

PRELIMINARY
FOR REVIEW ONLY

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SELECTED METALS AND ORGANICS IN MARINE
SEDIMENTS AND BIOTA IN BUZZARDS BAY
1985 AND 1986

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*Raw Data in
paper form.*

DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING
DIVISION OF WATER POLLUTION CONTROL
TECHNICAL SERVICES BRANCH
WESTBOROUGH, MASSACHUSETTS

IN

COOPERATION WITH THE MASSACHUSETTS
DIVISION OF MARINE FISHERIES

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FOREWORD

The Massachusetts Division of Water Pollution Control was established by the Massachusetts Clean Water Act, Chapter 21 of the General Laws as amended by Chapter 685 of the Acts of 1966. Included in the duties and responsibilities of the Division is the periodic examination of the water quality of various coastal waters, rivers, streams and ponds of the Commonwealth, as stated in Section 27, Paragraph 5 of the Acts. This section further directs the Division to publish the results of such examinations together with the standards of water quality established for the various waters. The Technical Services Branch of the Division of Water Pollution Control has, among its responsibilities, the execution of this directive. This report is published under the Authority of the Acts and is among a continuing series of reports issued by the Division presenting water quality data and analyses, water quality management plans, baseline and intensive limnological studies and other special studies. A complete listing of technical reports published by the Division is available upon request.

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ABSTRACT

The Massachusetts Division of Water Pollution Control's Technical Services Branch has collected data on the comparative levels of priority pollutants in sediments and selected biota of Buzzards Bay. The relative concentrations and spatial distribution of the elements cadmium, chromium, copper, lead, mercury and nickel along with information on PCB AROCLOR and PAH were compared from 32 sediment samples obtained from 22 stations located throughout the bay. The pollutant levels while generally low, coorelate well with the accompanying grain size and total organic carbon data.

Similar analysis was also conducted on samples of quohåugs (Mercenaria mercenaria), lobster (Homarus americanus), and winter flounder (Pseudopleuronectes americanus) collected at stations throughout the bay. Levels were uniformly low in all three species although spatial differences suggest the importance of the particle size and organic content of the sediments along with proximity to potential sources to elevated levels. Total metal concentrations were determined by direct atomic absorption spectroscopy, PCB by gas chromatography and PAH by gas chromatography/mass spectrometry. QA/QC information is also presented.

1.0 INTRODUCTION

1.1 Buzzards Bay 1986 Assessment of Metal Contamination in Selected Biota

Buzzards Bay like most of Coastal Massachusetts Marine Waters is the recipient of a wide range of chemical contaminants. The contributing sources include point sources, such as wastewater treatment effluent, combined sewer overflows, and industrial discharges. Non-point sources to marine waters include runoff, atmospheric deposition, agricultural runoff, contaminated sediments, and as a component of groundwater to name just a few. Accumulation of contaminants by the biota is achieved through one or two pathways; by ingestion, and/or by absorption. The transfer of these contaminants through the trophic levels of a food web can result in changes to the ecological integrity of that web or result in the bioaccumulation and transfer to man by ingestion commercially important species.

The Buzzards Bay 1986 examination of biota represents the Division's first extensive survey of selected pollutant levels in marine organisms. While the Division of Water Pollution Control's mandated concerns are with the Commonwealth's surface waters, it has long recognized that a better assessment of pollutant loadings could be gained through evaluation of other available data source including biota tissue and sediments. Acting as repositories for many of the priority pollutants they may also accumulate at concentrations much higher than in the overlying waters.

This data report is the fourth in a series of six (6) studies conducted during 1985 - 1986 by the Technical Services Branch of the Division of Water Pollution Control. These studies were conducted to update the Commonwealth's knowledge on water quality conditions within the Buzzards Bay Drainage (see appendix).

The studies are also part of a National Estuarine Management Program developed by the Federal Government's Office of Marine and Estuarine Protection and Region 1 of the Environmental Protection Agency. The program was developed to promote and coordinate efforts between federal, state, local authorities, research institutions and the public in identifying and correcting the environmental problems effecting this nation's estuaries.

The Division through it's Technical Services Branch (TSB) proposed and received funding during FY85 and FY86 to conduct a joint study with the Massachusetts Division of Marine Fisheries (DMF). The purpose would be to conduct a broad scale assessment of the levels of selected priority pollutants) PCB's and heavy metals) within three common organisms collected at stations located throughout the tidal portions of Buzzards Bay, excepting the waters of the Acushnet River and New Bedford Harbor. Personnel from the Division of Marine Fisheries were largely responsible for the biota collections and for all of the PCB analysis. This PCB data set will be reported under a separate cover by DMF.

The Division of Water Pollution Control study had three objectives:

1. To expand baseline data on the body burdens of heavy metals in selected marine species.
2. To collect biota samples from stations not utilized by Batelle New England in their New Bedford Superfund Studies to better establish any temporal or spatial variations within the bay.
3. To compare the data with the respective EPA and FDA alert levels to determine their acceptability for human consumption.

During the studies initial planning stages in FY85 a total of 50 biota samples from the forementioned three species were to be collected primarily from Areas II and III. The Division proposed and received approval as part of its FY86 project plan to expand the coverage to include stations throughout the bay. During the Spring of 1986 personnel from the two respective Division's began collecting, Quohaugs, *Mercenaria mercenaria*, Lobsters, *Homarus americanus* and Winter Flounder, *Rseudopleuronectes americanus*. These species were chosen because they are commercially important benthic dwellers, because they represent different trophic levels, their relative abundance and their ubiquity. In all the Division's collected 95 samples from 40 different locations, (for more specific information concerning station locations please consult Table 3 - 5 and Figures 3 - 5 which locate the respective stations).

The methods of collection varied with each species and will be described in greater detail within the "Materials and Methods section" of this report. Analytical protocols were developed from EPA approved procedures and referenced methods. For specific information concerning sampling schedules, parameters, collection methods, analytical and QA/QC procedures consult in appropriate materials and methods section as well as Tables 22 - 24.

1.2 Buzzards Bay 1985 - 1986 Assessment of Contamination Levels in Marine Sediments

The Buzzards Bay 1985 - 1986 sediment data report represented the Division's first extensive survey of selected polutant levels in marine sediments. The Division through it's Technical Services Branch proposed and received funding during FY85 and FY86 to conduct a broad scale assessment of the levels of selected priority pollutants (PAH's, PCB's and heavy metals) at stations located throughout the tidal portions of Buzzards Bay, excepting the waters of the Acushnet River and New Bedford Harbor.

This study had three objectives:

1. To provide data on levels of PCB's as Arcolors (1016/1242, 1248, 1254, 1260), selected heavy metals (Cu, Ni, Pb, Cd, Cr, and Hg), and PAH's from sediment stations located throughout the bay.
2. To compare the levels of the pollutants listed above the findings reported from the Battelle Superfund Study and other pertinent studies, as appropriate.

3. To determine if PCB from the New Bedford Harbor/Acushnet River Area can be found in the sediments from other regions of the bay.

Station locations were selected with the following criteria in mind:

1. Station has been previously sampled by other reseachers.
2. Stations are located in the vicinity of potential point and non-point sources.
3. Stations are located in areas where fine grained deposits were thought to exist.

During August of 1985, six (6) stations located in the Outer Bay (Area V), North of an imaginary line drawn between the Towns of Mattapoisett and Woods Hole, Falmouth were sampled. During the late spring and early summer of 1986, several preliminary surveys were made in 11 Inner Embayments. During these surveys the substrate type was characterized along with the station's proximity to shellfish resources. A total of ten (10) stations were selected for sampling. All of the Inner Embayment stations had been sampled by 10/23/86. On 10/28/86, with the assistance of the MDMF the last of 6 stations within the Lower Outer Bay and Elizabeth Islands were surveyed. All chemical analysis was completed by the end of November, 1986. TSB collected a total of 29 samples from 22 stations during the course of this project (Table 6 - 7 and Figures 6 - 10 locate the sediment stations).

Overlying water quality data as well as temperature, salinity and dissolved oxygen profiles were also collected and are reported in the respective Buzzards Bay 1985 and 1986 water quality data reports.

Field sampling was conducted according to methods described in this report and according to the Division's standard operating procedures document. Copies of this document are on file at the Technical Services Branch Office in Westborough, MA. Analytical protocols were developed from EPA approved procedures and referenced methods (for specific information consult the appropriate materials and methods section of this report as well as Table 22 - 24 for details concerning sampling schedules, parameters, collection methods, analytical and QA/QC procedures).

Due to the size of the Buzzards Bay Drainage Basin and limitations in equipment and personnel the Division divided the basin into five (5) areas. These areas were selected based on similarities in geology and hydrography and soil type. (See Figure). They are as follows:

- Area I - The subdrainage basins and Inner Embayments of the Western Shore from the Rhode Island/Massachusetts State Line to the Fairhaven/Mattapoisett Town Line.
- Area II - The subdrainage basins and Inner Embayments from the Fairhaven/Mattapoisett Town Line to the Western Shore of the Cape Cod Canal.

Area III - The subdrainage basins and Inner Embayments of the Eastern Shore from the Cape Cod Canal to Woods Hole, Falmouth.

Area IV - The Elizabeth Islands.

Area V - The Outer Bay, the marine seaward of the headlands out to the mouth of the bay.

This report will serve several purposes. First, it will present the biota metals data collected in 1986 and second, it will provide an interpretation of biota and sediment data sets.

2.0 DESCRIPTION OF BASIN

Buzzards Bay is a prominent coastal embayment of the New England Coast nestled between Cape Cod and Southern Massachusetts see Figure 7. The mouth of the Bay opens south into Rhode Island Sound. Along its western shore the drainage basin is formed by seven coastal river basins, with a total drainage area of approximately 350 square miles. From east to west the major river basins are: Agawam, Wankinco, Weweantic, Mattapoissett, Acushnet, Paskamanset/Slocums, and Westport.

Along the eastern shore from the Cape Cod Canal to Woods Hole, Falmouth, small river basins provide an additional 35 square miles of drainage area. The prominent freshwater streams along the eastern shore from north to south are: the Back River, Pocasset River, Wild Harbor River, and Herring Brook. A chain of islands (the Elizabeth Islands), separated by tidal channels (holes), forms the southeastern side of the Bay.

Geologically, the Buzzards Bay Basin is characterized as a low granitic upland with glacial till and outwash deposits forming the soils. The terrain can be described as low and gently rolling with numerous lakes and marshes. Maximum elevations range between 200 to 300 above mean sea level in the northernmost reaches of the basin.

The Bay itself is 28 miles long, averages eight miles in width and has an average depth of 50 feet in the central basin. The surface area of the Bay is estimated to be 235 square miles.

The numerous harbors and coves located along the Bay's jagged coastline are used extensively for recreational and commercial purposes; there are over 4,300 slips and moorings along the Bay. Over 20,000 vessels pass through the Cape Cod Canal and Buzzards Bay annually, transporting over 19 million tons of commercial cargo, including most of the number 2 fuel used in New England. New Bedford Harbor is the industrial and commercial center of the basin, carrying over from its earlier days as a principal whaling port. It is now one of the most important fishing ports in the United States, often leading the nation in the dollar value of fish landings.

The harbor also suffers the bay's most severe water quality problems. Extensive contamination of New Bedford Harbor was first documented during the mid-70's when a few sediment samples collected from the harbor were first analyzed for aromatic hydrocarbons. Interference in the expected results led to the discovery that the samples contained high levels of polychlorinated biphenyls (PCB's). Subsequent studies by other researchers, the U.S. Environmental Protection Agency, and state agencies such as the Division of Water Pollution Control and Marine Fisheries confirmed the widespread contamination of sediments and biota within the Acushnet River Estuary, Inner Harbor and portions of the Outer New Bedford Harbor. The likely sources for the PCB's have since been traced to two industrial operations which discharged wastewaters directly to the harbor and indirectly through the New Bedford municipal sewer system. The sediments underlying the entire estuary and Inner Harbor contain elevated levels of

PCB's. The concentrations range from a few parts per million (ppm) to 100,000 ppm. Currently the entire estuary and harbor have been designated by the U.S. Environmental Protection Agency as a Superfund site. Additional problems within the harbor include combined sewer overflows, industrial discharges, street runoff, discharges from marine vessels, municipal sewage treatment plant discharges, and poor water circulation within the Inner Harbor. Problems in other harbors within the basin include street runoff from urban development, discharges from failing septic systems, watercraft, leachate from landfills and agricultural runoff.

3.0 MATERIALS AND METHODS

3.1 Biota Field Collections

As previously mentioned in the Introduction Section this survey was conducted jointly with the Commonwealth's Division of Marine Fisheries. Personnel from their Southeast Regional Office did the majority of the field collections. Personnel from the Division of Water Pollution Control assisted in the collection of shellfish from Area II locations.

3.1.1 Winter Flounder

Winter flounder (Pseudopleuronectes americanus) were collected during the spring of 1986 by the Division of Marine Fisheries personnel in conjunction with their bi-annual bottom trawl survey of the Commonwealth's coastal waters. The following description was excerpted from DMF 1986 Massachusetts Inshore Spring Bottom Trawl Survey Cruise No. 8691 Summary Report Date 8/7/86.

"The objectives of these survey are: 1) to determine the spring distribution and relative abundance of fish species; 2) to determine the geographic extent and incidence of fish liver pathology; 3) to collect biological samples; and 4) to collect hydrographical data.

The Commonwealth's coastal waters are divided into five physiographic regions which are further subdivided into depth strata. Individual strata were grouped by regions (strata sets) to make data meaningful for resource managers. Of particular interest to this study was the region encompassing Buzzards Bay, Vineyard Sound, and coastal waters south of Martha's Vineyard. Pre-determined trawl sites were chosen randomly within each sampling stratum and allocated in proportion to stratum area. sites are occasionally relocated due to concentrations of fixed gear or because of untowable bottom.

A 20-minute tow at 2.5 knots was made at each station with a 3/4 size North Atlantic type 2 seam otter trawl (11.9 m headrope - 15.5 m foot-rope) rigged with a 7.6 cm rubber disc sweep; 19.2 m, 9.5 mm chain bottom legs; 18.3 m, 9.5 mm wire top legs; and 1.8 x 1.0 m, 147 kg wooden trawl doors. The net contained a 6.4 mm cod-end liner to retain small fish.

Standard bottom trawl survey techniques were used when processing the catch of each species. Generally, the total weight (nearest 0.1 kg) and length-frequency (nearest centimeter) were recorded on standard trawl logs."

A total of 35 individual fish were collected from three stations within Buzzards Bay. Two of these stations were located at the upper end of the Bay and the third off the New Bedford Outer Harbor. (See Table 5 and Figure 5 for more precise locations.) Fish collected by DMF personnel were frozen in polyethylene plastic bags and shipped to the Division of Marine Fisheries Laboratory located at the Cat Cove Marine

Laboratory, Salem, MA. Information regarding the size and sex of the fish may be obtained from the Division of Marine Fisheries. Samples were thawed in a stainless steel trough, and the edible portions removed from each fish. The edible portion was defined as the skinless filet of the flounder. Each filet was homogenized in a stainless steel blender and refrozen in either a glass beaker or wrapped in aluminum foil until extracted.

3.1.2. Lobster

Lobster samples (Homarus americanus) were collected by DMF personnel onboard/commercial lobstering operations. All samples were purchased from the fisherman except those from Cleveland's Ledge which were obtained from recreational fisherman. (Daniel McKiernan, DMF personnel communication).

The Lobster station locations are presented in Table 4 and Figure 4. A total of 27 lobsters from eight stations were collected, additional information regarding the size and sex of the lobster used may be obtained from the Division of Marine Fisheries. Samples were frozen in polyethylene plastic bags until shipped to the Cat Cove Marine Laboratory. Samples were thawed in a stainless steel trough, and the edible portion removed from each animal. The edible portion was defined as the combined meat and edible hepatopancreas, i.e., tomale. Each lobster sample was homogenized in a stainless steel blender and refrozen in either a glass beaker or wrapped in aluminum foil until extracted.

3.1.3 Quohaugs

Quohaugs (Mercenaria mercenaria) were collected from locations within the estuaries and inner embayments of Buzzards Bay known to have abundant shellfish resources and where the substrate was predominately soft bottom, i.e., mud, silt. The collections were conducted during the late spring - early summer prior to the onset of the spawning cycle. Collections were made from subtidal beds using a commercial 24-inch "bull rake" and from intertidal waters using a recreational 9-inch rake. Shellfish less than 51 mm in length were rejected. A composite of eight shellfish constituted a sample. At locations where shellfish were exceptionally abundant and of legal size sufficient numbers were collected to allow for replicate sampling. A total of 44 composite quohaug samples from 33 different locations were analyzed. (See Table 3 and Figure 3 for station locations.)

Each sample was frozen in a separate polyethylene plastic bag until shipped to the Cat Cove Marine Laboratory. Samples were thawed in a stainless steel trough, and the edible portion removed. The edible portion for quohaugs was defined as the shucked meat. Each sample was homogenized in a stainless steel blender and refrozen in either a glass beaker or wrapped in aluminum foil until extracted.

3.1.4 Analytical Methodologies: Biota

Table 8 provides a comparative list of sampling parameters, metals, by species within the designated areas. Upon receipt by the Lawrence Experiment

Station the samples were logged and processed according to approved procedures. Analysis was conducted by direct aspiration atomic absorption spectroscopy. In direct aspiration atomic absorption spectroscopy a sample is aspirated and atomized in a flame. A light beam from a hollow cathode lamp whose cathode is made of the element to be determined is directed through the flame into a monochromator, and onto a detector that measures the amount of light absorbed. Absorption depends upon the presence of free unexcited ground state atoms in the flame. Since the wavelength of the light is characteristic of only the metal being determined, the light energy absorbed by the flame is a measure of the concentration of that metal in the sample. Preliminary treatment of solids by atomic absorption is complicated by the complexity and variability of the sample matrix. This varies with the metal to be determined and the nature of the sample to be analyzed. When the breakdown of organic material is necessitated, the process included a wet digestion procedure. A list of the procedures used is found as Table 23 of this report. The reference section of this report provides additional information concerning analytical procedures, sample preparation and quality assurance/quality control.

Prior to 5/23/86 LES used a Perkin Elmer 403 spectrophotometer™ to analyze for metals. This instrument is not equipped with correction factor to filter out "background noise" caused by the matrix of the material being analyzed. The matrix effects tend to be additive thereby inflating the true levels. The analytical QA/QC procedures used by LES did not and could not reflect that interference. Biota samples delivered to LES after 5/23/86 were analyzed with a Varian AA-1475 spectrophotometer™ which did have the necessary background correction factor and are so noted in (Tables 9-10).

3.2 Sediment Field Collection

The sampling techniques employed during the collection period varied with the depth of water and the actual sampling devices employed. During the summer of 1985, the Division of Water Pollution Control's Technical Services Branch contacted with the Division of Marine Fisheries for use of their research vessel "F.W. Wilbour." The Wilbour provided a working platform for collection of water quality and sediments from stations located in the Outer Bay and along the Elizabeth Island Chain; areas identified by the Division for reporting purposes as Areas V and IV. Station locations were verified by use of the on-board LORAN C navigational equipment. Samples were rejected if they appeared to contain a high percentage of coarse grained sediments. During the initial collections in the Outer Bay, the Division employed two sampling devices. The first, a Phleger corer™, is a free-fall device suitable for collection of soft, sandy or semi-compacted sediments. It is composed of a hydrodynamically shaped lead weight with a stabilizing fin assembly which minimizes planning and turbulence during descent. The lower section of the corer is composed of variable lengths of galvanized steel coring tube having an internal diameter of 37 mm. Sediments are retained in the tube by the presence of a stainless steel core-catcher, the leaves of which remain open during the corer's penetration into the substrate and are then pressed closed by the weight of the trapped sediments. The Division used a 60 cm coring tube with a replaceable plastic liner insert. The corer and its components are manufactured by the Kahlisico International Corporation (P.O. Box 947, El Cajon, CA 92022).

The second device employed in the Outer Bay was a Ponar grab dredge quantitative bottom dredge manufactured by the Wildlife Supply Company (Saginaw, MI 48602). The dredge which has a sampling area of 23 x 23 cm. (9" x 9"), utilizes its weight, 28 kg (62 lbs), during descent to penetrate into the sediment. Upon retrieval, a simple tension release hinge levers the jaws of the dredge closed. Both devices were connected to the ship's winch by use of a shackle and 3/4 inch line. Each device was allowed to free fall to the bottom and returned to the deck by use of the ship's winch. The original intent was to use the corer with plastic inserts to estimate the relative depth of the redox boundary. However, this proved to be impractical since several of the samples collected showed no discernable redox boundary; as a consequence the corer was eliminated from the collections. A second problem arose with the use of the large Ponar, which repeatedly failed to close, necessitating repeated drops to obtain a sample. Various remedies were employed such as loosening all hinges, varying the rate of descent and by applying and releasing tension to the retrieval line. The failures appeared to be related to the depth of the water with a greater frequency of failure at the stations in deeper water. This suggested that the release hinge was always under tension and that the 3/4 inch line might be fanning out during descent. Subsequent surveys conducted in the summer of 1986 seemed to confirm this when a shift was made to 1/2 inch nylon line. The nylon line was found to be much lighter and seemed to provide more spring upon retrieval resulting in a much lower rate of failure.

Sediments from the inner embayments, (Areas I, II, III) were collected with Kahlisco's "petite ponar." This smaller version has a sampling area of 15 cm x 15 cm (6" x 6") and a weight of 10 kg (22 lbs). Collections were made from the Division's 17' "Boston Whaler"; retrieval was by hand. Station locations were verified by triangulation with various topographical features in the area after confirming the presence of silty, muddy sediments. The Division employed the following regimen during sample collections. Prior to each sample collection a member of the crew was responsible for preparing the Ponar dredge for sampling. The dredge was first washed in clean seawater to remove any adhering clumps of sediment. The interior of the dredge was then washed with reagent grade acetone followed by a rinse with reagent grade hexane, followed by a final rinse in clean seawater. The waste rinses were collected and transported back to the laboratory for disposal.

Upon retrieval of the dredge, it was opened and the contents placed in a galvanized steel wash tub. Glassware used in the sample collection were specifically purchased for that purpose or cleaned in a manner described in a TSB internal memorandum dated August 26, 1985 after consultation with the Lawrence Experimental Station (LES). Subsamples were taken in the following sequence, to minimize the possible cross contamination of the sediments with the metallic surfaces of the dredge: PCB's PAH's metals and grain size. During the 1986 collections two samples were generally taken at each station. The sediments destined for organic analysis were scooped into specially prepared jars which contained either a teflon or aluminum foil septum. Care was taken to minimize the collection of sediments in direct contact with the wash tub. Each sample was then tagged and placed

in an ice cooler for subsequent transport to the laboratory. Sediments collected from the inner embayments during the FY86 sampling period were split for organic analysis. Samples destined for grain size analysis were kept frozen until analysis. For more specific information regarding field and analytical protocols refer to Tables 14 and 15 and/or contact the Massachusetts Division of Water Pollution Control's Technical Services Branch.

3.2.1 Particle Size Analysis:

The particle size analysis was conducted according to the "pipet method" as described in a draft document entitled, "Protocols for Sampling Surficial Sediments for Physical/Chemical Variables." This was later supplemented with procedures found in the USGS publication, "National Handbook of Recommended Methods for Water Data Acquisition", revision 4/79.

Sediments collected in the field were tagged, placed in an ice filled cooler and transported back to the Technical Services Laboratory where they were kept frozen pending the grain size determinations.

After thawing, the sample was mechanically homogenized by mixing. A wet weight sub-sample of approximately 40-50 grams was removed and placed in a 2 liter beaker. Replicate grain-size analysis was conducted on every fifth sample. Since it was desired to obtain the true particle size distribution, the sample was treated with the prescribed 20 ml of 10% hydrogen peroxide (H_2O_2) solution to digest any organic matter. The resulting reaction was found to be too slow and the procedure modified to use 10 ml. increments of 30% H_2O_2 (Fisher Certified ACS) to speed up the digestion process. Approximately 100 mls of 30% H_2O_2 and 24 hours of digestion time per sample was required to completely digest all the organic matter. The sample was then boiled for several minutes to drive off any excess hydrogen peroxide solution.

The sample was then separated into coarse and fine fractions by wet sieving through a 63-micron stainless steel sieve. The sieving process continued with successive washes of deionized distilled water until clear water passed through the sieve. The coarse fraction retained by the sieve was transferred to a 250 ml beaker and dried in an oven at a temperature of 50° centigrade. The dried fraction was finally transferred to a dessicator for cooling.

The contents were then oven dried at 105° centigrade until all the moisture was driven off.

3.2.1.1 Coarse Fraction:

The coarse fraction was subsequently disaggregated using a mortar and pestle then transferred to a tared beaker and weighed to the nearest 0.1 mg on "Mettler H10 Analytical Balance" to obtain the total weight of the coarse fraction. A nest of U.S. standard sieves ordered from coarse (2 mm. mesh) to fin (0.0625 mm. mesh) was then assembled with a pan located on the bottom. The coarse fraction was placed in the top sieve and the whole nest shaken for 15 minutes on a mechanical shaker table. The contents of

each sieve was emptied onto a sheet of aluminum foil. The sieve screens were lightly tapped and brushed with a nylon brush to dislodge any adhering particles. The entire contents of each sieve was transferred from the aluminum sheet to a tared beaker where upon the individual size fractions were weighed to the nearest 0.1 mg. Additional material passing through the finest screen was added to the beaker containing the fine fraction.

3.2.1.2 Fine Fraction:

The fine fraction from the initial sieving was allowed to stand until the silts and clays settled out. The remaining clear supernatant was removed by siphoning. The residual fine fraction was transferred to a metal cup of a malt blender and 10 ml of a 1% solution of Calgon added to the mixture. The Calgon solution acted as a peptizer to prevent flocculation of the sediment particles. The mixture was blended for three minutes, transferred to a 1,000 ml graduated cylinder and brought up to a volume of approximately 900 mls with dionized distilled water. The mixture was allowed to stand for three hours and observed for signs of flocculation. If a definite band of clear water developed an additional amount of Calgon solution was added to the mixture. The volume of Calgon solution was recorded for future calculations. The sediment suspension was diluted to 1,000 mls by addition of dionized distilled water. The sample was thoroughly mixed with a long stirring rod and a 20 ml sample withdrawn from a depth of 20 cm to determine wet weight. This was placed in a tared 50 ml beaker; the pipet was washed with dionized distilled water and the rinse added to the beaker. The contents were then dried in an oven maintained at 105° centigrade until all the moisture was driven off. The contents were allowed to cool in a dessicator before being weighed to the nearest 0.1 mg to obtain an estimate of the total weight of fine fraction. The graduated cylinder was placed in a constant temperature bath, clamped in place for stability and brought up to the 1,000 ml mark with dionized distilled water. The sample was then thoroughly stirred to insure that the sediments were uniformly mixed throughout the water column. Fifteen seconds after cessation of the stirring, 20 mls of solution was withdrawn from a depth of 20 cm. This was placed in a tared 50 ml beaker; the pipet washed with dionized distilled water and the rinse added to the beaker.

The contents were allowed to cool in a dessicator before being weighed to the nearest 0.1 mg. Subsequent timed withdrawals were made in accordance with specified directions with the last withdrawal being made for PHI sizes 8.0 or less. All of the tared 50 ml beakers were then transferred to an oven maintained at 105° centigrade until all the moisture was driven off. The fractions were then allowed to cool and weighed to the nearest 0.1 mg.

3.2.2 Calculations:

The data for both the coarse fraction and the fine fraction were recorded in tabular form in a bound notebook. The weights of the samples withdrawn

during the pipet analysis were cumulative while those of the dry sieving were not. Corrections for the amount of peptizer were included in the calculations. The total sample weight was to be calculated from the weight of the fine fraction and the coarse fraction.

Upon completion of the methods detailed above and during the calculation phase it became apparent that the methodology contained several omissions and sources of error. Verification came from the methodology described in the forementioned "National Handbook of Recommended Methods for Water Data Acquisition" revision 4/79. the draft procedure made no provision for obtaining a dry weight of the subsample after treatment with the hydrogen peroxide. Therefore, there was no true measure of the total weight of the sample. The draft procedure also called for the addition of the Calgon dispersent to the fine fraction, whereas, the Handbook calls for its addition prior to separation into the coarse and fine fractions. The initial withdrawal to obtain an estimate of total fines was consistently smaller than the next withdrawal indicating some loss of fines. Accordingly, the reported grain size analysis underestimates the percentage of fines and the relative proportions of fine fractions. Particle size is reported in the following tables by "PHI size" as recommended by the subcommittee on sediment terminology of the American Geophysical Union (See Lane 1947.)

