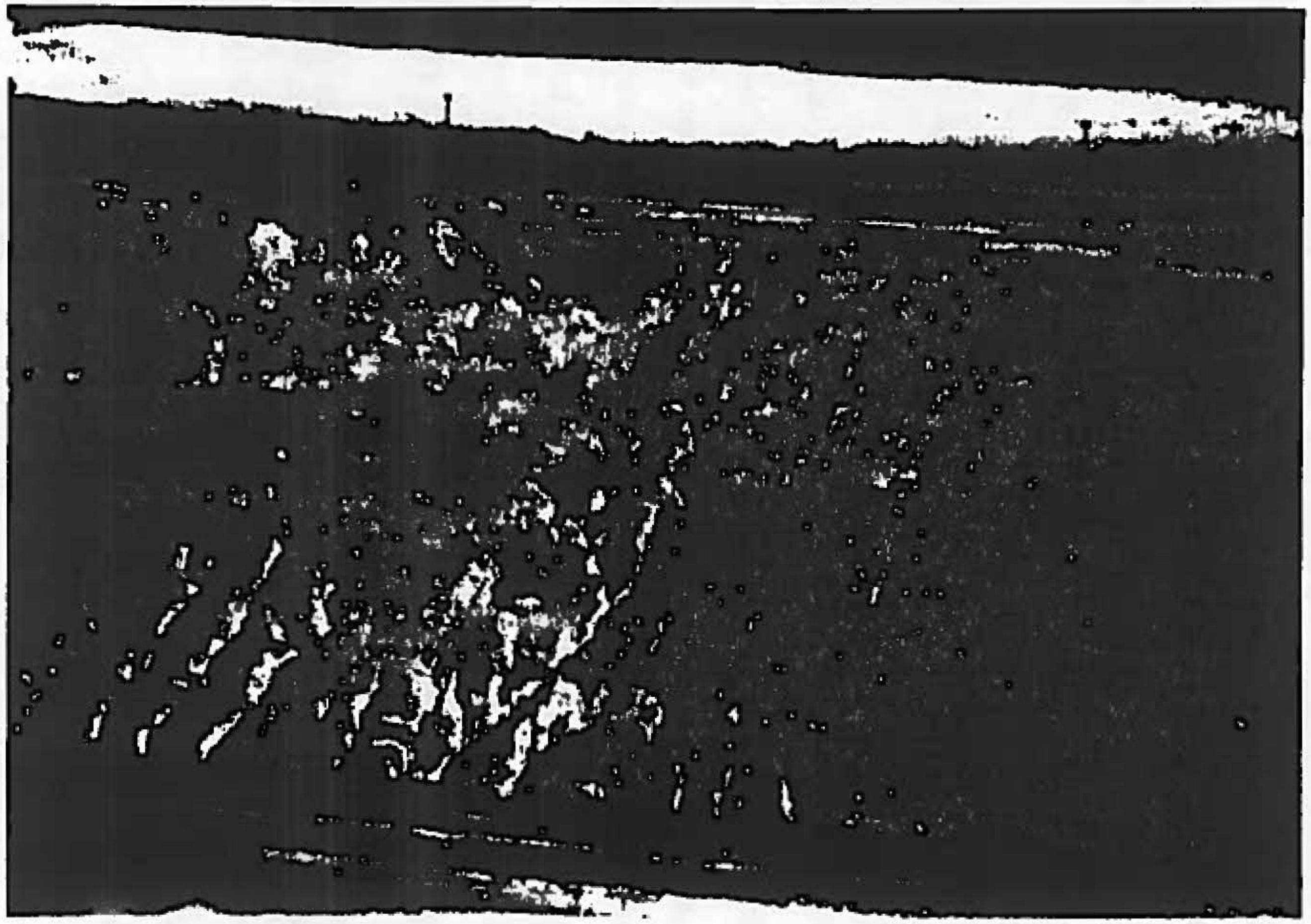


Figure 12. Aerial photograph, dated December 1984, of the recreational beach between profile locations 34+00 and 44+00. The dike road-way is shown at the top of the photograph. Note the gully erosion and the pronounced wave-cut escarpment along the bottom of photograph.

sectional profile or the contour maps. However, gullies were observed on the lower dike face during each of the surveys.

Gully formation is indicative of pluvial (rainfall-related) processes. Three variables are fundamental to the formation and location of gully erosion: gradient or slope, amount of rainfall, and sediment composition. Average slope measurements were calculated (Table 6) and compared to the aerial and ground photography and to the cross-sectional profiles. The profiles with average gradients of 4.1 degrees or less were relatively free of any gully erosion of the dike face. This was evident in profiles 22+00, 24+00, 36+00 and 40+00 which had was no evidence of gully erosion. For areas with gradients greater than 4.1 degrees, gully erosion was observed.

The headward extent of the gullies depends on gradient changes along the profile. Above the +10 foot contour, the profiles were consistent through time with no evidence of gully erosion. Between the +10 foot contour and the +5 foot contour, there was a measured increase in the gradient at the northern profiles 40+00, 44+00, 48+00 and 49+00. At each of these profiles, gully erosion was prevalent and accounted for the changes observed in the profiles. Generally, an increase in dike face gradient increased the extent of gully erosion.

EFFECTS OF REGRADING

The recreational beach was regraded in April 1985; essentially obliterating any and all features that had evolved. In the process of smoothing the beach face, material was taken from one area (presumably the upper dike face) and placed in eroded areas. In some cases the slope or gradient of the beach was increased (see Table 6; change in slopes from March to June 1985), inviting more serious erosion such as gully erosion and sheetwash.

TABLE 6. Average slope of recreational beach in degrees

Station Date	September 1984	December 1984	March 1985	June 1985	September 1985
22+00	3.7	3.6	3.5	3.5	3.5
24+00	3.9	3.8	3.8	3.5	3.6
28+00	4.4	4.3	4.3	4.2	4.1
30+00	4.7	4.7	4.7	4.6	4.5
32+00	4.5	4.6	4.2	4.1	4.1
36+00	4.1	4.2	4.0	3.8	3.8
40+00	4.0	3.9	3.9	3.9	3.9
44+00	4.3	4.5	4.1	4.2	4.2
48+00	5.0	5.2	4.5	5.3	4.8
49+00	4.5	4.8	4.2	4.7	4.2

NET EROSION AND DEPOSITION

From the beginning of the recreational beach study,May 1984 to September 1985 approximately 300 cubic yards (230m^3) of material were removed from the beach above mlw. The bulk of the material was from the lower dike face and foreshore areas (Figure 13). The main process of removal was wave erosion, resulting in the formation of a wave-cut escarpment. However, regrading (in the summer of 1984 and April 1985) contributed to further erosion by redistributing material from the dike face onto the wave-exposed foreshore area. Moreover, erosion occurred on the middle dike face, particularly at the north end, as a result of both pluvial processes (gully erosion) and regarding.

BEACH SEDIMENT DISTRIBUTION

The results of the textural analysis of beach sediment collected during the June 1985 survey are listed in the Fourth Year Data Report. Most of the beach sediments are classified as sand with sand percentages ranging from 58.7% to 100%. A few samples are classified as gravelly sand and sandy gravel with gravel percentages as high as 36.6%. Most of the sediments contained small amounts of silt/clay, ranging from a trace to 17.7%.

The distribution patterns of silt/clay and gravel on the recreational beach were similar to those found in the summer of 1984. Some trends can be inferred from the distribution pattern seen, even though the samples were collected after regarding.

Much of the finer material (silt/clay) was found in the middle of the dike face (Figure 14). The finer material was removed from the lower dike face and foreshore area by wave activity. Silt/clay was also removed from the top of southern portion of the dike face by deflation.

The distribution of gravel, on the other hand, appeared to be a result of anthropogenic processes (Figure 15). In the previous report (Wells et al., 1985), it was noted that coarser material was found on the north end of the

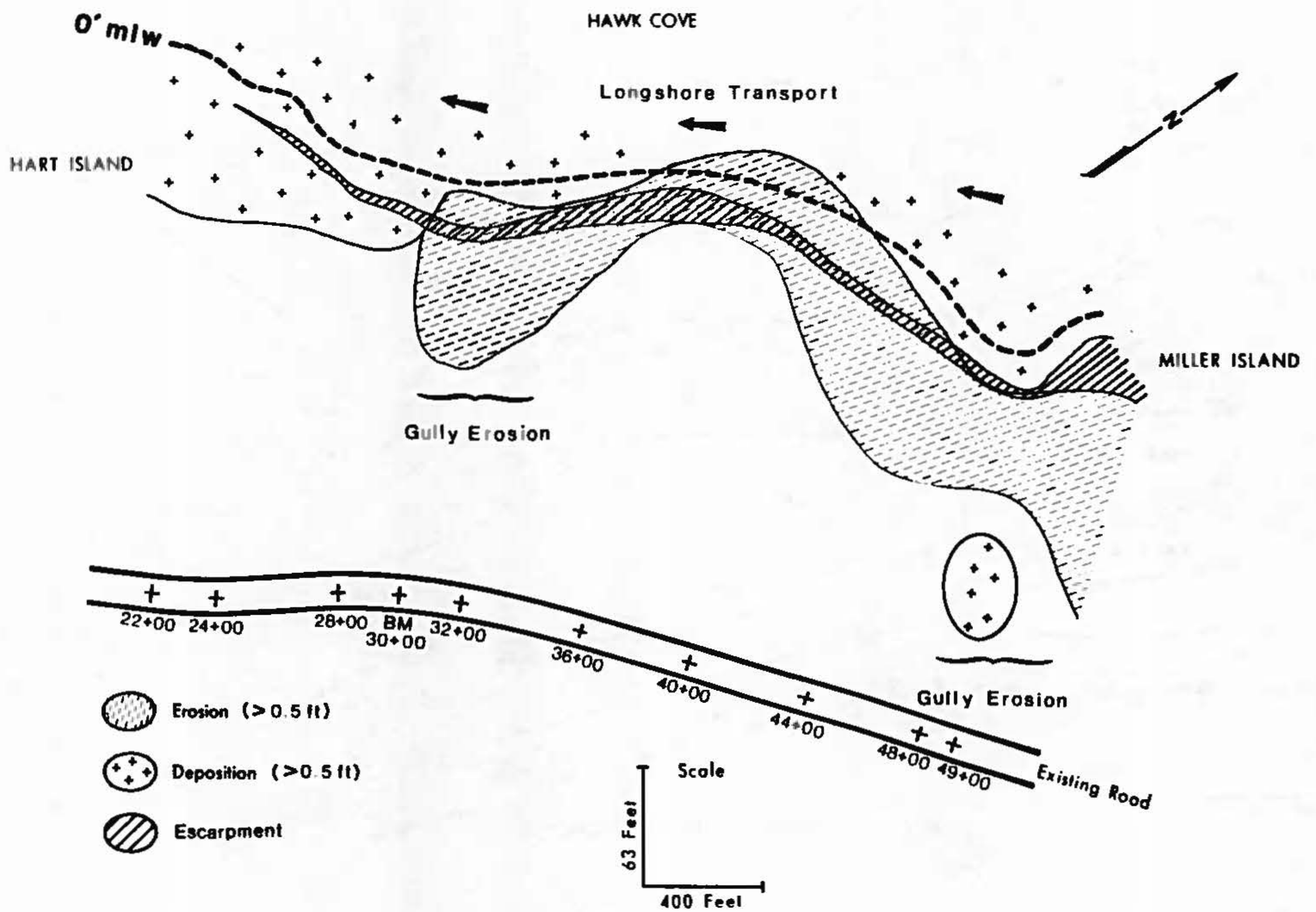


Figure 13. Map of the recreational beach summarizing erosional and depositional changes that took place between May 1984 and September 1985. The 0' mlw contour line is taken from the September 1985 survey data.

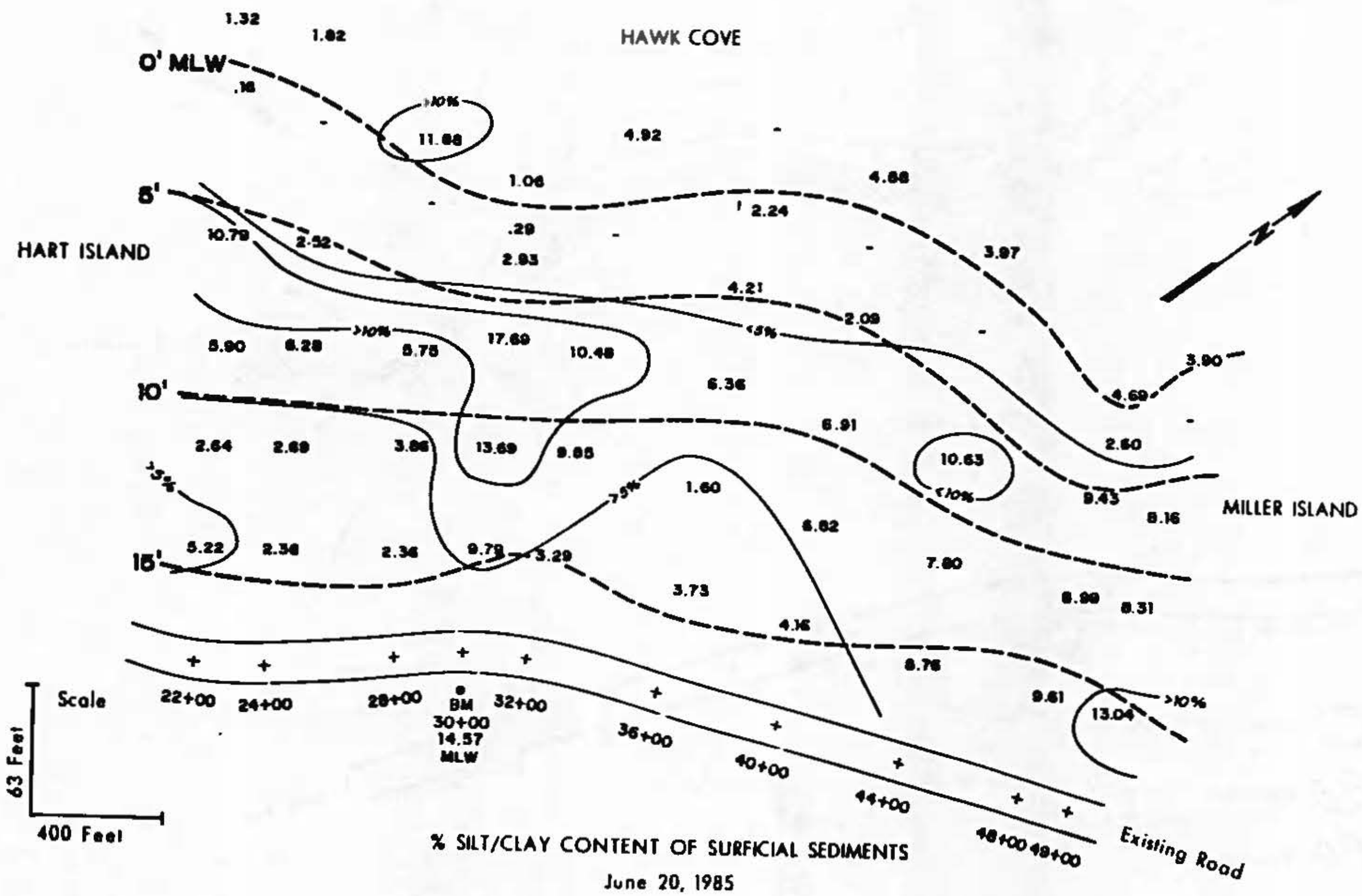


Figure 14. Map showing the areal distribution of silt/clay (percent weight) contained in the beach material.

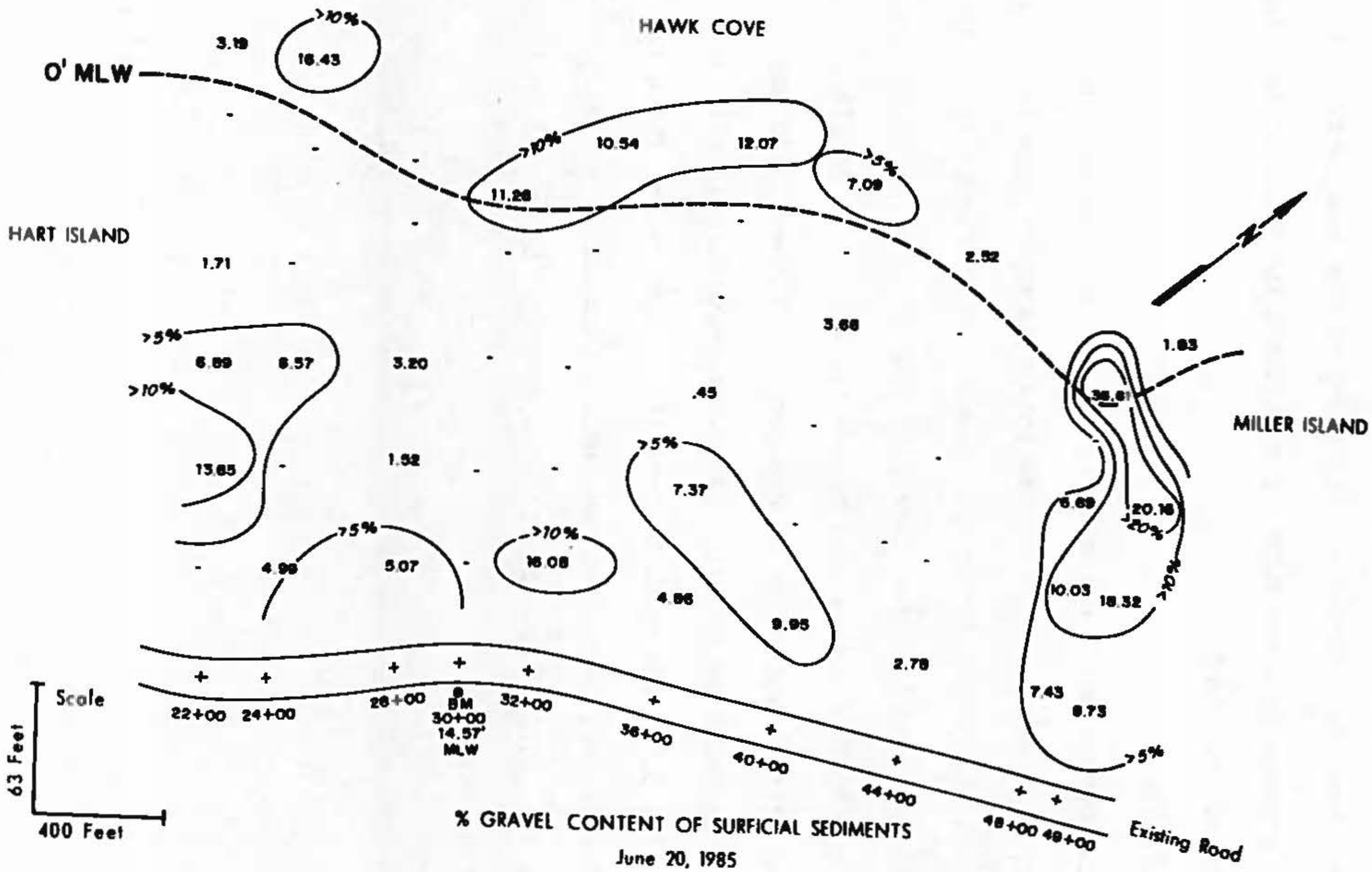


Figure 15. Map showing areal distribution of gravel (percent weight) contained in the beach material.

recreational beach, reflecting the type of material used to construct the beach and dike face. However, the percentages of gravel were greater than those observed in the second year. This increase may be attributed to winnowing of the finer material by sheetwash and gullying on the dike face and wave activity on the foreshore. Moreover, regrading of the beach may have exaggerated the process by concentrating additional material containing gravel on the north end of the beach.

EFFECTS OF VEGETATION

A recent development which effectively reduced erosion was the establishment of vegetation on the recreational beach and dike face. All of the vegetation was introduced by natural means. In September 1985, a variety of plants were growing on the dike face with the densest vegetation between profiles 36+00 and 40+00. There were many different types of plants on the beach, including several varieties of grasses, wildflowers, and small trees. The grasses found on the dike face were particularly effective in trapping fine, wind blown material (Figure 16). The grasses found near the upper foreshore were very dense and had begun to establish a small dune-like feature (Figure 17). The vegetative cover appears to be useful in trapping sand and deterring erosion.

Figure 16. Photograph taken in September 1985 of grasses that were growing on the upper dike face near profile location 36+00. The grasses are particularly efficient in "catching" fine-grained wind blown sediments, as seen in this photograph.

Figure 17. View of the recreational beach at profile 40+00, looking south toward Hart Island. The grasses have become very dense and began to establish a small dune-like feature. This photograph was taken in September 1985.

CONCLUSION

Based on the observed beach changes, both natural and anthropogenic processes have been operating actively on the recreational beach. Although the overall configuration of the beach was similar to that observed previously, continued erosion and deposition occurred. The southern end of the recreational beach became wider as a result of the longshore transport of sediments. The main agent of erosion has been wave attack of the foreshore by wind-generated waves. To a lesser degree, gully erosion has affected the dike face in areas where the slope is greatest.

To ameliorate the erosion problem, the recreational beach would have to be renourished with suitable material at the time of regrading to maintain or decrease beach gradients.

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APPENDIX A

Figures A-1 through A-7:

X-radiographs of gravity cores.

