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Distribution of Trace Metals in the Water Column, Sediments, and Shellfish of Narragansett Bay 127 pp. + Appendix 109 pp

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Narragansett Bay Estuary Program

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Report #NBP-89-25

FOREWORD

The United States Congress created the National Estuary Program in 1984, citing its concern for the "health and ecological integrity" of the nation's estuaries and estuarine resources. Narragansett Bay was selected for inclusion in the National Estuary Program in 1984 and designated an "estuary of national significance" in 1988. The Narragansett Bay Project (NBP) was established in 1985. Under the joint sponsorship of the U.S. Environmental Protection Agency and the Rhode Island Department of Environmental Management, the NBP's mandate is to direct a five-year program of research and planning focussed on managing Narragansett Bay and its resources for future generations. The NBP will develop a comprehensive management plan by December, 1990, which will recommend actions to improve and protect the Bay and its natural resources.

The NBP has established the following seven priority issues for Narragansett Bay:

- management of fisheries
- nutrients and potential for eutrophication
- impacts of toxic contaminants
- health and abundance of living resources
- health risk to consumers of contaminated seafood
- land-based impacts on water quality
- recreational uses

The NBP is taking an ecosystem/watershed approach to address these problems and has funded research that will help to improve our understanding of various aspects of these priority problems. The Project is also working to expand and coordinate existing programs among state agencies, governmental institutions, and academic researchers in order to apply research findings to the practical needs of managing the Bay and improving the environmental quality of its watershed.

This report represents the technical results of an investigation performed for the Narragansett Bay Project. The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement #CX812680 to the Rhode Island Department of Environmental Management. It has been subject to the Agency's and the Narragansett Bay Project's peer and administrative review and has been accepted for publication as a technical report by the Management Committee of the Narragansett Bay Project. The results and conclusions contained herein are those of the author(s), and do not necessarily represent the views or recommendations of the NBP. Final recommendations for management actions will be based upon the results of this and other investigations.

This report is an interim report and should not be considered a comprehensive synthesis of the existing data on this subject. The interested reader is encouraged to investigate additional sources of information.

Executive summary

This report summarizes data collected during the last two decades on the distribution and accumulation history of metals in the waters, sediments, and shellfish of Narragansett Bay. The report also summarizes results of process-oriented studies which help explain the observed distributions and their implications.

Metals examined include copper, lead, chromium, nickel, silver, cadmium, zinc, cobalt, manganese, and iron. Data sources include studies of dissolved and particle-associated metals in the Bay, studies of metal concentrations as a function of depth in submerged sediments and salt marsh sediments from Narragansett Bay, and studies of metal concentrations in shellfish, particularly quahogs, from different areas of the Bay.

The distribution of dissolved and particulate metals in the waters of Narragansett Bay is well documented thanks to intermittent synoptic studies which began in 1977. Dissolved cadmium, chromium, copper, iron, manganese, silver, nickel and lead all show a similar pattern of concentration variations within the Bay. Their concentrations are highest in or near the Providence River, then decrease systematically going towards the mouth of the Bay. The concentration maxima in the Providence River or Seekonk River reflect pollutant input in the surrounding industrial and population centers. The systematic decreases going down the Bay reflect dilution of metal-rich waters from the Providence River with trace metal poor seawater which enters the Bay and mixes upstream due to the tidal flows. Superimposed on this dilution is removal of the more reactive metals, including copper, lead and nickel, by adsorption on suspended particles.

The more recent synoptic studies of Bay metal chemistry have provided a comprehensive picture of the distribution of particulate trace metals as well as dissolved. The concentration of total suspended matter decreases from about 4 to 2 mg/L in going from the Providence River to the mouth of the Bay. Most suspended matter probably settles out near the source, which again is the highly urbanized area at the head of the Bay. Throughout the central part of the Bay, most particles suspended in the water column are probably surface sediment resuspended by the strong tidal currents. As expected, the concentrations of trace metals in this suspended matter are similar to values of underlying surface sediment. Around the Providence River, however, trace metal concentrations in suspended matter are much higher, due to proximal sources of pollution.

Data on metal concentrations and flow rates in rivers and in wastewater treatment facility effluents during dry weather conditions were used to provide an estimate of the relative loadings of these sources. While sewage treatment plants contribute about 7.5% of the fresh water input to the Bay, they account for about 80% of the geochemically reactive silver, chromium, copper and nickel entering the Bay. Lead and cadmium show a different pattern in loadings to the Bay compared with other metals; they are input to the Bay in significant quantities through rivers. Among the wastewater treatment facilities, pollutant metal inputs are generally dominated by Field's point. These estimates of relative loading must be qualified: data sets are not available for all sources at the same time; we did not have data on non-point source inputs or on wet weather inputs of metals; the available data are not well-suited to calculating annually or seasonally averaged loadings. Particulate data in rivers and in wastewater treatment effluents have very different chemical reactivities in estuarine systems that must be considered when comparing these sources.

Data on trace metal concentrations in the water column of the Bay collected over a decadal time period allow us to examine temporal trends in trace metal concentrations. The results show that, throughout the study period, concentrations have been low and relatively constant in the cleaner, southern portions of the Bay. In the more northerly, polluted reaches of the Bay, however, concentrations of copper, cadmium, and perhaps other metals appear to have been higher in the late 1970's than they were in recent years. There is thus some indication that improvements in wastewater treatment, and restrictions on lead in gasoline, have begun ameliorating trace metal contamination in Narragansett Bay.

Our understanding of the distribution of trace metals in Narragansett Bay is informed by data on concentration variations of these elements in about fifteen sediment cores from around the Bay. The most striking feature to emerge from these data is the difference in the concentrations of the various trace metals in the tops of the cores, relative to values in unpolluted sediments from about 1 m depth. At 1 meter depth, concentrations of trace metals are low and rather uniform throughout the Bay. At the surface, concentrations of most metals are much higher, reflecting pollutant input of copper, cadmium, lead, nickel, zinc, cobalt, and chromium. The concentrations of these metals increase from the mouth of the Bay to the areas around Providence, where sources of pollution are concentrated. The higher concentrations of pollutants near Providence are ascribed to nearby input of pollutant particles which settle out rapidly and are deposited near their source.

In addition to this ubiquitous pollution of sediments with trace metals throughout the Bay, there are a number of embayments and shoreline areas which have been particularly impacted because of their restricted circulation or proximity to major sources of pollution. These include Apponaug Cove, Pawtuxet Cove, and the area adjacent to the former Naval Air Rework Facility at Quonset.

Radiometric dating of sediments offers the hope of determining the history of pollution in Narragansett Bay. Two submerged cores from the upper portions of Narragansett Bay have been dated, along with a number of salt marsh cores. The results, taken together with downcore data on trace metal concentrations, show that detectable pollution of Narragansett Bay began around the middle of the 18th century and intensified during the latter half of the 19th century. The chronology is not yet good enough to inform us about the details of pollutant inputs to the Bay during the last few decades.

Most of the available information on trace metal contamination of shellfish comes from three extensive studies of metal concentrations in the quahog in different areas of the Bay. Throughout most of the Bay, metal concentrations in quahogs are fairly uniform, despite large concentration variations in the overlying waters and underlying sediments. In the most polluted regions, at the northern end of the Bay, however, concentrations of copper, cadmium, and lead are 2-3 times higher than the Bay-wide average. Similarly, in the area of the Bay adjacent to the former Naval Air Rework Facility, the mollusk *Pitar morrhuana* is highly enriched in silver, chromium lead and (to a lesser extent) other trace metals.

Long-term monthly monitoring of trace metal concentrations in quahogs by the R. I. Department of Health, begun in the early 1970's, shows no systematic trends in trace metal concentrations in any region of the Bay. Therefore it appears that trace metal contamination of shellfish has been rather constant during the last two decades, at least insofar as the quahog is representative of the other species. As trace metal body burdens of quahogs are in part physiologically regulated, constancy does not eliminate the possibility of trace metal concentration variations in the water column.

Studies summarized in this report document that waters and sediments throughout the Bay are enriched in pollutant trace metals to levels far above those obtaining naturally. The origin of the pollutants is the wastewater treatment facilities and other pollution sources concentrated dominantly in the population and industrial centers of the state. The distribution of pollutants in waters and sediments reflects their source. Pollutant concentrations are greatest in the upper reaches of the Bay.

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Appendix A: Dissolved and particulate trace metals in Narragansett Bay

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I. Introduction

Trace metals affect the biochemical systems of all organisms. Many trace metals are essential nutrients. At high levels they are toxic. The activities of man have greatly increased trace metal loadings in Narragansett Bay, as we shall see from data summarized below. There are two ways in which this increased loading may have had a deleterious ecological effect. The first is by inhibiting growth of plants or animals which play a key role in the food chain. The most profound such effect would be inhibition of phytoplankton growth, which, can occur at metal concentrations far below those found in the Bay. The second possible deleterious effect of increased loadings could be on fish or shellfish which are important sources of food for man.

In this report we survey data on trace metal distributions in water, sediments, and organisms of Narragansett Bay. Our three objectives are

(1) To summarize all the relevant data.

(2) To review the contemporary distribution of trace metals in the water, sediments and shellfish of Narragansett Bay, and to understand the sources of metals and the geochemical processes governing their distribution.

(3) To trace the evolution of trace metal loadings in the Bay, to the extent allowed by the available data.

This report consists of four sections, in addition to this introduction. The first is a discussion of dissolved and particulate trace metals in the Bay. This section summarizes the existing information on loadings, sources, and geochemistry of trace metals. It also includes a review of the process-oriented radiochemical study of particle-reactive trace metal behavior.

The second section deals with the distribution of trace metals in sediments. It addresses three topics: trace metals in surface sediments, metal distributions with depth in subtidal sediments of the Bay, and depth distributions of metals in salt marsh sediments.

In the third section, we discuss metal contents of shellfish. The focus is on three topics: metal contents of shellfish influenced mainly by the water column, metals contents of shellfish influenced by sediments, and historical variations.

The final section is a summary of areal and temporal trends.

II. Metals in Narragansett Bay Water

A. Introduction

This section examines the spatial and temporal trends in metal concentrations in the waters of Narragansett Bay. We will also identify the major processes that control these trends. Metals in the Bay exist in dissolved and particulate forms. Dissolved metals may be bound up in dissolved organic matter. The metals for which considerable data exist include cadmium, chromium, copper, iron, lead, manganese, nickel, silver, and zinc. Many of these metals are used extensively in industrial processes, and some of them can be toxic to marine organisms and to humans.

This section is divided into three major parts. The first describes radiotracer experiments carried out in the MERL mesocosms to understand the geochemistry of metals in the Bay, and the relation between their chemical behavior and removal rates to sediments. The second describes the distribution of total dissolved and particulate metals in the Bay. This part also examines the history of metal distributions in Bay waters during the last decade. The third part outlines the distribution of organically bound metals.

B. Evaluation of data quality

Nearly all the trace metal concentration data summarized in this section come from the authors' laboratories. The analyses have been done by us using state of the art techniques and extensive standardizations and calibrations. Except for a few small data sets identified in the report, we judge all data to be reliable.

C. Implications of radiotracer experiments and field data for metal removal times in Narragansett Bay

Peter Santschi and his collaborators have done a long and varied series of experiments aimed at using radiotracers to characterize removal rates of trace metals from Narragansett Bay. Since removal rates must be characterized to constrain mass balances, the results of these experiments are relevant to understanding the mass balance and steady - state concentration of metals in the Bay.

Four main types of experiments were done. 1) 150 l microcosms were established in the National Marine Water Quality Laboratory of the Environmental Protection Agency. Radiolabelled metals were added to these microcosms, and metal activity was followed as a function of time (Santschi et al., 1980). 2) Radiolabelled metals were added to microcosms of the Marine Ecosysystems Research Laboratory (MERL; microcosm volume = 14×10^3 l). Metal activity was again followed as a function of time (Santschi et al., 1983). Considerable attention was devoted to determining the speciation of metals in the water column. Metals were partitioned into the following operationally defined phases: particulate and colloidal (removed on 0.4 μ filter); adsorbed on activated charcoal; adsorbed on XAD; removed by Chelex; effluent (not removed by any afformentioned treatment) (Amdurer et al., 1983). 3) The removal rates of the radioactive daughters of uranium and thorium in Narragansett Bay were measured by analysis of the distribution of these elements in the Bay (Santschi et al., 1979, 1980). This work gives a direct estimate of the removal rate of stable Pb (the estimate is based on the ^{210}Pb residence time). It also gives a direct estimate of the removal rate and mechanism of Th from the Bay. The removal rate of Th was also measured in the tank radioisotope addition experiments. The good agreement between thorium removal rates in both environments is evidence that removal rates of particle - reactive metals measured in the tanks are representative of rates in the Bay. 4) Using radiolabelled "tracer microspheres" and other tools, Santschi and collaborators have studied removal mechanisms of particles (Santschi et al., 1983). The results give insights into processes by which particles, and associated trace metals, are removed from the water column.

All of the above experiments are complementary except the two types of mesocosm experiments (EPA tanks vs. MERL tanks). The general results from these experiments are similar. The MERL experiment is easier to scale to the Bay itself and we regard it as superseeding the EPA experiment.

The results of studies of radioisotope removal rates from MERL tanks are summarized in Table II-1. Elements are divided into four groups, according to their removal half times. First there are *particle reactive* elements. These are highly partitioned into the particulate phase and rapidly removed by settling and filter feeding. This group includes Fe, Hg, Sn, Be, Pb and other U-series daughters, and transuranics. It includes the ion Cr^{3+}, but not the chromate oxyanion. Second, there are the *recyclable* metals Mn and Co. Mn^{2+} is rapidly removed from the water column after oxidation; it is then added back to the water column after reduction to Mn^{2+} in the sediments. Co follows Mn closely. Third, there are the *biologically active* transition metals and elements forming oxyanions. These elements are only moderately particle - reactive, but are tightly coupled to biological cycles. Fourth, there are the *quasi - conservative* cations. These are largely unaffected by biological activity. They are not highly particle reactive, but are sufficiently reactive to be slowly removed into the sediments by adsorption.

For all elements, removal rates are higher in the summer than in the winter. The biggest single reason for this relationship is that the benthos are most active in the summertime, driving more rapid removal of metals adsorbed on particles suspended in the water column, and actively providing fresh sedimentary surfaces for the uptake of the quasi - conservative elements.

Studies of Th isotope geochemistry have shown that the removal rate measured in the Bay for this element is similar to its removal rate in the tanks. Half removal times were measured in the Bay from the concentration of ^{234}Th, which is produced at a known rate by ^{234}U (Table II-2). Based on these data, half removal times were predicted for microcosms. These values were then compared to times measured for microcosms from ^{228}Th addition experiments. Measured and predicted values are in good agreement, showing that (at least for thorium) removal rates measured in tanks are representative of rates in the Bay.

It is instructive to compare half removal times of metals with residence times of water in the Bay. To make this comparison it is necessary to consider correcting the half removal time data for the different geometries of the Bay and the tanks. If the rate limiting step in metal removal involves a chemical reaction in the water column, such as oxidation of Fe(II) to Fe(III), then removal times measured for tanks would be applicable to the Bay. If removal is limited by particulate settling or benthic filter feeding, then removal rates measured in tanks should be scaled by the ratio of the average height of the Bay to the height of the tanks. We have therefore recalculated the range in half removal times given in Table II-1 so that the maximum value is increased by the scaling factor for height.

According to Pilson (1985), the mean residence time of water in Narragansett Bay is 26 days, the range being 10 - 40 days. Residence times are shortest in the winter and longest in the summer (Fig. II-1). For each group of elements, we can use the seasonal relationship between flushing time and half removal time to make some general statements

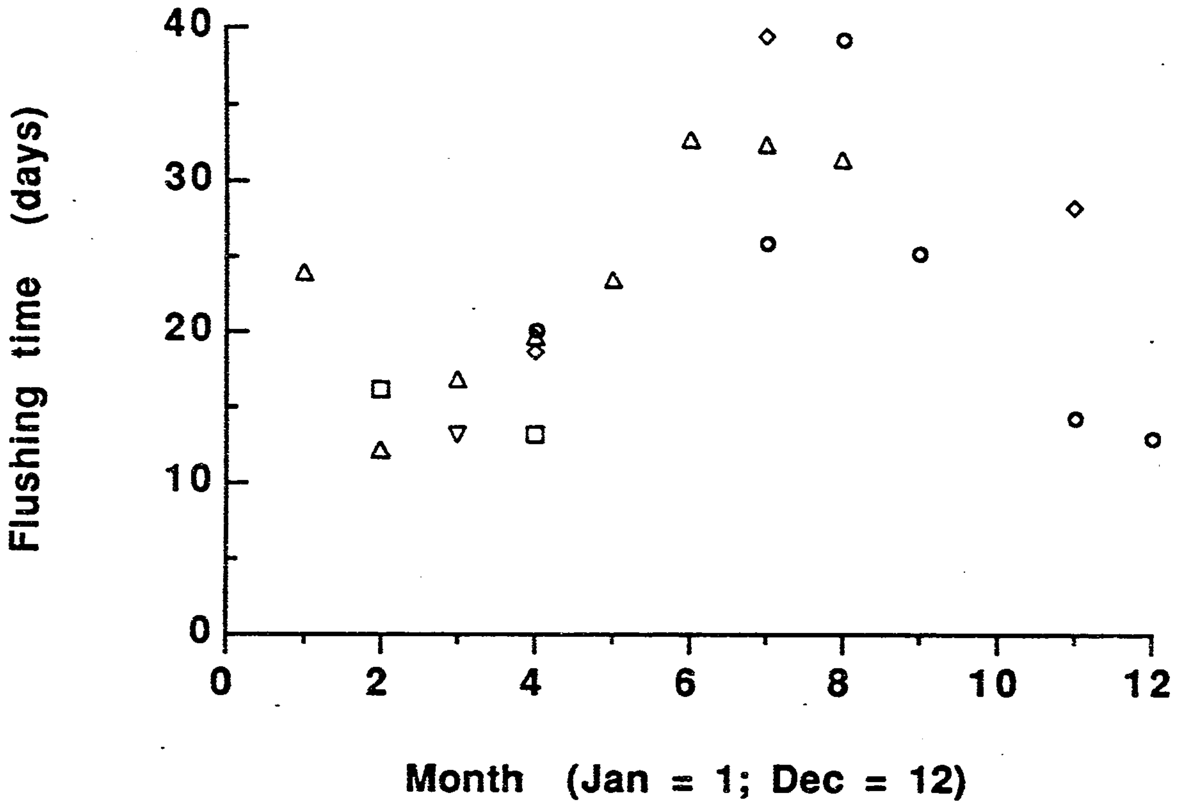
Table II-1. Half removal times (in days) of trace metals in MERL tanks and in Narragansett Bay. Values in MERL tanks were determined by radioisotope addition experiments. The ranges for the Bay were determined by adapting the minimum removal rates measured in the tanks, and scaling the maximum values by the ratio of the height of water in the Bay to the height of water in the tank (the scaling factor is 2.5).

Group of elements	Half removal times (days)			
	MERL tanks		Bay	
	Winter	Summer	Winter	Summer
Particle - reactive (Fe, Hg, Sn, Cr(III), Pb, Po, Th, Pu, Am, Be)	10-20	2-3	10-25	2-5
Recyclable (Mn, Co)	30 - 50	5-30	30-75	5-13
Biologically active (Zn, Cd, Se, As)	60-100	10-50	60-150	10-25
Quasi - conservative	150-600	80-150	150-375	80-200

Table II-2. Half removal times (in days) of 234Th in Narragansett Bay from solution to particles (t_c), particles to sediments (t_p), and water column to sediments (t_s) (from Santschi et al, 1980).

Date	Water temp.	t_c	t_p	t_s
1/16/78	5°C	8±2	6.3±2.5	17.9±1
2/21/79	1	3.1±.2	6.3±.6	11.0±.6
5/4/78	8	6.3±.5	1.3±.6	9.0±.6
5/19/78	11	.5±.05	3.5±.3	9.0±.6
7/25/78	22	1.5±.1	<.3	4.3±.2
8/21/79	20	1.0±.1	<.2	1.1±.1
10/23/79	16	.6±.1	.9±.3	1.8±.1
11/1/78	13	2.1±.1	.6±.1	3.0±.2
11/15/78	11	1.7±.2	1.4±.4	3.8±.2

Fig. II-1. Residence time of water in Narragansett Bay vs. month, calculated from data in Pilson (1985).



about whether or not removal is likely to be important. In the winter, flushing times are 10-25 days. Removal of particle reactive metals (with half times of times of 10 - 33 days) will range from minor to extensive. In the summertime, removal can be expected to be nearly total. For recyclable and biologically active metals, half removal times for both winter and summer overlap with water residence times. At some times, therefore, removal of these metals is likely to be extensive, at other times minor. The one permissible generalization is that removal of biologically active elements is never likely to be extensive in the winter. For the quasi - conservative elements, half removal times are always longer than residence times. The fraction of these elements removed is likely to range from a few percent to a few tens of percent.

The work of Amdurer et al (1983) and Santschi et al (1983) clarifies removal mechanisms, controls on removal half times, and speciation of elements in MERL tanks. Removal rates of particles from tanks are much faster than removal rates of elements, suggesting that the uptake of reactive elements on particles is the rate limiting step in removal. Particle removal rates are governed by physical settling velocities in the wintertime and by the rate of benthic filter feeding in the summertime. Summertime removal rates are, therefore, far faster. In the Wintertime, particle reactive metals are largely particulate; in the summertime they are largely dissolved. This observation is explained by the slower removal rate and higher standing stock of particles during winter. Recyclable, biologically active and quasi - conservative elements are mostly dissolved. Speciation studies show that a large fraction of the dissolved biologically active elements may be organically complexed.

D. Dissolved and particulate inorganic metals in Bay waters.

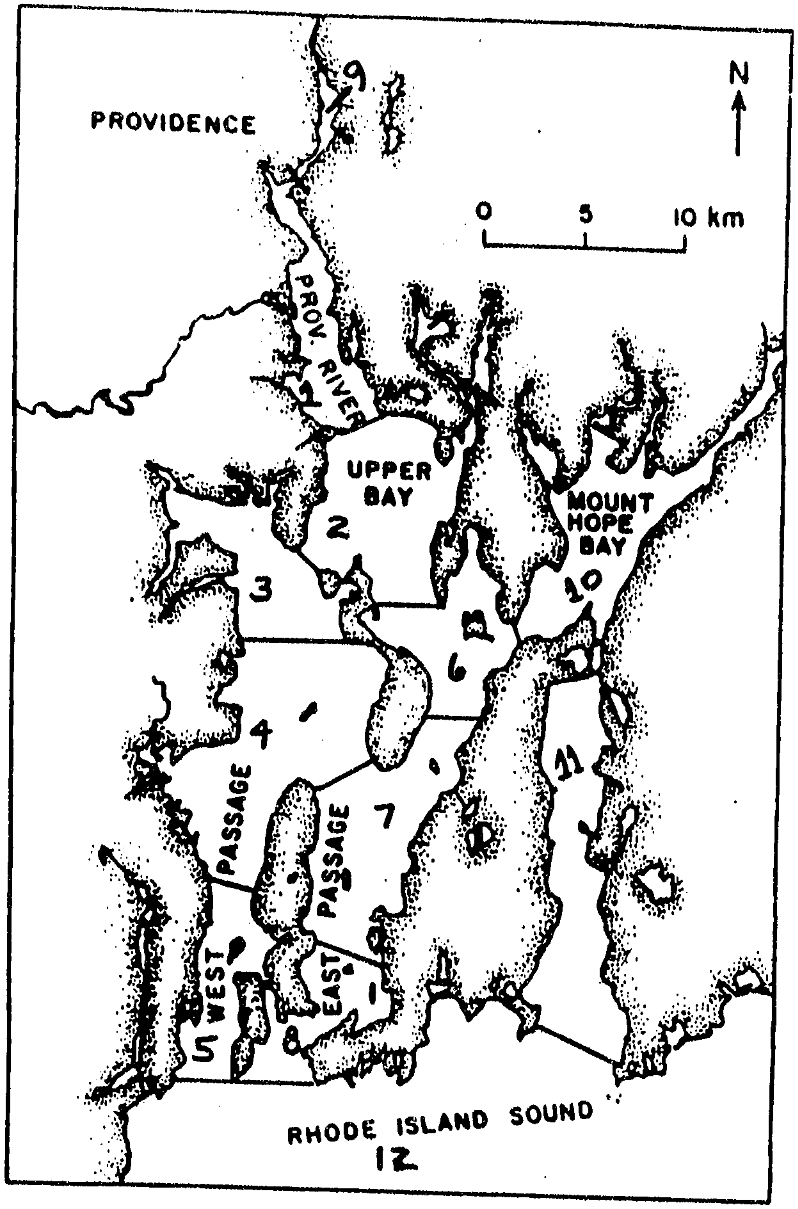
1. Objectives and data sources.

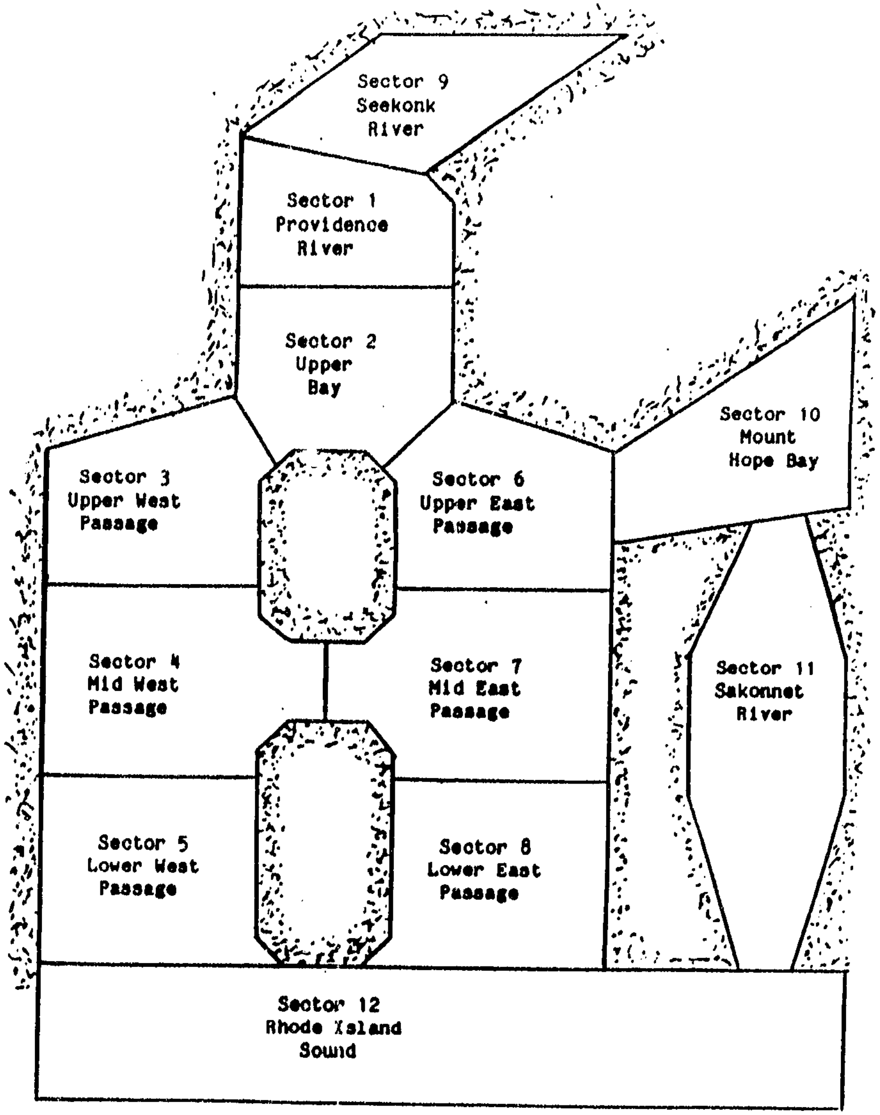
A database of metal concentrations in Narragansett Bay (BAYMETAL) was compiled from a variety of studies conducted between 1971 and 1986 (Kester et al., 1987). Major portions of the analytical data included in BAYMETAL were obtained by Carlton Hunt and by Douglas Cullen. In examining the metals data it is convenient to partition the Bay into sectors as shown in Figure II-2. Table II-3 lists the number of metal samples by month and by sector from BAYMETAL. Each sample represents one depth of sampling, and in most cases each sample was analyzed for a number of metals. The original sources should be consulted for details concerning the analytical methods used. In most cases dissolved and particulate metals were separated by 0.4 um filtration. Particulate metals were determined upon acid digestion and the dissolved metals were preconcentrated using chelation coprecipitation or solvent extraction. Atomic absorption spectroscopy was used for the analysis with a graphite furnace. The composite data sets listed in Table II-3 do not provide a good basis for understanding seasonal variations of metal concentrations in Narragansett Bay. The Providence River (sector 1) has been sampled most frequently, but only five months of the year have 10 or more samples. To establish seasonal variations in metal concentrations associated with temperature, phytoplankton, rainfall, or industrial production cycles would require a specially designed sampling program with a weekly or biweekly sampling frequency. Table II-3 indicates that sampling during the summer months has been sparse, but there is fairly good coverage during the first five months of the year and during the fall. Only the 1985-86 Sinbadd series included Mount Hope Bay and the Sakonnet River in their sampling.

Table 3. Summary of BAYMETAL samples by month for each sector; the number of samples are given for each sector in Narragansett Bay

Month	Sector													
	1	2	3	4	5	6	7	8	9	10	11	12	Total	BibID
Jan	10	4	1	3	16	1	1	2	2	0	0	3	43	Cul178a, Piot72a
Feb	3	1	1	3	1	0	1	1	1	0	0	1	13	Hunt80a
Mar.	0	4	2	2	2	2	4	4	11	0	0	4	35	Bend77a, Kest81a
Apr	11	5	2	8	5	6	7	3	2	6	2	6	63	Sin386a
May	12	7	3	12	5	8	8	4	1	6	3	8	77	Hunt80a, Sin486, Piot72a
Jun	0	0	0	2	1	0	0	0	0	0	0	0	3	Piot72a
Jul	0	0	0	3	0	0	0	0	0	0	0	0	3	Piot72a
Aug	6	6	0	2	2	0	0	0	0	0	0	1	17	Piot72a, Quin87a
Sep	3	2	0	4	1	2	1	0	9	0	0	0	22	Hunt80a, Piot72a
Oct	28	13	3	12	6	6	8	4	0	7	7	8	102	Cul180a, Piot72a, Sin185a
Nov	11	5	2	8	4	7	8	4	2	6	5	8	70	Sin185a
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total	84	47	14	59	43	32	38	22	28	25	17	39	448	

Fig. II-2. Map of Narragansett Bay (right) and a diagram showing partitioning of the Bay into eleven sectors plus Rhode Island Sound (left). Sectors 1 through 8 were defined by Kramer and Nixon (1978); their approach was extended to the Seekonk River (9), Mount Hope Bay (10), Sakonnet River (11), and Rhode Island Sound (12). Schematic box configuration for the sectors of Narragansett Bay (right). This format is used in Figure 3 to provide a statistical summary of data from the Bay.





Schematic Sectors for Narragansett Bay

2. Metal concentrations vs. latitude

There are several different ways to examine the variation in metal concentrations in Narragansett Bay waters. Graphs of concentration versus latitude, which of course increases going from the mouth of the Bay to its head, provide one approach. Such plots (e. g., Fig. II-3) contain a great deal of scatter. In many instances metal concentrations correlate with salinity; low salinity upper Bay water has high concentrations and lower Bay high salinity water has low metal concentrations. Tidal excursions cause large salinity and metal concentration variations at most locations in the Bay.

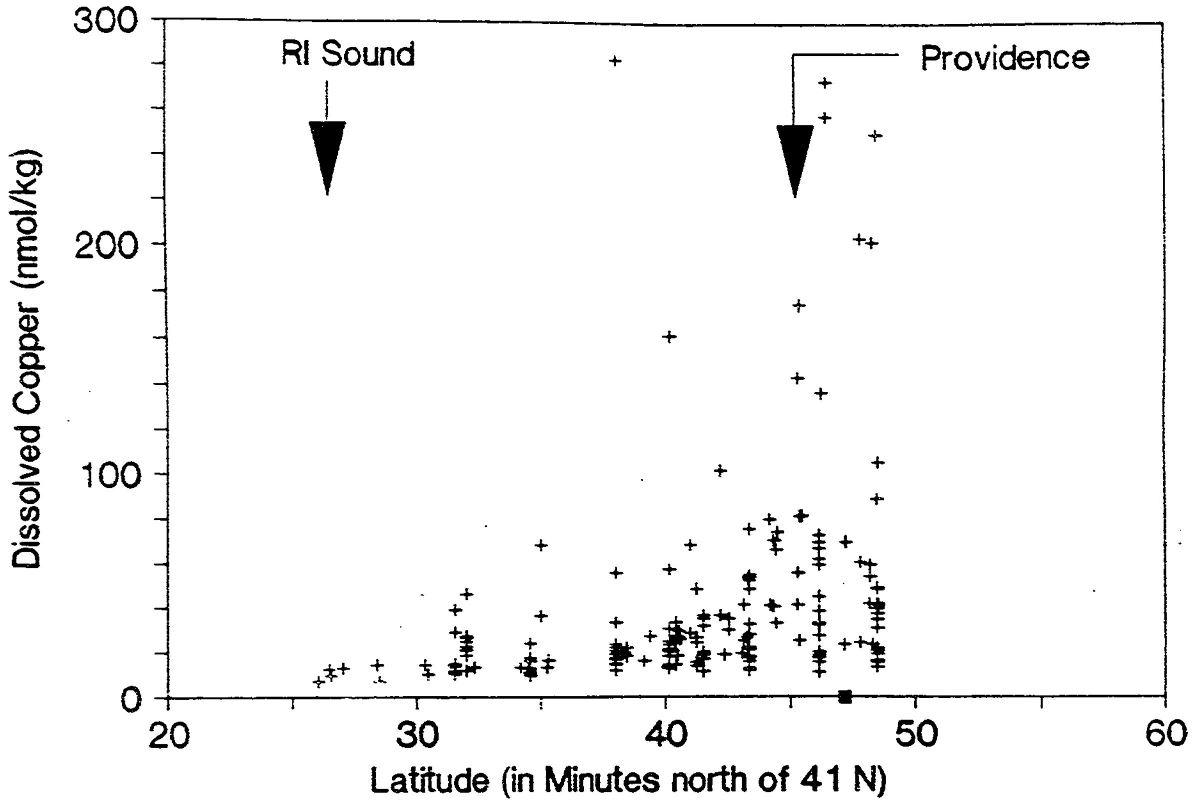
The principal axis of the three main sections of Narragansett Bay follow a north-south trend. It is convenient to show spatial variations in the Bay by plots versus latitude, with a composite plot including data from all sections of the Bay. This type of plot has been useful for metal variations in Bay sediments and in sessile organisms such as clams and mussels. A plot of dissolved metal concentrations in Narragansett Bay versus latitude will contain scatter due to tidal excursions, but it illustrates the level and variation in concentrations to which sessile organisms and sediments are exposed.

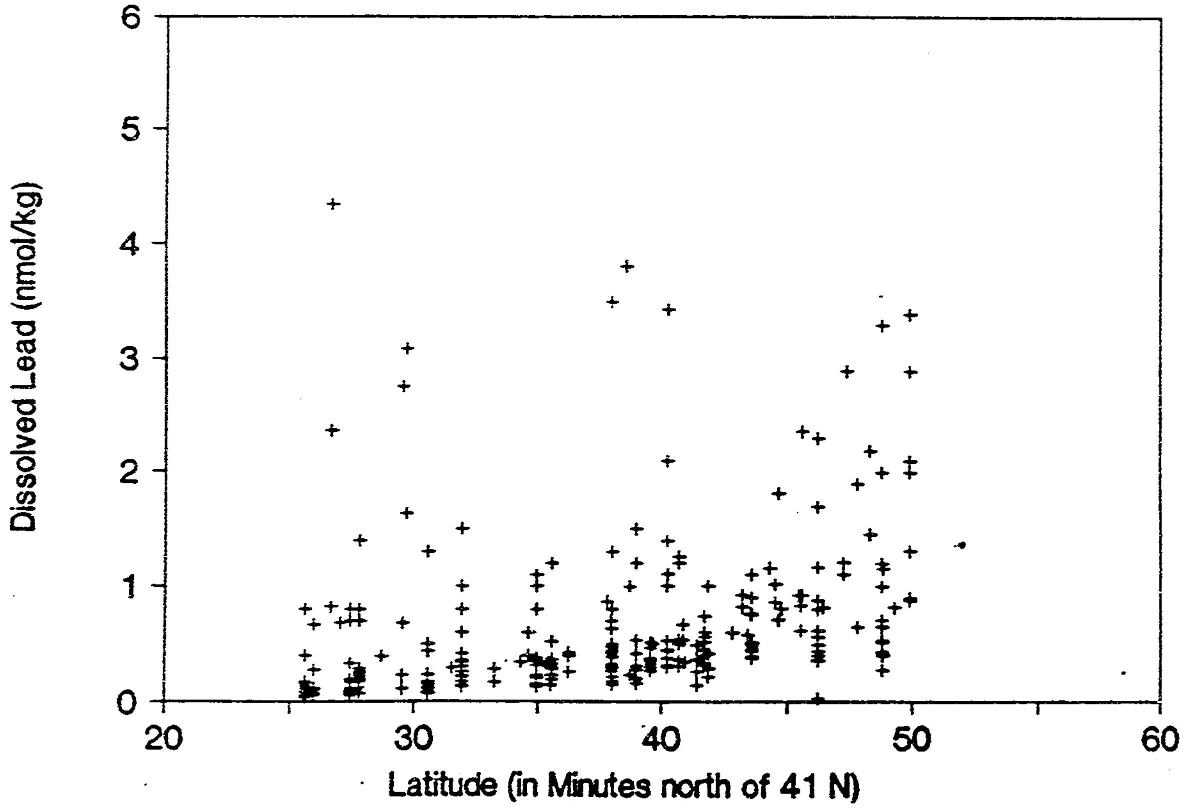
Figure II-3 a shows the plot for dissolved copper versus latitude based on the metals database compiled by Kester et al. (1987). At the mouth of the Bay dissolved copper variations are in the range of 1 to 5 nmol/kg, but near Providence the range is 2 to 280 nmol/kg. A similar plot for dissolved lead shows quite a different pattern (Figure II-3 b). The dissolved lead variations are in the range of 0.1 to 4 nmol/kg throughout the Bay. There may be two possible factors related to the difference in lead and copper variations in the Bay. The most important is that copper enters the Bay mainly from sewage effluents and rivers in the upper Bay, whereas lead has a significant source from deposition of atmospheric aerosols. A broader spatial distribution of lead inputs compared to copper could account for the difference seen between Figures II-3 a and b. A second factor that may be important is that particulate lead concentrations are similar in magnitude to dissolved concentrations, but for copper the dissolved fraction is 5 to 10 times greater than the particulate fraction. There is a two-fold decrease in suspended particulate matter down the Bay, and a nearly ten-fold dilution of the maximum dissolved metal concentrations down the Bay. Thus, metals transported mainly by the particulate phases may be more uniformly distributed in the Bay than those in the dissolved phase.

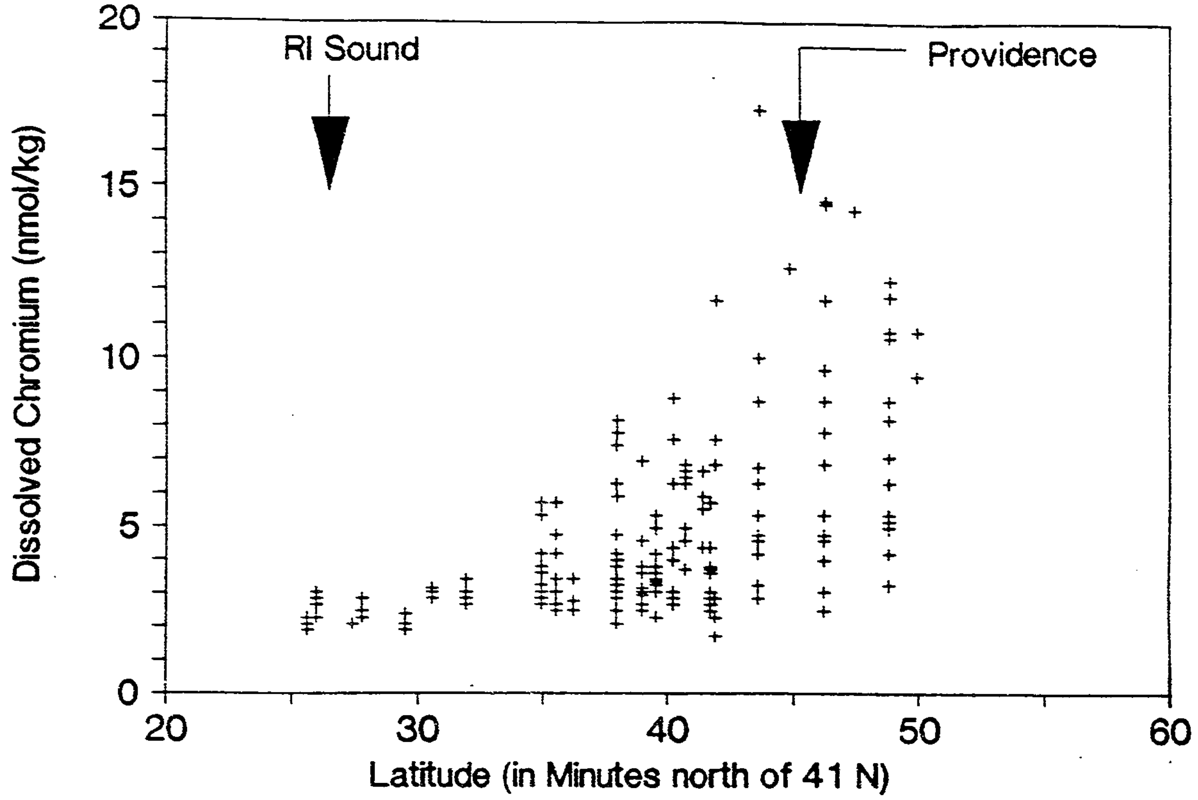
Latitudinal plots for dissolved chromium and nickel are shown in Figure II-3 c and d. Chromium is similar to copper in its distribution, but nickel shows a very steep decrease between 46'N and 40'N. This result suggests that dissolved nickel is removed more rapidly than copper or chromium. The latitudinal plots for silver and cadmium are shown in Figure II-3 e and f. These two metals are similar to copper and chromium, except that there are a few observations of high cadmium in the lower Bay.

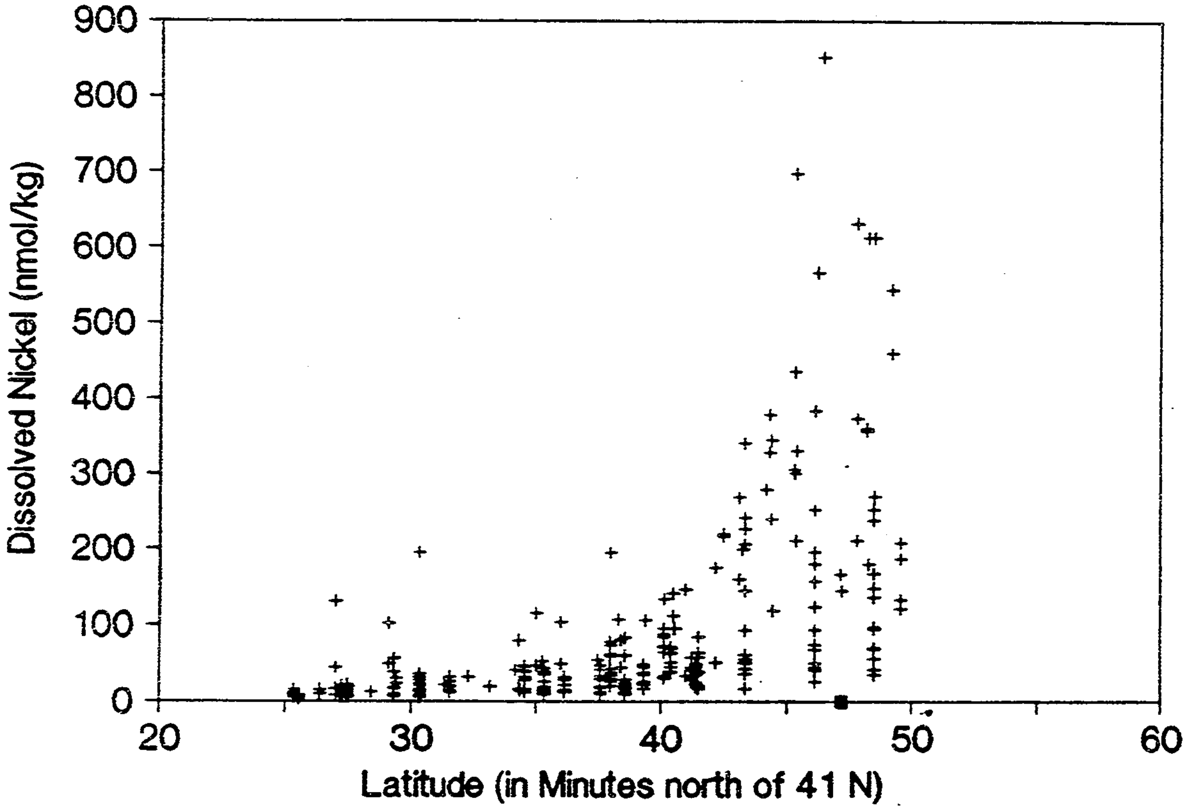
About one-half of the samples in the database used for these plots were obtained during the 1985-1986 Sinbadd series of cruises. (Dense clusters of points at specific latitudes generally reflect the Sinbadd data.) Sinbadd designed its sampling to be within two hours of high tide throughout the Bay. This approach is useful for obtaining as synoptic a view as possible of metal concentrations in the Bay. This sampling strategy, however, results in a biased data set for characterizing variability and contaminant concentration in the Bay. At high tide, high salinity-low metal concentration water makes its greatest extension into the Bay, and the low salinity water high in metal concentrations is compressed into the upper reaches of the Bay. Unfortunately, Sinbadd did not collect many samples from the Seekonk River, so the low salinity waters with high metal concentrations have been undersampled. While Figure II-3 provides a general picture of metal variations at each latitude in

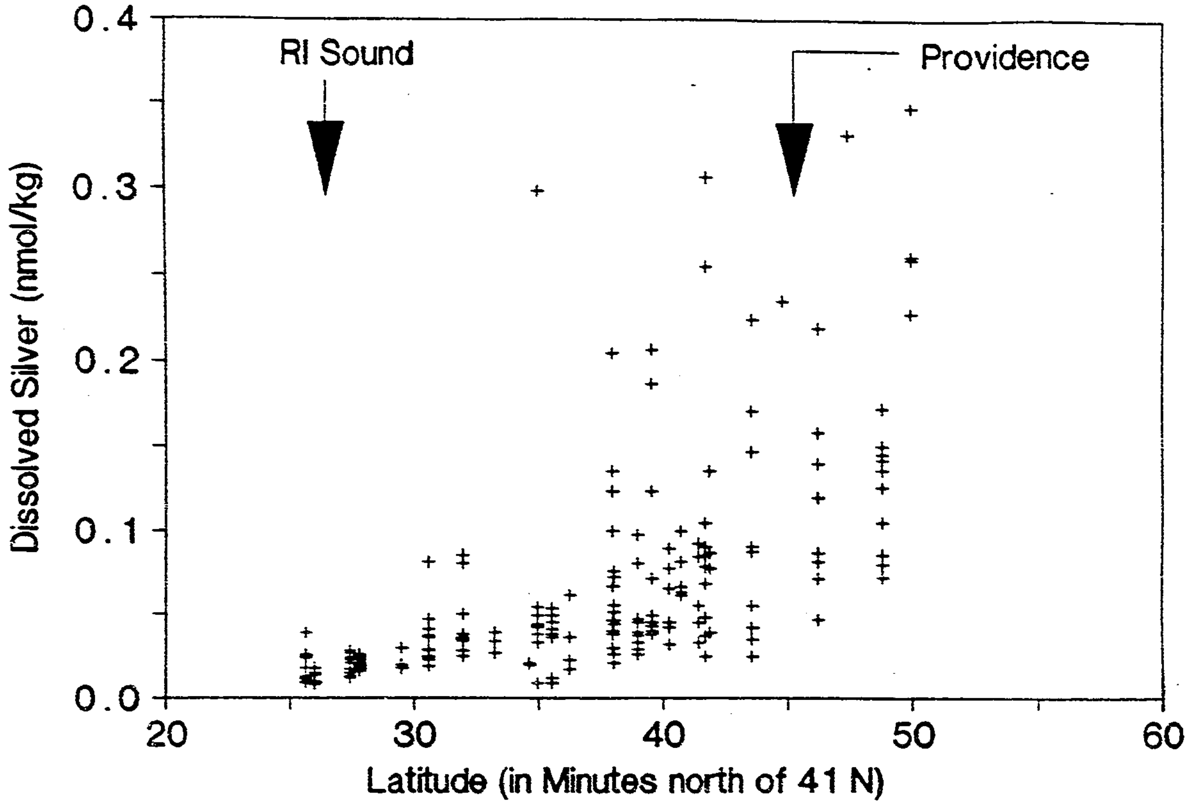
Fig. II-3. Dissolved Cu, Pb, Cr, Ni, Ag, Cd vs. latitude in minutes N. of 41° N latitude.