<u>CLASS NAME</u>	<u>MILLIMETERS</u>	<u>MICROMETERS</u>	<u>PHI VALUE</u>
Boulders	>256	--	<-8
Cobbles	256-64	--	-8 to -6
Gravel	64-2	--	-6 to -1

Very coarse sand	2.0-1.0	2,000-1,000	-1 to 0
Coarse sand	1.0-0.50	1,000-500	0 to +1
Medium sand	0.50-0.25	500-250	+1 to +2
Fine sand	0.25-0.125	250-125	+2 to +3
Very fine sand	0.125-0.062	125-62	+3 to +4

Coarse silt	0.062-0.031	62-31	+4 to +5
Medium silt	0.031-0.016	31-16	+5 to +6
Fine silt	0.016-0.008	16-8	+6 to +7
Very fine silt	0.008-0.004	8-4	+7 to +8

<u>CLASS NAME</u>	<u>MILLIMETERS</u>	<u>MICROMETERS</u>	<u>PHI VALUE</u>
Coarse clay	0.004-0.0020	4-2	+8 to +9
Medium clay	0.0020-0.0010	2-1	+9 to +10
Fine clay	0.0010-0.0005	1-0.5	+10 to +11
Very fine clay	0.0005-0.00024	0.5-0.24	+11 to +12
Colloids	<0.00024	<0.24	>+12

3.2.3 Priority Pollutants Sediment Analysis:

All field samples were immediately placed on ice at the time of collection and remained so until they were received by the Lawrence Experiment Station (LES). All samples were received by LES within two days of

collection, generally within 24 hours. TSB collected a total of 29 samples from 22 stations during the course of this project. Table 7 provides a comparative list of sampling parameters by area. Upon receipt by the laboratory the samples were logged and processed according to approved EPA procedures.

3.2.3.1 Metals Analysis

Analysis was conducted by direct aspiration atomic absorption spectroscopy. In direct aspiration atomic absorption spectroscopy a sample is aspirated and atomized in a flame. A light beam from a hollow cathode lamp whose cathode is made of the element to be determined is directed through the flame into a monochromator, and onto a detector that measures the amount of light absorbed. Absorption depends upon the presence of free unexcited ground state atoms in the flame. Since the wavelength of the light is characteristic of only the metal being determined, the light energy absorbed by the flame is a measure of the concentration of that metal in the sample.

Preliminary treatment of solids by atomic absorption is complicated by the complexity and variability of the sample matrix. This process varies with the metal to be determined and the nature of the sample to be analyzed. When the breakdown of organic material is necessitated, the process included a wet digestion procedure. A list of the procedures used is found as Table 15 of this report. The reference section of this report provides additional information concerning analytical procedures, sample preparation and quality assurance/quality control.

Prior to 5/23/86 LES used a Perkin Elmer 403 spectrophotometer™ to analyze for metals. It did not have a background correction factor to filter out "background noise" caused by the matrix of the material being analyzed, thereby resulting in artificially high levels. The analytical QA/QC procedures used by LES did not and could not reflect that interference. Sediment samples delivered to LES after 5/23/86 were analyzed with a Varian AA71475 spectrophotometer which did have the necessary background correction factor and are so noted in Table 8.

3.2.3.2. Organic Sediment Analysis

Gas chromatography was used to analyze for polychlorinated biphenyls according to the EPA Soxhlett Extraction Procedure For Sediments (U.S. EPA, October 1980). Confirmation was made by running the sample through a second column. Quantification was made by comparing sample results with known standards of Aroclors 1242, 1248, 1254 and 1260. Polycyclic aromatic hydrocarbons were analyzed by gas chromatography/mass spectrometry according to procedures described in U.S. EPA methods 3510 and 8100. Table 15 lists all analytical procedures employed as well as minimum detection limits. For more specific information regarding extraction procedures, laboratory QA/QC employed by LES contact the TSB office in Westborough, Massachusetts or the Lawrence Experiment Station, Lawrence, Massachusetts.

3.2.4 Total Organic Carbon Analysis

Total Organic Carbon levels were measured in 30 sediment samples collected from the bay. The methodology employed is fully described in "Methods for the Determination of Organic Substances in Water and Fluvial Sediments" Open File Report 82-1004 by the U.S.G.S.

Briefly, Total Organic Carbon levels, were estimated by subtracting the amount of total inorganic carbon determined by the modified Van Slyke method from the total amount of inorganic and organic carbon determined by induction furnace methodologies.

Ex.	Total Carbon	12.0 g/KG
	Total Inorganic Carbon	<u>.2</u> g/KG
	Total Organic Carbon	11.8 g/KG

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The following information was compiled from the Quality Assurance/Quality Control document prepared by Lawrence Experiment Stations Inorganic Chemistry Laboratory Standard Operating Procedures 1984 (Revised: 5/28/86.)

4.1 Data Handling

Each analyst records analytical data into bound work-books. The laboratory secretary transcribes and types the data onto report forms. The forms are checked for accuracy by the Chief of Laboratory. If approved, copies are sent to the Division's Boston Regional Offices.

4.2 Instrument Maintenance

All routine maintenance is performed by the analyst. Records are kept in a book which has been assigned to each instrument. The Instrumentation Laboratory atomic absorption Spectrometer (model #951V) is the only instrument in the inorganic chemistry laboratory under a service contract.

4.3 Quality Assurance

In addition to compliance with EPA's "Methods for Chemical Analysis of Water and Wastes" and "Standard Methods for the Examination of Water and Wastewater" (for analytical procedures and methodology), the following Quality Assurance plan is in effect for the following parameters: calcium, magnesium, sodium, potassium, all metals, ammonia, nitrate.

4.4 Purpose

To control the quality of all analytical data generated in and leaving the inorganic chemistry lab.

4.5 Precision

In order to ensure precise analytical data, one out of every ten samples shall be selected and run in duplicate. It shall be analyzed immediately after the set of ten it was selected from and prior to the next set of ten. It shall be recorded in the work-book in the order in which it is run and not at the end of the analysis. The duplicate data is then used as follows:

- a. The difference between the original sample and the duplicate is determined.
- b. The Standard Deviation of the differences (at least 20 is determined.)
- c. A Quality Control Chart is generated from this data using 1 and 2 standard deviations around zero. Two (2) standard deviations determines the upper and lower control limits. If a duplicate is out of control the analysis is stopped and the analyst checks for error. When the problem is solved, that set of ten (10) samples is re-analyzed.

4.6 Accuracy

In order to ensure accurate analytical data, the following two (2) methods shall be used.

- a. An EPA reference standard shall be run after every ten samples. These known concentrations indicate whether the working standards are good or bad, and whether the instrument settings have been properly set-up.
- b. To ensure the accuracy of actual field samples, one out of every ten samples (the duplicate sample) shall be spiked with a known amount of analyte. After analysis, the percent-recovery* of the spike shall be determined and used as follows:
 1. The mean (of at least 20 samples) of the percent recoveries is determined.
 2. The standard deviation of the percent recoveries is determined.
 3. A quality control chart is generated from this data, using 2 (two) and 3 (three) standard deviations around the mean percent-recovery; two (2) standard deviations determine the upper and lower warning limits; three (3) standard deviations determines the upper and lower control limits. If a spike is out of control, the analysis is stoped and the analyst checks for error. When the problem is solved, that set of ten (10) samples is re-analyzed.

4.7 Order of Analysis

A typical run should include the following: Standard, blank, EPA Reference, ten (10) samples, blank, duplicate, spike, EPA Ref., etc. All of the Q.C. data generated should be recorded on the Q.C. Charts and in a separate Q.C. data book. Variance from this plan must be approved the Lab. Chief.

4.8 Performance Evaluation

Our Laboratory's Quality Assurance Program also includes participation in EPA's semi-annual performance evaluation study, both for water pollution (WP series) and drinking water (WS series).

*Determine % recovery as follows:

$$\frac{\text{Sample} + \text{Spike} - \text{avg. (original} + \text{duplicate)}}{\text{Spike}} \times 100$$

4.9 Method Detection Limit (MDL)

MDL is established where applicable. It is determined for each method, for each instrument, and for each matrix. The MDL is determined by the analysis of seven replicates of spiked matrix samples. MDL is based upon the

performance of the entire measurement system. The Standard Deviation of the responses (S_m) in concentration units, is used to calculate the MDL as follows:

$$MDL = S_m(t.99)$$

Where:

$t.99$ = "Student's t value" appropriate for a one-tailed test at the 99% confidence level and a standard deviation estimate with $n-1$ degrees of freedom.

For seven samples $t.99 = 3.43$.

Example: Run seven replicate spikes, determine the standard deviation, multiply by 3.143. Resulting figure is MDL.

4.10 QA/QC QUOHAUGS MERCURY

QA/QC Data Transcribed from LES Record for Quohaugs

1. Date Analyzed: 5/16/86 LES #: 573926-936

	ml/Sample	ABS	ug/50 ml	ug/100 ml
Blank	100 ml	0.004		0.00
(.5) ug	100 ml	0.127		0.48
DUP #930	1.03g/100 ml	0.026	0.08	
DUP 930+ .3 Spike	1.23 g/100 ml	0.096	0.36	

% Recovery Calculations: 930 DUPL $0.08/1.03 = 0.08$
 DUP 930 + Spike $0.36/1.23 = 0.29$
 $0.29 - 0.075/0.30$ (Spike) = 72%

Analysis done on PE 403 Analyte Hg - MCV Method

2. Date Analyzed: 7/15/86 LES #: 574155-162

	100 ml	ABS	
Blank			
DUP #160	1.05	0.05	$0.05/1.05 = 0.05$
DUP #160 + 0.3 Spike	1.04	3.5	$0.35/1.04 = 0.34$

% Recovery Calculations: $0.34 - 0.05/0.3 = .97\%$

Calculation used to convert absorbance reading in ug/l to mg/kg dry weight:

$(\text{ug/Hg in 100 ml/vol analyzed}) \times \text{vol digested} \times$
 $1/\text{wt of sample} = \text{ug/g} = \text{mg/kg}$

Analysis done VARIAN 1475 + Vapor Generator Accessory (VGA 76) Manual Cold Vapor Method

QA/QC QUOHAUGS DATA (CONTINUED)

QA/QC Data Hg

3. Date Analyzed: 12/4/86

LES #: 575465-475

	<u>vol/wt/vol</u>	<u>ABS</u>	<u>ug/100 ml</u>
Digested Blank	50 ml/100 ml	0.1 ug	
Blank		0.9	Corrected to 0.0
Spike 3.0		3.3	Corrected to 3.0
DUP 475	50 ml/100 ml	0.7	
DUP 475 + 0.3 Spike		3.7	

% Recovery Calculations:

$$3.7 - 0.7/0.3 = 100\%$$

Sample Calculations for 405: $\text{ug/l/10} \times \frac{100}{50} \times \frac{1}{\text{wtg}} =$

$$5.1 - 0.1/10 \times \frac{100 \text{ ml}}{50 \text{ ml}} \times \frac{1}{10 \text{ g}} = \frac{5.0}{5(10)} = 0.10$$

4. Date Analysed: 12/4/86

LES #: 575476-489

	<u>vol/wt/vol</u>	<u>ABS</u>
Blank	100 ml	0.0
Spike 3.0	100 ml	3.0
DUP #584	50 ml/100	0.6
Spike + DUP #584	50 ml/100	3.5

% Recovery Calculations:

$$3.5 - 0.6/0.3 = 97\%$$

4.11 QA/QC LOBSTERS MERCURY

QA/QC Data Transcribed from LES Record

1. Date Analyzed: 5/16/86

LES #: 573916-925

	<u>ml Sample</u>	<u>ABS</u>	<u>ug 50 ml</u>	<u>ug/100 ml</u>
Blank	100	0.004	-	0.00
(0.5) Spike	100	0.129		0.49
DUP #920	1.15	0.028	0.09	
0.3 Spike + DUP #920	1.0	0.091	0.34	

% Recovery Calculations: $0.34 - 0.08/0.30 \times 100 = 87\%$

Formula used to convert ug/l to mg/kg

$\text{mg/kg} = \text{ug/g Hg} = \text{ug H Detected/Vol Analyzed} \times \text{Volume Digest} \times 1/\text{wt of sample}$

Sample is brought up to 100 ml = volume of digest absorbance value is converted to ug/100 ml - Based on standard curve developed with each new batch of sample.

2. Date Analyzed: 4/25/86

LES #: 573671-677

	<u>ml/Sample</u>	<u>ABS</u>	<u>ug 50 ml</u>
Blank	100 ml	0.003	0.00
.5 Spike	100	0.135	0.51
DUP #674	1.73	0.068	0.254
Spike + DUP #674	1.01	0.113	0.43

% Recovery Calculations: $0.43 - 0.25/0.30 = 60\%$

Example of calculations used for sample #573671:

$0.137/100 \times 100/1 \times 1/1.08 \text{ gm} = 0.137/1.08 = 0.13 \text{ ug/g} = \text{mg/kg}$

3. Date Analyzed: 8/15/86

LES #: 574558-567

DUP #563 25 ml $0.2 \text{ ug/l} \times 4 = 0.8 \times 100 \text{ ml} = 0.08 \text{ ug/100 ml}/10.26\text{g}$
 0.3 Spike + DUP #563 BROKE

QA/QC LOBSTER DATA (CONTINUED)

4. Data Analyzed: 2/10/87

LES #: 575923

	Original	Duplicate	Orig-Dup Difference	Spike & Sample	% Recovery
Cadmium	0.66	0.50	0.16	6.38	98
Chromium	<0.28	<0.29	0.00	6.02	*
Mercury	0.05	0.05	0.00	0.13	114
Lead	<0.47	<0.50	0.00	6.5	*
Nickel	0.57	0.40	0.17	5.4	83
Weight in Grams	10.6	10.08	-	8.47	-

Results Expressed in mg/kg

- Not Recorded

* Raw Data Reading Were Below Minimum Detection Limits

4.12 QA/QC WINTER FLOUNDER - MERCURY

QA/QC Data Transcribed from LES Record

1. Date Analyzed: 12/11/86

LES #: 575490-499

	<u>ml/Sample</u>	<u>ABS</u> <u>ug/ml</u>	
Digested Blank	50/ml	0.0	
Blank	50/100	0.0	
3.0 Spike		3.0	
DUP #499	50/100	0.9	$.09 \times 2/10 = 0.018$
3.0 Spike + DUP #499	50/100	3.6	$.36 \times 2/10 = 0.072$

2. Date Analyzed: 12/11/86

LES #: 575500-509

	<u>ml/Sample</u>	<u>ABS</u> <u>ug/ml</u>
Blank	50/100	0.0
3.0 Spike		3.0

3. Date Analyzed: 12/11/86

LES #: 575510-519

	<u>ml/Sample</u>	<u>ABS</u> <u>ug/ml</u>	
Blank (DW)		0.0	
3.0 Spike		3.0	
DUP #513	50/100 ml	2.1	$0.21 \times 2/10 = 0.42$
3.0 + DUP #513		4.9	$0.49 \times 2/10 = 0.98$

Values reported as < reflect below detection limits. The < value varies with the volume and weight of sample.

TABLE 1
BUZZARDS BAY BASIN CITIES AND TOWNS
LAND AREA - POPULATION

MUNICIPALITY	POPULATION 1940	POPULATION 1950	POPULATION 1970	POPULATION 1980	1980 DENSITY (persons/sq.mi.)
Acushnet	4,145	4,401	7,767	9,704	484
Bourne	3,815	4,720	12,636	13,874	338
Carver	-	-	2,420	6,988	182
Dartmouth	9,011	11,115	18,800	23,966	393
Fairhaven	10,938	12,764	16,332	15,759	1,297
Fall River*	-	-	96,898	92,574	2,815
Falmouth	6,878	8,662	15,942	23,640	531
Freetown*	630	475	4,270	7,058	204
Gosnold	136	56	83	63	5
Kingston*	-	-	5,999	7,362	397
Marion	-	-	3,466	3,932	275
Mattapoisett	-	-	4,500	5,597	321
Middleborough*	-	-	1,367	16,404	234
New Bedford	110,341	107,189	101,777	98,478	5,186
Plymouth	-	-	18,606	35,913	368
Rochester	-	-	1,770	3,205	95
Wareham	-	-	11,492	18,457	503

*These communities are not considered members of the Buzzards Bay Basin planning area due to their relatively small percentage of land area within the basin.

Source: Cities and Town Monographs, Department of Commerce and Development,
Commonwealth of Massachusetts

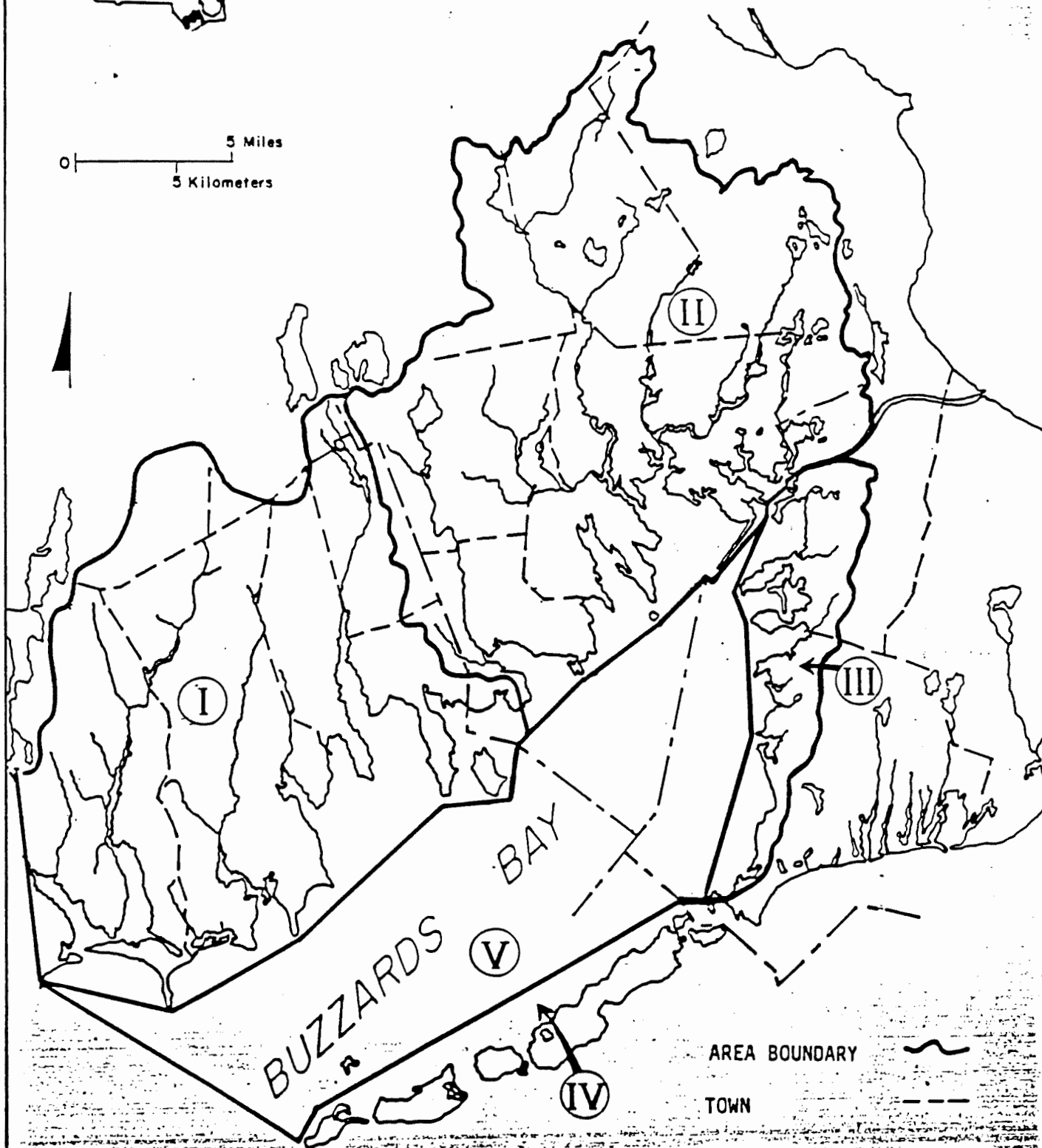
FIG. I

BUZZARDS BAY

COASTAL DRAINAGE AREAS



0 5 Miles
0 5 Kilometers



95 DWPC DRAINAGE BASIN CLASSIFICATION SYSTEM PER 314 CMR 4.05:

TABLE 2

BUZZARDS BAY BASIN

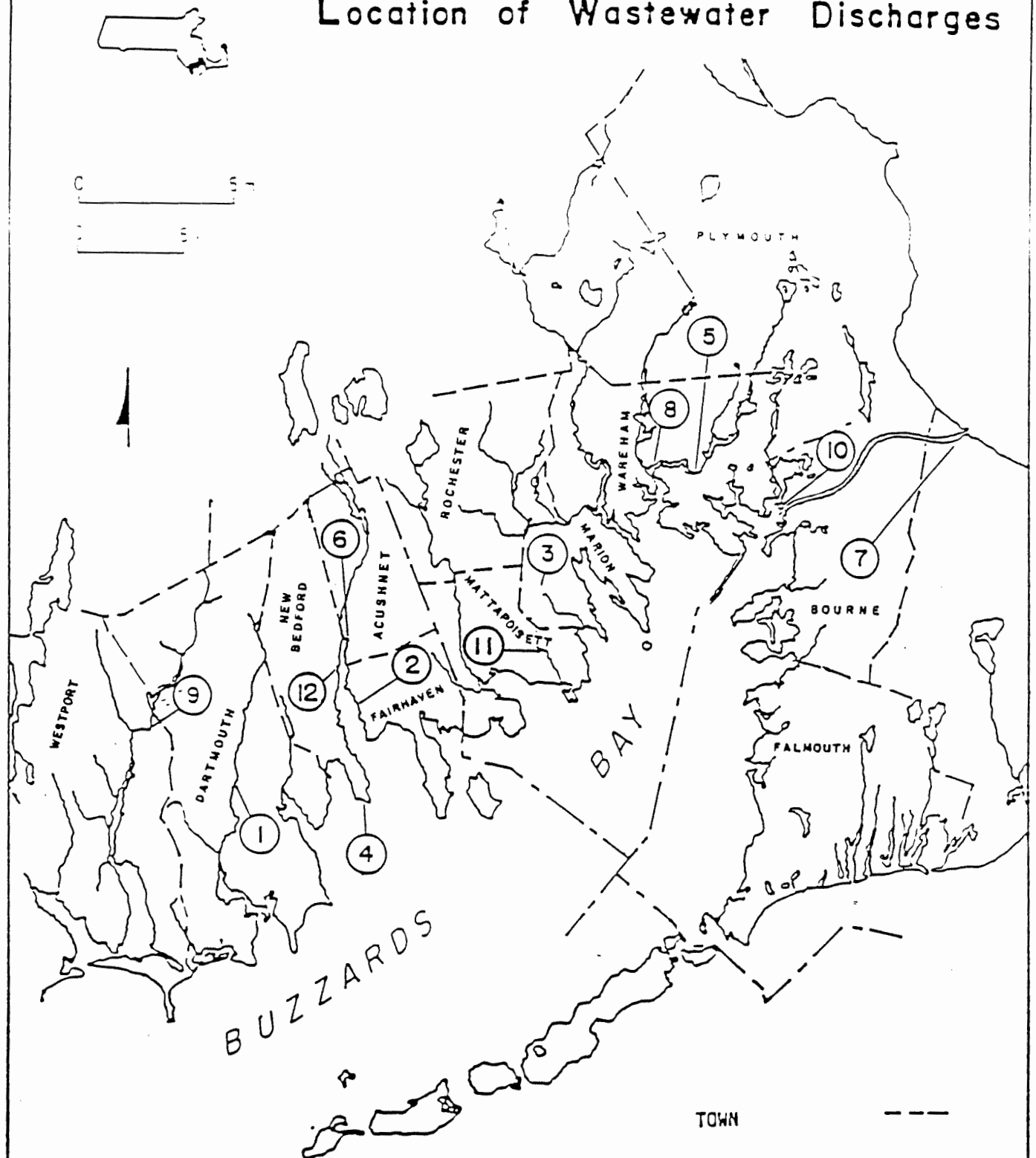
PRINCIPAL WASTEWATER DISCHARGES

<u>NUMBER</u>	<u>MUNICIPAL</u>
1	Dartmouth Wastewater Treatment Plant, Dartmouth
2	Fairhaven Wastewater Treatment Plant, Fairhaven
3	Marion Wastewater Treatment Plant, Marion
4	New Bedford Wastewater Treatment Plant, New Bedford
5	Wareham Wastewater Treatment Plant, Wareham
<u>INDUSTRIAL, BUSINESS, INSTITUTIONAL</u>	
6	Acushnet Company, Golf Division, Acushnet
7	Commonwealth Electric Company, Sandwich
8	Franconia Fuel Company, Wareham
9	Lincoln Park Amusement Company, Dartmouth
10	Massachusetts Maritime Academy, Bourne
11	Old Rochester High School, Mattapoisett
12	Revere Copper & Brass, New Bedford

FIG. 2

BUZZARDS BAY

Location of Wastewater Discharges



TOWN

COUNTY

TABLE 3

1986 BUZZARDS BAY BIOTA SURVEY

STATION LOCATIONS - QUOHAUGS (Mercenaria mercenaria)

STATION DESCRIPTION	DWPC STATION ID#	MAP LOCATOR ID#	LATITUDE	LONGITUDE	DMF COLLECTION ID#
AREA I (000 - 249)					
Westport River, Westport	218WPR	030	41°31'00"N	71°05'10"W	34
Apponagansett Bay, Dartmouth	214APB	140	41°34'30"N	70°56'30"W	31
Little River Mouth, Dartmouth	235LIR	090	41°31'49"N	70°58'15"W	32
Slocums River, Dartmouth	225SLR	080	41°30'30"N	70°58'00"W	33
Salters Point, Dartmouth	246BBI	130	41°31'47"N	70°57'01"W	40
Little Bay, Fairhaven	210NSB	200	41°37'50"N	70°51'40"W	25
East Cove, Fairhaven	215NBH	190	41°37'30"N	70°22'00"W	30
Brant Island Cove, Matapoissett	220NSB	210	41°37'45"N	70°49'00"W	24
AREA II (250 - 499)					
Mattapoissett Harbor Mattapoissett	242MPH	270	41°39'00"N	70°48'35"W	18A
Pine Island Pond, Mattapoissett	238MPH	280	41°38'55"N	70°46'20"W	23
Aucoot Cove, Marion	244AUC	290	41°40'30"N	70°45'30"W	22
Sippican Harbor by Marina, Marion	229SPH	330	41°40'30"N	70°44'00"W	11

TABLE 3 (CONTINUED)

STATION DESCRIPTION	DWPC STATION ID#	MAP LOCATOR ID#	LATITUDE	LONGITUDE	DMF COLLECTION ID#
AREA II (250 - 499) CONTINUED					
Planting Island Cove, Marion	236SPH	320	41°41'45"N	70°44'15"W	9A 9B
Weweantic River, Wareham	221WER	340	41°44'15"N	70°44'52"W	8
Marks Cove, Wareham	226WAR	380	41°44'12"N	70°43'35"W	7A 7B
Crab Cove, Wareham	224WAR	390	41°44'57"N	70°42'07"W	6
Bourne Cove, Wareham	230WAR	400	41°43'35"N	70°41'00"W	39
Onset Bay by Marina, Wareham	211ONB	440	41°44'06"N	70°39'00"W	5A 5B
Buttermilk Bay Center, Town Line, Wareham/Bourne T/L	214BMB	460	41°45'43"N	70°37'50"W	4
Hideway Village Cove, Bourne	224RMB	470	41°45'51"N	70°37'36"W	3A
Taylor Point, Bourne	240BMB	450	41°44'27"N	70°37'42"W	35
AREA III (500 - 749)					
Monument Beach, Bourne	206PHH	510	41°42'55"N	70°36'55"W	36
Barlows Landing, Bourne	210PCH	520	41°41'27"N	70°37'32"W	37
Red Brook Harbor, by Marina, Bourne	215RBH	530	41°40'15"N	70°37'50"W	15A 15B