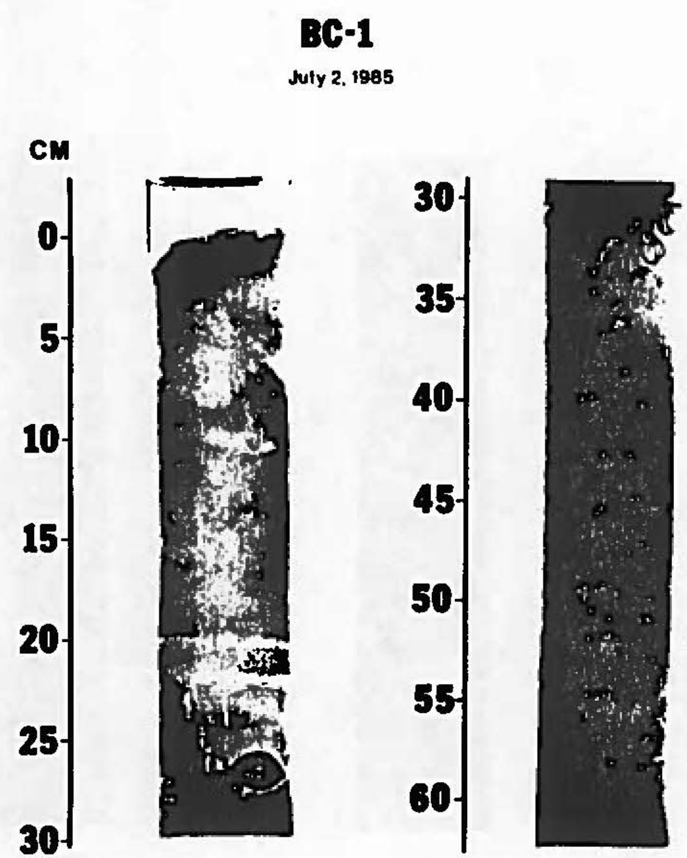

Figure A-1

BC-2

April 15, 1985

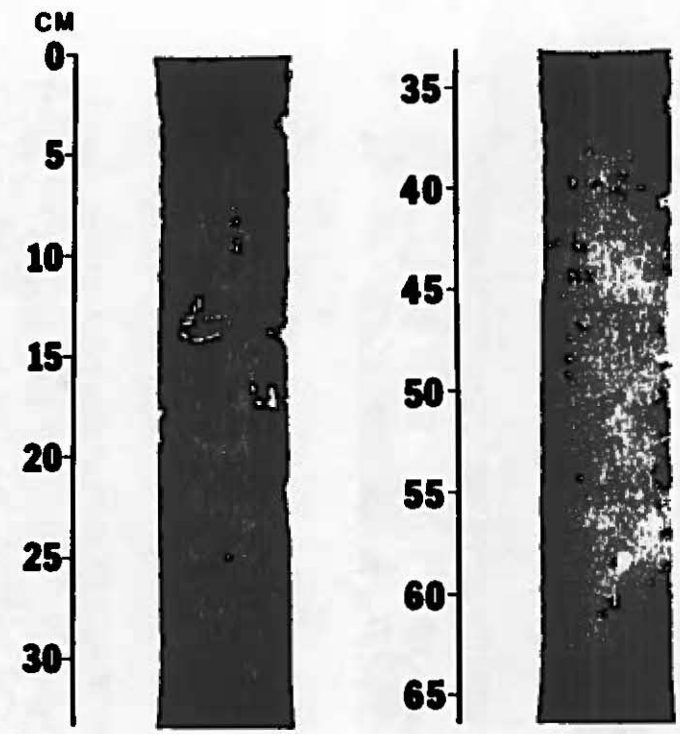

Figure A-2

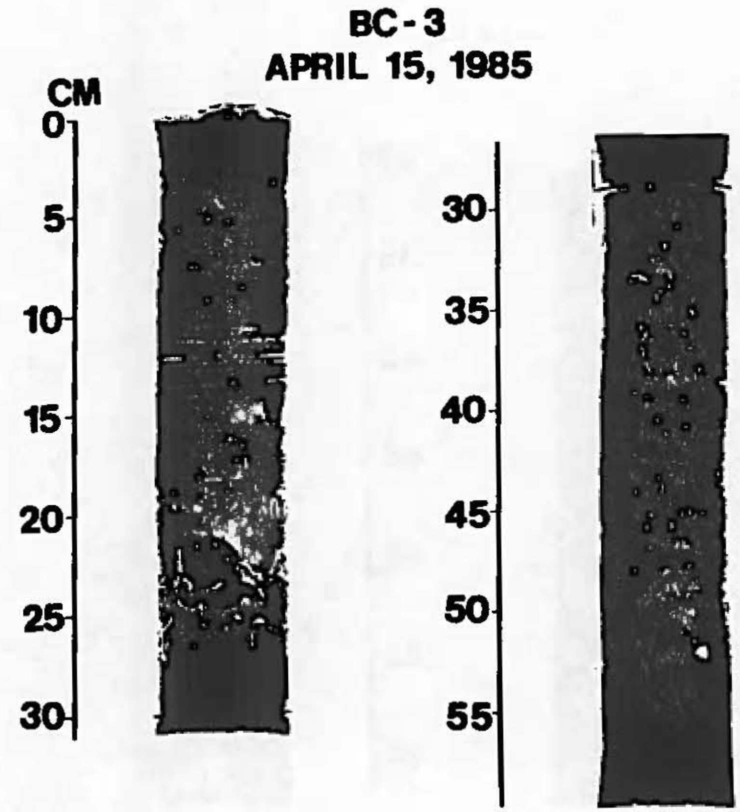

Figure A-3

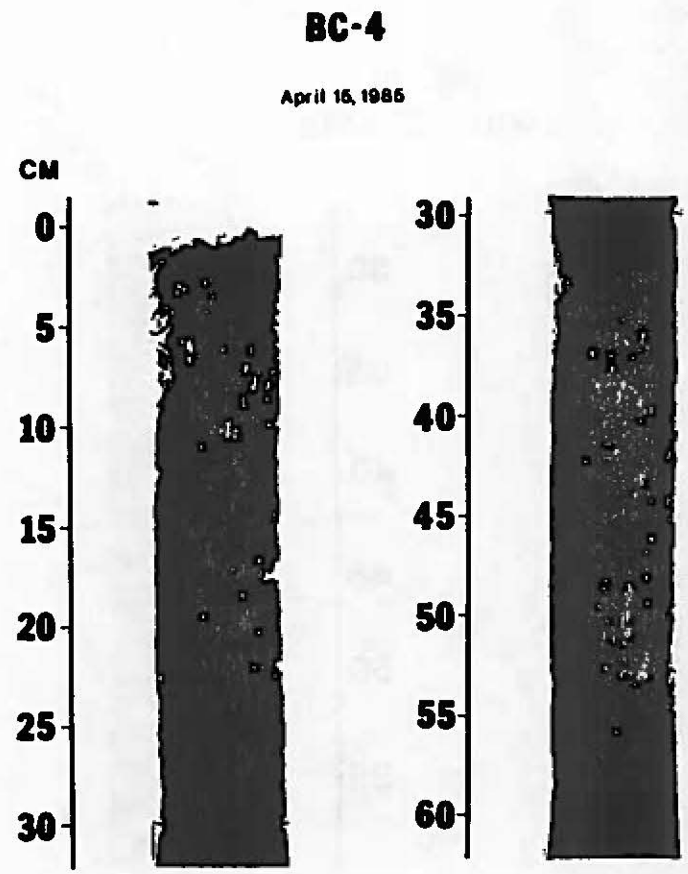

Figure A-4

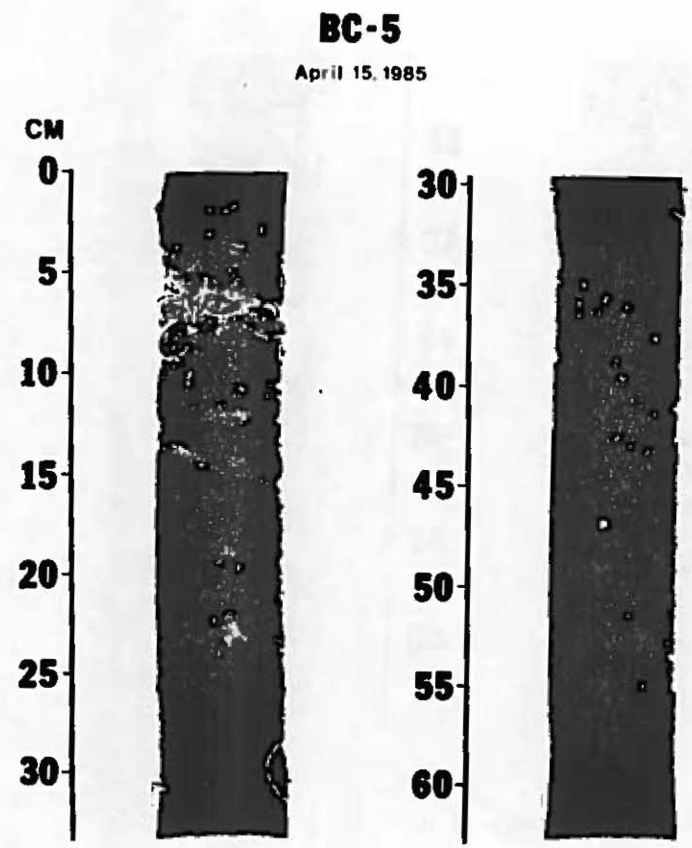

Figure A-5

BC-6

April 15, 1985

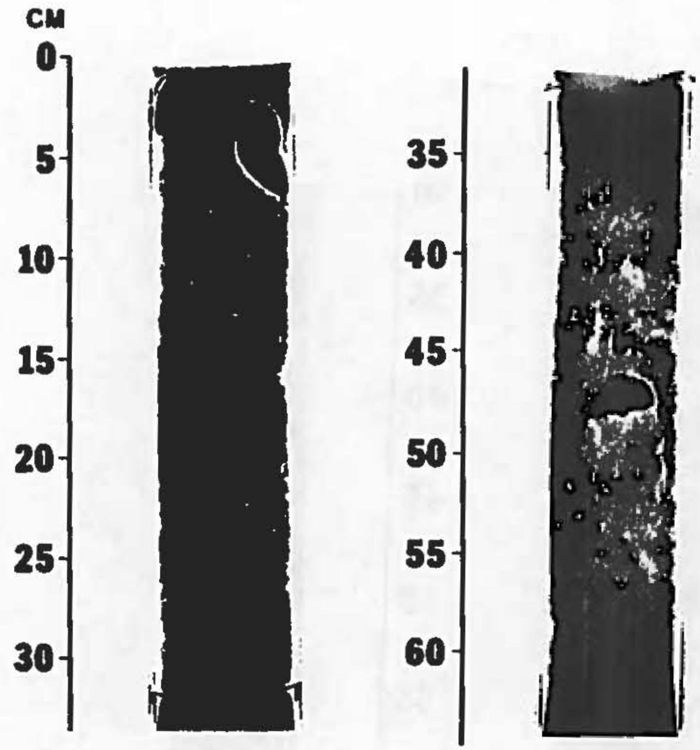

Figure A-6

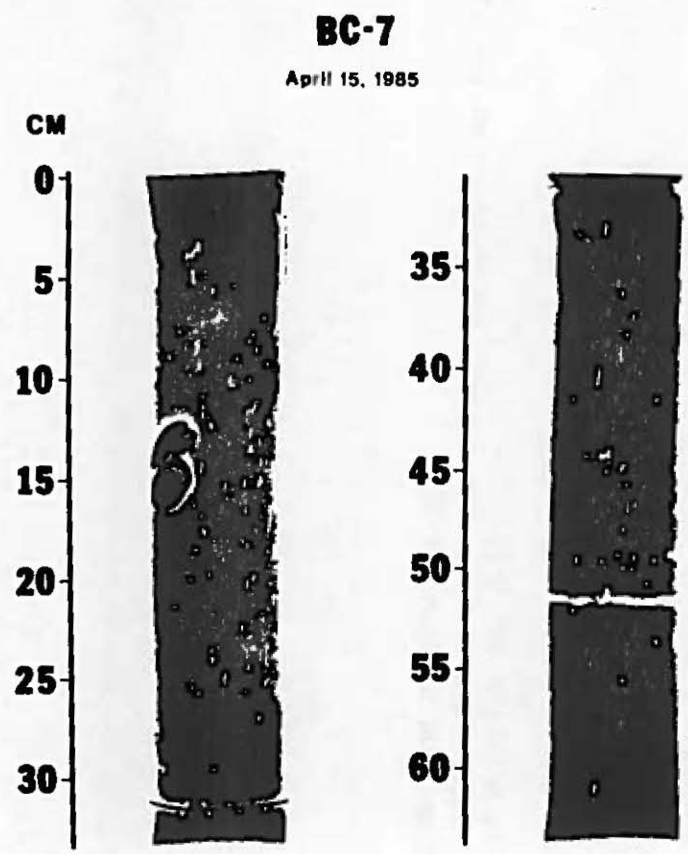

Figure A-7

APPENDIX B

Figures B-1 through B-10:
Graphs of beach profiles.

Figures B-11 through B-15:
Contour maps of the recreational beach based on elevation data from each profile survey.

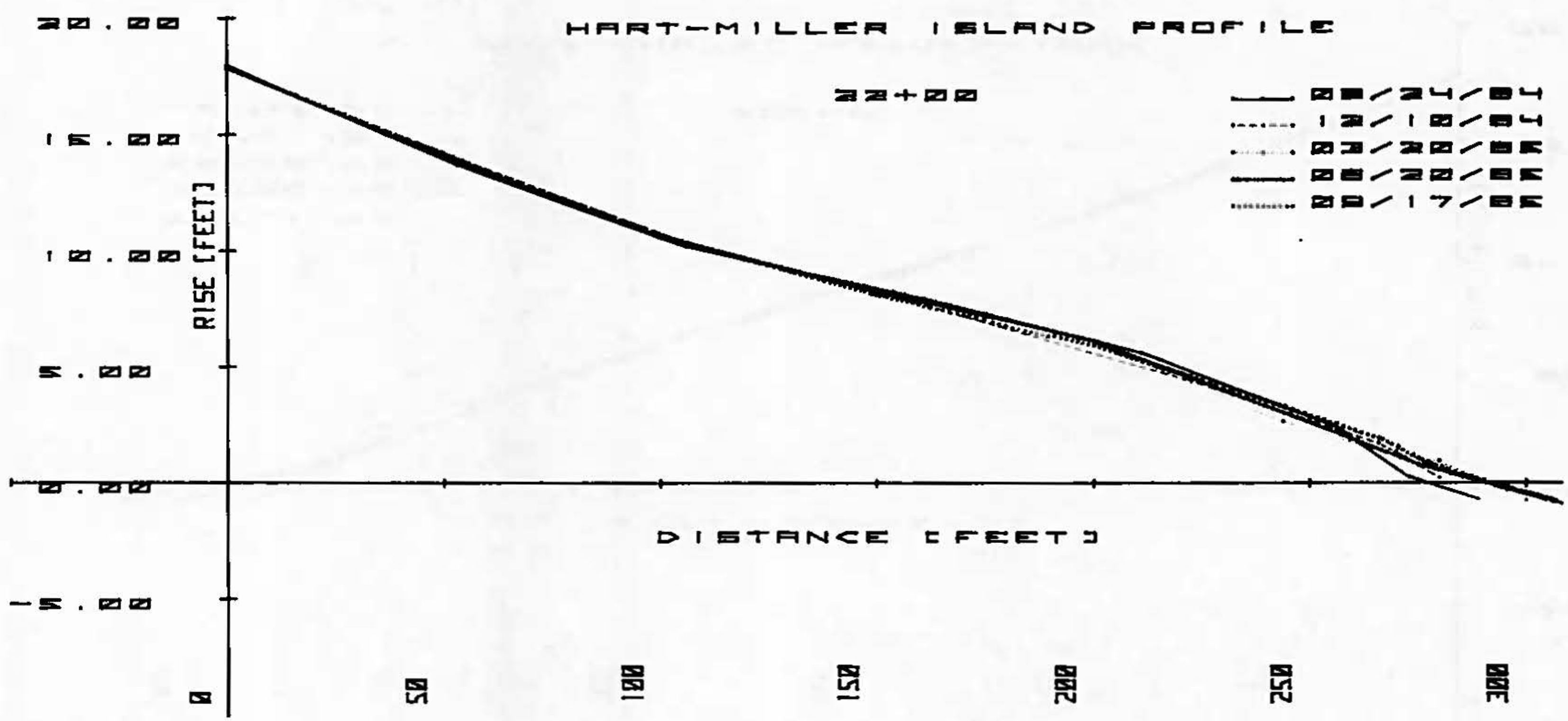

Figure B-1. Profile changes seen at Profile Station 22+00 during the study period.

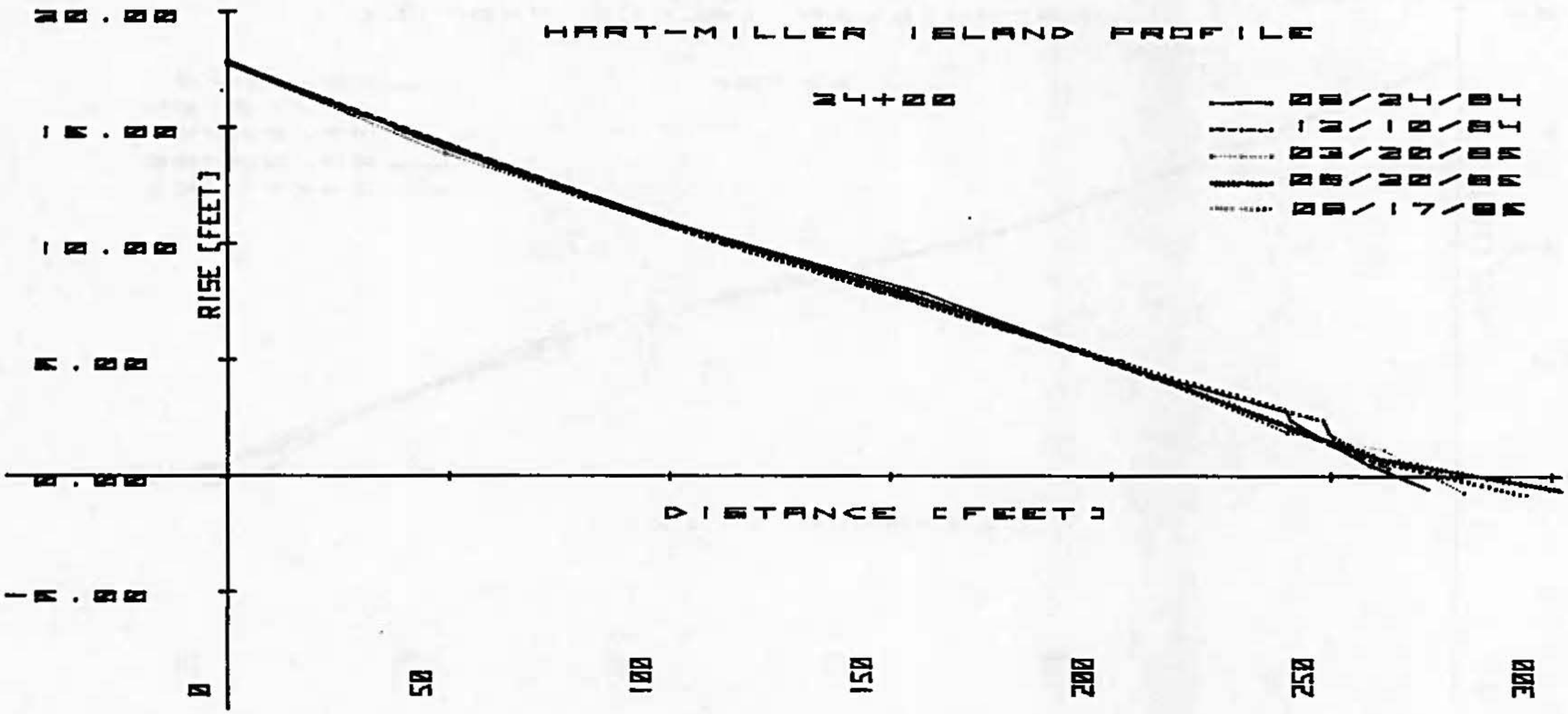

Figure B-2. Profile changes seen at Profile Station 24+00 during the study period.

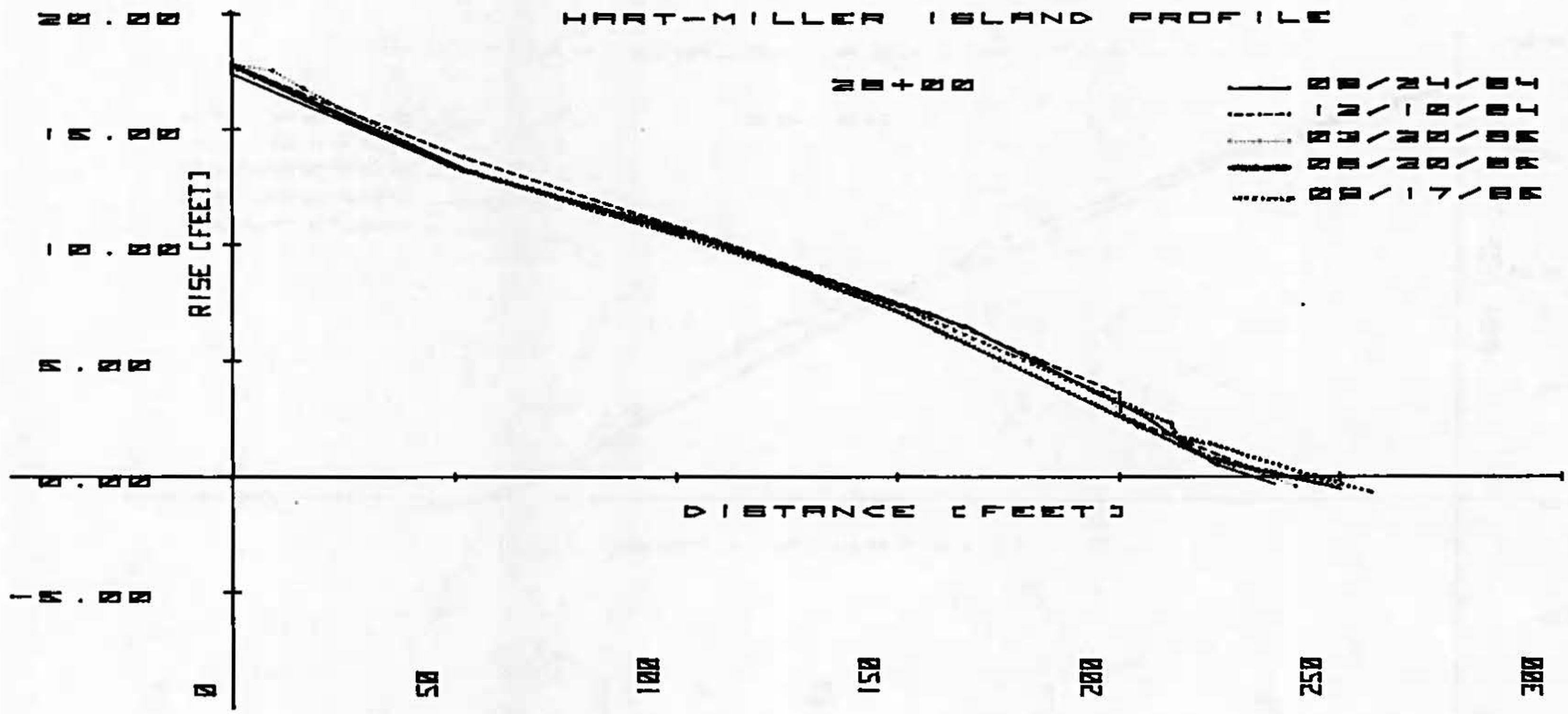

Figure B-3 Profile changes seen at Profile Station 28+00 during the study period.