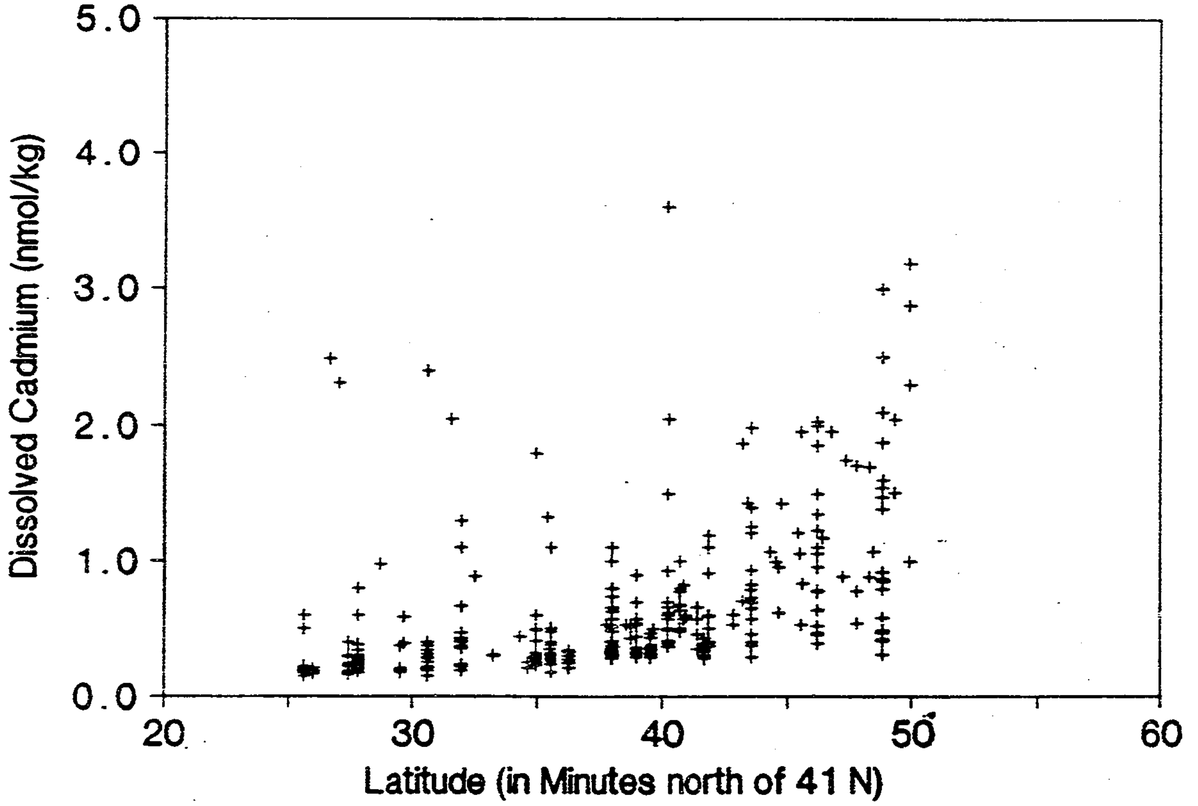





20
15
10
5
0
Dissolved Chromium (nmol/kg)
RI Sound
Providence
20
30
40
50
60
Latitude (in Minutes north of 41 N)


900
800
700
600
500
400
300
200
100
0
Dissolved Nickel (nmol/kg)
20
30
40
50
60
Latitude (in Minutes north of 41 N)


RI Sound
Providence
Dissolved Silver (nmol/kg)
0.4
0.3
0.2
0.1
0.0
20
30
40
50
60
Latitude (in Minutes north of 41 N)


Dissolved Cadmium (nmol/kg)
5.0
4.0
3.0
2.0
1.0
0.0
20
30
40
50
60
Latitude (in Minutes north of 41 N)

the Bay, the actual temporal variations at fixed locations may not be fully represented in this data set.

Particulate trace metal concentrations are plotted vs. latitude in Fig. II-4.

3. Dissolved Metal Concentrations

We will use a schematic representation of the Bay sectors (Figure II-2) to provide an overview of the variation of metal concentrations, and into this grid we will enter a brief statistical summary derived from BAYMETAL. Figure II-5a illustrates the summary for salinity. For each sector of the Bay we have shown the average salinity ± one standard deviation and the number of observations. Also given are the minimum and maximum salinities observed in each sector, which identifies the range of values. The sector averaged salinities show a systematic gradient down the Bay with by far the greatest variability and range occurring in sector 9 (the Seekonk River). The East Passage has slightly higher average salinities than does the West Passage, indicating the effects of tidal mixing and freshwater flow. The salinity data show that a slightly greater portion of the freshwater from the upper Bay mixes down the West Passage than down the East Passage; thus, we might expect that metals with sources in the upper Bay may have slightly higher concentrations in the West Passage than in the East Passage. In the sections that follow we will examine dissolved metal concentrations, metal-salinity relationships, the metal composition of particulate material, the sources of metals to the Bay, and variations in metal inputs and concentrations during the past 15 years.

Figure II-5b shows the sector summary for dissolved cadmium. Cadmium concentrations are a factor of 10 higher in the Seekonk River than in Rhode Island Sound. The concentrations drop by a factor of 4 between the Seekonk River and the Upper Bay. The Lower Bay has concentrations similar to Rhode Island Sound. Mount Hope Bay and the Sakonnet River do not show elevated concentrations of cadmium relative to Rhode Island Sound. We see slightly higher cadmium concentrations in the upper and mid West Passage than in the East Passage, as expected from the trend seen in salinity. The pattern for chromium in the Bay is similar to cadmium except the contrast between the Seekonk River and Rhode Island Sound is a factor of 4 instead of 10 (Figure II-5c).

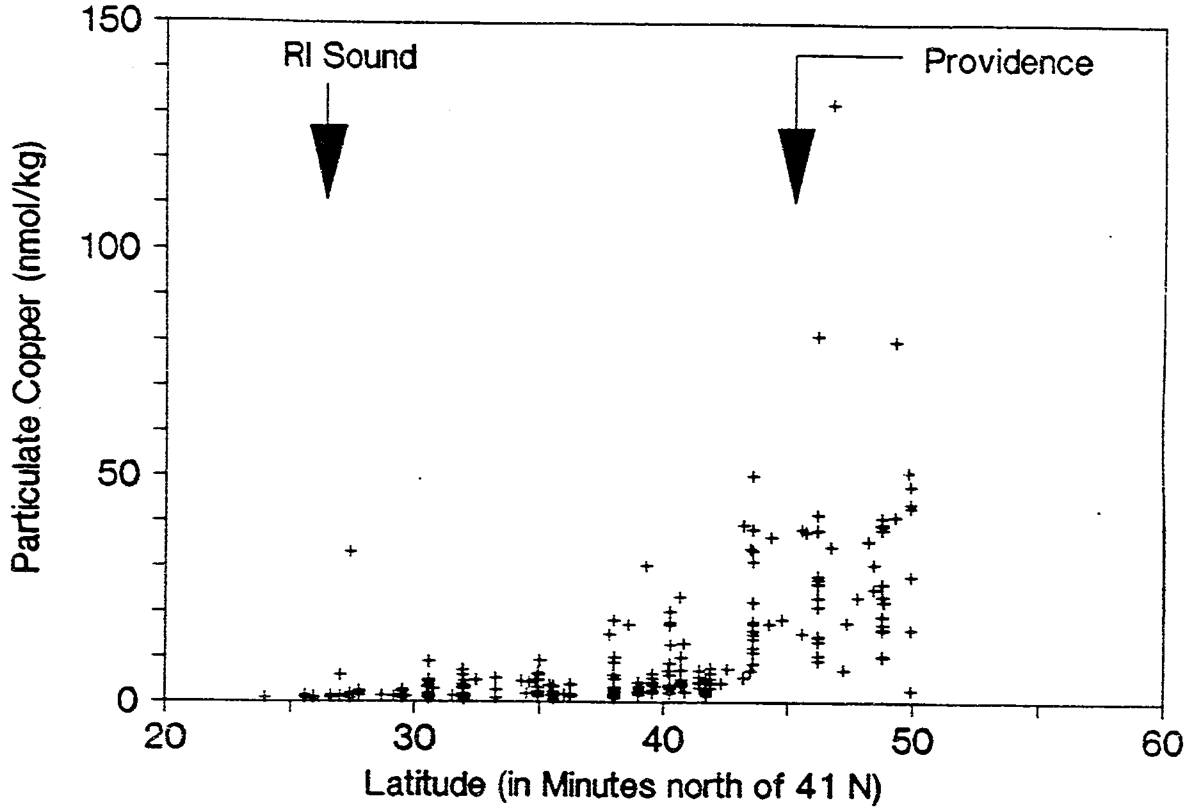
Copper in the Bay shows a very striking distribution (Figure II-5d). Unlike nearly all other metals, the highest concentrations are not found at the lowest salinities in the Seekonk River; the highest values occur in the Providence River where large amounts of copper enter the Bay from the Fields Point sewage treatment plant. The upper West Passage also has high copper concentrations that may be associated with Greenwich Bay. Copper in the lower West Passage appears to be higher than in Rhode Island Sound.

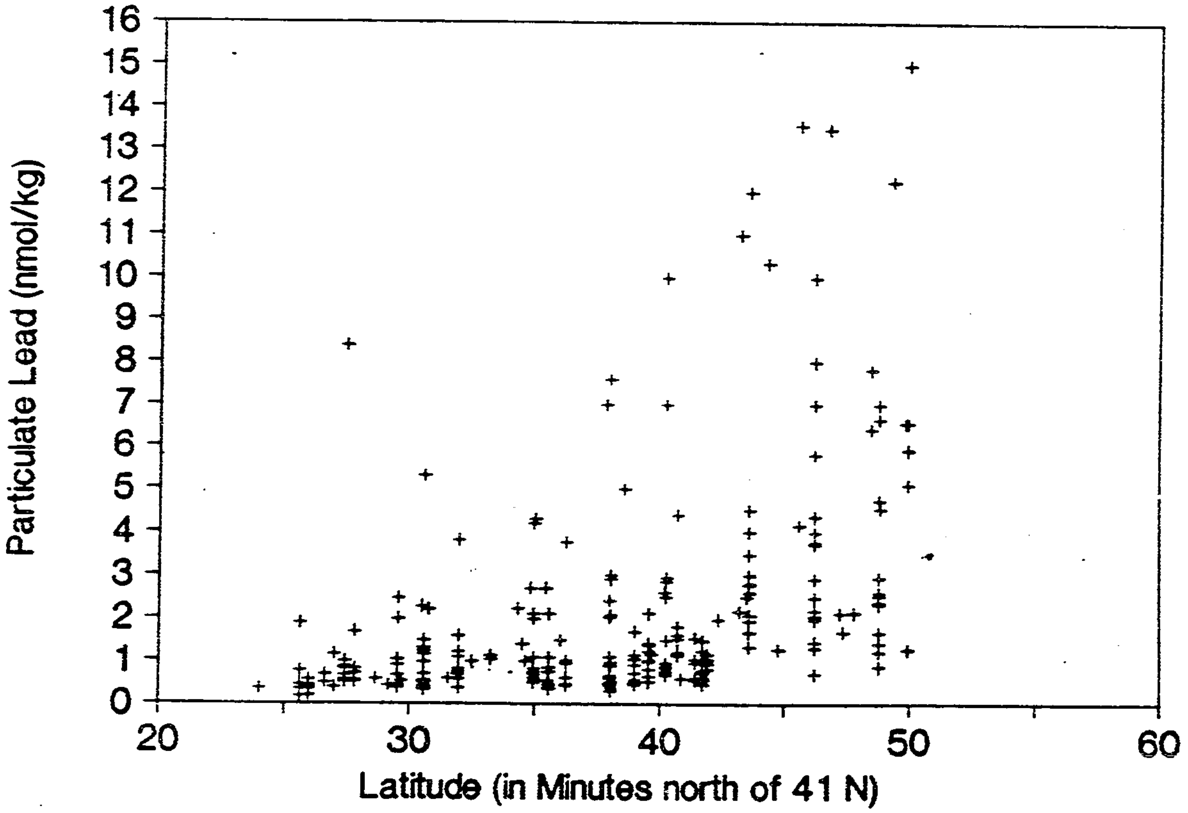
There are fewer measurements of dissolved iron in the Bay than for some of the other metals; unfortunately, the Sinbadd series did not include iron analyses. Iron is important because it is a chemically reactive metal in estuarine environments, and its chemical behavior (such as flocculation in a salinity gradient) can influence the fate of other metals. Iron shows high concentrations in sectors 1 and 3 similar to copper, and it may be influenced by local inputs in those regions (Figure II-5e).

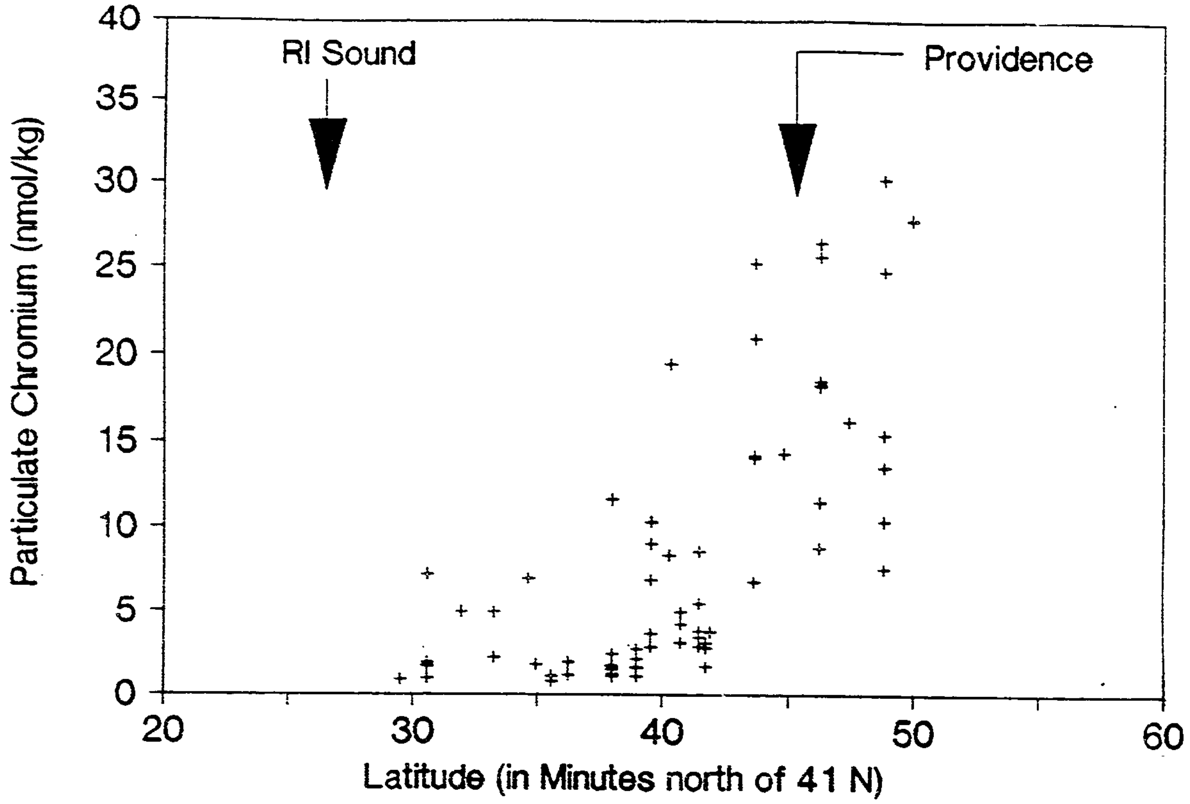
Manganese is another metal than can have a controlling influence on other metals. Figure II-5f shows a systematic gradient in manganese down the Bay. The manganese concentration in the Seekonk River is 15 times higher than in Rhode Island Sound. As in the case of iron, the Sinbadd data set did not include manganese measurements, so we have no values from BAYMETAL in Mount Hope Bay and the Sakonnet River.

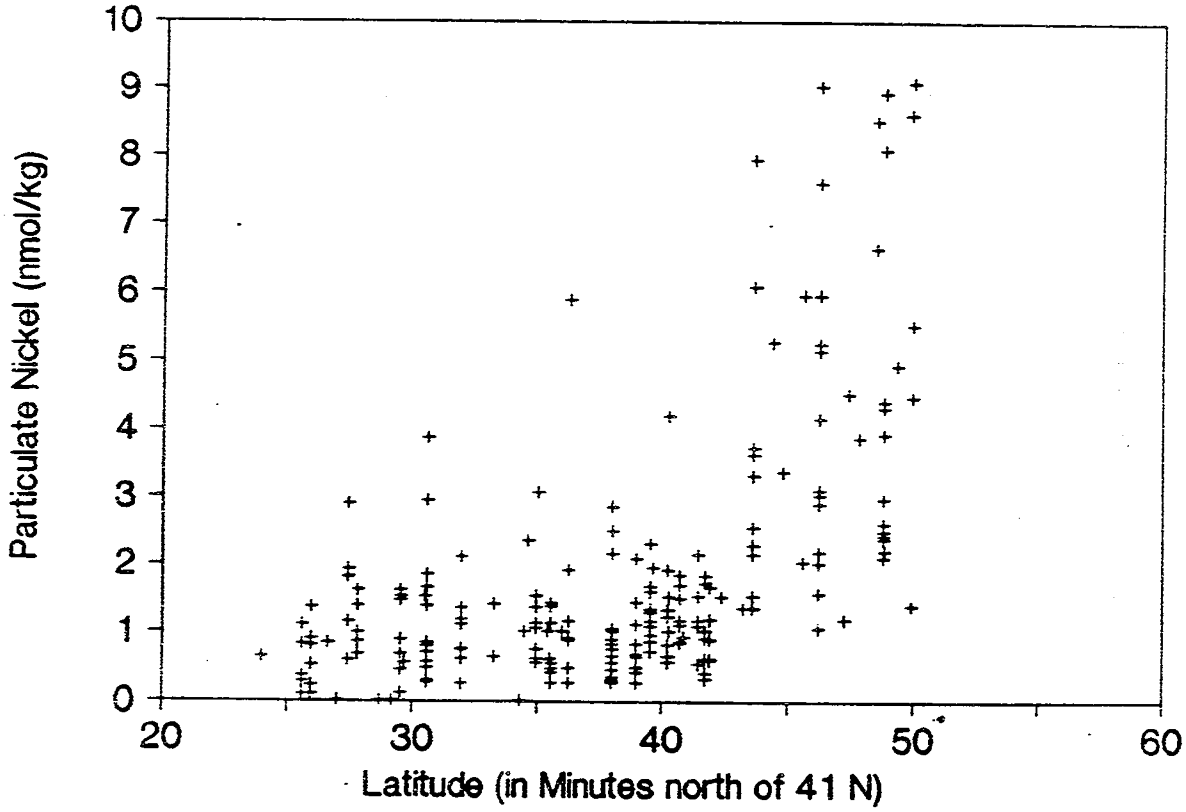
Silver concentrations decrease down the Bay (Figure II-5g). Mount Hope Bay has

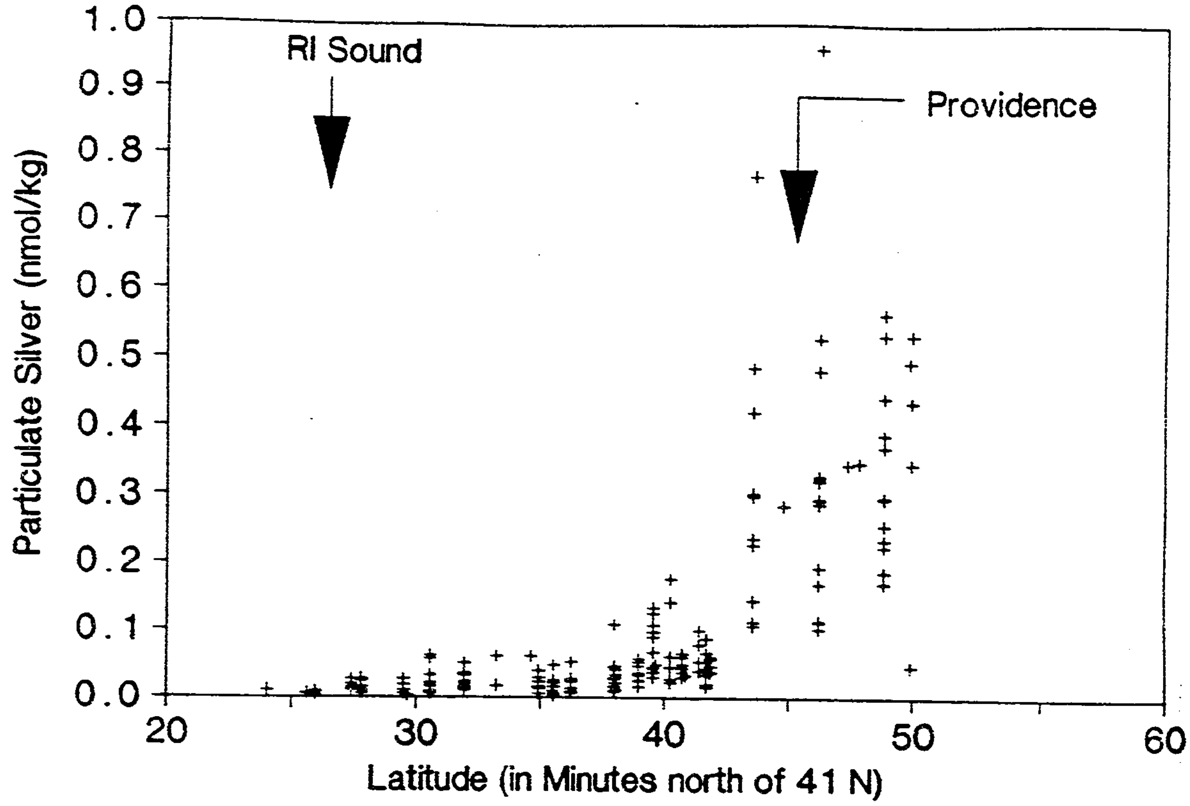
Fig. II-4. Particulate Cu, Pb, Cr, Ni, Ag and Cd vs. latitude.






RI Sound
Providence
Particulate Chromium (nmol/kg)
0
5
10
15
20
25
30
35
40
Latitude (in Minutes north of 41 N)
20
30
40
50
60


Particulate Nickel (nmol/kg)
0
1
2
3
4
5
6
7
8
9
10
Latitude (in Minutes north of 41 N)
20
30
40
50
60


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Particulate Silver (nmol/kg)
RI Sound
Providence
20
30
40
50
60
Latitude (in Minutes north of 41 N)

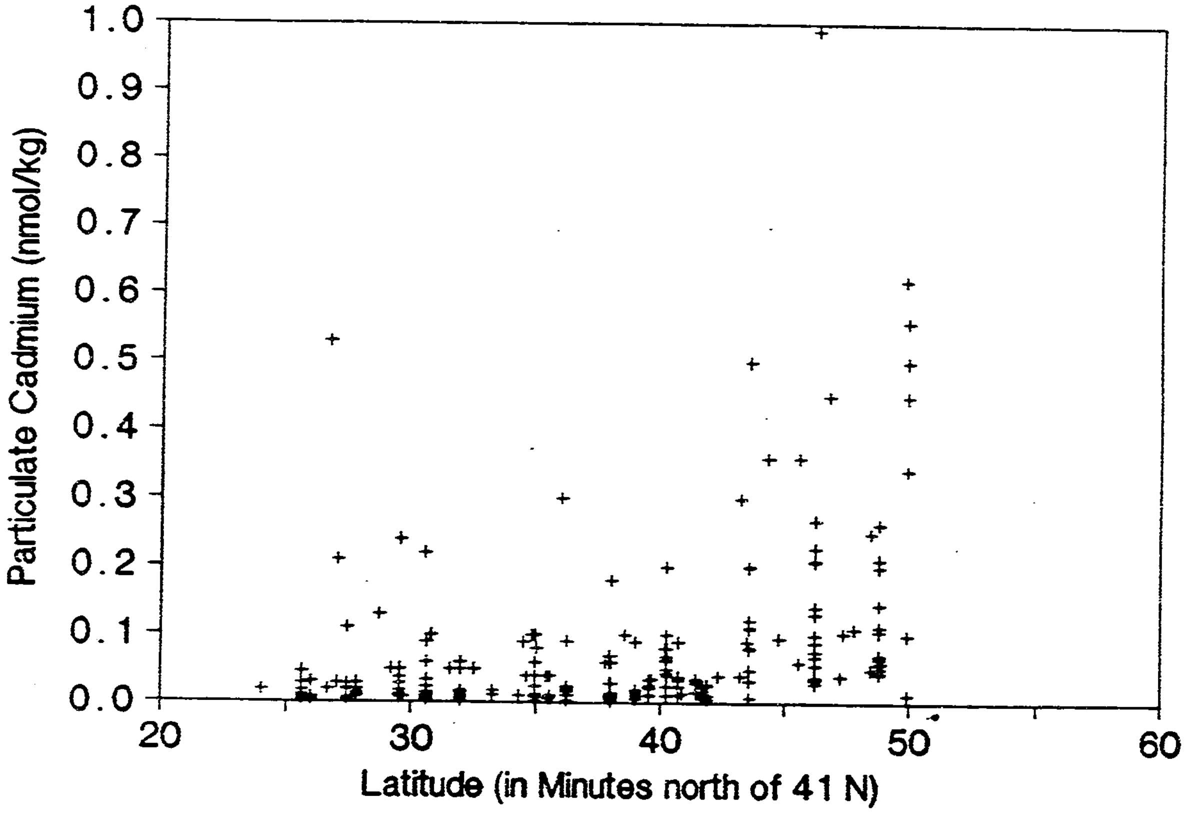
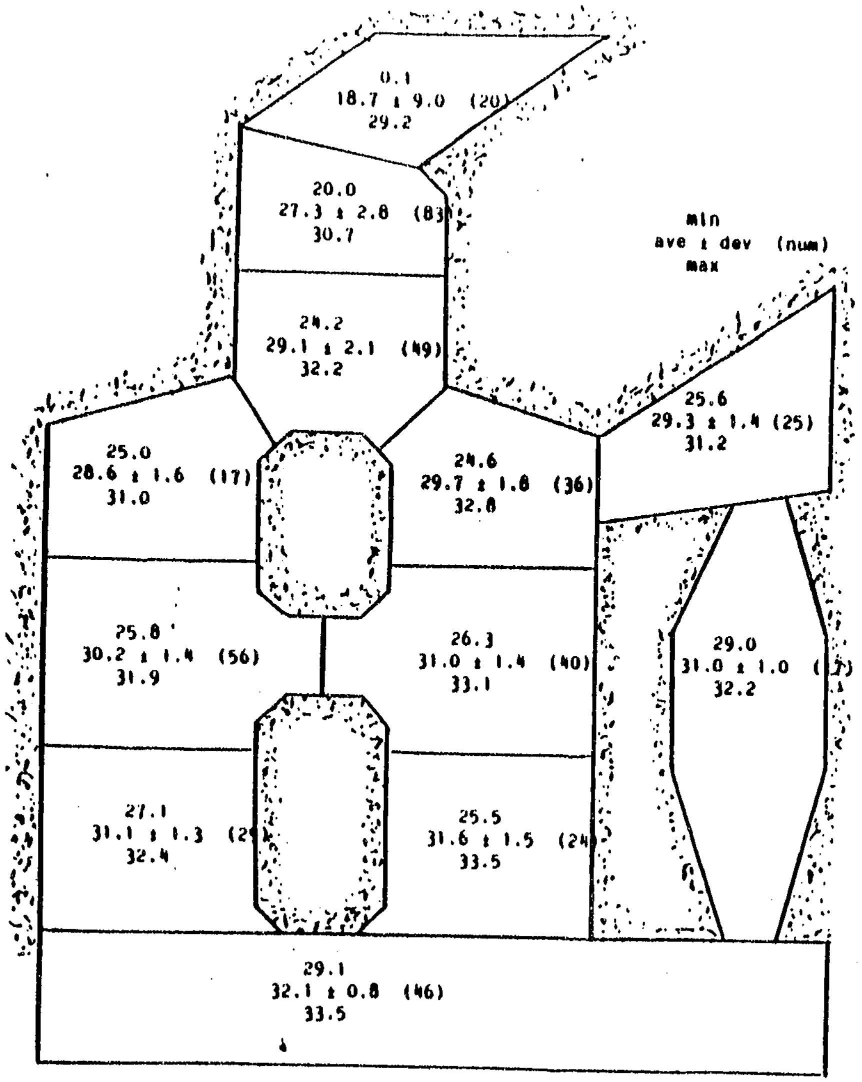
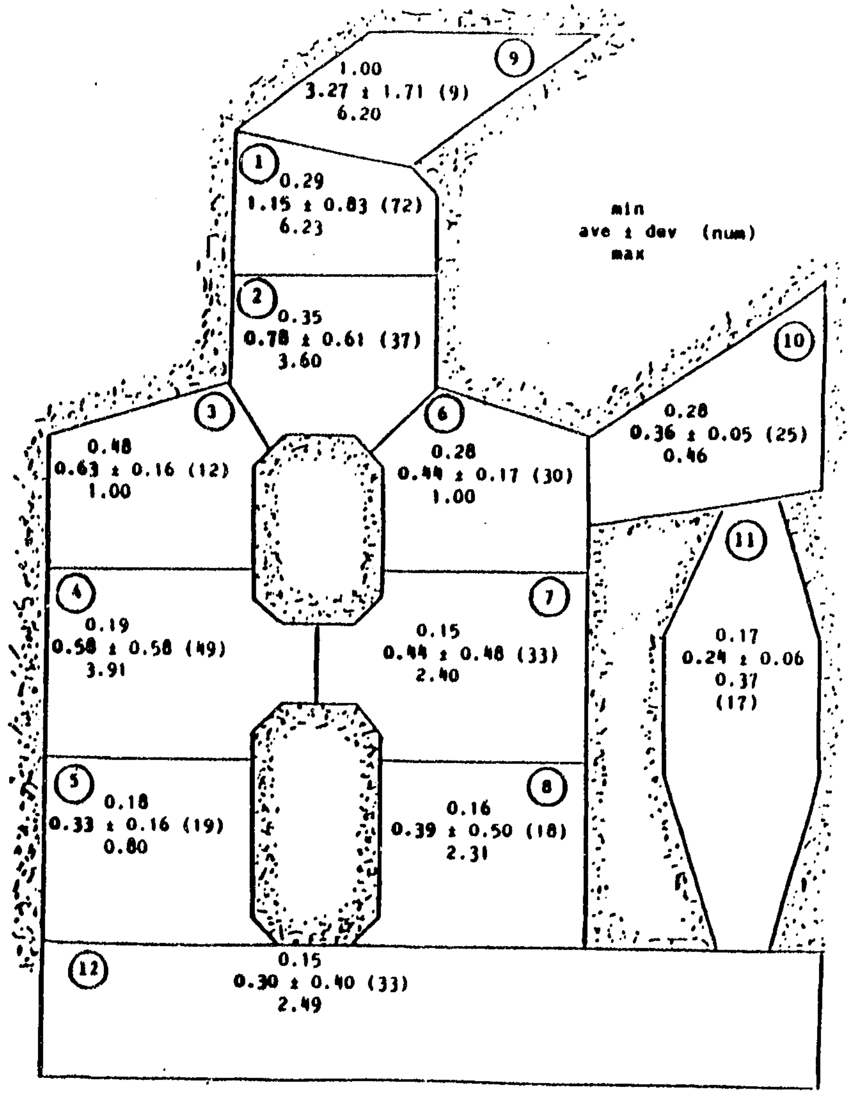

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Particulate Cadmium (nmol/kg)
20
30
40
50
60
Latitude (in Minutes north of 41 N)

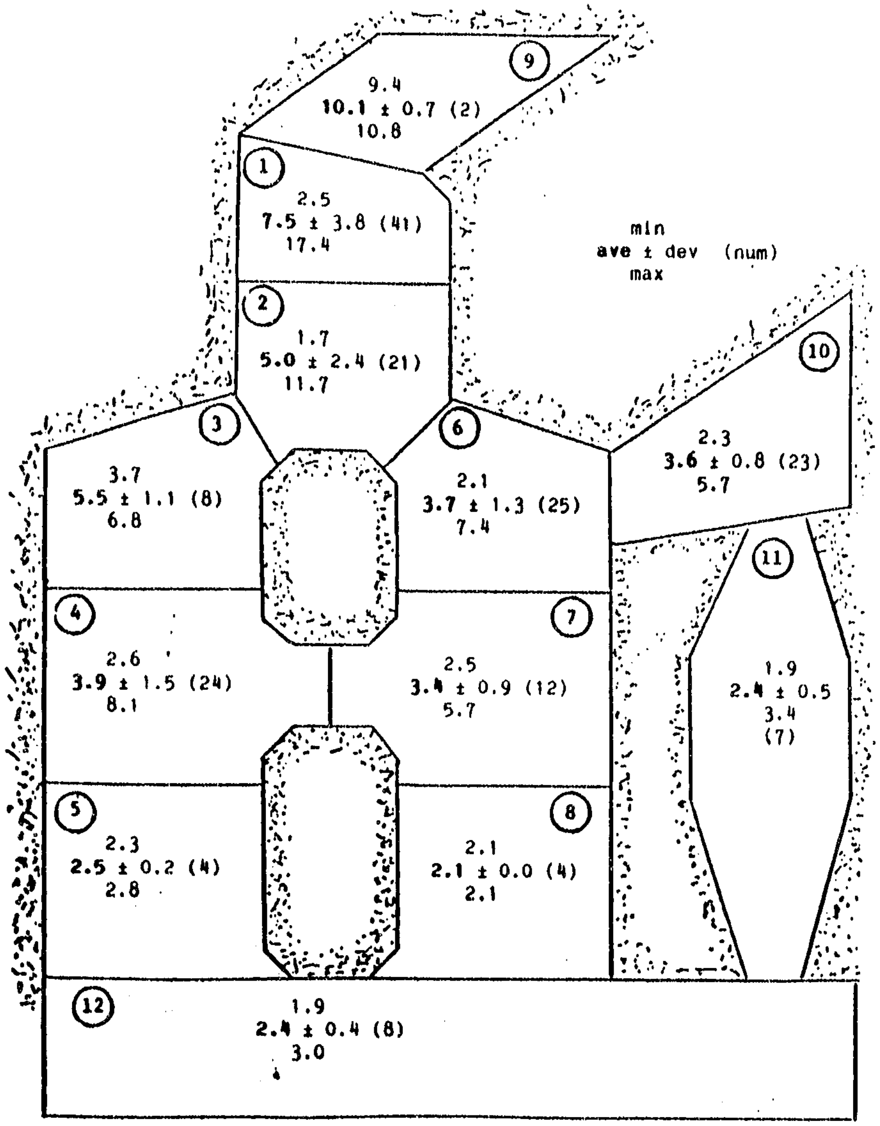
Fig. II-5. Statistical summary of parameters by sector: average, standard deviation, number of measurements, minimum, and maximum values. (a) Salinity; (b) Cadmium; (c) Chromium; (d) Copper; (e) Iron; (f) Manganese; (g) Silver; (h) Nickel; (i) lead; (j) Total suspended matter (TSM) Salinity is in o/oo, TSM is in mg/L, and all of the metals are in nmol/kg.



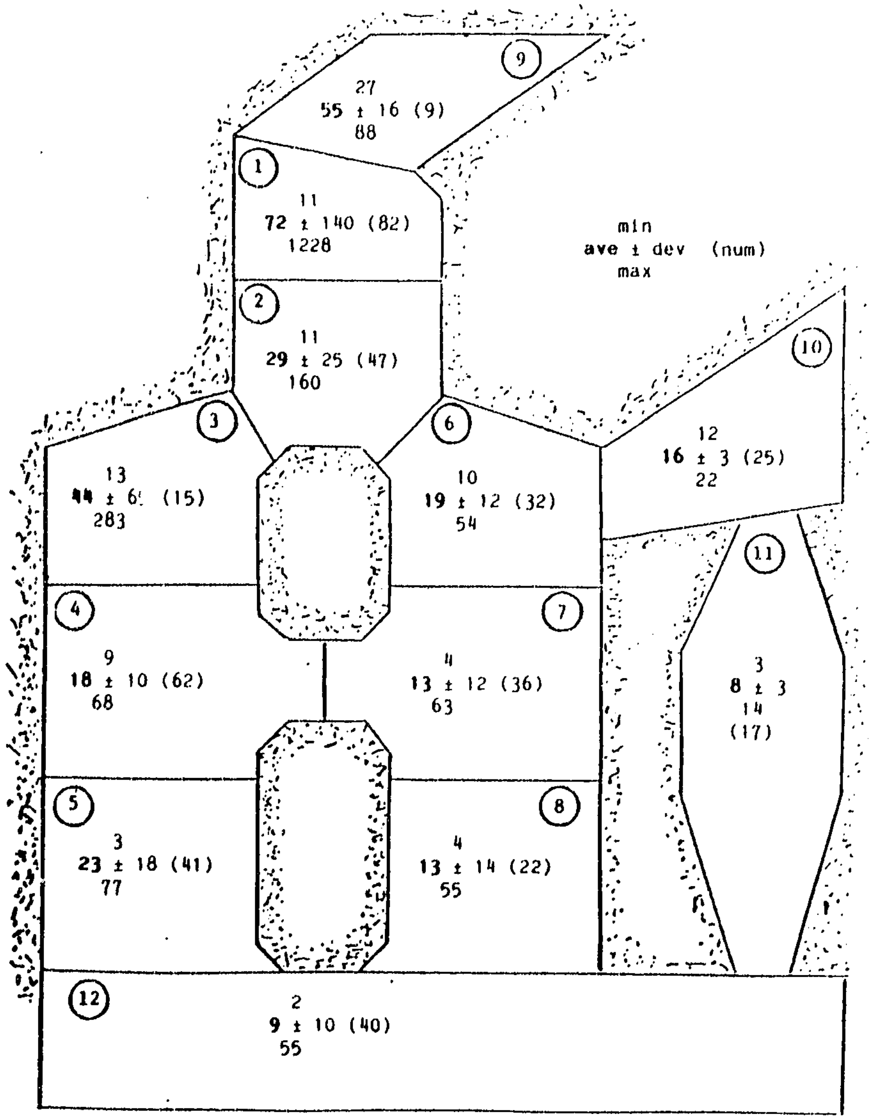
Salinity in Narragansett Bay waters (°/oo)



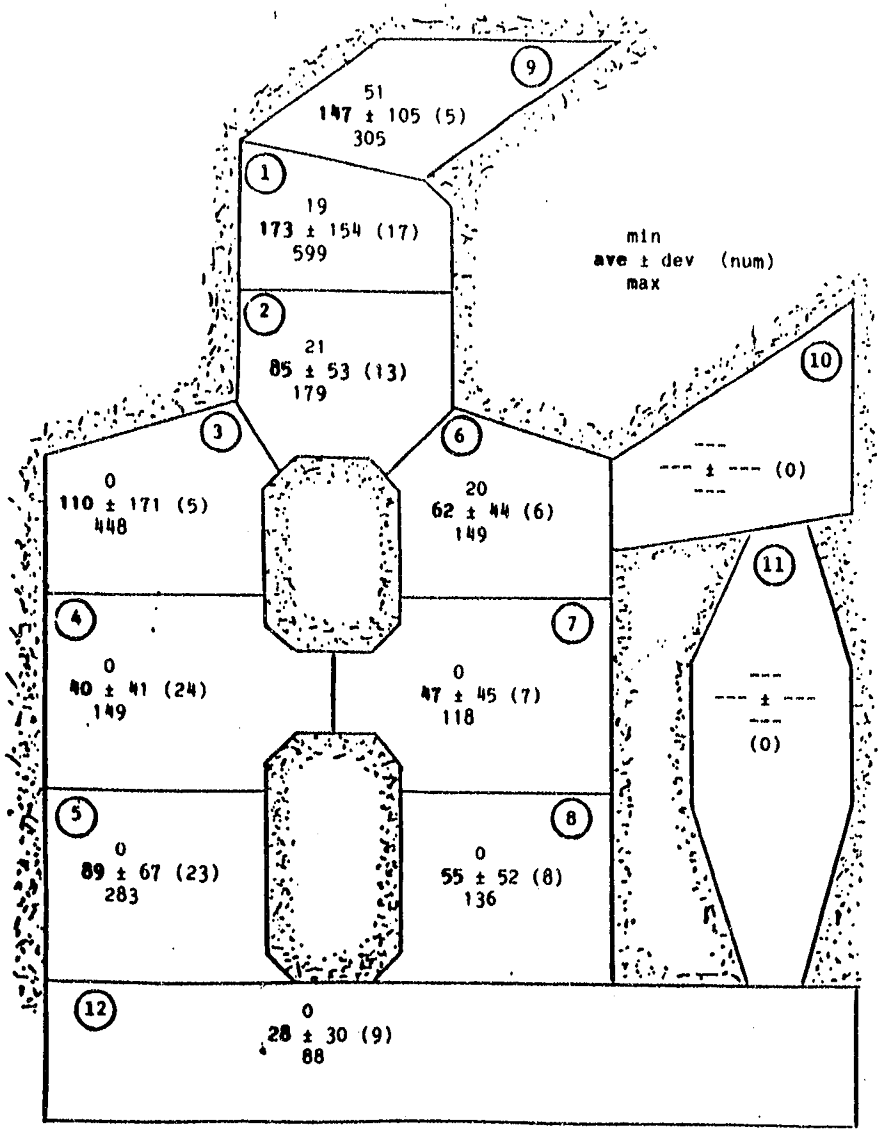
Dissolved cadmium in Narragansett Bay waters (nmol/kg)



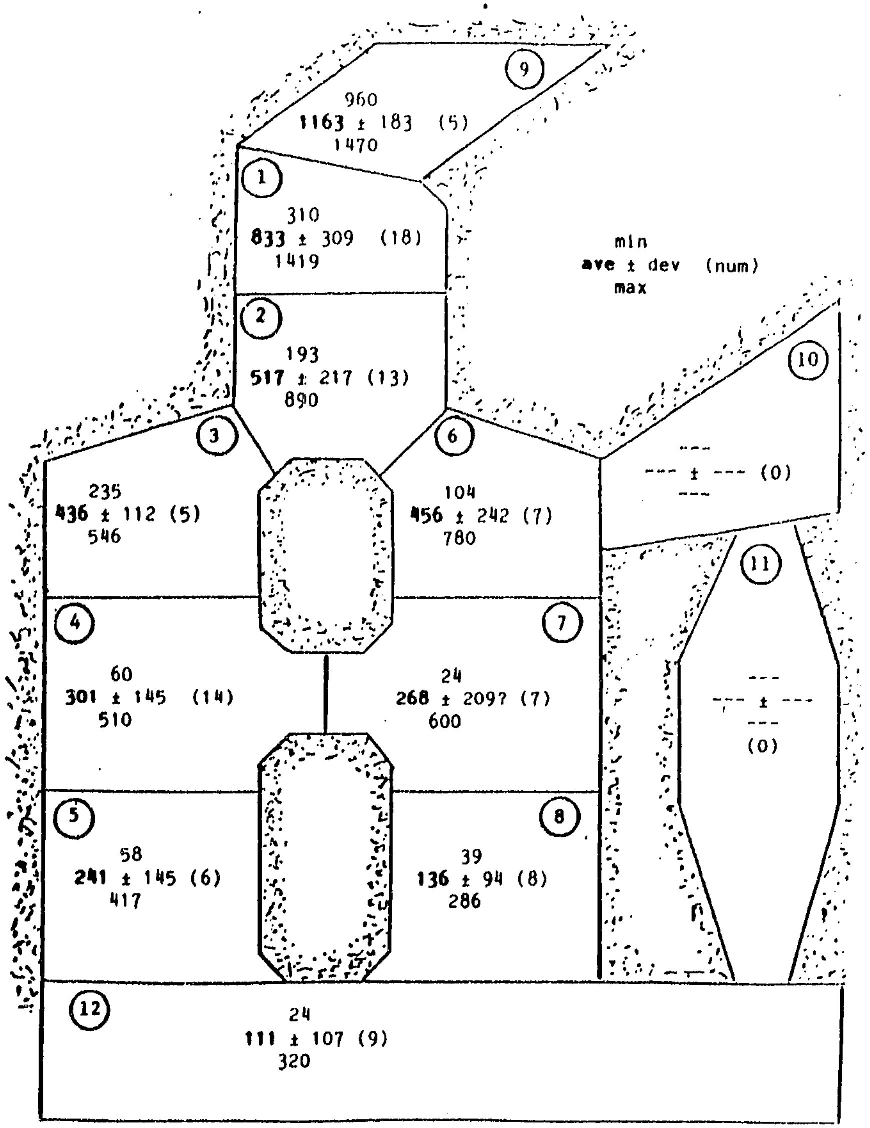
Dissolved chromium (nmol/kg) in Narragansett Bay waters.