TABLE 3 (CONTINUED)

STATION DESCRIPTION	DWPC STATION ID#	MAP LOCATOR ID#	LATITUDE	LONGITUDE	DMF COLLECTION ID#
AREA III (500 - 749)					
Squeteague Harbor, Bourne	220SQH	540	41°39'45"N	70°37'15"W	16A 16B 16C
Wild Harbor River, Falmouth	229WIH	640	41°38'10"N	70°39'00"W	21A 21B
West Falmouth Harbor, Falmouth	230WFH	650	41°36'20"N	70°39'00"W	38
Quohaug Pond, Falmouth	230GSC	660	41°35'33"N	70°38'22"W	20A 20B
Quissett Harbor, Falmouth	238QUH	670	41°32'25"N	70°39'40"W	19A 19B 19C
AREA IV (750 - 874)					
Cove at NE Gutter Naushon Island, Gosnold	227NUI	760	41°30'27"N	70°41'55"W	27
Cove Northside Nashawena Island, Gosnold	228NSI	780	41°26'15"N	70°36'55"W	28
Cove at E. End, Pasque Island, Gosnold	226PSI	770			26
Cuttyhunk Pond, Gosnold	229CHP	790	41°25'30"N	70°55'35"W	29

FIG. 3

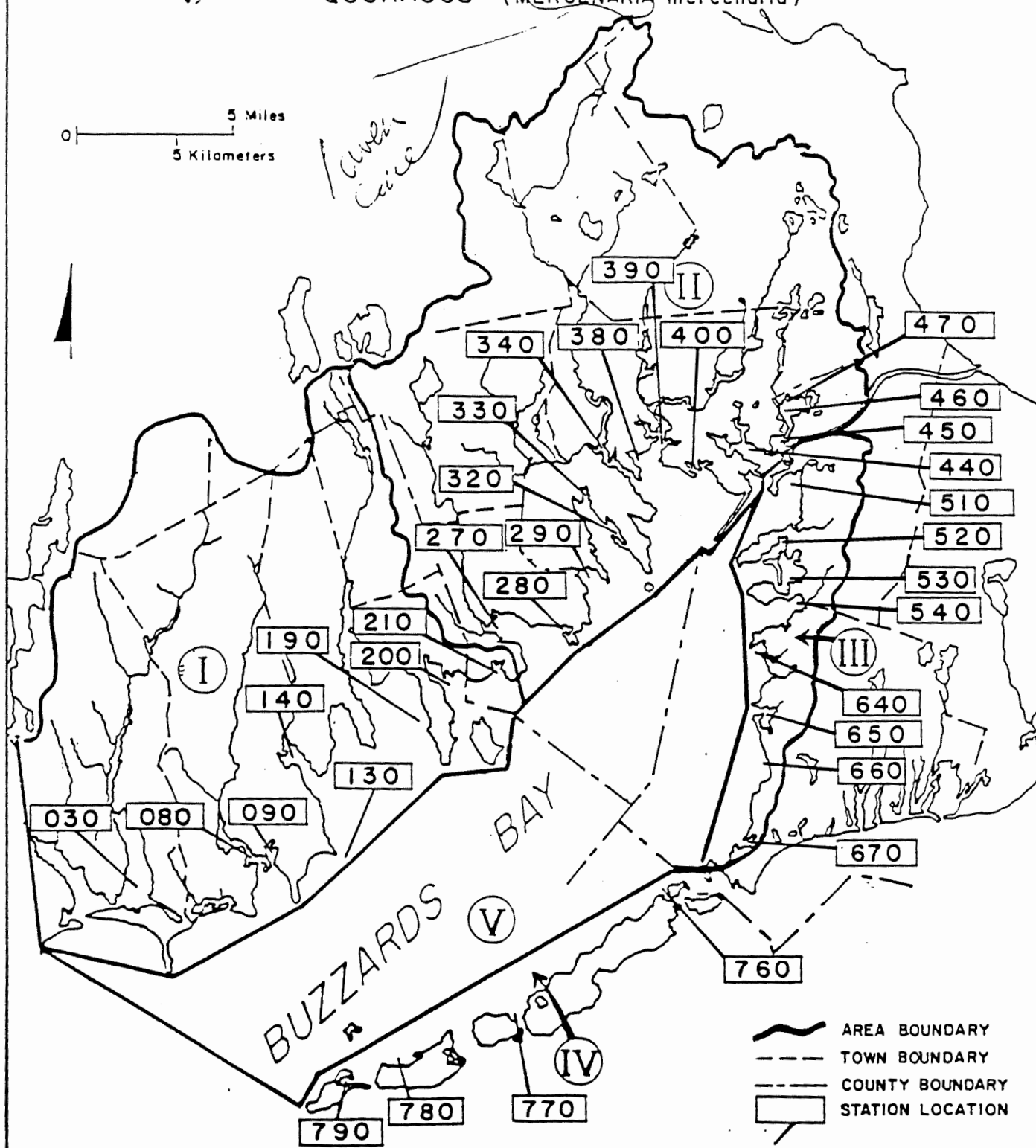
Buzzards Bay

1986 BIOTA SURVEY STATION LOCATIONS

QUOHAUGS (*MERCENARIA mercenaria*)



0 5 Miles
0 5 Kilometers



95 DWPC DRAINAGE BASIN CLASSIFICATION SYSTEM PER 314 CMR 4.05:

FIG. 4

Buzzards Bay

1986 BIOTA SURVEY STATION LOCATIONS

LOBSTERS (*HOMARUS americanus*)

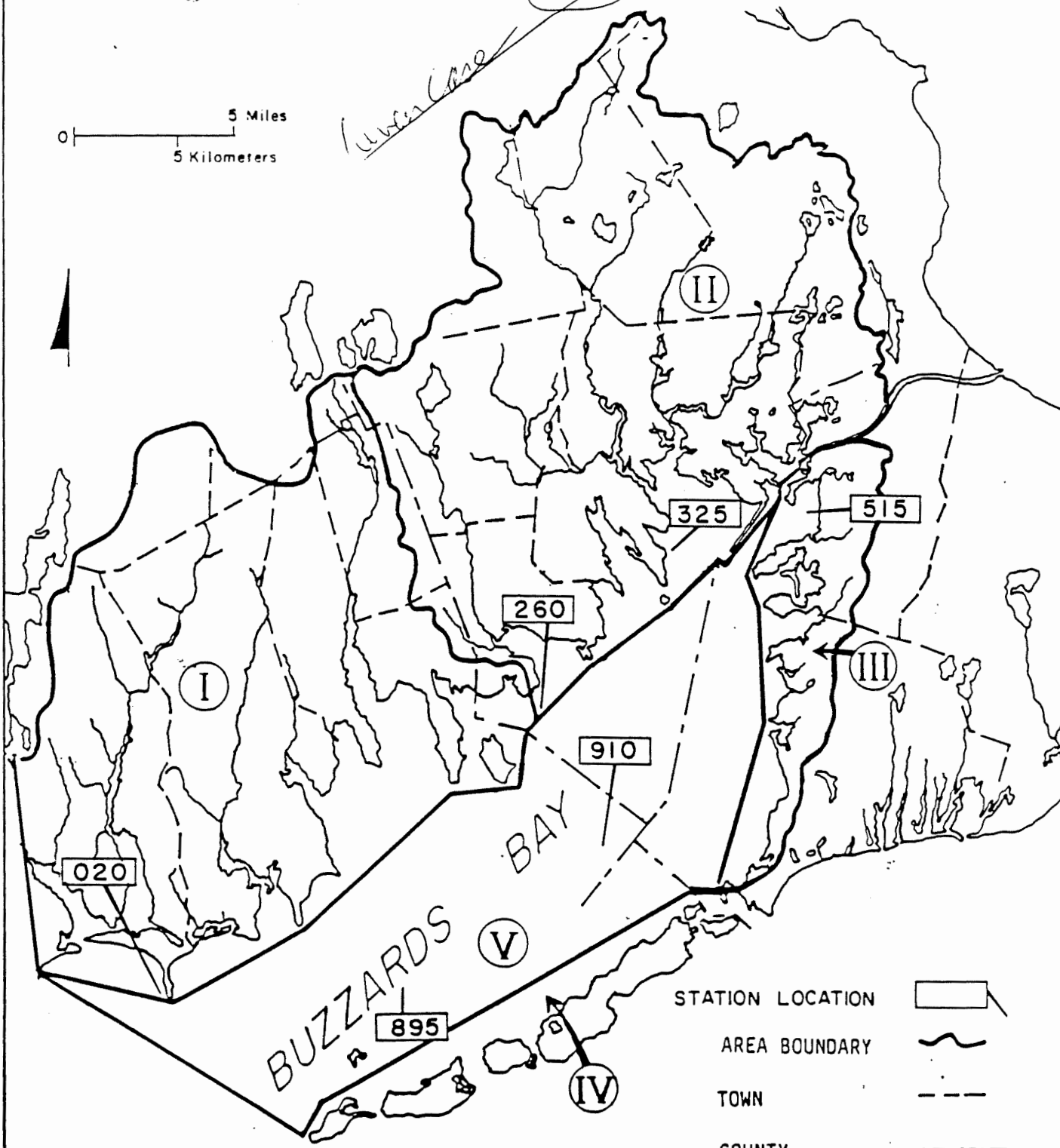


TABLE 4

1986 BUZZARDS BAY BIOTA SURVEY

STATION LOCATIONS - LOBSTERS (Homarus americanus)

STATION DESCRIPTION	DWPC STATION ID#	MAP LOCATOR ID#	LATITUDE	LONGITUDE	DMF COLLECTION ID#
AREA I (000 - 249)					
SW of Gooseberry Island, Westport	217RIS	020	41°27'.6	71°03'.4	A60 A61 A62 A63 A64
AREA II (250 - 499)					
NE of Cormorant Rock, Mattapoisett	248BBI	260	41°36'.4	70°47'.2	A55 A56 A57 A58 A59
Piney Point, Marion	240WAR	325	41°42'.5	70°42'.8	A54 A50 A52 A53
AREA III (500 - 749)					
Toby's Island, Bourne	207PHH	515	41°41'.5	70°37'.9	A45 A46 A48
AREA IV (750 - 874)					
NO DATA					
AREA V (875 - 999)					
1 Mile NE Buoy #8	206BBO	895	41°29'.6	70°52'.6	A65 A66 A67 A68 A69
1 Miles S of Buoy #10	207BBO	910	41°32'.1	70°46'.3	A70 A71 A72 A73 A74

FIG. 5

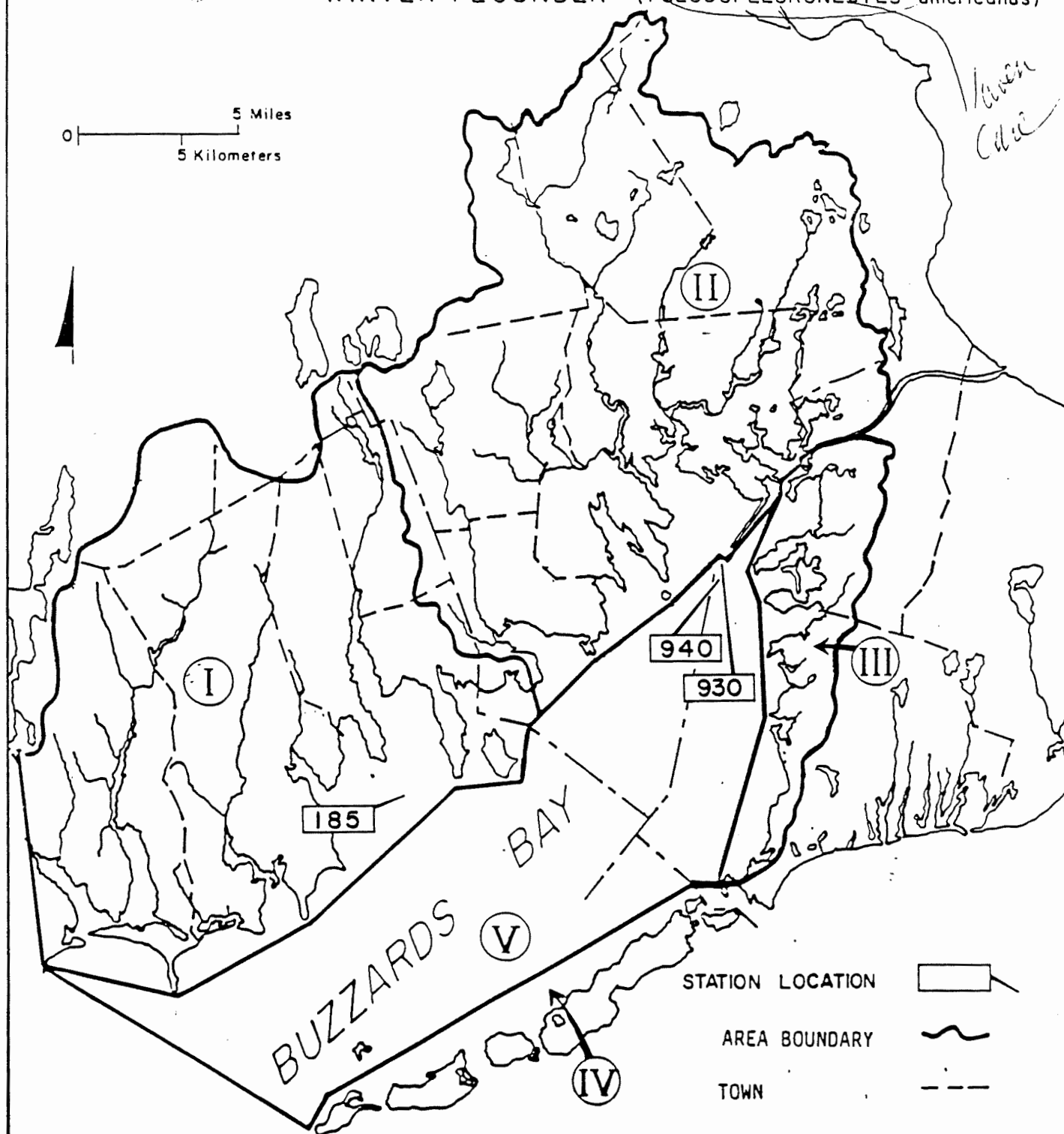
Buzzards Bay

1986 BIOTA SURVEY STATION LOCATIONS

WINTER FLOUNDER (*PSEUDOPLEURONECTES americanus*)



0 5 Miles
0 5 Kilometers



95 DWPC DRAINAGE BASIN CLASSIFICATION SYSTEM PER 314 CMR 4.05:

TABLE 5

1986 BUZZARDS BAY BIOTA SURVEY

STATION LOCATIONS - WINTER FLOUNDER (Pseudopleuronectes americanus)

STATION DESCRIPTION	DWPC STATION ID#	MAP LOCATOR ID#	LATITUDE	LONGITUDE	DMF COLLECTION ID#
AREA I (000 - 249)					
E of Round Pt., New Bedford	280NBH	185	41°31'	70°51'	41-2 41-3 41-4
AREA II (250 - 499)					
NO DATA					
AREA III (500 - 749)					
NO DATA					
AREA IV (750 - 874)					
NO DATA					
AREA V (875 - 999)					
S of Stoney Pt., Dike, Wareham	270BBO	940	41°39'	70°42'	33-1 33-2 33-3 33-4 33-5 33-6 33-7 33-8 33-9 33-10 33-11 33-12 33-13 33-14 33-15

TABLE 5 (CONTINUED)

STATION DESCRIPTION	DWPC STATION ID#	MAP LOCATOR ID#	LATITUDE	LONGITUDE	DMF COLLECTION ID#
AREA V (875 - 999) CONTINUED					
W of Wings Neck, Falmouth	275BBO	930	41°45'	70°43'	34-1
					34-2
					34-3
					34-4
					34-5
					34-6
					34-7
					34-8
					34-9
					34-10
					34-11
					34-12
					34-13
					34-14
					34-15
					34-16

TABLE 6

1985-1986 BUZZARDS BAY SEDIMENT SURVEY

STATION LOCATIONS - AREAS I-III

STATION NUMBER	LOCATION DESCRIPTOR	LATITUDE	LONGITUDE	DATE SAMPLED
<u>Area I</u>				
10WPE13	Westport River East Branch at Hix Bridge, Westport	41°34'13"N	71°04'19"W	6/23/86
13WPH16	Westport Harbor, Main Channel at Can #25, Westport	41°30'51"N	71°04'14"W	6/23/86
11AB10	Apponagansett Bay, north of Padanarum, Dartmouth	41°35'14"N	70°55'58"W	7/24/86
15SR20	Slocums River at Gaffney Road Landing, Dartmouth	41°32'45"N	71°00'03"W	7/24/86
<u>Area II</u>				
41MH0800	Mouth of Mattapoissett Harbor at Nun #4, Mattapoissett	41°38'15"N	70°47'25"W	7/16/86
24WA0180	Wareham River at Crab Cove, Wareham	41°44'57"N	70°42'07"W	7/16/86
110B0200	Onset Bay, Basin between Wickets Island and Onset Island, Wareham	41°44'10"N	70°38'34"W	7/16/86
1RB010	Red Brook, at mouth of Red Brook, Wareham/Bourne town line	41°45'48"N	70°37'59"W	10/23/86
<u>Area III</u>				
15RBH030	Red Brook Harbor at Can #13, Bourne	41°40'30"N	70°37'24"W	10/23/86
37QH030	Center Harbor at Can #7, Falmouth	41°32'24"N	70°39'39"W	10/09/86

FIGURE 6

BUZZARDS BAY

SEDIMENT STATION LOCATIONS

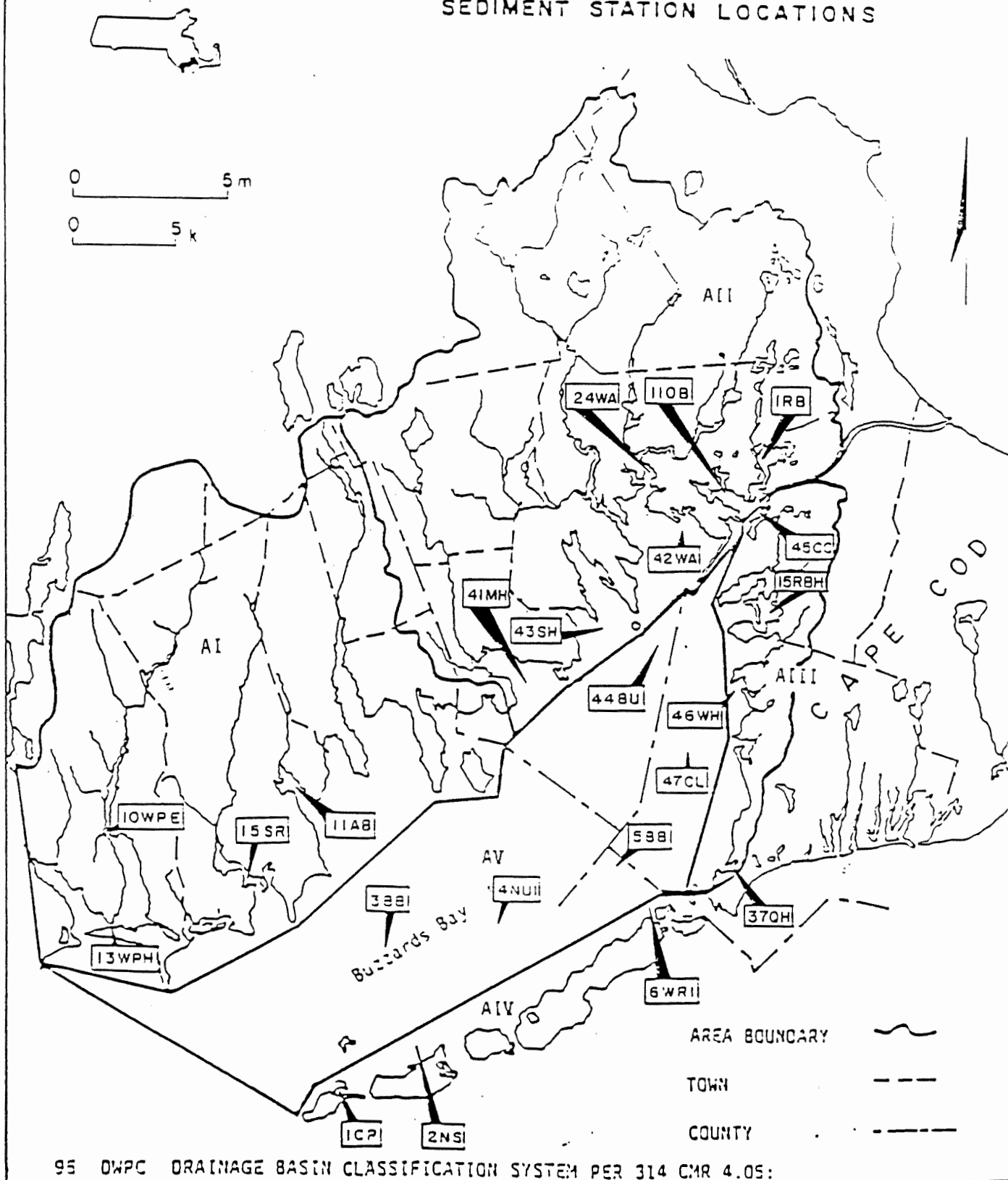


TABLE 7

1985-1986 BUZZARDS BAY SEDIMENT SURVEY STATIONS
STATION LOCATIONS - AREAS IV-V

STATION	LOCATION DESCRIPTOR	LATITUDE	LONGITUDE	LORAN-C
<u>Area IV</u>				
0	Cuttyhunk Pond Center Harbor, Gosnold	41°25'50"N	70°56'69"W	14250.1/25543.0.0
0	Weepecket Island between Weepecket and Ucatena Island, Gosnold	41°30'83"N	70°43'48"	14155.8/25455.8
<u>Area V</u>				
0	Nashawena Island west of #7 bell, Gosnold	41°27'34"N	70°53'54"W	14231.6/25529.0
	Outer Bay east of R8 Gong. Approximate Station 0 (Sanders) ¹ , Gosnold	41°29'13"N	70°52'52"W	14215.0/25527.4
0	Naushon Island off Kettle Cove. Approximate Station 9 (New England Aquarium) ² , Gosnold	41°30'14"N	70°49'60"W	14195.2/25505.9
400	Buzzards Bay halfway between navigational markers BW'/WI', Gosnold	41°32'77"N	70°43'02"W	14145.0/25460.0
500	Wareham River south of Indian Neck, Wareham	41°42'N	70°42'W	14100/2548
500	Sippican Harbor south of Converse Point, Marion	41°40'N	70°44'W	14122/25507
300	Anchorage C, Marion	41°40'N	70°41'W	14103.9/25484.0
1	Cape Cod Canal berthing basin, Bourne	41°44'19"N	70°38'21"W	14066.4/25474.8
08	Wild Harbor outside 30 ft. contour, Falmouth	41°38'10"N	70°39'02"W	14099.8/25454.6
20	Cleavelands Ledge, Falmouth	41°35'38"N	70°41'06"W	14125.5/25461.2

references
references

TABLE 8

1986 BUZZARDS BAY BIOTA METALS SURVEY
COMPARISON OF PARAMETERS MEASURED VS. AREA

PARAMETER	AREA				
	A1	A2	S3	A4	A5
Actual vs proposed number of stations (In preliminary survey)					
Shellfish Stations	8-0	13-7	8-4	4-0	0-0
# of Samples	8	24	15	4	
Metals Total - Cadmium	8-8	24-24	15-15	4-4	N
Chromium	8-8	24-24	15-15	4-4	O
Copper	8-8	24-24	15-15	4-4	D
Lead	8-8	24-24	15-15	4-4	A
Mercury	8-8	24-24	15-15	4-4	T
Nickel	8-8	24-24	15-15	4-4	A
Lobster	1-1	2-2	1-1	O	2-2
Metals Total - Cadmium	10-10	14-14	3-3	NO	10-10
Chromium	7-10	14-14	3-3	D	10-10
Lead	10-10	14-14	3-3	A	10-10
Mercury	10-10	14-14	3-3	T	10-10
Nickel	10-10	14-14	3-3	A	10-10
Winter Flounder	1-1	O	O	O	2-2
Metals Total - Cadmium	3-3	N	N	N	16-16
Chromium	3-3	O	O	O	16-16
Copper	3-3	D	D	D	16-16
Lead	3-3	A	A	A	16-16
Mercury	3-3	T	T	T	16-16
Nickel	3-3	A	A	A	16-16

TABLE 9

1986 BUZZARDS BAY BIOTA METALS SURVEY

SUMMARY OF TOTAL METALS IN QUOHAUGS (Mercenaria mercenaria)

mg/kg DRY WEIGHT

DWPC STATION NUMBER	MAP LOCATOR ID#	DMF SAMPLE #	LES REF (1)	WET WEIGHT OF SAMPLE IN GRAMS	TOTAL CADMIUM	TOTAL CHROMIUM	TOTAL COPPER	TOTAL LEAD	TOTAL MERCURY	TOTAL NICKEL
AREA I 000 - 249										
218WPR	030	34	575483	-	<0.20	<0.30	1.1	0.60	0.014	0.60
225SLR	080	33	575482	-	0.20	<0.30	1.1	0.60	0.008	0.70
235LIR	090	32	575481	-	0.20	<0.30	0.90	0.60	0.014	0.50
246BBI	130	40	575489	-	0.20	<0.30	1.9	<0.50	0.026	0.50
214APB	140	31	575480	-	0.20	<0.30	2.1	1.3	0.020	0.50
210NSB	200	25	575474	-	<0.20	<0.30	3.4	1.1	0.018	0.50
215NBH	190	30	575479	-	<0.20	<0.30	1.0	<0.50	0.12	0.50
220NSB	210	24	575473	-	<0.20	<0.30	1.0	1.0	0.024	0.90
AREA II 250 - 499										
242MPH	270	18A	574162	10.3	0.40	0.20	3.1	<0.50	0.06	0.50
		18B	575467	-	<0.20	<0.30	1.2	<0.50	0.016	0.70
238MPH	280	23	575472	-	<0.20	<0.30	0.90	1.0	0.014	0.70

TABLE 9 (CONTINUED)

DWPC STATION NUMBER	MAP LOCATOR ID#	DMF SAMPLE #	LES REF (1)	WET WEIGHT OF SAMPLE IN GRAMS	TOTAL CADMIUM	TOTAL CHROMIUM	TOTAL COPPER	TOTAL LEAD	TOTAL MERCURY	TOTAL NICKEL
AREA II 250 - 499 CONTINUED										
229SPH	330	11	573936	-	0.15	0.74	4.6	1.3	0.07	1.1
		11B	575935	10.3	<0.19	<0.29	3.3	<0.49	0.06	0.49
236SPH	320	9A	573934	-	0.15	0.30	2.8	0.65	0.11	0.65
		9B	573935	-	0.10	0.40	2.9	0.65	0.12	0.55
		9C	575934	10.4	<0.19	<0.29	1.9	<0.48	0.08	0.48
244AUC	290	22	575471	-	<0.20	<0.30	2.3	<0.50	0.016	0.80
221WER	340	8	573933	-	0.15	0.30	2.3	0.75	0.03	0.64
		8B	575933	10.0	<0.20	<0.30	1.4	<0.50	0.02	0.80
226WAR	380	7A	573931	-	0.25	0.50	2.6	0.50	0.05	0.75
		7B	573932	-	0.15	0.34	1.6	0.59	0.06	0.06
		7C	575932	10.4	<0.19	<0.29	1.3	<0.48	0.02	0.58
224WAR	390	6	573930	-	0.15	0.60	2.4	1.1	0.07	1.3
		6B	575931	5.2	<0.39	<0.58	2.9	<0.97	0.02	<0.97
230WAR	400	39	575488	-	<0.02	<0.03	1.6	<0.50	0.024	0.60

TABLE 9 (CONTINUED)