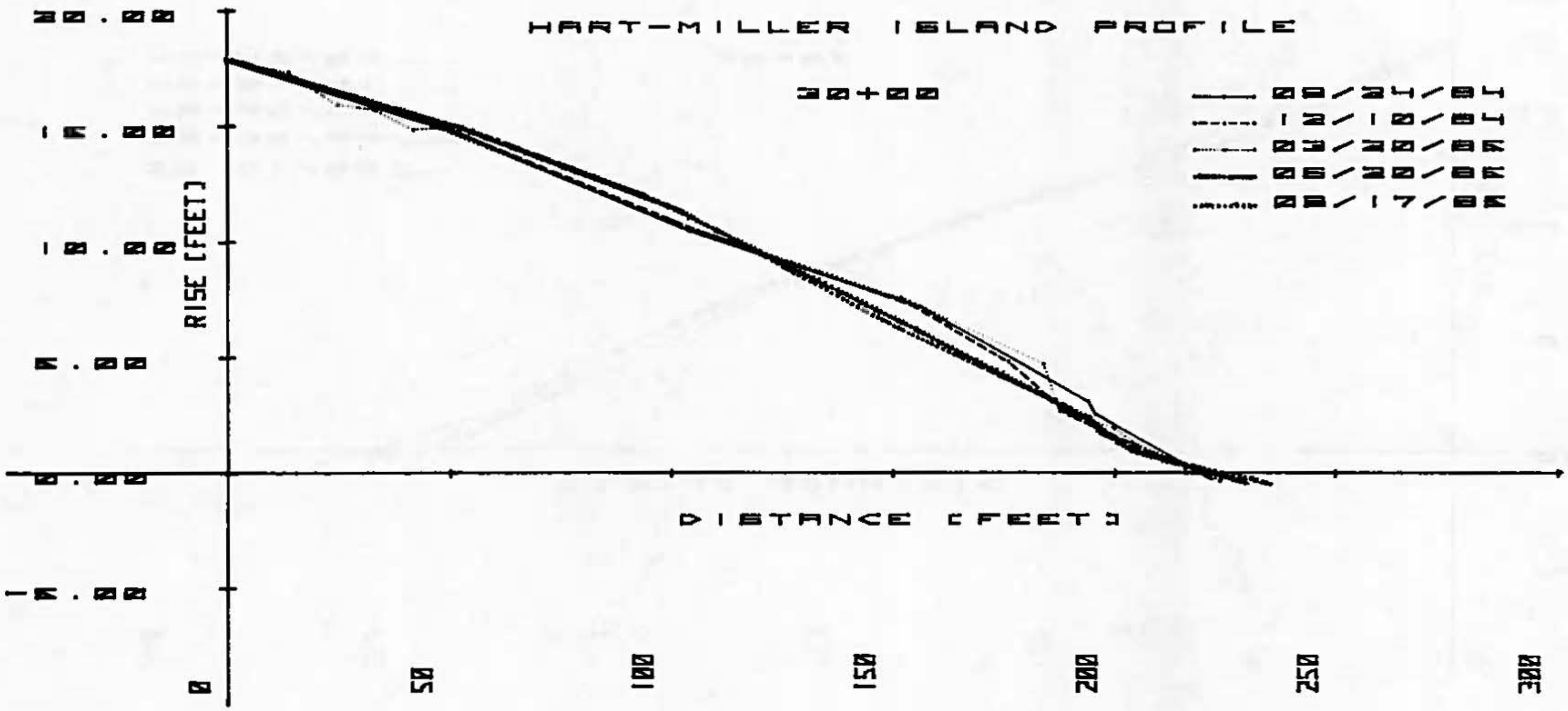

Figure B-4, Profile changes seen at Profile Station 30+00 during the study period.

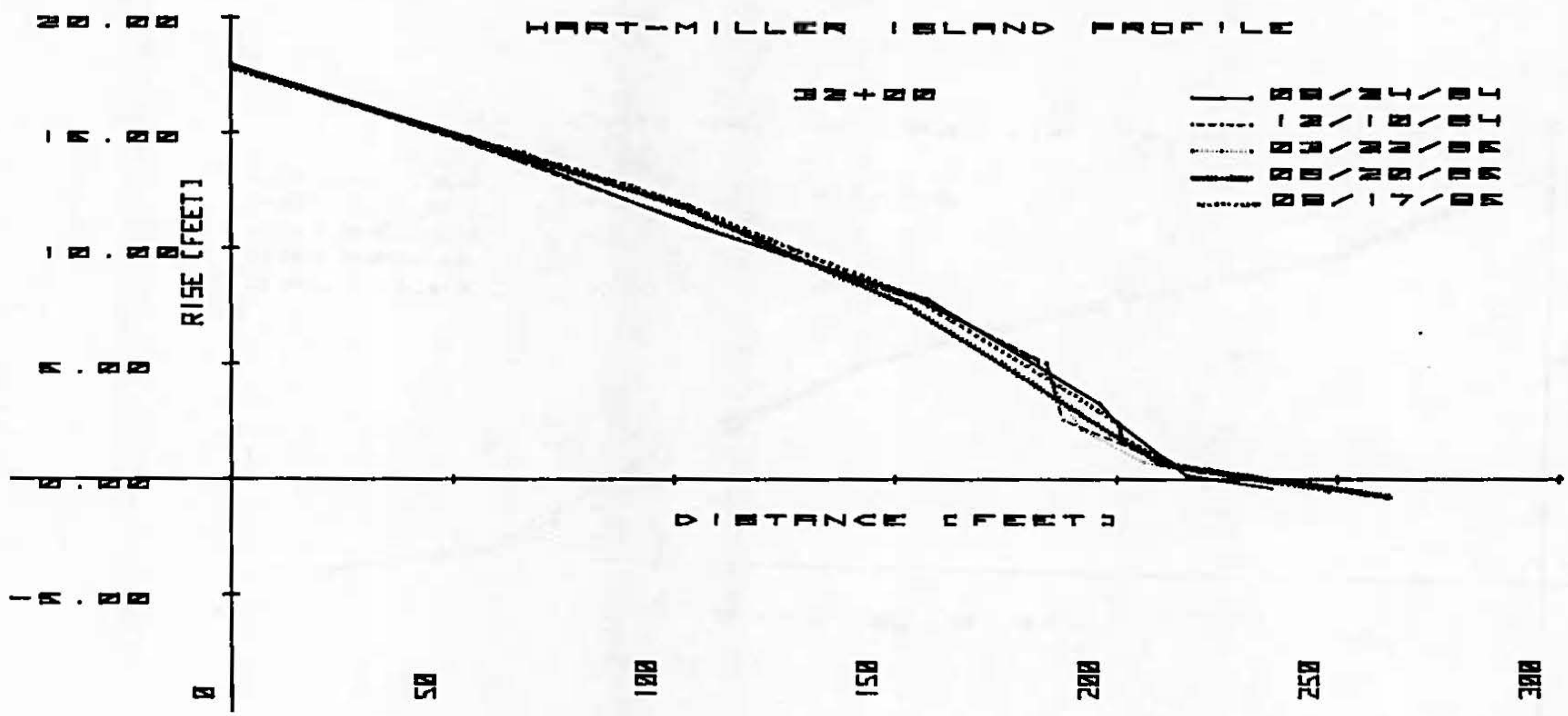

Figure B-5. Profile changes seen at Profile Station 32+00 during the study period.

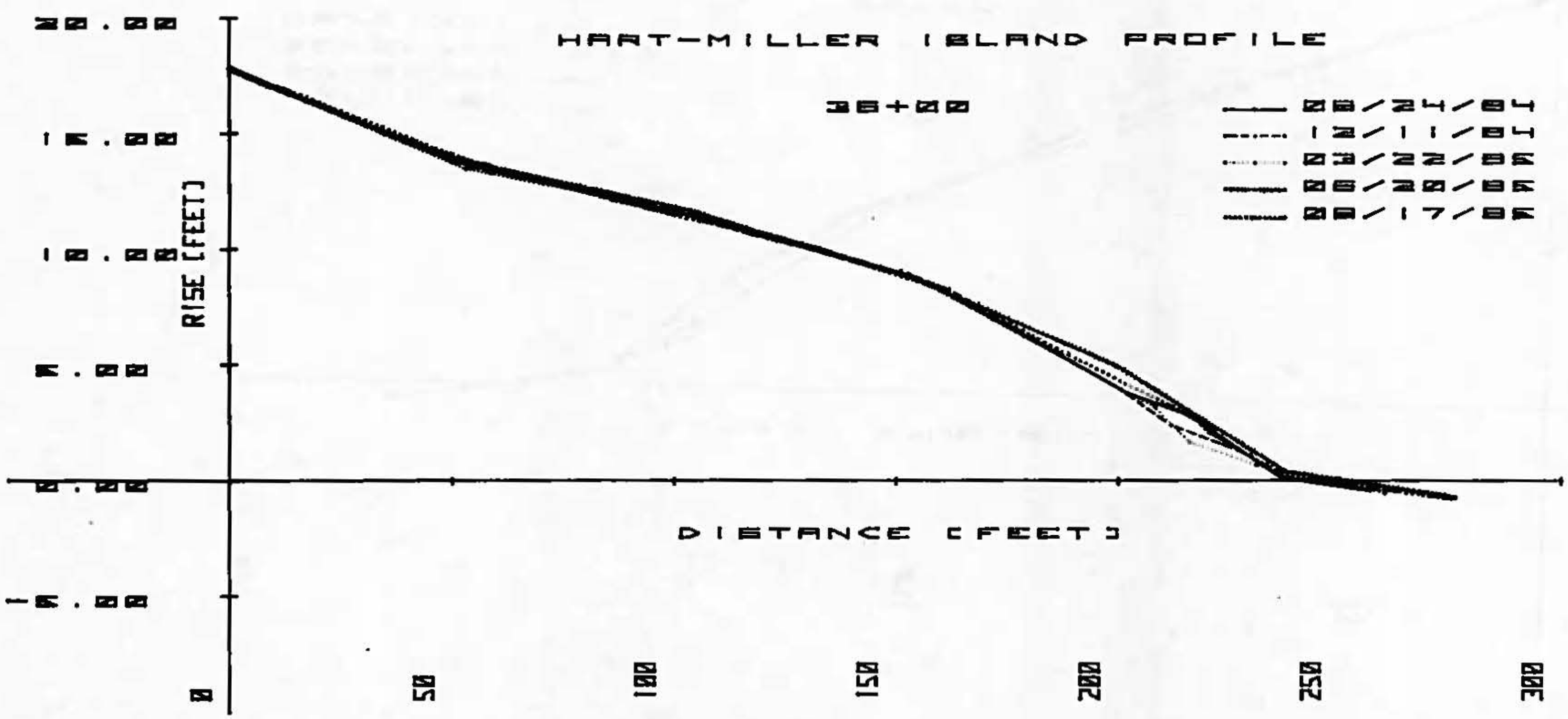

Figure B-6. Profile changes seen at Profile Station 36+00 during the study period.

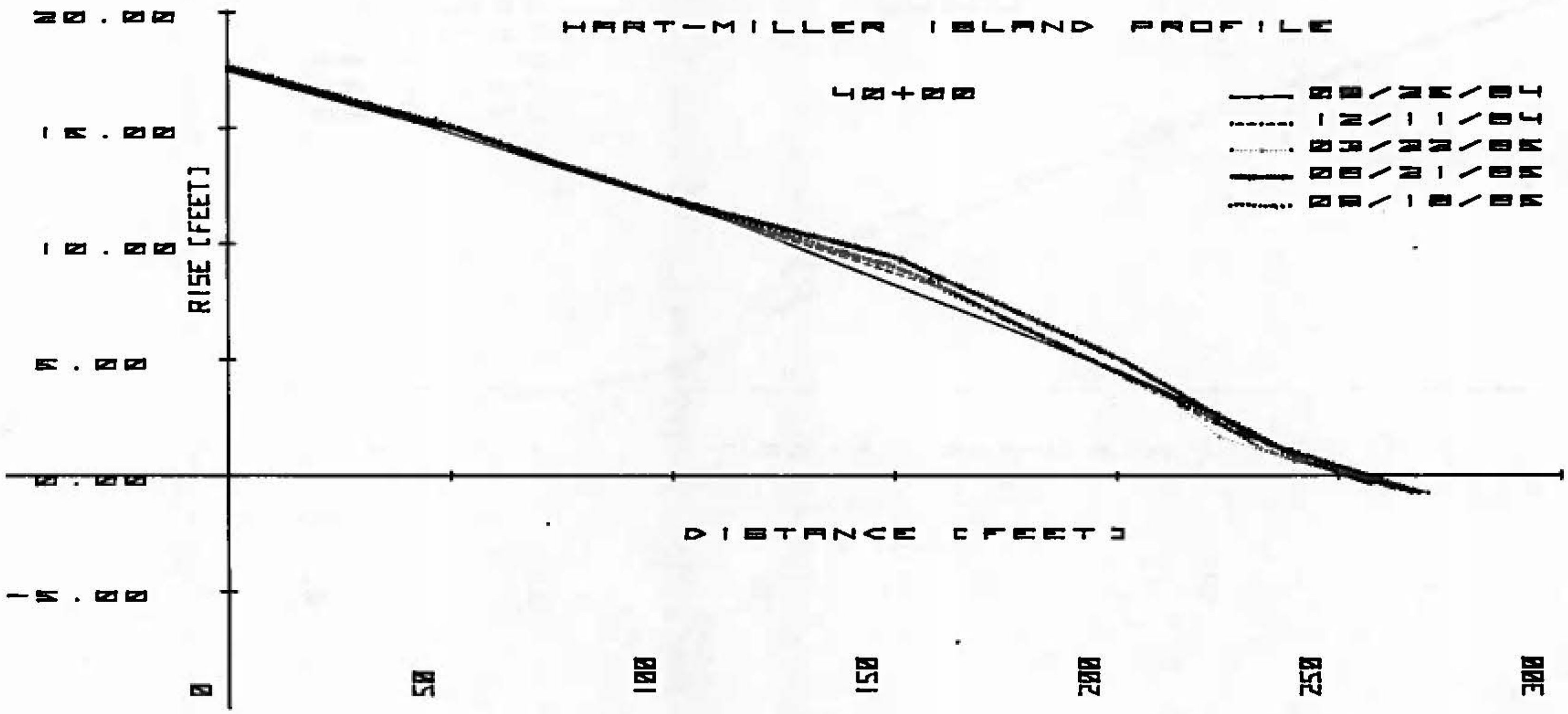

Figure B-7 Profile changes seen at Profile Station 40+00 during the study period.

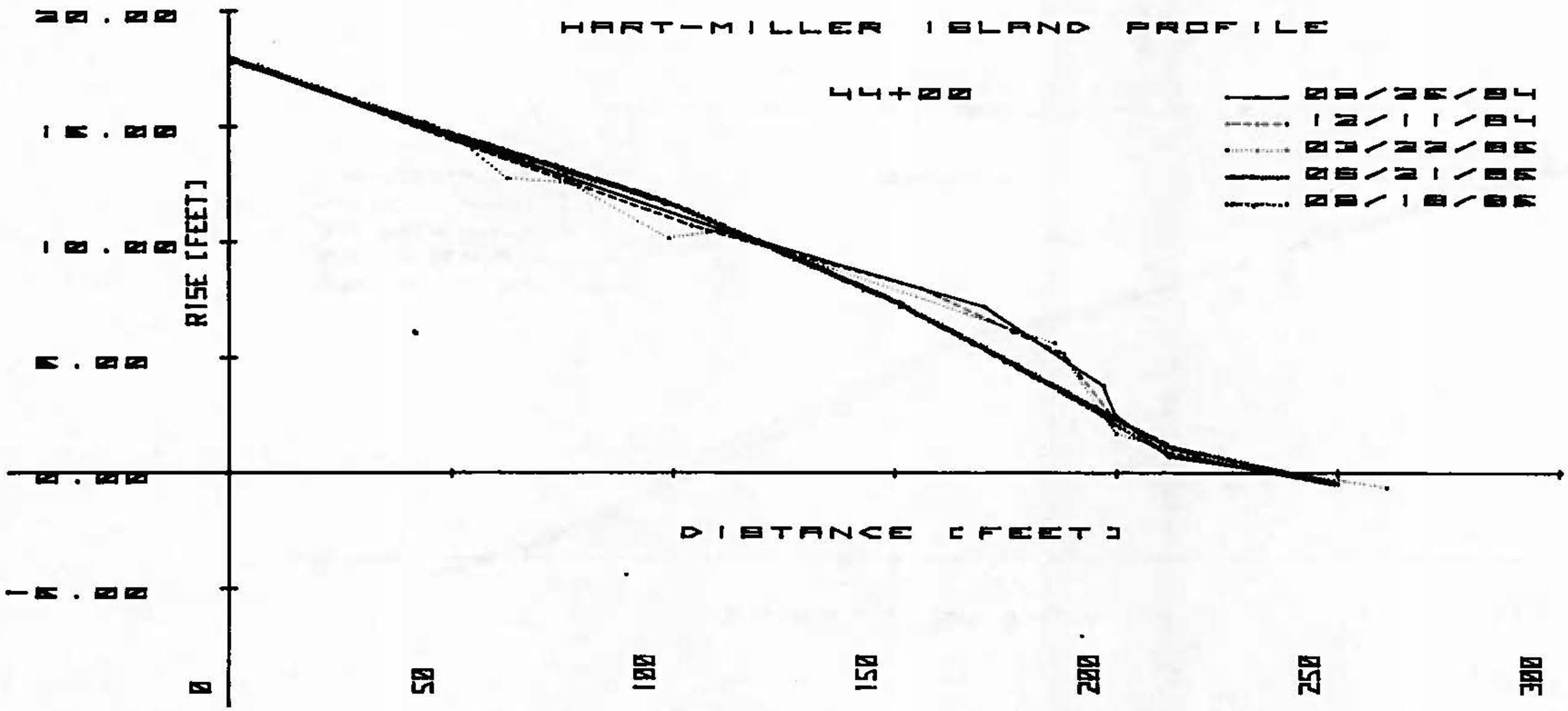

Figure B-8 Profile changes seen at Profile Station 44+00 during the study period.

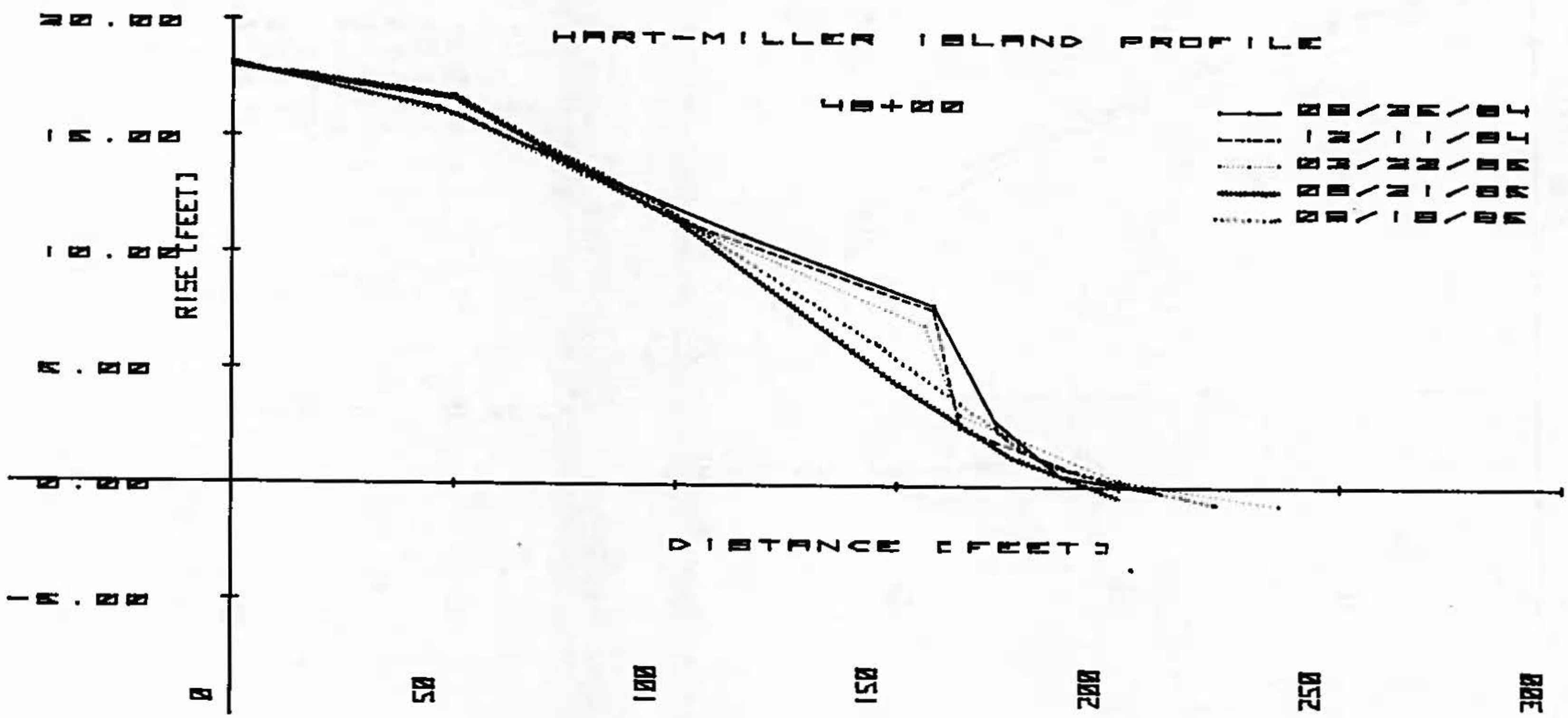

Figure B-9 Profile changes seen at Profile Station 48+00 during the study period.