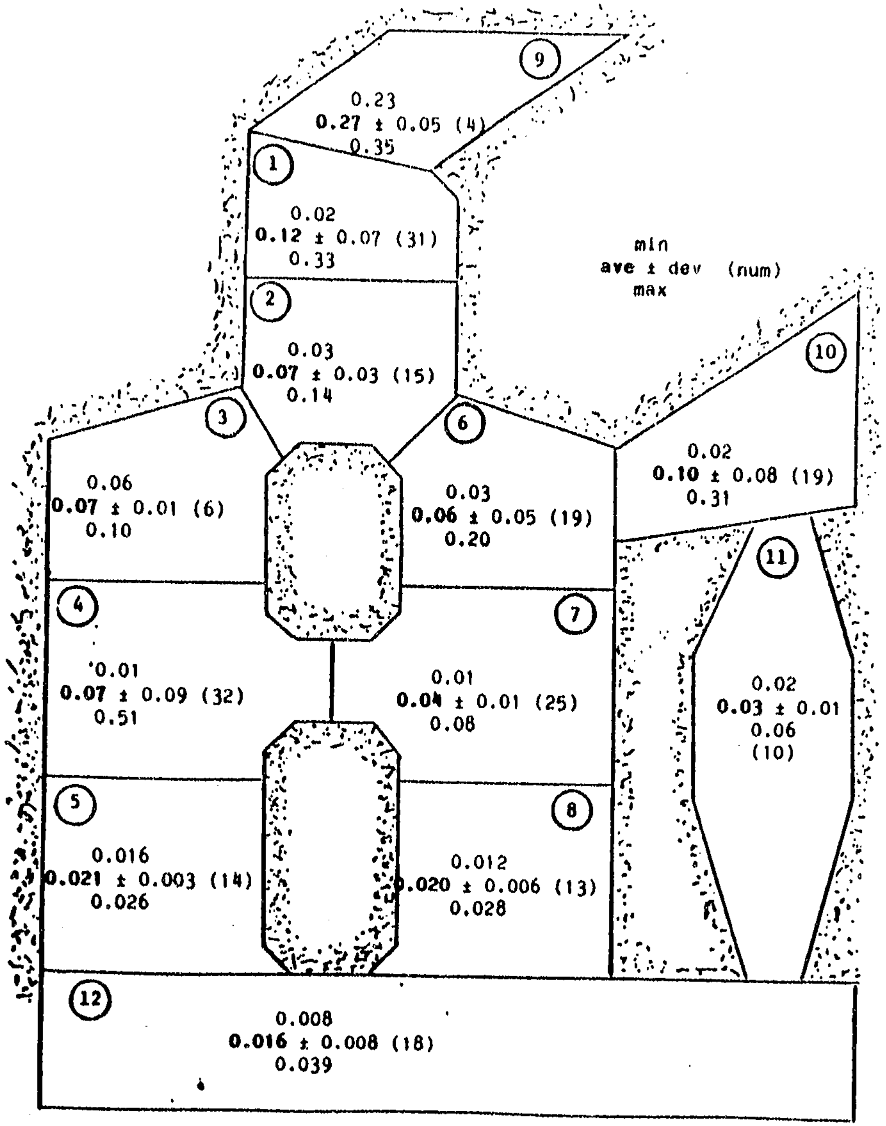
Dissolved copper (nmol/kg) in Narragansett Bay waters



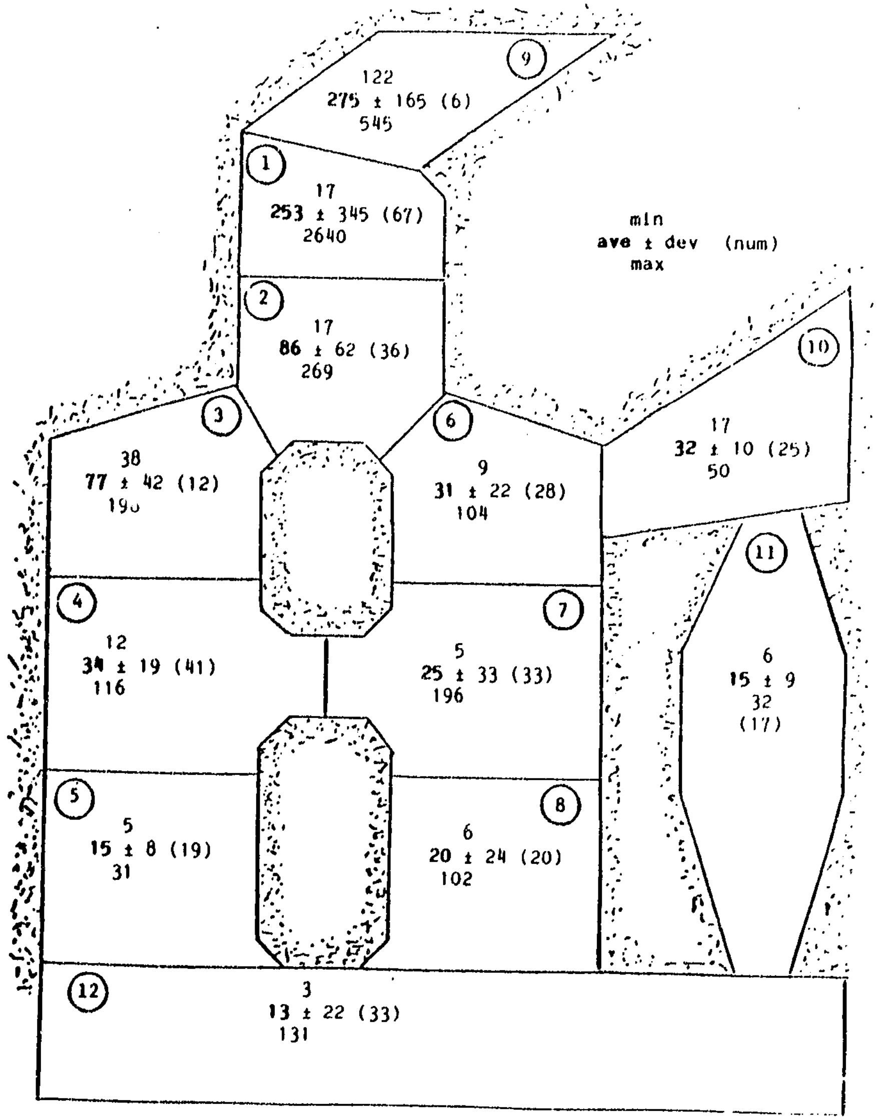
Dissolved Iron (nmol/kg) in Narragansett Bay waters



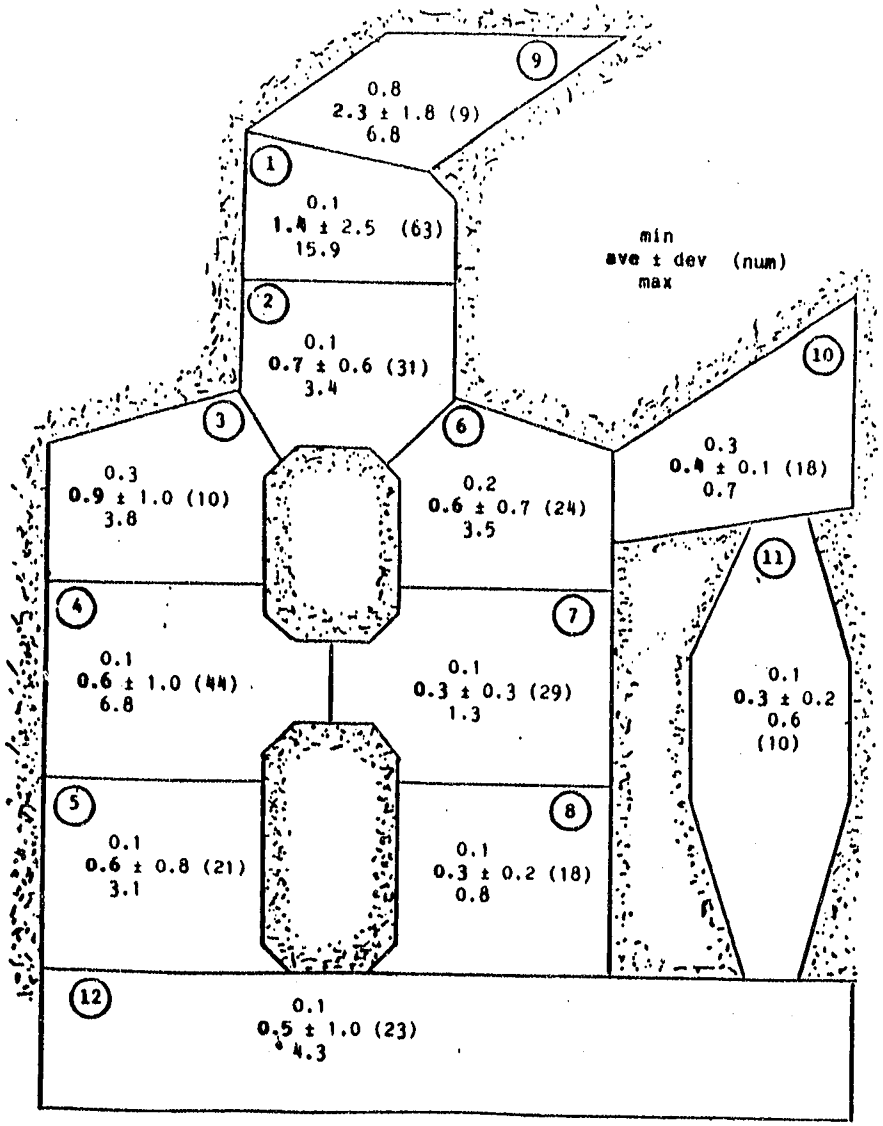
Dissolved Manganese (nmol/kg) in Narragansett Bay waters



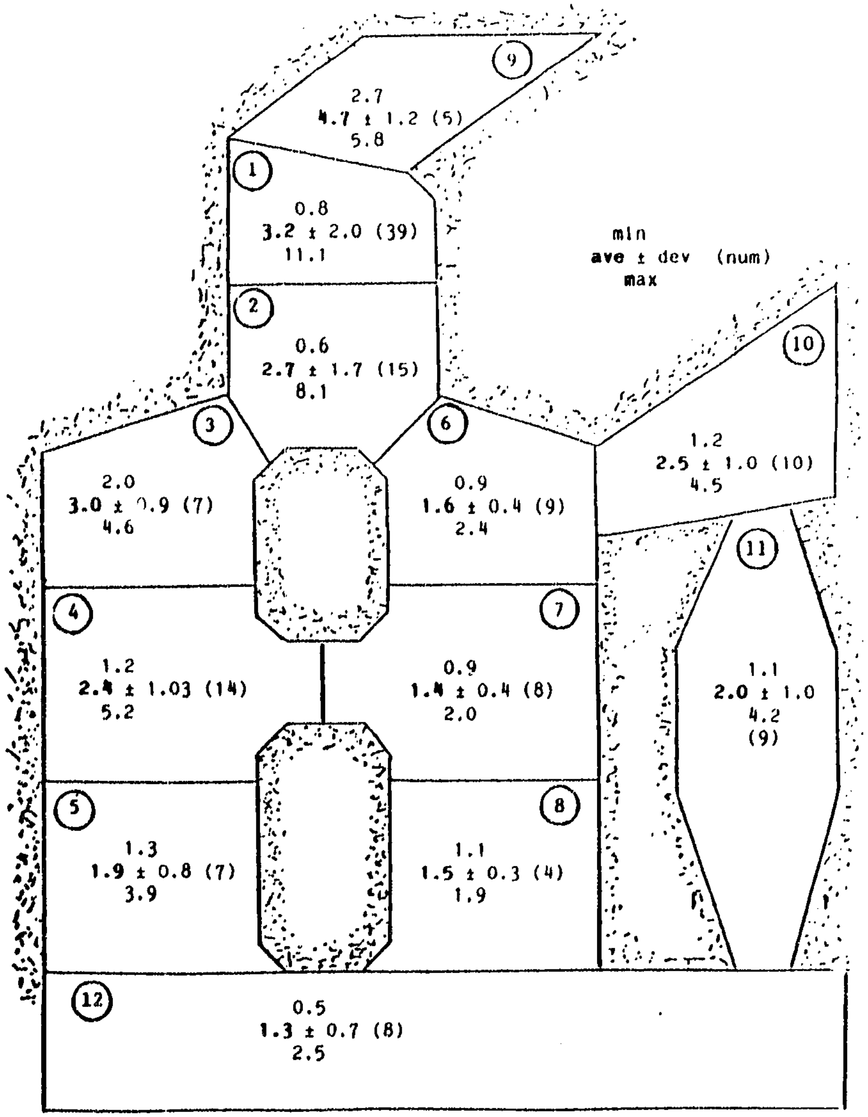
Dissolved silver (nmol/kg) in Narragansett Bay waters



Dissolved nickel in Narragansett Bay waters (nmol/kg)



Dissolved lead (nmol/kg) in Narragansett Bay waters



Total suspended matter in surface waters ($z <= 3$ meters) in Narragansett Bay.

silver concentrations similar to those of the Providence River, which is unusual compared to the other metals. This result suggests that there is a significant source of silver into Mount Hope Bay as well as into the Seekonk River.

Dissolved lead concentrations are shown in Figure II-5i. The highest values are found in the Seekonk and Providence Rivers. The West Passage has average lead concentrations twice those of the East Passage in the Lower Bay. Mount Hope Bay does not show the elevated levels of lead seen in upper Narragansett Bay.

We will consider the composition of suspended particulate matter in a subsequent section of this report, but it is useful to summarize the variations of total suspended matter (TSM) in the Bay at this point (Figure II-5j). For this purpose we have shown the TSM in the surface waters of the Bay (the upper 3 meters) to avoid consideration of variations in TSM due to tidal resuspension of bottom sediments. There is a consistent gradient in TSM down the Bay. The East Passage has lower concentration than the West Passage.

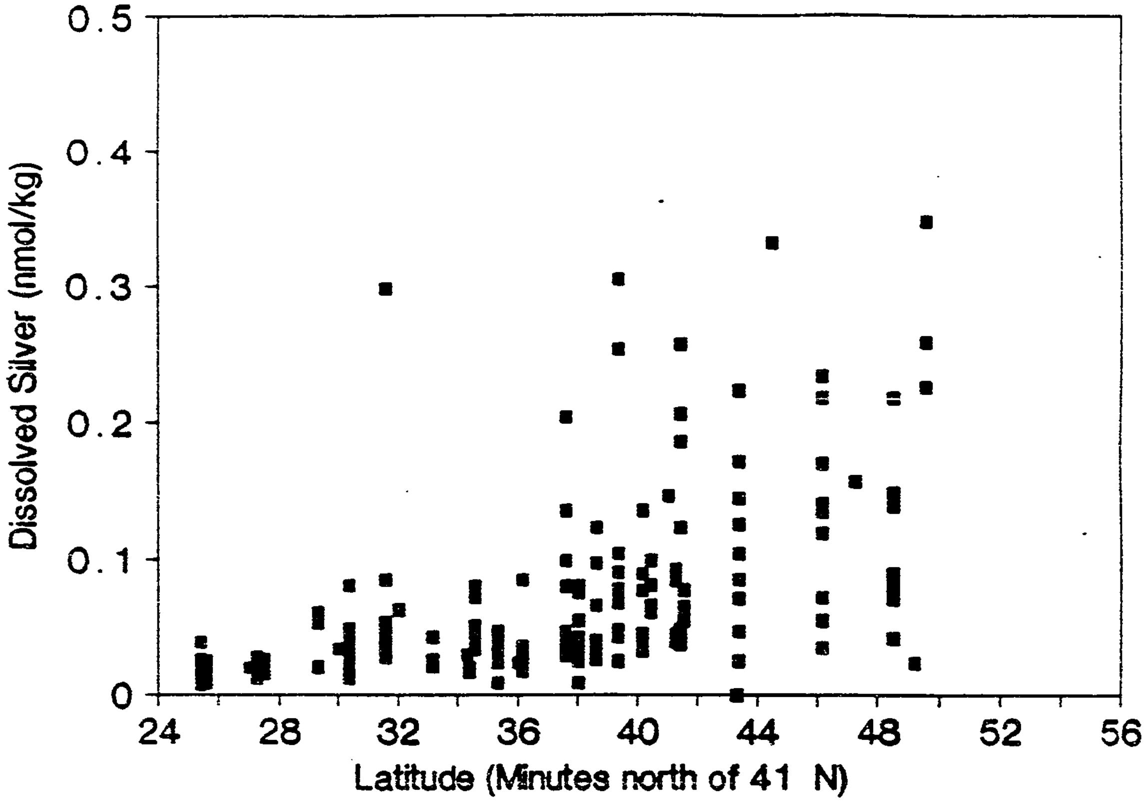
Figure II-5 shows the overall variations in dissolved metal concentrations in the Bay; it also shows the variability within each segment and the number of observations in the BAYMETAL database. In order to present spatial gradients down the Bay in a more quantitative fashion one would like to construct a plot of metal variation with latitude, which increases with increasing proximity to the head of the Bay. Such a plot is illustrated for silver in Figure II-6 (top). While a general trend is evident, there is a great amount of scatter. A concentration of 0.05 nmol/kg can be found almost throughout the entire length of the Bay, and at any one location the concentration varies by a factor three. Some of this variability may result from changes in the amount of silver entering the Bay at various times from pollution sources. An important factor in this variation, however, is shown in Figure II-6 (bottom). Salinity shows a large amount of variation within the Bay. Water of 28 permil can be found almost everywhere except the shallow and upper reaches of the Seekonk River. The variation in salinity is due to mixing induced by the ebb and flow of the tide. In order to characterize the spatial gradients down the Bay we need to remove the effect of salinity variability at each location.

The following procedure was used to remove the effects of salinity variations from the down-Bay gradient of metal concetrations. The BAYMETAL data were sorted according to salinity and the metal concentrations and latitude of each sample were averaged in 2 permil salinity intervals from 0 to 34 permil salinity. The average metal concentration versus average latitude for the 2 permil salinity intervals is shown in Figure II-7 a for Ag, Cd, Cu, and Ni. Silver and cadmium show monotonic decreases down the Bay with most of the gradient occurring in the upper 20 km (in the Seekonk-Providence River-Upper Bay segments). Copper and nickel show a different pattern down the Bay with the highest values occurring at about 41° 44'N. These maximum values are found near Field's Point where there is a significant input of these metals from the Narragansett Bay Commission sewage treatment plant that services Providence. A sharp gradient in Cu and Ni occurs south of the Providence River, but it appears that the waters in the entire West Passage have elevated concentrations of these metals compared to Rhode Island Sound.

4. Dissolved Metals versus Salinity

The relationship between metal concentrations and salinity is useful when examining the processes that control metals in an estuary. Variations in salinity provide an index of the amount of mixing between fresh water and seawater from outside the estuary. The salinity in Rhode Island Sound at the entrance of Narragansett Bay is typically 32 permil (Figure II-5a). The average salinity in the Providence River is 27 permil, which represents a mixture

Fig. II-6. Dissolved silver concentrations with distance down the west Passage from Providence to RI Sound (upper). Salinity versus distance in West Passage (lower).



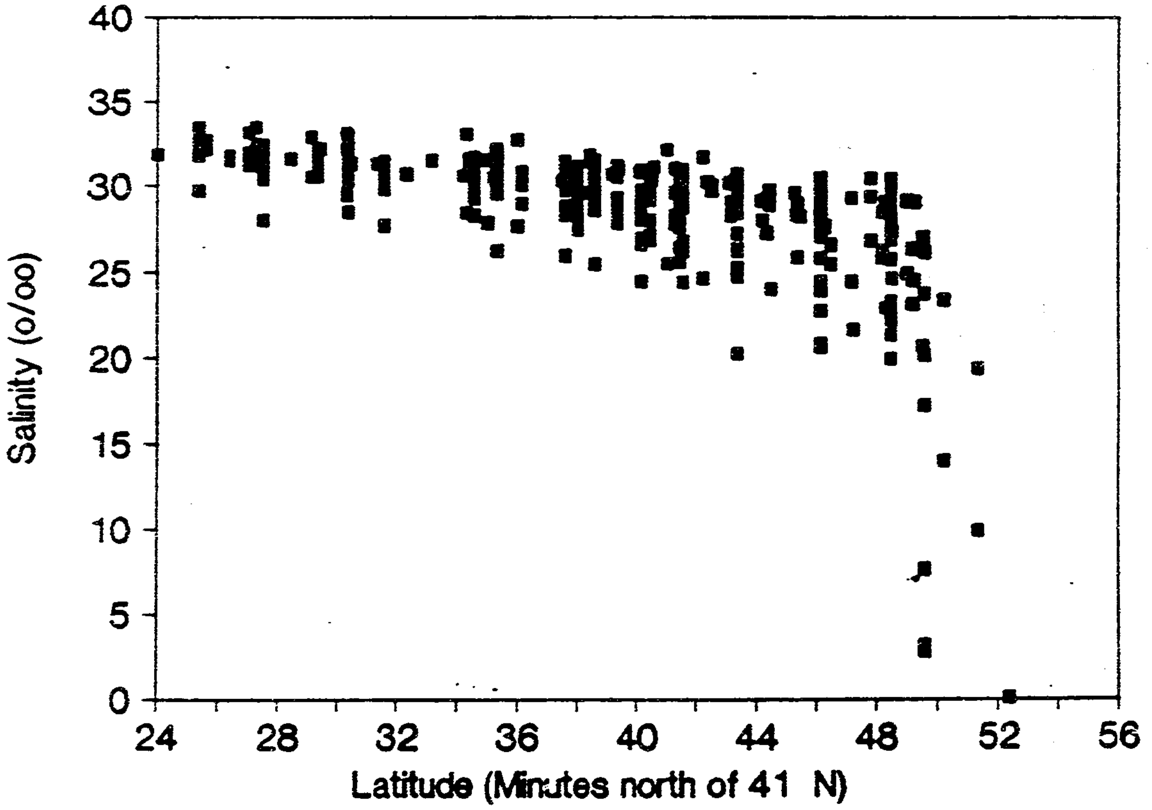
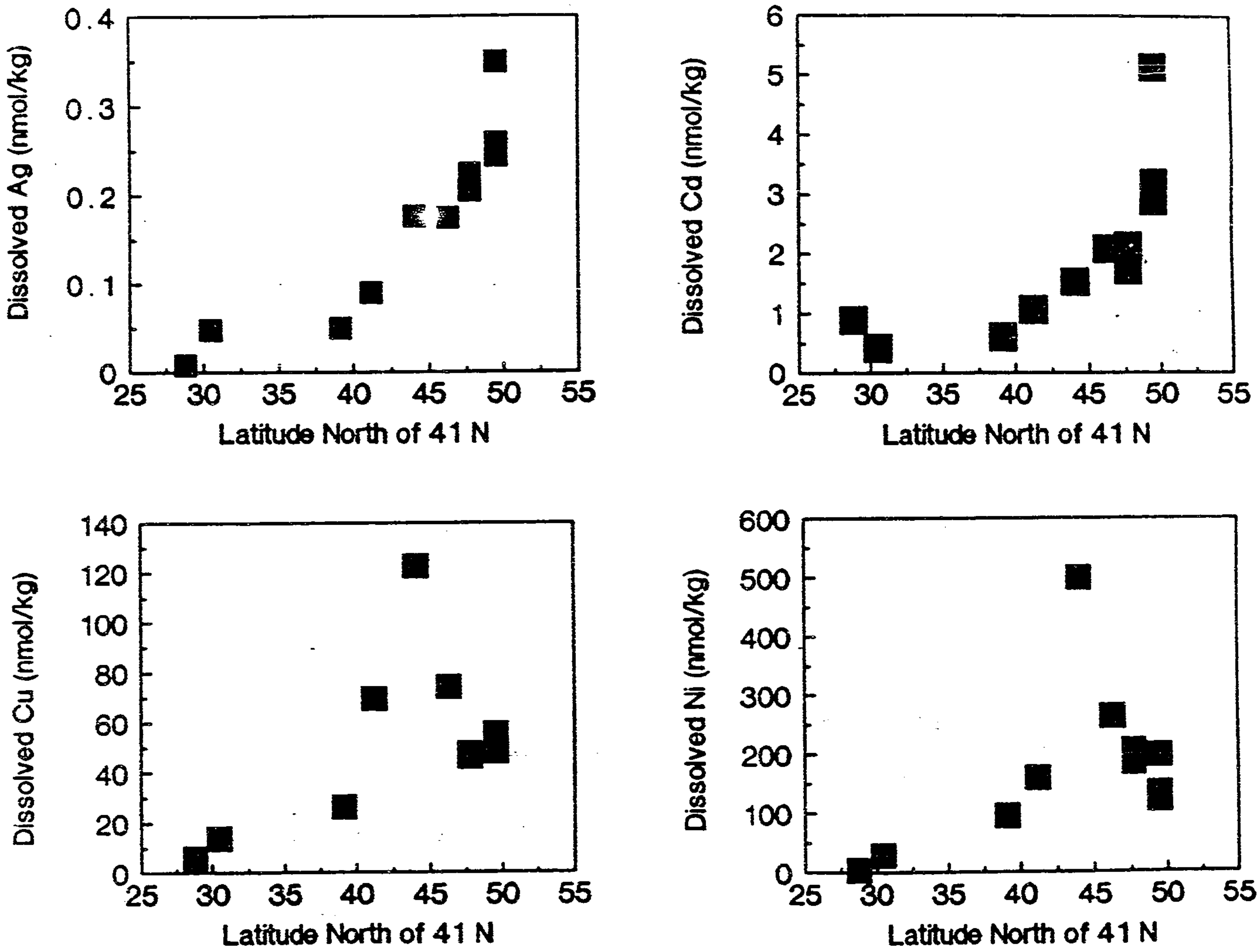


Fig. II-7 a. Dissolved metal concentrations down the Bay. The data were average in 2 o/oo salinity intervals from 0 to 36 o/oo and plotted at the average latitude, in minutes north of 41^{o} N, of each salinity interval.



that is 16% fresh water and 84% Rhode Island Sound seawater.

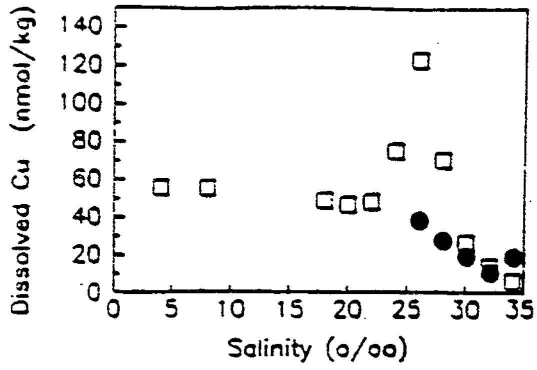
Figure II-7 b also shows plots of Cu, Pb, Ni, and total suspended matter (TSM) versus salinity. The concentrations for each constituent were separated into two groups: those from depths within the upper 3 meters of the water column and those from depths greater than 3 meters. The concentrations were then averaged in 2 permil salinity intervals; there are 11 such intervals for the surface waters and 5 salinity intervals for the deeper waters. One objective of this plot is to determine if the metal-salinity relationship differs between surface and deep waters. For samples from the upper 3 meters Cu, Pb, and Ni show maximum concentrations at about 26 permil salinity, which occurs mainly in the Providence River segment of the Bay. We conclude that the concentrations of each of these metals in the Bay is greatly affected by pollutant inputs of the upper Bay. For salinities less than 30 permil the surface waters have higher concentrations of Cu, Pb, and Ni than the waters from greater then 3 meters depth. The TSM shows a significant source at 26 permil salinity along with the three metals in Figure II-7 b; the TSM in deeper waters is probably influenced by tidal current resuspension of bottom sediments. The metal-salinity plots for Ag, Cd, Cr, and Fe are shown in Figure II-7 b. With the exception of the deep waters with a salinity of about 26 permil Ag shows a nearly linear relationship over a salinity range of 8 to 35 permil. Cadmium shows a linear relationship over the entire salinity range. Chromium is similar to Cu and Ni, but its maximum concentration occurs at 20 permil rather than 26 permil. This difference suggests that Cr has a different set of sources in Narragansett Bay than do the other metals that have mid-salinity maxima. The iron data in the Bay are quite limited; there appears to be a linear relationship in surface waters over the salinity range 24-35 permil, and deep waters have higher values, possibly due to resuspension of bottom sediments.

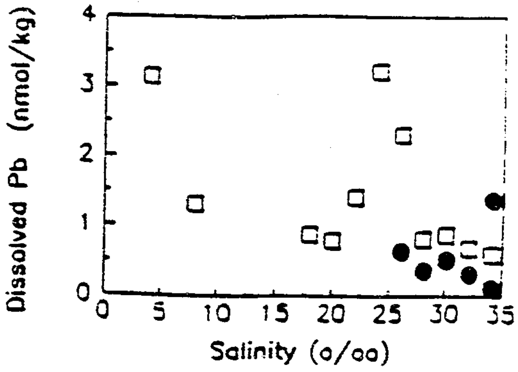
Figure II-7 b shows that a simple two member (freshwater-seawater) mixing model is not appropriate for Cu, Pb, Ni, and Cr variations in Narragansett Bay. If we consider the portion of the salinity mixing relationship above 26 permil salinity it appears that TSM concentrations in surface waters mix conservatively down the Bay (the relationship is linear), whereas Cu, Pb, and Ni show signs of removal from surface waters (the relationships are non-linear). For salinities less than 26 permil we see minimum concentrations in the range of 10-20 permil, indicating substantial removal processes from the water column in the Seekonk and Providence Rivers. This removal most likely includes the incorporation of metals into bottom sediments in that region.

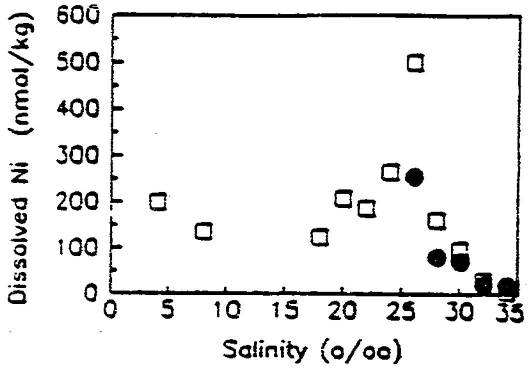
5. Metal composition of Particulate Matter in Narragansett Bay

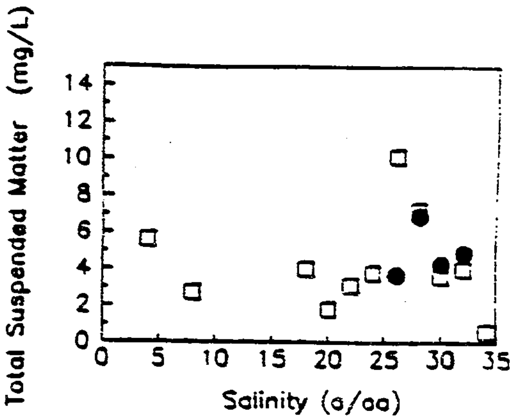
The preceding discussion of metals in the Bay has considered the dissolved fraction (that portion of each metal that passes through a 0.4 um filter). The particles retained by filtration also contain various amounts of metals. These particles may be of several types; they include small planktonic organisms, marine organic detritus, resuspended bottom sediments, mineral particles eroded from the land, and particulate wastes discharged to the Bay by sewage treatment plants and industrial discharges. The suspended particulate matter contains metals that are tightly bound in mineral crystals and in organic matrices; these tightly bound metals will not exchange readily with the dissolved forms of the metals in the water column. Metals can also be adsorbed on the surface of particles; this fraction of the particulate metal concentration can be transferred to and from the particles fairly rapidly. Adsorption and desorption can be important processes in the transport of metals in estuaries and can be important in the transfer of metals to the food web. Small sized particles, which tend to remain suspended in the water column longer than large particles,

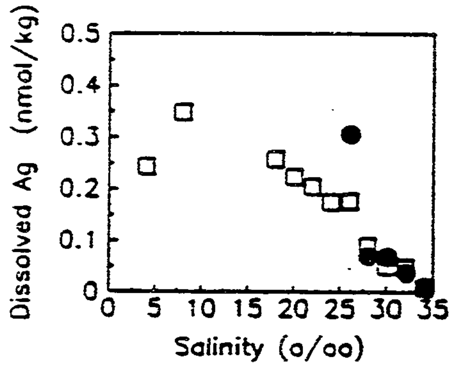
Fig. II-7 b. Dissolved metal-salinity plots through the Bay. Squares are for all samples from depths <= 3 m; solid dots are for depths > 3 m. The data were averaged in 2 o/oo salinity intervals.

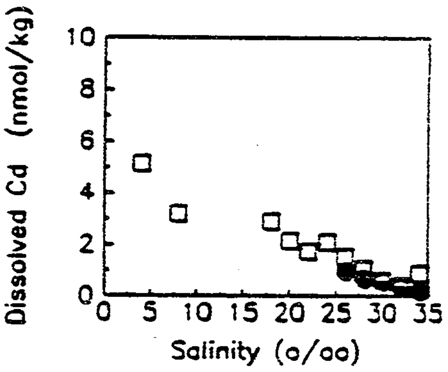

Dissolved Cu (nmol/kg)
140
120
100
80
60
40
20
0
0 5 10 15 20 25 30 35
Salinity (o/oo)

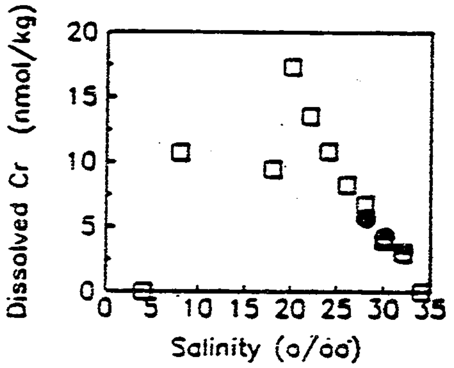

Dissolved Pb (nmol/kg)
4
3
2
1
0
0 5 10 15 20 25 30 35
Salinity (o/oo)

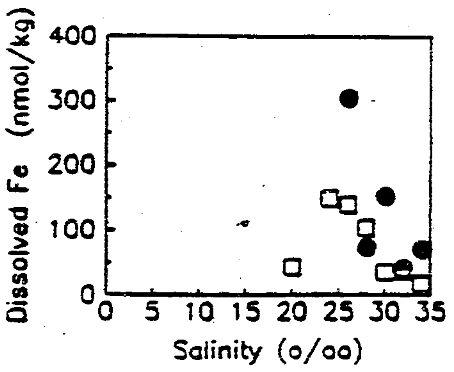

Dissolved Ni (nmol/kg)
600
500
400
300
200
100
0
0 5 10 15 20 25 30 35
Salinity (o/oo)


Total Suspended Matter (mg/L)
14
12
10
8
6
4
2
0
0 5 10 15 20 25 30 35
Salinity (o/oo)


Dissolved Ag (nmol/kg)
0.5
0.4
0.3
0.2
0.1
0
0 5 10 15 20 25 30 35
Salinity (o/oo)


Dissolved Cd (nmol/kg)
10
8
6
4
2
0
0 5 10 15 20 25 30 35
Salinity (o/oo)


Dissolved Cr (nmol/kg)
20
15
10
5
0
0 5 10 15 20 25 30 35
Salinity (o/oo)


Dissolved Fe (nmol/kg)
400
300
200
100
0
0 5 10 15 20 25 30 35
Salinity (o/oo)

are especially important for adsorption-desorption processes.

The BAYMETAL database contains values for particulate concentrations of a number of metals and for TSM. The simplest situation would be if the particles in Narragansett Bay were well mixed so that collections of such particles would have the same composition. If this were the case, there would be a good correlation between particulate metal concentrations in the water column and TSM; the differences among samples would reflect the number of particles per liter. As we will see, the Bay is not so simple. A more realistic expectation would be that there are at least two types of particles in the Bay, with each type having a characteristic composition. One type could be biogenic material (living and detrital) while the other could be mineral. Or alternatively, one could be the fine and less dense fraction while the other could be heavier and larger. The small particles would be transported through the Bay, and the settling particles would be deposited on the bottom of the Bay with occasional resuspension by tidal currents. A final complicating factor in particulate metal variations in the Bay is that some metal pollutants may enter the Bay in sufficient quantity to cause elevated concentrations for some of the particulate metals.

In order to sort out some of these factors we have plotted particulate metal concentration versus total suspended matter for those regions of the Bay least influenced by pollutant inputs. As suggested by the dissolved metal concentrations, the regions of the Bay where pollution sources are significant are not always the same for different metals. The Seekonk and Providence Rivers have high concentrations of all the metals examined. Silver is also high in Mount Hope Bay. Figure II-8 a shows plots of particulate nickel and particulate lead versus TSM in all sectors of the Bay except the Seekonk and Providence Rivers. A trend is evident, though there is quite a bit of scatter. The slope of a line describing the overall trend provides a measure of the typical composition of particulate matter in the Bay away from regions impacted by pollution sources. Table II-4 gives the composition of mid-and lower-Bay particulate matter.

Figure II-8 b shows plots of particulate metal concentrations in Narragansett Bay versus TSM. The symbol chosen for the plot identifies the segment of the Bay from which each value was obtained; a dashed line shows the relationship of particulate metal versus TSM based on lower Bay segments (Table II-5). The results show that particulate matter in segments 9 and 1 (the Seekonk and Providence Rivers) is enriched with Cu, Cr, Ni, Pb, Ag, and Cd relative to the TSM relationship in the lower Bay. The data for iron and manganese are sparse, but manganese is higher in lower Bay particulate matter than in particles found in segments 9 and 1. This difference may be the result of conversion of dissolved Mn to particulate down the estuary, and may also reflect the fact that Mn does not have as large a pollution source at the head of the Bay as do the other metals.

6. Sources of Metals to Narragansett Bay

There are a number of sources of metals to Narragansett Bay. Rivers bring metals to the Bay as a result of weathering processes on land and from the accumulation of discharges from industrial and municipal wastes. Sewage treatment plants discharge metals to the Bay in the effluents after removal of settleable solids and the decomposition of organic material. Some industries discharge metals to the Bay in point-source effluents. The tidal exchange of waters between the Bay and Rhode Island Sounds brings metals into the Bay and removes them from the Bay. Some metals enter the Bay from deposition of atmospheric particles. Metals enter the Bay from general runoff in the drainage basin including the urban runoff from populated areas and to a lesser extent the runoff from agricultural lands. More progress has been made in quantifying the point sources (rivers,

Table II-4

Typical values for the composition of particulate matter in Narragansett Bay. These values are based on the slope of particulate metal concentration versus total suspended matter concentration for those sections of the Bay least affected by riverine and pollution sources.

Metal	Concentration in Particles (nmol/mg)	Sections of the Bay Excluded in MeP-TSM Plots
Iron	220	9, 1, and 4
Copper	1.0	9, 1, and 2
Chromium	0.94	9, 1, and 2
Nickel	0.37	9 and 1
Lead	0.36	9 and 1
Silver	0.011	9, 1, 2, and 10
Cadmium	0.0062	9 and 1

Table II-5. Summary of freshwater inputs to segments of Narragansett Bay. U.S. Geolgical Survey river gauge stations are often located some distance upstream from the discharge to the Bay. Total drainage areas are from the mouth of the river; total flow is calculated by multiplying the gauged flow by the total area divided by the area of the watershed above the gauging point.

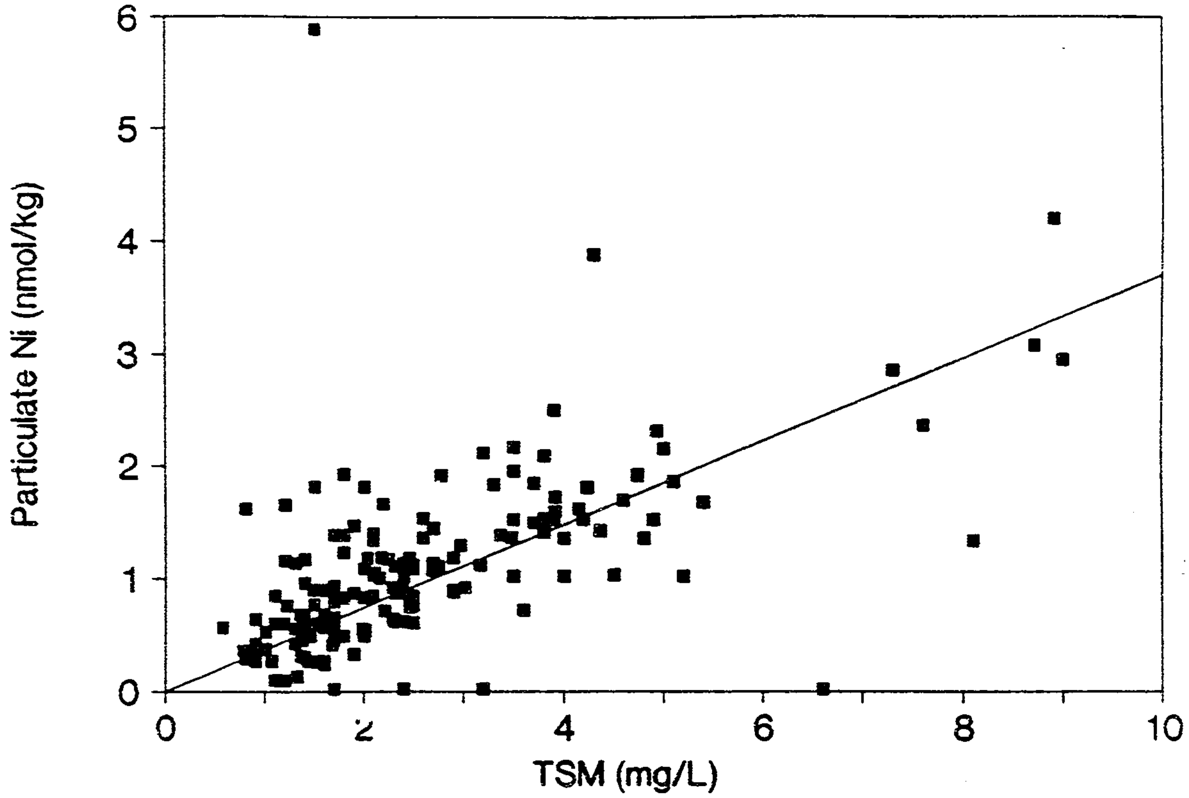
River	Segment	Gauged		Total	
		Area (km^2)	Flow (m^3s^{-1})	Area (km^2)	Flow (m^3s^{-1})
Taunton	10	668	13.6	1,197	24.4
Three-Mile	10	218	4.8	220	4.8
Segreganset	10	27	0.6	39	0.9
Blackstone	9	1,077	21.5	1,155	23.1
Ten-Mile	9	138		139	3.1
Rummins	9	11		11	
Pawtuxet	1	518	9.6	518	9.6
Woonasquatucket	1	124	2.0	124	2.0
Mohassuck	1	57	1.1	57	1.1
Palmer	2	11	0.2	123	2.2
Barrington	2	24		24	0.4
Potowomut	3				
Hunt	3	60	1.3	60	1.3
Frenchtown	4	19		19	

Total Narragansett Bay Drainage Area = 4,708 km^2
Total Area Accounted for = 3,686 km^2 or 78.3% of Total

Water input from Sewage Treatment Effluents:

Sector	Source	Flow	Sector	Source	Flow
			(m^3s^{-1})		(m^3s^{-1})
10	Fall River	1.05	3	East Greenwich	0.05
9	Bucklin Pt	0.99	4	Quonset Pt	0.04
1	Fields Pt	2.84	6	Bristol	0.09
1	East Prov.	0.32	7	Newport	0.43
2	Warren	0.09	7	Jamestown	0.03

Fig. II-8 a. Particulate nickel and particulate lead vs. Total Suspended Matter. Note that, in these plots, the scales are expanded relative to those in Fig. II-8 b.



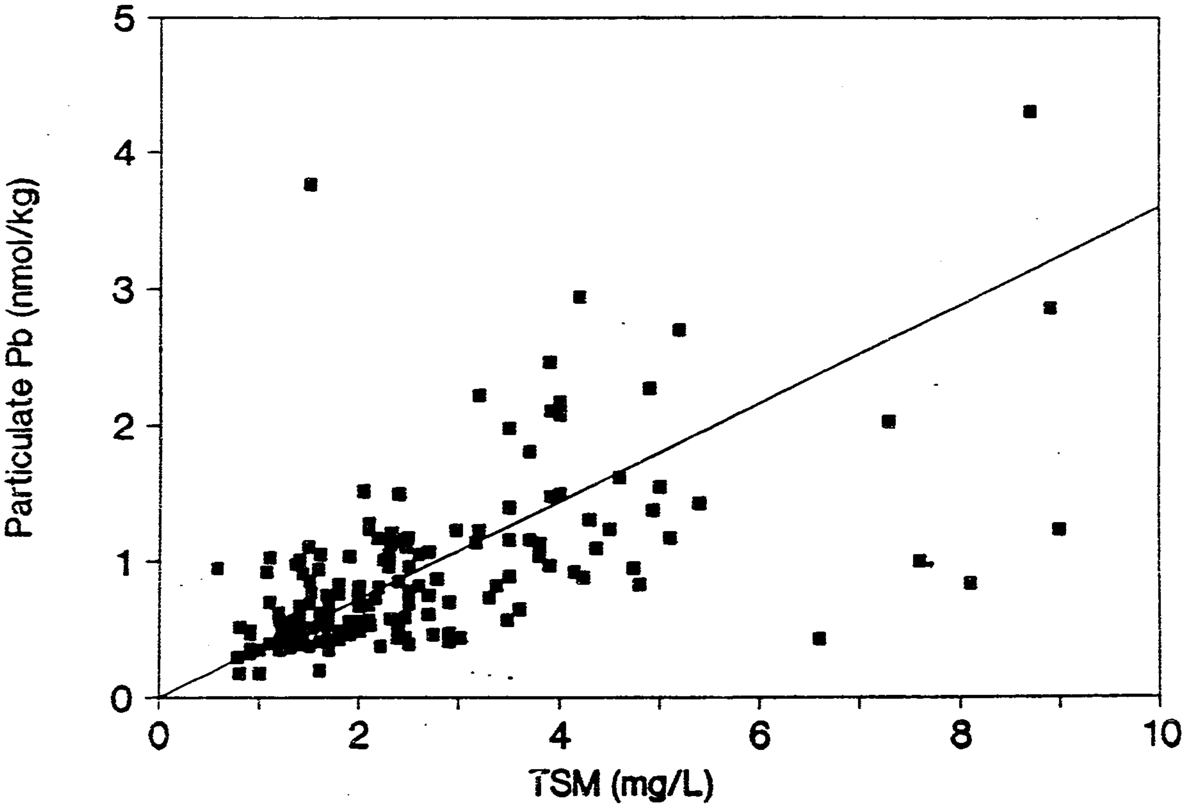
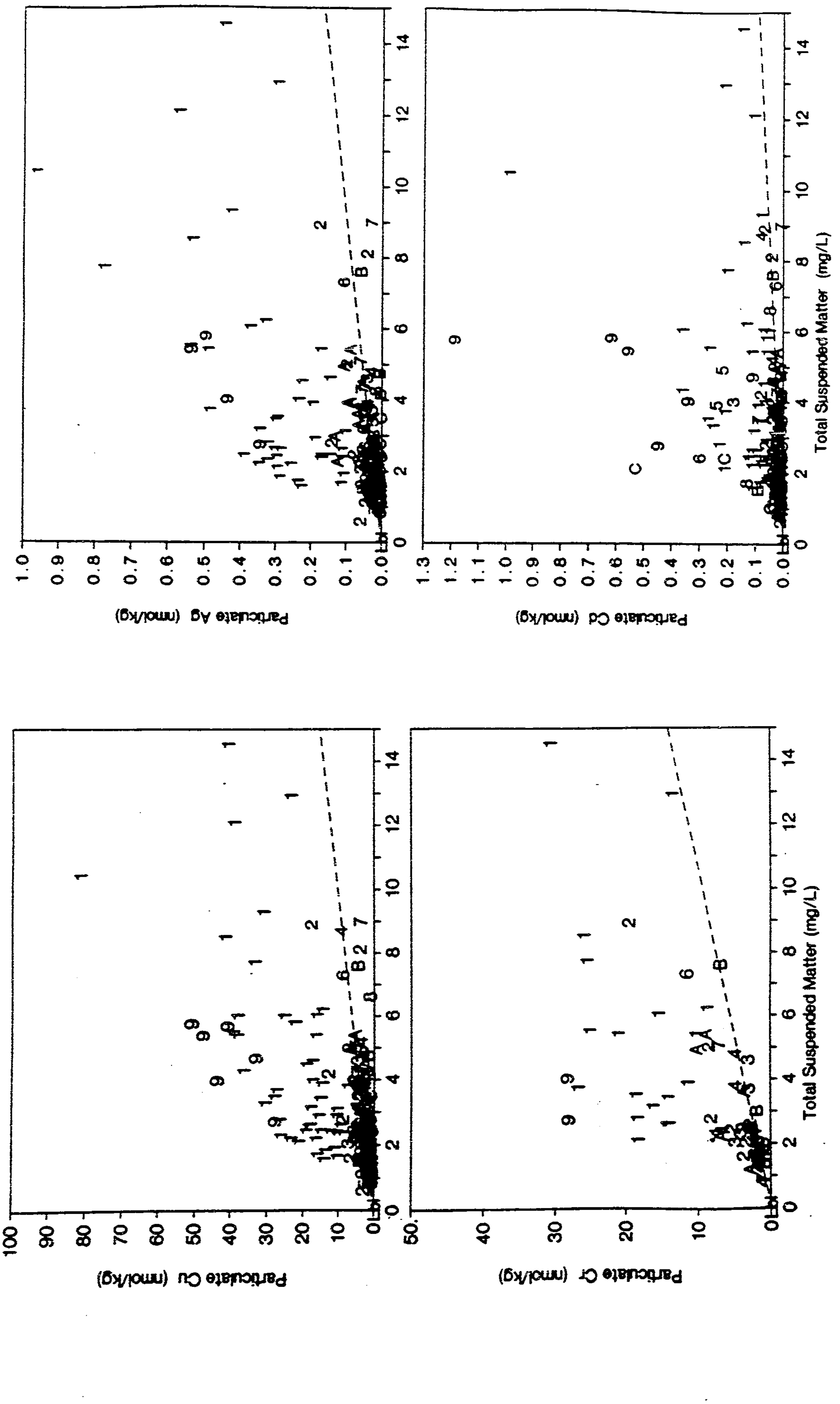
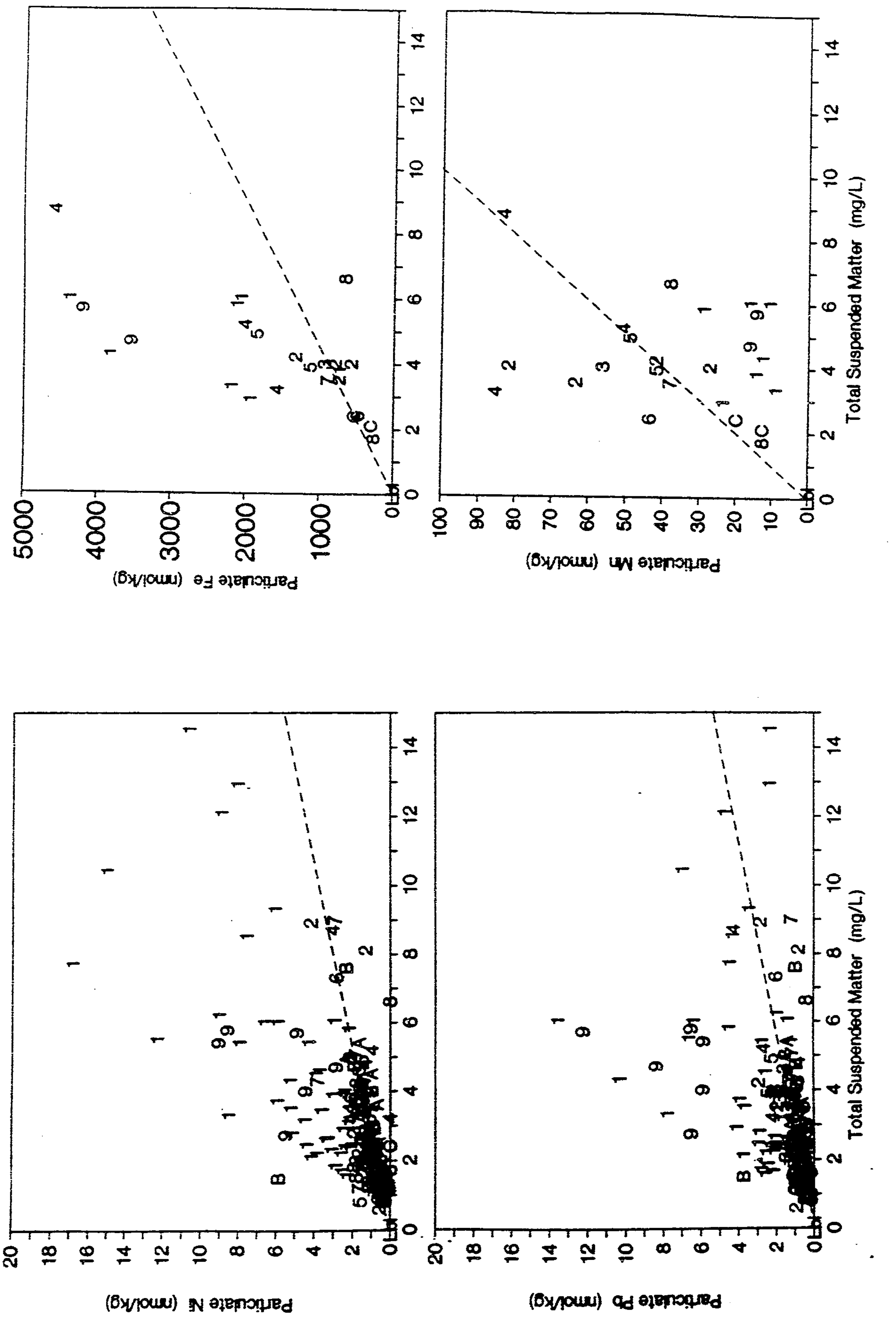


Fig. II-8b. Variation of particulate metal concentrations in the Bay with Total Suspended Matter (TSM) concentrations. The plotting symbol is the sector number from which the sample was collected (1-9, A=10, B=11, C=12). The dashed line is based on the slope of the particulate metal-TSM correlation for the Lower Bay sectors (see Table II-4).


Particulate Ag (nmol/kg)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Particulate Cd (nmol/kg)
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Particulate Cu (nmol/kg)
100
90
80
70
60
50
40
30
20
10
0
Particulate Cr (nmol/kg)
50
40
30
20
10
0
0
2
4
6
8
10
12
14
Total Suspended Matter (mg/L)


Particulate Fe (nmol/kg)
0
1000
2000
3000
4000
5000
Particulate Mn (nmol/kg)
0
10
20
30
40
50
60
70
80
90
100
Particulate Ni (nmol/kg)
0
2
4
6
8
10
12
14
16
18
20
Particulate Pb (nmol/kg)
0
2
4
6
8
10
12
14
16
18
20
Total Suspended Matter (mg/L)
0
2
4
6
8
10
12
14

sewage treatment facilities, industrial effluents) of metals to the Bay than the diffuse inputs (runoff and atmospheric deposition).