DWPC STATION NUMBER	MAP LOCATOR ID#	DMF SAMPLE #	LES REF (1)	WET WEIGHT OF SAMPLE IN GRAMS	TOTAL CADMIUM	TOTAL CHROMIUM	TOTAL COPPER	TOTAL LEAD	TOTAL MERCURY	TOTAL NICKEL
AREA II 250 - 499 CONTINUED										
211ONB	440	5A	573928	-	0.10	0.29	4.3	1.1	0.05	0.83
		5B	573929	-	0.10	0.25	3.6	1.1	0.04	0.59
		5C	575930	10.2	<0.19	<0.29	2.6	<0.49	0.04	0.59
214BMB	460	4	573927	-	0.15	0.20	2.5	0.55	0.03	0.65
		4B	575929	10.5	0.29	0.28	1.7	<0.48	0.02	1.6
224BMB	470	3A	573926	-	0.15	0.64	3.3	1.1	0.02	1.2
240BMB	450	35	575484	-	<0.20	<0.30	1.2	0.60	0.014	0.50
AREA III 500 - 749										
260PHH	510	36	575485	-	<0.20	<0.30	1.2	1.0	0.018	0.60
210PCH	520	37	575486	-	<0.20	<0.30	1.6	0.60	0.024	0.60
215RBH	530	15A	574161	-	0.30	0.20	2.4	<0.50	0.12	1.4
		15B	575465	-	<0.20	<0.30	1.7	<0.50	0.100	1.7
220SQH	540	16A	574155	-	0.29	0.29	2.9	0.79	0.05	<0.50
		16B	574156	-	0.30	0.20	2.9	0.50	0.04	<0.50
		16C	575470	-	<0.20	0.30	1.4	<0.50	0.014	0.80

TABLE 9 (CONTINUED)

DWPC STATION NUMBER	MAP LOCATOR ID#	DMF SAMPLE #	LES REF (1)	WET WEIGHT OF SAMPLE IN GRAMS	TOTAL CADMIUM	TOTAL CHROMIUM	TOTAL COPPER	TOTAL LEAD	TOTAL MERCURY	TOTAL NICKEL
AREA III 500 - 749 CONTINUED										
229WIH	640	21A	574160	10.1	0.30	0.20	2.0	<0.50	0.03	<0.50
		21B	575470	-	<0.20	0.30	1.4	<0.50	0.014	0.80
230WFH	650	38	575487	-	<0.20	<0.30	1.1	<0.50	0.012	0.70
210GSC	660	20A	574159	10.4	0.29	0.20	4.7	<0.50	0.03	<0.50
		20B	575469	-	<0.20	<0.30	1.0	0.60	0.016	0.70
238QUH	670	19A	574157	-	0.30	0.50	4.3	0.70	0.18	2.0
		19B	574158	-	0.30	0.90	10.0	<0.50	0.37	<0.50
		19C	575468	-	<0.20	<0.30	3.2	0.90	0.208	0.80
AREA IV 750 - 874										
228NSI	780	28	575477	-	<0.20	<0.30	0.50	0.50	0.014	0.60
227NUI	760	27	575476	-	<0.20	<0.30	0.70	<0.50	0.010	<0.50
226PSI	770	26	575475	-	<0.20	<0.30	1.0	<0.50	0.014	<0.50
229CHP	790	29	575478	-	<0.20	<0.30	1.3	1.0	0.052	0.60

AREA V 875 - 999

NO DATA

- Not Reported

LES RES (1) Denotes Lawrence Experiment Station sample #. Note all LES REF > 573999 indicate analysis completed on P.E. 403 without background correction (see Methodology Section 3.1.4)

TABLE 10

1986 BUZZARDS BAY BIOTA METALS SURVEY

SUMMARY OF TOTAL METALS IN LOBSTERS (Homarus americanus)

mg/kg DRY WEIGHT

DWPC STATION NUMBER	MAP LOCATOR ID#	LES REF (1)	WEIGHT OF SAMPLE IN GRAMS	TOTAL CADMIUM	TOTAL CHROMIUM	TOTAL LEAD	TOTAL MERCURY	TOTAL NICKEL
AREA I 000 - 249								
217RIS	020	573923	-	0.63	N=7	0.38	0.06	0.38
		573924	-	0.83		0.29	0.11	<0.25
		573916	-	0.60	<0.13	<0.27	0.07	<0.34
		573917	-	1.00	<0.10	0.35	0.12	0.25
		573925	-	0.44		0.25	0.15	<0.25
		575924	10.1	0.69	0.30	<0.49	0.04	0.59
		575925	10.1	0.69	<0.30	<0.49	0.04	2.2
		575926	10.3	0.68	<0.29	<0.48	0.08	0.48
		575927	10.4	0.96	<0.29	<0.48	0.08	0.48
		575928	10.5	0.57	<0.29	<0.48	0.10	0.57
	325	573675	20	0.90	0.15	0.35	0.09	0.55
		573676	20	0.75	0.15	0.20	0.07	<0.25
		573677	20	0.65	0.25	0.20	0.14	0.25
		573674	20	1.0	0.15	0.20	0.15	0.30
248BBI	260	573918	-	2.5	<0.10	0.44	0.13	0.25
		573919	-	0.40	<0.10	0.30	0.05	<0.25
		573920	-	0.70	<0.10	0.40	0.08	<0.50
		573921	-	0.49	<0.10	0.34	0.06	<0.25
		573922	-	0.58		0.19	0.06	<0.24

TABLE 10 (CONTINUED)

DWPC STATION NUMBER	MAP LOCATOR ID#	LES REF (1)	WEIGHT OF SAMPLE IN GRAMS	TOTAL CADMIUM	TOTAL CHROMIUM	TOTAL LEAD	TOTAL MERCURY	TOTAL NICKEL
AREA II 250 - 499 CONTINUED								
248BBI	260	575919	10.0	2.3	<0.29	<0.50	0.09	0.60
		575920	10.2	.39	<0.29	<0.49	0.03	<0.49
		575921	10.3	0.68	0.49	<0.49	0.06	<0.49
		575922	10.6	.59	<0.28	<0.47	0.03	0.66
		575923	10.6	.66	<0.28	<0.47	0.05	0.57
AREA III 500 - 749								
207PHH	515	573671	20	0.60	0.10	0.25	0.13	<0.25
		573672	20	0.45	0.15	0.25	0.14	<0.25
		573673	20	0.60	0.15	0.25	0.15	<0.25
AREA IV 750 - 874								
NO DATA								
AREA V 875 - 999								
206BBO	895	574562	10.3	<0.39	<0.58	<0.97	0.008	<0.97
		574559	10.17	<0.39	<0.59	<0.98	0.008	<0.98
		574560	10.2	<0.39	<0.59	<0.98	0.008	<0.98
		574567	10.12	<0.40	<0.59	<0.99	0.008	<0.99
		574563	10.26	<0.39	<0.58	<0.97	0.008	<0.97
207BBO	910	574558	10.1	<0.39	<0.59	<0.99	0.008	<0.99
		574564	10.06	<0.40	<0.50	<0.99	0.008	<0.99
		574566	10.0	<0.40	<0.50	<1.0	0.008	<1.0
		574565	10.5	<0.38	<0.57	<0.95	0.008	<0.95
		574561	10.07	<0.40	<0.60	<0.99	0.028	<0.99

- Not Reported

LES REF (1) Refers to Lawrence Experiment Station Sample Number

Note: All LES reference #'s greater than 59399 analyzed on a Varian 1475 (see Methodology Section 3.2.3)

TABLE 11

1986 BUZZARDS BAY BIOTA METALS SURVEY

SUMMARY OF TOTAL METALS IN WINTER FLOUNDER (Pseudopleuronectes americanus)

DWPC STATION #	LES #	DMF ID#	DMF LAB #	Cd mg/kg	Cr mg/kg	Cu mg/kg	Hg mg/kg	Ni mg/kg	Pb mg/kg
270BBO	575496	33-1	P 1132	<0.20	<0.30	0.70	0.064	<0.50	<0.50
	575497	33-2	P 1133	<0.20	<0.30	0.40	0.028	<0.50	<0.50
	575498	33-3	P 1134	<0.20	<0.30	0.50	0.024	<0.50	<0.50
	575499	33-4	P 1135	<0.20	<0.30	0.20	0.018	<0.50	<0.50
	575513	33-5	P 1149	<0.20	0.40	0.30	0.032	<0.50	<0.50
	575500	33-6	P 1136	<0.20	<0.30	0.80	0.016	<0.50	<0.50
	575501	33-7	P 1137	<0.20	0.30	0.60	0.030	<0.50	<0.50
	575502	33-8	P 1138	<0.20	<0.30	0.20	0.226	<0.50	<0.50
	575514	33-9	P 1150	<0.20	0.40	0.90	0.040	<0.50	<0.50
	575503	33-10	P 1139	<0.20	0.40	0.40	0.008	<0.50	<0.50
	575515	33-11	P 1151	<0.20	0.30	1.4	0.028	<0.50	<0.50
	575504	33-12	P 1140	<0.20	0.30	0.30	0.010	<0.50	<0.50
	575505	33-13	P 1141	<0.20	0.60	0.20	0.032	<0.50	<0.50
	575506	33-14	P 1142	<0.20	<0.30	1.1	0.018	<0.50	<0.50
	575516	33-15	P 1152	<0.20	<0.30	1.3	0.038	<0.50	<0.50
	575495	33-16	P 1131	<0.20	<0.30	0.40	0.036	<0.50	<0.50
275BBO	575517	34-1	P 1153	<0.20	<0.30	0.40	<0.024	<0.50	<0.50
	575518	34-2	P 1154	<0.20	0.60	1.1	0.020	<0.50	<0.50
	575519	34-3	P 1155	<0.20	<0.30	0.90	0.028	<0.50	<0.50
	575520	34-4	P 1156	<0.20	<0.30	1.4	0.042	<0.50	<0.50
	575490	34-5	P 1126	0.20	<0.30	1.2	0.012	<0.50	<0.50
	575521	34-6	P 1157	<0.20	<0.30	0.70	0.026	<0.50	<0.50
	575522	34-7	P 1158	<0.20	<0.30	0.60	0.022	<0.50	<0.50
	575491	34-8	P 1127	<0.20	<0.30	0.70	0.072	<0.50	<0.50
	575523	34-9	P 1159	<0.20	0.30	1.0	0.030	<0.50	<0.50
	575524	34-10	P 1160	<0.20	<0.30	0.80	0.036	<0.50	<0.50

TABLE 11 (CONTINUED)

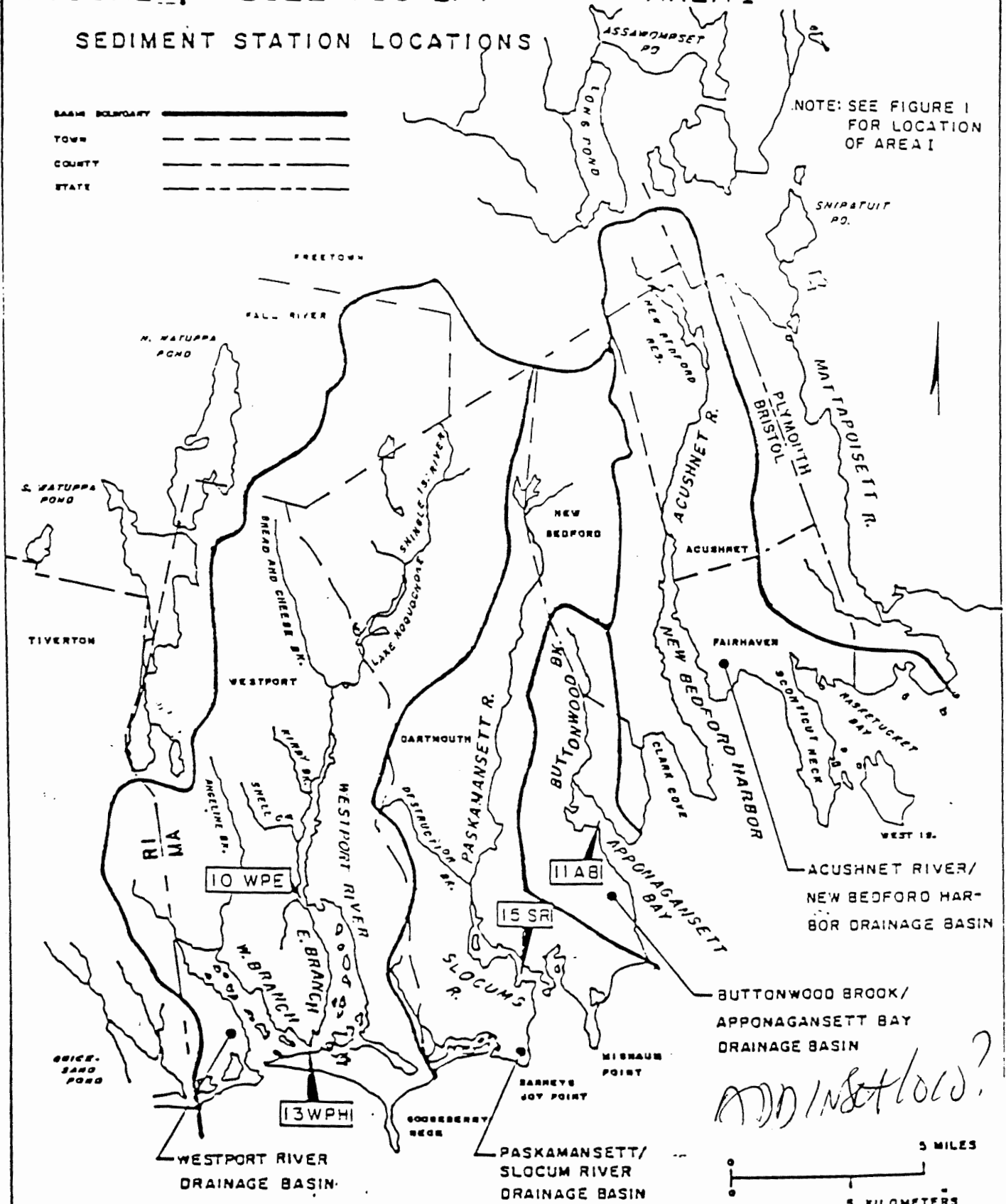
DWPC STATION #	LES #	DMF ID#	DMF LAB #	Cd mg/kg	Cr mg/kg	Cu mg/kg	Hg mg/kg	Ni mg/kg	Pb mg/kg
275BBO	575507	34-11	P 1143	<0.20	0.40	0.70	0.044	<0.50	<0.50
	575508	34-12	P 1144	<0.20	0.40	1.1	0.082	<0.50	<0.50
	575509	34-13	P 1145	<0.20	0.30	0.70	0.072	<0.50	<0.50
	575510	34-14	P 1146	<0.20	<0.30	0.40	0.018	<0.50	<0.50
	575511	34-15	P 1147	<0.20	0.30	0.80	0.032	<0.50	<0.50
	575512	34-16	P 1148	<0.20	0.50	0.50	0.024	<0.50	<0.50
280NBH	575493	41-2	P 1129	<0.20	<0.30	0.40	0.028	<0.50	<0.50
	575494	41-3	P 1130	<0.20	<0.30	0.60	0.022	<0.50	<0.50
	575492	41-4	P 1128	<0.20	<0.30	0.20	0.010	<0.50	<0.50

FIGURE 7 BUZZARDS BAY SEDIMENT STATION LOCATIONS

AREA I

BASIN BOUNDARY —————
TOWN - - - - -
COUNTY - - - - -
STATE - - - - -

NOTE: SEE FIGURE 1
FOR LOCATION
OF AREA I



add in station?

FIGURE 8 BUZZARDS BAY AREA II

SEDIMENT STATION LOCATIONS

WEWEANTIC R./SIPPICAN
HARBOR DRAINAGE BASIN

BASIN BOUNDARY

TOWN BOUNDARY

COUNTY BOUNDARY

AGAWAM - WANKINCO -
WAREHAM RIVER
DRAINAGE BASIN

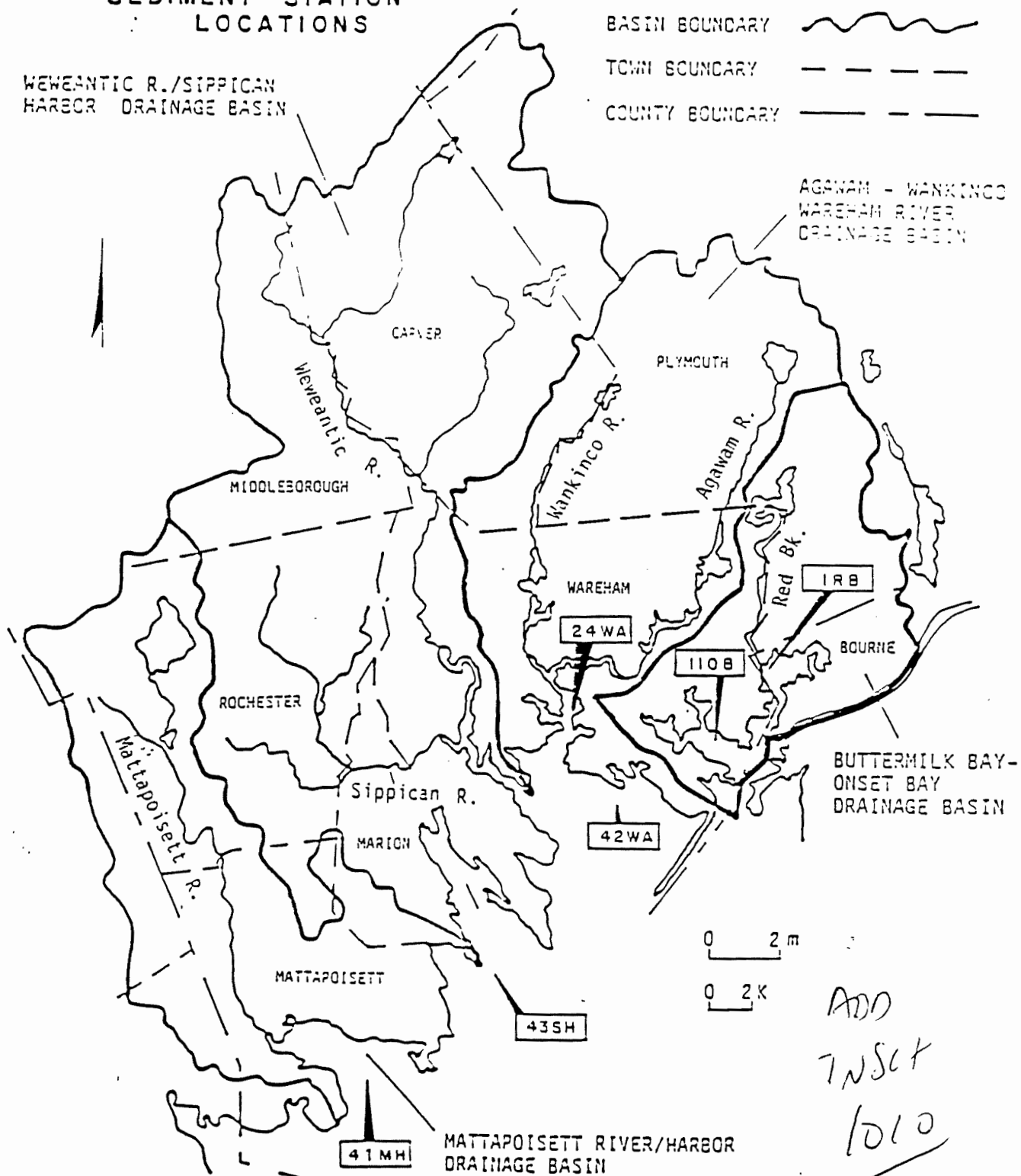


FIGURE 9
BUZZARDS BAY
AREA III

SEDIMENT STATION
LOCATIONS

NORTH

15RBH

BOURNE
FALMOUTH

SOUTH

37QH

BUZZARDS
BAY

CAPE
COD

ADD
INSET
1000

0 1 m

0 1 km

AREA BOUNDARY

TOWN BOUNDARY

FIGURE 10

BUZZARDS BAY AREAS IV & V

SEDIMENT STATION LOCATIONS

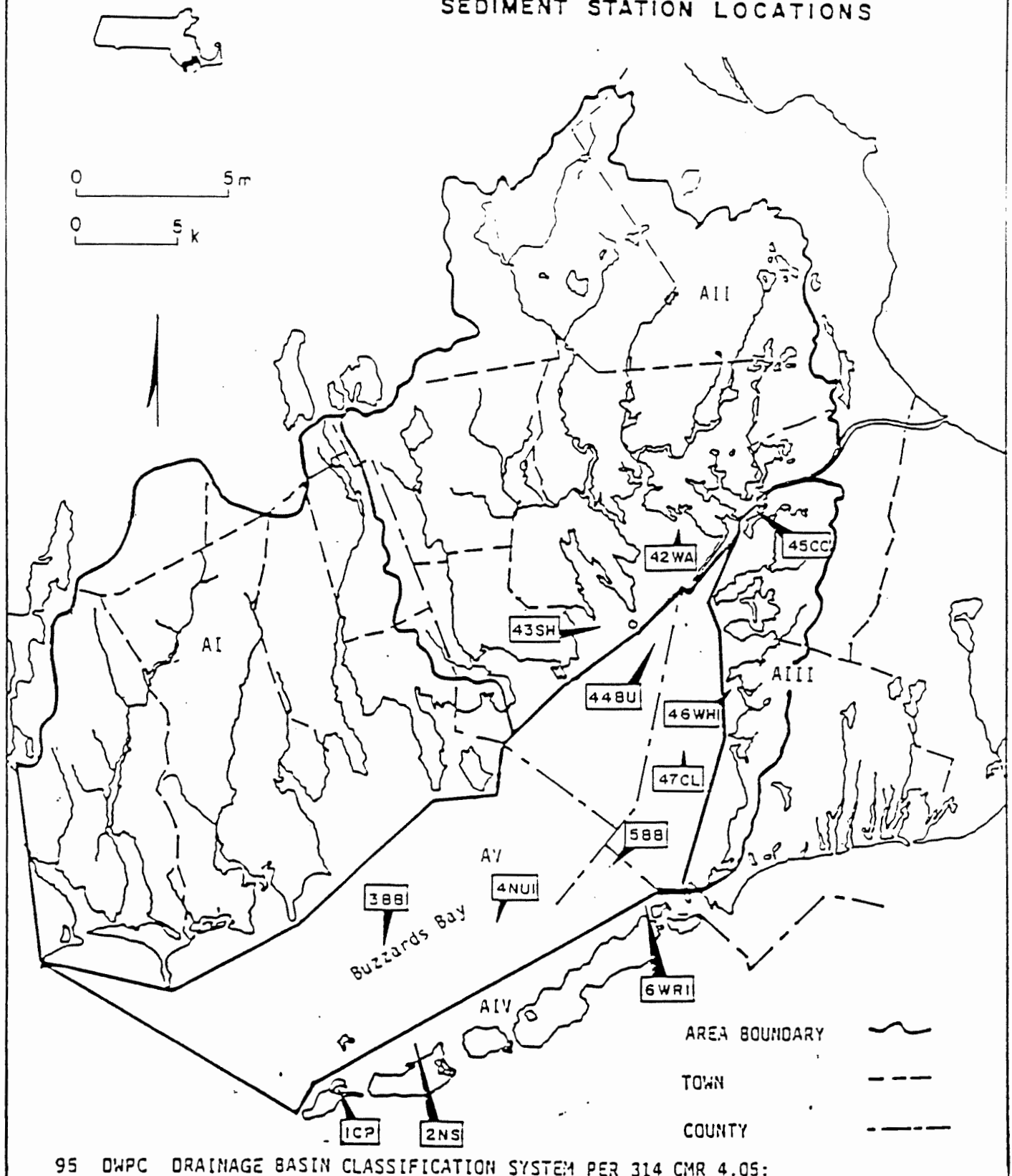


TABLE 12

1985-1986 BUZZARDS BAY SEDIMENT QUALITY SURVEY

COMPARISON OF PARAMETERS MEASURED VS. AREA

PARAMETER	AREA				
	A1	A2	A3	A4	A5
Actual vs. Proposed Number of Stations (in preliminary survey)*	4-4	4-6	2-5	2-2	10-10
Overlying Water Quality **	4-4	4-4	2-2	2-2	10-10
Grain Size Analysis	4-4	4-4	2-2	2-2	10-10
Metals	4-4	3-4	2-2	1-2	9-10
Total (Silver)***	0-4	0-4	2-2	0-2	0-10
Total (Cadmium)***	4-4	0-4	2-2	1-2	9-10
Total Chromium	4-4	3-4	2-2	1-2	9-10
Total Copper	4-4	3-4	2-2	1-2	9-10
Total Mercury	4-4	3-4	2-2	1-2	9-10
Total Nickel	4-4	3-4	2-2	0-2	6-10
Total Lead	4-4	3-4	2-2	1-2	9-10
Total Zinc	0-4	3-4	2-2	0-2	0-10
Polychlorinated Biphenyls	4-4	4-4	2-2	2-2	10-10
Polycyclic Aromatic Hydrocarbons	4-4	4-4	2-2	1-2	10-10
Total Organic Carbon	4-4	4-5	2-2	2-2	10-10

* See FY85 and FY86 Work Plans

** See Buzzards Bay 1985 and 1986 Water Quality Survey Data Reports

*** Metals included in parenthesis represent those not included in the original proposal

TABLE 13

1985-1986 BUZZARDS BAY SEDIMENT SURVEY

HEAVY METALS (mg/kg dry wt.)

AREAS I-V

	TOTAL CADMIUM	TOTAL CHROMIUM	TOTAL COPPER	TOTAL LEAD	TOTAL MERCURY	TOTAL NICKEL
<u>STATION</u>						
			<u>Area I</u>			
10WPE13	2.0	10	8.0	9.0	0.095	12
13WPH16	1.0	6.5	21	24	0.070	7.5
11AB10 (1)	<1.0	17	22	14	0.1	7.0
11AB10 (2)	1.5	30	50	44	0.15	13
15SR20 (1)	4.0	22	17	26	0.1	10
15SR20 (2)	4.0	24	21	18	0.1	14
			<u>Area II</u>			
41MH0800 (1)	*	4.0	9.5	21	2.6	3.0
41MH0800 (2)	*	11	14	21	0.36	4.5
24WA0180 (1)	*	16	24	34	0.95	4.5
24WA0180 (2)	*	10	14	30	0.23	2.5
110B0200 (1)	*	21	20	28	0.17	9.0
110B0200 (2)	*	26	27	44	0.16	12
1RB010		S a m p l e l o s t				
			<u>Area III</u>			
15RBH030 (1)	1.2	22	30	29	0.112	8.8
15RBH030 (2)	<0.8	3.6	4.4	12	0.040	<2.0
37QH030 (1)	1.6	28	92	72	2.112	16
37QH030 (2)	1.6	28	88	64	1.576	16
			<u>Area IV</u>			
1CP10 (1)	<0.80	22	52	52	0.368	*
1CP10 (2)	<0.80	20	48	44	0.480	*
6WPI10		S a m p l e l o s t				

TABLE 13 (CONTINUED)

STATION	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL
	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL
	<u>Area V</u>					
2NSI10 (1)	<0.80	20	11	19	0.128	*
2NSI10 (2)	<0.80	21	9.6	20	0.112	*
3BB10 (1)	<0.80	19	8.4	18	0.112	*
3BB10 (2)	<0.80	21	9.6	20	0.112	*
4NUI10	<0.80	8.0	4.0	5.2	0.096	*
5BB20	S a m p l e l o s t					
42WA0400**	<1.0	8.5	4.5	8.0	0.05	4.5
43SH0500**	<1.0	9.0	9.0	15	0.10	6.0
44BU0300**	<1.0	13	12	14	0.10	7.0
45CC01**	<1.0	2.5	1.0	5.5	<0.01	2.5
46WH008**	<1.0	2.5	5.0	9.5	0.03	4.0
47CL020**	<1.0	7.0	9.0	12	0.05	8.5

* No data

** Analyzed on Perkin Elmer 403 spectrophotometer. All others on a Varian AA-1475.

Numbers in parentheses indicate replicate samples at that station

TABLE 14

1985-1986 BUZZARDS BAY SEDIMENT SURVEY

PCB AROCLOR (ug/g) AND PAH (ug/g) DRY WEIGHT

AREAS I-V

STATION	1016/ 1242	1248	1254	1260	PAH(1)
	<u>Area I</u>				
10WPE13 (1)	ND	ND	ND	ND	ND
10WPE13 (2)	ND	ND	ND	ND	ND
13WPH16 (1)	ND	ND	ND	ND	ND
13WPH16 (2)	ND	ND	ND	ND	ND
11AB10 (1)	0.29	ND	ND	ND	ND
11AB10 (2)	0.25	ND	ND	ND	ND
15SR20 (1)	ND	ND	ND	ND	ND
15SR20 (2)	ND	ND	ND	ND	ND
<u>Area II</u>					
41MH0800 (1)	ND	ND	ND	ND	ND
41MH0800 (2)	ND	ND	ND	ND	ND
24WA0180 (1)	ND	ND	ND	ND	ND
24WA0180 (2)	ND	ND	ND	ND	ND
110B0200 (1)	ND	ND	ND	ND	ND
110B0200 (2)	ND	ND	0.89	ND	ND
1RB010	ND	ND	ND	ND	1-0.15 3-0.33 4-0.22
<u>Area III</u>					
15RBH030	ND	ND	ND	ND	3-0.32 4-0.21
37QH030	<0.56	ND	ND	ND	1-0.20 3-0.51 4-0.38
<u>Area IV</u>					
1CP10	ND	<0.16	<0.56	ND	1-0.18 3-0.34 4-0.22
6WPI10	ND	ND	ND	ND	NA

TABLE 14 (CONTINUED)

STATION	1242/ 1016	1248	1254	1260	PAH(1)
	<u>Area V</u>				
2NSI10	ND	<0.16	<0.56	ND	1-0.51 2-0.35 3-0.64 4-0.43 5-0.25
3BB10	ND	ND	ND	ND	ND
4NUI10	ND	ND	<0.56	ND	ND
5BB20	ND	ND	ND	ND	ND
42WA0400	ND	ND	ND	ND	ND
43SH0500	ND	ND	<0.56	ND	ND
44BU0300	ND	ND	ND	ND	ND
45CC01	ND	ND	ND	ND	ND
46WH008	ND	ND	ND	ND	ND
47CL020	ND	ND	<0.56	ND	ND

Code - PAH 1 = Phenanthrene
 2 = Anthracene
 3 = Fluoranthene
 4 = Pyrene
 5 = Benzo(a)anthracene

ND = Not Detected

(1) No standard available for quantitation. The mass spectrum obtained was compared to a mass spectral data base for identification.