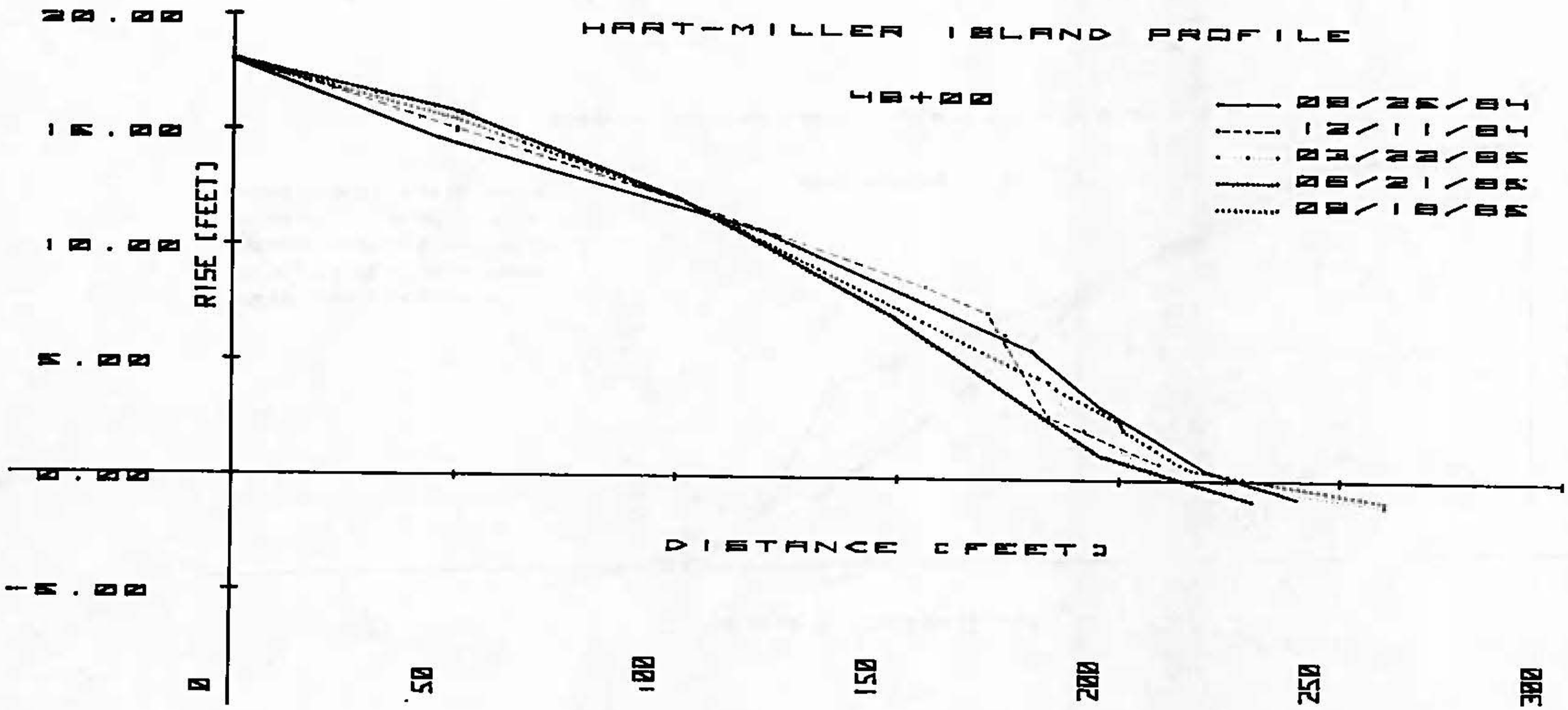

Figure B-10 Profile changes seen at Profile Station 49+00 during the study period.

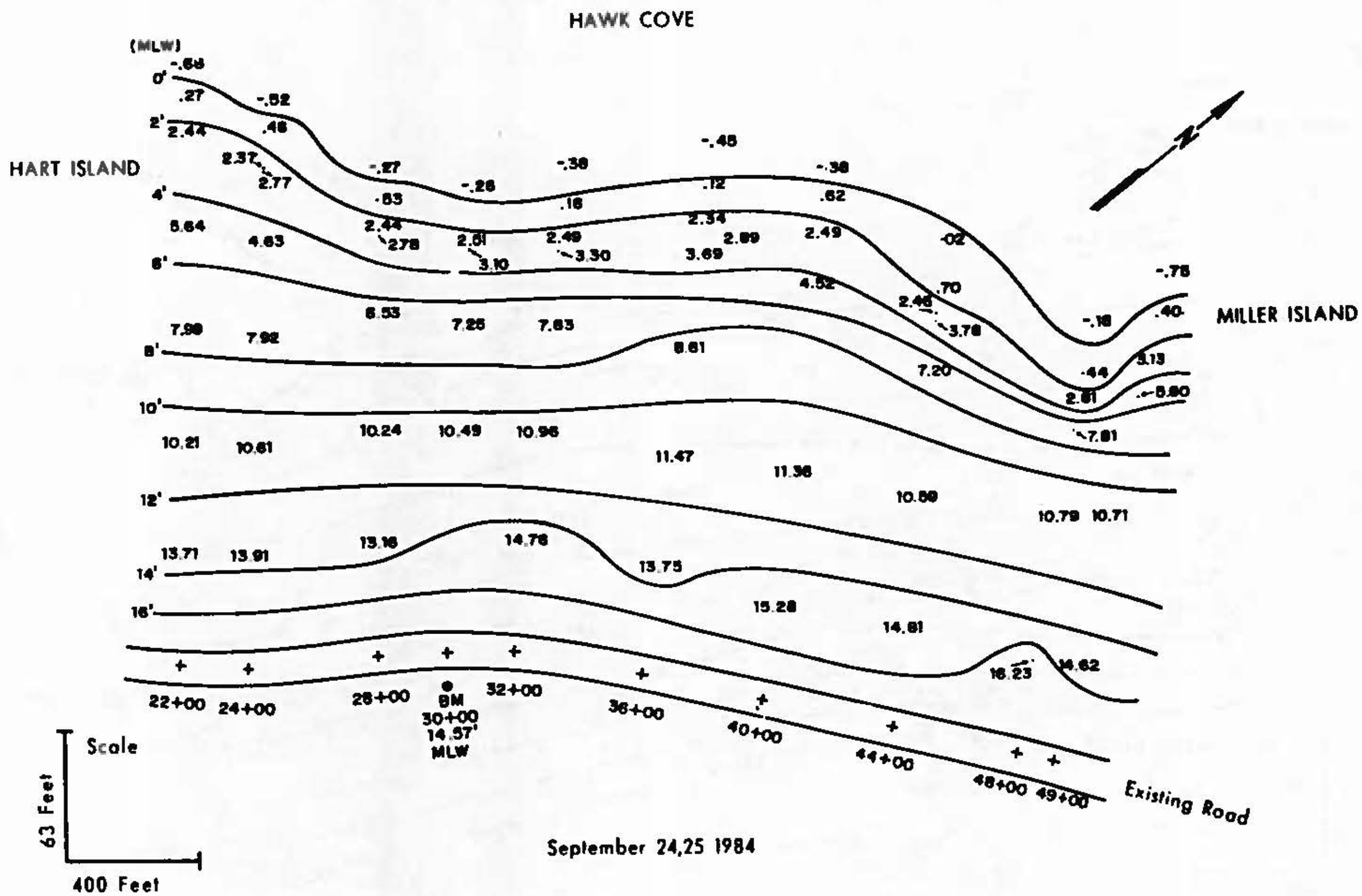

Figure B-11. Contour map of recreational beach based on September, 1984 survey.

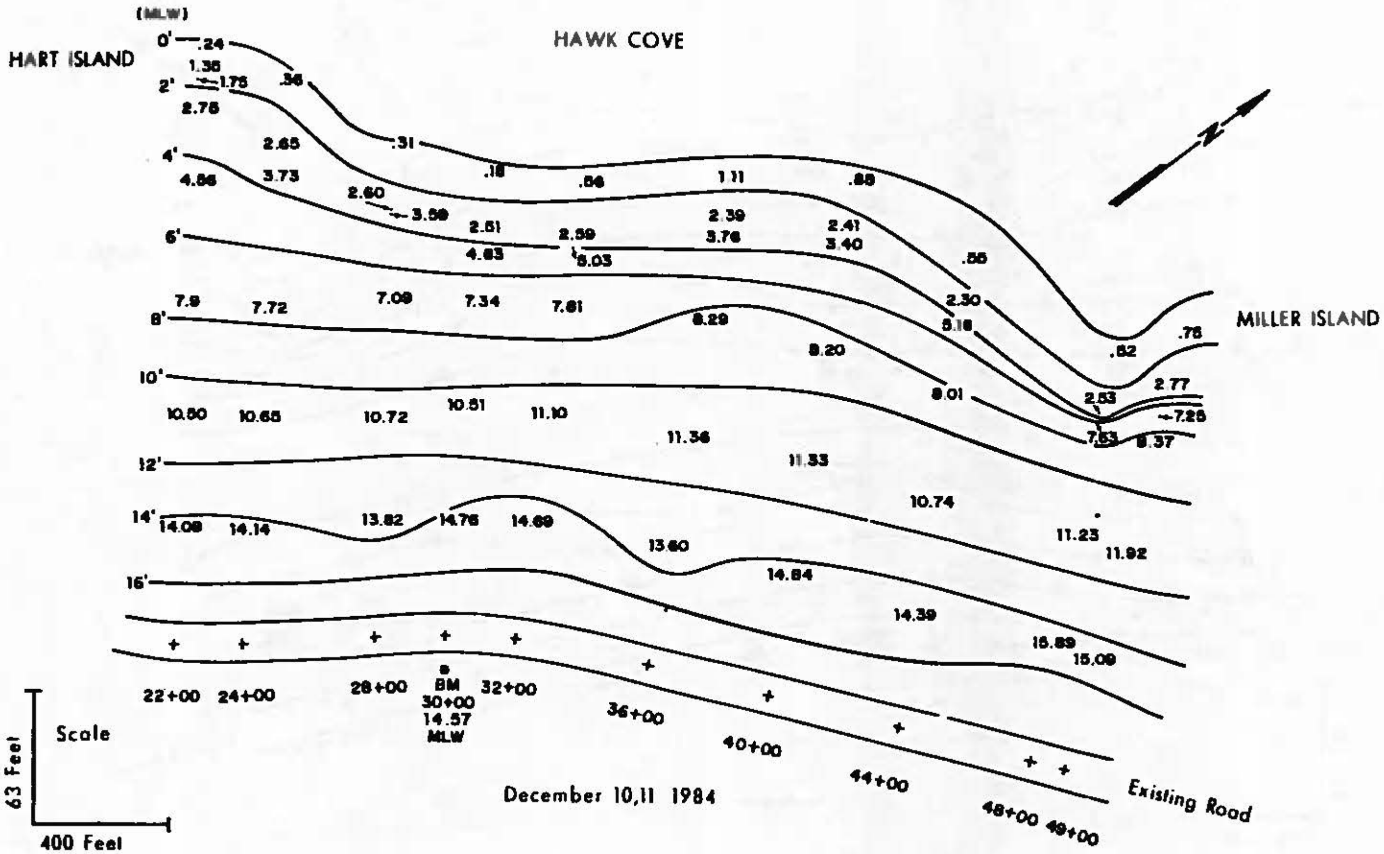

Figure B-12. Contour map of recreational beach based on December, 1984 survey.

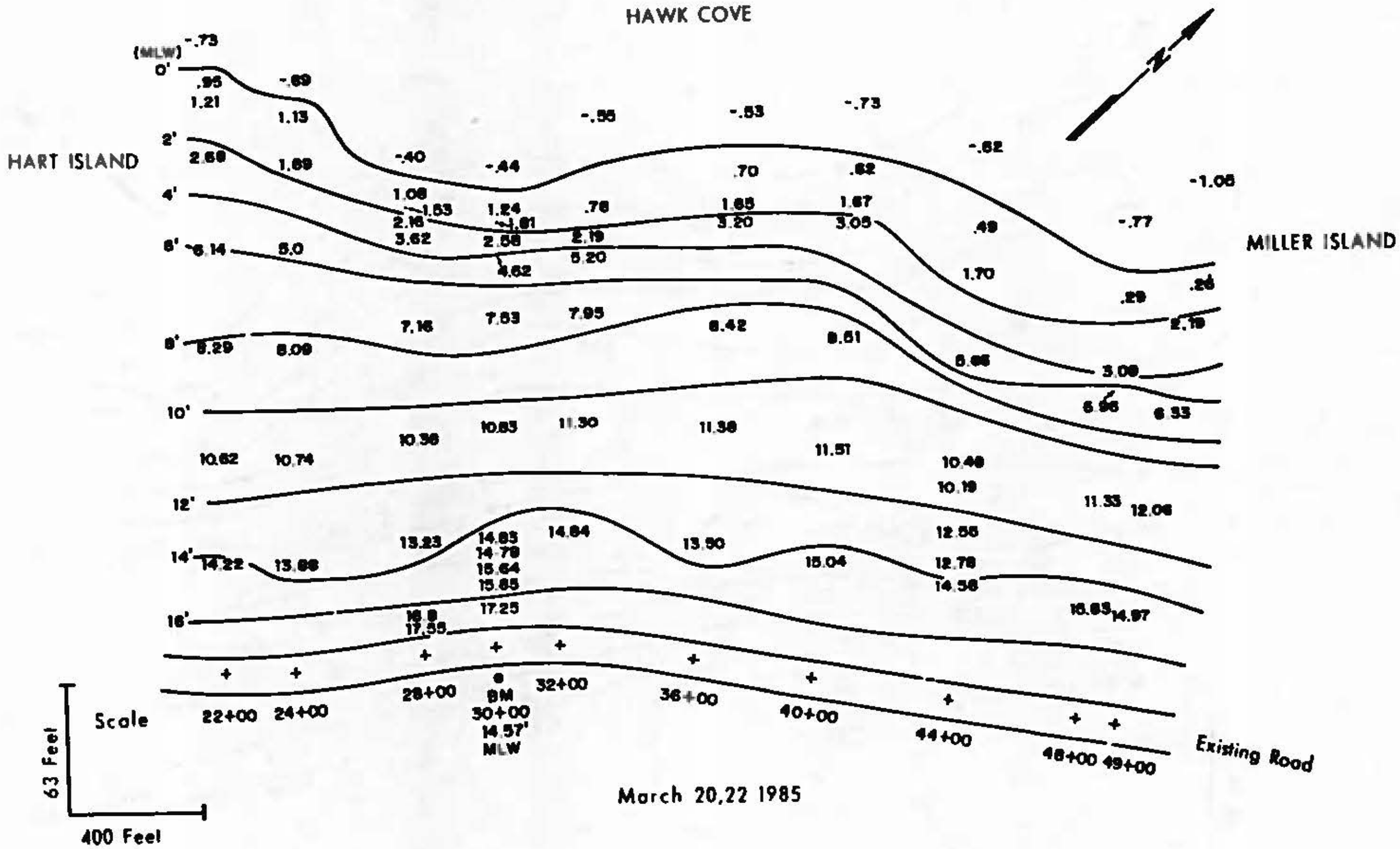

Figure B-13. Contour map of recreational beach based on March, 1985 survey.

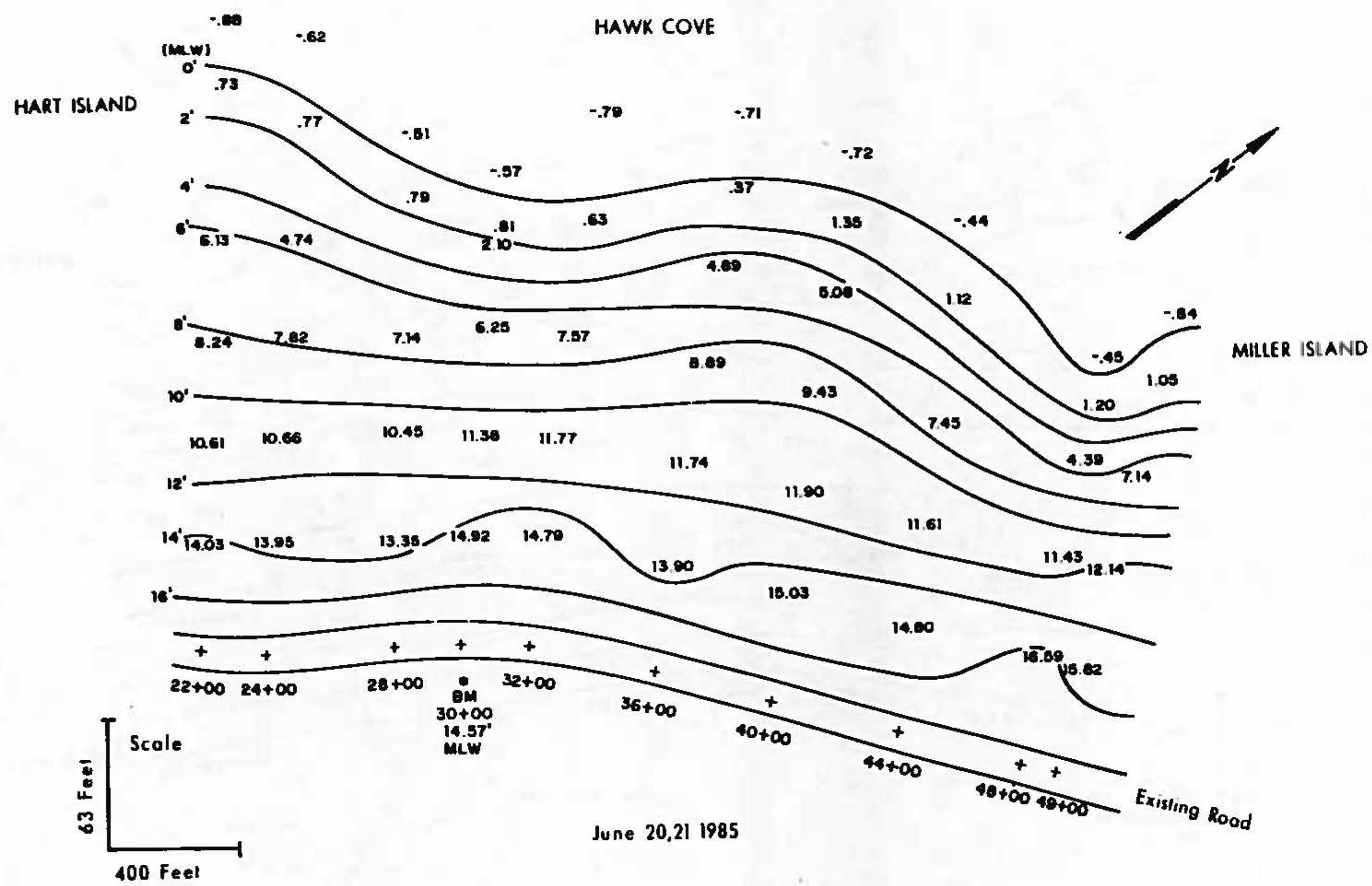

Figure B-14. Contour map of recreational beach based on June, 1985 survey.