Identifying all the sources of freshwater and metals to Narragansett Bay is not a simple task. Pilson (1985) presented one of the first attempts to compile a total budget of water entering the Bay. Table II-5 lists the sources of water into the Bay from rivers and from wastewater treatment facilities. The flow for the larger rivers is gauged, often at points considerably upstream from the discharge into the Bay. For our purposes we would like to have data (flow and chemical composition) at the mouth of each river. When this was not available we have used the area of the drainage basin above the mouth of the river along with the gauged flow and gauged area to calculate total flow. This calculation assumes that river input is proportional to drainage area. About 92.5% of the freshwater entering the Bay comes through rivers and about 7.5% comes through sewage treatment plants (Table II-5).

Table II-6 summarizes a set of analyses during 1985-1986 for the major rivers entering the Narragansett Bay system. There are fairly large variations in the concentration of a given metal in each river, and some differences among the rivers. Four of the rivers (Blackstone, Moshassuck, Woonasquatucket, and Pawtuxet) deliver much of the freshwater into the Seekonk and Providence River regions of Narragansett Bay.

During the SINBADD study samples were collected and analyzed for metals from the effluents of sewage treatment plants throughout the Bay. These data are listed in Table II-7. Pilson and Hunt (1989) suggested that some of the large differences between the October 1985 data and subsequent values (e. g. Ag, Ni and Pb) may be due to analytical factors. These data were provided by the Narragansett Bay Commission and were not analyzed by the SINBADD investigators who did the water column measurements. Additional data for waste water treatment facility (WWTF) effluents are given in Table II-8. These data were obtained from the files at the R. I. Department of Environmental Management. As in the case of the rivers there is considerable variability from month to month.

The data for rivers and sewage treatment plant effluents have been used to estimate typical values for the amount of metals entering the Bay from these sources during 1986 (Table II-9). While sewage treatment plants contribute only 7.5% of the freshwater input to the Bay, they account for more than 80% of the dissolved silver, chromium, copper, and nickel entering the Bay. While there are gaps in the data shown in Table II-9 it is evident that Field's Point is a major source of Ag, Cu, Ni and Pb to the Bay. The Blackstone River also contributes a significant portion of dissolved lead. The Blackstone and Taunton Rivers are important sources of Cd. The Blackstone Valley WWTF appears to be a major source of Cr.

This analysis of metals data in Narragansett Bay identifies regional variations among the eleven sectors (plus Rhode Island Sound). While some issues of water quality management may treat the Bay as a whole, others may require input assessment on a regional basis. For example, it may not be useful to consider metal inputs from the Taunton River to Mount Hope Bay in evaluating metal inputs to the Providence River and Seekonk River sectors of the Bay. In compiling Table II-9 data were not available for all possible sources. Inputs from non-point sources were not available. The 1986 WWTF data did not include the loading input of metals from the East Providence WWTF. Hunt and Pilson (1989) summarized municipal sewage treatment plant effluent data for the period of the SINBADD cruises. The East Providence WWTF effluent flow rate ranged from 9% to 14% of the Fields Point WWTF effluent flow rate, and in nearly all cases the East Providence metals concentrations were less than those of Fields Point (Hunt and Pilson, 1989). Consequently, the lack of East Providence WWTF data for Sector 1 in Table II-9 will not change the overall results substantially. Additional data are needed for a complete metals input assessment. The data sets used to compile Table II-9 did not include metals input for the Ten-Mile, Potowomut, and Hunt Rivers.

Another problem that arises in constructing an assessment of metal loading that includes rivers and WWTF inputs is that dissolved and particulate phases in rivers and sewage effluents are not directly comparable. Rivers generally contain large quantities of metals in particulate mineral phases that contribute sediment to the estuary, but are not geochemically reactive in the marine environment on the short time scales of estuarine mixing. The particulate fraction of WWTF discharges, on the other hand, are largely associated with organic detritus that can decompose and contribute metals to the estuarine geochemical cycle. The loading in Table II-9 is presented as dissolved metal inputs, because they do not include the particulate fraction of the river inputs. The particulate fraction of the WWTF inputs, however, were included because these metals can participate in estuarine geochemical cycling. In order to account for the differences in the nature of river borne particulate metals and WWTF effluent particulate metals, we would need information of the transformations within the estuary of dissolved and particulate phases associated with river and WWTF inputs to Narragansett Bay.

While there are definite limitations in our ability to specify metal loadings to the Bay based on the available data, Table II-9 provides a preliminary assessment and illustrates the gaps in the existing information. Pilson and Hunt (1989) provided an assessment of the metals loading to the Providence River during the four SINBADD cruises and presented similar conclusions concerning the relative magnitudes of river and WWTF inputs.

7. Temporal Trends of Metals in the Bay

During the past 15 years there have been increasing efforts and expenditures to reduce contaminant input to Narragansett Bay. Have these actions led to improvements in the water quality of the Bay and to reductions in metal concentrations?

There are two major groups of data contained in BAYMETAL. One set was obtained independently by Bender, by Quinn, by Cullen, and by Hunt in 1977-1980 and the other set was obtained by the SINBADD sampling in 1985-1986. There are four metals for which the data are sufficient to test whether or not their concentrations have changed over this time period. Figure II-9 shows a plot of dissolved copper versus salinity with the pre-1981 data plotted as alphabetic labels (indicating the investigator) and the 1985-86 data plotted as open boxes. The data suggest a four-fold decrease in the maximum copper

Table II-6. Concentrations of dissolved (D) and total (T) metals in rivers entering Narragansett Bay. The concentrations are in nmol/kg. The first three entries for the Blackstone River are from Quinn (1987); the first three entries for the Pawtuxet River are from Quinn et al. (1985); the remaining data are from the SINBADD data reports.

Taunton River Date	Flow m3/s	Salt	AgD	AgT	CdD	CdT	CrD	CrT	CuD	CuT	NiD	NiT	PbD	PbT
22-Oct-85	--	25.90	--	--	6	6	--	--	39	42	79	221	--	--
19-Nov-85	17.8	17.77	--	--	8	7	--	--	39	66	92	108	--	--
08-Apr-86	15.0	0.03	--	--	1	2	10	17	49	55	31	31	5	11
20-May-86	5.0	0.77	--	--	1	1	15	32	60	65	41	48	4	33
Blackstone River														
08-Jul-85	23.6	--	--	0.6	2	3	--	58	126	154	269	273	--	--
20-Aug-85	19.3	--	--	0.7	3	5	25	73	101	148	348	358	--	--
08-Oct-85	44.3	--	--	0.9	8	11	40	202	145	239	409	460	9	44
24-Oct-85	12.3	0.04	--	--	10	13	22	44	96	147	211	215	5	13
20-Nov-85	42.9	0.03	--	--	11	18	18	48	125	157	146	166	4	16
09-Apr-86	28.0	0.02	--	--	8	9	19	34	79	101	130	146	4	12
21-May-86	10.0	0.05	--	--	5	8	18	34	105	134	397	494	10	49
Mohassuck River														
23-Oct-85	0.2	0.15	0.26	0.3	3	2	14	27	59	88	158	166	6	17
20-Nov-85	1.7	0.05	--	--	2	11	24	31	101	122	75	77	11	17
09-Apr-86	1.1	0.06	--	--	2	3	9	20	87	150	39	40	9	36
21-May-86	0.5	0.07	--	--	1	3	14	31	87	186	60	61	8	28
Woonasquatucket River														
23-Oct-85	--	3.30	--	--	4	4	--	--	282	504	1465	1244	--	--
20-Nov-85	--	0.03	--	--	1	1	56	47	39	51	89	92	4	14
09-Apr-86	2.0	0.74	--	--	2	3	113	123	139	184	211	239	9	29
21-May-86	0.8	0.99	0.21	0.2	1	2	79	115	81	149	170	223	6	29
Pawtuxet River														
7-Jun-83	--	--	--	1.8	82	84	10	38	235	470	680	680	33	50
2-Aug-83	--	--	--	0.2	4	4	23	38	140	190	340	360	12	24
10-Sep-84	--	--	--	0.9	12	18	8	38	315	360	410	410	4	14
24-Oct-85	2.9	0.31	--	--	21	20	12	16	175	197	527	556	4	12
20-Nov-85	19.3	0.01	--	--	1	1	6	13	78	123	155	166	4	12
09-Apr-86	10.0	0.04	--	--	9	11	6	13	118	163	247	280	5	13
21-May-86	6.0	0.09	0.44	0.5	5	8	8	24	130	231	300	411	4	9

Table II-7. Metal data for sewage treatment plant effluents during the SINBADD series (from Pilson and Hunt, 1989, Table A-10, NA is not analyzed).

Facility	Date	Flow	Metals in nmol/kg					
		m3/s	AgT	CdT	CuT	CrT	NiT	PbT
Blackstone Valley	Oct 21-24, 1985	NA	1001	133	551	<173	3834	1197
	Nov 18-21, 1985	0.88	<93	18	692	750	2317	<87
	Apr 7-10, 1986	1.01	<65	107	<330	884	1602	<140
	May 19-22, 1986	1.09	<65	<44	2816	788	988	<140
Bristol	Oct 21-24, 1985	NA	844	302	<157	<173	699	738
	Nov 18-21, 1985	0.14	<93	27	724	192	85	<87
	Apr 7-10, 1986	0.09	<65	<44	<330	<173	<256	<140
	May 19-22, 1986	0.06	139	71	708	1057	<256	<140
East Greenwich	Oct 21-24, 1985	NA	1400	151	771	<173	1465	1602
	Nov 18-21, 1985	0.05	<93	18	2312	461	596	883
	Apr 7-10, 1986	0.05	<65	44	4059	1384	460	372
	May 19-22, 1986	0.05	<65	<44	2816	788	988	<140
Fields Point	Oct 21-24, 1985	2.28	1075	205	10571	788	11774	1284
	Nov 18-21, 1985	2.37	<93	27	5459	1865	613	174
	Apr 7-10, 1986	2.67	<65	<44	5160	981	5197	<140
	May 19-22, 1986	4.03	<65	<44	2910	1538	10632	<140
East Providence	Oct 21-24, 1985	0.21	797	142	157	<173	2828	1144
	Nov 18-21, 1985	0.33	<93	27	330	404	1090	<87
	Apr 7-10, 1986	0.37	<65	<44	<330	<173	<256	<140
	May 19-22, 1986	0.35	<65	<44	<330	423	1022	<140
Fall River	Oct 21-24, 1985	1.01	1057	187	<157	<173	1073	1660
	Nov 18-21, 1985	1.12	<93	18	834	231	324	179
	Apr 7-10, 1986	1.09	<65	44	<330	558	<256	<140
	May 19-22, 1986	0.99	<65	<44	661	654	<256	<140
Newport	Oct 21-24, 1985	0.50	1075	258	<157	<173	1125	1260
	Nov 18-21, 1985	0.37	<93	53	944	423	239	125
	Apr 7-10, 1986	0.53	<65	222	1101	1500	<256	<140
	May 19-22, 1986	0.31	<65	151	881	1115	<256	294
Warren	Oct 21-24, 1985	0.06	510	205	456	<173	1176	1110
	Nov 18-21, 1985	0.12	<93	<18	1133	231	1227	179
	Apr 7-10, 1986	0.10	<65	<44	1526	192	<256	<140
	May 19-22, 1986	0.07	<28	<27	2564	308	682	<193
Jamestown	Oct 21-24, 1985	NA	NA	NA	NA	NA	NA	NA
	Nov 18-21, 1985	0.05	<65	80	<330	<173	<256	<140
	Apr 7-10, 1986	0.02	<65	<44	<330	<173	<256	<140
	May 19-22, 1986	0.01	<65	<44	<330	269	<256	<140
Quonset Point	Oct 21-24, 1985	NA	NA	NA	NA	NA	NA	NA
	Nov 18-21, 1985	0.07	<65	89	645	1538	2096	<193
	Apr 7-10, 1986	NA	NA	NA	NA	NA	NA	NA
	May 19-22, 1986	0.03	<28	<27	2360	865	886	<193

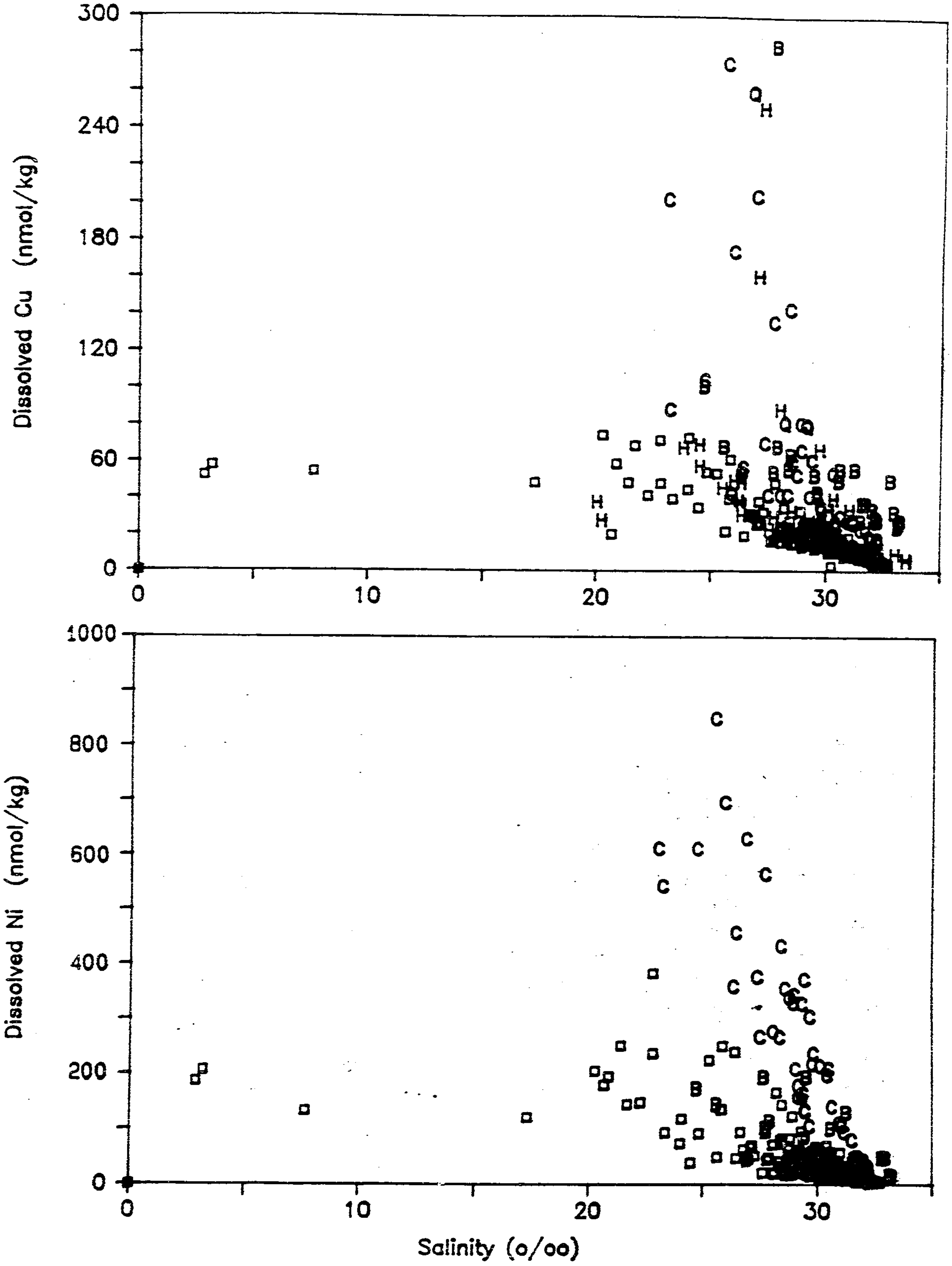
Table II-8. Metal concentrations in the effluent from Wastewater Treatment Facilities entering Narragansett Bay. Data are from RI Dept of Environmental for the year 1986.

						(nmol/kg)					
Facility	Month	Flow	TSS	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Zn
		(m3/s)	(mg/L)								
Blackstone Valley	1	0.71	47.9	--	4788	2014	--	--	2914	--	--
	2	0.91	43.9	--	--	--	--	--	--	--	--
	3	0.95	31.0	--	--	--	--	--	--	--	--
	4	0.87	38.9	--	--	--	--	--	--	--	--
	5	0.84	51.9	--	--	--	--	--	--	--	--
	6	0.93	55.0	--	14478	2045	--	--	3663	--	--
	7	0.87	40.2	--	--	--	--	--	--	--	--
	8	0.94	63.3	--	--	--	--	--	--	--	--
	9	0.83	42.6	--	2615	1620	--	--	2062	--	--
	10	0.82	45.5	--	--	--	--	--	--	--	--
	11	0.86	82.9	--	--	--	--	--	--	--	--
	12	1.14	32.9	--	--	--	--	--	--	--	--
Bristol	1	0.1[illegible]	41.2	--	--	--	--	--	--	--	--
	2	0.14	39.8	--	--	--	--	--	--	--	--
	3	0.12	42.0	<5	<50	944	<50	<.5	2215	93	979
	4	0.08	97.0	--	--	--	--	--	--	--	--
	5	0.07	37.0	--	--	--	--	--	--	--	--
	6	0.06	45.0	<5	<50	1573	<50	<.5	<40	<10	3518
	7	0.06	64.5	--	--	--	--	--	--	--	--
	8	0.06	55.0	--	--	--	--	--	--	--	--
	9	0.05	60.0	<5	<50	1888	<50	<.5	<40	<10	1682
	10	0.07	61.0	--	--	--	--	--	--	--	--
	11	0.09	48.0	--	--	--	--	--	--	--	--
	12	0.18	31.7	<5	<50	944	<50	<.5	<10	<100	1835
East Greenwich	1	0.03	36.0	178	192	2360	917	2.5	682	93	5812
	2	0.04	30.0	44	192	--	579	2.5	682	93	2447
	3	0.04	53.0	44	385	2045	724	2.5	682	93	3212
	4	0.03	97.0	44	577	2045	965	2.5	682	93	2172
	5	0.03	43.0	142	385	3146	531	--	682	93	3518
	6	0.03	42.0	44	961	2360	241	2.5	682	93	1377
	7	0.03	67.0	1779	1346	1416	627	2.5	682	93	1071
	8	0.03	43.0	44	961	2360	241	2.5	682	93	1530
	9	0.03	51.0	44	1346	2202	434	2.5	682	93	1682
	10	0.03	84.5	44	961	2832	579	2.5	682	93	2141
	11	0.03	44.0	44	2884	2989	531	2.5	682	185	3518
	12	0.04	36.0	44	2115	1258	241	2.5	852	93	6577
Field's Point	1	2.04	45.0	27	577	7755	159	2.0	9048	102	7801
	2	2.28	33.0	18	865	6827	193	--	7906	380	9315
	3	2.27	--	27	538	7362	338	--	5606	445	413
	4	2.12	30.0	27	519	6355	159	19.9	6730	65	765
	5	2.02	33.0	53	308	4483	169	1.5	9542	278	8305
	6	2.19	65.0	53	--	15463	473	5.0	19083	56	16825
	7	2.27	31.0	71	--	5097	473	1.0	10462	241	10141
	8	2.41	25.0	133	--	4090	642	8.5	9746	185	8841
	9	2.20	55.0	80	--	7047	169	4.0	11194	260	15142
	10	1.97	66.0	116	--	9895	574	1.1	9508	371	13001
	11	2.10	67.0	53	--	12223	425	2.0	8792	306	16825
	12	3.16	49.0	205	--	10776	907	1.0	10973	612	12879

Table II-9. Summary of metal inputs to Narragansett Bay from rivers (dissolved fraction only) and from wastewater treatment facilities (dissolved plus particulate). The values are based on the 1986 WWTF data (Table II-8) with annual average flow rates and flow weighted averages for the rivers (Table II-6).

Source	Flow m^3s^{-1}	Loading (moles/day)						Percent of Total for Each Source					
		Ag	Cd	Cr	Cu	Ni	Pb	Ag	Cd	Cr	Cu	Ni	Pb
Segment 9: Seekonk River													
Blackstone River	25.8	0.200	1.60	5.0	26.0	9.0	6.0	3	40	7	12	4	35
Ten-Mile River	--	--	--	--	--	--	--	-	-	-	-	-	-
Blackstone Valley WWTF	0.9	--	--	55.0	13.0	21.0	--	-	-	75	6	8	-
Segment 1: Providence River													
Pawtuxet River	9.6	0.02	0.40	0.6	9.0	19.0	1.0	0	10	1	4	8	6
Woonasquatucket River	1.4	0.001	0.02	1.2	1.5	2.4	0.4	0	1	2	1	1	2
Moshassuck River	0.9	<0.001	0.01	0.1	0.7	0.5	0.2	-	0	0	0	0	1
Fields Point WWTF	2.3	5.60	1.50	10.0	160.0	190.0	8.0	94	38	14	74	76	47
Segment 3: Upper West Passage													
Potowomut River	--	--	--	--	--	--	--	-	-	-	-	-	-
Hunt River	--	--	--	--	--	--	--	-	-	-	-	-	-
East Greenwich WWTF	0.03	0.030	0.06	0.3	0.6	0.2	0.2	1	2	0	0	0	1
Segment 6: Upper East Passage													
Bristol WTTF	0.09	0.09	--	--	1.0	2.0	--	2	-	-	0	1	-
Segment 10: Mount Hope Bay													
Taunton River	12.6	--	0.40	1.0	5.0	6.7	1.4	-	10	1	2	3	8
Total Loading		6	4	73	217	251	17	100	100	100	100	100	100
% Rivers		4%	61%	11%	20%	15%	52%						
% WWTF		96%	39%	89%	80%	85%	48%						

Fig. II-9. Dissolved metals versus salinity. The squares are samples collected in 1985-1986 (SINBADD). The letters are from samples collected prior to 1981 (Bender, 1977; Cullen, 1978; Hunt, 1980; Quinn, 1980).



concentration observed in the 25-27 permil salinity range (typically in the Providence River). In the lower Bay the difference may be about 10-30 nmol/kg. BAYMETAL includes one sample obtained by Cullen in January 1978 with a dissolved copper concentration of 1,228 nmol/kg; this sample was collected in the boil produced above the Field's Point discharge pipe in the Providence river. This sample was not included in the analysis of this section.

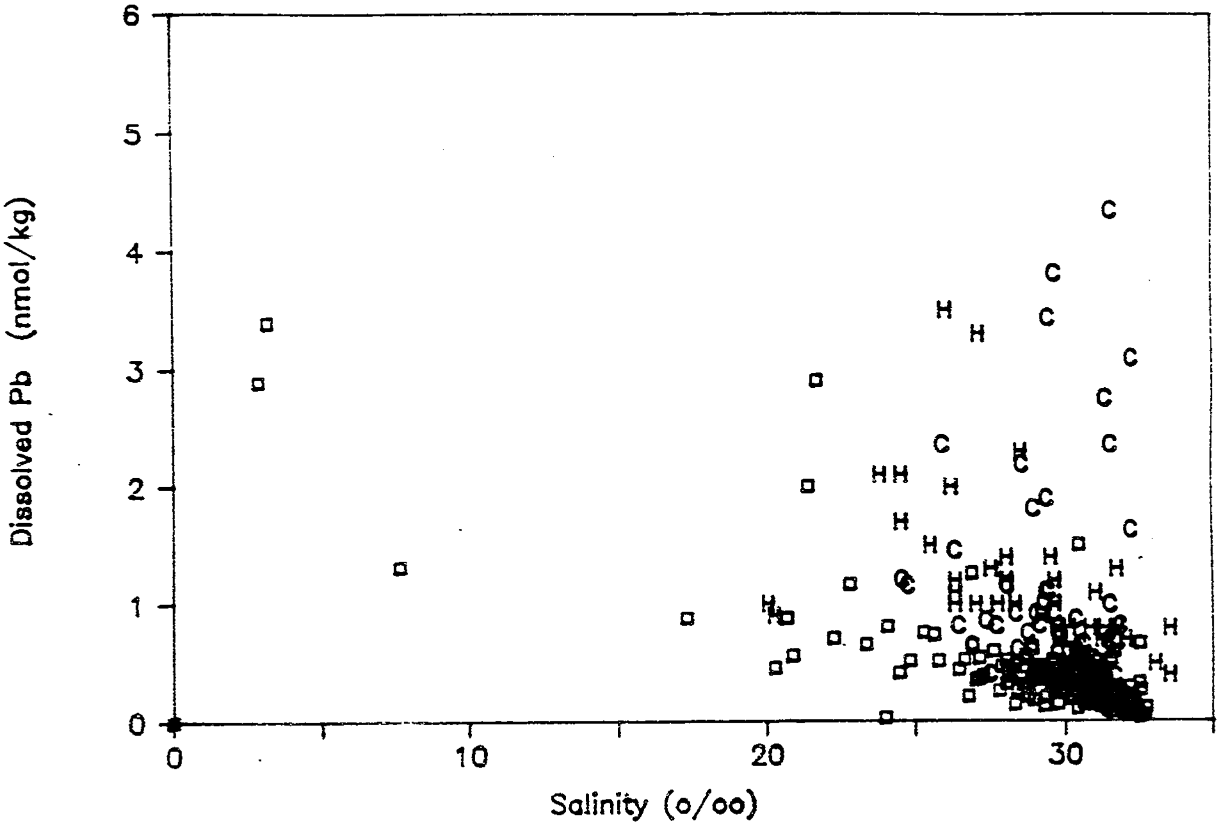
In making a comparison of this type one is always concerned about the analytical reliability of data from different investigations and time periods. There was a major re-evaluation of seawater trace metal analytical procedures in the mid to late 1970's, as analysts became more aware of the problems associated with contamination during sampling and processing of seawater. Several factors support the view that the difference in the pre-1981 and the more recent data is due to a real decline in standing stocks of trace metals in the Bay, rather than analytical errors. At low copper concentrations and high salinities, where contamination and analytical errors in the earlier measurements would be most noticeable, the two sets of data converge to within 10 nmol/kg. The large difference between the two sets of data is seen in the salinity range most influenced by pollution sources in the Providence River. The very high concentrations (greater than 120 nmol/kg) which were never seen in the SINBADD series were found by all four earlier investigations. This earlier set included samplings during January, February, March, May, August, September, and October whereas SINBADD sampling occurred in April, May, October, and November. It is unlikely that seasonal factors would have caused SINBADD to miss the very high concentrations if they were present in 1985-86.

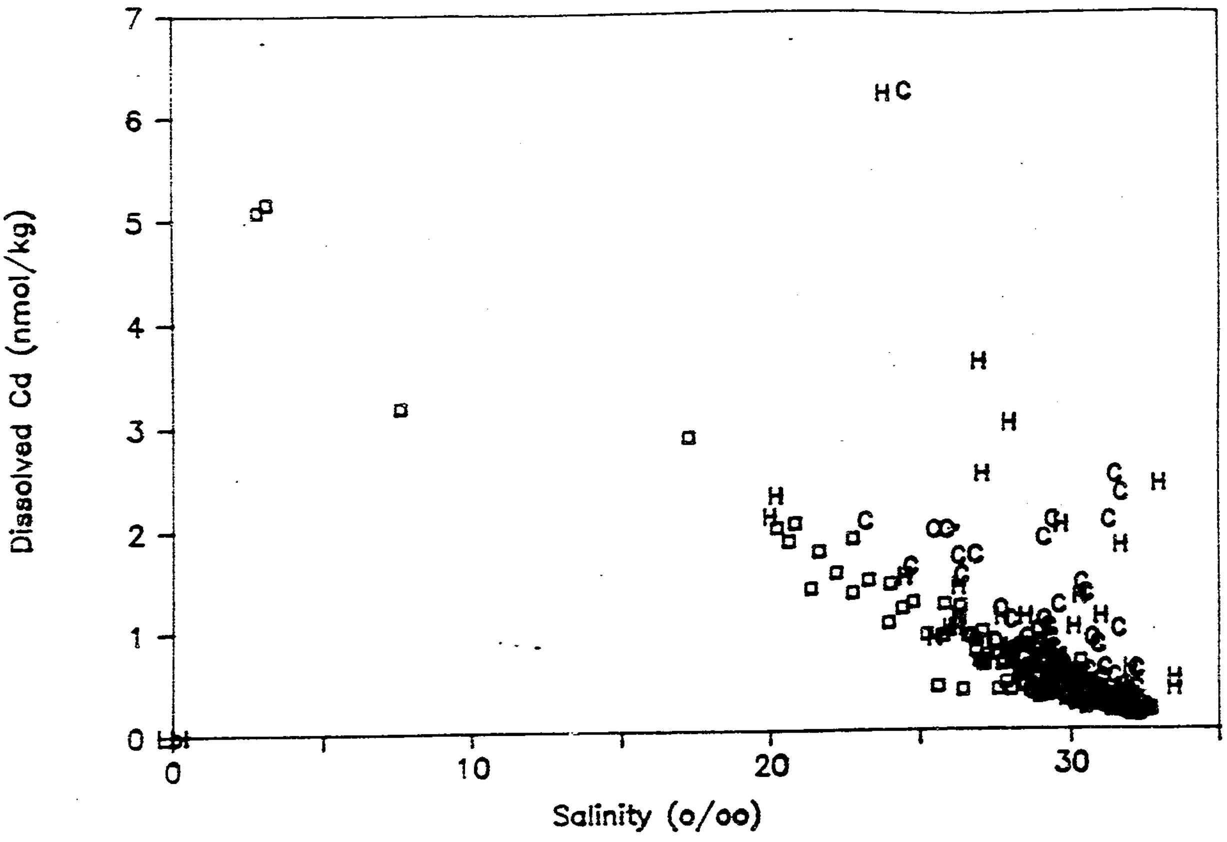
Figure II-9 shows a comparison of the early and the recent data for nickel in the Bay. Cullen found nickel concentrations about twice those seen by SINBADD in the salinity range 23-30 permil. Cullen's values agree with the SINBADD values at high salinity. We saw in previous sections that Cu and Ni have large inputs from sewage treatment effluents--especially Field's Point. Both metals show a similar pattern in this comparison of early and recent Bay concentrations. Silver and chromium also show large inputs from sewage treatment effluents, but the data were not sufficient to make the comparison for the two time periods.

The time comparison can also be made for cadmium (Figure II-10, top) and lead (Figure II-10 bottom). Cadmium has a more linear relationship to salinity over a wide salinity range than does Cu or Ni. Hunt and Cullen both found higher Cd concentrations than SINBADD in a portion of their samples, but they generally found values in good agreement with the recent data over the entire salinity range that they sampled. The time comparison for lead is not as clear. SINBADD found a value of Pb of about 3 nmol/kg above 20 permil salinity, and Cullen and Hunt found a number of values in the range of 2-4.5 nmol/kg for salinities above 20 permil. Other samples by Hunt and Cullen fall within the cluster of the SINBADD results. The shift from use of leaded to non-leaded gasoline that has occurred since the late 1970's should decrease the input of lead to Narragansett Bay. Lead enters the Bay from more diffuse sources (atmospheric deposition and urban runoff) than is typical for copper and nickel. It should be noted that BAYMETAL contains dissolved lead data obtained by Piotrowicz in 1971 from the lower West Passage; he did not determine salinity so his values could not be plotted in Figure II-10. However, his values for dissolved lead were in the range of 10-50 nmol/kg, or 10 times the values found by subsequent investigators. We think this is an instance in which an earlier data set was obtained without sufficient control of contamination.

The metal concentrations presented in this report can be related to EPA water quality criteria for those metals for which criteria have been established. It is evident that only in

Figure II-10. As for Figure II-9, but with Pb and Cd data plotted.





the upper portion of the Bay (mainly in the Seekonk and Providence Rivers) does one find substantially elevated concentrations of some metals. The water quality criteria are expressed in terms of total metal concentration. Table II-10 lists representative dissolved, particulate, and total (dissolved + particulate) concentrations for five metals in the upper region of the Bay. These waters of the Bay exceed the water quality criteria for Cu and Ni by a factor of two and Pb is 50% of the criterion. Future efforts should be made to estimate metal loading and cycling.

E. Organically complexed metals in Narragansett Bay

1. Introduction

Trace metals in marine waters are partitioned into a variety of different forms. The dissolved fraction of the metal may exist as free ions or as various inorganic ion-pair complexes (Stumm and Brauner, 1975; Zirino and Yamamoto, 1972; Dyrssen and Wedborg, 1974). In some cases, metal-organic complexes may be an important component. Specifically, numerous studies have suggested that a significant fraction of dissolved copper may be organically complexed (Hart and Davies, 1981; Kremling et al., 1981; Van Den Berg, 1982; Hirose et al., 1982; Piotrowicz et al., 1982; Montgomery and Santiago, 1978; Sugai and Healy, 1978; Batley and Gardner, 1978). The chemical speciation of copper is important because it controls its geochemical behavior in seawater. For example, the sorption-desorption characteristics on suspended particles, the availability for biological uptake, and the toxic effects on marine organisms will be influenced by the copper species present. However, the amount of dissolved copper that is organically bound, the chemical nature of this association, the variation in extent of complexation in different marine waters, and the sources of the copper-organic complexes are poorly understood.

Copper-organic species may originate from complexation of inorganic copper ions by the humic fraction of dissolved organic matter (DOM) (Mantoura et al., 1978), or by algal metabolites which complex copper upon their release into seawater (McKnight and Morel, 1979; Van Den Berg et al., 1979; Ragan et al., 1979). Complexes may also be biosynthesized by marine algae and subsequently either actively exuded or released when the organisms die and the cell ruptures (Mantoura, 1981). The relative importance of each source will vary spatially and temporally due to changes in chemical, biological and hydrographic parameters.

The concentrations of dissolved trace metals (Cu, Co, Fe, Ni, Zn) in interstitial waters of marine sediments often exceed predicted concentrations based on the solubility products of the most likely mineral phase (Presley et al., 1972; Elderfield et al., 1981). Subsequent measurements of organic matter isolated from interstitial waters by dialysis (Nissenbaum and Swaine, 1976) and acid-precipitation of organic matter (Elderfield, 1981) suggest that significant quantities of dissolved copper in the interstitial waters of estuarine sediments are complexed with organic matter having the general characteristics of humic substances. These complexes of intermediate polarity may explain the observed excess solubility of copper in the presence of high concentrations of sulfide.

We have recently developed a method for the isolation of metal-organic complexes seawater using D18 reverse-phase hydrophobic liquid chromatography (Mills and Quinn, 1981; Mills et al., 1982). This review summarizes our work on the geochemistry of dissolved copper-organic complexes in the waters of Narragansett Bay (Mills and Quinn, 1984). It also includes a summary of our studies on organic copper and organic chromium

Table II-10. Relationship of the Providence and Seekonk Rivers metal concentrations to U.S. EPA Water Quality Criteria. Dissolved metals are based on typical values from Fig. II-4; particulate values are from sectors 1 and 9 in Fig. II-8. Total metal is the sum of dissolved and particulate. All are nmol/kg.

Metal	Dissolved	Particulate	Total	Water Quality Criteria
Ag	0.2 + 0.1	0.5 + 0.2	0.7 + 0.3	21
Cr (as VI)	9 + 1	20 + 10	29 + 20	960
Cu	60 + 10	30 + 10	90 + 20	46
Ni	250 + 50	10 + 6	260 + 56	135
Pb	2 + 1	8 + 4	10 + 5	27

complexes in sediment interstitial waters from this estuary (Douglas et al., 1986).

2. Experimental

a. Sampling

Seawater samples for a transect survey were collected from 17 locations in the Providence River (Sta. 1-6) and Narragansett Bay (Sta. 7-17) on August 29, 1980. Additional stations sampled during the survey included: the Blackstone River (Sta. A) and Pawtuxet River (Sta. B) as well as effluents from the Fields Point, Bucklin, and Riverside sewage treatment facilities (Sta. C, D and E, respectively). In addition to the transect, seawater samples were periodically collected from March through August 1980 from a mid-bay station (Sta. S). Sediment cores were collected from a station about 1 km east of water station 14 on May 22, 1984. Sediments from this location had been used in an experiment at the Marine Ecosystems Research Laboratory (MERL) and they were sampled on August 22, 1983 after 28 months in the mesocosms. All sampling locations are shown in Figure II-11.

Water samples were collected at a depth of about 1 m in 1 L acid-cleaned Teflon bottles using a custom made PVC sampling pole which allowed the bottles to be opened and closed underwater. This procedure eliminated contamination from the sea-surface microlayer, which is enriched in copper and organic compounds (Duce et al., 1972; Pellenburg and Church, 1979). The sediment samples were collected by diver insertion of a 16 cm diameter acid washed acrylic corer to a depth of 18-22 cm. Care was taken to ensure that the surface sediment floc remained intact. In addition, bottom water samples were collected and water temperatures recorded. The cores were removed from the benthos, capped and returned to the surface where they were placed upright into an insulated container. All samples were returned to the laboratory and processed as soon as possible after collection.

b. Analytical methods

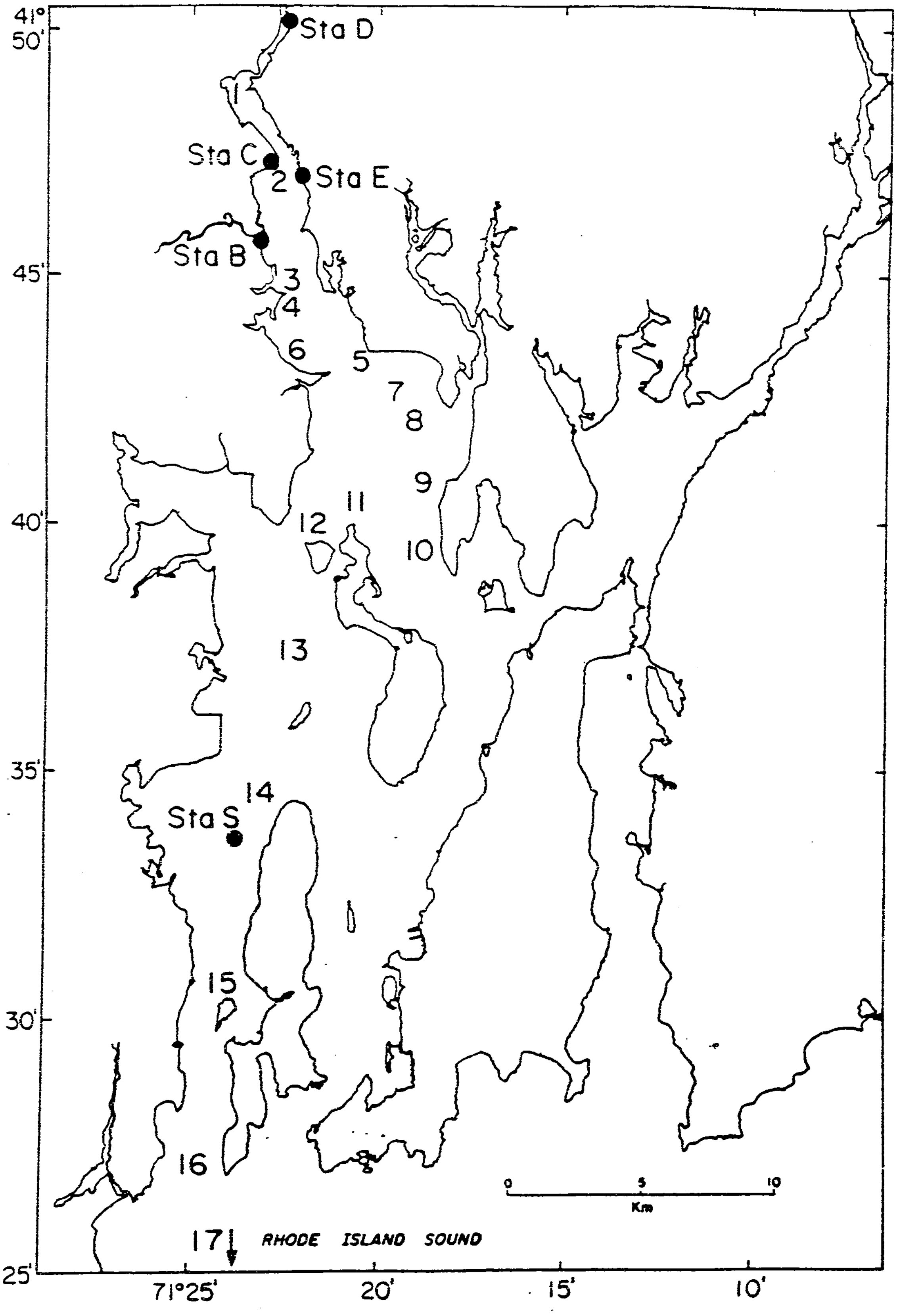
Complete details of the isolation procedures and chemical analyses used in our studies have been reported by Mills (1981), Mills and Quinn(1984), Douglas (1986), and Douglas et al. (1986).

3. Results and discussion

a. General

The uppermost region of Narragansett Bay is called the Providence River (Figure II-11) and receives inputs of organic matter and metals from a variety of sources, including: rivers, municipal and industrial effluents, combined sewer overflows, and storm drains. (It is important to note that the Providence River is not a river, only a designated region of the Bay.) The waters in this region of the Bay are not well mixed and thus the behavior of the dissolved components cannot be investigated using salinity mixing diagrams. However, Graham et al., 1976 in their study of manganese in Narragansett Bay, assumed that water entering the open Bay from the Providence River is well mixed at the mouth of the river. The open Bay (Sta. 17) can then be considered to encompass the narrow salinity regime (generally 30-32 permil) where mixing occurs between well mixed water at the mouth of the Providence River in the upper Bay and waters of Rhode Island Sound located outside the Bay. Since their analysis provides a reasonable interpretation of the behavior of manganese during mixing within the Bay, we will make the same assumption in this study. Although the salinity range is very narrow, it does include the entire West Passage of the

Fig.II-11. Station locations in the Providence River and Narragansett Bay, Rhode Island including the Blackstone River (Sta. A) and Pawtuxet River (Sta. B). The outfalls from the Fields Point, Bucklin and Riverside sewage treatment facilities are located at Sta. C, D and E, respectively.



Bay and such an approach proves useful for our study.

b. Copper-organic complexes in Narragansett Bay waters

The concentration of dissolved copper-organic complexes ranged from 0.12-2.30 ug Cu/Kg (Table II-11) with the highest values found in the Providence River then progressively decreasing down Bay with the organic copper fraction comprising from 14 to 70% of the total dissolved copper. Within the open Bay stations (sta. 7-17), dissolved copper and organic copper appear to follow conservative mixing (Figure II-12 a, c) while the particulate copper concentration decreases rapidly from the mouth of the river to the lower Bay (Figure II-12 b), indicating dilution and removal within this mixing regime. A plot of dissolved organic versus total dissolved copper for the open Bay stations (Figure II-13) shows these values are closely correlated (r = 0.99) within an average of 62% of the total dissolved copper in the organic fraction.

The concentration of dissolved organic carbon (DOC) observed during the transect survey varied from 0.96-8.27 mgC/1 (Table II-11) and had a complex distribution throughout the Bay (Figure II-12d) and was not directly correlated with organic copper (Figure II-12c). In Figure II-14, DOC concentrations and measured values of chlorophyll-a (C. Oviatt, personal communication) are plotted station by station and as function of latitude, expressed as minutes north of 41^{o} N. The chlorophyll-a values were taken as an indicator of phytoplankton populations within the Bay. The substantial increase in DOC (Figure II-14, Stas. 13-16) resulting from phytoplankton production occurs in the same region in which the concentration of organic copper follows conservative mixing (Figure II-12c). It appears that the recent phytoplankton - generated DOC has little impact on the fraction of dissolved copper that is organically bound. However, this does not preclude the possibility that phytoplankton may exude or release organic compounds which complex copper ions. The ability to produce copper binding organic ligands has been found to vary with different algal species (McKnight and Morel, 1979) as well as stage of growth. Thus, different results might be obtained at a different time or during a bloom of different species composition. Also, Narragansett Bay receives a significant input of copper binding terrigenous organic material via river and sewage effluents. The presence of this material may mitigate the effect of any small contribution from algal metabolites. The role of phytoplankton in producing copper complexing ligands may be of greater importance in marine environments where the contribution of terrigenous material is much less than Narragansett Bay.

The flux of organic copper into the Providence River was calculated using the concentrations in Table II-11 and the flows given in Table II-12. The calculated August flux is 10.7 Kg Cu/d which is about 10% of the calculated total copper flux (104 Kg Cu/d). A mass balance calculation for dissolved organic copper entering the Bay in August indicates a small excess (18%) in the amount of organic copper leaving the Bay over that entering the Bay in the Providence River. However, this excess is about the same as the calculated error in the estimate. Although additional copper-organic complexes may be formed within the Bay, no definite conclusions can be drawn without additional studies. The data also indicate that, during August, about 14% of the dissolved copper entering the Bay is organically complexed (Table II-13) while approximately 60% of that leaving the Bay is organically bound (Figure II-13). Since the flux of organic copper entering and leaving the Bay is nearly in balance and about 75% of the total dissolved copper is removed, inorganic species of dissolved copper must be preferentially removed. Thus, organically bound copper is the major copper species transported through the Bay into coastal Rhode Island waters. This suggests that complexation of dissolved copper by naturally occurring organic ligands may inhibit removal from the dissolved phase. Similar

Table II-11. Results of analyses of samples collected from Narragansett Bay in the August 1980 transect survey.

Sta no.	S o/oo	DOC mg C/1	Dissolved[1] Cu µg/kg	Organic Cu µg/kg	Particu-late µg/kg	Total[2] Cu µg/Kg	Organic[3] Cu %	Particu-[4] late Cu %
1	25.88	4.62	2.63	0.99	2.42	5.05	37.6	48
2	26.64	8.27	16.4	2.30	1.10	17.5	14.0	6
3	28.22	5.34	5.12	1.58	2.26	7.38	30.8	30
4	29.15	5.07	5.02	1.46	2.38	7.40	29.1	32
5	30.29	7.46	3.35	1.37	2.14	5.49	40.9	39
6	30.12	4.26	1.36	0.80	2.18	3.54	58.8	61
7	30.18	6.50	1.23	0.73	1.90	3.13	59.3	61
8	30.23	3.47	1.19	0.77	--[5]	--[5]	64.7	-
9	30.34	4.55	1.17	0.75	1.47	2.64	64.1	55
10	30.67	2.14	1.02	0.54	0.48	1.50	52.9	32
11	30.67	4.43	0.92	0.63	0.47	1.39	68.5	34
12	30.78	1.91	0.81	0.57	0.83	1.64	70.4	51
13	30.94	3.12	0.82	0.47	0.61	1.43	57.3	43
14	31.16	5.18	0.82	0.52	0.46	1.28	63.4	36
15	31.32	3.28	0.61	0.40	0.38	0.99	65.6	38
16	31.65	3.76	0.48	0.26	0.14	0.62	54.2	22
17	31.87	0.96	0.23	0.12	0.06	0.29	52.3	21

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[1] Dissolved Cu includes both inorganic and organic copper;
[2] Sum of dissolved and particulate concentrations;
[3] (Organic Cu/Dissolved Cu) x 100;
[4] (Particulate Cu/Total Cu) x 100;
[5] Sample contaminated.

Table II-12. Results of analyses of samples collected from rivers and sewage discharge into Narragansett Bay in the August, 1980 transect survey.

Sta.	S ‰	DOC mg C/1	Dissolved Cu µg/kg	Organic Cu µg/kg	Particulate Cu µg/kg	Total Cu µg/Kg	Organic Cu %	Particulate Cu%
Blackstone River	0.43	8.01	6.53	3.09	1.47	8.00	47.3	18
Bucklin Sewage	0.54	54.8	3.51	2.67	53.3	56.8	76.1	94
Fields Pt. CSO (1)	20.23	7.50	63.2	7.87	24.4	87.6	12.4	28
Fields Pt Sewage	15.93	9.17	145	16.6	39.7	185	11.4	21
Pawtuxet River	0.43	9.80	4.65	2.08	3.35	8.00	44.7	42
Riverside Sewage	0.33	N.D.[2]	8.04	5.97	4.7	9.04	74.3	52

[1] combined sewage overflow;

[2] Not determined (frozen vials cracked during storage).

Table II-13. Calculated flow weight average concentrations of river and sewage inputs for August transect.[1]

Freshwater input	Flow[2] $10^4 m^3/d$	Fraction total flow	Dissolved Cu (µg/kg)	Flow-weighted dissolved Cu (µg/kg)	Organic Cu (µg/kg)	Flow-weighted organic Cu (µg/kg)	Particulate Cu (µg/kg)	Flow-weighted Particulate Cu (µg/kg)
Blackstone River	50.6	0.459	6.54	3.00	3.09	1.42	1.47	0.69
Bucklin Sewage	6.5	0.059	3.51	0.21	2.67	0.16	53.3	3.14
Pawtuxet River	31.6	0.286	4.65	1.33	2.08	0.59	3.35	0.97
Riverside Sewage	1.8	0.016	8.04	0.13	5.97	0.10	4.70	0.08
Field Point Sewage	19.8	0.180	374[3]	67.3	41.5[3]	7.47	99.4[3]	17.8
Summation	110			71.9		9.74		22.8

[1] See text for details of calculation;

[2] Flow data from August 29, 1980;

[3] Corrected to 0‰ salinity assuming conservative dilution.

Fig. II-12. Concentration versus salinity mixing diagrams for (a) dissolved copper, (b) particulate copper, (c) organic copper and (d) dissolved organic carbon in the August 1980 transect survey.