Values reported as less than (<) indicate that the parameter was detected but at concentrations too low for quantification.

TABLE 15

1985-1986 BUZZARDS BAY SEDIMENT SURVEY

PARTICLE SIZE ANALYSIS PERCENT COARSE AND FINE FRACTION

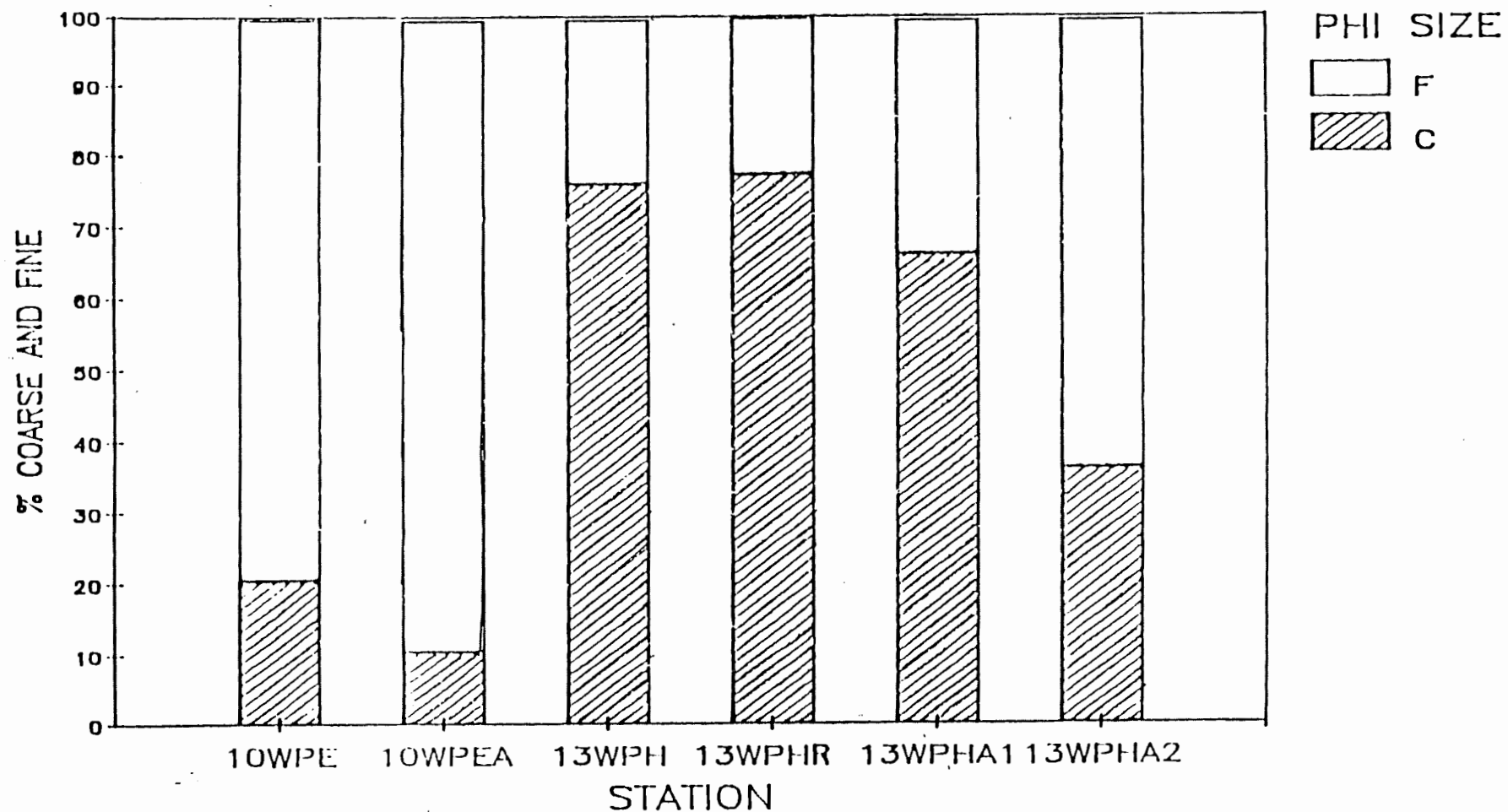
<u>STATION</u>	<u>PERCENT FINE</u>	<u>PERCENT COARSE</u>
<u>Area I</u>		
10WPE13 (1)	79.06	20.54
10WPE13A (2)	83.75	10.54
13WPH16 (1)	23.61	75.83
13WPH16 R	22.55	77.15
13WPH16A (2)	33.27	66.06
11AB10 (1)	50.86	48.84
11AB10 (2)	66.82	31.58
15SR20 (1)	90.06	9.84
15SR20 (2)	80.68	19.27
<u>Area II</u>		
41MH0800 (1)	49.50	49.82
41MH0800 (2)	30.10	69.34
41MH0800 (2) R	28.07	71.71
24WA0180 (1)	61.13	38.22
24WA0180 (2)	40.10	59.54
110B0200 (1)	66.01	33.73
110B0200 (1) R	66.21	33.54
110B0200 (2)	85.44	14.25
1R3010A (1)	26.78	73.08
1R3010B (2)	14.07	85.56
<u>Area III</u>		
15RBH030A (1)	93.22	6.10
15RBH030B (2)	70.81	28.57
37QH030A (1)	95.19	4.43
37QH030A R	93.34	6.12
37QH030B (2)	93.52	6.05
<u>Area IV</u>		
1CP10	63.64	39.96
6WPI10 (1)	44.57	55.27
6WPI10 (2) R	43.27	56.57

TABLE 15 (CONTINUED)

<u>STATION</u>	PERCENT	PERCENT
	<u>FINE</u>	<u>COARSE</u>
	<u>Area V</u>	
2NSI10	82.74	16.61
3BB10 (1)	75.48	24.27
3BB10 (2)	76.18	23.64
4NUI10	31.24	68.70
5BB20	85.23	14.62
42WA0400	19.25	80.69
43SH0500	24.30	75.57
44BU0300	24.63	75.13
45CC01	11.35	88.50
45CC01 R	13.50	86.39
46WH008	5.85	93.93
46WH008 R	10.62	89.27
47CL020	23.99	75.60

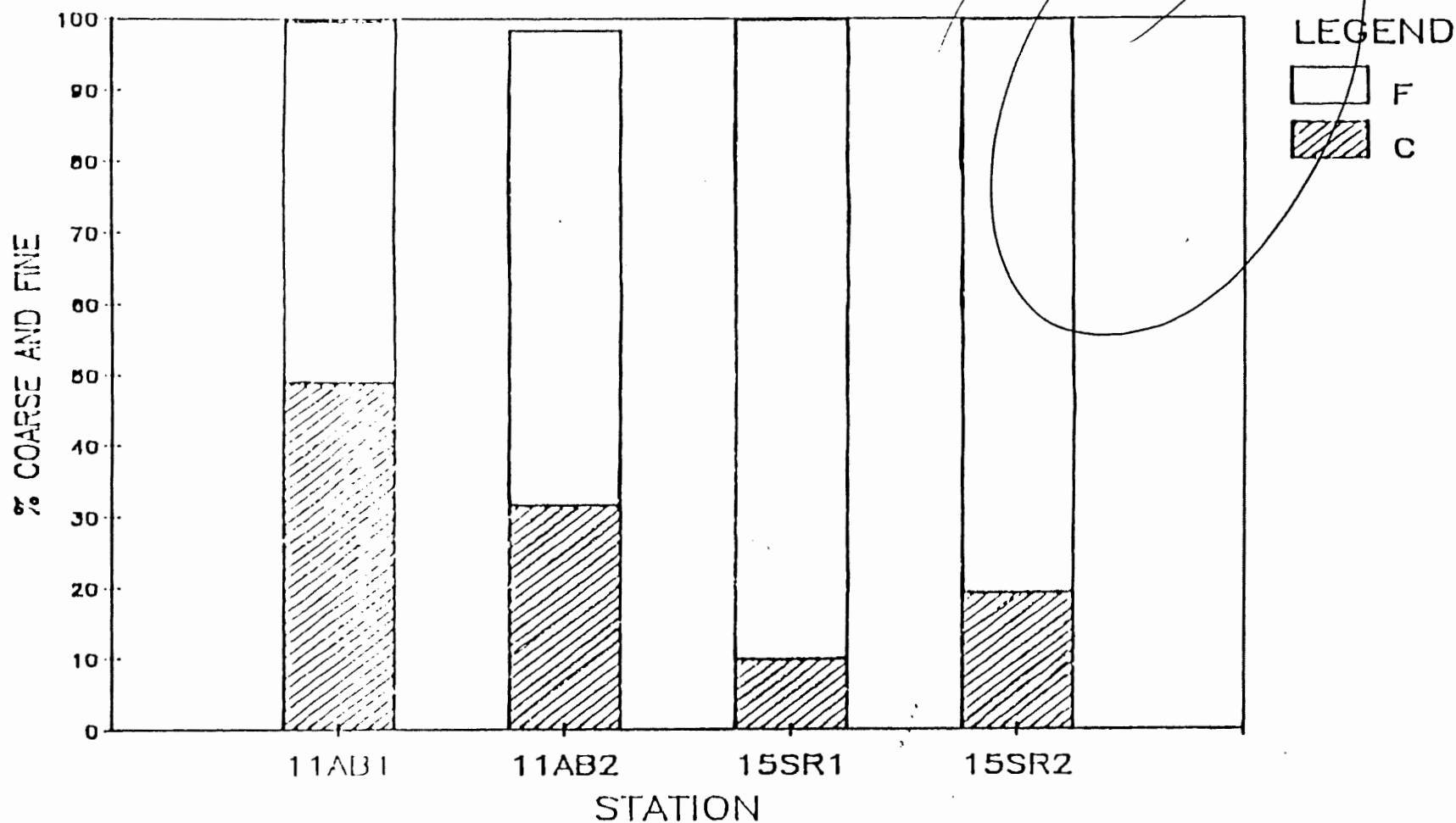
R = Replicate grain size analysis
 (1)= First sample
 (2)= Second sample

FIGURE 11
BUZZARDS BAY PARTICLE SIZE ANALYSIS
% COARSE AND FINE - AREA I
WESTPORT RIVER



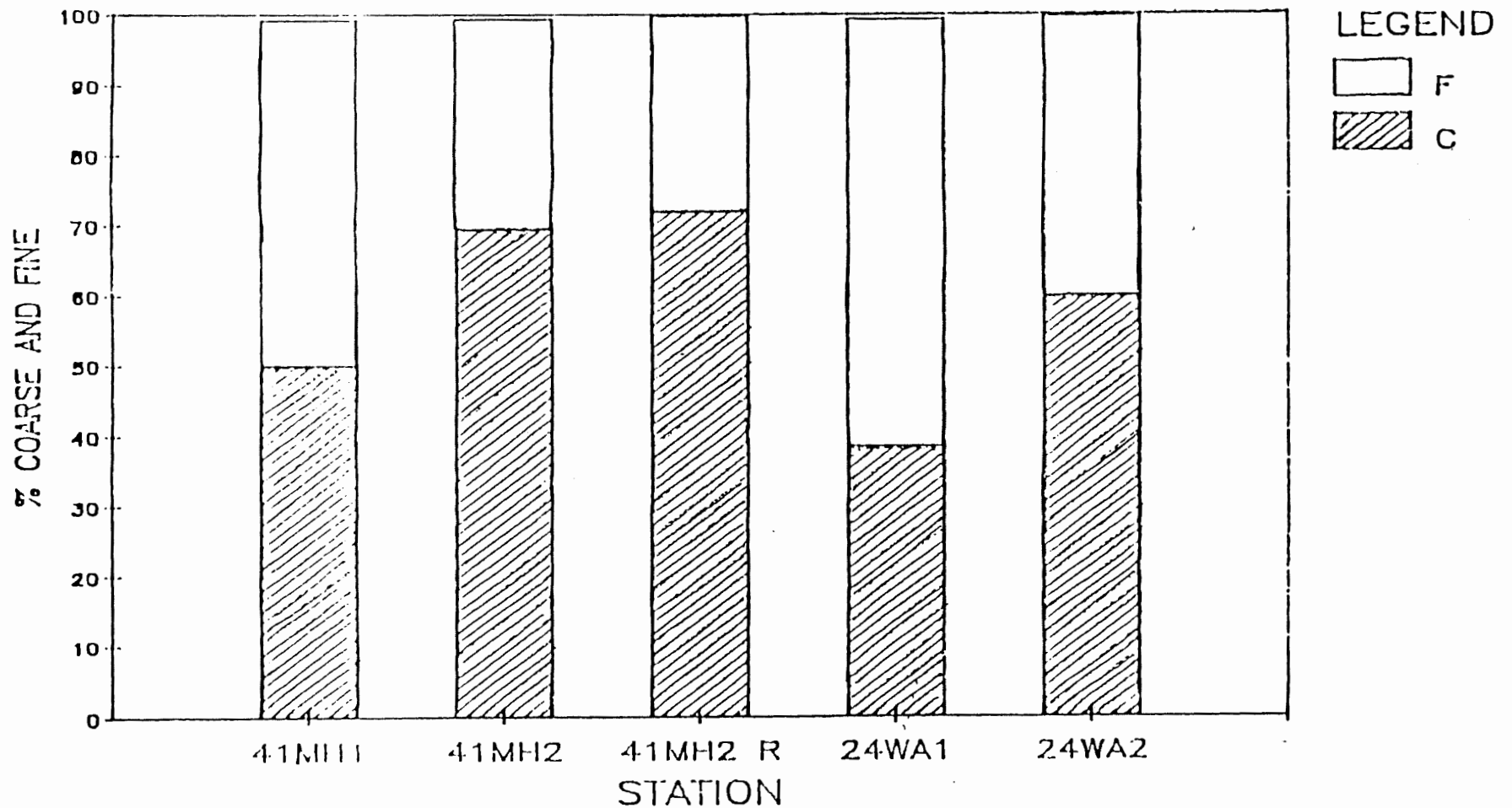
R DENOTES REPLICATE OF GRAIN SIZE ANALYSIS.

FIGURE 12
BUZZARDS BAY PARTICLE SIZE ANALYSIS
% COARSE AND FINE - AREA 1
APPONAGANSETT BAY / SLOCUM RIVER



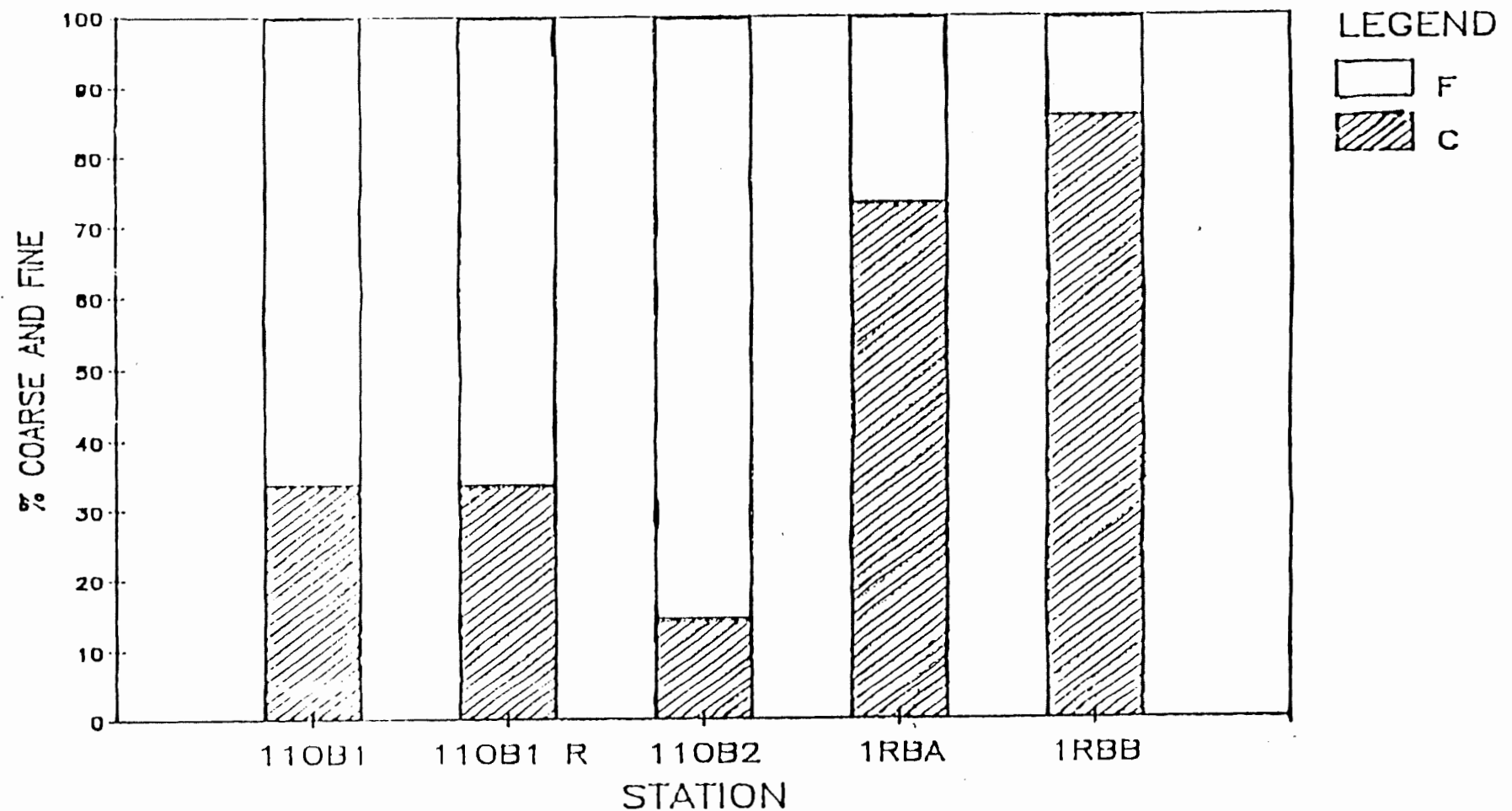
R DENOTES REPLICATE OF GRAIN SIZE ANALYSIS.

FIGURE 13
BUZZARDS BAY PARTICLE SIZE ANALYSIS
% COARSE AND FINE - AREA II
MATTAPOISETT HARBOR / WAREHAM RIVER



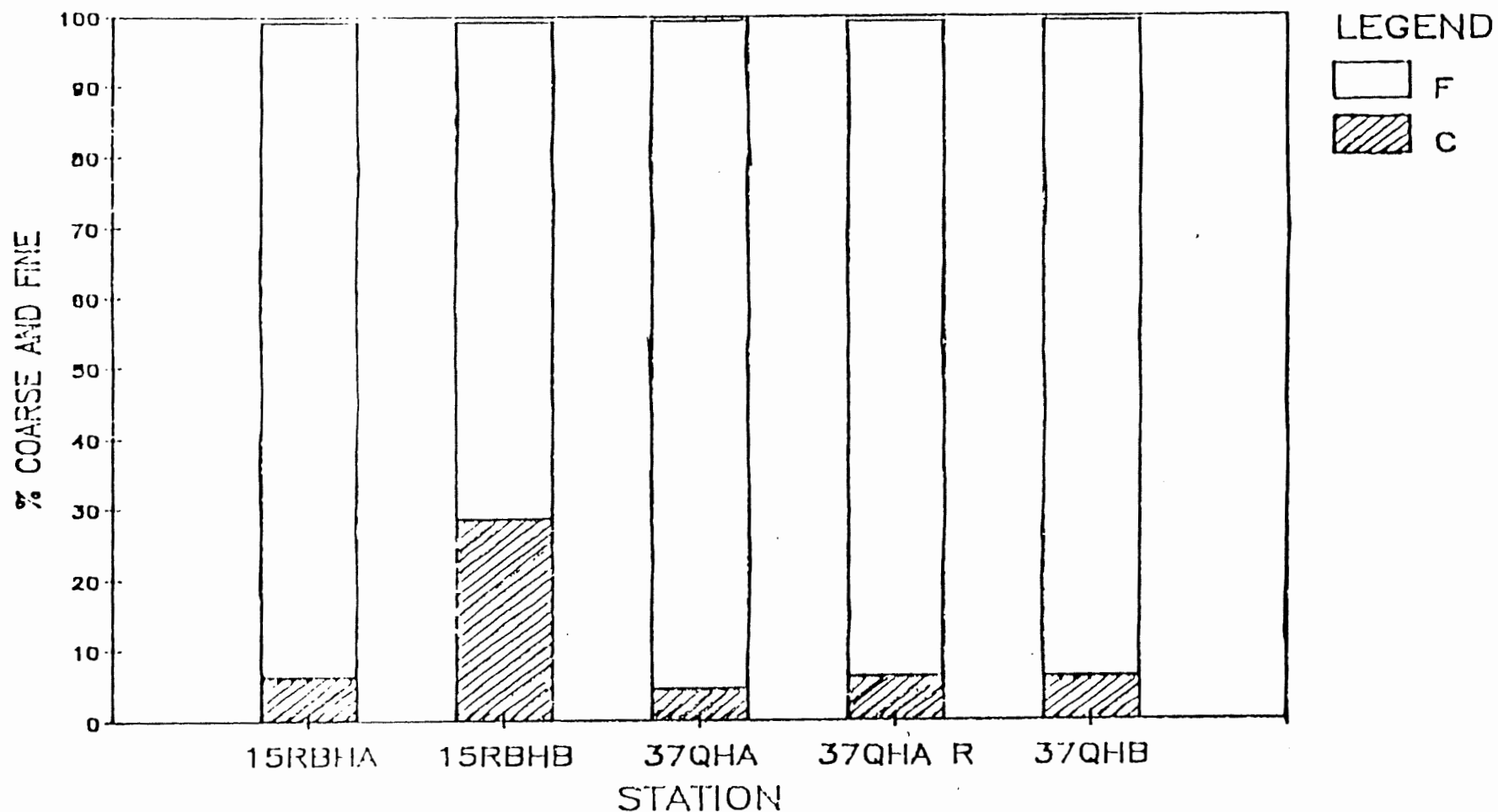
R DENOTES REPLICATE OF GRAIN SIZE ANALYSIS.

FIGURE 14
BUZZARDS BAY PARTICLE SIZE ANALYSIS
% COARSE AND FINE - AREA II
ONSET BAY / RED BROOK



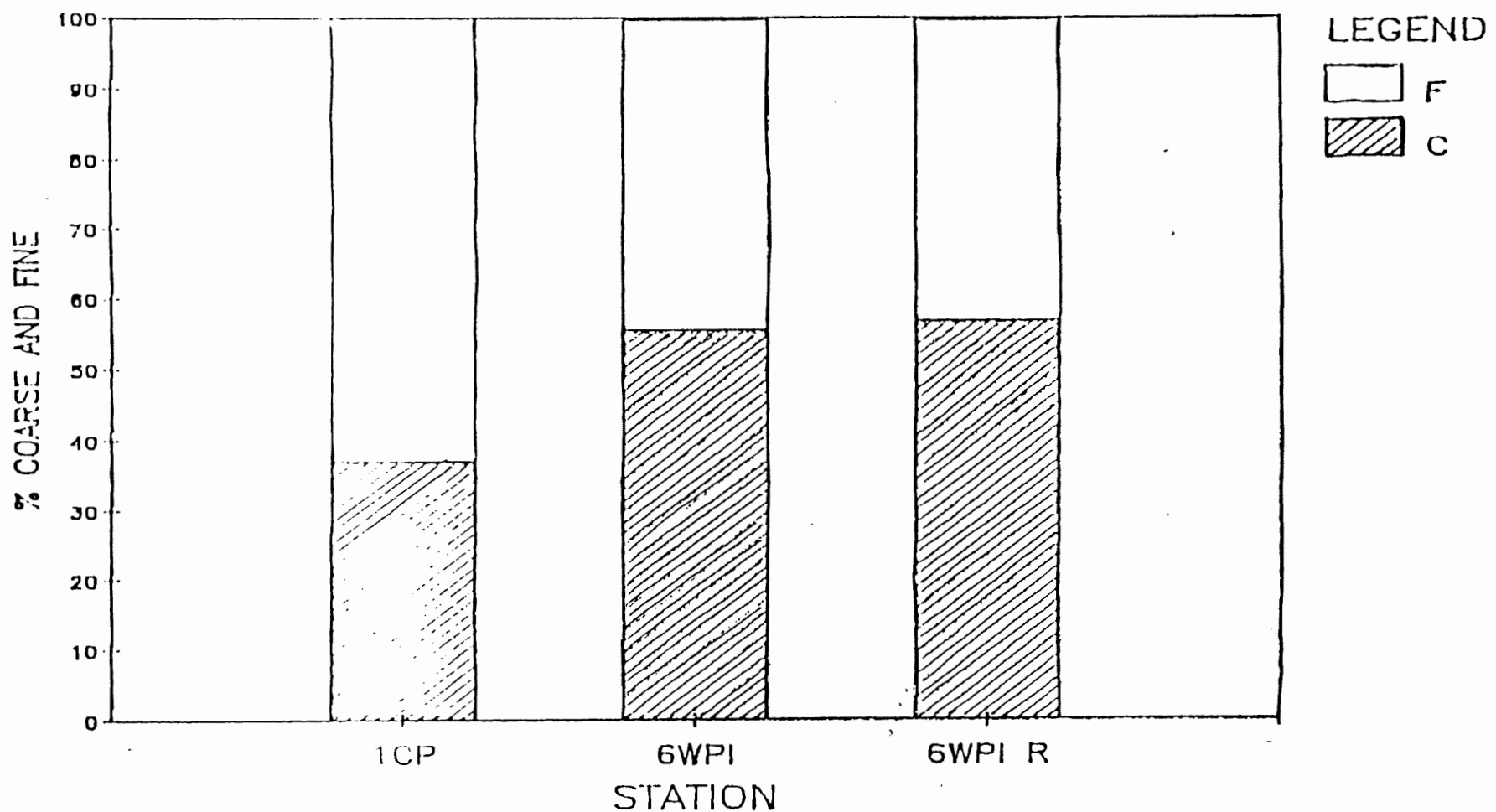
R DENOTES REPLICATE OF GRAIN SIZE ANALYSIS.