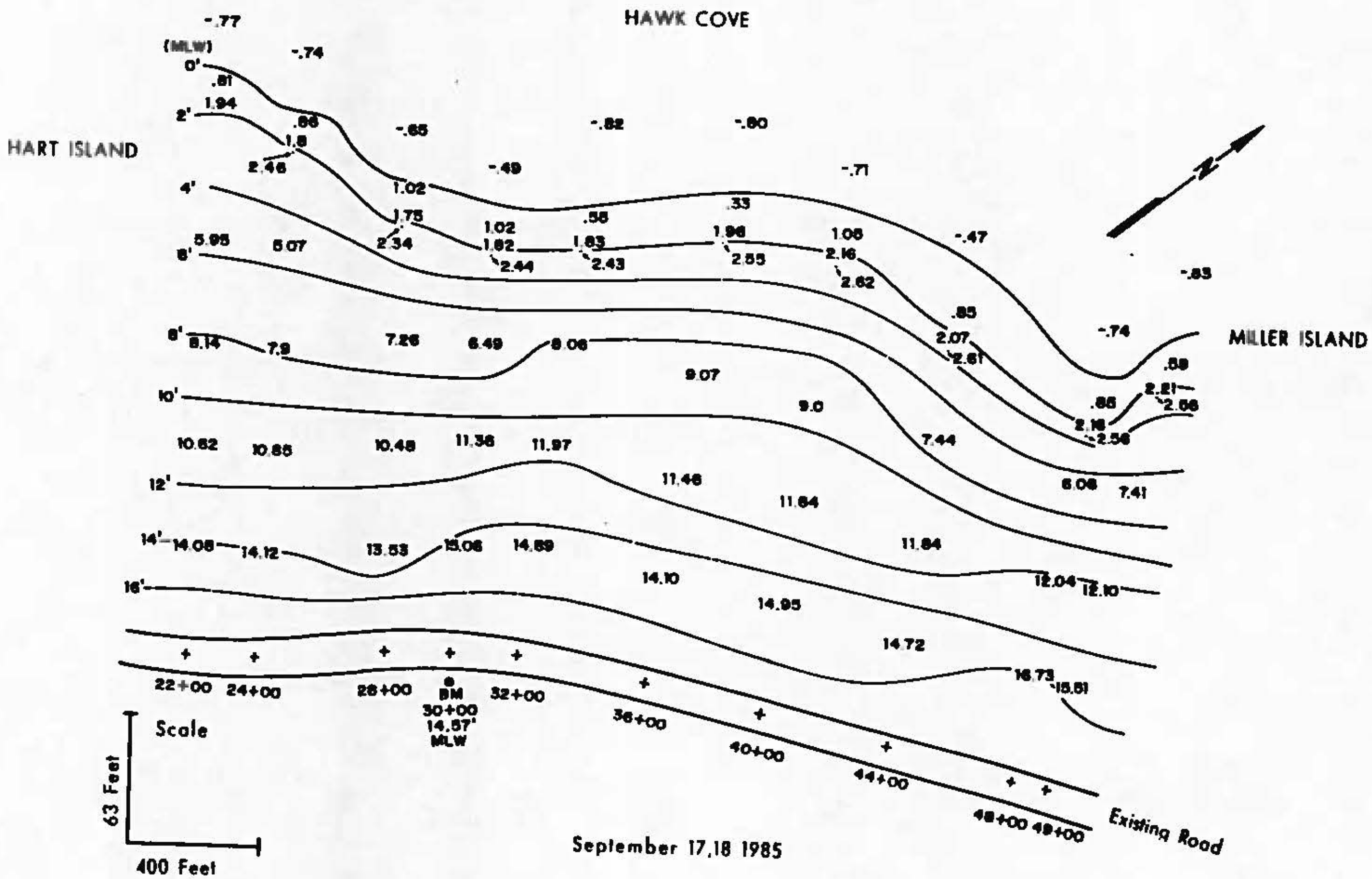

Figure B-15. Contour map of recreational beach based on September, 1985 survey.

BENTHIC STUDIES

October 1984 - April 1985

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TABLE OF CONTENTS

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ABSTRACT

Benthic invertebrates were monitored at the Hart and Miller Island Containment Facility for the primary purpose of observing possible operational effects. Areas investigated were the nearfield silt-clay site at the rehandling and discharge pier, the effluent shell bottom area, and the epibenthic fauna on the pilings of piers surrounding the facility. Four farfield stations served as reference sites. Samples were taken by means of Van Veen grab at 13 stations in October 1984 and in April 1985. Pilings were sampled for epibenthos at various depths at four locations. All samples were washed on a 1mm screen. Salinity, which is the major factor controlling benthic populations in this area, was 1-2 ppt higher than normal due to low freshwater inflow. This favored opportunistic dominants such as the amphipods Leptocheirus plumulosus ,and Corophium , and the worm Scolecolepides viridis. Twenty-three species were collected at the oyster shell community, 16 species at the silt-clay stations, and 11 species on the pilings. Numbers of individuals were greatest during the spring because of juvenile recruitment.

Statistical analyses included species diversity, dominance factor, cluster analysis, Friedman's Non-parametric Test and Student-Newman-Keuls Test. Stations where analysis indicated problems or differences could be explained on the basis of sampling station misplacement, slow recovery from early 1983 dredging, and influence from outside the containment facility.

Recommendations were made for continued monitoring of these populations with a more critical look at smaller juvenile forms, rearrangement of nearfield station locations, and more frequent sampling.

INTRODUCTION

This is the fourth annual report of benthic studies conducted at the Hart and Miller Islands Containment Facility. This year samples were collected in October 1984 and in April 1985. Pre-established stations were sampled on each occasion for the primary purpose of observing possible operational influences on the nearfield infaunal macroinvertebrate populations at the rehandling and sluice-gate sites. Other stations were newly established to study the vertical and lateral distribution of epifaunal populations on nearby pilings. These stations replaced the riprap stations monitored during the third year (Pfitzenmeyer 1985). Reference stations located some distance from the island were sampled to follow the natural changes in population densities and to aid in statistical analysis.

METHODS

In any monitoring study, techniques should be kept as consistent as possible to facilitate comparisons between present and past observations. The progressive development of the containment facility necessitated some adjustment in the location of sampling stations (Fig. 1). However, the method of sampling the benthos remained the same. At each station three replicate bottom samples were obtained with a Van Veen grab, which took a $0.1m^2$ area of sediment varying from 6 to 15cm in depth, depending on the texture of the bottom. These samples were washed separately upon a 1mm screen and preserved in 10% formalin colored with a small amount of rose Bengal stain to facilitate separation of specimens from detritus. The number of each species was counted and recorded separately for each of the replicate grabs. Specimens which were damaged or disaggregated were included in the count only if the head portion could be identified.

Epifaunal sampling was new to the project this year. Our original intention was for a SCUBA diver to sample the stone riprap surrounding the containment facility. However, we found that better and more rapid samples could be obtained from the fauna attached to the concrete pilings which support the fishing and boat piers. These pilings are spaced at intervals around the perimeter of the island very close to the stone riprap, so presumably the same populations were sampled. An area approximately 10cm x 10cm was sampled at specified depths by scraping the attached fauna from the concrete piling surfaces. In the laboratory, the samples were treated similarly to the infaunal samples.

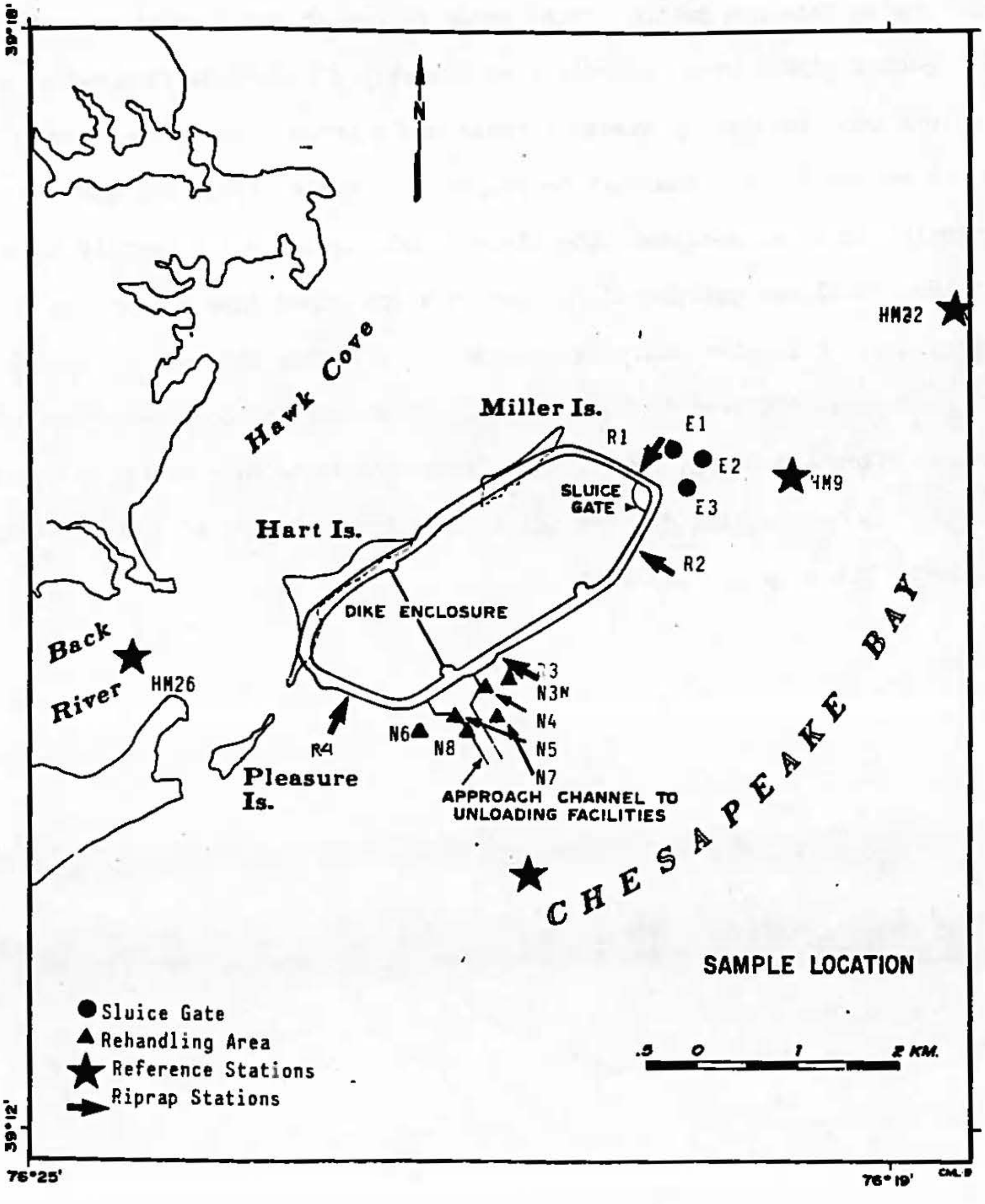

Figure 1

Sampling Station Locations for the Present Study

Water temperature and salinity were measured with an induction salinometer near the surface and bottom of the water column at selected stations (Table 1). Bottom depths were recorded from the ship's recording fathometer and stations were located by means of radar and a Loran C position finder.

A method of rank analysis as proposed by Fager (1975) was used to determine dominant species. The Shannon and Wiener (H') diversity index (Pielou, 1966) was calculated for each station after data conversion to $base_2$ logarithms. A cluster analysis program for grouping stations by faunal similarity was acquired through the BMDP-77 Biomedical Computer Programs P-Series (Dixon and Brown, 1977). The Student-Newman-Keuls multiple range test was used in determining differences in the abundances of individuals between stations (Nie et al., 1975).

TABLE 1. Water temperatures and salinities taken at selected stations during the two sampling periods

Station	October 1984				April 1985			
	Temperature °C		Salinity ppt		Temperature °C		Salinity ppt	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
E1	15.4	15.4	5.9	6.2	8.5	8.5	4.1	4.1
N3	14.9	15.3	6.3	6.8				
N5	15.2	15.5	6.2	6.2				
N7	15.3	15.3	6.7	6.6				
HM16	15.5	15.5	6.6	8.7	8.7	7.4	5.3	5.5
HM22	15.5	15.5	6.4	6.1				
HM26	16.0	15.8	6.4	6.5	8.5	8.5	5.4	5.8
N4					8.4	8.4	4.5	4.6

RESULTS AND DISCUSSION

GENERAL OBSERVATIONS

The major factors controlling benthic population densities and species occurrence around Hart and Miller Islands are seasonal and yearly variations in salinity. During this period of observations we encountered higher than normal salinities because of the comparatively low freshwater flows entering the Bay from the Susquehanna River. Figure 2 shows the monthly total of freshwater passing Conowingo Dam during the current year compared to the 10-year monthly mean. Each month was below normal with the exception of December 1984. The higher than usual salinities favored dominance by some species such as the amphipod Leptocheirus plumulosus, the clam Macoma spp., and the worm Scolecolepides viridis; but this condition was not favorable for populations of the clam Rangia cuneata.

Another factor influencing faunal abundance is the preference of benthic species for particular bottom substrates. Pronounced differences are evident where certain species are found only on hard surfaces such as naturally occurring oyster shells, while others must have soft mud bottoms in order to survive. These opposing modes of existence preclude collective analysis of sampling stations, and require separation of stations into groups of similar bottom types. At Hart and Miller Islands we have monitored three substrate types: oyster shell bottom, the softer silt-clay mixture, and the riprap or piling surfaces. By chance, the substrate in the area of the effluent discharge pipe is composed of oyster shell; therefore these stations can be separated naturally from the remaining nearfield stations.

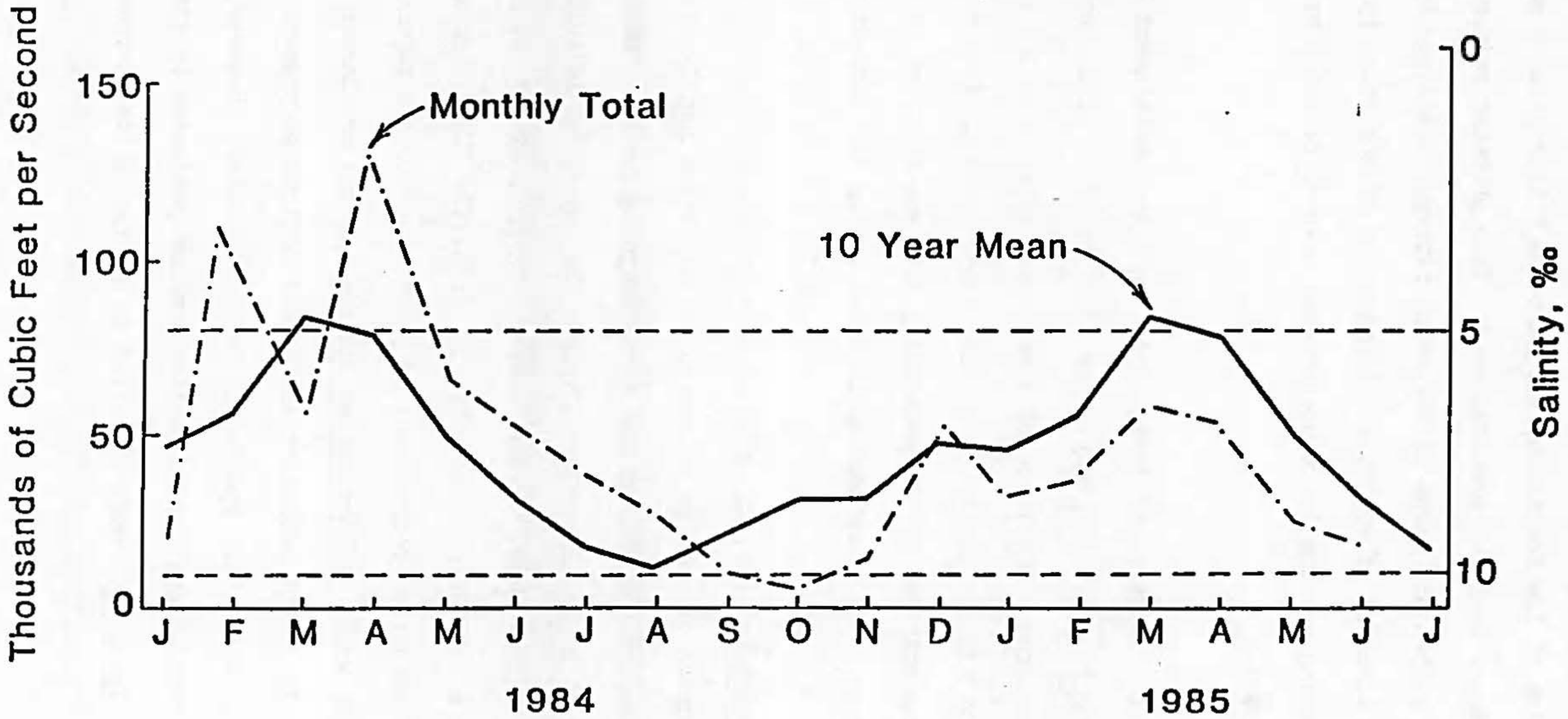

Figure 2. Monthly total of freshwater passing Conowingo Dam for the current sampling year as compared to the 10 year monthly mean

Although water temperature data were not collected during the critical winter period of ice formation, the Hart and Miller Islands area had fewer days of ice coverage than the previous year. This probably reduced detrimental effects on epibenthic fauna of the stone riprap and pilings by reducing the amount and duration of scouring. Dehydration of the fauna by exposure to air and wind during extreme low winter tides, however probably was not less than in previous years.

Periodic discharge of dredge spoil into the containment facility took place during this year's study. The quantity of material, however, was not sufficient to cause a release of supernatant water from the site. The detection of minor alterations in the fauna resulting from vessel-associated activity concentrated at the rehandling pier was reported previously (Pfitzenmeyer, 1985), and was again noted during the current monitoring year.

Effluent Stations (E1, E2, E3)

The number of species collected on the predominantly oyster shell substrate during the October and April sampling periods remained rather constant with 22 and 23, respectively. The number of individuals, however, dramatically increased. An average of 1719 individuals per m^2 was collected in October and 5337 individuals per m^2 in April. This increase was attributed mainly to recruitment of juveniles into the populations of two species, the worm Scolecolepides viridis and the crustacean Corophium lacustre. It is not necessary that shell bottoms be present for S. viridis, as this is also a dominant species in soft substrates. However, the presence of shells acts as a possible protection against predation by other organisms. Corophium lacustre, however, lives in tubules which it constructs on firm surfaces such as shells and therefore should be more abundant on this type of bottom. Of the 23 species which were collected on the shell bottoms, only four actually require hard surfaces for completion of their life histories. These are the mollusc Congeria leucophaeta, two species of barnacles Balanus spp. and C. lacustre. Four species do not require a hard surface but were common on shell, probably because of easier foraging conditions or better protection. These were the crustaceans Cassidinidea lunifrons, Melita nitida and Rithropanopeus harrisi, and the flatworm Stylochus ellipticus, which is a predator of barnacles.

Approximately two-thirds of the species on the oyster shell bar at Hart and Miller Islands were actually soft bottom inhabitants but occurred here because of the presence of silt mixed with the shell. This may provide a more productive and protected habitat than a homogeneous substrate for species like S. viridis. Species spill-over from the oyster bar to soft bottoms also may have occurred because of the occasional clam shells (R. cuneata) on the surface mud.

Nearfield Stations (N3, N4, N5, N6, N7, N8)

Because the shell stations are a transition zone which supports animals from both infaunal and epifaunal communities, fewer species (15-16) were found at the homogeneous silt-clay nearfield stations. Fewer individuals were also found at the soft bottom stations. An average of 632 animals per m^2 was found in October, and 1498 per m^2 in April. In this area L. plumulosus showed the largest single increase (5-fold) in numbers. The abundance of S. viridis doubled during this same period. Two other abundant species, R. cuneata and the crustacean Cyathura polita exhibited slight decreases in abundance.

The nearfield stations were located at the rehandling pier which was the point of barge discharge of spoil into the containment facility. Water depths at these stations were 4.5 to 4.8m with the exception of one station (5) where dredging took place in the latter part of 1983. The depth was increased to 6.3m in the area of this station to facilitate vessel operation. Evidence was presented in the previous interpretive report (Pfitzenmeyer, 1985) on faunal disruption at this point since March 1984. The reduction in species and number of individuals was still evident. Much of the flocculent and lighter silt layer of the sediments had been swept away presumably by prop-wash, and a basal heavy clay substrate remained. This clay bottom is not as desirable as silt for most benthic organisms, with the exception of C. polita, which was found more abundantly at Station N5 than at the other nearfield stations. The dominant species, L. plumulosus and S. viridis, were very much reduced here. The affected area is small and therefore, the loss is not considered important or serious to the ecosystem at Hart and Miller Islands.

Reference Areas (HM9, HM16, HM22, HM26)

The four reference stations collectively exhibited an increase in population density similar to that at the effluent and nearfield stations. The net increase was not as great due to reduced numbers at two station: HM26, at the mouth of Back River, and HM22 at Spry Island. The fauna at the mouth of Back River continued to exhibit unusual characteristics relative to the other stations, which makes its continued status as a reference station questionable. However, this station may be useful as a nearby example of an impacted zone. The April populations at HM22 were slightly less abundant than the October populations because of unusually high numbers of one species (L. plumulosus) in October. Numbers and species collected at HM22 in April were not anomalous with respect to other stations since this was the most upbay station where the rate of salinity change was more pronounced. The most diverse reference station was HM9 because of the heterogeneous silt and oyster shell substrate. One interesting feature of this station was the absence of molluscs during the April sampling period. This resulted in only five fewer individuals than collected during the previous sampling period. The above-normal salinities during this period probably contributed to the reduction of low-salinity mollusc species. A transition, through replacement of down-bay higher salinity species, should take place over the summer months.

Epifauna (R1, R2, R3, R4)

Initial investigations during 1983-1984 into the recruitment of animals attached to the riprap stone surfaces were limited to a depth of 0.3m. During this year's study, a SCUBA diver was used to obtain samples from various depths. Samples were taken from the fabricated concrete pilings which support the piers at various locations around the containment island. These proved more efficient and better surfaces for sampling than the stone riprap and provided equivalent information. The pilings are located about 9 to 15m from the dike, and should in the future provide immediate evidence of any detrimental seepage from the containment area.

In October the diver obtained samples at 3-foot (0.9m) depth intervals to the bottom of the piling at about 3.6m. Inspection of these samples indicated no clear progression of individual species or abundances with depth, so only surface (0.3m), mid depth (1.8m) and bottom (3m) samples were reported.

The most abundant species at all depths in October was C. lacustre (Table 2). This amphipod, which builds mud tubes on hard surfaces, was also the most abundant species at the effluent or shell stations. Barnacles also were abundant at all depths on the pilings. The polychaete worm Nereis succinea and the clam C. leucophaeta, which are also associated with shell bottoms, were moderately abundant. Colonial growth forms were more dense at the stations on the downbay end of the Island. A total of 11 species were identified from the pilings and all are inhabitants of nearby benthic shell stations. Because of their close proximity and accessibility to the containment facility, the presence and abundance of these species should provide appropriate tests of any contamination associated with dike seepage or other releases from the facility.

In April, samples were taken at 1, 6, 1.8 and 10-foot (0.3, 1.8 and 3.0m) depth. Only three species were found in low densities at the 1-foot depth. These were the crustaceans C. lacustre and Gammarus daiberi and the mollusc C. leucophaeta. Only basal remains of barnacles were found at this depth, indicating that physical scouring by ice had occurred. Visual observations indicated this condition continued to a depth of 0.9m. Nine additional species were found on the middle and bottom sections of the pilings (Table 2). The number of species was about the same as found in October samples but the density was less. Colonial species, with the exception of the hydroid Cordylophora sp., were absent from the April samples, but the number of species was increased by several temporary benthic forms. A second year of comparison sampling at these sites would prove valuable. This year's observations indicated that repopulation of the ice-defaunated section of the pier and shoreline (the top 0.3-0.9m) was rather rapid in the spring and that epifaunal recruitment was relatively uniform from the surface to the bottom (3.6-4.5m). These facts together with species occurance information will be important in assessing any future observed changes.