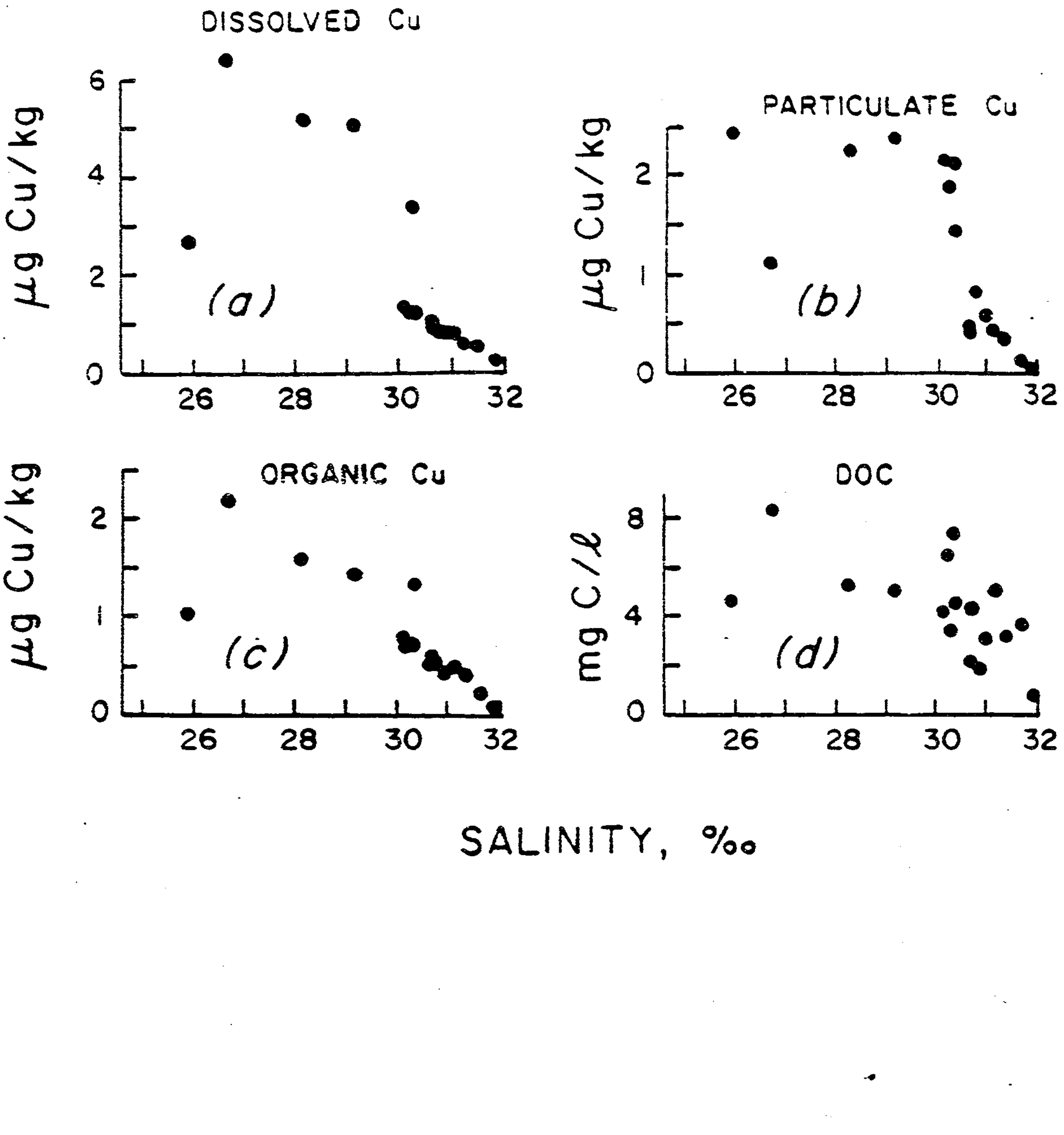


Fig. II-13. Organic copper concentration plotted versus total dissolved copper concentration for the open Bay stations 7-17 for the August 1980 transect survey. (Slope = 0.62; correlation coefficient = 0.99). Error bars are shown for dissolved copper value of 0.61 µg/Kg and organic copper value of 0.40 µg/Kg.

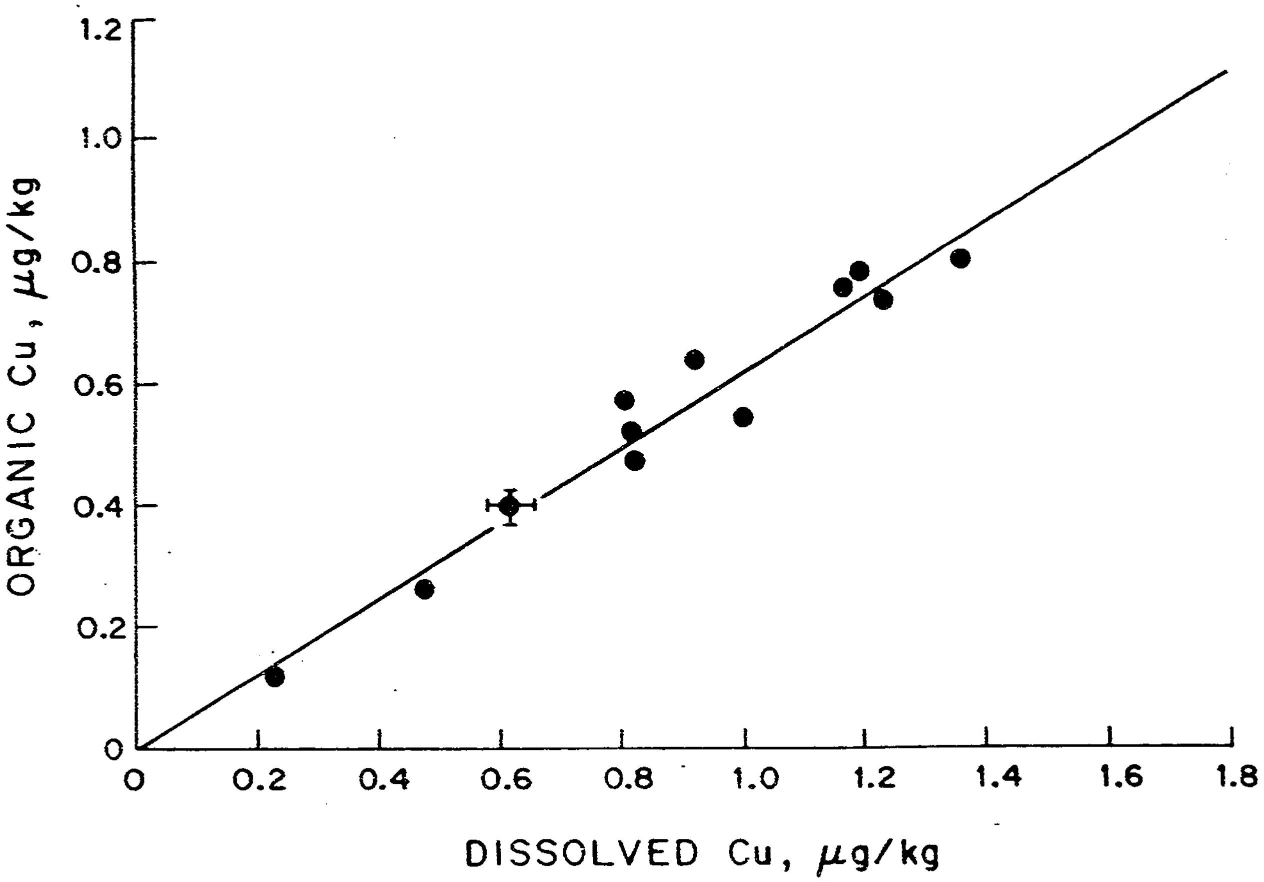
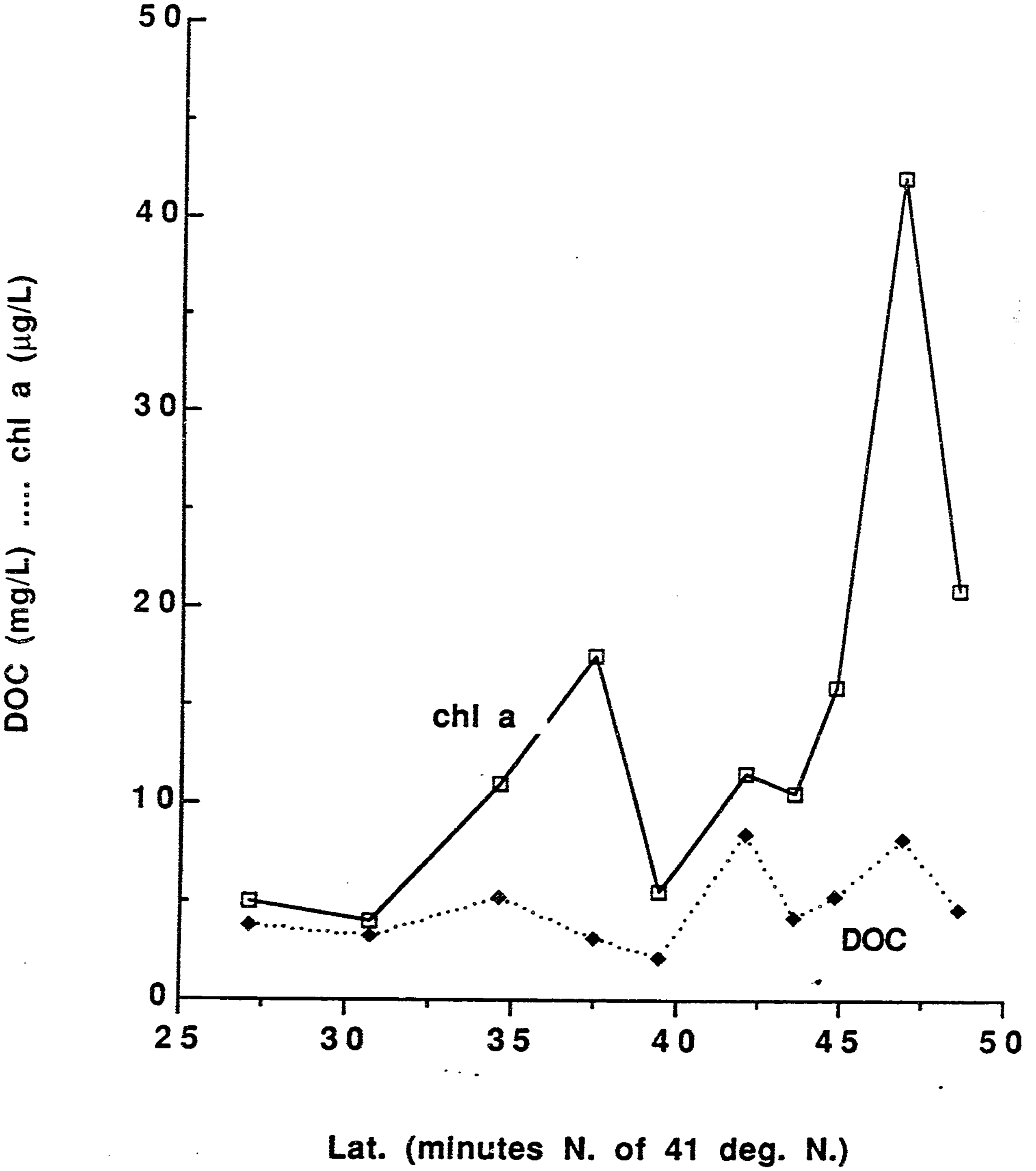


Fig. II-14. Concentration of chlorophyll-a and dissolved organic carbon as a function of distance from Fields Point for the August 1980 transect survey. Chlorophyll-a values are shown by circles and the dashed line. DOC values are shown by triangles and the solid line.



results were obtained by Sholkovitz and Copland (1981) in their study of the Water of Luce.

We have previously studied the chemical nature of copper-organic complexes isolated from Narragansett Bay seawater using C_{18} RPLC (Mills et al., 1982). The results of this study indicate that the copper is associated with a broad range of labile acidic sites involving oxygen donor ligands on the DOM and that this material is relatively polar with some aromatic character. The general physico-chemical characteristics of this copper complexing fraction of the DOM is consistent with the properties of humic materials found in soils and natural waters (Schnitzer, 1972; Weber and Wilson, 1975; Wershaw et al., 1977). It is likely that this material would be more characteristic of fulvic type acids since humic acids have been shown to be flocculated and removed upon the initial mixing of fresh water and seawater in estuarine mixing studies (Sholkovitz, 1976; Sholkovitz, 1978). Also, fulvic acid has a lower molecular weight range and contains more polar functional groups and is more water soluble.

c. Time Series Study in Narragansett Bay

The results of the analyses of samples collected during March through August at Station S (Figure II-11) are presented in Table II-14. Dissolved copper varied from 0.71-2.46 ug/Kg while particulate copper ranged from 0.06-1.12 ug/Kg. Dissolved copper values tended to be highest in March through May when fresh water influx was at a maximum which is reflected in the salinity values obtained during this period. Particulate copper values showed no apparent trend. The concentration of organic copper varied from 0.20-0.84 ug/Kg and comprised from 21-66% of the dissolved copper. This percentage was lowest for the spring months then generally increased as the summer progressed. The March 25 value of 34% was exceptional in this regard and will be discussed subsequently. DOC concentrations varied from 1.75-6.20 mg/Kg, with the elevated values obtained in March and April, and rapidly decreasing to the lower values found in May and June then gradually increasing in July and August.

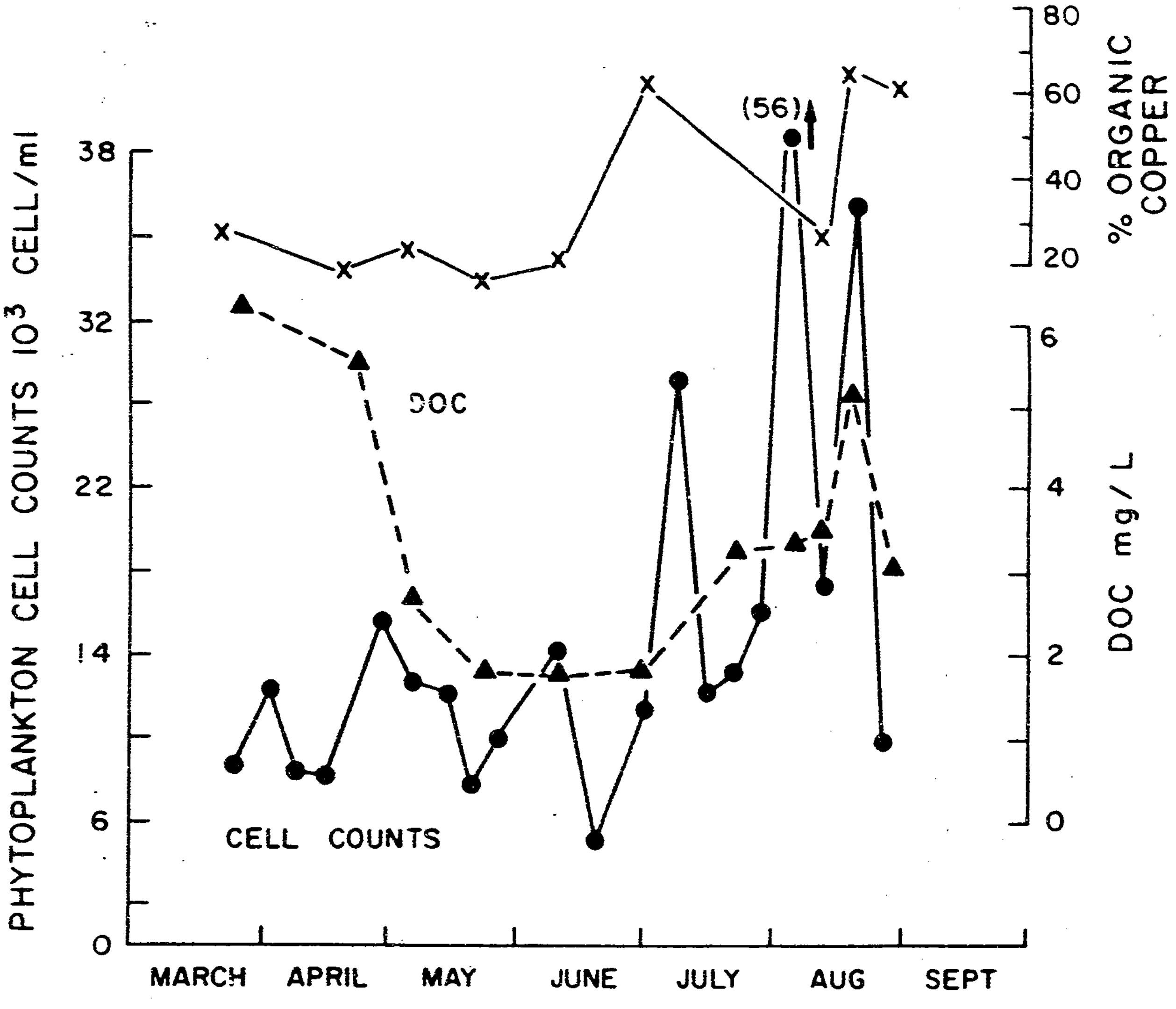
The DOC concentration and phytoplankton cell count (T. Smayda, personal communication) are plotted vs. time in Figure II-15. There was relatively little variation in phytoplankton activity during March-June. A series of blooms occurred in July and August with cell concentrations reaching as high as 56,000 cells/ml followed by a sharp decline to pre-bloom levels by September. The elevated DOC concentrations found in March and April were apparently unrelated to phytoplankton activity which was relatively low at this time. It was also considered that the elevated DOC values may be due to biological production during the winter-spring diatom bloom which occurs annually in Narragansett Bay. The 1979-1980 bloom began in the last week of December, reached a maximum in early January then declined rapidly at the end of the month (C. Oviatt, pers. communication). It seems unlikely that DOC production associated with this bloom would persist until April. Kerr and Quinn (1980) found that DOC values returned to background levels within two weeks following bloom senescence. A large storm had passed through the area on March 21-22, delivering 9 cm of rainfall. The Fields Point sewage treatment facility is unable to maintain effective treatment of wastes with the large additional inflow of storm water runoff channeled into the plant by combined sewers. Thus, waste treatment is halted and consequently large quantities of DOM are flushed into the Bay. It seems likely that this high organic carbon loading is responsible for the elevated DOC values found in late March and in April. Since the Fields Point effluents are also the major source of both total dissolved and organic copper, the high concentrations (Table II-14) obtained in March are probably also related to the storm event. The gradual increase in DOC concentration in July and August is coincident with the phytoplankton blooms which occurred during this

Table II-14. Results of analysis of samples collected from Narragansett Bay at a mid-bay location (Sta. S) from April to September, 1980.

Sample date	S o/oo	organic carbon mg/kg	Dissolved Cu µg/kg	Organic Cu µg/kg	Particulate Cu µg/kg	Organic Cu %
3/25/80	27.0	6.20	2.46	0.84	ND	34
4/22/80	28.0	5.55	1.66	0.40	0.06	24
5/06/80	30.0	2.64	1.32	0.37	0.26	28
5/23/80	28.0	1.77	1.55	0.33	0.82	21
6/10/80	31.0	1.75	0.83	0.20	0.73	24
7/01/80	30.78	1.83	0.85	0.54	0.72	63
7/22/80	31.10	3.22	0.95	0.48	0.24	50
8/05/80	30.78	3.34	0.84	0.29	0.47	34
8/12/80	30.94	3.50	1.38	0.39	0.13	28
8/19/80	31.38	5.18	0.71	0.47	1.12	66
8/29/80	31.16	3.10	0.82	0.52	0.46	63

ND = not determined

Fig. II-15. The variation in phytoplankton cell counts, dissolved organic carbon and organic copper (as % total dissolved copper) during March 1980 through August 1980 at Sta. S. Cell counts are shown by circles and the solid line. DOC values are shown by triangles and the dashed line. Percent organic copper values are shown by crosses and the solid line.



period and reflects the input of recently generated DOM. A similar trend was observed in the Bay during the summer in 1976 (Kerr and Quinn, 1980).

The fraction (%) of dissolved copper which is organically complexed is also plotted as a function of time in Figure II-15. The percent organic copper does not appear to be related in any simple way to the phytoplankton cell concentration. Although the organic copper fraction was elevated in July, this increase occurred before the first bloom peak. The percent organic copper then gradually declined through the period of maximum phytoplankton activity in early August before increasing again in late August and into September when phytoplankton activity sharply declined. In addition, the data obtained from the time series study (Figure II-15) indicate no correlation between organic copper concentrations and the amount of DOC present, which is in agreement with the data.

d. Sediment interstitial DOC

The amount of total DOC (T-DOC) and SEP-PAK DOC (SP-DOC) in the Bay and MERL cores are shown in Figure II-16 and Table II-15 (a and b, respectively). In both cases, the values appear to increase with depth in the core to about 6 cm, and then they generally decrease with depth. The SP-DOC responds in a regular fashion to changes in T-DOC in the core and accounts for 14-40% of the interstitial water DOC (Figure II-16c). A larger fraction of the DOC appeared to be associated with the SEP-PAK fraction in the MERL core than in the Bay core. This may be due to a difference in redox potentials between the cores. The MERL core (Mesocosm #5) appeared to be more anoxic as measured by H_2S, Eh, and Mn profiles than the Bay core (Figure II-17 a and b), probably due to the reduced abundance of macrofaunal organisms within the MERL mesocosms.

e. Sediment interstitial copper

Results for interstitial copper measurements are presented in Figure II-18. Figure II-18a represents the Bay data in which both total (T-Cu) and organic copper (SP-CU) generally decrease with depth in the core with two mid-depth maximums at approximately 2 and 6 cm. Organic copper ranged from 22-67% of the total dissolved copper and responded to changes in the total dissolved copper within the core (Figure II-18c). Overlying water values of 20 nmol/Kg T-Cu and 11 nmol/Kg for SP-Cu (plotted at Z = O, Figure II-18a) suggest that these sediments may be supplying both forms of copper to the overlying water. However, this observation may merely reflect the presence of low bottom water copper levels due to tidal influx of Rhode Island Sound water within the estuary's tidal wedge. Also, the direction of this copper flux may vary with the tides.

A second explanation for the observed Bay interstitial copper distribution is a possible remobilization of solid phase copper with subsequent release into the interstitial waters. Both dissolved iron and manganese exhibit broad maximums in the 2-6 cm region (Figure II-17a) suggesting a reduction of the manganese and iron oxides to a more soluble form ($Mn^{+4} > Mn^{+2}$, $Fe^{+3} > Fe^{+2}$). Solid phase copper may also be solubilized by this reduction (Sawlan and Murray, 1983) and be released to the interstitial waters as well. This dissolved copper may then form additional complexes with DOM as well as diffuse to areas of lower dissolved copper concentration such as the overlying water and deeper sulfide regions in the sediment (see Figure II-18a).

The total copper budget was analyzed on all interstitial water samples in the Bay core (Figure II-18a). Total copper was measured prior to SEP-PAK isolation and compared to the sum of SEP-PAK copper and post SEP-PAK copper (dissolved copper not retained by the SEP-PAK). The average budget recovery was 100% with a RSD of 11%, and is of the same magnitude as reported by Mills et al. (1982) for thirteen replicate seawater samples (107 ± 10%).

Figure II-18b is a plot of dissolved copper versus depth for the MERL core. The total

Table II-15 A. Concentrations in Narragansett Bay sediment interstitial waters (5/22/84).

Depth	Org Cu NMOL/KG	TCU NMOL/KG	TCU SUM[a] NMOL/KG	ORG CR NMOL/KG	TCR NMOL/KG	TCR SUM NMOL/KG
[b]ow	10.60	20.32	18.84	0.14	0.00	0.1
.5	12.84	22.70	22.56	0.88	2.18	0.88
1.5	15.77	39.66	37.07	0.92	1.92	2.01
2.5	20.14	36.07	38.34	1.11	3.80	5.14
3.5	9.34	16.50	16.34	1.34	4.26	3.65
4.5	17.22	26.84	25.56	1.44	4.51	3.27
5.5	8.86	40.08	27.44	2.29	5.77	6.13
6.5	5.74	8.55	11.11	3.57	15.38	12.61
7.5				6.81	22.30	16.67
8.5	1.92	8.34	8.79	8.25	15.38	14.98
9.5						
10.5	3.10	4.95	6.00	11.62	23.26	24.12
11.5				12.04	30.96	25.50
12.5						
13.5	2.11	5.21	4.59	17.12	41.64	35.20

Depth cm	SP-DOC UMOL/KG	DOC UMOL/KG	MN UMOL/KG	FE UMOL/Kg	NH3 UM	H2S UM	Eh MV	pH =
b_{ow}	24	130	.23		3	0	405	8.001
.5	89	653	16.00	7.27	50	0	54	7.52
1.5	125	366	17.17	16.72	57	0	-24	7.55
2.5	160	910	17.56	26.22	59	0	-67	7.44
3.5	301	1544	17.17	42.58	69	0	-47	7.48
4.5	312	2238	16.78	29.37	98	0	-46	7.60
5.5	692	4480	12.52	24.28	106	0	-38	7.62
6.5	533	3547	15.23	44.46	159	0	-64	7.51
7.5			14.74	44.74			-63	7.41
8.5	451	2954	13.19	30.74	170	0	-51	7.42
9.5								
10.5	239	1460	8.54	4.74	102	50	-101	7.52
11.5			6.11	5.87	151	89	-156	7.49
12.5								
13.5	200	1557	3.39	.48	154	110	-191	7.54

Table II-15 B. Concentrations in MERL sediment interstitial waters (Tank 5; 8.22.83).

Table II-15 B. Concentrations in MERL sediment interstitial waters (Tank 5; 8.22.83).

Depth CM	ORG CU NMOL/Kg	TCU NMOL/KG	ORG CR NMOL/KG	TCR NMOL/KG	SP-DOC UMOL/KG	DOC UMOL/KG	MN UMOL/KG	NH3 UM	H2S UM	Eh MV	pH
0	18.05	50.63	0.16	0.00	82	334	0.31	5	0	301	8.00
.5	13.09	28.57	2.03	2.03	122	875	10.98	48	0	37	7.50
1.5	10.94	19.96	0.94	2.38	223	1071	6.06	98	0	12	7.71
2.5	11.10	25.90	1.41	3.36	238	1018	4.06	101	0	-6	7.74
3.5	7.90	21.12	2.05	5.90	400	1480	3.46	128	0	-8	7.75
4.5	7.95	20.17	7.47	15.74	844	2859	3.18	149	0	-89	7.70
5.5	6.71	20.07	3.60	9.37	716	3293	3.00	145	0	-101	7.70
6.5	5.87	16.29	3.71	9.30	759	1945	2.55	162	0	-110	7.72
7.5	3.30	11.99	3.65	8.94	210	1090	2.58	144	41	-123	7.72
8.5	3.88	11.46	3.91	9.20	326	1276	2.55	180	79	-150	7.75
9.5	4.09	11.01			344	1712	2.46	210	100		
10.5	3.77	10.23	6.46	18.96	402	1727	2.18	218	127		
11.5	4.30	10.60	7.59	23.45	192	768	1.95	253	183		

[a] SUM = org Cu plus Cu not retained by the SEP-PAK;
[b] OW = overlying water.

Fig. II-16. (A) Interstitial T-DOC and SP-DOC versus depth for the Bay core; (B) Interstitial T-DOC and SP-DOC for the MERL core. (C) SP-DOC versus T-DOC for bay and MERL cores.

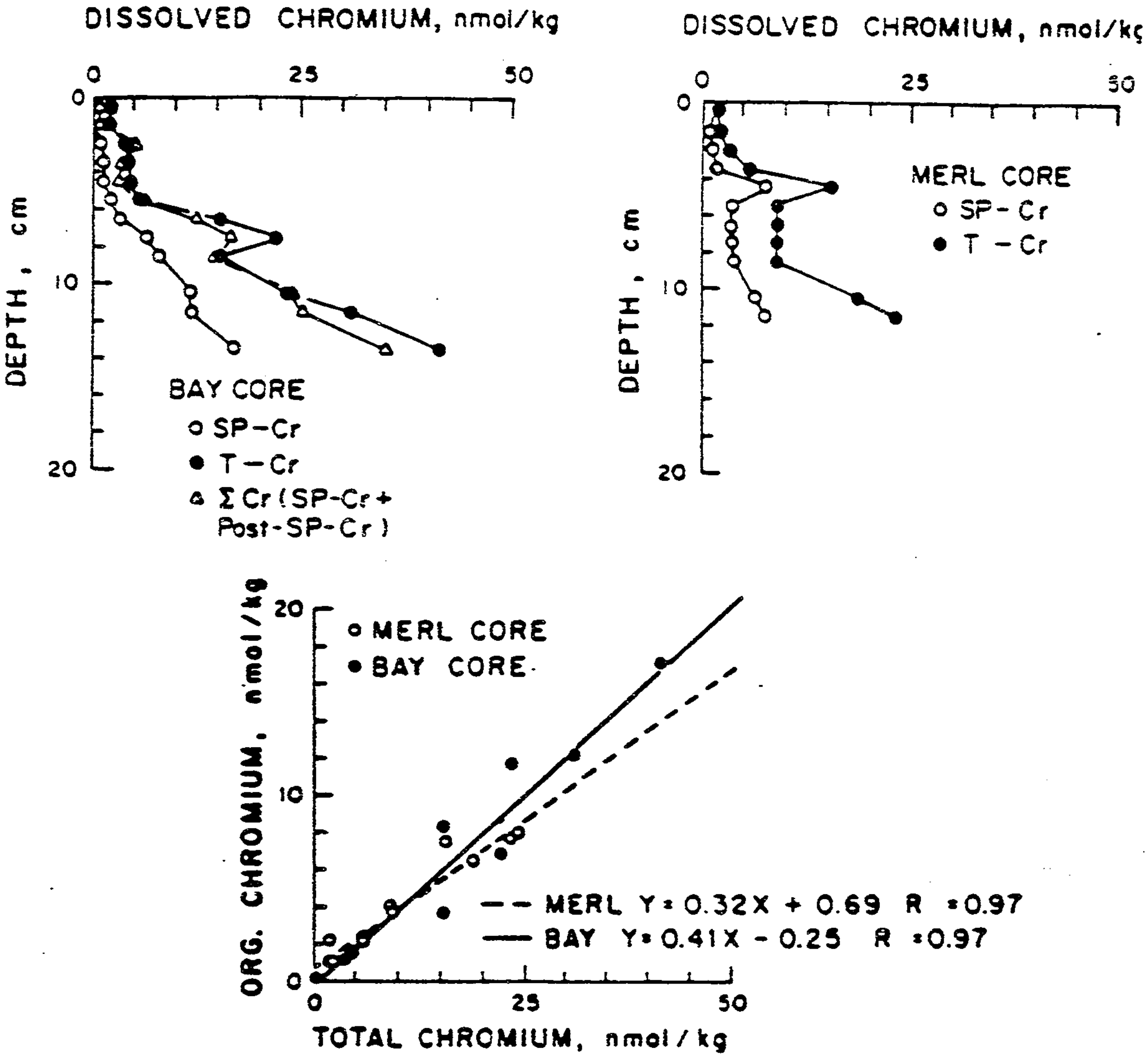


Fig. II-17. (A) Interstitial Eh, Fe, Mn and H_2S versus depth for the bay core. (B) Interstitial Eh, Mn and H_2S versus depth for MERL core.

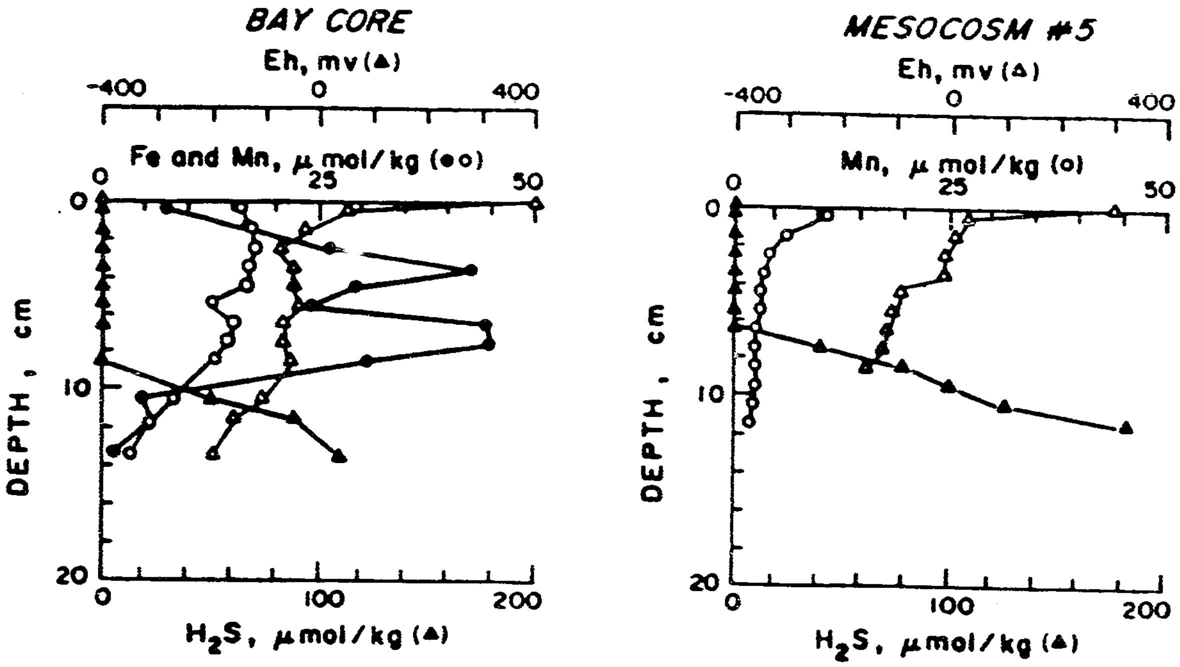
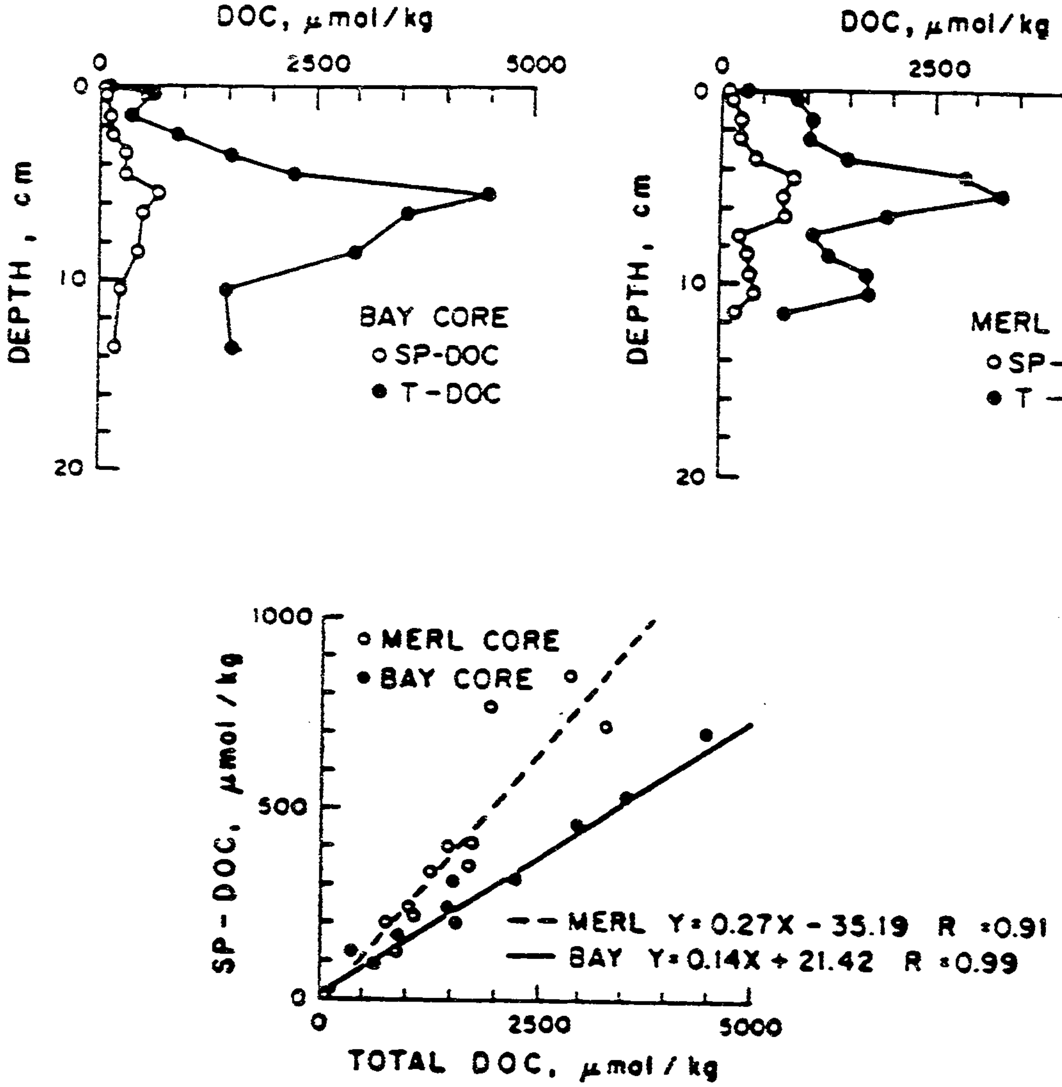


Fig. II-18. (A) Interstitial SP-Cu, T-Cu and budget total copper versus depth for the Bay core; (B) Interstitial SP-Cu and T-Cu versus depth for the MERL core; (C) organic copper (SP-Cu) versus total copper (T-Cu) for Bay and MERL cores.



and organic copper concentrations decrease with depth but only exhibit a slight mid-depth maximum at 2.5 cm and there is less variability than in the Bay core. The MERL mesocosms do not have the daily tidal bottom flow that is present at the Bay site, although the water in the systems does have the same residence time as the Bay (approximately 27 days, Pilson, 1980). Therefore, these systems may act as large water column buffers which do not respond in a rapid fashion to changes associated with estuarine tidal flow. This may explain why the direction of the concentration gradient suggests that there is a flux of both forms of copper into the MERL sediments, while the data for the Bay core indicates a possible net flux out of the sediments. The observed profile may also reflect the fact the MERL sediment appeared to be more reducing than the Bay sediment, as previously discussed. As a result, Mn remobilization (and possibly Cu remobilization) occurred within the upper cm or possibly few mm of the MERL sediments thereby releasing these soluble metals to the overlying water rather than at depth, as in the case of the Bay sediment.

The chemical relationship between total and organic copper with depth in the two cores is quite similar with an average of 40% of the total copper organically complexed (Figure II-18c). Below 10 cm where the presence of hydrogen sulfide was detected (Figure II-17 a and b), the major inorganic copper species is Cu^{+1} (Emerson et al., 1983). The inorganic chemistry of Cu^{+1} would be controlled by sulfide mineral precipitation and formation of soluble bisulfide or polysulfide complexes (Boulegue, 1977 and Emerson et al., 1983). Since the ratio of SP-Cu/T-Cu did not appear to change significantly in the more anoxic deeper region of the sediment, it suggests that the organically complexed copper is in apparent equilibrium with the inorganic species and is not preferentially protected from sulfide mineral formation by its organic association.

f. Sediment Interstitial Chromium

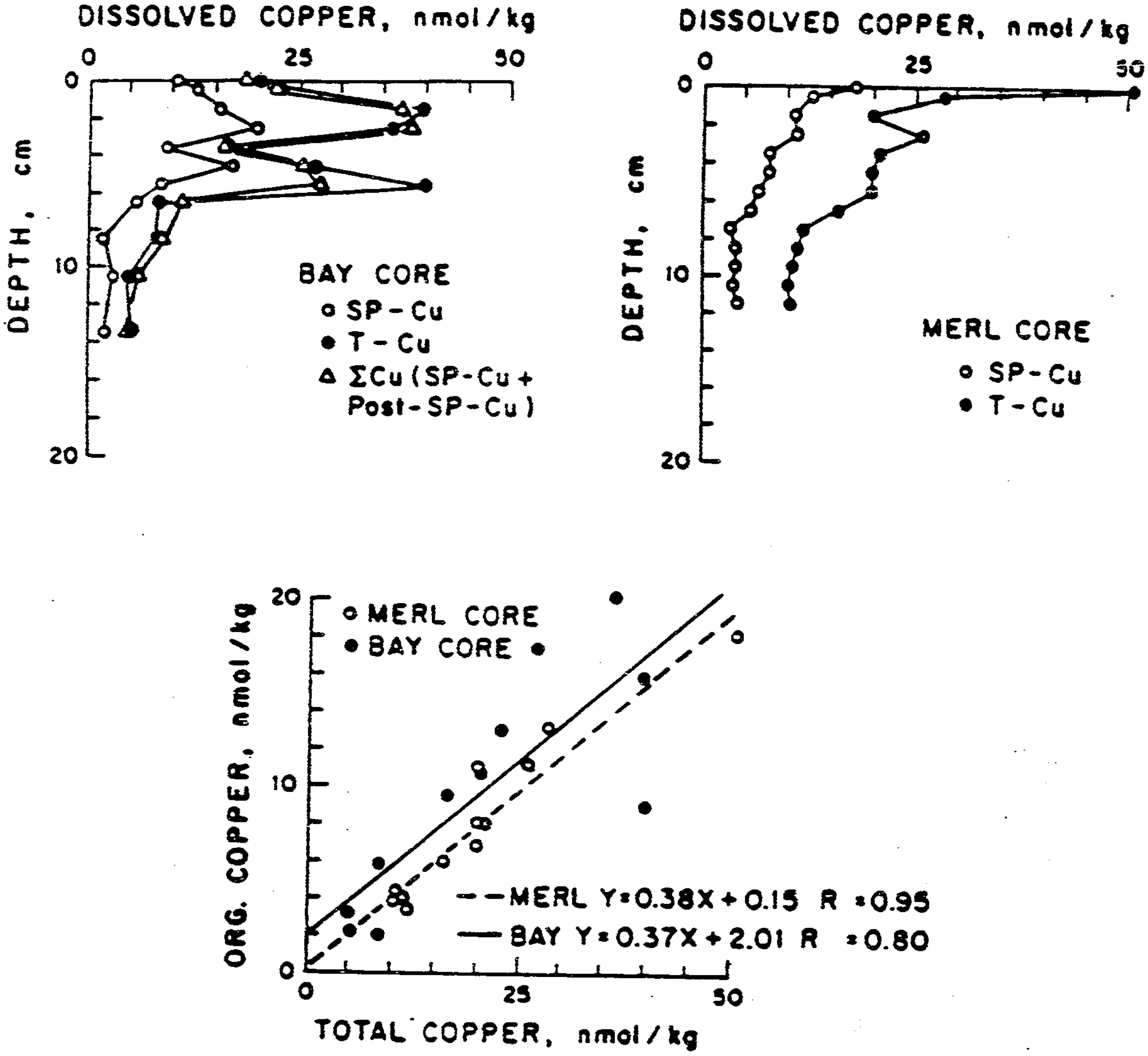
Total (T-Cr) and organic chromium (SP-Cr) were measured in both Bay and MERL cores (Figure II-19 a and b), in which concentrations ranged from 1-41 nmol/kg T-Cr and 0.1-17.0 nmol/Kg SP-Cr. Overlying water concentrations of T-Cr and SP-Cr were less than the detection limits for these measurements (1 nmol/Kg and 0.1 nmol/Kg, respectively). Both T-Cr and SP-Cr increased with depth in the core, with SP-Cr between 23-55% of the T-Cr (Figure II-19c). A budget was determined in the Bay sample for T-Cr, SP-Cr and post SEP-PAK Cr (dissolved chromium not retained by the SEP-PAK cartridge, P-SP-Cr). The budget recovery was 92% with a RSD of 22%.

Based on the Eh and pH measurements for these cores (Table II-15; pH pore water = 7.4 ± 0.2; pH overlying water = 8.0), the oxidation state of interstitial chromium would be that of Cr^{+3} (Hem, 1977; Emerson et al., 1979; and Van Der Weijden and Reith, 1982). The data suggests that Cr^{+3} is being remobilized from some mineral phase, possibly chromic hydroxide (Elerfield, 1970), chromite (Hem, 1977), or diatom tests (Cranston, 1983; Kastner, 1981). Organic complexes are possibly being formed in situ (Brumsack and Gieskes, 1983) due to this interstitial water increase of Cr^{+3} and because of the large crystal field stabilizing energy associated with the formation of organic coordination complexes (Murray et al., 1983). For example, the trivalent chromium-organic matter association is so stable that it is found in the oxidizing water column (Nakayama et al., 1981; Emerson et al., 1979; Van Der Weijden and Reith, 1982).

4. Summary

The dissolved copper concentrations in Narragansett Bay during August 1980 ranged from 0.23-16.4 ug Cu/Kg. Analysis of the data obtained during the August transect survey

Fig. II-19. (A) Interstitial SP-Cr, T-Cr and budget total chromium versus depth for the Bay core. (B) Interstitial SP-Cr and T-Cr versus depth for the MERL core. (C) Organic chromium (SP-Cr) versus total chromium (T-Cr) for Bay and MERL cores.



indicated that about 75% of the dissolved copper entering the Bay is removed. Most of this removal must occur within the Providence River since the salinity - mixing relationship indicated that dissolved copper followed conservative mixing in the mid to lower Bay. Particulate copper concentrations varied from 0.06-2.42 ug Cu/Kg and generally comprised 40% of the total copper. Particulate copper concentrations decreased rapidly from the upper to lower Bay as a result of both removal and mixing with the waters of Rhode Island Sound which have low particulate copper concentrations.

The major source (90%) of both dissolved and particulate copper to Narragansett Bay is effluent from sewage treatment plants which discharge into the Providence River. The major source of organic copper to the Bay is effluent from the Fields Point sewage treatment facility. Organic copper concentrations ranged from 0.12-2.30 ug/Kg and comprised from 14-70% of the total dissolved copper. The transect data indicated that organic copper mixes conservatively within the mid to lower Bay and that the amount entering and leaving the Bay is nearly in balance. Thus, complexation of copper by DOM may be an important factor in controlling the transport of dissolved copper to coastal and oceanic waters.

The amount of organic copper was not directly correlated with the DOC concentrations and thus is related to the qualitative nature rather than the quantity of DOM present. Recently generated DOM originating from phytoplankton production within the Bay has little effect on the fraction of dissolved copper which is organically bound. The results from a time series study at the mid-bay station reflected a similar trend with the lowest organic copper values obtained during the spring months then generally increasing as the summer progressed. An exception to this trend was a high organic copper value obtained in March which was probably related to a large input of sewage DOM associated with runoff from a large storm.

Dissolved organic complexes of copper and chromium are present in the interstitial waters of mid-Narragnasett Bay sediments and they represent a significant amount of the total dissolved metal (22-67% T-Cu and 23-55% T-Cr). Copper and chromium have different geochemical distributions in the sediments, yet both form strong organic complexes that may play an important role in the transport of these trace metals across the sediment water interface. Dissolved copper-organic complexes enter the sediments by diffusion from the overlying water or are formed in situ during sediment diagenesis. Within the sulfate reduction zone, the interaction of Cu with DOM is not sufficiently strong to prevent copper sulfide formation.

Organic complexes of chromium are formed at depth within the pore waters due to the remobilization of solid phase chromium as a result of diagenetic processes followed by the formation of chromium organic complexes. These complexes may be an important factor in increasing the solubility of chromium and thus allowing its transport to the overlying water column.

III. Sediment composition

A. Introduction

To a first approximation, the trace metal concentrations in Narragansett Bay sediments are governed by the composition of sediment entering the Bay. However, there are a number of other factors which affect trace metal concentrations and their variability. Probably the most important is proximal input and sediment transport. Sediments in the Bay appear to be transported, on the average, between 1-10 km before they settle to the seafloor at the point where they will ultimately be buried (the actual distance undoubtedly varies considerably depending on grain size and many other factors). Hence trace metal content at a point in the Bay reflects trace metal concentrations in the sources affecting the area being examined, as well as sediment dispersal patterns in the study region. A second factor is chemical reaction between sediments and Bay water while the particle is *en route* to its resting place. As a result of such reactions, trace metals may be gained or lost by particles. A third process altering sedimentary metal composition is diagenesis. In this process, there are changes in the composition of sediments as a result of respiratory O_2 consumption and other biological processes associated with metabolic processes in sediments. Finally, trace metals are redistributed vertically within sediments by bioturbation, the result of the burrowing and feeding activity of organisms.

The second process (adsorption and desorption) mainly has the effect of enriching particles in reactive trace metals. In the case of sediments which are always submerged, diagenesis does not extensively alter the composition of trace metals in the affected sediment (Bender et al., 1977). The exception is manganese, which is rapidly released from the sediment in the O_2 - free environments characterizing sediments in the Bay. Thus in the case of submerged sediments, the composition of newly accumulating sediments reflects the material entering the Bay, as augmented by adsorption of particle reactive metals, and its dispersal. Downcore variations in trace metal concentrations reflect time variations in trace metal concentrations and the vertical mixing of sediment by bioturbation.