FIGURE 15
BUZZARDS BAY PARTICLE SIZE ANALYSIS
% COARSE AND FINE - AREA III
RED BROOK HARBOR / QUISSETT HARBOR



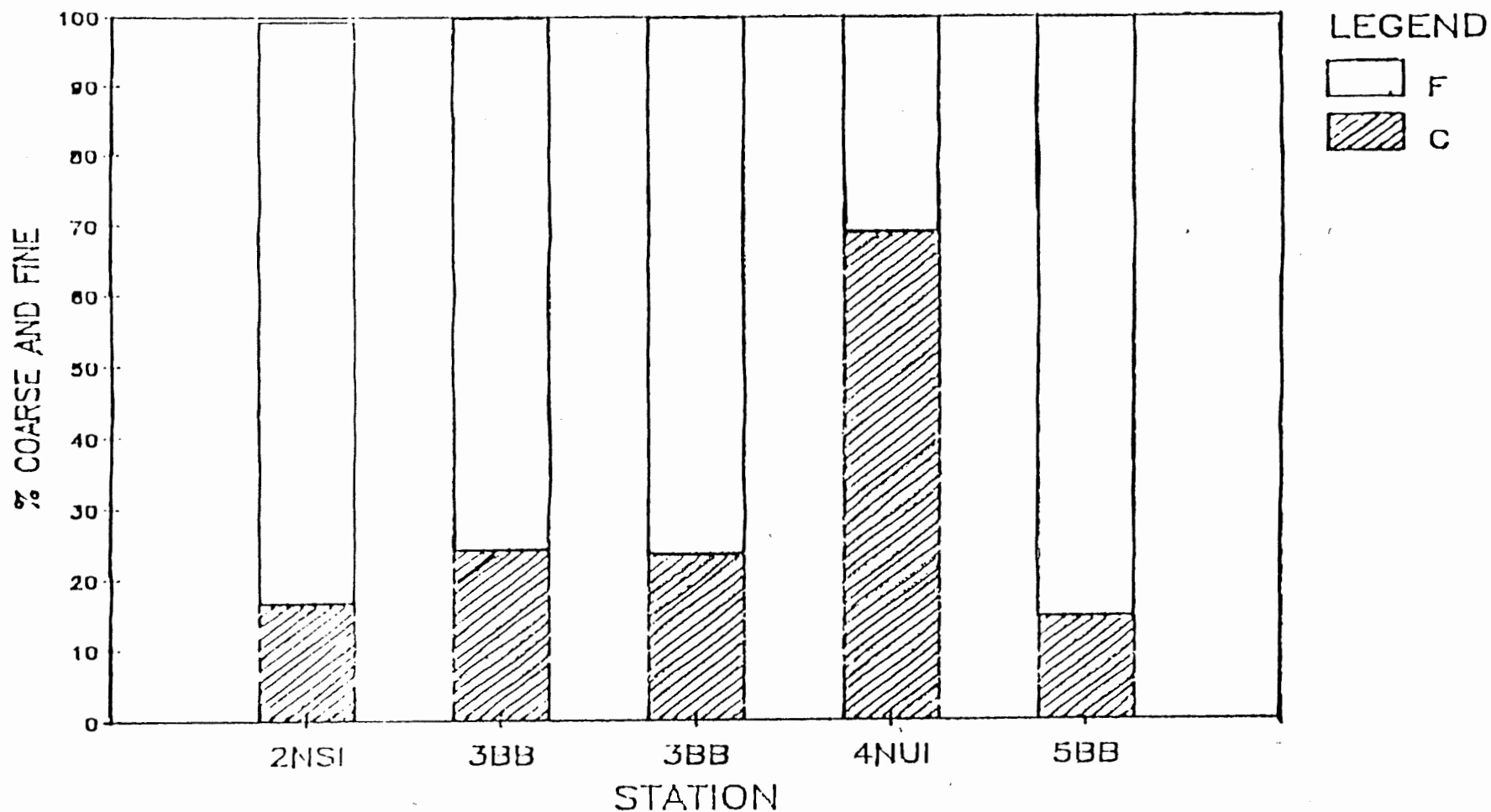
R DENOTES REPLICATE OF GRAIN SIZE ANALYSIS.

FIGURE 16
BUZZARDS BAY PARTICLE SIZE ANALYSIS
% COARSE AND FINE - AREA IV
ELIZABETH ISLANDS



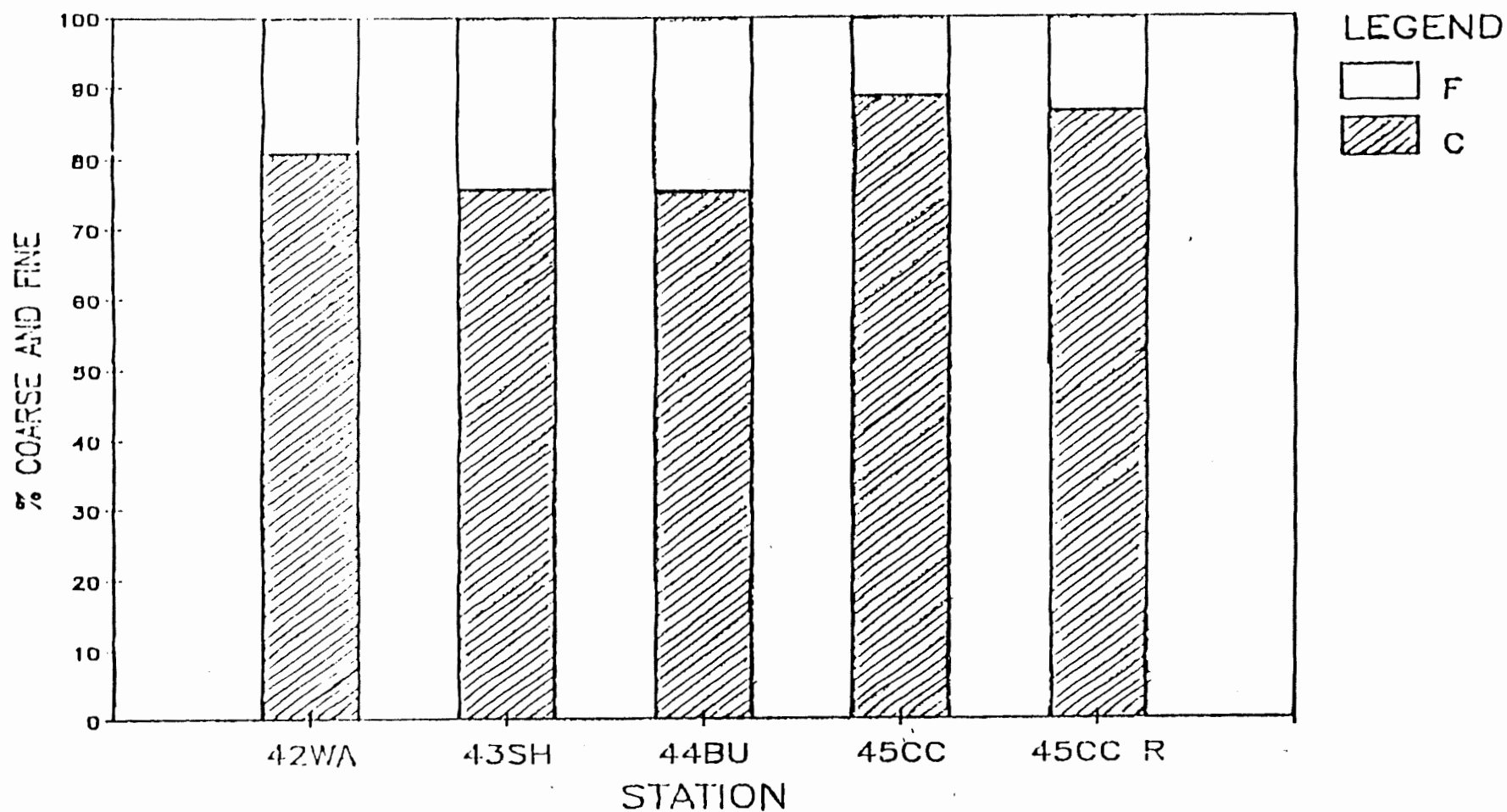
R DENOTES REPLICATE OF GRAIN SIZE ANALYSIS.

FIGURE 17A
BUZZARDS BAY PARTICLE SIZE ANALYSIS
% COARSE AND FINE - AREA V
OUTER BAY



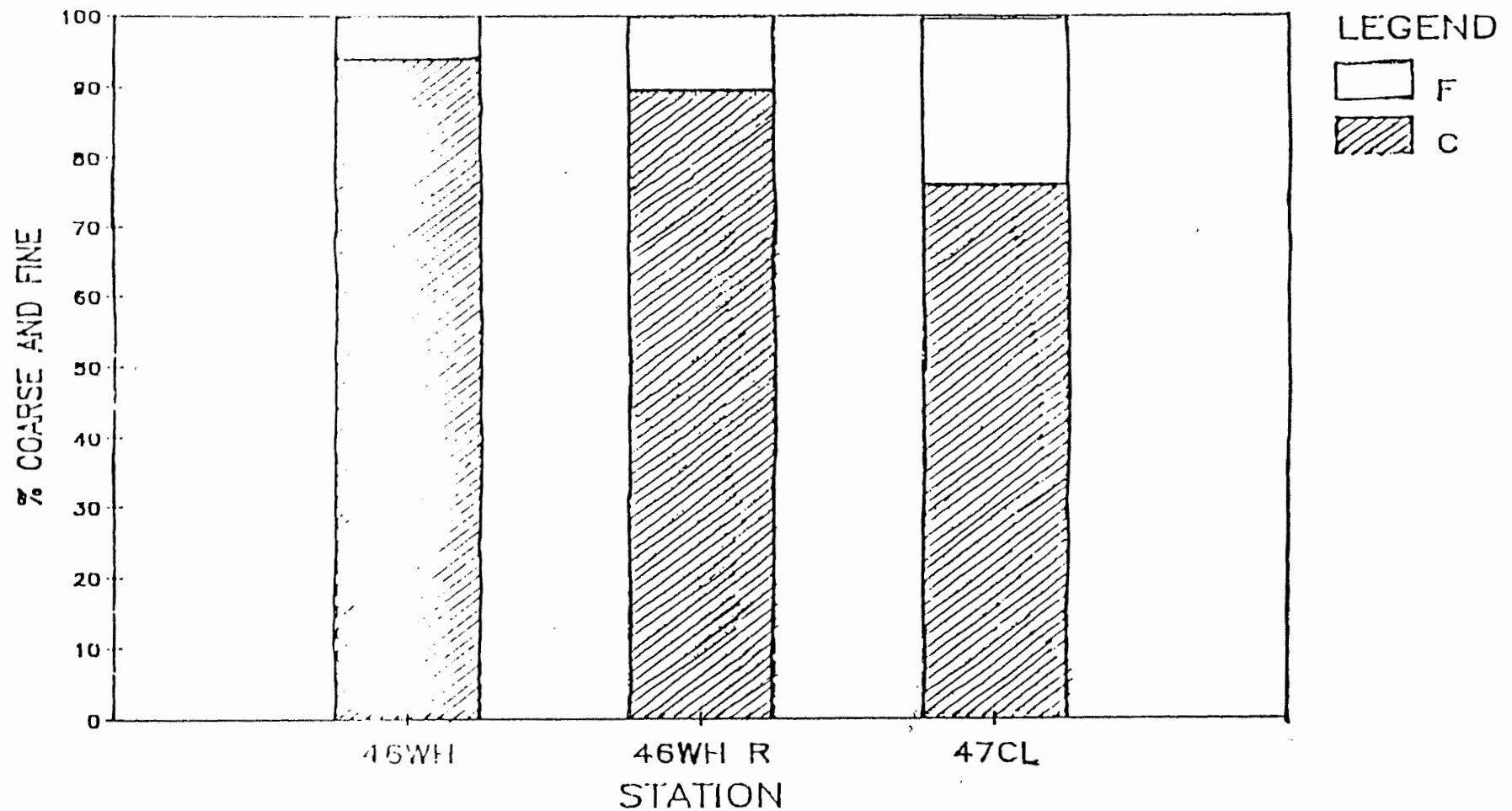
R DENOTES REPLICATE OF GRAIN SIZE ANALYSIS.

FIGURE 17B
BUZZARDS BAY PARTICLE SIZE ANALYSIS
% COARSE AND FINE - AREA V
OUTER BAY



R DENOTES REPLICATE OF GRAIN SIZE ANALYSIS.

FIGURE 17C
BUZZARDS BAY PARTICLE SIZE ANALYSIS
% COARSE AND FINE - AREA V
OUTER BAY



R DENOTES REPLICATE OF GRAIN SIZE ANALYSIS.

TABLE 16

1985 - 1986 BUZZARDS BAY SEDIMENT SURVEY

TOTAL ORGANIC CARBON DATA

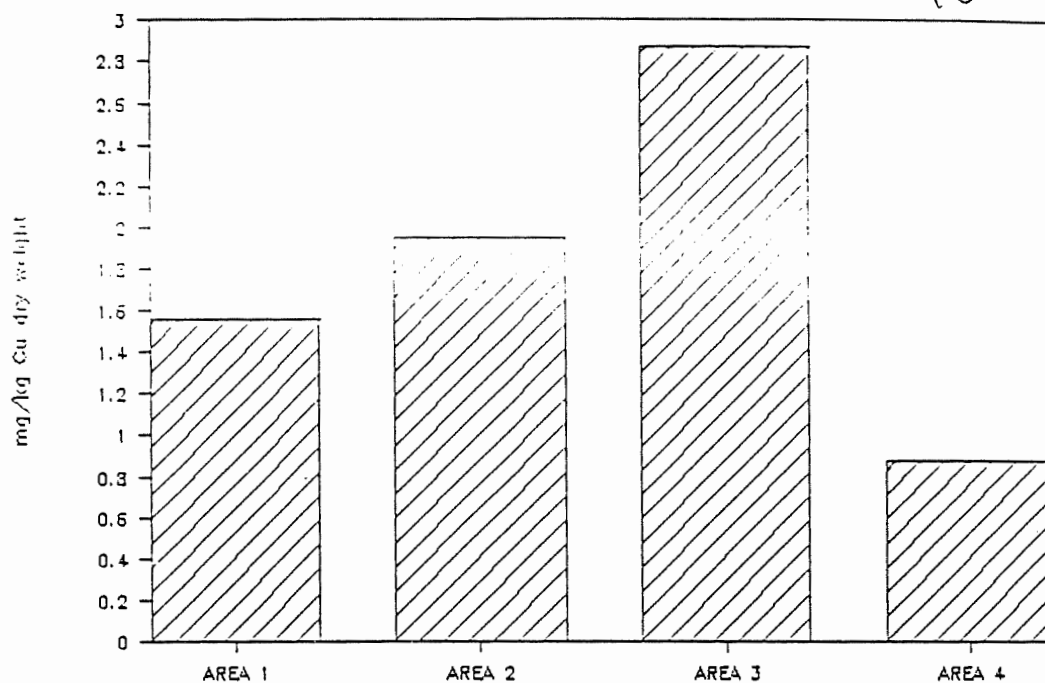
<u>STATION</u>	<u>TOTAL ORGANIC CARBON (g/kg)</u>
AREA I	
10WPE13	38.9
13WPH16	10.9
11AB10	19.4
155R20	35.7
AREA II	
41MH0800	11.9
24WA0180	21.91
110B0200	25.6
110B0200A	34.5
1RB010	72.9
AREA III	
15RBH030	39.6
15RBH030A	39.5
37QH030	31.9
AREA IV	
1CP10	38.8
6WRI10	11.8
AREA V	
2NSI10	18.8
3BB10	16.6
4NVI10	8.2
5BB20	17.4
42WA0400	10.5
42WA0400A	59.3
43SH0500	7.8
43SH0500A	9.2
44BU0300	4.9
44BU0300A	5.0
45CC01	2.6
45CC01A	3.1
46WH008	11.9
46WH008A	11.1
47CL020	12.9
47CL020A	7.8

Station identification numbers ending with an a denote sample replicate.

FIG.18 1986 BUZZARDS BAY BIOTA SURVEY
TOTAL METALS CONC. IN QUOHAUGS (*MERCENARIA mercenaria*)

COPPER

Laver C. 1986



MERCURY

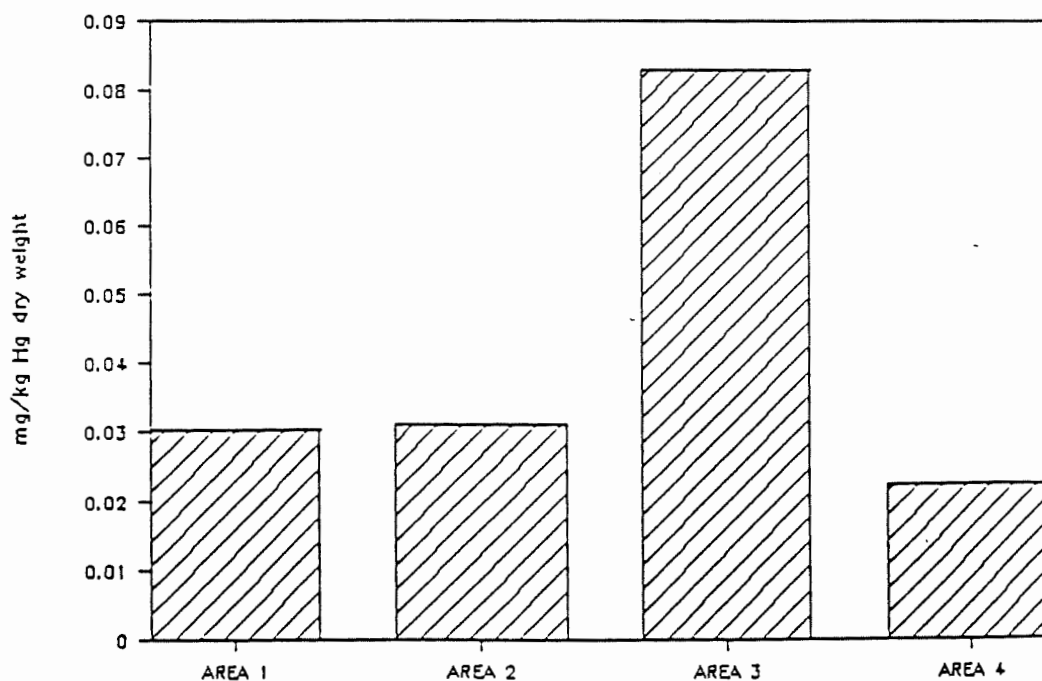
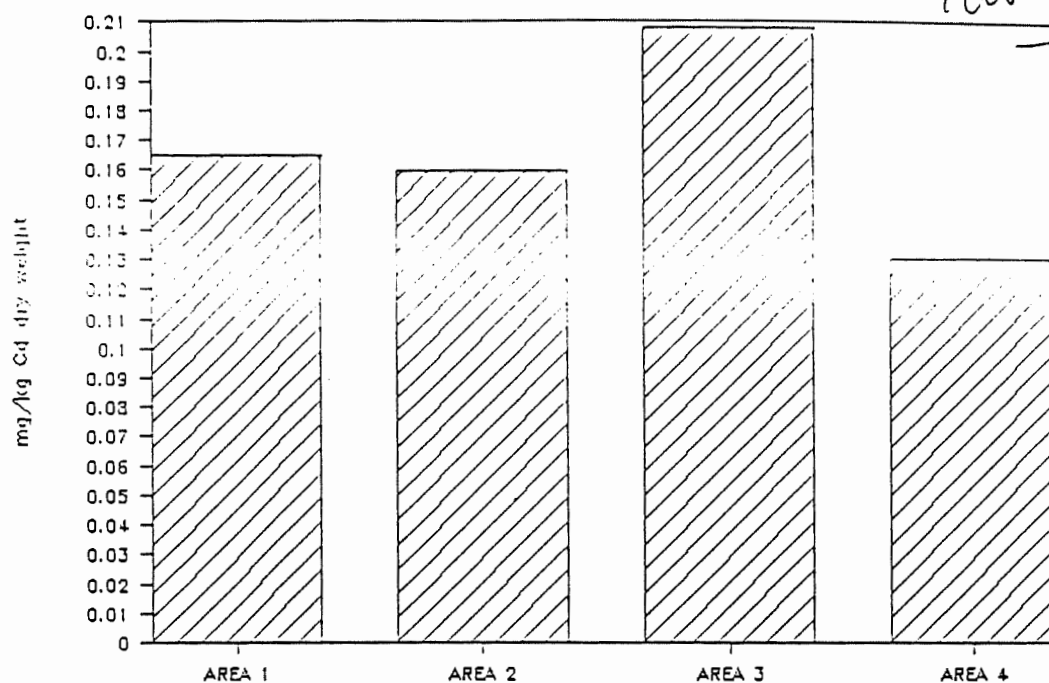


FIG.19 1986 BUZZARDS BAY BIOTA SURVEY

TOTAL METALS CONC. IN QUOHAUGS (*MERCENARIA mercenaria*)

CADMIUM

Level Carl



CHROMIUM

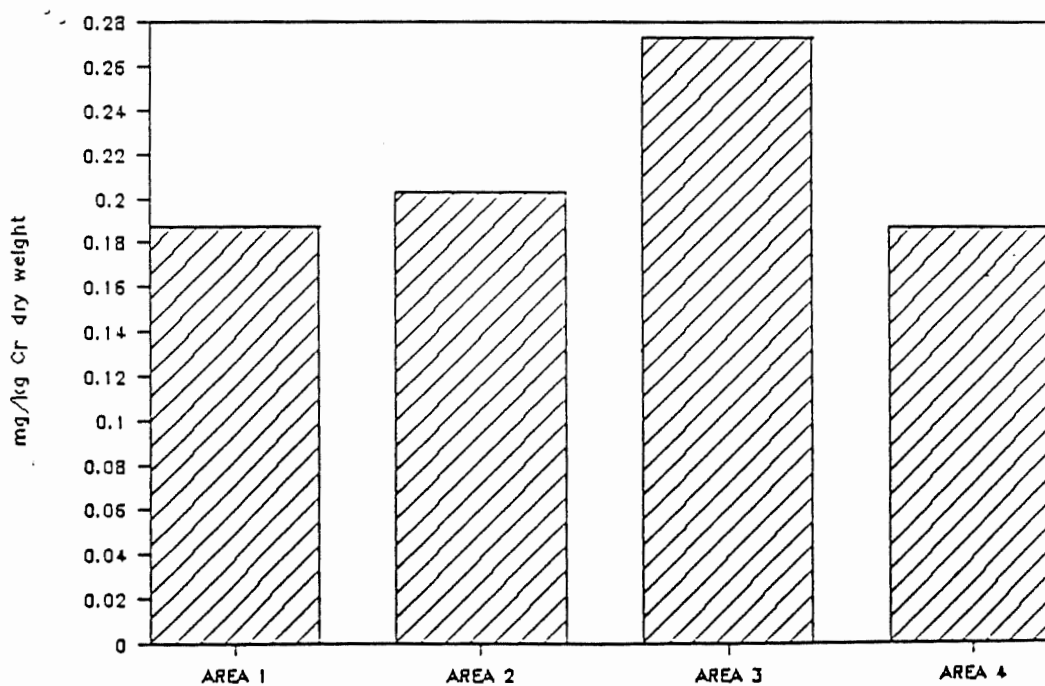
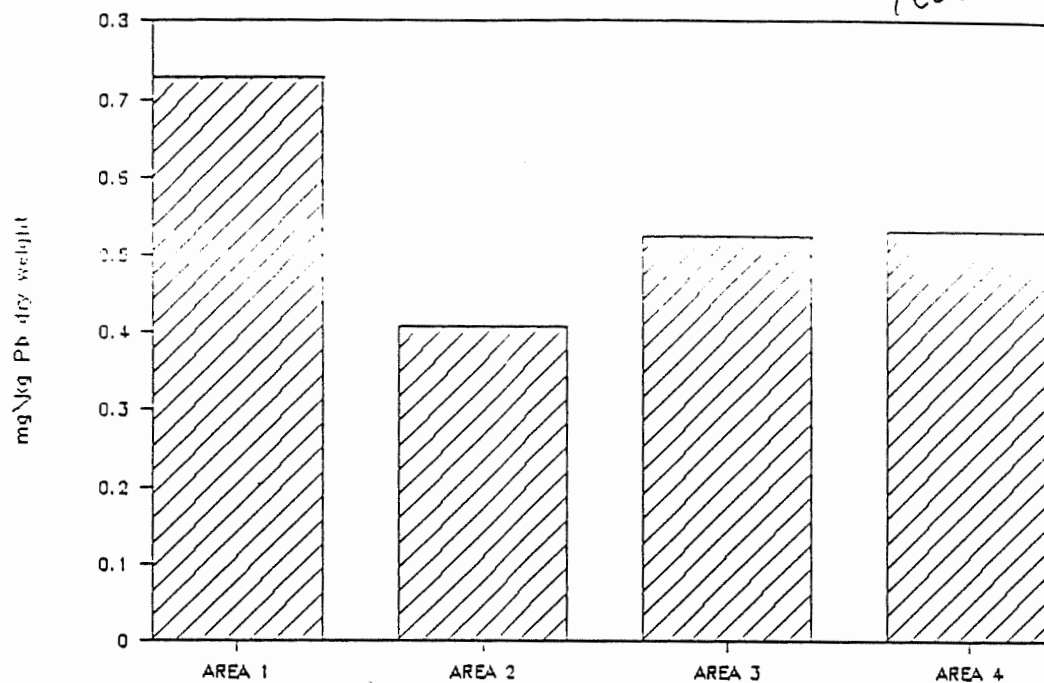


FIG. 20 1986 BUZZARDS BAY BIOTA SURVEY
TOTAL METALS CONC. IN QUOHAUGS (*MERCENARIA mercenaria*)

LEAD

(well over)