TABLE 2. List of species found on the pilings at the Hart and Miller Island Containment Facility in order of descending abundance

October 1984			April 1985		
Rank	Species	Abundance Index*	Rank	Species	Abundance Index*
1	Corophium lacustre	43	1	Corophium lacustre	34
2	Balanus subalbidus	33	2	Balanus subalbidus	25
3	Nereis succinea	29	3	Cordylophora caspia	22
4	Congeria leucophaeta	27	4	Nereis succinea	17
5	Cordylophora caspia	20	5	Polydora ligni	11
6	Victorella pavida	14	6	Congeria leucophaeta	11
7	Polydora ligni	10	7	Chironimidae g. spp.	3
8	Garveia franciscana	6	8	Scolecolepides viridis	2
9	Stylochus ellipticus	6	9	Balanus improvisus	2
10	Stiliger niger	1	10	Gammarus daiberi	1
11	Membranipora tenuis	1	11	Gammarus tigrinus	1
			12	Stylochus ellipticus	1

* Abundance indices are sums of very abundant (4), abundant (3), moderate (2), and present (1), for three samples at each station.

STATISTICAL ANALYSIS

Species Diversity

A major component in the structural analysis of a community of animals is the expression of species diversity. Maximum diversity exists if each individual belongs to a different species and minimum diversity exists if all individuals belong to the same species. Many measures of diversity have been proposed, but the most popular and the one employed in this study and in studies from previous years was the one based on information theory (Shannon and Weaver, 1963). In a variable low salinity region such as the Upper Chesapeake Bay, low diversity is the more likely and probably more desirable condition. The number of species is small, 23 maximum at any one station, and for the benthos to be of value to higher trophic levels (fish and crabs), one or relatively few species should be present in abundance. Table 3 lists the species diversity for all stations during the two sampling periods. Generally lower diversities occured in April because of the recruitment of S. viridis and C. lacustre in large numbers. When the abundance of these species was reduced in October as a result of summer predation and natural attrition, diversity values were higher. The effluent stations generally had higher diversity (Table 3) because the individuals were scattered among more species, thereby reducing dominance. Even after the summer decline in individuals, generally higher numbers distributed among more species were found at the effluent stations because of the protection from predation afforded by the shells. Stations within each substrate group appeared comparable, which indicated that no serious problems existed. The values at station N5, the rehandling pier, where numbers of most species were low because of dredging and prop-wash, were not extreme for that group of stations.

TABLE 3. Total number of species (S) and individuals (N) in combined triplicate samples at each station for the two sampling methods

	October 1984				April 1985			
	S	N	H'	D	S	N	H'	D
E1	18	911	3.227	.39	14	1883	2.081	.80
E2	16	254	3.068	.48	18	1347	1.812	.86
E3	13	398	1.821	81	17	1622	1.962	.79
N3	9	260	1.810	.85	11	501	1.965	.75
N4	8	152	1.605	.81	13	618	1.761	.86
N5	11	99	1.978	.81	6	120	1.571	.88
N6	6	233	1.198	.88	9	375	1.376	.92
N7	11	219	2.213	.74	10	600	1.314	.91
N8	9	186	1.780	.80	12	509	1.395	.86
HM9	14	228	2.312	.73	17	1318	2.050	.80
HM16	11	343	1.413	.86	9	433	1.099	.92
HM22	11	647	1.612	.84	10	528	1.751	.80
HM26	12	286	1.972	.75	12	178	1.906	.74

H' = Diversity Index

D = Dominance Factor

in large numbers. When the abundance of these species was reduced in October as a result of summer predation and natural attrition, diversity values were higher. The effluent stations generally had higher diversity (Table 3) because the individuals were scattered among more species, thereby reducing dominance. Even after the summer decline in individuals, generally higher numbers distributed among more species were found at the effluent stations because of the protection from predation afforded by the shells. Stations within each substrate group appeared comparable, which indicated that no serious problems existed. The values at station N5, the rehandling pier, where numbers of most species were low because of dredging and prop-wash, were not extreme for that group of stations.

Dominance

The dominance factor (McNaughton and Wolf, 1970) is the proportion of the total number of individuals in the sample belonging to the two most abundant species. These values clearly point out how the fauna of this area is dominated (70-80%) by two species. When the dominance measures were low usually the diversity was highest. For example, two of the effluent stations for the October 1984 samples had dominance values below 0.50 and diversity values above 3. The other station of this set was different, with opposite values (Table 3). A check on individual species indicated that station E3 was not taken from the same bottom type (oyster shell) as the other two. No barnacles were present and a comparatively high number of S. viridis indicated the bottom was mostly silty-clay. The dominance value of 0.81 was similar to other stations of similar bottom type. The reference shell station HM9 may not have been at the usual location since only one barnacle was found there. It was possible that the oyster shells had been smothered by recent spoil deposits, but the distribution of the remaining fauna at these stations did not indicate new sedimentation. During the spring, when high numbers of juvenile S. viridis and C. lacustre dominated the shell samples, dominance was comparable to all other areas. Reduction of these species during the summer months should lower dominance to the 30-40% range.

Dominant Species

Biological index values were employed to determine dominant species for each area and sampling period (Wade, 1972). Dominant species have changed little since the initiation of the project in 1981. Five species have assumed various places as the first three dominants in soft bottoms (Table 4).

TABLE 4. The first three shell and soft bottom dominant species for October 1984 and April 1985

	Shell Stations		Silt-Clay Stations	
	Effluent	Reference	Nearfield	Reference
October	N. succinea	S. viridis	S. viridis	L. plumulosus
	C. lacustre	C. lacustre	C. polita	S. virdis
	B. subalbidus	N. succinea	R. cuneata	C. polita
April	C. lacustre	S. viridis	L. plumulosus	S. viridis
	S. viridis	C. lacustre	S. viridis	L. plumulosus
	N. succinea	N. succinea	C. polita	C. polita

The two molluscs, Macoma spp. and R. cuneata, have appeared and disappeared depending on past salinity conditions. In 1981 to 1983 Macoma spp. were dominant but with lower salinity during the latter half of 1983 and 1984 R. cuneata was dominant. Beginning in late 1984 R. cuneata numbers declined and the three dominant species were L. plumulosus, C. polita and S. viridis.

Species replacement with varying salinity also occurs on shell bottoms. The mollusc, C. leucophaeta, and the barnacles, Balanus improvisus and B. subalbidus, assume dominant roles during periods of declining salinity but lose their position to the tube-dwelling crustacean, C. lacustre, as salinity increases. Species which do not require shell surfaces, such as N. succinea or S. viridis, occur in large numbers because of the silty-clay substrate among the shell surfaces. Table 4 lists the dominants for both bottom types found in this transition year from a period of low salinity to one of higher salinity. All species in this area appear transitional with the exception of L. plumulosus and S. viridis, which are major permanent dominants.

Cluster Analysis

An objective way of grouping stations of similar faunal characteristics is through the use of cluster analysis (BMDP 1981, Computer Program P2M). Cluster analysis was used in past studies at Hart and Miller Islands and clearly indicated a faunal response to bottom type. Any unusual grouping of stations would suggest changes due to other factors and require further inspection. For the October 1984 data (Fig. 3), it was apparent that the stations with the shortest array of distances were the nearfield stations, which had similar bottom types. But one of these stations (N5) stood apart from the others in its grouping. This station was in the area which was dredged in late 1983 to increase the depth from 4.2 to 6.3m for better boat access to the rehandling pier. About a year later, faunal species and numbers

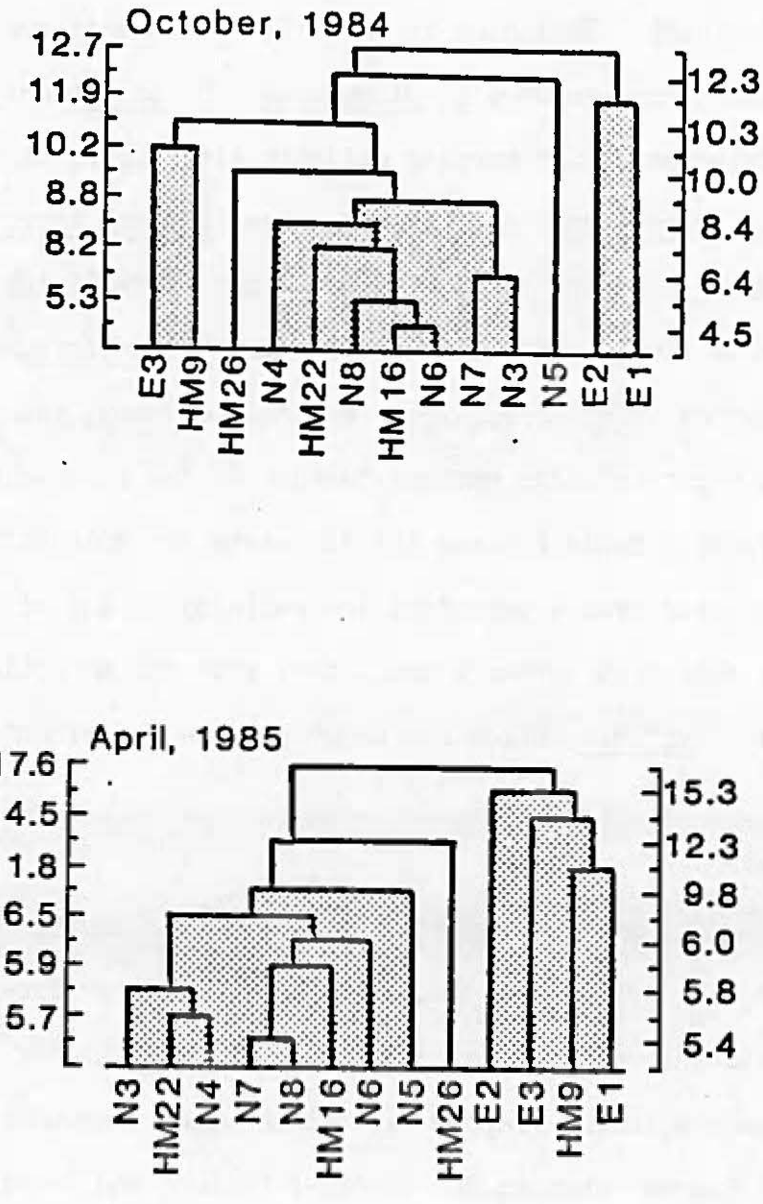

Figure 3. Cluster analysis for two sampling periods, October 1984 and April 1985

were lower, as they had been previously (Pfitzenmeyer, 1985). The fauna at neighboring station N6 also were affected initially by the dredging and this station still was not tightly grouped with others of similar characteristics. Station HM26, which is located at the mouth of Back River, always had detectable faunal differences even though the bottom type was similar to other stations. Two of the effluent or oyster shell stations (E1 and E2) were grouped together, while a third station (E3) was allied with the shell reference station HM9. As stated earlier the latter stations were not exclusively on shell substrates as evidenced by the lack of epifaunal organisms. Scattered patches of silt-clay on the bar or vessel drift between samples may have accounted for this sampling variation. It is of interest to note that this analysis had the sensitivity to detect these minor variations.

In April, after population recruitment from last year's reproduction, the cluster analysis showed two strong groupings: (1) the effluent or shell stations and their reference station, and (2) the other group of the nearfield or soft-bottom stations. Station N5, or the dredged station, was slightly discernible and again was the last to join that grouping. One station, HM26 (Back River), was still isolated from either group. As a result of this analysis, it may be concluded that the minor effects to the benthic fauna because of dredging still remained at one limited area at the rehandling pier. Beginning in spring of 1984, however, repopulation was slowly progressing in this area.

Friedman's Non-parametric Test

This two-way analysis by rank (Elliott, 1977) was again employed to indicate differences between samples taken at the nearfield, effluent, and reference groups. These groups of stations were tested separately and then the reference stations were added and the test repeated. The species analyzed for each station was selected on the basis of dominance or common occurrence, and also on its expected occurrence at a particular station. A probability of 0.05 or less was chosen as the level of significant difference for sample means.

For October the only difference measurable by this test was found when the test was applied to combined data from effluent and reference stations. Although it was not within the scope of this test to determine between which stations differences occurred, the data indicated that one reference station (HM9) had a fauna unlike that of the effluent stations. This was discussed earlier, and the possible cause was an errant sample station or uncommon sediment type.

As a further indication of the heterogeneous nature of the shell substrate, the April samples showed a significant difference in the group of effluent stations. One station (E2) had a consistently lower count of organisms than the other two stations in the group. However, when the reference station was added to the group and the test repeated, the difference was not significant. This test adequately indicated that differences in faunal abundance between groups of stations did not result from containment facility operation. Substrate variability was the most probable cause of these differences.

TABLE 5. Results of Friedman's non-parametric test for differences in abundance of selected species between stations

Source	d.f	X^2	$X^2_{.05}$
October			
Nearfield	5	1.00	11.07
Nearfield + Reference	8	4.80	15.51
Effluent	2	4.67	5.99
Effluent + Reference	3	15.13*	7.82
Reference	2	4.50	5.99
April			
Nearfield	5	6.46	11.07
Nearfield + Reference	8	12.73	15.51
Effluent	2	11.60*	5.99
Effluent + Reference	3	5.64	7.82
Reference	2	2.00	5.99

* probability less than 0.05 of greater X^2 under the null hypothesis of no difference in rank abundance between stations

Student-Newman-Keuls Test

The Student-Newman-Keuls (SNK) multiple range test (Tables 6 and 7) tests subsets of means, and indicates whether a subset's highest and lowest means differ by more than the shortest significant range ($p < .05$) for a subset of that size. This test was again used to determine if there were significant differences in faunal abundance between stations. The combined counts of the numbers of each species in the triplicate samples were $\log_2$ transformed before analysis.

The effluent stations had the lowest mean abundance in the October samples. These stations had the oyster shell substrate in common, and therefore had similar fauna. However, because of the reasons stated earlier concerning bottom substrate variation, there were significant differences between each station. The reference stations HM26, HM16 and nearfield station N3 were not significantly different from each other. Another group of similar stations were nearfield station N8 and N4. All other nearfield stations at the rehandling pier were significantly different from each other, probably because of barge activity. Spry Island reference station HM22 had a large number of L. plumulosus and a more diverse fauna, resulting in its separation.

The following spring, after the recruitment of new individuals into the population, the analysis still showed significant differences among most stations (Table 6). There was identity within three groups: effluent stations E1 and E2; nearfield stations N3 and N8; and nearfield station N6 and reference station HM22. Shell stations E3 and reference station HM9 had means closest to the grouped E1 and E2. Nearfield stations N4, N5 and N7 were significantly different from all other stations. The dredged station N5 was farthest removed statistically from all stations.

The results of this and the preceeding analyses of these stations for the two sampling periods further illustrate the caution which should be employed in

TABLE 6. The Student-Newman-Keuls test of significance among means of individuals per station for the October 1984 sampling period. Subsets show grouping of stations not significantly different ($P<0.05$). Stations in a vertical column and row by themselves are significantly different from others.

October 1984 Subset	Station Numbers
1	E1
2	E2
3	E3
4	HM9
5	N5
6	N7
7	HM26 HM16 N3
8	HM22
9	N8 N4
10	N6

Analysis of Variance

Source	D.F	Sum of Sq.	Mean Sq.	F	F Prob.
Between Groups	12	37.3328	3.1111	553.748	.0000
Within Groups	26	.1461	.0056		
Total	38	37.4788			

TABLE 7. The Student-Newmans-Keuls test of significance among means of individuals per station for the April 1985 sampling period. Subsets show of grouping of stations not significantly different ($P<0.05$). Stations in a vertical column and row by themselves are significantly different from others.

April 1985 Subset	Station Numbers
1	E2 E1
2	E3
3	HM9
4	N4
5	N3 N8
6	HM26
7	N7
8	N6 HM22
9	HM16
10	N5

Analysis of Variance

Source	D.F.	Sum of Sq.	Mean Sq.	F	F Prob.
Between Groups	12	52.0115	4.3343	303.872	.0000
Within Groups	26	.3709	.0143		
Total	38	52.3823			

the objective assessment of effects on the fauna. The inherent variability of the benthic populations, sampling errors and the analysis chosen can influence results. The final decision on what constitutes a significant and detrimental effect should be based on subjective appraisals as well as those which can be statistically measured.

SUMMARY AND CONCLUSIONS

1. To adequately monitor the benthic populations surrounding Hart and Miller Islands, three groups of macroinvertebrates should be investigated. They are the epifauna, or those attached to the hard surfaces of the pilings and riprap; the infauna, which are found in the soft, silt-clay bottom; and the oyster shell community which includes representatives of both substrates.
2. During the current sampling year, water salinities averaged above normal. This favored abundance of the amphipod Leptocheirus plumulosus clams (Macoma spp.) and the polychaete worm Scolecolepides viridis, but reduced populations of the brackish-water clam Rangia cuneata.
3. The amount and duration of winter ice appeared less than during the previous two years, but still severe enough to eliminate practically all fauna from the surface to a depth of 1m. Dehydration resulting from low winter tides may have also had a profound effect.
4. The increase in numbers of individuals between October and April was due to the recruitment of juveniles into the population. In the oyster shell community, the increase was due mainly to S. viridis and the amphipod Corophium lacustre. In the soft silt-clay community it was because of L. plumulosus and S. viridis.
5. Totals of 23 species were collected at the oyster shell sampling stations, and 16 species at the silt-clay sites. Eleven species were found on the pilings and all were common inhabitants of nearby benthic shell stations.
6. Epifaunal populations in October did not exhibit any changes in population structure or density with depth (3.6m maximum). By April only three sparsely distributed species remained or had recruited into the defaunated 0-1m depth range.

7. Low species diversity at the sampling stations was generally related to high numbers of S. viridis and C. lacustre. Low diversities and large numbers of a few species are the expected condition in a region of low and variable salinity such as Hart and Miller Islands.
8. Dominance values suggest that 70 to 80% of the fauna was dominated commonly by two species. Five different species can become dominant depending on yearly evironmental conditions, usually salinity.
9. Cluster analysis indicated a grouping of stations in response to bottom type. One station, nearfield N5, which was dredged in late 1983, remained different from the other nearfield stations. Adjacent station N6 also appeared to retain some effects of dredging. Back River reference station HM26 was isolated from the grouping of stations with similar bottom type.
10. Stations which were shown to be statistically different by Friedman's Non-parametric and Student-Newman Keuls tests were affected by dredging and sampling variability and did not demonstrate effects of the containment facility per se.

RECOMMENDATIONS

1. Infaunal and epifaunal benthic populations should be monitored no less critically during the upcoming year when effluent discharge from the containment island probably will take place. Four years of data, from pre-construction through construction and early operation of the facility are a valuable baseline and will be essential for assessment of possible future benthic population changes.
2. Nearfield stations could better detect any leakage from the facility by being arranged in a peripheral pattern rather than being grouped in any one area.
3. Sampling of the epibenthic fauna on the pilings, which are close to the stone riprap sustaining wall, should continue. An epibenthic reference station would be desirable for analytical purposes.
4. Benthic specimens for chemical analysis should not be limited to any one species. The program should be adaptable to analysis of species which occur in greatest numbers or biomass during a particular sampling season.
5. A more critical inspection of the benthic populations could be made if smaller juvenile forms were included in the analysis, by use of a small mesh screen for sorting. Moreover, it would be desirable to sample more frequently than twice a year.