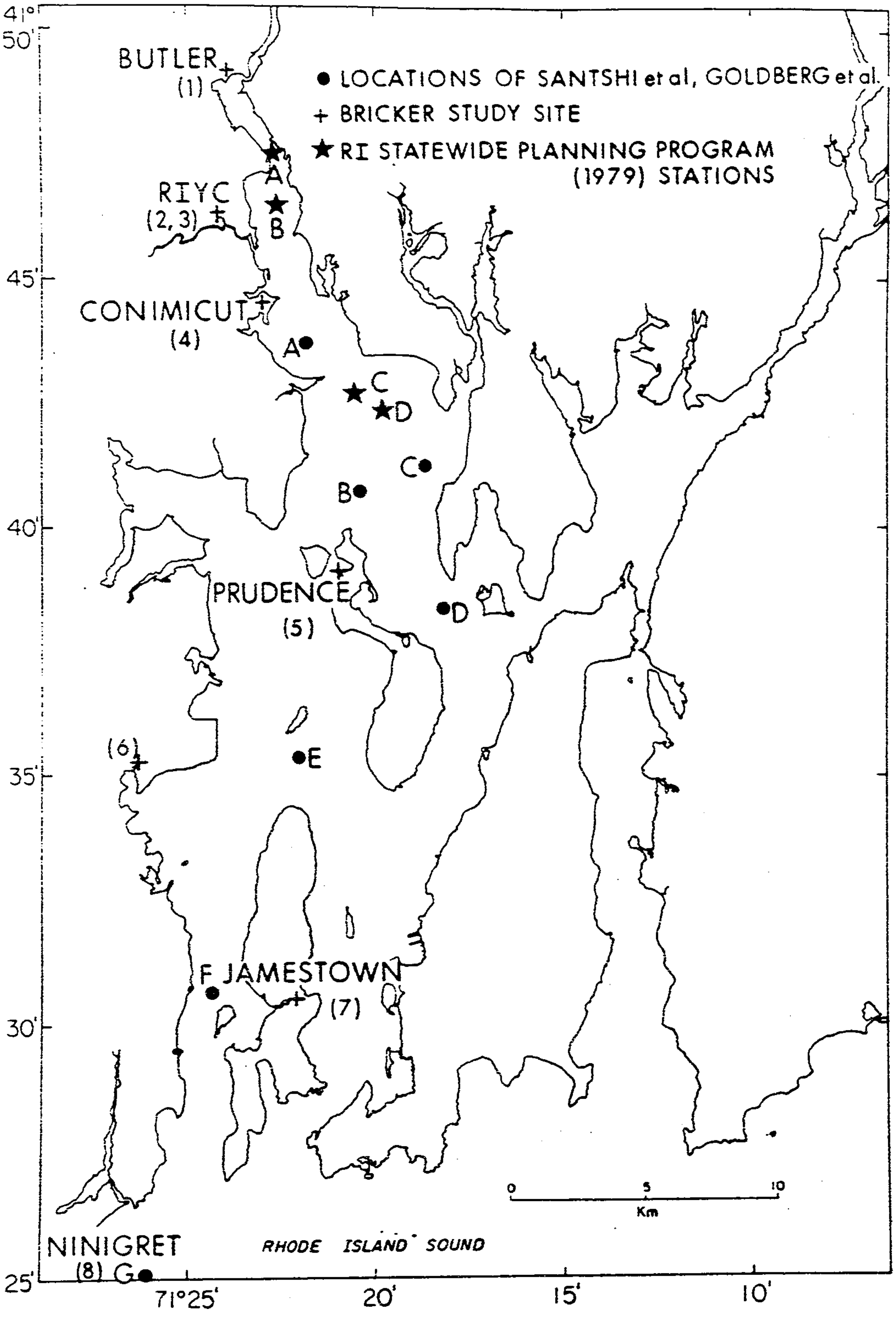
In salt marshes, bioturbation is absent but diagenesis has a much larger impact on sediment composition. The impact of diagenesis results from the production of pyrite (FeS_2) in the O_2 - free sedimentary environment, and the subsequent oxidation of pyrite to iron hydroxide and sulfuric acid (H_2SO_4) when the tide is low and air enters the sediment. The sulfuric acid can cause salt marsh sediments to be highly acidic, and readily dissolve trace metals. As a result of sulfuric acid dissolution, there are erratic variations in trace metals concentrations superimposed on the long term variability in trace metal - depth profiles, which reflect temporal changes in trace metal concentrations of particles entering the Bay.

In this section, we will first examine how trace metal concentrations change in the open areas of the Bay with location and with depth in the sediment (locations of study sites are given in Fig. III-1). Next, we will examine evidence for extensive local trace metal contamination of sediments in shoreline areas near sources of pollution. Third, we will discuss how the trace metal content of salt marsh sediment varies with location in the Bay and with depth in the sediment. Finally, we will briefly discuss the timing of increases in metal loadings in Bay sediments.

B. Consideration of data quality for metal concentrations in sediments

Metals in Narragansett Bay have been analyzed by two techniques: neutron activation

Fig. III-1. Location of cores studied for solid phase trace element composition.



analysis and atomic adsorption spectrophotometry. The latter has been applied to both acid-leached and completely dissolved sediments. The results should be comparable for metal-rich sediments such as those found in the Bay. The analytical procedures used are well grounded, and we judge all data to be reliable. The only question mark applies to the Corps of Engineers data summarized in Seavey and Pratt (1979). No information about standards or analytical methodology is available. However, based on the general agreement with other sediment data, we accept these results too as reliable.

C. Trace metals in submerged sediments from the main channels

The striking characteristic of trace metal concentrations in Narragansett Bay is the elevated levels in surface sediments of the Bay compared to sediments at 1 m depth, which probably were deposited before man began exerting a dominant influence. In Table III-1, trace metal concentrations are listed for sediments at the bottom of cores at least 95 cm in length. Concentrations of Cu, Cd, Pb, Ni, Zn, Co, and Cr are all less than 30 ppm (µg/gm dry weight). Of the cores represented in this table, "Sant F" and "Sant B" are from the main channels (Santschi et al., 1984) ("SB" cores are salt marsh samples analyzed by Suzanne Bricker Urso). Despite the fact that these two cores are taken from locations about 8 km apart, trace metal concentrations in the deepest sediments are similar. For example, concentrations of Cu, Cd, Pb, Zn, Co, Cr, Fe and Mn vary by less than a factor of 2 -- generally much less. The trace metal levels in the deepest sediments from these two cores may be representative of preanthropogenic levels in the main channels of the Bay.

Trace metal concentrations in surface sediments taken throughout the Bay (Table III-2) are much higher than in sediments at 1 m depth. For example, Pb in surface sediments ranges from 14-149 ppm compared to 10-15 at 1m, and Cu ranges from 9-250 compared to 4-7 at 1 m. Concentrations of Ni, Cr, and Cd are similar in Block Island Sound sediments and in Bay sediments at 1 m depth, but within the entire Bay proper concentrations of these metals in surface sediments are elevated with respect to values at 1 m. The elevated concentrations in surface sediments are undoubtedly due to man's impact.

The main centers of pollution are at the head of the Bay. Therefore we would expect trace metal concentrations in surface sediments to be greatest at the head of the Bay, and this is found (Fig. III-2). Going from Block Island Sound towards the north (towards the center of population), trace metal concentrations in surface sediments increase strongly. Pb, Zn, Cd, Cr and Ni concentrations all increase by roughly an order of magnitude. The Cu concentration increases by about a factor of 25. Mn and Fe concentrations vary considerably but show no consistent trend. Because of the high background abundances of these latter two metals in unpolluted Bay sediments, pollution does not affect concentrations very much. Manganese can be released from the sediments as a result of diagenetic processes, and variations in its concentration within the Bay may reflect this process in addition to source concentration variations. Cobalt concentrations do not appear to vary with location in the Bay or depth in core. Bay sediments appear to be largely uncontaminated with this element.

Within the dredged channel itself, trace metal concentrations (Table III-2) are again clearly elevated with respect to background levels. However, metal concentrations in dredged channel sediments appear to be somewhat lower than nearby sediments out of the dredged channel. For example, concentrations of Pb, Cu, Cr, and Zn are all lower in dredged channel cores C and D than in surrounding main channel cores (A, B, and C). Dredging itself may remove highly polluted sediments and lower the pollutant metal levels in the dredged channel.

Table III-1. Trace metal concentrations in the bottom samples from the deep Santschi et al. (1984) cores and the Bricker cores, tabulated in order of increasing Fe concentrations.

Core	Depth (cm)	Cu µg/g	Cd	Pb	Ni	Zn	Co	Cr	Fe mg/g	Mn
SB.PrH	97	1.3	0.01	2.7	2.9	7.6		3.1	4.5	21
SB.YC2	95	0.1		0.87		3.3			4.5	34
SB.But	95	5.4		<1		8.9		3.8	4.8	51
SB.PrL	97	2.5	0.02	1.6	3.9	8.4		4.9	7.3	40
SB.Nin	99	6.5				0.6		1.6	8.6	24.2
SB.James	95	2.2		0.02		15.5		4.7	9.4	54
Sant F	100	4	0.08	15	5	26	5	22	10.7	105
Sant B	96	7	0.1	10	18	26	3	19	11.1	102
SB.Conim	97	7	0.38	0.9	9.3	27		29.3	20	246

Bricker cores (SB): PrH = Prudence Island high marsh; YC 2 = Rhode Island Yacht Club No. 2; But = Butler Hospital; PrL = Prudence Island low marsh; Nin = Ninigret Pond; James = Jamestown; Conim = Conimicut Point.

Santschi et al. (1984) cores (Sant): F = Site F; B = Site B.

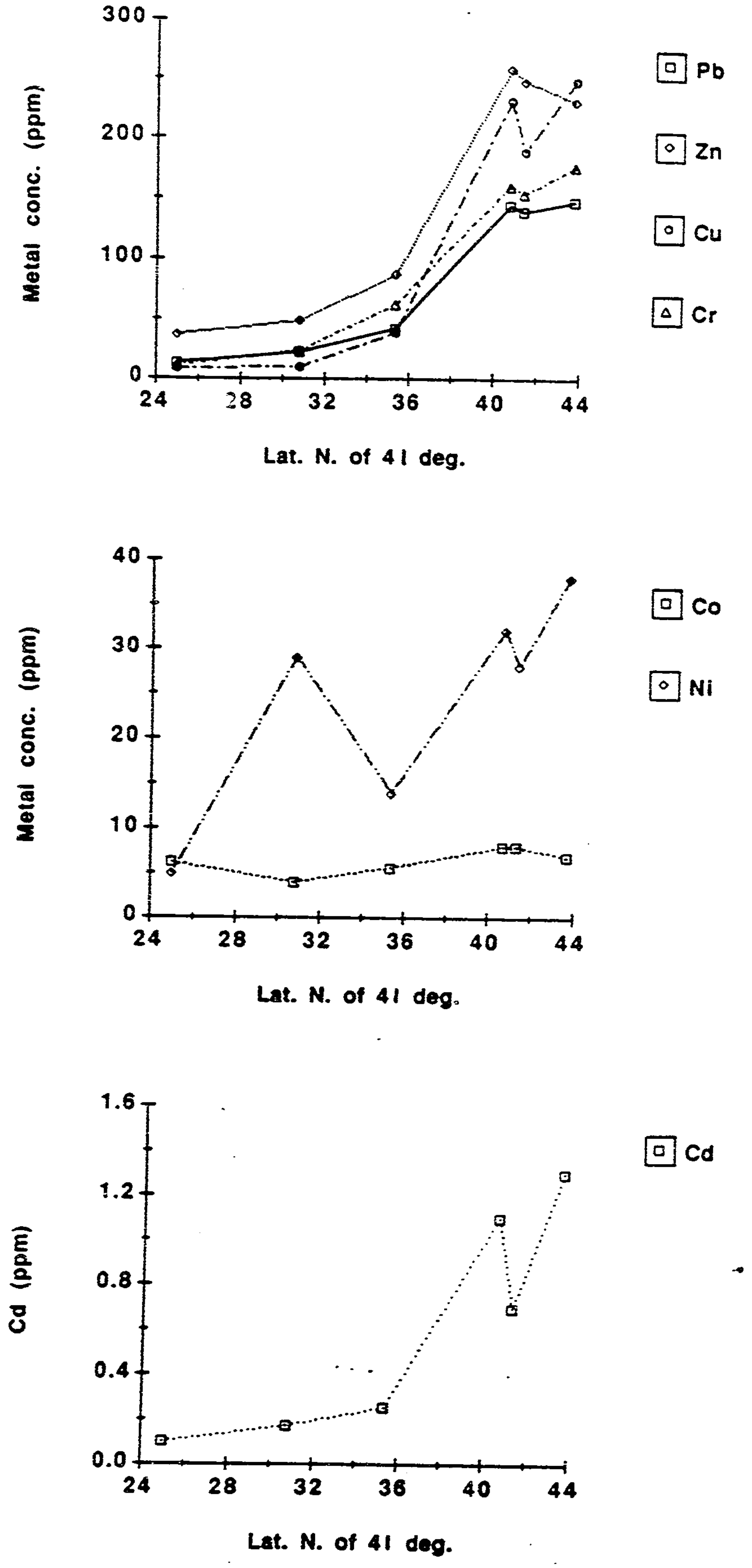
Table III-2a. Trace metal concentrations in the tops of cores from the main channels in Narragansett Bay. Latitude and longitude expressed as minutes N of 41 deg. N, and minutes W of 71 deg. W.

Core	Lat N of 41	Long W of 71	Depth (cm)	Pb µg/g	Zn	Cd	Cu	Cr	Mn mg/g	Fe µg/g	Co	Ni
G	25	26	0.5	14	37	0.1	9	11	240	9.8	6.1	5
F	30.79	24.4	1	23	49	0.17	10	24	91	8	4	29
E	35.35	21.98	0.5	42	87	0.25	39	62	151	14.6	5.7	14
B	40.73	20.51	1	145	260	1.1	232	161	221	29.1	8	32
C	41.39	18.75	1.5	140	250	0.7	190	155	410	33	8	28
A	43.73	21.88	1	149	232	1.3	250	178	185	17.6	6.9	38

Table III-2b. Trace metal concentrations in sediments from the dredged channel in Narragansett Bay (from Rhode Island Statewide Planning Program, 1979; 208 Water Quality Plan for Rhode Island). All concentrations are in units of ppm.

Station	Pb	Cu	Zn	Cd	Cr	Hg
A	567	1048	996	10.9	377	1.4
B	160	418	334	3.2	189	.63
C	55	96	98	2.9	66	.40
D	79	158	167	2.9	75	.49

Fig. III-2. Trace metal concentrations in sediment core tops, vs - minutes N. of 42°N latitude.



Downcore trace metal - depth profiles at the two sites (B and F: Fig. III-3) reflect the contrasting rates of sedimentation in the different parts of the Bay. According to Santschi et al. (1984), the sedimentation rate at Site B is about 0.5 cm/yr. The entire core thus reflects approximately 200 years of sedimentation. In the top ~ 10 cm or so, trace metal concentrations are roughly constant, as a result of mixing by bioturbation. At greater depths, concentrations vary in ways reflecting the different input histories of the metals. Cu and Cd concentrations rise, reaching maxima at depths of about 12 and 20 cm respectively; concentrations then fall abruptly. Cr, Mn and Fe concentrations are nearly constant to the bottom of the core. Pb and Zn concentrations fluctuate, then begin falling abruptly towards unpolluted values at about 70 cm depth.

Santschi et al. (1984) attempted to interpret the Cu and Pb profiles in terms of the history of regional pollution. They pointed out that the maxima in the Cu and Pb concentrations in core B at 26 cm corresponds to deposition in about 1870 (note that compaction causes age to increase more slowly downcore than depth), and suggested that the contamination peaks were caused by copper smelting and coal mining at the time. The zinc and cadmium peaks may have a similar origin.

The trace metal profiles for Site F also have constant concentrations in the upper 10 cm, again the result of bioturbation. Concentrations of Ni (top sample excluded) and Co are constant downcore, as are those of Mn and Fe; apparently sediments of the lower Bay are not polluted by any of these metals. Concentrations of Cu, Cd, Zn and Pb all decrease rapidly below ~ 10 cm depth, and reach background levels by a depth of 20 cm. Again the pattern can be understood in terms of the sedimentation rate. According to Santschi et al. (1984), sedimentation at Site F is very slow - on the order of 0.01 cm/yr. If they are correct, the last 400 years of have produced only 4 cm of sediment. The occurrence of metal pollution to a depth of 10 cm and below simply reflects downward transport by bioturbation. The radionuclide data of Santschi et al. indicate that bioturbation extends to about 20 cm depth; hence background levels are found below this depth.

The preceding discussion demonstrates the general trends characterizing trace metal distributions in the Bay: an increase in concentrations towards Providence, reflecting the most intensive pollution at the center of population, and a decrease in concentrations as depth increases from 20 cm to 1 m, reflecting the decrease towards background levels in sediments which accumulated before the influence of man was manifested.

Superimposed on these general trends are "hot spots" which reflect intense local pollution. The most extensive of these "hot spots" is the one found near Quonset Point, which derived from the U. S. Naval Air Rework Facility (NARF) which operated between 1942 and 1973. Eisler et al. (1977) showed that sediments off Quonset Point were polluted with several trace metals, and the pollution halo extended several kilometers from the source (Figure III-4). Other "hot spots" are confined to geographically isolated sites, heavily impacted by pollution, on the borders of the Bay (Seavey and Pratt, 1979). These include Apponaug Cove (Warwick), Brushneck Cove, Bullock's Cove, Greenwich Cove, Newport Harbor, Pawtuxet Cove, Warwick Cove, and Wickford Cove. Locations of these sites are shown in Figure III-5, and trace metal concentrations are given in Table III-3.

D. Trace metals in salt marsh sediments of Narragansett Bay

Having discussed the distribution of trace metals in continuously submerged sediment in Narragansett Bay, we now turn our attention to their distribution in cores taken from salt marshes. Thanks to the extensive work of S. Bricker Urso and S. Nixon, we have a prodigious amount of data on this topic.

Table III-3. Concentrations of trace metals in samples from the surface of sediments in harbors and coves of Narragansett Bay (based on Corps of Engineers data summarized in Seavey and Pratt (1979)). Concentrations are given in parts per million.

Location	Mercury	Lead	Zinc	Cadmium	Chromium	Copper	Nickel	Vanadium
Apponaug Cove	.032-2.5	33-777	38-855	2.2-6.5	18-1127	27-428	16-78	43-115
Brushneck C.	.12-.64	33-168	52-408	1.9-10	19-168	46-204	8-82	24-102
Bullock's C.	.14-1.6	12-273	31-528			36-956		
Greenwich C.	1.6-2.0	143-170	352-510	3.6-4.1	212-230	184-194	31	82-164
Little Narragansett Bay	0-.83	6.5-76	9-158	.4-4.8	6-87	5-140	5-38	5-70
Newport Harb.	.3-1.2	87-200	93-410	.1	41-68	38-150	32-60	15-68
Pawtuxet Cove	.3-2.5	41-565	57-1250	.5-5.6	22-565	62-1211	16-178	22-194
Pt. Jud. Har.	.24-.42	14-21	18-30	1.8-8.5	4.6-6.9	13-23	12-21	18-31
Prov. R.	.06-1.8	16-836	41-1379	1.0-12.5	11-460	34-1358	8-199	15-105
Warwick Cove	.12-1.6	16-159	43-424	.5-4.2	8-88	21-165	13-47	32-94
Wickford C.	.2-4.4	26-160	40-274	2.1-7.2	8-74	26-159	21-61	42-96

Fig. III-3 (a). Trace metal concentrations vs. depth downcore (Core B).

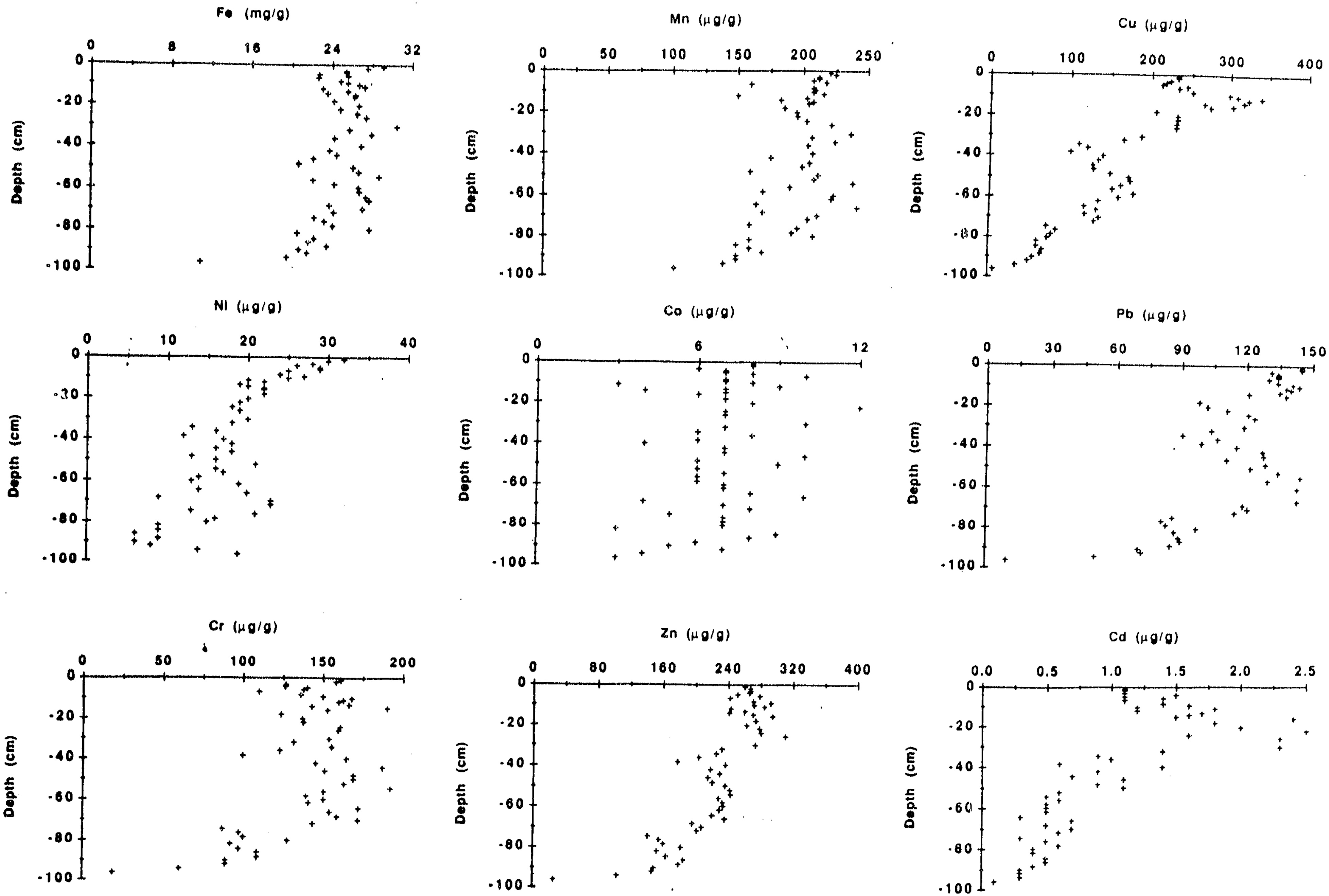


Fig. III-3 (b). Trace metal concentrations vs. depth downcore. (Core F)

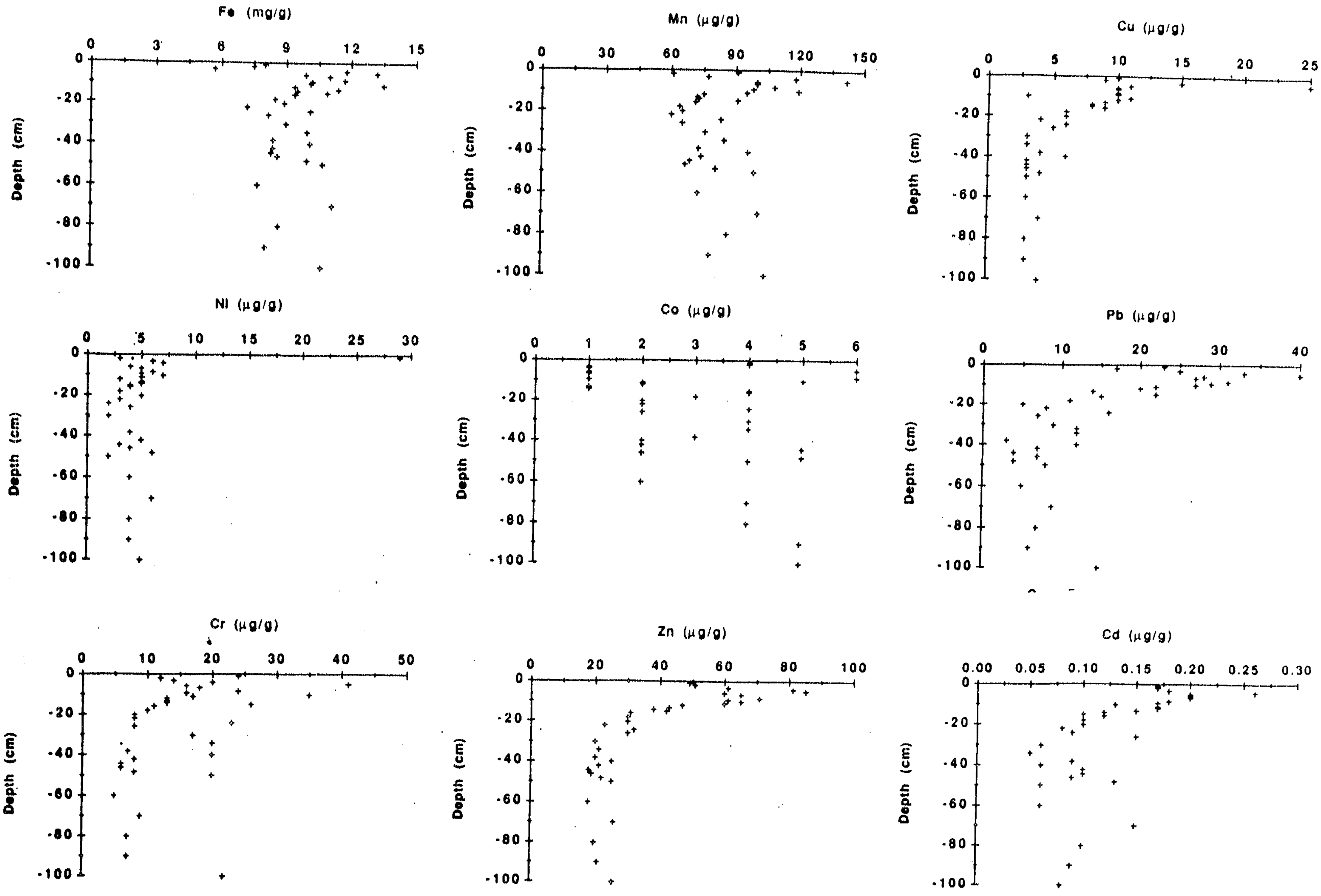


Fig. III-4. Sediment trace metal concentrations in the area of the Naval Air Rework Facility (from Eisler et al., 1977).

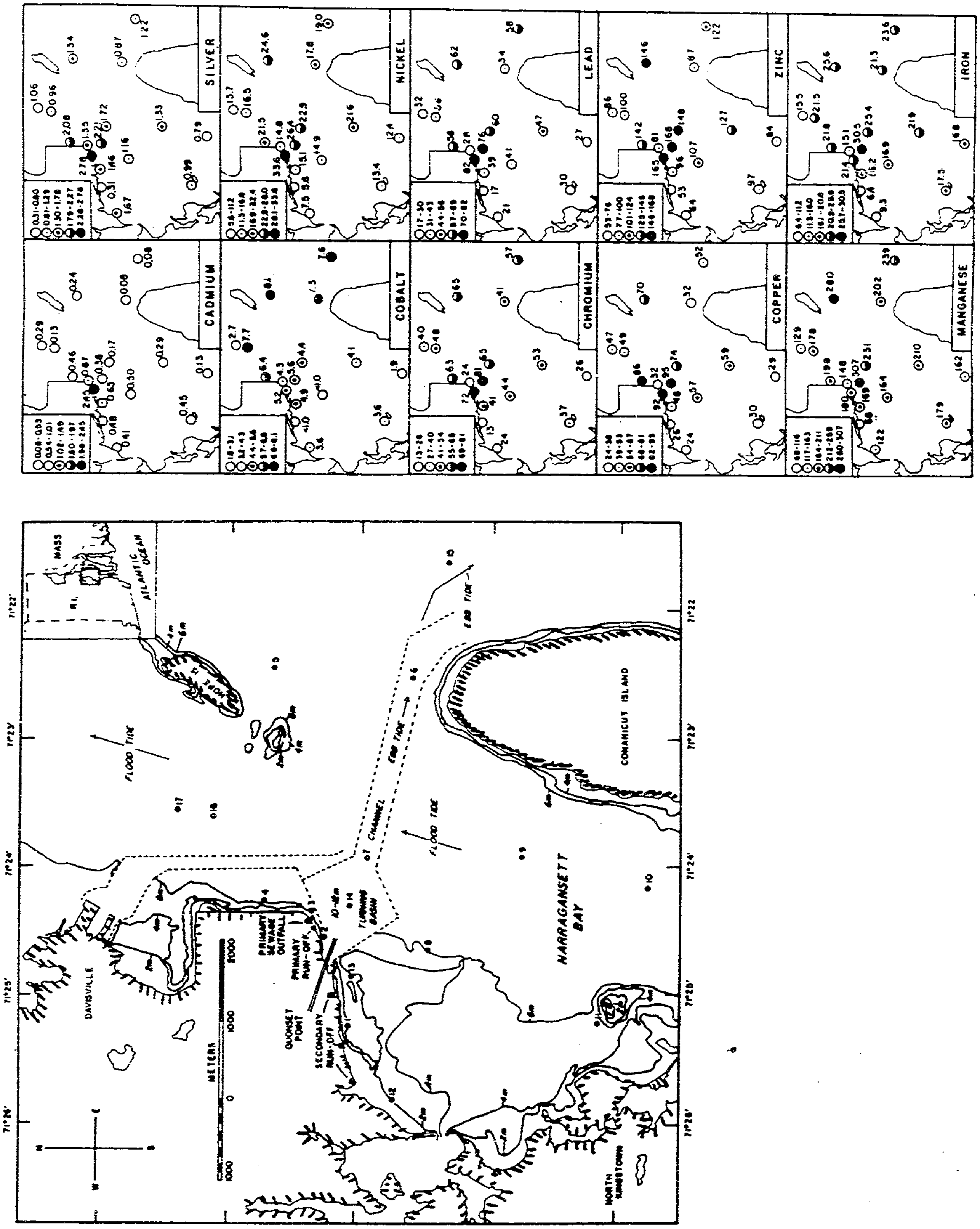
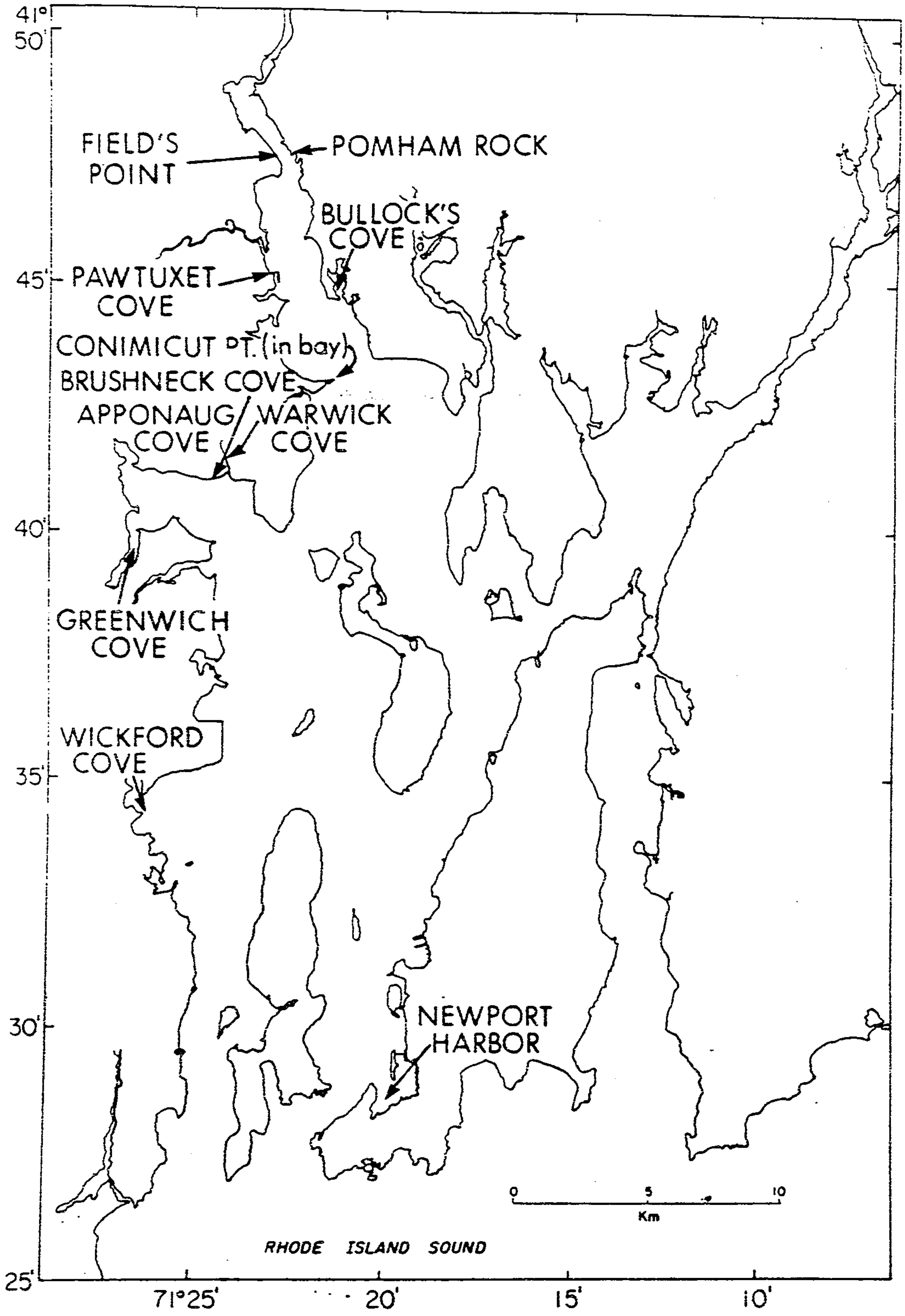


Fig. III-5. Location of cores in bays where sediment trace metal content has been measured.



Sites chosen by Urso and Nixon for analysis are shown on the map of the Bay in Figure III-1. Metal concentrations in surface sediments, with cores arranged according to increasing distance from the head of the Bay, are given in Table III-4. For marsh cores, as for continuously submerged cores, it is apparent that surface sediments are polluted throughout the Bay, and that the levels of metal pollution are systematically greatest near the center of population.

In the northern reaches of the Bay, the trace metal concentrations of salt marsh sediments appear to be considerably lower than levels in nearby submerged cores. This can be seen by comparing trace metal concentrations in R I Yacht Club cores (2 and 3) with concentrations in core B from the dredged channel, and comparing concentrations in the salt marsh core from Conimicut Point (core 4) with core A from the main channel. Towards the mouth of the Bay, the trend reverses, with salt marsh cores having higher pollutant levels than main channel cores (compare salt marsh core 6 with main channel core 7, and salt marsh core 7 with open channel core F). Even in Ninigret Pond, levels of trace metal pollution are substantial. It has been suggested that atmospheric fallout is an important source of direct pollution to salt marsh sediments. If so, the slow dropoff in pollutant trace metal abundances with distance from Providence may be due to the wide dispersal of atmospheric pollution.

As we would expect from data for the submerged cores, concentrations of pollutant trace metals in salt marsh sediments have increased dramatically over the time span covered by the cores. The trends are illustrated in Fig. III-6, where we plot trace metal concentrations vs. depth for R. I. Yacht Club core No. 1, representative of a highly polluted environment in the northern part of the Bay, and the Ninigret Pond core, taken from a less impacted area. In both cores, Fe and Mn concentrations vary considerably, showing no consistent trend with age (depth). The variations are likely due to changes in the composition of the material being deposited and (especially for manganese) the extent of diagenetic remobilization; they do not necessarily reflect pollution. Downcore concentrations of Pb, Cu, Zn and Cr also vary in a complex way, but in both cores all four of these elements show this common feature: their concentrations decrease to very low levels towards the bottom of the cores. The upcore increases, then, reflect contamination of the sediments by pollution. The concentrations of pollutant metals are consistently higher in the R. I. Yacht Club core, as would be expected.

E. History of pollutant metal loading as reflected in Narragansett Bay sediments

Santschi et al. (1984) and Bricker-Urso et al. (1988) have discussed the history of metal pollution in Narragansett Bay sediments, with emphasis on copper. In both papers, it was concluded that copper pollution increased dramatically around 1865-1885. There are two approaches leading to this conclusion. First, the history of industrial activity around Narragansett Bay indicates a large increase in metal processing around this time (Santschi et al., 1984; Bricker-Urso et al., 1988). Second, in all dated rapidly accumulating Bay cores, there is a sharp increase in the copper concentration at a depth corresponding roughly to the above age interval. The relevant depth is about 25 cm in submerged core B (Fig. III-6a), 35 cm for the R. I. Yacht Club salt marsh cores (Fig. III-1), and about 40 cm for the Ninigret salt marsh core (Fig. III-6b).

Data from both submerged and salt marsh cores at the head of the Bay indicate that extensive pollution of sediments in these areas began about 1750 or even earlier. Beginning at about this time, concentrations of Cu, Pb, Cr, Zn, and Cd become elevated

Table III-4. Concentrations of trace metals in the tops of salt marsh cores from Narragansett Bay. Concentrations are given in units of µg/g. Cores are listed from proximity of the head of the Bay (Butler Hospital) to the mouth (Ninigret).

Location	Iron	Mangan.	Copper	Nickel	Zinc	Chrom.	Lead	Cadm.
Butler Hosp	26300	329	48		157	190	564	
RIYC # 1	10000	287	325		2552		328	
Conimicut	8710	181	95	13	72	86	105	.098
Prudence Hi	12200	410	26	11	37	20	12	.20
Prudence Lo	9120	107	72	17	110	36	62	.34
Jamestown	17400	370	30		130	23	85	
Ninigret	10900	94	20			9.7	59	

Fig. III-6 (a). Trace metal concentrations vs. depth for a salt marsh core from the Rhode Island Yacht Club (RIYC) location.

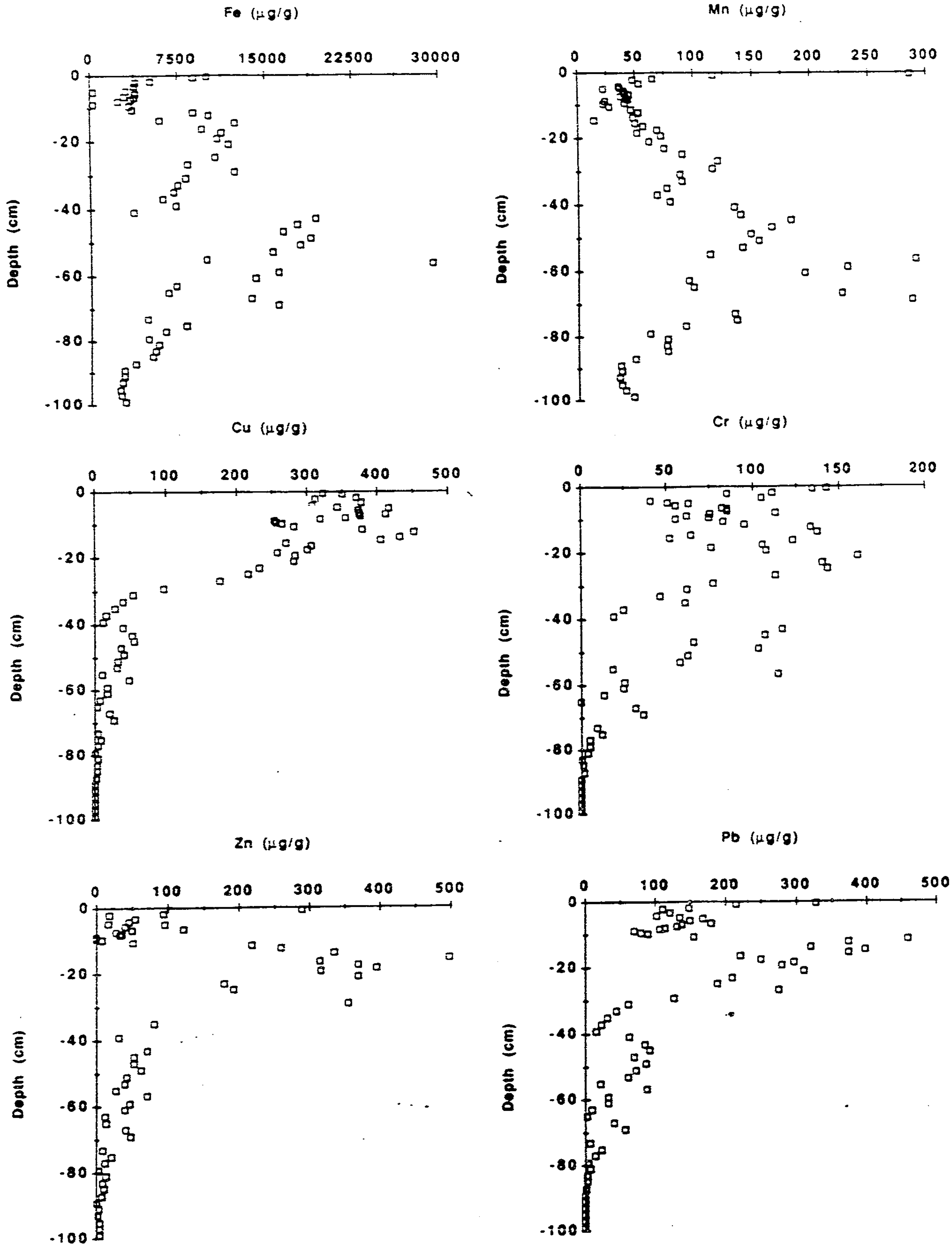
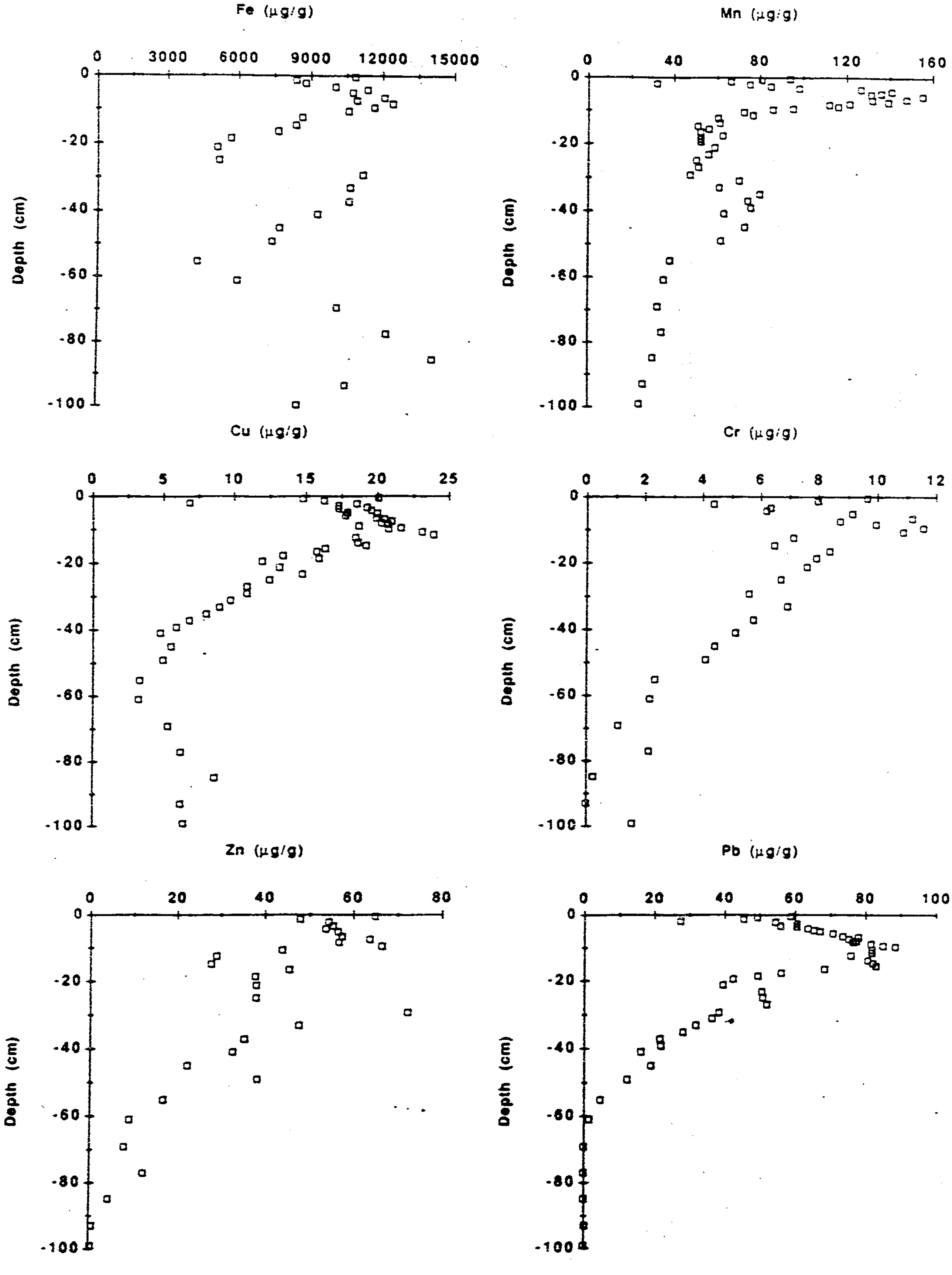


Fig. III-6 (b). Trace metal concentrations vs. - depth for a salt marsh core from the Ninigret Pond location.



above background levels in both sets of cores. See, for example, the data for submerged core B (Fig. III-3a), showing increases in all these elements at about 90 cm depth, and the R. I. Yacht Club salt marsh core, showing increases in Cu, Cr, Zn and Pb at about 55 cm depth (Fig. III-6a). The Ninigret data (Fig. III-6b) and Jamestown salt marsh data do not show such an increase. Bricker et al. (1988) have suggested that salt marsh sediments at the head of the Bay are polluted by both atmospheric and fluvial transport, while those at the mouth are polluted in metals by atmospheric transport only. This may be the reason for different pollutant histories in the two sets of cores.

F. Summary

The sedimentary trace metal data show the following five major features:

1. Extensive pollution of all surficial submerged and salt marsh sediments in the region of the Bay, with respect to preanthropogenic levels.
2. Much higher levels of pollutant loadings in surficial sediments near Providence than at the mouth of the Bay.
3. Pollutant trace metal "hot spots" in restricted environments bordering population centers and regions of concentrated industrial activity.
4. An increase, going forward in time, in trace metal pollutant loadings, beginning around 1750, for sediments in the upper part of the Bay.
5. An additional sharp increase in trace metal pollutant loadings, between 1865-1885, for sediments throughout the Bay.
6. Fluctuating levels of trace metal loading between 1885 and the present day.

IV. Shellfish composition

A. Introduction

The focus of this review is to present a historical summary of trace metal levels found in tissues of marine organisms, particularly bivalve mollusks, that have been collected from the Narragansett Bay estuary. The data that have been assembled for this review collectively span a period of about 20 years, with the earliest studies of metals in Narragansett Bay organisms taking place in 1968 or so.

In the review of this collection of data it was interesting to note that the investigations of trace metals in bivalve tissues were approached from two different research perspectives. In one approach the trace metal burdens of bivalve tissues were considered from the perspective of human health while the other approach evaluated bivalve tissue concentrations relative to the organism's environment. The common denominator in each of these perspectives is the capacity of a filter feeding bivalve to concentrate metal levels above those present in the environment.

The capacity of some marine organisms to concentrate selected metals hundreds or thousands of times greater than their surroundings has led, in some instances, to serious human health problems. Incidents of mercury and cadmium poisonings of human populations in Japan were attributed to the consumption of fish and shellfish that were contaminated from the exposure of elevated metal levels from the direct discharge of industrial waste into marine waters. To safeguard against similar occurrences in Rhode Island, the Rhode Island Department of Health and U.S. Food and Drug Administration have monitored tissue metal concentrations of the commercially important quahog since the early 1970's. These surveys detail quahog tissue concentrations collected from closed (Providence River), conditionally closed (Upper Narragansett Bay), and commercially open shellfish beds. At present, colliform bacteria levels resulting from the discharge of sewage into Narragansett Bay are used by state authorities to establish areas closed or conditionally closed to shellfishing.

In addition to the monitoring of bivalve tissues to assess risks to human health, other studies have examined some of the factors that influence trace metal accumulations by marine and estuarine bivalves. Studies have shown, for example, that seasonal changes in bivalve tissues are due to changes in environmental variables, temperature dependent biological variations, and other seasonally dependent biological variations. Tissue size may influence trace metal concentrations, and this aspect should be addressed when considering an organism for monitoring purposes. An organism's mode of feeding and geographical location within an estuary are especially important factors that influence the uptake of trace elements in an estuarine setting. In this regard, bivalves that feed directly from the water column would be exposed to very different metal concentrations than a bivalve that derived its nutrition from consuming materials from surface sediment.

Even organisms that have similar feeding modes, such as obligate filter feeding bivalves like the quahog (*Mercenaria mercenaria*), and the blue mussel (*Mytilus edulis*), may not be exposed to the same metal regimes because of their respective positions in the water column and the preference for particular substrates. Each organism derives its total nutritional requirement by filtering water through specialized gills, but because the quahog prefers soft sediment, and the blue mussel prefers a harder substrate, each organism is exposed to different sources of metal. To take this a step further, the quahog is exposed to dissolved and particulate metal in the water column, and, because of its close association with sediments, may be exposed to resuspended sediment and the release of metal from pore waters. The blue mussel's preference for hard substrates would tend to reduce exposure to resuspended sediment and pore water releases. Because of their abundance and commercial importance, these two organisms have been used almost exclusively to evaluate water quality relationships within the Narragansett Bay estuary. The one pattern that emerges from these studies despite all of the variables that have to be taken into account, is that exposure of quahog or mussel populations to increased metal levels in the water column will result in a corresponding increase in the tissues of the exposed populations.

Although the ultimate objectives and perspectives of the Narragansett Bay studies varied, the end result is that there is an historical record that represents a chemical view of Narragansett Bay from a biological standpoint. From trace metal information detailed in these studies we are attempting to reconstruct possible trends in water quality of Narragansett Bay from organisms that are intimately linked with its waters.

B. Evaluation of data quality, and units in which data are reported

The data sets of Cullen and Thibeault/Bubly are accompanied by extensive intercalibrations and standardizations, and are judged reliable.

For the crucial data set from the Rhode Island Department of Health, documentation was not available. The strongest basis for accepting this data set is that RI/DOH values for quahog trace metal concentrations are similar to those reported by Cullen and Thibeault/Bubly. We believe that some results in this data set may be spurious, but believe that overall it is a reliable index of trends in trace metal concentrations of quahogs in the Bay.

No documentation is available for the few additional data.

Results from process-oriented control studies, done in the EPA/NMWQL laboratory, are not tabulated in the appendices, but are summarized briefly in the text. These data are judged to be reliable based on personal communications about procedures used and the analysts involved.