NICKEL

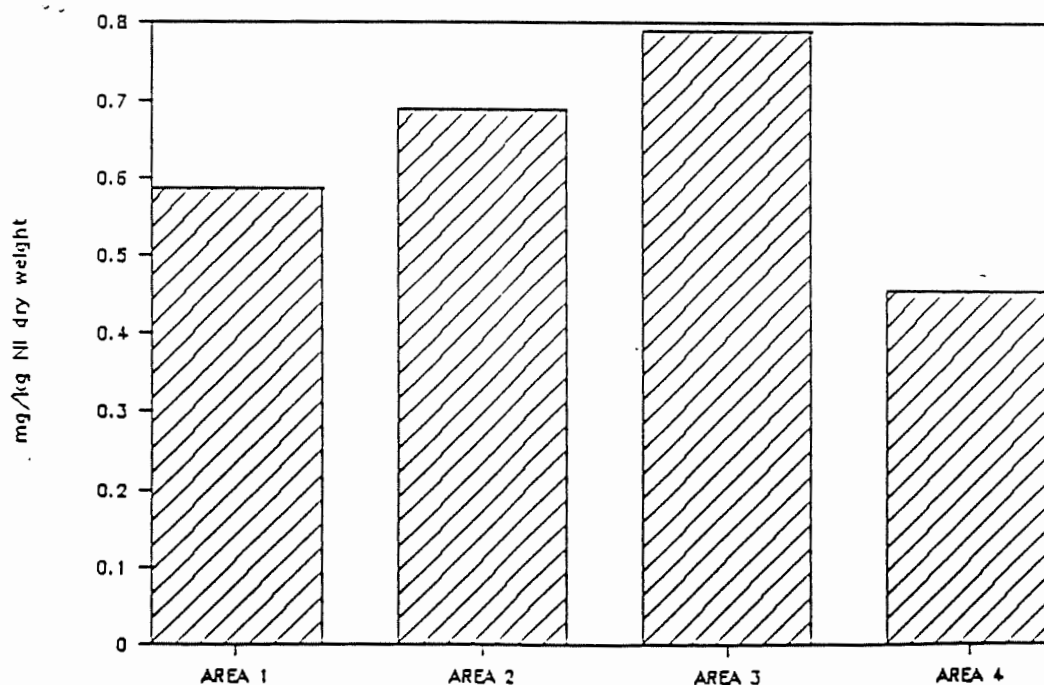


FIG.21 1986 BUZZARDS BAY BIOTA SURVEY

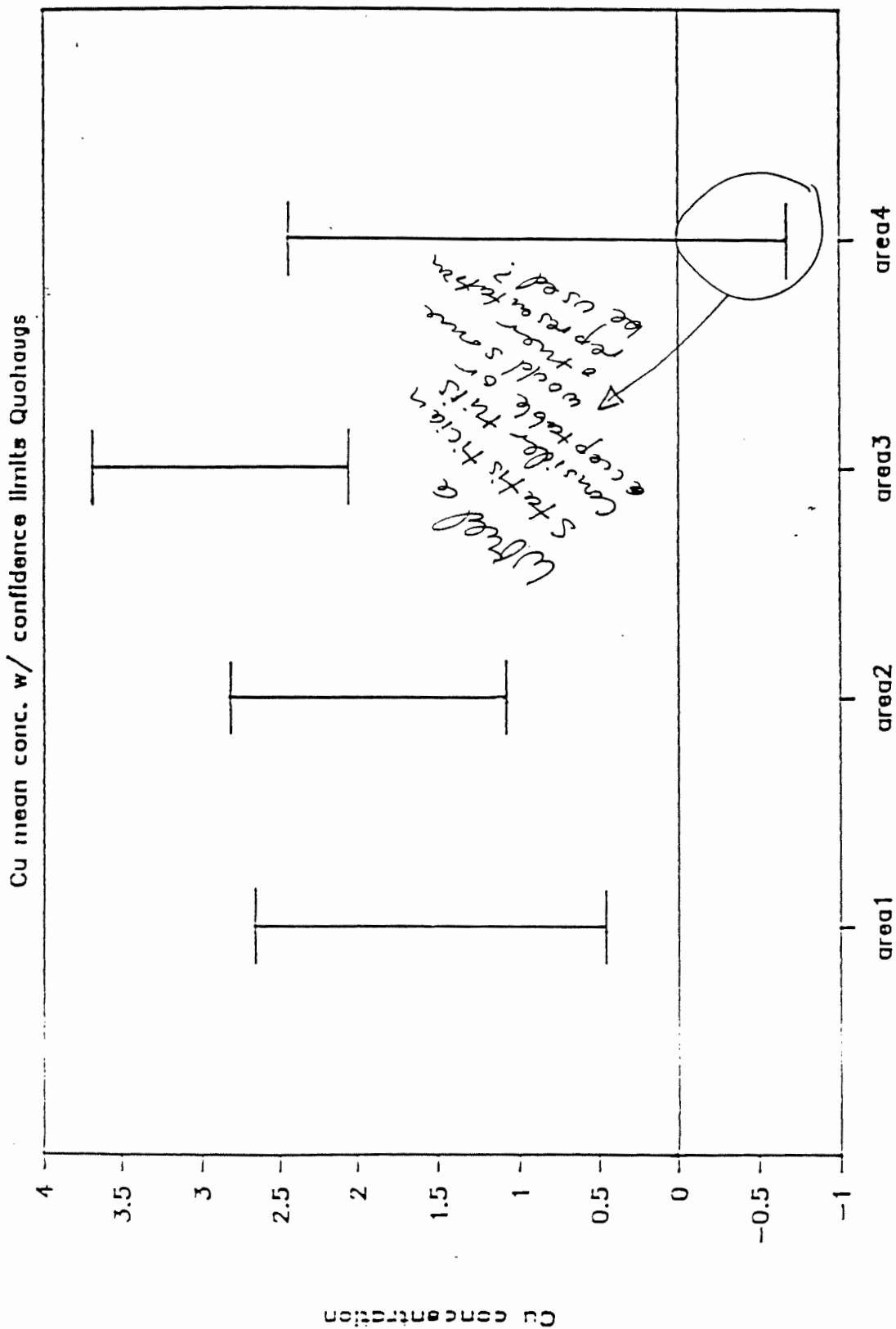


FIG.22 1986 BUZZARDS BAY BIOTA SURVEY

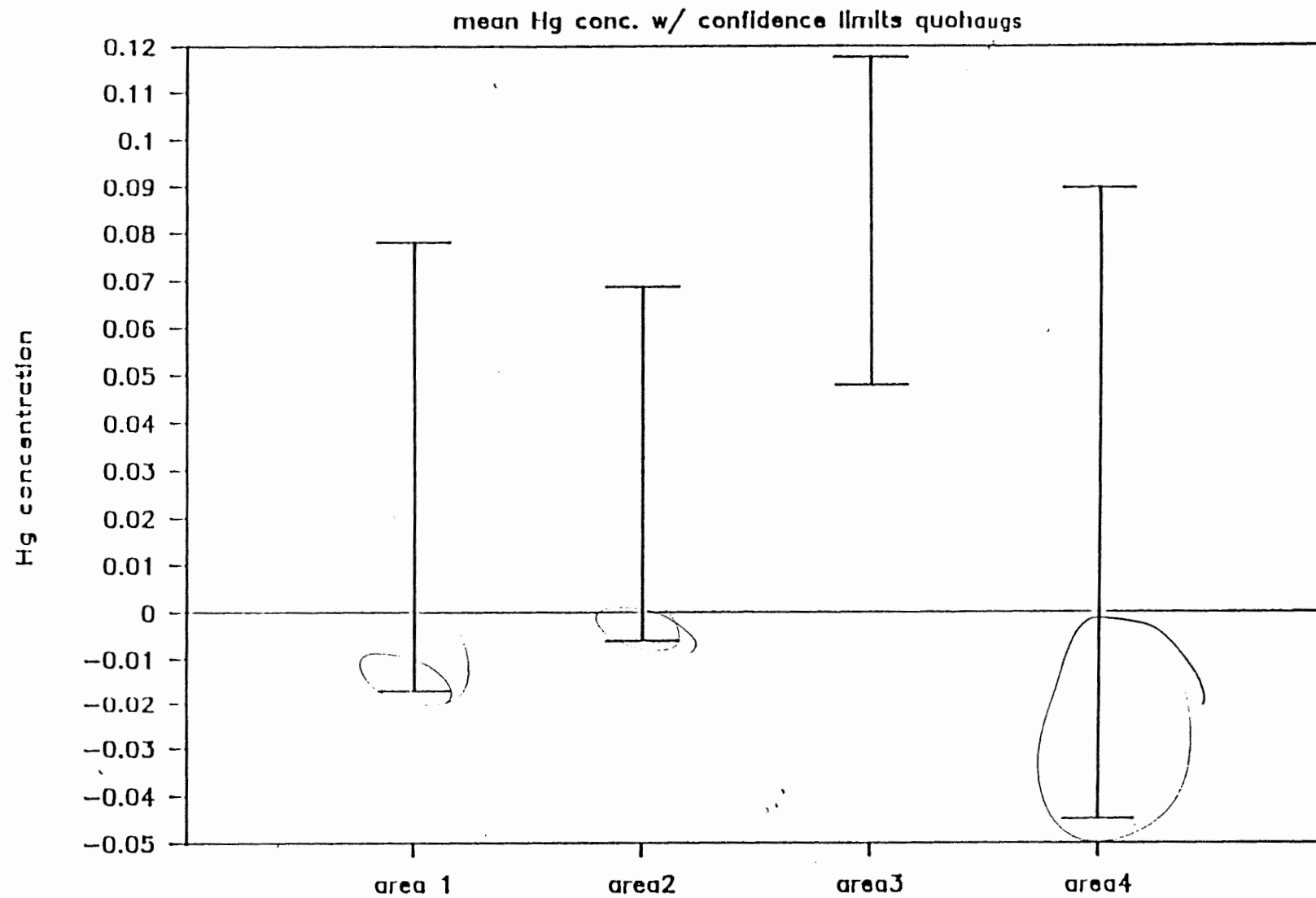


FIG. 23 1986 BUZZARDS BAY BIOTA SURVEY
FREQUENCY PLOT: CADMIUM CONCENTRATIONS IN
LOBSTERS FROM AREA V

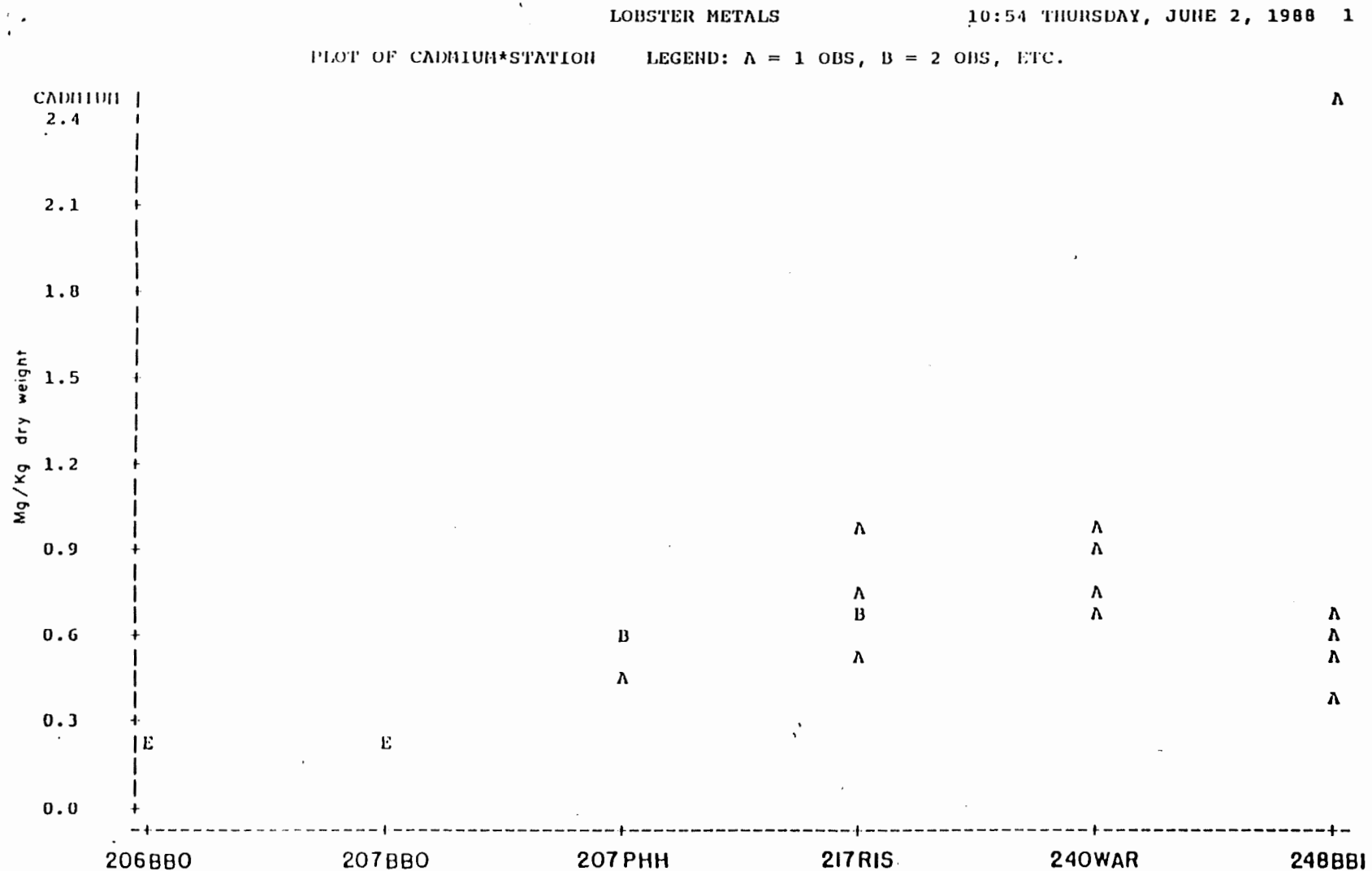


FIG.24 1986 BUZZARDS BAY BIOTA SURVEY

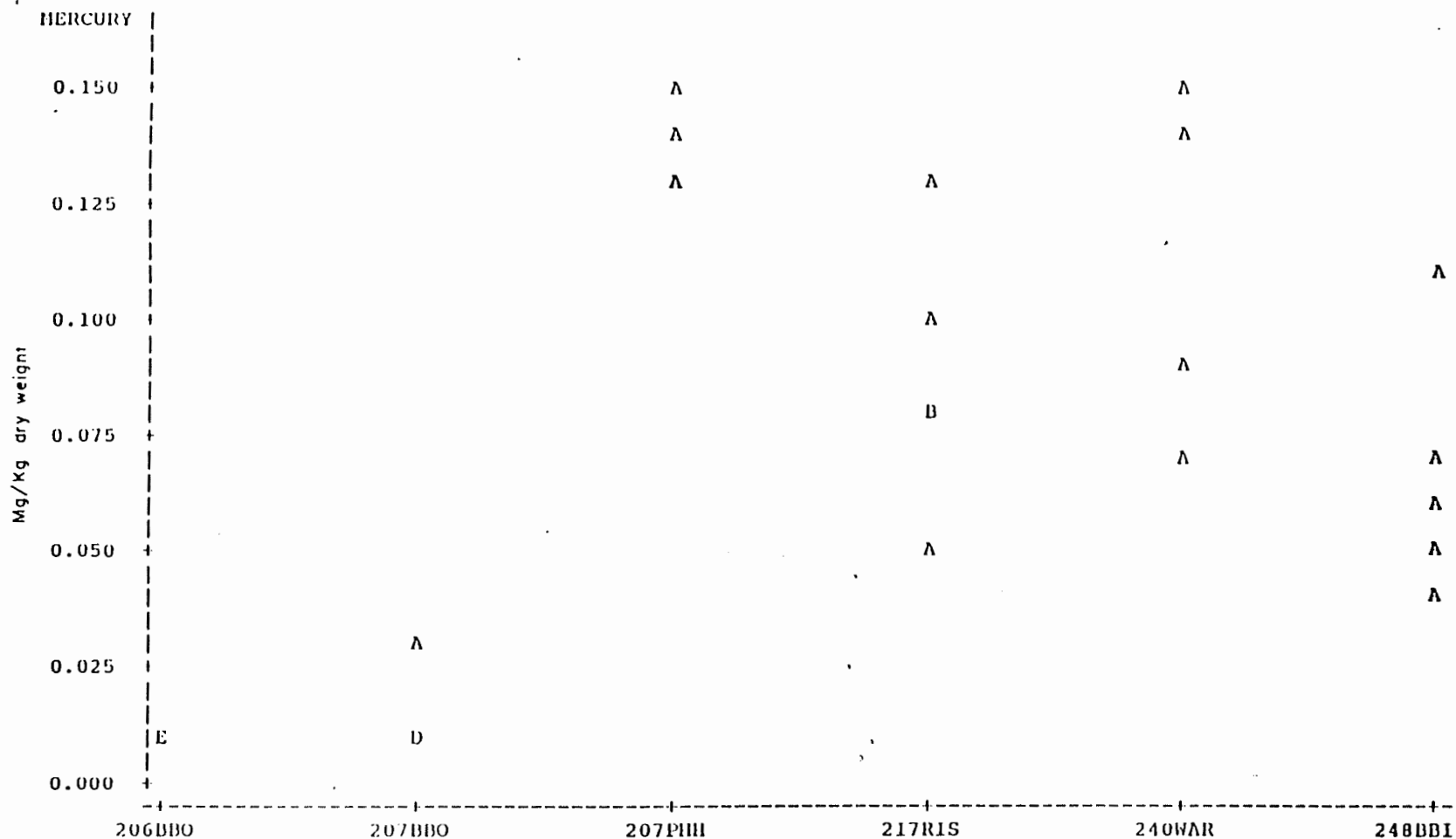
FREQUENCY PLOT: MERCURY CONCENTRATIONS IN LOBSTERS FROM AREA V

LOBSTER METALS

10:50 THURSDAY, JUNE 2, 1988 1

PLOT OF MERCURY*STATION

LEGEND: A = 1 OBS, B = 2 OBS, ETC.



7.0 DISCUSSION

7.1 Data Set Summary

The approach taken in analyzing the data was to determine if there were any significant differences in the spatial distribution of metals concentrations within the biota and sediment. The null hypothesis is that there are no significant differences in the levels of priority pollutants found in shellfish, lobsters, winter flounder or sediments within Buzzards Bay.

Metals levels in sediments with the exception of mercury were generally found to be positively correlated with the percent fines ($<63 \mu\text{m}$). The degree of correlation varied with each form of metal (see Figure 25). While not quantified, there are positive indications that proximity to anthropogenic sources is reflected by the spatial distribution of priority pollutants.

Exposure standards for public health protection consideration exist for only a few toxic contaminants in seafood (Capuzzo, McElroy, unpublished report). Metals levels in shellfish were found to be uniformly low. The body burdens of lobsters and winter flounder generally showed no significant spatial differences. An exception was observed in lobsters collected from stations located in the Outer Bay which showed significantly lower levels of mercury than at other stations.

Samples of quohaugs, sediments and lobsters collected along the cape side of the bay consistently recorded the highest observed levels.

7.1.1 Quohaug Metals

This data set consists of 51 samples from 33 stations. As noted in (3.1.3) of the method of the methodology section each sample consisted of 8 legal size $> 51 \text{ mm}$ shellfish, which were analyzed for 6 metals; cadmium, chromium, copper, lead, mercury, and nickel. Metals concentrations within the shellfish were below FDA National Shellfish Sanitation Program alert levels (Capuzzo, McElroy, unpublished report) and showed no significant differences in spatial distribution. The shellfish with the highest total copper and mercury levels were found along the cape side of the bay particularly within Quissett Harbor.

TABLE 17

1986 BUZZARDS BAY BIOTA SURVEY

SPATIAL AND QUALITATIVE DISTRIBUTION OF QUOHAUG DATA SET

Area 1	8 Stations	8 Samples	0 Duplicates	0 Replicates
Area 2	13 Stations	24 Samples	5 Duplicates	3 Replicates
Area 3	8 Stations	15 Samples	3 Duplicates	2 Replicates
Area 4	4 Stations	4 Samples	0 Duplicates	0 Replicates

Table 9 presents all of the metals data while Figure 18 displays the mean concentrations of each metal by area. After reviewing the data set a screening process was employed to determine which groups of data would receive further analysis. As can be seen the reported levels for cadmium, chromium, lead and nickel are uniformly low and consist largely of values at or less than the MDL (minimum detection limit).

Secondly, different analytical equipment was employed over the course of the survey (see Methodology Section 3.14). After receiving archived shellfish samples from the Division of Marine Fisheries Cat Cove Marine Laboratory and analysis of variance of paired samples was conducted to determine if significant differences could be found between the reported results. The data subset consisted of 7 samples which had been analyzed on a Perkin Elmer 403 spectrophotometer™ without background correction, with samples from the same station which were analyzed on the A Varian 1475 Spectrophotometer™ with background correction. Less than values were included in the statistical computations by assuming a value of $5/8$ ths the reported minimum detection limits: Example reported value of $<0.29 \times 5/8 = 0.18$.

The Anova table below summarizes the results for each metal:

SOURCE OF VARIATION			DF	SS	MS	F _s
Cadmium PE 403 vs VARIAN	mean 0.1429		1	.0014	.0014	0.35 ns
	mean 0.1629					
individuals			6	.0285	.0048	1.2 ns
remainder			6	.0242	.0040	
Chromium PE 403 vs VARIAN	mean 0.4186		1	.1380	.1380	7.0*
	mean 0.2200					
individuals			6	.1441	.0240	1.0 ns
remainder			6	.1179	.0197	
Copper PE 403 vs VARIAN	mean 3.0714		1	3.02	3.02	13.13*
	mean 2.1429					
individuals			6	7.68	1.28	5.57*
remainder			6	1.38	0.23	
Lead PE 403 vs VARIAN	mean 0.85		1	0.90	0.90	22.5**
	mean 0.34					
individuals			6	0.47	0.08	2.0 ns
remainder			6	0.23	0.04	
Nickel PE 403 vs VARIAN	mean 0.85		1	0.05	0.05	.33 ns
	mean 0.74					
individuals			6	0.44	0.07	.47 ns
remainder			6	0.89	0.15	

$$F_{.05} [1,6] = 5.99$$

$$F_{.05} [6,6] = 4.28$$

$$F_{.01} [1,6] = 13.75$$

ns - not statistically significant at the 05% level

* - statistically significant at the 0% level

** - statistically significant at the 01% level.

Significant differences were noted between the two "treatments" for the metals, chromium, copper and lead, with the "Varian" generally reporting a lower values. An exception was noted with the metal cadmium. The reasons for this are likely

to be related to the treatment of less than (<) values in these computations: where values are reported as being less than detection limits a value of 5/8ths the reported detection limit was assumed. The high number of less than values precluded further analysis at this time and a decision was made therefore to set aside the cadmium, chromium, lead, and nickel data sets and focus further analysis on the total copper and mercury data sets.

Copper is ubiquitous in the rocks and minerals of the earth's crust. (Turekian and Wedepohl (1961), estimated the mean concentration of copper in granitic rocks to range between 10 and 30 ppm. Summerhayes et al (1977), working with sediment data collected by Moore (1963), from Central Buzzards Bay estimated the mean concentration of copper in fine-grained sediments (Protogreywackes) to be 22.9 ppm and found a mean of 5.4 ppm within the sands.) Copper occurs usually as sulfides and oxides and occasionally as metallic copper. Weathering and dissolution of these natural minerals results in background levels of copper in natural surface water at concentrations generally well below 20 ppb., (McGinn, 1981 unpublished report). Elemental copper is readily oxidized by organic and mineral acids. Oxidized copper is absorbed on clays, sediments, and organic particulates forming various inorganic and organic compounds. Higher concentrations of copper are usually from anthropogenic sources like domestic sewage and industrial sources (McGinn, 1981 unpublished report). Within the Buzzards Bay Drainage Basin, likely sources include the New Bedford Wastewater Treatment Plant where mean concentrations of 34.5 mg/l were measured in the effluent discharge (DWPC 1987 Wastewater Discharge Survey Report), industrial waste discharges from plating and metal fabricating industries, urban runoff and as a component in anti-fouling paints.

The "Varian" copper data set exhibited a large range of values (0.5 mg/kg - 10 mg/kg), with a mean concentration of 2.11 (sum 84.5 / 40). Reported LES values were all above the detection limits of .02 mg/l. In Figure 21 the mean concentrations and 95 percent confidence limits for total copper in the Quohaugs was plotted against the area locations with Area 3 showing the highest levels. An Anova however disclosed no significant differences between areas at the 95% level.

The Anova Table below summarizes the results for copper:

SOURCE OF VARIATION	DF	SS	MS	F _s
Differences between area means	3	17.55	5.85	2.47 ns
Differences within areas	36	85.2879	2.3691	

$$F_{.05} [3, 36] = 2.87$$

The next comparison made was between the highest copper values found in the Quohaug samples with an "alert level" of (10.0 ug/mg wet weight), issued by the National Shellfish Sanitation Program.

It should be noted that the NSSP alert levels are not based on human health/epidemiological concerns but were developed to provide a baseline of background concentrations for individual species. To make the comparison it is necessary to convert the data from a dry weight measure to wet weight. A standard value of 80% water was assumed for the Quohaugs (personal communication, Judith McDowell Capuzzo), accordingly dry weight measures were converted to wet weight by dividing the dry weight values by five (5).

TABLE 18

1986 BUZZARDS BAY BIOTA SURVEY

COMPARISON OF HIGHEST TOTAL COPPER VALUES IN QUOHAUGS (*Mercenaria mercenaria*)

WITH NSSP ALERT LEVEL OF 10 ug/g WET WEIGHT

DWPC STATION ID#	MAP LOCATOR ID#	LES #	TOTAL COPPER DRY WEIGHT mg/kg	TOTAL COPPER WET WEIGHT ug/g
AREA I				
214APB	140	575480	2.1	0.42
210NSB	200	575474	3.4	0.68
AREA II				
242MPH	270	574162	3.1	0.62
229SPH	330	575935	3.3	0.66
244AUC	290	575471	2.3	0.46
224WAR	390	575931	2.9	0.58
211ONB	440	575930	2.6	0.52
AREA III				
215RBH	530	574161	2.4	0.48
220SQH	540	574155	2.9	0.57 (1)
		574156	2.9	
		575466	2.7	
210GSH	660	574159	4.7	0.94
238QUH	670	574157	4.3	1.17 (1)
		574158	10.0	
		575468	3.2	

(1) Mean of three samples

As can be seen the reported values are substantially below the 10 ug/g NSSP alert level.

Mercury can be found in the environment in several different forms ranging from elemental to dissolved inorganic and organic species. Turekian and Wedepohl (1961), estimated the mean concentration of mercury in granitic rocks to be 0.08 ppm. The finding that certain occurring conditions to convert inorganic and organic forms of mercury to the highly toxic methyl or dimethyl mercury makes virtually all forms potentially hazardous to the environment (McGinn, 1981 unpublished report). Mercury in its methylated form is the only metal known to biomagnify in successive levels of aquatic food chains (Office of Technology Assessment, 1987). Mercury is adsorbed on clays, sediments, and organic particulates forming various inorganic and organic compounds. Higher concentrations of mercury are usually from anthropogenic sources such as domestic sewage and industrial sources (McGinn, 1981 unpublished report). Within the Buzzards Bay Drainage Basin, sources are not well documented but are likely to include wastewater treatment plant effluent, industrial waste discharges, and urban runoff.

The mercury concentrations Buzzards Bay Quohaugs exhibited a wide range of values (0.008 mg/kg - 0.37 mg/kg dw), with a mean concentration of 0.0495 (sum 1.98 / 40), with area 3 reporting the highest levels. Reported LES values were all above the detection limit of 0.0002 mg/l. In Figure 21 the mean concentrations and 95 percent confidence limits for total mercury in the Quohaugs was plotted against the area locations with area 3 showing the highest levels. An Anova however disclosed no significant differences between areas at the 95% level.

The Anova Table below summarizes the results for mercury:

SOURCE OF VARIATION	DF	SS	MS	FS
Differences between area means	3	0.0268	0.0089	2.02 ns
Differences within areas	36	0.1588	0.0044	

$$F_{.05 [3, 36]} = 2.87$$

The next comparison made was between the highest mercury values found in the quohaug samples and the U.S. FDA action level of (1.0 ug/g wet weight). To make the comparison it is necessary to convert the data from a dry weight measure to wet weight. A standard value of 80% water was assumed for the quohaugs (personal communication, Judith McDowell Capuzzo) and dry weight measures were converted to wet weight by dividing the dry values by five (5).

TABLE 19

1986 BUZZARDS BAY BIOTA SURVEY

COMPARISON OF HIGHEST TOTAL MERCURY VALUES IN QUOHAUGS (Mercenaria mercenaria)

WITH FDA ALERT LEVEL OF 1.0 ug/g

DWPC STATION ID#	MAP LOCATOR ID#	LES #	TOTAL MERCURY DRY WEIGHT mg/kg	TOTAL MERCURY WET WEIGHT ug/g
AREA I				
215NBH	190	575479	0.12	0.0240
AREA II				
236SPH	320	573934	0.11	0.0220
		573935	0.12	0.0240
AREA III				
215RBH	530	574161	0.12	0.0240
238QUH	670	574157	0.18	0.0360
		574157	0.37	0.0740
		575468	0.208	0.0416

All values were found to be well below the FDA action limit of 1.0 ug/g wet weight.

7.1.2 Metals Concentrations in Lobsters

The lobster data set consists of 27 individual lobsters collected from 6 stations. The stations are frequented by commercial fisherman and provide good spatial distribution, being located in 4 of the 5 areal designations. As noted in (3.1.2) of the methodology section, each sample consisted of the edible tissue (meat and tomale) from an adult lobster analyzed for 5 metals; cadmium, chromium, lead, mercury, and nickel. While spatial variation was observed body burdens in the lobster were found to be low.

Figure 23 and 24 present frequency plots of the mean concentration of each metal for the lobsters at each station. The lobster data set like its Quohaug and Winter Flounder counterparts is largely comprised of total metals levels at or below the MDL. It should be noted that where less than values existed a value of 5/8 ths of the MDL was employed to provide the estimate. The data shows considerable overlap of values with no clear spatial differences noted. Different analytical equipment was employed over the course of the survey as was the case with the Quohaug samples, (see Methodology Section 3.14). It was therefore necessary to determine whether or not significant differences existed in the reported results between the two machines (A Perkin Elmer 403 Spectrophotometer™ without background correction, and a Varian 1475 Spectrophotometer™ with background correction).

The data subset chosen for comparison consisted of 10 lobster samples from two stations. The null hypothesis was that there is no significant difference between the paired samples. An analysis of variance of paired samples was conducted to determine if significant differences could be found between the reported results. Due to the forementioned problem of less than values the paired comparison was conducted only on the cadmium data.

The Anova Table below summarizes the results for Total Cd:

SOURCE OF VARIATION	DF	SS	MS	FS
STATION 217RIS				
Cadmium PE 403 mean 0.7000 vs VARIAN mean 0.7180	1	.0008	.0008	
individuals	8	.2729	.0341	0.0235
STATION 248BBI				
Chromium PE 403 mean 0.9340 vs VARIAN mean 0.9240	1	.0003	.0003	
individuals	8	5.5340	.6917	.0004

$$F_{.05} [1, 8] = 5.32$$

No significant differences were noted between the two "Treatments." The comparatively large variance between individuals suggests that other sources of variability such as sex differences, breeding condition, to name a few may be controlling cadmium levels in the lobsters. Given the non-significance between the two treatments a decision was made to pool the cadmium levels and obtain mean concentration.