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TABLE A. List of species and total number of individuals per triplicate $0.1m^2$ Van Veen benthic grab

October 1984	Shell Stations				Silt-Clay Stations								
Species	Effluent			Reference	Nearfield						Reference		
	E1	E2	E3	HM9	N3	N4	N5	N6	N7	N8	HM16	HM22	HM26
RHYNCHOCOELA (Ribbonworms)													
Micrura leidyi	1	1	7		7	1	1	1		2	3	1	5
ANNELIDA (Worms)													
Heteromastus filiformis			4	2		1	1	5	1	2		1	
Nereis succinea	193	72	20	22	2	1	2		13				
Polydora ligni	17	25	7	5	9		26		10	1		20	3
Scolecolepides viridis	32	15	259	98	126	99	4	32	69	46	43	139	10
Streblospio benedicti	21						2		3	1	1	2	32
Limnodrilus hoffmeisteri	6											1	
Capitella capitata			2	1							1		
PLATYHELMINTHES (Flatworms)													
Stylochus ellipticus	24	4	2	2									
MOLLUSCA (Molluscs)													
Congeria leucophaeta	8	11	2										
Macoma balthica											6	2	
Macoma mitchelli					1			1			3		
Rangia cuneata	2	3	4	5	95	11	6		93	6	4	60	5
Stiliger niger		1											

(continued)

N4 = X1F4517

TABLE A. (continued)

October 1984	Shell Stations				Silt-Clay Stations								
Species	Effluent			Reference	Nearfield						Reference		
	E1	E2	E3	HM9	N3	N4	N5	N6	N7	N8	HM16	HM22	HM26
ARTHROPODA (Crustaceans)													
Balanus improvisus	2	7											
Balanus subalbidus	137	33		1									
Cyathura polita	57	17	63	15	13	14	54	20	19	24	24	11	8
Cassidinidea lunifrons	93												
Edotea triloba						1			2	1			3
Leptocheirus plumulosus				1	5	24	1	174	7	102	253	406	177
Corophium lacustre	165	51	23	68			1		1				
Gammarus tigrinus	1	1		3					1				
Melita nitida	93	10	1	4									1
Chirodotea almyra		1					1						1
Chironomidae g. spp.	1				2							4	40
Rithropanopeus harrisi	58	2	4	1			1						

check this out 6/26/03

TABLE B. List of species and total number of individuals triplicate 0.1m^2 Van Veen benthic grab

April 1985	Shell Stations				Silt-Clay Stations								
Species	Effluent			Reference	Nearfield						Reference		
	E1	E2	E3	HM9	N3	N4	N5	N6	N7	N8	HM16	HM22	HM26
	5405	5406	5307	5291									
RHYNCHOCOELA (Ribbonworms)													
Micrura leidyi		2		2	3	3	1	2	2	3	2		2
ANNELIDA (Worms)													
Heteromastus filiformis	2	2			1	1		2		2	1		2
Nereis succinea	124	24	159	96	4	6	2	1	8	6	2	2	3
Polydora ligni	15	7	16	6									
Scoecolepides viridis	758	581	449	716	168	208	10	108	108	57	60	132	118
Limnodrilus hoffmeisteri	3		3	1					1			1	
Capitella capitata											1		
Stylochus ellipticus			2										
MOLLUSCA (Molluscs)													
Congeria leucophaeta	1		2										
Macoma balthica			1			2	2			3	8	2	
Macoma mitchelli					3	5		3	6	4	1	1	6
Rangia cuneata	1	2	1		86	42			16	27		68	6

(continued)

TABLE B. (continued)

April 1985	Shell Stations				Silt-Clay Stations								
Species	Effluent			Reference	Nearfield						Reference		
	E1	E2	E3	HM9	N3	N4	N5	N6	N7	N8	HM16	HM22	HM26
ARTHROPODA (Crustaceans)													
Balanus improvisus	53	11	37	35									
Balanus subalbidus	63	3	4	21									
Cyathura polita	31	50	74	29	18	18	42	17	16	23	18	15	13
Cassidinidea lunifrons	35	2		20									
Edotea triloba			1		1	2		1					
Leptocheirus plumulosus	2	67	6	16	208	322	63	238	438	381	340	292	11
Corophium lacustre	748	581	838	333	6	7			1	1		14	1
Gammarus palustris	1	2											
Gammarus tigrinus		4		1									
Melita nitida	36	5	7	15					2				
Chirodotea almyra		1	1			1							
Monoculodes edwardsi		1											
Chironomidae g. spp.			3	1	3	1		2	3			1	14
Rithropanopeus harrisi	13	2	20	23						1		1	

HART AND MILLER ISLANDS CONTAINMENT FACILITY STUDY

---FINFISH STUDIES---

FOURTH INTERPRETIVE REPORT, 1984 - 1985

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INTRODUCTION

Major engineering projects in both non-tidal and tidal waters can considerably alter the natural ecosystems over a wide area. Such projects can have both negative and positive influences on local biota, thereby necessitating significant amounts of data collection to document these effects. Properly interpreted, these data can be used to determine management strategies to minimize adverse effects, and enhance positive effects. The data collected both prior to and during construction have been reported (Ritchie 1977; Tsai & Millsaps, 1982) with present data covering the completed structure and its operation as a containment facility. Use of the area by finfish and crabs appears considerable and tends to indicate that the structure may function like an artificial reef, although induced currents along the south and east faces may reduce use by some desirable species. The intensive semiannual survey, while duplicating some of the previous sampling techniques, has also included additional techiques to augment and refine population information.

Methods

Four gear types were used during the 1984-85 sampling period: trawls, seine, eel pots and fish traps. Gill nets, although used during previous years, proved to difficult and dangerous to operate in the vicinity of the rock revetments, so their use was eliminated from this year's program.

For clarity, each gear type is treated as a separate task with a chart to indicate sample locations. Measurements of salinity, temperature, depth and bottom type were recorded for each site. Biometric data were recorded when possible for detailed age class analysis of striped bass, white perch, yellow perch and channel catfish.

Bottom Net Trawls

Trawl samples were taken from the Research Vessel (R/V) Aquarius at eight of the original ten stations of Tsai & Millsaps (1982). A similar trawl (7.5m width, 0.5cm mesh cod end) was used at three additional stations. The latter stations were generally within 35m of the rock revetments, while the former were considerably farther offshore. Lengths and weights of target species were measured when possible, and tissue samples of white perch and blue crabs were taken for analysis of toxic organics and heavy metals.

The following data were recorded for each station:

1. Catch-numbers and weights (where possible) by species
2. Catch per unit effort, by species (CPUE)
3. Diversity index by station
4. Salinity and temperature

Figure 1 shows the locations of the eight orginal R/V Aquarius trawl sites and Figure 2 shows the three additional inshore trawl sites.

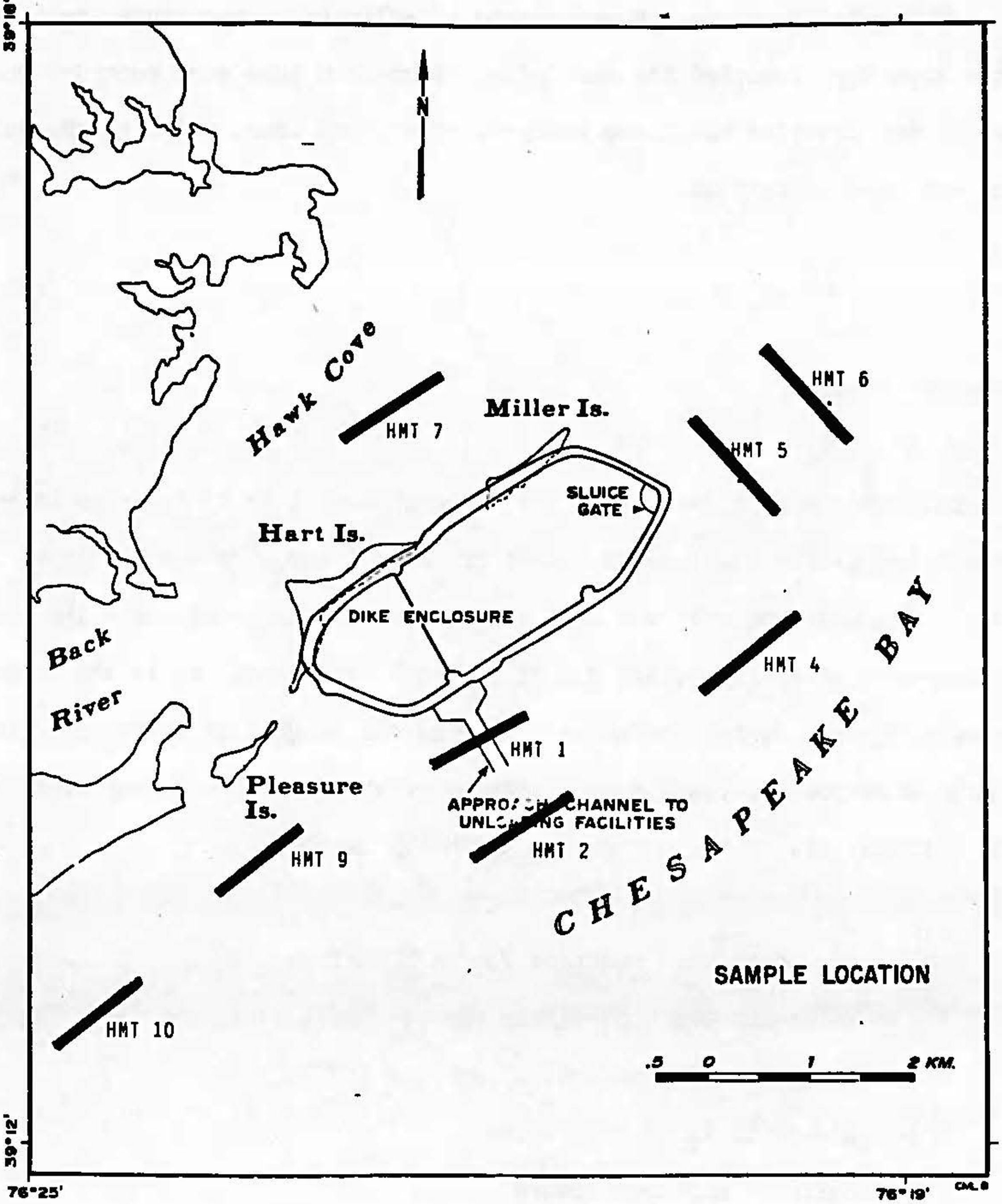

Figure 1

Bottom Net Trawl Stations

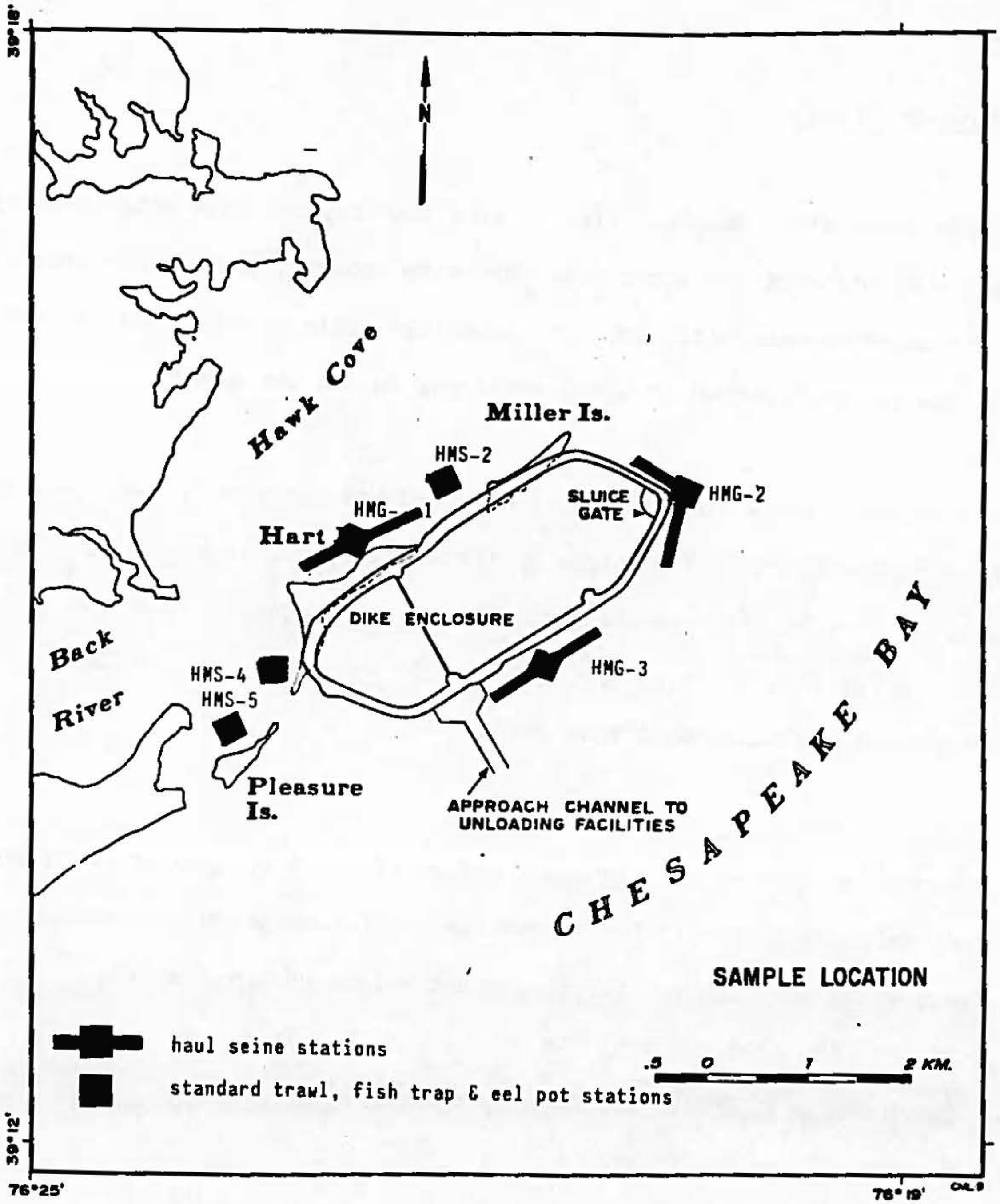

Figure 2

Haul Seine, Trawl, Fish Trap & Eel Pot Stations

Haul Seine Sites

The seine sites sampled (Fig. 2) were the only suitable sites remaining after completion of the structure. One site, however (HMS-2) has undergone severe shore erosion with resultant shoaling. This is the public access beach area and is heavily used by local residents during the summer.

A standard seine (61m long by 1.8m deep) was set from a boat, paid out in a semi-circle with one end anchored on shore. The net, with an area of $591m^2$ was brought in by hand and the catch data were recorded as outlined below. After 30 minutes, a duplicate sample was taken. The following data were recorded or calculated when possible:

1. Number of species and aggregate weight of catch by species (with samples of sufficient size). For target species (white perch) the sample or subsample was measured for length and weight by age class.
2. Effort (the area swept by the gear for each site).
3. Catch Per Unit Effort for each species by site.
4. Species diversity for each site.
5. Salinity and temperature.

Eel Pots

Twenty commercial-style eel pots (6.35mm square wire mesh) were placed in the same general area as the three inshore trawl sites (Fig 2). The numerous interstices in the rocky face of the containment facility could theoretically provide an ideal eel habitat. To assess this, pots were set on the rocky toe of the face at approximately 4.5m depth. In the absence of a rocky face at site HMG-1, pots were set in approximately 1.8m of water among spotty stands of aquatic plants. The pots were baited with a prepared herring bait because other baits normally used for eels were only seasonally available. Pots were left in place for 24 hours and retrieved on three consecutive days. Inclement weather occassionally precluded daily retrieval. The eel pots and data recording procedures conformed to Maryland Department of Natural Resources eel research work.

The following data were recorded and analyzed:

1. Catch by size (subjective categories-small, medium, large) with by-catch species recorded.
2. Weight of catch (when possible).
3. Effort by pot days.
4. CPUE.
5. Salinity and temperature.

Fish Traps

Four traps were employed in place of the unwieldy and inefficient fyke nets used in previous years. These traps (known as "D" traps) are large (1.7m long, 0.8m wide, 2.5cm hexagonal mesh) but have proved successful in flowing tributaries and turbulent waters. The traps were set approximately 15m from the toe of the rocky face at sites HMG-2 and HMG-3 and within 90m of shore at site HMG-1 (Fig. 2). The traps were baited with cans of cat food which had been punctured repeatedly to permit slow release of their contents. Although not a common practice on the Chesapeake, this method has proved successful in fish and lobster traps in the Atlantic Ocean.

Pots were left in place for 24 hours and on three consecutive days. Inclement weather occasionally precluded daily retrieval.

Data recorded for the traps at each site included:

1. Catch by species with weights taken where possible.
2. Effort in trap days.
3. Catch Per Unit effort.
4. Salinity and temperture.

RESULTS

Gear Functions

Compared to the previous year's gear efficiency, this year's array proved more successful at performing the required tasks (Casey, 1985). Fish traps, although functional, had smaller catches than expected. Trap leads would have helped considerably, but would have been extremely difficult to construct and attach at the depths sampled. Catches were comparable to those of the inshore trawl net and because of this, an expanded trawl program with additional stations will be used in the future in place of the traps.

Eel pots again functioned successfully when placed on the toe of the rock revetment. As before, the catch was less than expected, indicating that the area may not yet be used to a large extent by local eel populations. Pots frequently snagged on rocks but none were lost. In the future, only a small number of pots will be used to monitor the population, unless increases are noted.

Sampling by bottom trawl appears the most successful method, given the existing working conditions. This gear type, while inefficient at sampling large individuals of various finfish species, does ensnare the smaller ones quite well. Fixed gear (traps and gill nets) have proved to be exceptionally difficult and dangerous to operate with the vagaries of weather and proximity of the rock face. Any future expansion of the program, however, should include short-term use of gill nets to sample the larger species unavailable to the trawl net. For the present, the trawl net is more workable when operated in poor sea conditions within 30m of the rock toe.

A total of 8,004 individuals representing 21 species were taken by all methods during the 1984-85 survey. Except for a few species, little change was noted between this and the 1983-84 survey period.

Salinity, Temperature, Bottom Type, Current and Weather

Both salinity and temperature were fairly uniform at all sites within each sampling period, so variations in catch within periods could not be related directly to these two parameters. Bottom type, current and temporary weather conditions may have had a more pronounced effect. This, however, was a subjective field observation and difficult to substantiate. Sites HMG-2 and HMG-3 are exposed to the open Bay and thus subject to considerable wave and current action. The bottom at these sites is reasonably hard by trawl net standards with little relief and devoid of vegetation. Site HMG-1 is different as it is reasonably protected from severe wave action and lacks the strong currents of the other two sites. Here the bottom is a softer mud and frequently contoured with vegetation. The vegetation consists of Eurasian water milfoil (*Myriophyllum spicata*), eel grass (*Zostera marina*), red head grass (Potamogeton perfoliatus) and filamentous green algae. This yields a variety of species as illustrated by the inshore trawl catch. Inshore catches in close proximity to the rocks also show variety, and when compared to adjacent offshore sites (Table 10) tend to support the hypothesis that the structure is an attractant. As this is the first year for inshore trawl samples, more data are needed to further define any effect of the structure.

Salinity & Temperature, All Sites

	Salinity o/oo	Temperature °C
October 1984	7.0	17.4
April 1985	3.8	13.8
May 1985	4.8	18.6

TABLE 10. Comparison of inshore trawl sites with adjacent offshore trawl sites

	NO. INDIVIDUALS			
	FALL 1983	FALL 1984	SPRING 1984	SPRING 1985
HMG-3	-	562	-	554
HMT-2	265	171	55	4
HMG-2	-	2880	-	393
HMT-6	37	87	31	166
HMG-1	-	149	-	309
HMT-7	224	18	2	100
	NO. SPECIES			
	FALL 1983	FALL 1984	SPRING 1984	SPRING 1984
HMG-3	-	5	-	12
HMT-2	7	6	3	4
HMG-2	-	8	-	9
HMT-6	1	5	1	2
HMG-1	-	11	-	11
HMT-7	7	3	2	2

NOTE: - = no inshore trawl sites during this sampling period.

Beach Seine

A total of 1,897 individuals, representing 16 species were taken during the 1984-85 seine sampling unit. These species are identified in Tables 1 and 2.

Striped bass	Morone saxatilis
White perch	Morone americana
Yellow perch	Perca flavescens
Atlantic silverside	Menidia menidia
Bay anchovy	Anchoa mitchilli
Menhaden	Brevoortia tyrannus
American eel	Anguilla rostrata
Gizzard shad	Dorosoma cepedianum
Pipefish	Synhatus fuscus
Carp	Cyprinus carpio
Pumpkinseed	Lepomis gibbosus
Spot	Leiostomus xanthurus
Striped killifish	Fundulus majalis
Bluefish	Pomatomus saltatrix
Banded killifish	Fundulus diaphanus
Blue crab	Callinectes sapidus

As with the previous year's sample, anchovies and silversides were the most common species. With some exceptions diversity and distribution were similar to obervations from the past year's survey. For the October sample, however,

TABLE 1. Beach Seine October 1984

STATION	HMS-5				HMS-4				HMS-2			
	1		2		1		2		1		2	
	NO.	CPUE	NO.	CPUE	NO.	CPUE	NO.	CPUE	NO.	CPUE	NO.	CPUE
Striped bass 1	4	68			2	34			1	17	1	17
Yellow perch	1	17					1	17				
White perch	6	101	1	17	36	608	1	17				
Atl. silverside	7	118	17	287	15	254	31	558	58	980	34	575
Spot	6	101	4	68	16	270	2	39				
Bay anchovy	30	507	5	85	22	372	3	51				
Bluefish			1	17								
Banded killifish					1	17			1	17	19	321
Pipefish							1	17				
Striped killifish									5	85	1	17
Blue crab			2	34	1	17						
Total	54		30		92		40		64		55	
	d=1.94				d=2.07				d=0.51			

CPUE = no. individuals/hectare
d = Diversity Index (Shannon-Weaver)

TABLE 2. Beach Seine May, 1984

STATION	HMS - 5 (1)		HMS - 5 (2)		HMS -4 (1)		HMS -4 (2)		HMS - 2 (1)		HMS - 2 (2)	
	NO.	CPUE	NO.	CPUE	NO.	CPUE	NO.	CPUE	NO.	CPUE	NO.	CPUE
Yellow perch	2	34			3	51	6	101				
Banded killifish	1	17							23	289	6	101
Atl. silverside	73	1234	45	761	74	1251	248	4191	18	304	15	254
Bay anchovy	255	4310	355	6000	117	1977	207	3498				
Menhaden	2	34	1	17								
White perch			1	17	10	169	4	68				
Am. eel					1	17						
Gizzard shad					1	17						
Pipefish					1	17						
Carp							2	34				
Pumpkinseed							1	17				
Striped killifish							3	51	9	152	11	186
Spot									9	152	16	270
Blue crab	3	51	1	17	7	118	13	220				
Total	336		403		214		484		59		48	
	d= 1.00				d= 1.57				d= 1.88			

CPUE = no. individuals/hectare
d= Diversity Index (Shannon Weaver)

declines were noted in menhaden and striped bass. The May samples showed significant decline only in menhaden. Overall, virtually the same number of individuals and species were taken. Tables 1 and 2 illustrate the catch by numbers, CPUE by species, and Shannon-Weaver diversity indices (d) for the primary sample.

Research Vessel Aquarius (offshore trawl sites)

The offshore trawl sites were located a minimum of several hundred meters from the rock revetment. This is in contrast to the inshore trawls which were within 35m of the revetment's toe. At these essentially open water sites approximately 33% fewer species were caught per season than at the inshore sites. Altogether a total of 2,690 individuals representing 10 species were caught. White perch, spot and blue crabs were the bulk of the fall samples with white perch the major spring catch (See Table 3). There was an increase of nearly 100% in number of individuals caught, but a slight decline in number of species (from 13 to 10) compared to the previous year's samples. Sites HMT-9 and HMT-10 had the greatest numbers and species caught in the fall sample, and HMT-10 the largest numbers in the spring. This result was also similar to the previous year's figures.

Except for HMT-6, species diversity as determined by the Shannon-Weaver diversity index was fairly uniform in both fall and spring (Table 4).