All shellfish trace metal data are reported in units of µg/gm in the soft (shell-free) parts of the organism. The Cullen data on quahogs, and the Phelps and Katz data on mussels, and the Thibeault/Bubly data on quahogs are reported in terms of organism dry weight. RI DOH data are reported in terms of wet weight. The wet weight is approximately 5 times the dry weight, allowing rough conversion from one set of units to the other (data presented here are *not* converted).

One other distinction between the various data sets is that Cullen removed the kidneys prior to analysis. No other authors did this. The effect of removing kidneys is probably to decrease metal contents somewhat, since metals are concentrated in kidneys, and perhaps to decrease variability as well.

C. Trace metal distribution in the quahog in Narragansett Bay

It is for the quahog, *Mercenaria mercenaria,* that we have the most trace metal data. There are three important data sets describing the distribution of trace metals in this species. The first is the data set of the Rhode Island Department of Health. Beginning in 1971, the RI DOH collected samples of *Mercenaria* from 12 different stations throughout the Bay each month, and analyzed the samples for trace metals as well as other variables. Along with Sheldon Pratt and Steven Hale of the University of Rhode Island, we have summarized the data from this study by culling results from the original data reports. The result is a remarkable data set summarizing variations in trace metal concentrations of *Mercenaria* at different locations in the Bay, on a monthly basis, back to 1971. However, this summary must be viewed with some caution, because the analytical techniques are not completely documented, especially for the early studies.

The second data set comes from the work of D. Cullen (1984), who studied the trace metal chemistry in *Mercenaria* taken at two different sampling periods at nine stations in the Bay. Cullen's data are important because they are of high quality and because they cover the widest range of sampling locations.

The third data set comes from the study carried out by Thibeault/Bubly Associates (1987). These data are also of high quality and are of particular interest because they document the size dependence of trace metal concentrations in *Mercenaria*.

Caution must be taken when comparing data from the different studies. The RI DOH samples were analyzed on a wet weight basis, whereas the Cullen and Thibeault samples were analyzed on a dry weight basis. Concentrations in the RI DOH samples should be multiplied by about a factor of 5 to put them on a dry weight basis. The Thibeault/Bubly and RI DOH sample analyses were done on bulk soft parts. The Cullen analyses were done on bulk soft parts with kidneys excluded. Since trace metal - rich stones can form in clam kidneys, the trace metal content of the Cullen samples may be somewhat lower, but possibly less variable, than that of the samples studied by other groups.

In using the data to investigate temporal and areal variability in the trace metal contents of *Mercenaria*, it is obviously essential to understand the effects of season and size. The RI DOH data set can be used to study seasonality of *Mercenaria* trace metal levels. S. Pratt and S. Hale (personal communication) have thoroughly investigated this topic, and showed that there is no discernible change in *Mercenaria* trace metal contents during the year (Appendix C). The importance of size on *Mercenaria* metal levels can be investigated using the Thibeault data set, as quahogs in different size classes were measured. The results show that there is no consistent relationship between concentration and size for any of the metals they studied. These findings are auspicious for our study as they indicate that trends in *Mercenaria* trace metal burdens should be due to location and long - term temporal variability.

Given this background, we now examine the data of Cullen and the RI DOH in more detail. Locations of the stations analyzed in these two studies are shown in Fig. IV-1.

Fig. IV-2 presents a series of scatter diagrams comparing average concentrations of Pb, Cu, Ni, Cd and Zn on log-log plots. The plots show that average concentrations of all these metals covary. Therefore there are clearly significant geographical variations in the trace metal contents of *Mercenaria* around the Bay.

What is interesting is that *Mercenaria* trace metal levels do not vary systematically with distance down the Bay. This can be seen from the plots in Fig. IV-3. In these plots, data of Cullen for individual organisms (on the left) and average body burden (on the right) are plotted vs. latitude north of 41°. As we have seen earlier, trace metal concentrations in both the water column and the sediments increase towards the north. For *Mercenaria*, only lead shows a clear trend with latitude, with concentrations increasing to the north as expected. Iron and manganese concentrations vary erratically, perhaps reflecting diagenetic patterns in the sediments in some way that we cannot now discern. Concentrations of other trace elements are systematically enriched in trace metals in the northernmost sample, undoubtedly reflecting pollution in the Providence River. Otherwise, however, there are no clear trends in *Mercenaria* trace metal burdens in the Bay.

In Fig. IV-4, trace metal concentrations in *Mercenaria* samples analyzed by the RI DOH are plotted vs. collection date. Data are plotted for Sites 4 and 5 in the more polluted

Fig. IV-1. Locations of quahogs studied by RI DOH, Thibeault/Bubly, and Cullen.

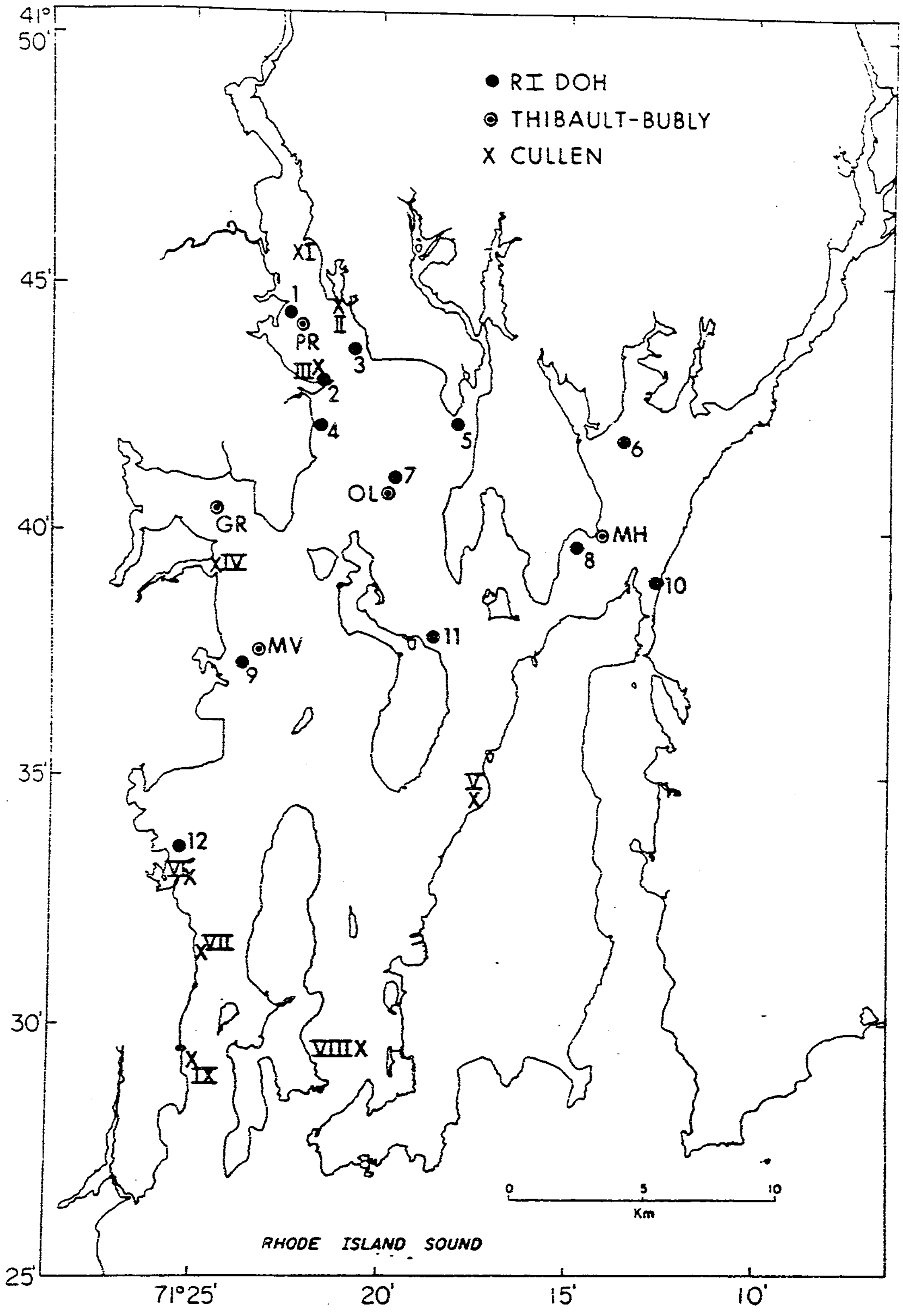
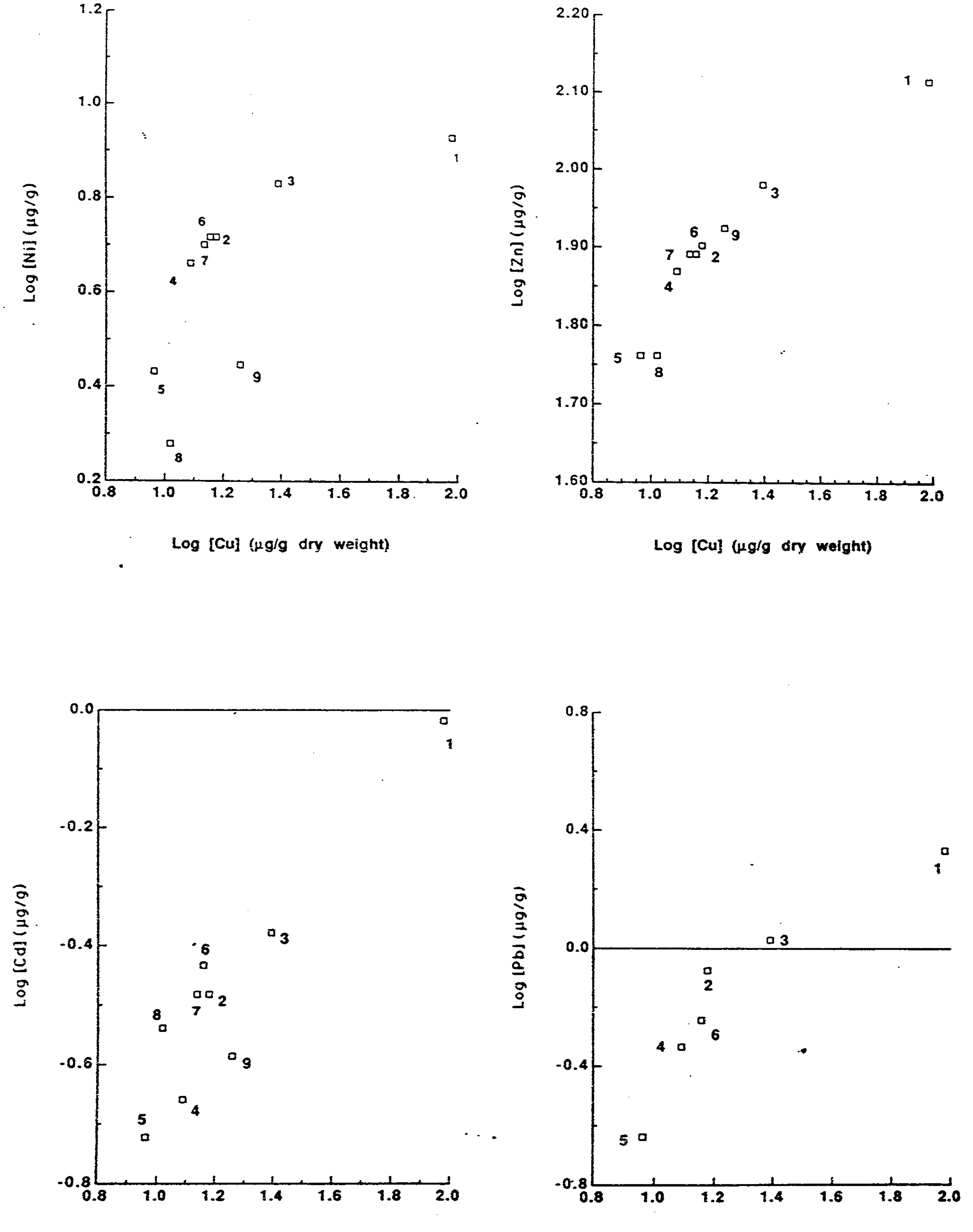
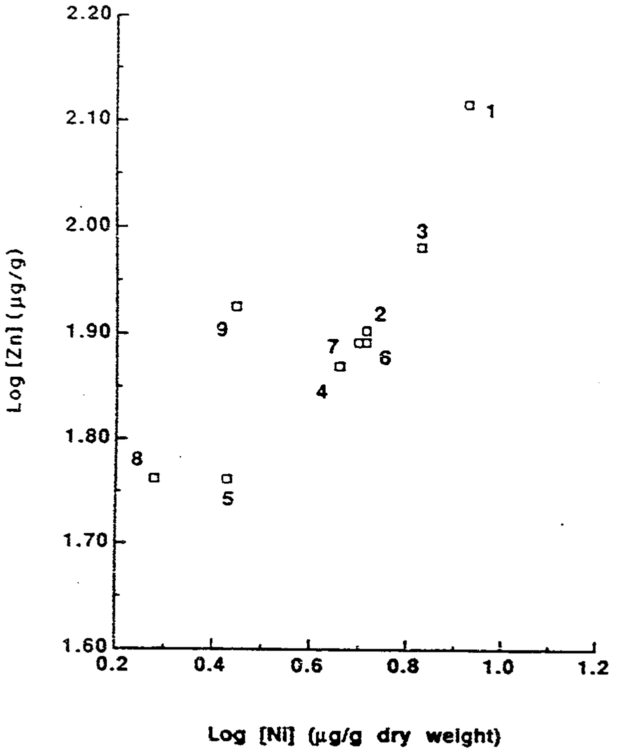
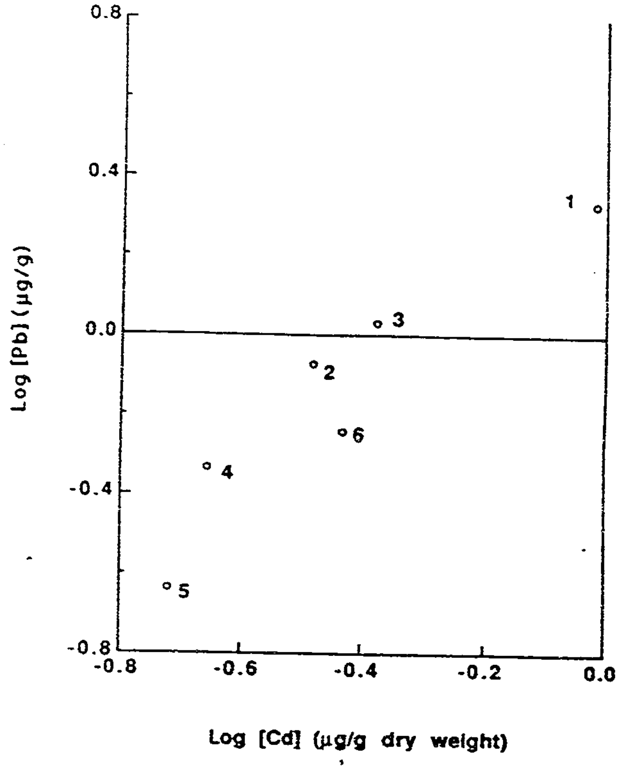
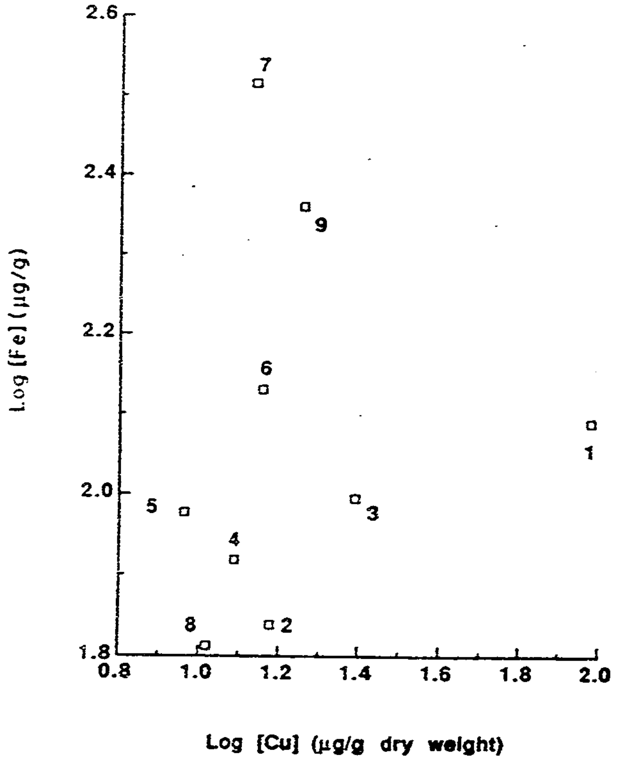


Fig. IV-2. Log-log scatter plots showing that concentrations of most divalent cations covary in Mercenaria tissue. Fe and Mn are exceptions because of their redox chemistry. Plotted points are averages. Numbers next to data points are station numbers. Data from Cullen (1984).




Log [Zn] (µg/g)
2.20
2.10
2.00
1.90
1.80
1.70
1.60
0.2
0.4
0.6
0.8
1.0
1.2
Log [Ni] (µg/g dry weight)
1
3
2
9
7
6
4
8
5


Log [Pb] (µg/g)
0.8
0.4
0.0
-0.4
-0.8
-0.8
-0.6
-0.4
-0.2
0.0
Log [Cd] (µg/g dry weight)
1
3
2
6
4
5


Log [Fe] (µg/g)
2.6
2.4
2.2
2.0
1.8
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Log [Cu] (µg/g dry weight)
7
9
6
1
5
3
4
8
2

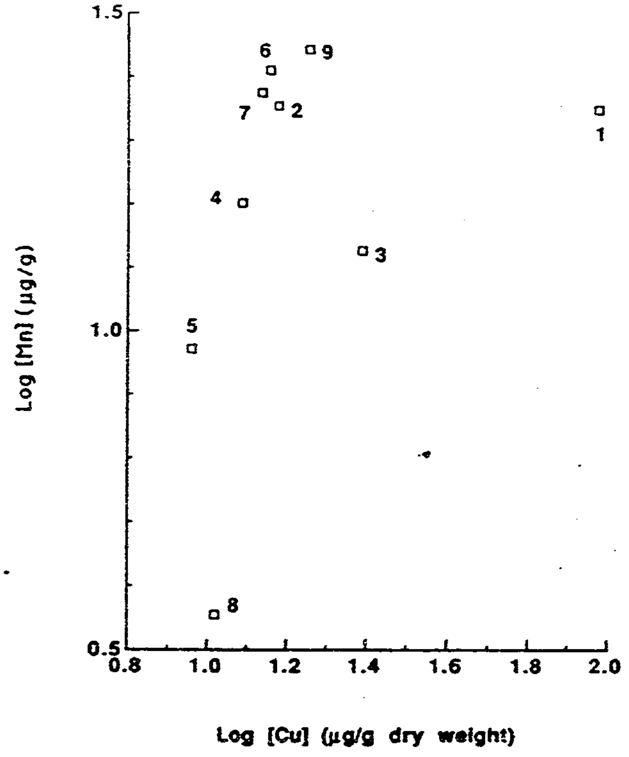

Log [Mn] (µg/g)
1.5
1.0
0.5
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Log [Cu] (µg/g dry weight)
6
9
7
2
1
4
3
5
8

Fig. IV-3. Variations down the Bay in trace metal concentrations in individual samples of Merceneria. x-axis is minutes north of 41° N latitude.

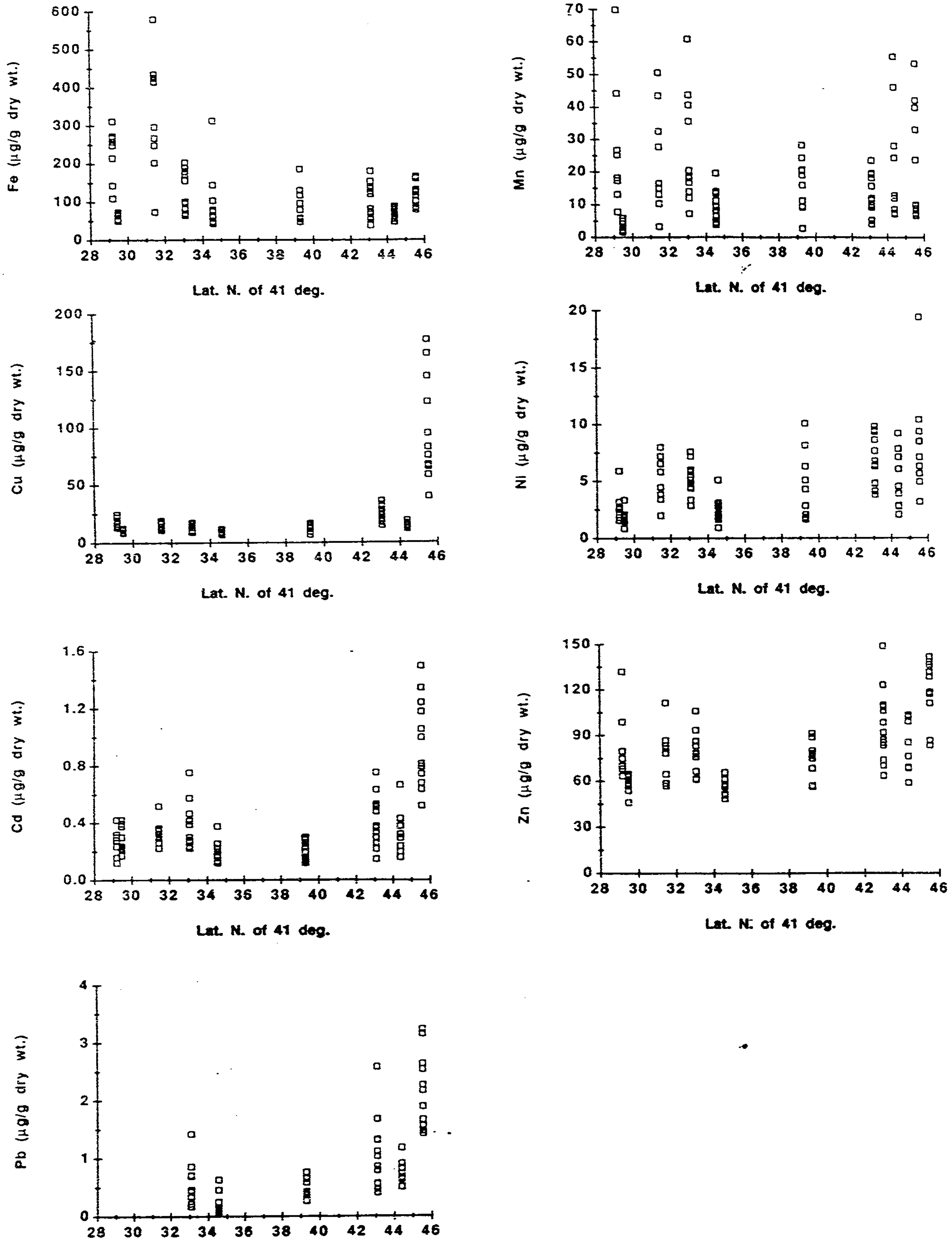


Figure IV-4 (a). Trace metal concentrations in quahogs vs. time at two stations in the northern end of Narragansett Bay (data from the R. I. Department of Health).

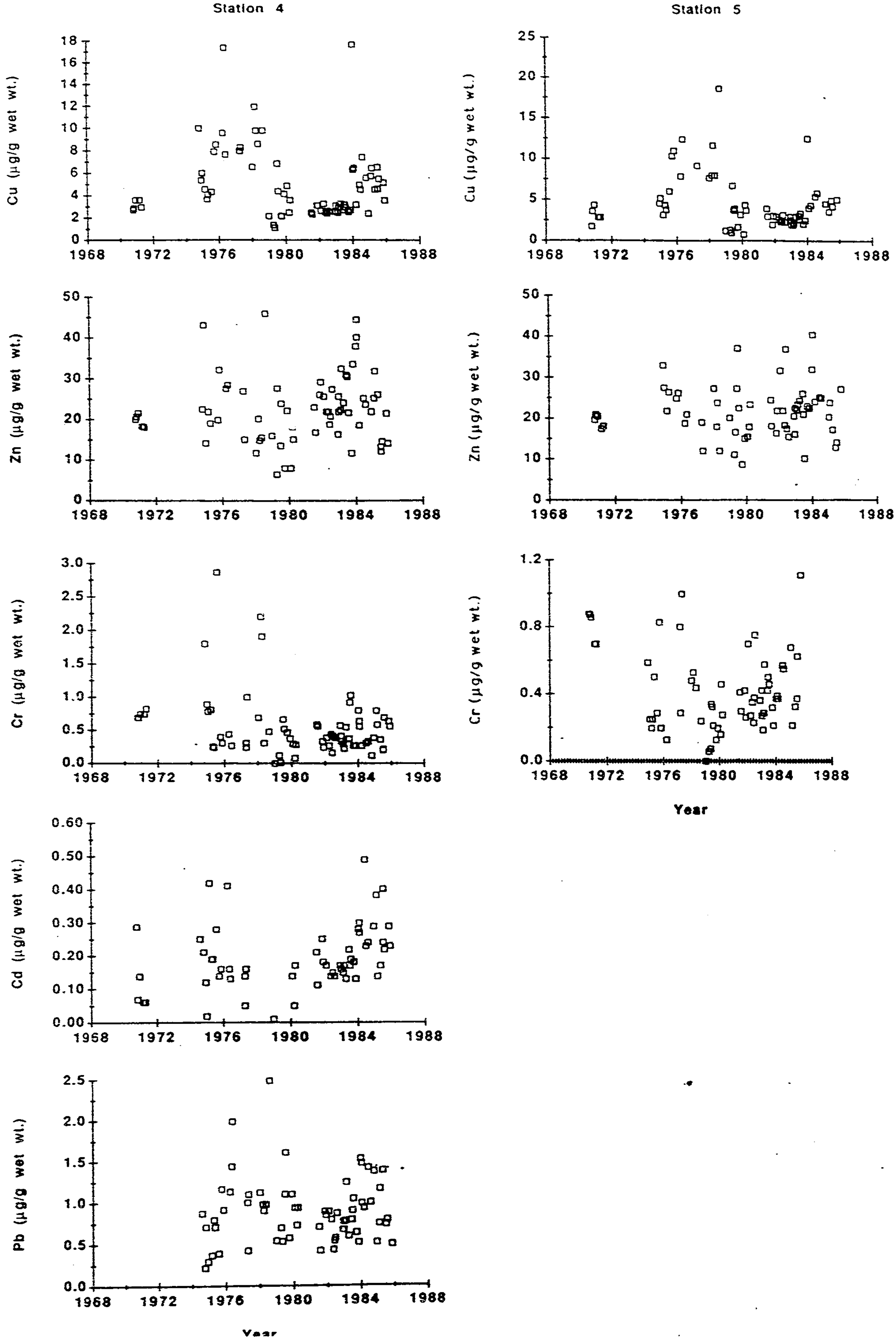
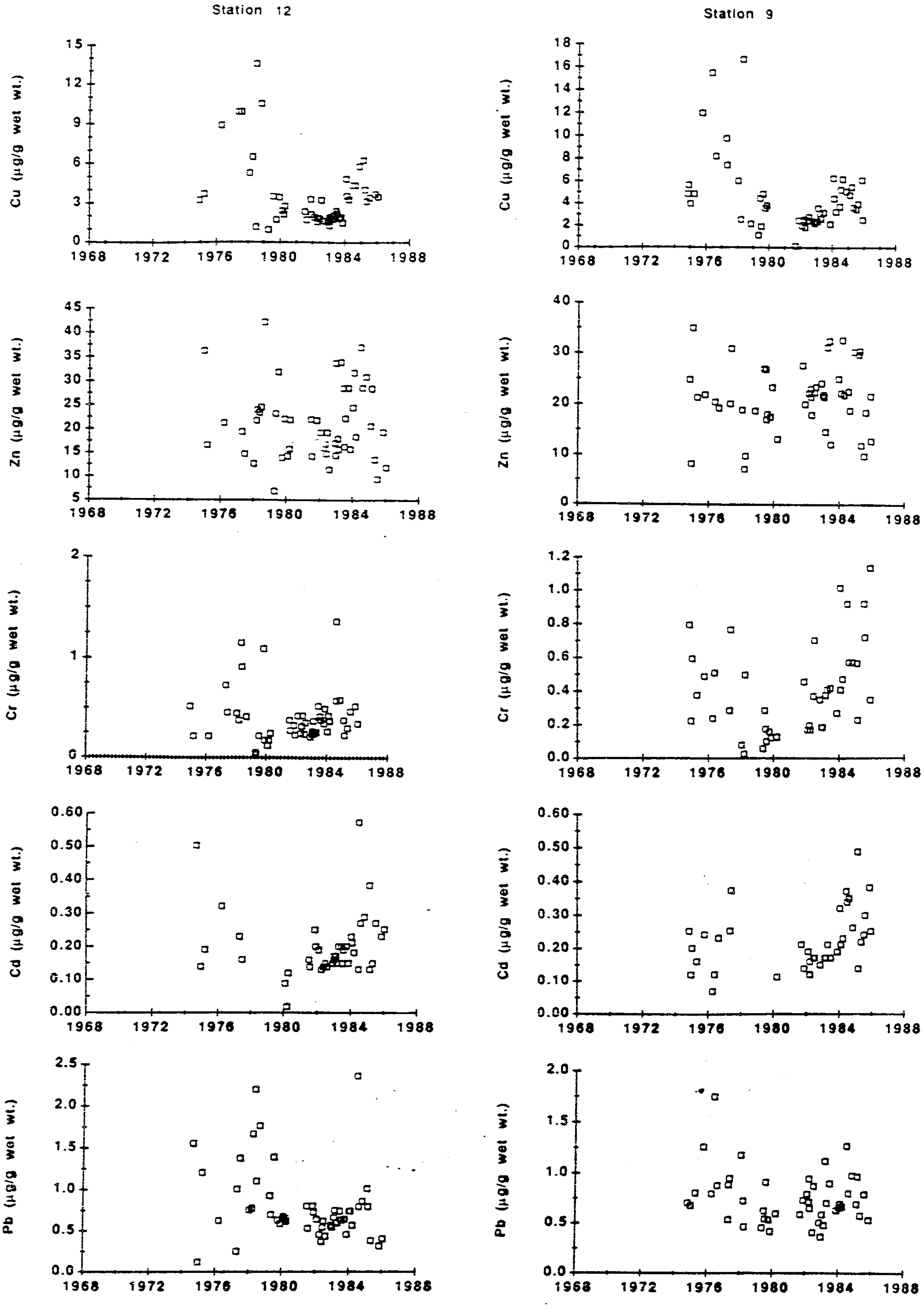

Station 4
Station 5
Cu (µg/g wet wt.)
Zn (µg/g wet wt.)
Cr (µg/g wet wt.)
Cd (µg/g wet wt.)
Pb (µg/g wet wt.)
0
2
4
6
8
10
12
14
16
18
5
15
20
25
30
40
50
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0.4
0.8
1.2
0.00
0.10
0.20
0.30
0.40
0.50
0.60
1968
1972
1976
1980
1984
1988
Year
Year

Figure IV-4 (b). Trace metal concentrations in quahogs vs. time at two stations in the southern end of Narragansett Bay (data from the R. I. Department of Health).


Station 12
Station 9
Cu (µg/g wet wt.)
0
3
6
9
12
15
0
2
4
6
8
10
12
14
16
18
Zn (µg/g wet wt.)
5
10
15
20
25
30
35
40
45
0
10
20
30
40
Cr (µg/g wet wt.)
0
1
2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Cd (µg/g wet wt.)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Pb (µg/g wet wt.)
0.0
0.5
1.0
1.5
2.0
2.5
1968
1972
1976
1980
1984
1988
Year

northern part of the Bay, and for Sites 9 and 12 in the cleaner southern part of the Bay. The data show considerable scatter. This scatter has a number of causes, including biological variability and possibly, to a lesser extent, occasional analytical problems. Certainly the scatter might reflect temporal variability in trace metal contamination of Bay sediment or water. However, the most important feature of the data is the absence of long term trends for any of the metals studied. While there may well have been oscillations of pollutant levels in the Bay, any monotonic, long term variations in the level of metal concentrations in *Mercenaria* have been less than a factor of 2 since 1971. No change in levels was apparent in data up to 1989 (S. Pratt, personal communication).

D. Distribution of trace metals in the mussel (*Mytilus edulis*)

Phelps and Galloway (unpublished manuscript) and Phelps and collaborators (unpublished data) carried out various experiments to determine how rapidly the trace metal burden in Mytilus responded to a change in the environmental trace metal concentrations. What they observed was that the response is very rapid, *Mytilus* reaching a value "at equilibrium" with its environment in a matter of days. They found that this "equilibrium" value will then be maintained, as long as the environment itself is unchanged. However, in highly polluted environments, trace metal levels in *Mytilus* appear to be constant for a period of 6 months or so, then rise. It may be that pollutants eventually break down the ability of organisms to effectively regulate trace metal uptake and depuration.

Phelps and Katz (unpublished manuscript) reported on the trace metal contents in the mussel, *Mytilus edulis*, as interpreted by statistical analysis. In their studies, mussels collected at a common location in the Bay were placed in wire cages suspended 1 meter above the bottom at various sites. Their work is thus a control study aimed at understanding various factors governing the trace metal body burdens of mussels. Their study had two aspects. The first concerned temporal variability in body burdens of trace metals. They measured trace metal concentrations in ambient mussel populations near Prudence Island on a monthly basis from June through December of 1977, as well as in June and July of 1978 and April of 1979. Results are presented in Fig.IV-5.

This temporal study showed that there are large seasonal variations in most metals studied. Concentrations of Cu, Al, Ni, Fe, Cd and Pb all were at a minimum around August and at a maximum around November. Superimposed on this were differences in seasonal variations from one metal to another. For example, Cu and Ni concentrations rose 1-2 months earlier than those of other metals. Also, samplings done in the summer of 1979 showed that the seasonal pattern is not precisely replicated. Finally, Zn showed no statistically significant temporal variability.

Phelps and Katz outlined a number of possible causes for seasonality. One is the reproductive cycle. They showed that maximum trace metal burdens nearly coincide with the maximum in the percentage of ripe gametes. Other possible causes are changing loads of metal source (food, resuspended sediments) and changing depuration rates.

Phelps and Katz (unpublished manuscript) also placed mussels in cages, deployed the cages at five locations in the Bay (Fig. IV-6), and subsequently measured metal concentrations in the mussels. Metal concentrations are plotted vs. station number in Fig. IV-7. The location goes toward the mouth of the Bay as the station number rises. As would be expected, metal concentrations at each location vary with time of collection. However, all metals follow one of two trends. Zn, Ni, Pb, Cu, and Cd decrease going from the head of the Bay to the mouth. Al and Fe increase from head to mouth in August, 1978, but not in September, when the northernmost and southernmost stations have the

Fig. IV-5. Trace metals in mussels suspended 1m above bottom near Prudence Island, vs. month.

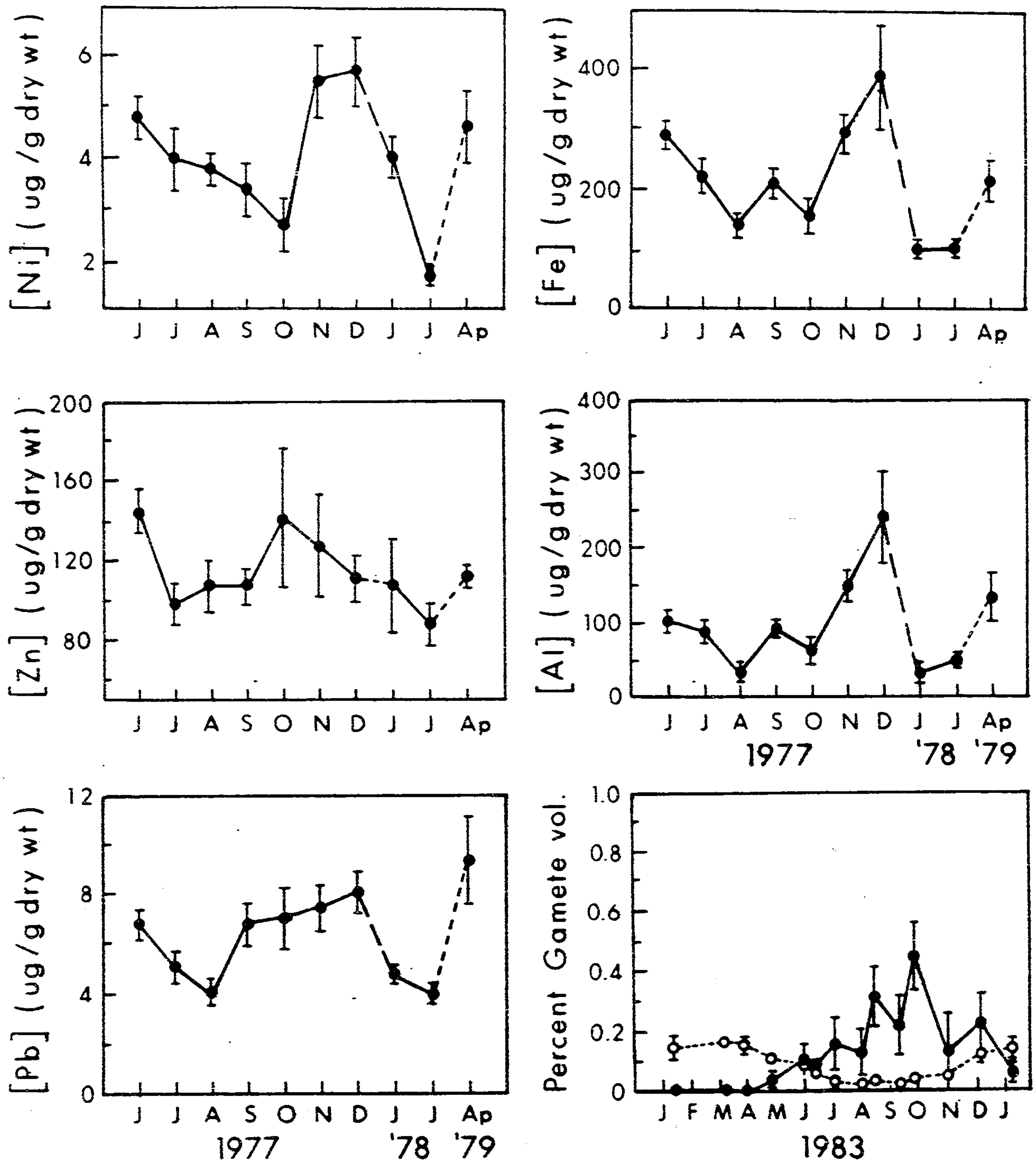


Fig. IV-6. Study sites of Phelps & Katz.

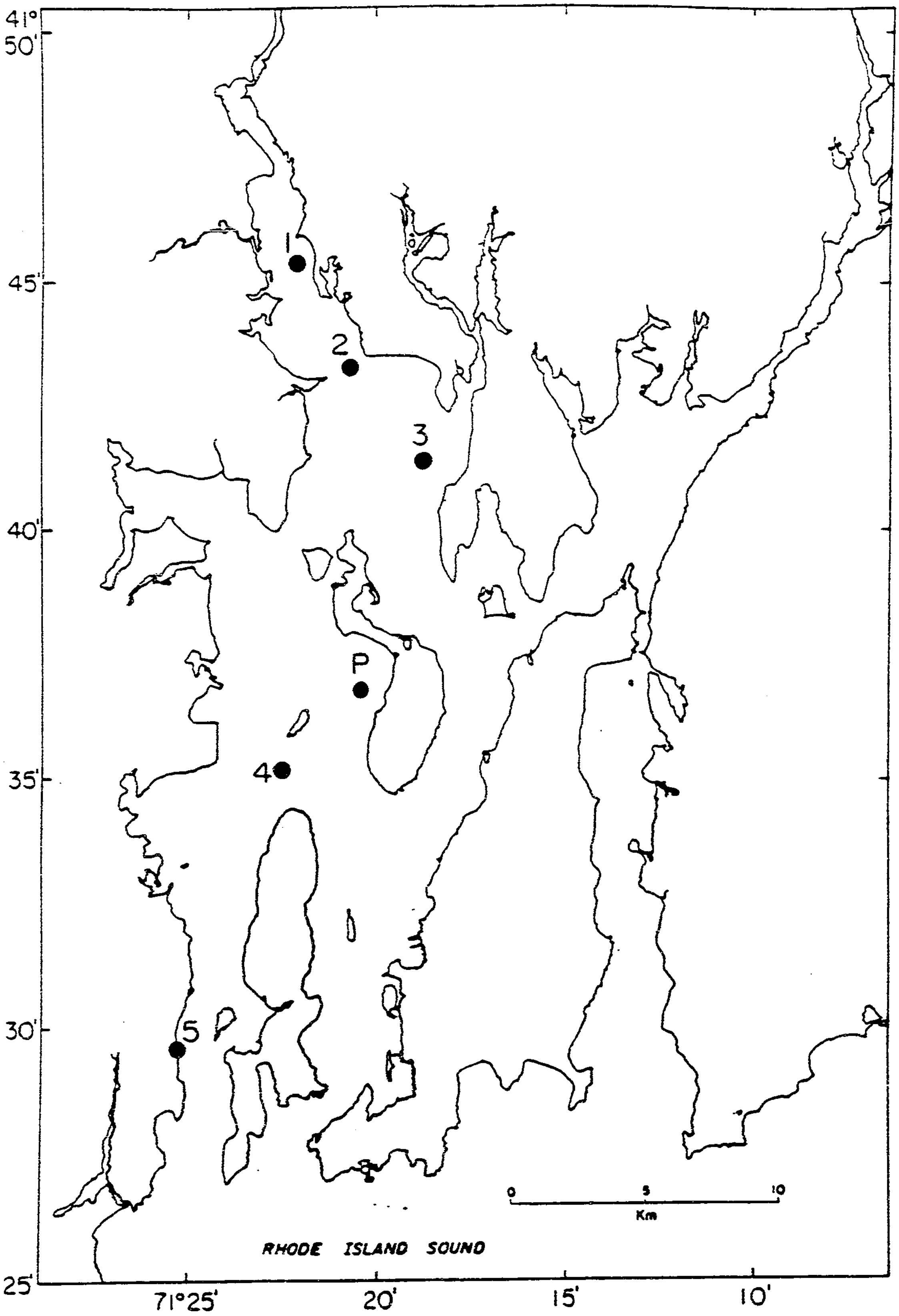
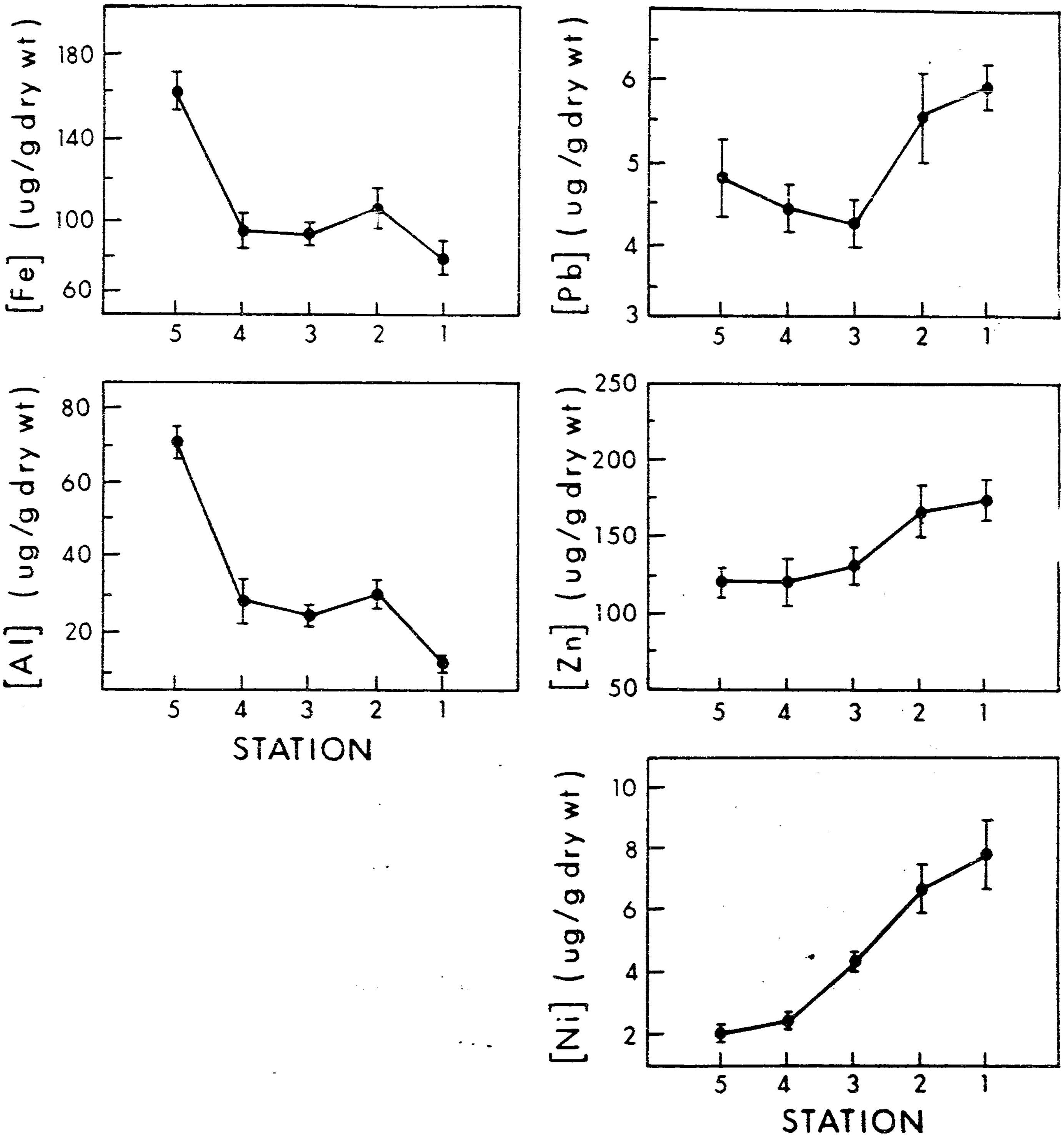


Fig. IV-7. Pb, Zn, Ni, Fe and Al vs. Sta. No. (1 = head of Bay, 5 = near mouth) for mussels suspended 1m above bottom.



highest concentrations.

E. Local anomalies in shellfish trace metal concentrations

There is only one study of the composition of shellfish in a highly polluted environment -- that of Eisler et al. (1978) at the former Naval Air Rework Facility (NARF) at Quonset Point, the same area where Eisler et al. (1977) documented extensive metal pollution (see "Sediments" section of this report). Their study area is shown in Fig. IV-8, along with areal variations of the concentrations of ten trace metals in the widgeon clam *Pitar morrhuana*. In general, those clams collected nearest to the source of pollution were most highly enriched in trace metals. The trend is strongest for silver, chromium, and lead, and weak for zinc, cadmium, iron, copper, nickel, and manganese. Based on these data, together with those for *Mytilus* and *Mercenaria*, it appears likely that pollutant trace metals are present in elevated levels in shellfish in other regions of the Bay as well.

F. Summary of trace metals pollutants in shellfish

Three main results emerge from the foregoing discussion.

1. Concentrations of trace metals in shellfish are much higher around Providence than in the less polluted, southerly, parts of the Bay. This pattern is the result of proximity to pollutant sources and the associated enrichment of trace metals in sediments in the northern part of the Bay.
2. Analysis of the RI DOH data set on trace metals in *Mercenaria* over nearly two decades shows no monotonic trends in trace metal pollution levels. These data do not rule out the possibility that trace metal pollution has fluctuated during this period, but they show that changes have been within the range that quahogs can tolerate without changing their body burdens.
3. In one small, heavily polluted area of the Bay, trace metal levels in bivalves are elevated as a result of a local pollutant source. It is likely that other areas are similarly affected.