Further comparisons with the lobsters were made using just the total cadmium and total mercury levels. It should be noted again that where less than values were employed, a value of 5/8 ths of the MDL was used in the calculations. No significant difference in cadmium levels was noted.

The Anova Table below summarizes the Cadmium results for:

SOURCE OF VARIATION	DF	SS	MS	FS
Differences between station means	5	2.0828	0.4166	2.63 ns
error	21	3.3252	0.1583	

$$F_{.05} [5, 21] = 2.68$$

The data for mercury however shows a highly significant difference in mercury concentrations between stations with most of this difference being accounted for in the lobsters collected from the "Area V, Outer Bay Stations."

The Anova Table below summarizes the results for Mercury:

SOURCE OF VARIATION	DF	SS	MS	FS
Differences between station means	5	0.0588	0.0118	21.68
error	21	0.0114	0.0005	

$$F_{.05} [5, 21] = 2.68$$

$$F_{.0001} [5, 21] = 6.32$$

$$F_5 [5, 21] = 21.68***$$

Interpretations regarding the spatial differences in the levels of metals found in the lobster tissue must be viewed with caution since this comparative area approach does not take into account the mobility of the animals, differences in habitat, food sources, sex, size or such factors as weight. In addition the relatively small sample sizes and low variability particularly within the Area V sets tend to exaggerate the magnitude of the spatial variability.

7.1.3 Winter Flounder Metals

The biota metals for winter flounder populations within Buzzards Bay consist of 35 individual fish collected from 3 stations (see Section 3.1.1 of the Methodology Section) for collection methods Table 11 presents the total data set while Table 21 summarizes the data by individual metal and station due to the large number of less than values no further analysis of the data set has been conducted at this time.

TABLE 20
1986 BUZZARDS BAY BIOTA SURVEY
SUMMARY OF TOTAL METALS IN WINTER FLOUNDER

DWPC STATION ID#	280NBH	270BBO	275BBO
DMF STATION ID#	41	33	34
NUMBER/STATION	N = 3	N = 16	N = 16
<u>Cadmium</u>			
Mean		ALL VALUES <0.20	
Standard	0	0	0
Deviation			
Range		ALL <0.2	
<u>Chromium</u>			
Mean	<0.30	0.27	0.28
Standard	0	0.12	0.13
Deviation			
Range	ALL <0.3	<0.3-0.6	<0.3-0.6
<u>Copper</u>			
Mean	0.4	0.61	0.81
Standard	0.2	0.39	0.29
Deviation			
Range	0.2-0.62	0.2-1.4	0.4-1.4
<u>Mercury</u>			
Mean	0.02	0.037	0.036
Standard	0.009	0.042	0.02
Deviation			
Range	0.01-.028	0.008-0.186	<0.24-0.82
<u>Nickel</u>			
Mean		ALL VALUES <0.50	
Standard			
Deviation			
Range			
<u>Lead</u>			
Mean		ALL VALUES <0.50	
Standard			
Deviation			

7.1.4 Sediments Metals

The sediment metals data set as noted in Section (3.2) of the methodology section consists generally of 2 replicate grab samples taken from the top 10 cm (4 inches) of sediments from 22 stations located throughout the bay. Samples were analyzed for grain size, total organic carbon, and a suite of 6 to 8 metals including cadmium, chromium, copper, lead, mercury and nickel. Metals levels showed positive correlations with increasing percentages of fine grained materials. Highest metals were reported from the cape side of the bay particularly within Quissett Harbor. In most aquatic systems, suspended and bottom sediments contain many times the concentrations of trace metals than are dissolved in the overlying water (Horowitz and Elrick). Grain size is a significant factor controlling the sediments capacity for collecting and concentrating trace metals and a likely factor in spatial and temporal variability. Numerous researchers have demonstrated a strong correlation between decreasing grain size and increasing metal concentrations. This correlation is the result of numerous factors, both physical and chemical. These factors include surface area, cation exchange capacity, surface charge, concentration of iron and manganese oxides and hydroxides, concentration of organic matter, and concentration of clay minerals (Horowitz and Elrick). These correlations vary however from element to element and from location to location (Horowitz and Elrick).

Table 12 provides a general accounting of the numbers and types of analyses conducted as part of the 1985 - 1986 Buzzards Bay sediment quality survey. It should be noted that different analytical equipment was employed in the metals analysis over the course of the study (see methodology section (3.2.3.1)). Table 13 presents this data set the samples which were analyzed using the Perkin Elmer 403 Spectrophotometer™ are identified by a double**. Since they represent samples which are comprised largely of coarse grained-sediments and the reported total metals are uniformly low a decision was made to include them in subsequent analysis.

The first step employed in analyzing the sediment data was to conduct a series of correlations between the individual metals and the percent fines. The term "percent fines" being defined as the grain size fraction within the samples, smaller than 63 microns. Positive correlations were found for total chromium, copper and lead. Correlations were not performed on the cadmium or nickel data sets due to missing data or because the sets contained large numbers of values less than the detection limits.

The mercury data set did not correlate well with the percent fines ($R = 0.26$) and may reflect different retention rates for mercury in sediments due to methylation, or preferential binding to organic materials which would not be reflected by grain size analysis. Figure 25 presents the respective scatter plot graphs between the forementioned metals and percent fines.

A second comparison was made by estimating the average percentage of fine grained materials in each area and comparing these values with the mean concentrations of selected metals. Table 17 presents the number of samples, mean, standard deviation and sample range on all samples collected by area. Data from Area V clearly showed a difference in percent fines and was consequently grouped into two sub groups, Va which was comprised of stations located north of an imaginary line drawn between the Town of Mattapoisett and Woods Hole, Falmouth, while Area Vb stations were located south of this line out to the mouth of the bay. While such a comparison

masks the variability exhibited within water bodies and within stations, it demonstrates the influence of proximity to known and potential sources and to a lesser extent the parent source of the sediments. Figures 26 and 27 present these comparisons, of particular interest are the elevated levels of metals found in Areas II, III and IV. The relatively high values seen from Area IV (Elizabeth Island Chain) were at first puzzling, since area IV was assumed to have the least exposure to anthropogenic sources. Significantly however the data presented for Area IV came from Cuttyhunk Pond. Cuttyhunk Pond is used intensively during the summer months for the mooring and anchoring of pleasure boats while the island maintains the island chain's only year-round population. The influence of "proximity to known sources" can also be demonstrated in the data from the Outer Bay Area 5B, where the composition of the sediment samples average 70 percent fine grained material, while metals concentrations were uniformly low.

FIG.25 1986 BUZZARDS BAY BIOTA SURVEY
SCATTERPLOTS OF SELECTED TOTAL METALS vs
% FINE SEDIMENTS (< 63 um)

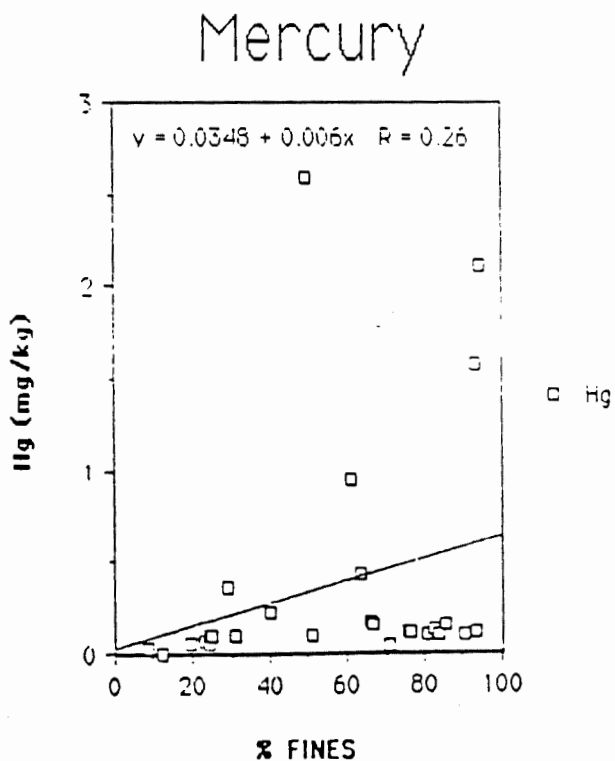
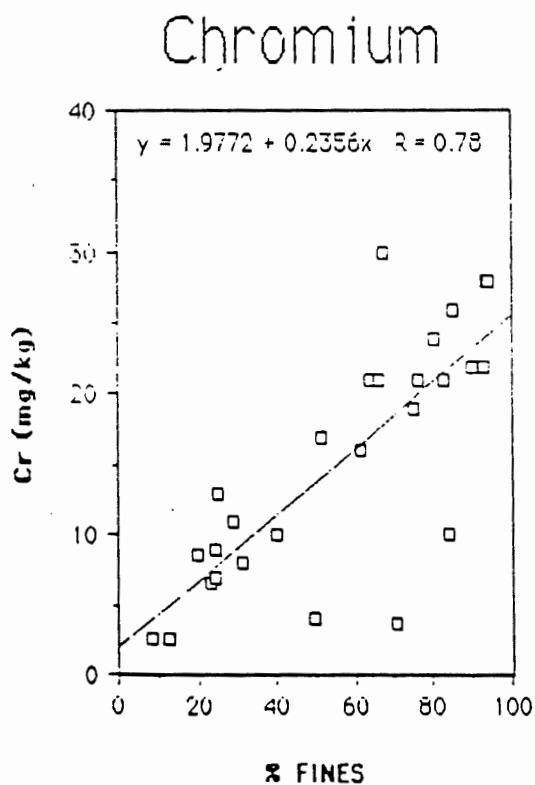
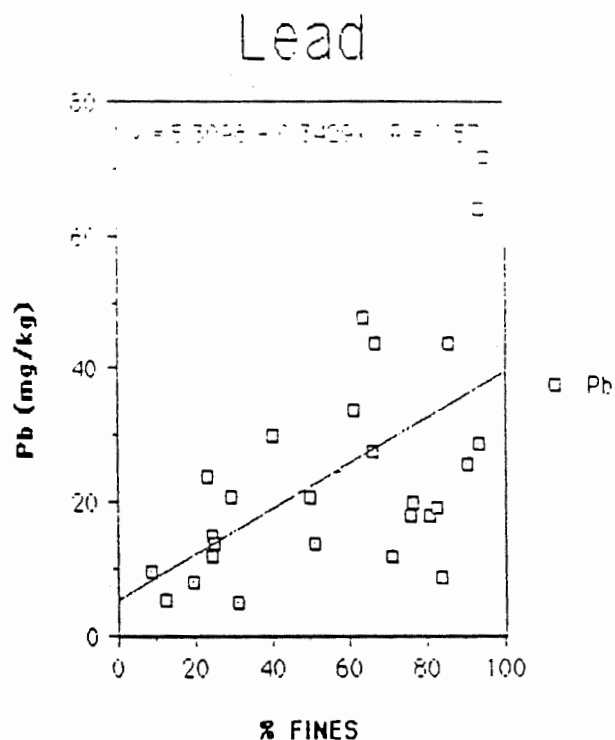
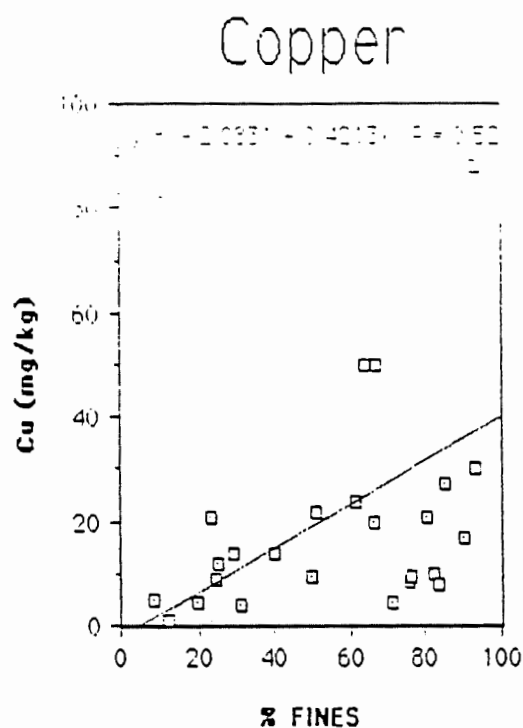


FIG. 27 1986 BUZZARDS BAY BIOTA SURVEY
Mean % of Fines Mean Conc. Metals

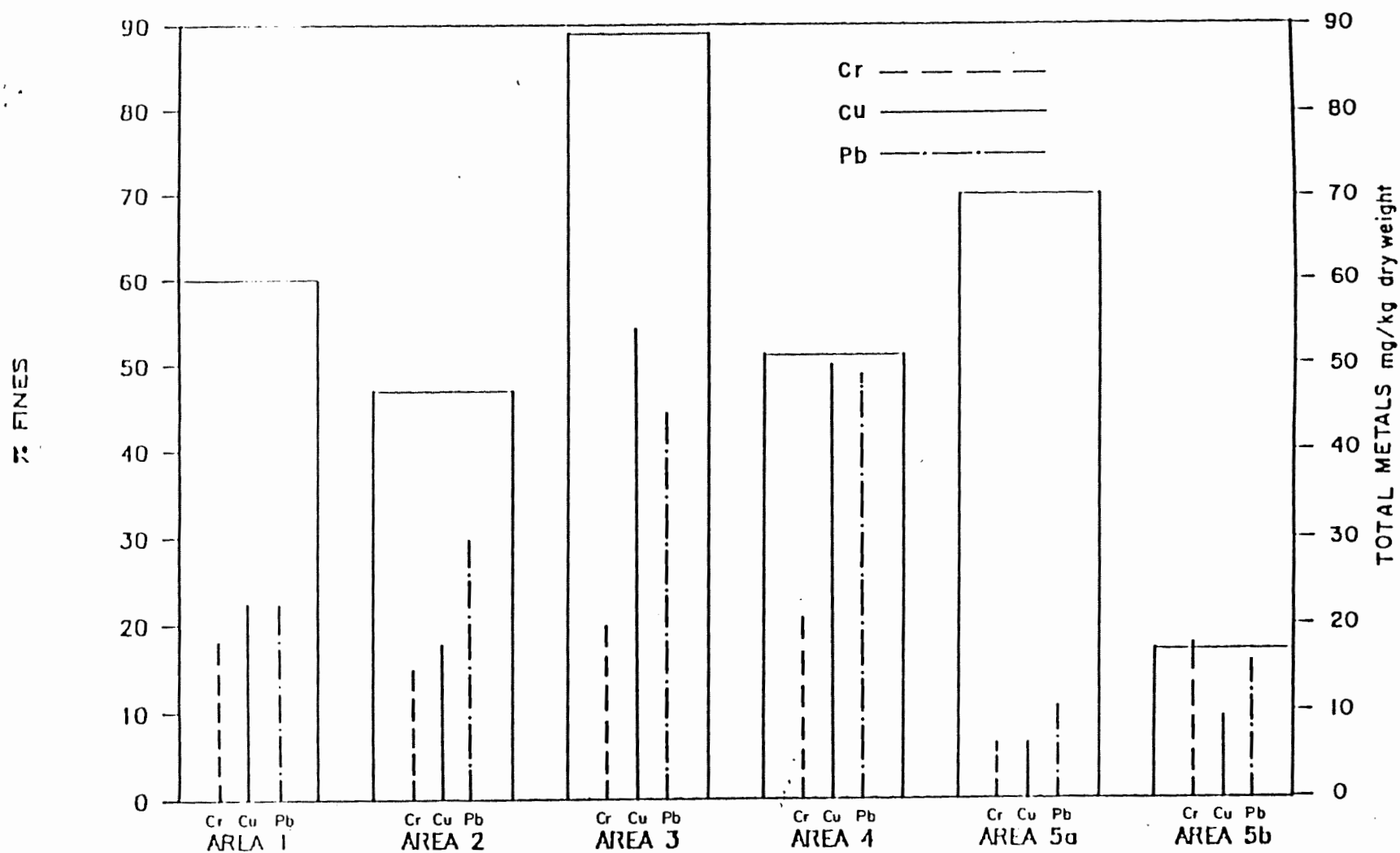


FIG.26 1986 BUZZARDS BAY BIOTA SURVEY
Mean % of Fines Mean Conc. Mercury

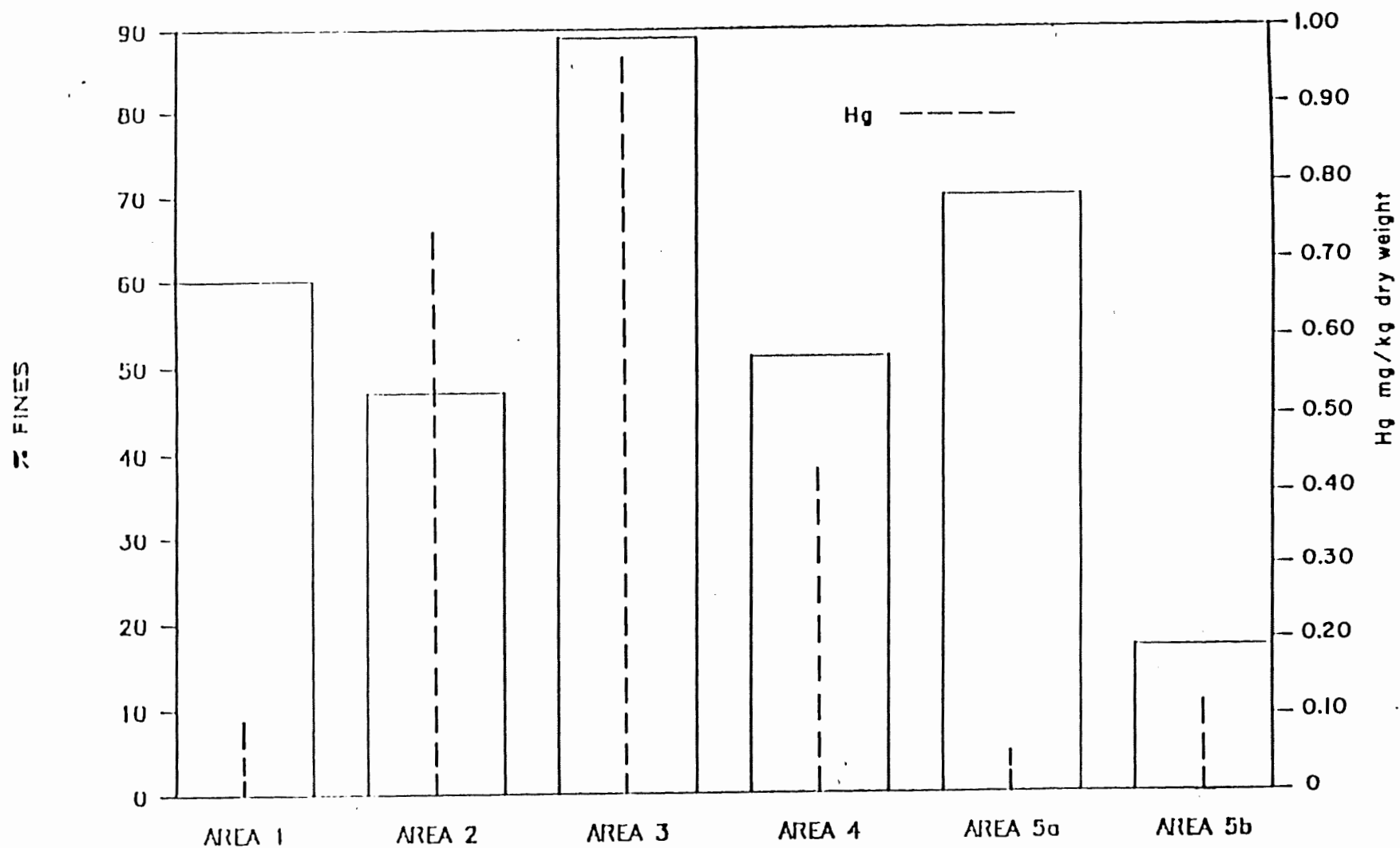


TABLE 21

1985-1986 BUZZARDS BAY SEDIMENT SURVEY

SUMMARY OF PERCENT FINE GRAINED SEDIMENTS (<63 μ m) BETWEEN AREAS

AREA	NUMBER OF SAMPLES	MEAN % OF FINES	STANDARD DEVIATION	RANGE
I	9	59.52	27.59	22.55- 90.06
II	10	46.74	22.60	14.07- 85.44
III	5	89.22	10.32	70.81- 95.19
IV	3	50.60	9.24	39.96- 56.57
Va	8	16.69	7.31	5.85 - 24.63
Vb	5	70.17	22.16	31.24- 85.23

N = 40

7.1.5 Organic Contaminants in Sediments

Many of the same influences found to affect the movement and fate of heavy metals in sediments also affect the distribution of organic contaminants. These factors include surface area, cation exchange capacity, surface charge, concentration of iron and manganese oxides and hydroxides, concentration of organic matter, and concentration of clay minerals (Horowitz and Elrick). Organic chemicals when released into the environment are distributed according to defined set of principles and processes. In its simplest sense (no degradation) this can be described as "partitioning" behavior. The extent to which a chemical will partition into a given environmental medium is a function of medium's properties and the properties of the chemical. The chemical properties include its vapor pressure, solubility, molecular structure.

Polychlorinated biphenyls (PCB) are classified as non-polar organic chemicals and therefore preferentially bind to organic matter following the principal of "like dissolves like." Conversely polyaromatic hydrocarbons can be classified as being base-neutral extractables and consequently more soluble at higher pH levels.

The organic contaminants in the Buzzards Bay Data Set exhibited a low rate of detection with only 11 samples from a possible 145, reporting detectable levels of a PCB Aroclor and of these, only 3 reporting levels above the detection limit. PAH samples showed similarly low detection of 5 positive samples. The data set does not warrant further analysis at this time.

TABLE 22

1985-1986 BUZZARDS BAY SEDIMENT SURVEY

PARAMETER AND COLLECTION METHODS EMPLOYED AT SEDIMENT STATIONS

PARAMETER	SAMPLE VOLUME (liters)	SAMPLE CONTAINER	IMMEDIATE SHIPBOARD PROCESSING & STORAGE
PCB 1016/1242 Sediment	2(25-100 g)	G/Aluminum Foil Septum	Cool to 4°C
PCB 1248 Sediment	2(25-100 g)	G/Aluminum Foil Septum	Cool to 4°C
PCB 1254 Sediment	2(25-100 g)	G/Aluminum Foil Septum	Cool to 4°C
PCB 1260 Sediment	2(25-100 g)	G/Aluminum Foil Septum	Cool to 4°C
PAH's Sediment	2(25-100 g)	G/Aluminum Foil Septum	Cool to 4°C
Copper Sediments	25-100 g	G/Teflon Septum	Cool to 4°C
Nickel Sediments	25-100 g	G/Teflon Septum	Cool to 4°C
Lead Sediments	25-100 g	G/Teflon Septum	Cool to 4°C
Cadmium Sediments	25-100 g	G/Teflon Septum	Cool to 4°C
Chromium Sediments	25-100 g	G/Teflon Septum	Cool to 4°C
Mercury Sediments	25-100 g	G/Teflon Septum	Cool to 4°C

G = Glass

TABLE 23

1986 BUZZARDS BAY BIOTA METALS

SAMPLING PARAMETERS AND ANALYTICAL METHODS

PARAMETER	METHOD	REPORTED AS	LIMITS OF DETECTION	REFERENCE	MAXIMUM HOLDING TIME
<u>Metals Analysis</u>					
Cadmium - Tissue	AA spectro air-acetylene flame (1)	mg/kg (d.w.)*	0.2	EPA Method 213.1	6 months
Total Chromium - Tissue	AA spectro air-acetylene flame (1)	mg/kg (d.w.)*	0.2	EPA Method 218.1	6 months
Total Copper - Tissue	Atomic Absorption, direct aspiration (1)	mg/kg (d.w.)*	0.2	EPA Method 220.1	6 months
Total Lead - Tissue	Atomic Absorption, direct aspiration (1)	mg/kg (d.w.)*	0.5	EPA Method 239.1	6 months
Total Mercury - Tissue	Manual Cold Vapor Technique	mg/kg (d.w.)*	0.0002	EPA Method 245.5	6 months
Total Nickel - Tissue	AA spectro air-acetylene flame (1)	mg/kg (d.w.)*	0.3	EPA Method 249.1	6 months
Total Silver - Tissue	AA spectro air-acetylene flame (1)	mg/kg (d.w.)*	0.2	EPA Method 272.1	6 months
Total Zinc - Tissue	Atomic Absorption, direct aspiration (1)	mg/kg (d.w.)*	0.2	EPA Method 289.1	6 months

(1) U.S. EPA. Environmental Monitoring and Support Laboratory. Oct. 1980. Interim Methods for the Sampling and Analysis of Priority Pollutants in Sediments and Fish Tissue. Cincinnati, OH.

TABLE 24
1985-1986 BUZZARDS BAY SEDIMENT SURVEY
SAMPLING PARAMETERS AND ANALYTICAL METHODS

PARAMETER	METHOD	REPORTED AS	LIMITS OF DETECTION	REFERENCE	MAXIMUM HOLDING TIME
<u>Grain Size Analysis</u>					
- Sediment	"Pipet Method"	phi size (mm)	--	EPA Draft Document 1985	--
<u>Metals Analysis</u>					
Cadmium - Sediment	AA spectro air-acetylene flame (3)	mg/kg (d.w.)*	0.2	EPA Method 213.1	6 months
Total Chromium - Sediment	AA spectro air-acetylene flame (3)	mg/kg (d.w.)*	0.2	EPA Method 218.1	6 months
Total Copper - Sediment	Atomic Absorption, direct aspiration (3)	mg/kg (d.w.)*	0.2	EPA Method 220.1	6 months
Total Lead - Sediment	Atomic Absorption, direct aspiration (3)	mg/kg (d.w.)*	0.5	EPA Method 239.1	6 months
Total Mercury - Sediment	Manual Cold Vapor Technique	mg/kg (d.w.)*	0.0002	EPA Method 245.5	6 months
Total Nickel - Sediment	AA spectro air-acetylene flame (3)	mg/kg (d.w.)*	0.3	EPA Method 249.1	6 months
Total Silver - Sediment	AA spectro air-acetylene flame (3)	mg/kg (d.w.)*	0.2	EPA Method 272.1	6 months
Total Zinc - Sediment	Atomic Absorption, direct aspiration (3)	mg/kg (d.w.)*	0.2	EPA Method 289.1	6 months

TABLE 24 (CONTINUED)

PARAMETER	METHOD	REPORTED AS	LIMITS OF DETECTION	REFERENCE	MAXIMUM HOLDING TIME
<u>PAH's</u>					
- Sediment	Gas chromatography/Mass Spectrometry	ug/kg (d.w.)*	(1)	EPA Method 3510 (2) EPA Method 8100 (2)	7 days to extraction, 40 days to analysis
<u>Polychlorinated Biphenyl Analysis</u>					
PCB 1016/1242 - Sediment	Gas chromatography	ug/g	0.16	EPA Soxhlet Procedure (3)	7 days to extraction, 40 days to analysis.
PCB 1248 - Sediment	Gas chromatography	ug/g	0.084	EPA Soxhlet Procedure (3)	7 days to extraction, 40 days to analysis.
PCB 1254 - Sediment	Gas chromatography	ug/g	0.56	EPA Soxhlet Procedure (3)	7 days to extraction, 40 days to analysis.
PCB 1260 - Sediment	Gas chromatography	ug/g	0.17	EPA Soxhlet Procedure (3)	7 days to extraction, 40 days to analysis.

(1) No standard available for quantitation. The Mass Spectrum obtained was compared to a Mass spectral data base for identification.

(2) Proposed Sampling and Analytical Methodologies for Addition to Test Methods for Evaluating Solid Waste - Physical/Chemical Methods. SW-846. Second Edition. 1984.

(3) U.S. EPA. Environmental Monitoring and Support Laboratory. Interim Methods for the Sampling and Analysis of Priority Pollutants in Sediments and Fish Tissue. 1980 Oct. Cincinnati, OH.

* Dry weight

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