TABLE 3. Offshore (R/V Aquarius) Trawls
catch by Station
October 1984

STATION	HMT-1	HMT-2	HMT-4	HMT-5	HMT-6	HMT-7	HMT-9	HMT-10	TOTAL
White perch	49	70	92	18		2	445	277	953
Spot	37	87	32	69	72	6	217	146	666
Channel catfish		1			1			1	3
Hogchocker		2	1		1			1	5
Menhaden		1		1				3	5
Striped bass			1	1	1		1	1	5
Harvestfish								1	1
Blue crab	13	10	16	13	12	10	9	16	99
Site Totals:	99	171	142	102	87	18	672	446	1,737
APRIL, 1985									
White perch	27		109	128	163	96	129	278	930
Channel catfish	1		3						5
White catfish		1							1
Hogchoker		1	1	1					3
Yellow perch		1							1
Menhaden				1		4	2		7
Striped bass			1		3				4
Blue crab	1	1							2
Site Totals:	29	4	114	131	166	100	131	278	953

TABLE 4. Offshore (R/V Aquarius) Trawl
CPUE and Diversity
October, 1984

	HMT-1	HMT-2	HMT-4	HMT-5	HMT-6	HMT-7	HMT-9	HMT-10
White perch	96	142	150	40		5	788	612
Spot	73	176	52	152	136		385	322
Channel catfish		2			2			3
Hogchoker		4	2		2			3
Menhaden		2		2				7
Striped bass			2	2	2		9	2
Harvestfish								2
Blue crab	26	20	27	29	23	24		35
	d=2	d=1.42	d=1.35	d=1.33	d=0.84	d=1.35	d=1.1	d=1.32
White perch	53		178	283	308	230	229	614
Channel catfish	2		5	2				
White catfish		2						
Hogchoker		2	2	2				
Yellow perch		2						
Menhaden				2		10	4	
Striped bass			2		6			
Blue crab	2	2						
	d=0.43	d=	d=0.32	d=0.19	d=0.13	d=0.24		

The primary difference in this sample year appeared to be the abundance of certain species. Many more white perch were encountered this year (1,883) than the last (227). Furthermore, no anchovies were taken this year versus 493 for the previous years, and the abundance of blue crabs was down from 200 to 101.

These differences may have been only a response by local populations to temporary local conditions and not a result of major population fluctuations. Table 5 illustrates comparision of offshore trawl catch data over a three-year period. The difference in sampling times between the 1983 and 1984 samples was unavoidable, but differed by only ten days, 1 o/oo salinity and 2°C. While the numbers of most species repesented in the most recent samples were similar to the previous year's sample, white perch showed a marked increase. Offshore spring samples (Table 3) also showed a considerable increase in the catch of this species for this sample year.

The area offshore of the Hart and Miller Islands complex appears relatively stable with respect to species occurrence. Seasonal variations in abundance were the most apparent factor noted in these observations.

TABLE 5. Total catch by species in bottom trawls

Species	August 1981[1]	August 1982[2]	Sept. 1983[3]	Oct. 1984[4]
Spot	6,840	697	564	666
Bluefish	1	4	7	
Croaker	–	–	78	
Hogchoker	311	25	13	5
Anchovy	366	72	493	
White perch	468	81	9	953
Summer flounder	17	–	11	
Striped bass	1	3	4	5
Gizzard shad	–	–	2	
Menhaden	24	2	10	5
Blue crab	(3)*	(3)	199	99
American eel	118	–		
Channel catfish	12	42		3
Sea trout	82	1		
Winter flounder	3			
Pipefish	1			
Naked goby		1		
Harvestfish				1

[1]Tsai, 1982
[2]CRC Publ. #114, 1984
[3]3rd Interpretive Report, 1984
[4]present data

*not recorded

Eel Pots

Eel pot catches were generally inconsistent with the previous year's catch. Table 6 illustrates the variability of eel catch by site and season. Eel catch varied from 1.4 to 0.2 eels/pot day over the two years with no consistency even at the same site. The incidental catch of blue crabs was more consistent than eel catch.

With its numerous interstices, the rock revetment has the potential to be an ideal eel habitat, yet catches remained low. This could be caused by pot avoidance, which is unlikely given past experience in other areas; or the revetment may not be the ideal habitat previously postulated. Eels appear to prefer more sluggish, weather-protected habitats than found along the revetments. Population of the revetment may still take place but at a much slower rate than expected. For this reason, a reduced pot sampling program should be conducted in the future so as to monitor the existing population.

Catches of blue crabs were considerable, especially among sub-legal size crabs. Although eel pots are less efficient in catching crabs than the results indicate, the revetment may serve as habit for smaller, more vulnerable life stages of crabs.

TABLE 6. Eel pot catch comparison between 1983-84 and 1984-85

	October, 1983				October, 1984			
	HMG-3	HMG-2	HMG-1	Total	HMG-3	HMG-2	HMG-1	Total
American eel	76	4	11	91	6	5	5	16
Blue crab	26	9	25	60	12	16	26	54
Pumpkinseed					1		11	12
Spot					1		1	2
Channel catfish						2	1	3
	Average 1.3 eels/pot day				Average 0.2 eels/pot day			

	May, 1984				May, 1985			
	HMG-3	HMG-2	HMG-1	Total	HMG-3	HMG-2	HMG-1	Total
American eel	15	13	5	33	14	43	28	85
Blue crab	18	6	22	46	40	59	17	116
Pumpkinseed			3	3			1	1
White perch			1	1				
Channel catfish					1		1	2
	Average 0.6 eels/pot day				Average 1.4 eels/pot day			

Fish Traps

Fish trap catches were low in abundance but reasonably consistent, with the exception of the May 1984 samples (Table 7). This may have been caused by prolonged rough sea conditions experienced during that period, or low salinity (0.5 o/oo) as opposed to 4.8 o/oo for May 1985.

Overall, white perch was the most common species, averaging 3.3 to 5.5 per pot-day among the three productive sample periods. Catch in these traps however, was still low, suggesting that, consistent with past experience, they are best suited to more protected, shallower tributaries. Net leads attached to these traps might have increased catch markedly by directing fish movement, but would have been virtually impossible to set in the depths worked. Even so, the traps gave a good accounting of species in the nearshore area and adjacent to the revetment. These species were also present in the inshore trawl samples, confirming the apparent structure-associated attraction discussed in the Inshore Trawl section below.

TABLE 7. Fish trap catch comparison between 1983-84 and 1984-85

	October, 1983				October, 1984			
	HMG-3	HMG-2	HMG-1	Total	HMG-3	HMG-2	HMG-1	Total
White perch	48	1	28	77	58	19	22	99
American eel	4		3	7				
White catfish	1			1				
Bluefish	1		5	6				
Hogchoker	1	1		2	2			2
Spot		6	6	12	1	2	6	9
Menhaden			1	1				
Channel catfish					2		1	3
Pumpkinseed					3		2	5
Yellow perch					3		2	5
Brown bullhead							1	1
Blue crab		2		2	3	6	1	10
	8 species caught				8 species caught			

	May, 1984				May, 1985			
	HMG-3	HMG-2	HMG-1	Total	HMG-3	HMG-2	HMG-1	Total
White perch		3		3	22	22	15	59
Yellow perch					10	6	3	19
Pumpkinseed			2	2	7	5	28	40
Hogchoker					1	3	1	5
Brown bullhead					2	5	2	9
Blue crab			3	3	7	17	9	33
	3 species caught				6 species caught			

Inshore Trawl

Inshore trawl sampling was by far the most productive of the several sampling methods. A total of 4,842 individuals representing 15 species were taken, with 74% of the individuals taken in the October sample (Table 8).

In the fall sample, bay anchovies were the most abundant (57%) although the majority of this catch was obtained at a single site (HMG-2). Next in abundance were spot (37%) and blue crab (3.5%). In the spring sample, bay anchovies again comprised the bulk of the catch (54%), with white perch next (19.5%) and blue crab (8.3%). Spot were only 2.4% of the catch (Table 9). While the number of individuals was greater in the fall, the number of species represented was greater in the spring. No inshore trawl data were collected in previous years. However, a comparison of the inshore sites with adjacent offshore sites can give an indication of the general attractiveness of the physical structure to finfish. Table 10 outlines and compares the catch of individuals and species of adjacent inshore and offshore sites (See Figures 1 and 2 for site locations). An examination of catch abundance indicates that in all cases the inshore catch exceeded offshore catch by 70% to 99%, averaging 85%. Species occurrence and rank abundance were similar inshore and offshore. These data support the hypothesis that the structure is an attractant for finfish. Data from subsequent years will be used to further define and document the effect.

TABLE 8. Inshore trawl catch, by site
October 1984

Station Species	HMG-3	HMG-2	HMG-1	Total Individuals
Spot	474	798	51	1,323
White perch	24	15		39
Hogchoker	9	2	1	12
Channel catfish			5	6
Striped bass		7	1	8
Summer flounder		2		2
Anchovy		2,023	38	2,061
Carp		1	1	2
Yellow perch			6	6
Pumpkinseed			3	3
Brown bullhead			2	2
Blue crab	54	32	41	127
TOTAL SPECIES	4	8	10	
		CPUE-RANGES		
Spot	870-30	1,103-319	138-0	
White perch	38-3	27-6	15-0	
Hogchoker	18-3	3-0	3-0	
Channel catfish	3-0	0	15-0	
Striped bass	0	9-3	3-0	
Summer flouder	0	6-0	0	
Anchovy	0	3,588-188	114-0	
Carp	0	3-0	3-0	
Yellow perch	0	0	12-0	
Pumpkinseed	0	0	9-0	
Brown bullhead	0	0	6-0	
blue crab	81-15	42-27	69-27	

TABLE 9. Inshore trawls catch, by site
May 1985

STATION Species	HMG-3	HMG-2	HMG-1	Total Individuals
Spot	15	15	14	44
White perch	146	84	1	231
Hogchoker	3	23	1	27
Channel catfish	3	6	~~4~~ 1	13
Striped bass	3		4	7
Summer flounder				0
Anchovy	235	216	227	678
Carp	1			1
Yellow perch	18	2	18	38
Pumpkinseed			9	9
Brown bullhead	68	1	13	82
Banded killifish			1	1
Menhaden	1	1	13	15
Eel	2	8		10
Blue crab	58	38	8	104
TOTAL SPECIES	12	10	11	

CPUE-RANGES

	HMG-3	HMG-2	HMG-1
Spot	18-9	30-0	0
White perch	269-0	141-18	30-3
Hogchoker	3-0	42-6	3-0
Channel catfish	6-0	9-3	3-0
Sriped bass	9-0	0	9-0
Summer flounder	0	0	0
Anchovy	371-126	317-39	556-36
Carp	3-0	0	0
Yellow perch	21-15	6-0	30-3
Pumpkinseed	0	0	21-3
Brown bullhead	144-27	3-0	24-0
Banded killifish	0	0	3-0
Menhaden	3-0	3-0	39-0
Eel	6-0	24-0	0
Blue crab	105-33	45-24	12-3

TABLE 10. Comparison of inshore trawl sites with adjacent offshore trawl sites

NO. INDIVIDUALS

	FALL 1983	FALL 1984	SPRING 1984	SPRING 1985
HMG-3	-	562	-	554
HMT-2	265	171	55	4
HMG-2	-	2880	-	393
HMT-6	37	87	31	166
HMG-1	-	149	-	309
HMT-7	224	18	2	100

NO. SPECIES

	FALL 1983	FALL 1984	SPRING 1984	SPRING 1984
HMG-3	-	5	-	12
HMT-2	7	6	3	4
HMG-2	-	8	-	9
HMT-6	1	5	1	2
HMG-1	-	11	-	11
HMT-7	7	3	2	2

NOTE: - = no inshore trawl sites during this sampling period.

Conclusions and Recommendations

The survey to date has documented the presence of at least 22 species in the water surrounding the containment facility, the majority of which are found immediately adjacent to the facility. Trawl sampling, while limited in its ability to catch large finfish, appears to be the most suitable gear for the area. Data collection by this method in future years may better define the structure's use by various species. Along the eastern and southern revetment faces, currents and the exposed nature of the revetment may limit the types of species occupying this niche. Observations of local sportfishermen indicate the greatest catches may be coming from immediately around the off-loading docks. Here, currents are disrupted, forming eddies that trap food and perhaps, attract more fish. The construction of a few short rock groins perpendicular to the rock revetment, with proper placement, could break up currents and reduce wave action. This should stimulate greater use by eels and other species taking advantage of calmer waters.

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PROJECT IV

ANALYTIC SERVICES

by

Department of Natural Resources
Coastal Resources Division
Tidewater Administration
and
Water Resources Administration

SUMMARY

The levels of 36 individual trace organic contaminant compounds were determined in samples of sediment, white perch (Morone americana), and clam (Rangia cuneata) tissue. In general, the levels of these toxic organics were below detection limits with the exception of PCB's and 4,4 DDE. The 4,4 DDE was found to be above the detection level only in the fish tissue. There were no toxic organics above detection limits in clam tissues. Moderate levels of PCB's and DDE's were found in white perch tissue. The PCB levels in sediment have decreased considerably compared to background data from the 1982-83 report (CRC, 1984). None of the pollutants detected in tissue samples were found at levels where a hazard to humans would be indicated if ingested.

INTRODUCTION

Sampling of sediment and biota in the Hart-Miller Island area was performed on five dates: October 9, 1984, November 5, 1984, April 2-3, 1985, and April 16, 1985. The sampling was done mainly in the fall and spring to determine seasonal variability. The raw data for the samples that were above detection levels are presented in the 1984-85 Data Report.

METHODS OF ANALYSIS

Analysis of 36 organic compounds (Table 1) was performed on each sample. Gas Chromatography/Mass Spectrometry analyses of the following classes of organic contaminants were made: herbicides, pesticides, polychlorinated biphenyls (PCB) and polynuclear aromatic compounds (PAH). The protocols and detection limits used for these analyses were recommended by the EPA/WRA laboratory for consistency with prior data collected under these investigations.

Trace Organics in Sediments

Surficial sediments were collected at seven stations. The raw data for the seven sediment stations may be found in the 1984-85 Data Report. The data are

TABLE 1. List of 36 compounds analyzed

Butyl Benzyl Phthalate	Toxaphene
Di-n-octyl Phthalate	PCB's, Total
Bis(2-Ethylhexyl) Phthalate	Benzo (b) fluoranthene
Di-n-butyl Phthalate	Acenaphthene
Diethyl Phthalate	Acenaphthylene
Dimenthyl Phthalate	Anthracene
Aldrin	Benzo (a) anthracene
Alpha BHC	Benzo (a) pyrene
Beta BHC	Benzo (g,h,i) perylene
Gamma BHC (Lindane)	Benzo (k) fluoranthene
Chlordane	Chrysene
4,4'-DDD	Dibenzo (a,h) anthracene
4,4'-DDE	Fluoranthene
4,4'-DDT	Fluorene
Dieldrin	Ideno (1,2,3-cd) pyrene
Endrin	Naphthalene
Heptachlor	Phenanthrene
Heptachlor Epoxide	Pyrene

consistent with the low solubility of PCB's and their tendency to be strongly sorbed to sediment particles (Means et al., 1980).

In spring 1985 samples, only PCB's were found to be above detection levels (Figure 1). The levels were low compared to baseline data collected for past reports.

Trace Organics in Clam (*Rangia cuneata*) Tissue

There were no organic contaminants, including PCB's, above detectable levels at any of the stations. There were eleven total samples collected for clam tissue. Six samples were collected on November 5, 1984 and five samples were collected on April 2, 1985. Two samples were lost from the April 2, 1985 set of samples. One sample was lost due to a lab accident; the other sample could not be processed because of insufficient material.

Trace Organics in White Perch (*Morone americana*)

Nineteen samples were collected for organic analysis. Seven samples were collected on April 3, 1985 and twelve samples were from the October 9, 1984 collection date. Some samples were deleted from analysis due to poor labeling. The samples that were deleted included two from April 3, 1985 and ten from October 9, 1984.

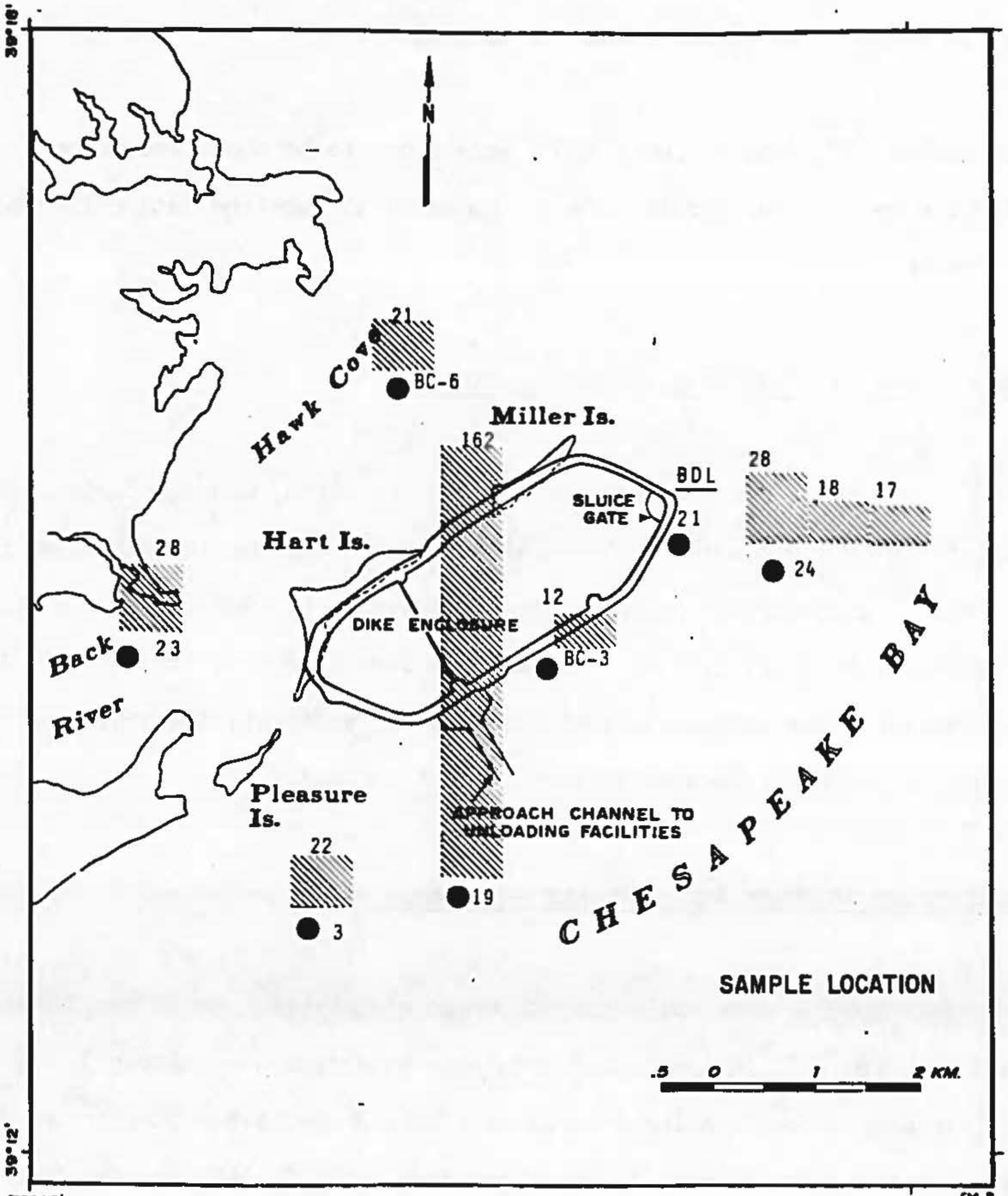

Figure 1

PCB Levels in Sediment
(parts per billion, ug/kg)

BDL-Below Detectable Level

There were only two contaminants which were above detection levels in the white perch tissue: total PCB's and 4,4 DDE. Although the PCB levels appear high (Figure 2), they are far below the maximum permissible tissue concentration for edible fish, which is 5,000 ppb (U.S. EPA, undated). Measured PCB levels can vary greatly in fish, depending on the age of the fish, the spawning season, the number of fish in the sample and technology. White perch PCB levels were lower in the fall than in the spring samples, as in earlier years.

The DDE levels that were detected were very low in the parts per billion (Figure 3). The levels appear to be dropping in the area compared to baseline data. According to the 1982-83 report, the DDE level was 410 ppb for HMT-10; in this current year's data, the level was only 172 ppb. Although the 1982 data were collected in fall and the 1985 data were collected in spring, this is a greater decrease than expected from seasonal variability alone. Further evidence of this decrease is obvious when comparing the data from station HMT-1. In February 1983 the DDE level was 553 ppb; in October 1984 at the same station the level was only 196 ppb. This shows a large decrease because traditionally the fall level should be higher than the spring level.

<u>Metals in Biota</u>

Data on metals in biota were received too late to be included in this report.

CONCLUSIONS AND RECOMMENDATIONS

1. Of 36 organic contaminants measured, only DDE and total PCB's were above detection limits in any of the samples; only PCB's were above the detection limit in sediment samples; both DDE and PCB's were detected in white perch tissue; and no organic contaminants were detectable in clam tissue.

2. The general distribution of PCB concentrations in sediment samples did not implicate the containment facility as a source. Low concentrations near the dike suggested dilution of background sediment levels by uncontaminated dike material during construction.

3. The presence of PCB's and DDE in white perch tissue should not be attributed to impacts of the containment facility. The PCB concentrations were consistent with low-level, food-chain bioaccumulation due to background sediment PCB concentrations. Moreover, these fish are mobile, and there is no indication that their body burdens were accumulated in the vicinity of Hart and Miller Islands.

4. Clam tissues showed no detectable organic contamination. As these organisms are mostly immobile, they should better reflect contamination associated with the containment facility than white perch.

5. Monitoring of sediments and biota for organic contaminants should continue with emphasis placed on benthic species such as *Rangia cuneata*. It would be very desirable to monitor body burdens of organisms which are food for benthic-feeding fish, such as *Scolecolepides* sp. In this way, some estimate of food chain accumulation could be made.

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