G. Trace metal loadings in shellfish from Narragansett Bay compared with other areas

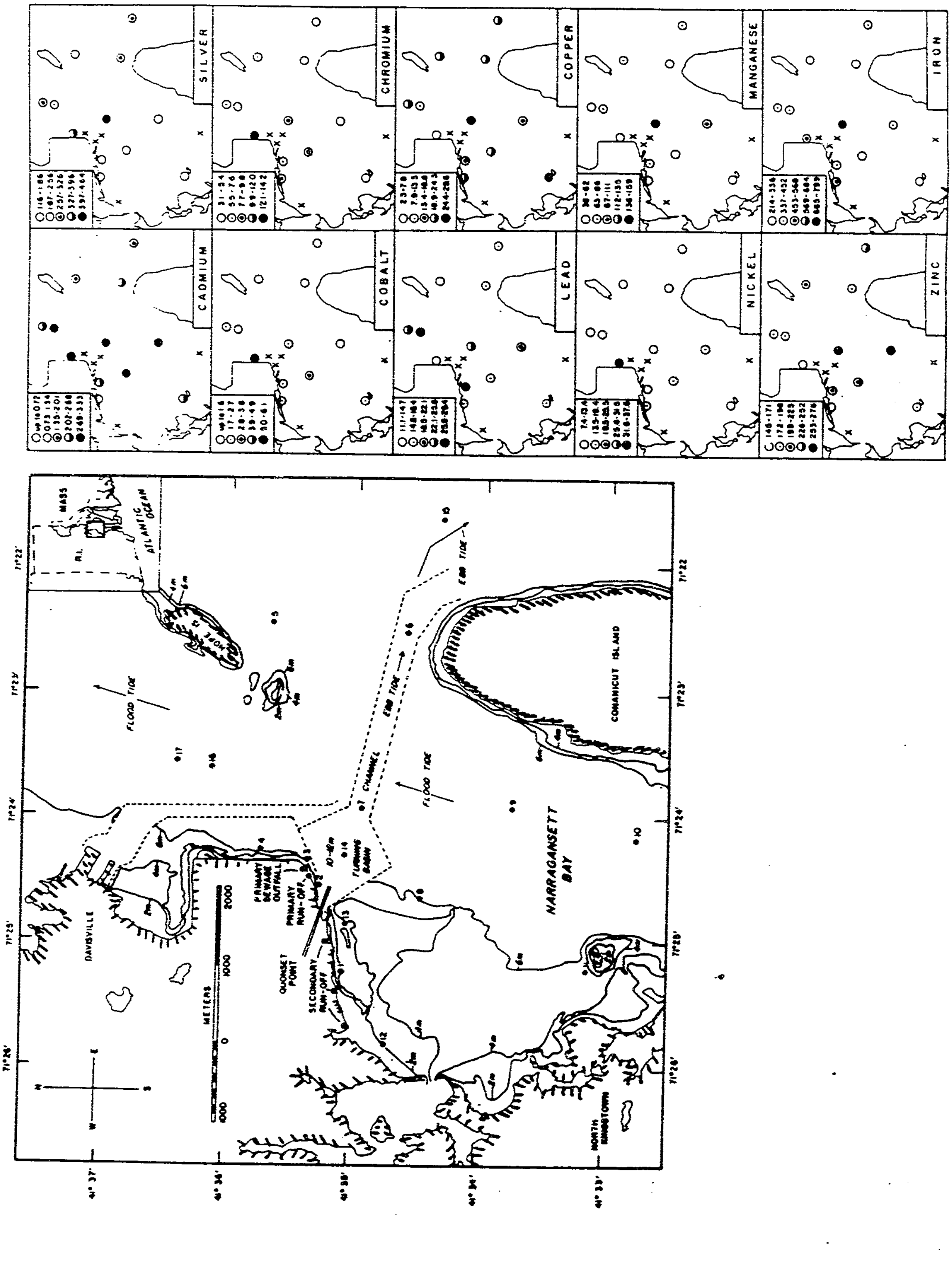
Caspar (1988) recently summarized average values of trace metal loadings in four species of clams from coastal states throughout the United States. His results for *Mercenaria* (Table IV-1) are relevant to this study. Average concentrations of trace metals in specimens from Rhode Island are comparable to, although generally somewhat higher than, average values for all *Mercenaria* samples studied. This result may reflect the ability to *Mercenaria* to regulate body burdens of contaminants, rather than a general similarity in the environmental loadings which influence *Mercenaria* trace metal contents. In any case, the results of a study such as Caspar's will always reflect the difficulty in sampling in a representative way. Nevertheless, Caspar's study indicates that the trace metal contents of quahogs in Narragansett Bay and its marginal waters are similar to concentrations in the nation's coastal waters.

H. Environmental significance of trace metal loadings in Narragansett Bay

Table IV-1. Wet weight concentrations of trace metals in Mercenaria from Narragansett Bay, Barrington River, Bristol Harbor, Greenwich Bay, Point Judith Pond, Warren River, and Wickford Harbor, compared to average trace metal concentrations in 11 states (Caspar, 1988).
Units: mg/gm wet weight.

Metal	11 State Average	R. I. Average
Lead	.24	.27
Cadmium	.086	.10
Chromium	.40	.51
Cobalt	.30	.44
Copper	3.7	2.7
Nickel	1.4	2.2
Zinc	18	20

Fig. IV-8. Concentrations of 10 elements in widgeon clams (Pitar morrhuana) from stations in NARF study area. Values shown are in mg element per kg dry weight soft parts, as determined by atomic absorption spectrophotometry. No P. morrhuana were collected at stations marked x (from Eisler et al., 1978).



1. Response of shellfish to water column concentrations

Eisler and Henneckey (1971) investigated levels at which dissolved trace metals are toxic to organisms. The concentrations of Cu, Ni, Pb, Cd, Zn and other trace metals in the Bay, summarized in section II, are far below the levels of toxicity, at least as defined by LD-50 experiments. At the same time, it is well known that trace metals present at sublethal levels can still have adverse biological effects on shellfish, by affecting reproduction or other biological functions.

A more immediate concern is that high trace metal loadings in shellfish can affect human health. In Table IV-2, there is a comparison of trace metal levels at which shellfish ingestion is potentially hazardous to humans (Australian NHMRC data), proposed FDA alert levels for *Mercenaria*, and maximum values observed in *Mercenaria* in Narragansett Bay, according to the data set of Cullen (1984). The proposed FDA alert levels signify unusually high pollutant loadings, rather than human health hazards. Concentrations of all metals in Bay samples are below Australian NHMRC levels and FDA alert levels, and *average* levels in the Bay are of course well below the maxima. This comparison suggests that there is no health hazard from eating quahogs, and again illustrates the point that metal levels in *Mercenaria* in Narragansett Bay are not highly elevated with respect to other populated estuaries.

2. Response of phytoplankton to water column concentrations

A number of workers have shown that phytoplankton growth can be inhibited at metal concentrations far below those in Narragansett Bay (see, for example, Fitzwater et al., 1982, and papers cited therein). There is thus the possibility that trace metal loadings in the Bay affect the ecology of that water body in a profound way by influencing the growth rate of the phytoplankton which form the base of the food chain.

Table IV-2. Comparison of Australian National Health and Medical Research Council recommended maximum concentrations, FDA National Shellfish Sanitation Program Alert Levels for trace metals in *Mercenaria,* and maximum concentrations of trace metals in *Mercenaria* in Narragansett Bay (data from Cullen,1984). The value for maximum Cu in Mercenaria in the Bay excludes data for the northernmost station of Cullen. Wet weight values are multiplied by a factor of 5 to give dry weight equivalents. Units: µg/gm dry weight.

Metal (observed)	Australian NHMRC	FDA alert levels*	Narr. Bay (maximum value)
Copper	150	50	40
Zinc	5,000	330	150
Cadmium	10	2.5	1.5
Lead	10	20	3.3

*These alert levels were never formally adopted

V. Overall summary

Based on the sedimentary record and the modern mass balance of trace metals in Narragansett Bay, there can be no doubt that trace metal distribution in the Bay is dominated by pollutant inputs, together with the geochemical processes that modify the effects of input and transport. The sediment data show that, in the northern part of the Bay, pollutant loadings were significant by 1750. Between about 1865-1885, pollutant loadings increased throughout the Bay, and the southern reaches first became heavily polluted. Since around the turn of the century, pollutant loadings have been roughly constant, judging from the sedimentary record. They have fluctuated considerably, but monotonic long term increases and decreases are generally absent for most metals at most study sites. The one important recent trend is the apparent decrease in dissolved trace metals in the Bay between the late 1970's and the mid 1980's.

The importance of pollution as a source of trace metals to the Bay is reflected by areal variations of trace metal concentrations of waters, sediments, and shellfish. In all three, metal concentrations at the more industrial head of the Bay, close to the pollutant sources, are far higher than at the mouth. In addition, marginal areas of the Bay with proximal sources of pollution have sediments which are polluted, and in at least one case have shellfish which are polluted as well.

Within the main Bay, the relative loadings of trace metals in water, sediments, and shellfish can be intercompared by considering how average concentrations of trace metals in the different materials vary from one sector to the next. For the purpose of this discussion, we have repeated Figure II-2 as Figure V-1. In Table V-1, we tabulate sector-averaged concentrations of dissolved trace metals, surface sediments, mussels, and quahogs. Metals considered are Zn, Pb, Cd, Ni, and Cu. The most interesting sectors are 1-5, from the head of the Bay to the mouth of the West Passage, for which the most data are available. As noted earlier, there is a decrease in concentrations down-Bay for all materials.

This tabulation shows that there is no simple relationship between concentration decreases of water and sediments as a function of distance down the Bay. Thus from Sector 1 to Sector 5, the dissolved Cd concentration decreases by a factor of 3, whereas that of sediments drops by a factor of 8. Dissolved Ni falls by a factor of 17, compared to <2 for sedimentary Ni. Dissolved Cu falls by a factor of about 4, compared to 25 for sedimentary Cu. The different magnitudes of the decreases reflect the different processes governing water and sediment metal loadings. Water column Zn, Pb, Cd, Ni and Cu distributions largely reflect input and mixing. Sediment trace metal distributions, on the other hand, reflect input and transport before deposition. Relative distributions of dissolved and sedimentary trace metals in the Bay differ because there are differences in the compositions of the end-member sources at the head and mouth of the Bay, and also because water is mixed much more extensively throughout the Bay (particles tend to settle out near their source).

The relationships between shellfish loadings and water and sediment loadings are more complex. Shellfish derive their trace metals from one or more of three sources: water, sediments, or food. Food itself derives its trace metals from one of the three sources, so that water and sediments are the only ultimate sources of metals in shellfish. For this reason, there must be some relation between metals in shellfish on the one hand, and metals in water and/or sediments on the other.

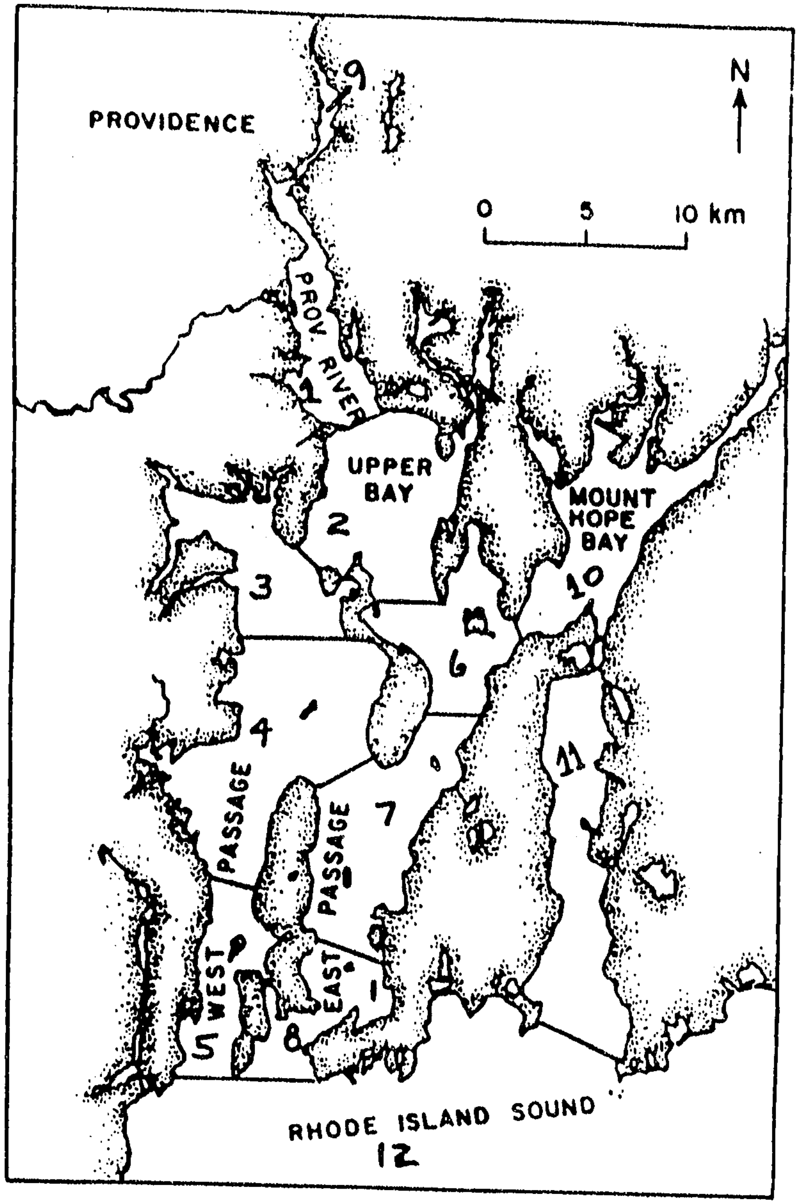
The nature of the relationship is, however, expected to be extremely complex. Factors governing shellfish loadings were discussed in the previous chapter, and the literature up to

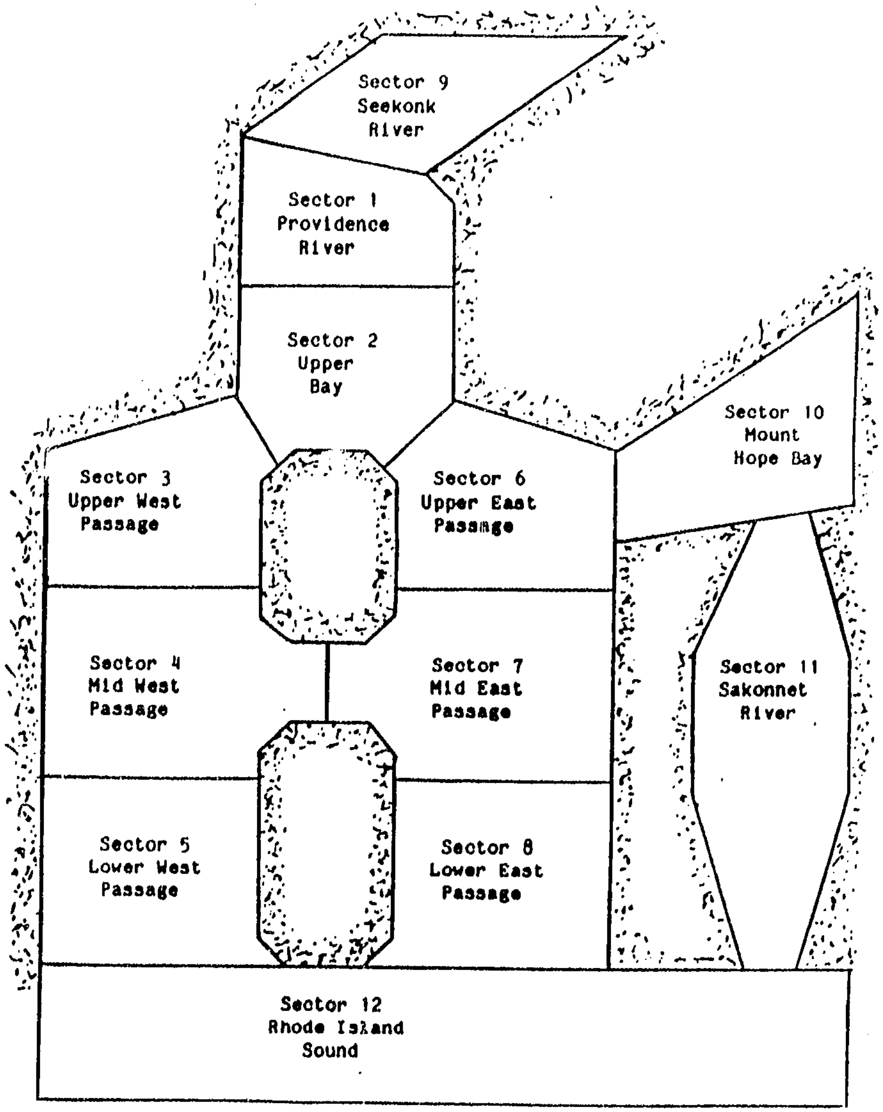
Table V-1. Comparison of trace metal concentrations in water, sediments, mussels , and quahogs

Water data (dissolved, in nmol/L): Fig. II-5
Sediment data (ppm): Table II-2a
Mussel data (µg/gm dry weight): Table IV-7 (avg. plotted)
Quahog data (µg/gm dry weight): Table IV-3 (avg. plotted)

	Bay segment	Water	Sediment	Mussels	Quahogs
Zn	1		232	174	131
	2		255	150	102
	3				75
	4		87	120	78
	5		49	120	81
	6				
	7				58
	8				58
Pb	1	1.4		6	2.2
	2	0.7		4.9	1.2
	3	0.9			0.46
	4	0.1		4.3	0.57
	5	0.1		4.8	
	6	0.2			
	7	0.3			0.23
	8	0.3			
Cd	1	1.15	1.3		0.96
	2	0.78	0.9		0.52
	3	0.63			0.22
	4	0.58	0.25		0.37
	5	0.33	0.17		0.3
	6	0.44			
	7	0.44			0.19
	8	0.39			0.29
Ni	1	253	38	8.7	8.5
	2	86	30	6.1	6.5
	3	77			4.3
	4	34	14	2.4	5.2
	5	15	29	2.2	3.9
	6	31			
	7	25			2.7
	8	20			1.9
Cu	1	72	250		96
	2	29	211		39
	3	44			
	4	18	39		14.4
	5	23	10		16
	6	19			
	7	13			9.2
	8	13			10.5

Fig. V-1. Map of Narragansett Bay (right) and a diagram showing partitioning of the Bay into eleven sectors plus Rhode Island Sound (left). Sectors 1 through 8 were defined by Kramer and Nixon (1978); their approach was extended to the Seekonk River (9), Mount Hope Bay (10), Sakonnet River (11), and Rhode Island Sound (12). Schematic box configuration for the sectors of Narragansett Bay (right). This format is used in Figure 3 to provide a statistical summary of data from the Bay.





Schematic Sectors for Narragansett Bay

about 1980 was exhaustively reviewed by Eisler (1981). According to Eisler, there are several types of controls. The first is environmental. Trace metal concentrations may be affected by water temperature, salinity, and concentrations of other metals and trace organics. Season, depth, and perhaps other variables can have a direct or indirect effect. Second, there are metabolic variables, such as feeding rates, reproductive state, and size or age. Complicating things further is the fact that there are large variations in trace metal burdens of different organisms, the most notable of which is concentration in kidney stones. Another way to view the problem is to consider that trace metal burdens reflect the balance between uptake and depuration, neither process being all that well understood.

Nevertheless one robust result to emerge from Eisler's review is that trace metal loadings of shellfish increase with trace metal abundances in the environment. This relationship held in both empirical (field) studies and controlled laboratory experiments. Eisler summarized a number of examples where trace metal body burdens were found to be proportional to dissolved concentrations in water. However a simple proportionality was not always found. In some cases, metal levels in organisms rose more rapidly than environmental concentrations, while in other cases body burdens seemed to saturate. Experiments on mussels, described in the previous section of this report, suggest one cause of this behavior: after a long residence in a highly polluted environment, shellfish may lose their ability to depurate.

As might be expected, the sector averages summarized in Table V-1 show a qualitative relationship between metal loadings in sediments, water and shellfish, but no simple quantitative relationship. In all cases, metal loadings fall from the head of the Bay to the mouth. However, the decrease is uneven. In going from sector 1 to 5, for example, the Pb content of water falls by a factor of 14, whereas that of mussels falls by only about 20%. The drop for quahogs is intermediate. The dissolved Ni concentration drops much more than the shellfish concentration, while the sediment levels decrease less than any others. On the other hand, the down-Bay dropoffs in Cu and Cd are similar (at least to within a factor of 2), for water and quahogs.

There may, in fact, be simple relationships between dissolved concentrations in water and body burdens in shellfish, for certain metals and selected shellfish. In most cases, however, the controls on metal uptake by shellfish are not well enough understood to allow us to achieve a mechanistic understanding of factors governing their composition.

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Appendix A: dissolved and particulate trace metals in Narragansett Bay waters

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Compilation of Trace Metal Concentrations in Narragansett Bay Waters

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ABSTRACT

This report contains a compilation of trace metal concentrations in the waters of Narragansett Bay. The data are in two files: one for samples at various times from throughout the Bay, and one for a time-series data set of samples collected at the URI Bay Campus in the lower West Passage. In the baywide file values are given for dissolved, particulate, and total concentrations of Ag, Cd, Cr, Cu, Fe, Mn, Ni, Pb, and particulate Al. Additional variables are included in the data table to identify sample location, temperature, salinity, turbidity, and date. The data were obtained from a number of analysts in studies conducted from 1971 through 1987; a bibliography is included listing the original sources of the data. The time-series file includes concentrations of Al, Cd, Cu, Fe, Mn, TSM, salinity, and chlorophyll a. Many of the data sets included here have not been published previously. This database is available on floppy disk as Lotus 1-2-3 spreadsheets for database manipulation and plotting. Missing values in the tables are designated by negative quantities which can be filtered out while working with the data. This report does not include an analysis or interpretation of the trace metal data.

INTRODUCTION

As part of the Narragansett Bay Project conducted by the RI Department of Environmental Management and funded by the U.S. Environmental Protection Agency and the National Oceanic and Atmospheric Administration we have compiled a database of trace metal concentrations in the waters of Narragansett Bay. This work was part of an overall effort to compile data on historic trends in characteristics of water quality and resources in the Bay. Our work was one component of a project that involved Michael L. Bender, Suzanne Bricker-Urso, James G. Quinn (who were involved in metals data compilation and analysis) and related projects by Scott Nixon, Michael Pilson, Perry Jeffries, and Theodore Smayda.

Over the years there have been a number of investigations of trace metals in Narragansett Bay. Some of these studies have resulted in publications in the scientific literature, but in many cases the original data were not published or readily available for interpretation. It seemed useful to bring together as much of the data as possible which were judged to be of good analytical quality. Such a compilation of trace metal concentrations could then be examined to discern spatial and temporal trends in Narragansett Bay. The database could also provide additional insights into the processes that influence trace metal concentrations in this estuarine system.

A large number of analysts devoted substantial time and expertise to obtain the samples, perform sample preparations and analyses, and compile the results utilized here. These analysts have made their unpublished data available for this database. Some of the largest portions of this database were created by Carlton Hunt (and the analysts he supervised) during the time that he worked at the the URI Marine Ecosystems Research Laboratory and by Douglas Cullen while he was a graduate student at GSO and employed by the Narragansett EPA Laboratory and URI. If other investigators utilize the data contained in this compilation, we request that credit be given to the originators of the data that are used.

This report provides a brief description of the database. We will not present an analysis or interpretation of metal concentrations in Narragansett Bay in this Technical Report. Subsequent reports will summarize the features that can be extracted from these data and will consider their relationship to processes occurring in the Bay. The database consists of two major files; one contains metal concentrations from various locations in the Bay, and the other contains time-series data of waters at the URI Bay Campus in the West Passage near the mouth of the Bay.

THE BAYWIDE DATA FILE

Data from throughout Narragansett Bay were compiled in a dBase III file and exported to a Lotus 1-2-3 spreadsheet for manipulation (King, 1987). Copies of this spreadsheet are available from us. The data are arranged in a tabular form with the columns comprising various parameters and the rows consisting of the observations of each parameter. Table 1 lists the headings for the 46 columns that appear at the top of the spreadsheet (cells A1 to AT1). There are 438 data lines in the table; with the column headings there are a total of 439 rows in the spreadsheet.

The following explanation is provided for the column headings and the variables they describe. We designated a series of sectors for general geographical regions of Narragansett Bay. The regions and sector numbers are shown in Figure 1, and they are listed as "Sect" in the spreadsheet. For some purposes it may be useful to pool all observations within a sector and use the sector as a generic location rather than the more specific latitude and longitude coordinates. We followed the sector sequence used by Kremer and Nixon (1978) and extended it to include the Seekonk River, Mount Hope Bay, the Sakonnet River, and Rhode Island Sound. The sector numbers tend to go in three north-south sequences from west to east across the Bay. Data in the table are sorted by sector number and by sampling date. The "Date" column provides the month and year of each observation; it is derived from the "DayNum" column (cell AR1) which is a sequential day number during the twentieth century and can be used with Lotus 1-2-3 date functions to extract the day of the month if desired. We computed a set of linear distances down the Bay from arbitrary head points to provide variables that can be used in examining spatial gradients down the Bay. Two of these distance variables go through the Seekonk and Providence Rivers down the West Passage and down the East Passage; the arbitrary starting point for the Pawtucket through West Passage ("P-W") and Pawtucket through East Passage ("P-E") transects is 41° 52' 30" N, 71° 23' 30" W. The other two distance variables provide transects through Mount Hope Bay and the East Passage ("M-E") or through Mount Hope Bay and the Sakonnet River ("M-S"); the starting point for these variables is 41° 49' 30" N, 71° 07' 00" W. All four distance variables are in kilometers.

The depth of each observation is given in the column "z(m)", with the units being meters. Concentrations are given for three fractions of each metal: D=dissolved, P=particulate, T=total, unfiltered. The metals are Ag, Al, Cd, Cr, Cu, Fe, Mn, Ni, Pb, and Zn; the code for each fraction is

Table 1. Listing of variables in the Narragansett Baywide trace metal water column concentration data file; these variables are the column headings in the spreadsheet data table. An explanation of each variable is given in the paragraphs above and on page 4.

Sect	Date	P-W	P-E	M-E	M-S	z(m)	AgD	AgP	AgT	AlP
CdD	CdP	CdT	CrD	CrP	CrT	CuD	CuP	CuT	FeD	FeP
FeT	MnD	MnP	MnT	NiD	NiP	NiT	PbD	PbP	PbT	ZnD
ZnP	ZnT	TSM	Salt	Turb	Temp	SigT	Long	Lat	BibID	
DayNum	Sta	Lbl								

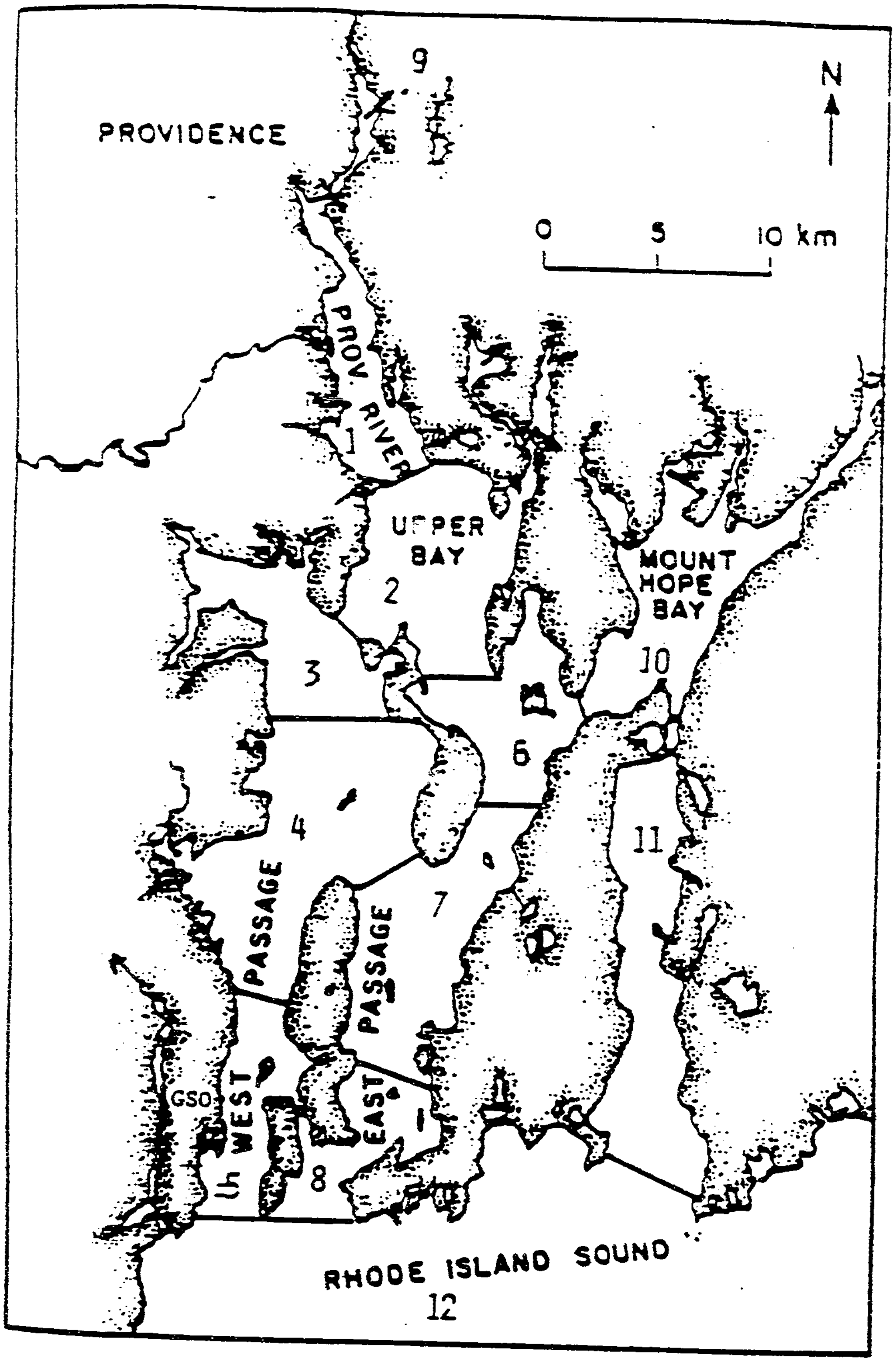

Figure 1. Map of Narragansett Bay showing the regions designated as sectors and listed as Sect in the data table; sectors 1 through 8 were defined previously by Kremer and Nixon (1978); we extended their approach to the Seekonk River (9), Mount Hope Bay (10), Sakonnet River (11), and Rhode Island Sound (12).

appended to the chemical symbol in the column heading. All metal concentrations are nmol/kg. "TSM" is total suspended matter in units of mg/kg. "Salt" is salinity in parts per thousand. "Turb" is turbidity in percent; this parameter was derived from a transmissometer which yields percent transmittance. The "Turb" is 100 - %Transmittance to provide a numerical value which varies in the same sense as turbidity (Hunt, personal communication). "Temp" is water temperature in °C. "SigT" is the sigma-t calculated from Salt and Temp, using the UNESCO 1979 equation of state. "Long" is the minutes.seconds of longitude for each sampling location. All longitude values are between 71 and 72 °W; the 71° was omitted to save space. "Lat" is minutes.seconds of latitude for each sampling location. All latitudes are between 41 and 42 °N; the 41° was omitted to save space. Please note that Lat and Long are composite variables--the integer portion is minutes of latitude or longitude; the decimal portion is seconds of latitude or longitude, it is not decimal minutes. "BibID" is a code we used to designate each bibliographic source from which the data were obtained. This code is composed of the first four characters of the source name and the last two digits of the publication year. The Reference List for this report gives the complete citation for the sources of data in the data file. "Sta" is the originator's station number. "Lbl" is a label we used in constructing some plots from this data file; it is extracted from the first character of the BibID.

Each row in the data table represents the observations from a single sample. Thus, each row is for one location, at one time, and at one depth. When variables were not reported for a sample, they were assigned a negative value of -999 so that subsequent column arithmetic would also generate negative values (but they will differ from -999). When manipulating the data set, a filter can be used to exclude all negative values.

We initially included a set of data reported by Graham et al. (1976) in this database, but comparisons of their manganese values with those by other workers showed a large difference in the MnP and MnD versus salinity plots. It appears that their sample storage procedure, which included freezing the samples, resulted in a conversion of dissolved Mn to particulate Mn. We, therefore, chose to exclude those data from this database.

MERL TIME-SERIES DATA FILE

The second data file in this database is a comprehensive set of trace metal concentrations in waters at the URI Marine Ecosystem Research Laboratory (MERL). Carlton Hunt and coworkers performed weekly or biweekly analyses of several fractions of metals (Al, Cd, Cu, Fe, Mn, Ni, and Pb) in the "header" tank at MERL. The water in this tank is pumped directly from Narragansett Bay near the URI Bay Campus dock (see Fig. 1 for location), and it has a residence time in the header tank of about 20 minutes; the volume of the tank is 3000 liters. Hunt has found that the concentrations of metals in this tank are indistinguishable from water column concentrations in the Bay off the GSO dock. We have used this data set to provide a time-series of metal concentrations at one point in the Bay (sector 5). The data extend from 29 August 1977 through 23 November 1980. This time series analysis was resumed for the summer months during 1983 and 1984, but we found these data to be inconsistent with the earlier data; they were based on a different preconcentration procedure. We,

Table 2. Listing of variables in the MERLTIME data file. These variables appear as column headings in the Lotus 1-2-3 spreadsheet containing these data. The codes A, D, and P for the metals indicate analytical fractions--acid dissolvable, dissolved, and particulate respectively. NumDate is a sequential day number during the 20th century; Chla is chlorophyll _a_ concentration.

Date NumDate Time AlP CdD CdP CuA CuD CuP

FeA FeD FeP MnA MnD MnP PbD PbP Salt TSM Chla

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therefore, did not include the summer 1983 and 1984 data in this data file, except for the MnD which was done by direct injection atomic absorption analysis and would not be affected by the preconcentration procedure.

The MERLTIME data file is a Lotus 1-2-3 spreadsheet similar to BAYMETAL. The variable names are listed in Table 2. For each metal there are several analytical fractions that were determined; these fractions are designated by a code appended to the chemical symbol. The D and P codes are for dissolved and particulate fractions as in the BAYMETAL file. The A is for acid dissolvable; this procedure consisted of making an unfiltered sample 10% HNO_3 and analyzing directly by atomic absorption spectroscopy. A value of -9 in the data table indicates no data. The data are arranged in chronological order.

The two data files described here are listed in tabular form in Appendix A and Appendix B. They are available on $5^1/_4$" 360 KB floppy disk for IBM-PC compatible microcomputers.

REFERENCES

Note: The bibliographic code centered above some of these references is the BibID that appears in the BAYMETAL file; it is derived from the first four characters of the source plus the last two digits of the publication year plus an alphabetic sequence character to assure that each code is unique

BEND77A

Bender, M.; and the Narragansett Bay Study Group. 1977. A Spring, 1977, nutient, oxygen, and metal balance for Narragansett Bay, Rhode Island. Chemical Oceanography Class Project. Graduate School of Oceanography, URI, Narragansett, R.I. 15 pp.

CULL80A, CULL78A

Cullen, J. D. 1987. URI Technical Report (In Preparation). Graduate School of Oceanography, URI, Narragansett, R.I.

Graham, W. F.; Bender, M.; and Klinkhammer, G. P. 1976. Manganese in Narragansett Bay. Limnology and Oceanography 24:665-673.

HUNT80A

Hunt, C. D. 1980. Unpublished data: Narragansett Bay Survey - February, May, and September 1980 - Data Summary.

SIN386A

Hunt, C. D.; Fox, M. F.; Warren, W. M.; Jackson, S. R.; and Pilson, M. E. Q. 1987. Narragansett Bay Water Quality Monitoring and Source Strength Measurements: Cruise and Data Report, SINBADD 3. Corrected Trace Metal Data. Marine Ecosystems Research Laboratory, Graduate School of Oceanography, URI, Narragansett, R.I. 84-86.

SIN486B

Hunt, C. D.; Fox, M. F.; Jackson, S. R.; and Pilson, M. E. Q. 1987. Narragansett Bay Water Quality Monitoring and Source Strength Measurements: Cruise and Data Report, SINBADD 4. Corrected Trace Metal Data. Marine Ecosystems Research Laboratory, Graduate School of Oceanography, URI, Narragansett, R.I. 112-114.

SIN185A

Hunt, C. D.; Sampou, P. A.; Jackson, S. R.; Warren W. M.; Cullen, J. D.; Coyne, J.; and Pilson, M. E. Q. 1987. Narragansett Bay Water Quality Monitoring and Source Strength Measurements: Cruise and Data Report, SINBADD 1. Marine Ecosystems Research Laboratory, Graduate School of Oceanography, URI, Narragansett, R.I. #-#.

SIN385B

Hunt, C. D.; Warren, W. M.; Sampou, P. A.; Jackson, S. R.; and Pilson, M. E. Q. 1987. Narragansett Bay Water Quality Monitoring and Source Strength Measurements: Cruise and Data Report, SINBADD 2. Corrected Trace Metal Data. Marine Ecosystems Research Laboratory, Graduate School of Oceanography, URI, Narragansett, R.I. 70-72.

KEST81A

Kester, D. R.; and Huizenga, D. L. 1981. Chemical Evaluation of the Hunt Chemical Effluent in the Seekonk River. Report to the R.I. Coastal Resources Management Council. 31 pp.

King, D. W. 1987. Narragansett Bay Metals Database Structure and Use. Technical Report No. 87-8, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, 14 pp.

Kremer, J.N and Nixon, S.W. 1978. A Coastal Marine Ecosystem: Simulation and Analysis. Springer-Verlag, Berlin, 217 pp.

PIOT77A

Piotrowicz, S. R. 1977. Studies of the Sea to Air Transport of Trace Metals in Narragansett Bay. PhD. Dissertation, University of Rhode Island. 170 pp.

QUIN87A

Quinn, J. G. 1987. A review of metal-organic complexes in the Narragansett Bay Estuary. In Preparation for the Trace Metals Section of the Narragansett Bay Historical Review.

Appendix A

Listing of the BAYMETAL data file

The spreadsheet for these data contains 46 columns by 440 rows. The following listing appears in three blocks; the first 18 columns are listed in pages 1-7 of the table, columns 19 through 36 appear on pages 8-14, and the remainder of the columns are on pages 15-21.

Units:

Variable	Units
P-W, P-E, M-E, M-S	km
z(m)	m
All metals	nmol/kg
TSM	mg/kg
Salt	o/oo
Turb	%, see page 3 for explanation
Temp	°C
SigT	(Density - 1000) kg m^{-3}
Long	min.sec
Lat	min.sec
DayNum	Days since 1 Jan 1900

28-Dec-87 Listing of BAYMETAL Data File Page 1

Sect	Date	P-W	P-E	M-E	M-S	z(m)	AgD	AgP	AgT	AlP	CdD	CdP	CdT	CrD	CrP	CrT	CuD
01	Jan-78	18.0	18.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	124.8
01	Jan-78	10.3	10.3	0.0	0.0	10	-999	-999	-999	-999	0.39	-999	-999	-999	-999	-999	23.31
01	Jan-78	16.2	16.2	0.0	0.0	1	-999	-999	-999	-999	1.07	0.04	-999	-999	-999	-999	40.79
01	Jan-78	7.1	7.1	0.0	0.0	1	-999	-999	-999	-999	1.5	0.36	-999	-999	-999	-999	104.0
01	Jan-78	13.6	13.6	0.0	0.0	7	-999	-999	-999	-999	0.53	0.06	-999	-999	-999	-999	24.38
01	Jan-78	7.9	7.9	0.0	0.0	10	-999	-999	-999	-999	1.07	0.06	-999	-999	-999	-999	23.31
01	Jan-78	13.6	13.6	0.0	0.0	1	-999	-999	-999	-999	1.96	0.05	-999	-999	-999	-999	173.2
01	Jan-78	7.9	7.9	0.0	0.0	1	-999	-999	-999	-999	-999	0.36	-999	-999	-999	-999	201.2
01	Jan-78	11.3	11.3	0.0	0.0	1	-999	-999	-999	-999	1.96	0.25	-999	-999	-999	-999	274.0
01	Jan-78	10.3	10.3	0.0	0.0	1	-999	-999	-999	-999	6.23	0.45	-999	-999	-999	-999	1228.
01	Feb-80	17.6	17.6	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
01	Feb-80	7.2	7.2	0.0	0.0	1	-999	-999	-999	4800	3	0.5	-999	-999	-999	-999	88
01	Feb-80	12.4	12.4	0.0	0.0	1	-999	-999	-999	4800	2	0.2	-999	-999	-999	-999	66
01	Feb-80	12.4	12.4	0.0	0.0	1	-999	-999	-999	2600	1.5	0.1	-999	-999	-999	-999	69
01	Feb-80	17.5	17.5	0.0	0.0	1	-999	-999	-999	3100	1.4	0.1	-999	-999	-999	-999	48
01	Feb-80	7.2	7.2	0.0	0.0	1	-999	-999	-999	2000	2.1	0.2	-999	-999	-999	-999	37
01	Aug-80	8.3	8.3	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	41.42
01	Aug-80	13.3	13.3	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	80.63
01	Aug-80	16.3	16.3	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	79.06
01	Aug-80	11.3	11.3	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	258.2
01	Aug-80	17.8	17.8	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	21.42
01	Aug-80	17.8	17.8	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	52.76
01	Sep-80	17.6	17.5	0.0	0.0	1	-999	-999	-999	2800	0.7	0.09	-999	-999	-999	-999	18
01	Sep-80	12.4	12.4	0.0	0.0	1	-999	-999	-999	4000	1.1	0.2	-999	-999	-999	-999	32
01	Sep-80	7.2	7.2	0.0	0.0	1	-999	-999	-999	3400	2.5	0.1	-999	-999	-999	-999	250
01	Oct-80	17.9	17.9	0.0	0.0	7	-999	-999	-999	-999	1.432	-999	-999	-999	-999	-999	26.29
01	Oct-80	13.5	13.5	0.0	0.0	1	-999	-999	-999	-999	0.836	-999	-999	-999	-999	-999	80.27
01	Oct-80	13.8	13.8	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	141.7
01	Oct-80	8.1	8.1	0.0	0.0	12	-999	-999	-999	-999	0.543	-999	-999	-999	-999	-999	24.29
01	Oct-80	15.5	15.5	0.0	0.0	1	-999	-999	-999	-999	0.623	-999	-999	-999	-999	-999	32.75
01	Oct-80	8.1	8.1	0.0	0.0	1	-999	-999	-999	-999	1.708	-999	-999	-999	-999	-999	203.0
01	Oct-80	13.9	13.9	0.0	0.0	6	-999	-999	-999	-999	1.21	-999	-999	-999	-999	-999	40.90
01	Oct-80	8.2	8.2	0.0	0.0	2	-999	-999	-999	-999	0.889	-999	-999	-999	-999	-999	58.90
01	Oct-80	13.8	13.8	0.0	0.0	6	-999	-999	-999	-999	1.059	-999	-999	-999	-999	-999	55.21
01	Oct-80	15.7	15.7	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	69.66
01	Oct-80	8.2	8.2	0.0	0.0	1	-999	-999	-999	-999	1.699	-999	-999	-999	-999	-999	53.36
01	Oct-80	15.5	15.5	0.0	0.0	1	-999	-999	-999	-999	0.961	-999	-999	-999	-999	-999	65.51
01	Oct-80	17.7	17.7	0.0	0.0	1	-999	-999	-999	-999	0.792	-999	-999	-999	-999	-999	51.82
01	Oct-80	7.2	7.2	0.0	0.0	1	-999	-999	-999	-999	0.854	-999	-999	-999	-999	-999	40.75
01	Oct-80	12.0	12.0	0.0	0.0	1	-999	-999	-999	-999	1.174	-999	-999	-999	-999	-999	135.0
01	Oct-80	15.7	15.7	0.0	0.0	3	-999	-999	-999	-999	0.996	-999	-999	-999	-999	-999	40.13
01	Oct-80	8.1	8.1	0.0	0.0	6	-999	-999	-999	-999	0.783	-999	-999	-999	-999	-999	59.82
01	Oct-85	7.2	7.2	0.0	0.0	0	-999	0.348	-999	-999	1.88	0.109	-999	8.67	-999	-999	47.98
01	Oct-85	12.4	12.4	0.0	0.0	1	-999	0.296	-999	-999	1.23	0.045	-999	7.73	-999	-999	61.4
01	Oct-85	12.4	12.4	0.0	0.0	7	-999	0.112	-999	-999	0.64	0.039	-999	3.02	-999	-999	17.59
01	Oct-85	7.2	7.2	0.0	0.0	6	-999	0.964	-999	-999	0.42	0.99	-999	5.09	-999	-999	20.52
01	Oct-85	12.4	12.4	0.0	0.0	2	-999	0.234	-999	-999	0.79	0.065	-999	4.71	-999	-999	27.15
01	Oct-85	7.2	7.2	0.0	0.0	3	-999	0.325	-999	-999	-999	0.076	-999	-999	-999	-999	-999
01	Oct-85	12.4	12.4	0.0	0.0	13	-999	0.224	-999	-999	0.39	0.069	-999	2.45	-999	-999	10.95
01	Oct-85	17.6	17.6	0.0	0.0	3	-999	0.102	-999	-999	0.83	0.03	-999	4.15	-999	-999	27.62
01	Oct-85	7.2	7.2	0.0	0.0	13	-999	0.107	-999	-999	0.31	0.049	-999	3.21	-999	-999	13.27
01	Oct-85	17.6	17.6	0.0	0.0	0	-999	0.187	-999	-999	1.21	0.044	-999	6.7	-999	-999	54.46
01	Oct-85	17.6	17.6	0.0	0.0	10	-999	0.145	-999	-999	0.38	0.033	-999	2.83	-999	-999	12.03
01	Nov-85	12.4	12.4	0.0	0.0	7	0.071	0.423	-999	-999	0.523	0.079	-999	5.28	-999	-999	18.51
01	Nov-85	17.6	17.6	0.0	0.0	1	0.223	0.287	-999	-999	1.989	0.056	-999	17.35	-999	-999	74.67
01	Nov-85	17.6	17.6	0.0	0.0	5	0.087	0.112	-999	-999	0.654	0.008	-999	6.22	-999	-999	21.14
01	Nov-85	7.2	7.2	0.0	0.0	2	0.135	0.236	-999	-999	0.925	0.082	-999	10.56	-999	-999	39.5
01	Nov-85	12.4	12.4	0.0	0.0	0	0.218	0.389	-999	-999	2.032	0.112	-999	14.61	-999	-999	58.78
01	Nov-85	7.2	7.2	0.0	0.0	11	0.072	0.169	-999	-999	0.488	0.068	-999	4.9	-999	-999	18.98
01	Nov-85	12.4	12.4	0.0	0.0	12	0.071	0.568	-999	-999	0.47	0.105	-999	4.53	-999	-999	17.28
01	Nov-85	7.2	7.2	0.0	0.0	4	0.085	0.114	-999	-999	0.584	0.035	-999	6.22	-999	-999	21.75
01	Nov-85	17.6	17.6	0.0	0.0	11	0.042	-999	-999	-999	0.576	-999	-999	4.71	-999	-999	17.59
01	Nov-85	7.2	7.2	0.0	0.0	0	0.141	0.227	-999	-999	1.544	0.109	-999	11.79	-999	-999	41.5
01	Nov-85	12.4	12.4	0.0	0.0	2	0.157	0.256	-999	-999	1.858	0.071	-999	14.52	-999	-999	20.06
01	Apr-86	8.6	8.6	0.0	0.0	0	0.332	0.484	-999	-999	1.753	0.208	-999	14.33	26.7	-999	68.96
01	Apr-86	15.8	15.8	0.0	0.0	1	0.234	0.345	-999	-999	1.43	0.103	-999	12.63	16.2	-999	73.28
01	Apr-86	12.4	12.4	0.0	0.0	2	0.119	0.285	-999	-999	0.959	0.095	-999	8.67	14.29	-999	38.11
01	Apr-86	12.4	12.4	0.0	0.0	12	0.086	0.194	-999	-999	0.393	0.089	-999	3.96	11.42	-999	15.43

Sect	Date	P-W	P-E	M-E	M-S	z(m)	AgD	AgP	AgT	AlP	CdD	CdP	CdT	CrD	CrP	CrT	CuD
01	Apr-86	7.2	7.2	0.0	0.0	0	0.144	0.295	-999	-999	1.474	0.21	-999	10.75	18.29	-999	39.5
01	Apr-86	17.6	17.6	0.0	0.0	2	0.09	0.171	-999	-999	0.733	0.051	-999	5.22	7.5	-999	32.24
01	Apr-86	7.2	7.2	0.0	0.0	13	0.125	0.144	-999	-999	0.41	0.121	-999	4.15	6.74	-999	16.35
01	Apr-86	17.6	17.6	0.0	0.0	13	0.025	0.37	-999	-999	0.288	0.069	-999	3.21	15.42	-999	12.65
01	Apr-86	17.6	17.6	0.0	0.0	0	0.17	0.299	-999	-999	1.256	0.081	-999	9.99	14.16	-999	54.23
01	Apr-86	12.4	12.4	0.0	0.0	0	0.139	0.303	-999	-999	1.055	0.11	-999	9.62	14	-999	44.74
01	Apr-86	7.2	7.2	0.0	0.0	2	0.149	0.321	-999	-999	0.872	0.228	-999	8.11	18.41	-999	30.7
01	May-86	7.2	7.2	0.0	0.0	4	0.104	0.295	-999	-999	0.794	0.211	-999	6.98	13.48	-999	34.56
01	May-86	17.6	17.6	0.0	0.0	15	0.035	0.444	-999	-999	0.401	0.145	-999	4.53	30.57	-999	15.89
01	May-86	12.4	12.4	0.0	0.0	4	0.081	0.488	-999	-999	0.776	0.111	-999	6.79	21.04	-999	32.71
01	May-86	7.2	7.2	0.0	0.0	12	0.079	0.293	-999	-999	0.471	0.269	-999	5.28	18.58	-999	15.58
01	May-86	7.2	7.2	0.0	0.0	0	0.171	0.536	-999	-999	1.391	0.263	-999	12.26	25.05	-999	48.45
01	May-86	17.6	17.6	0.0	0.0	6	0.055	0.17	-999	-999	0.462	0.058	-999	5.28	10.3	-999	21.91
01	May-86	12.4	12.4	0.0	0.0	0	0.218	0.774	-999	-999	1.352	0.201	-999	11.69	25.44	-999	71.89
01	May-86	12.4	12.4	0.0	0.0	11	0.047	0.532	-999	-999	0.454	0.141	-999	4.53	25.9	-999	17.43
01	May-86	17.6	17.6	0.0	0.0	1	0.146	0.328	-999	-999	0.938	0.131	-999	8.67	8.74	-999	53.54
02	Mar-77	22.8	22.8	0.0	0.0	17	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	28.35
02	Mar-77	22.8	22.8	0.0	0.0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	67.72
02	Mar-77	20.1	20.1	0.0	0.0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	100.7
02	Mar-77	20.1	20.1	0.0	0.0	20	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	36.22
02	Jan-78	24.3	24.3	0.0	0.0	5	-999	-999	-999	-999	2.05	0.04	-999	-999	-999	-999	23.15
02	Jan-78	24.3	24.3	0.0	0.0	1	-999	-999	-999	-999	0.62	0.04	-999	-999	-999	-999	23.46
02	Jan-78	18.4	18.4	0.0	0.0	8	-999	-999	-999	-999	1.87	0.08	-999	-999	-999	-999	25.04
02	Jan-78	18.4	18.4	0.0	0.0	1	-999	-999	-999	-999	0.71	0.04	-999	-999	-999	-999	40.94
02	Feb-80	24.3	24.3	0.0	0.0	1	-999	-999	-999	4300	3.6	0.3	-999	-999	-999	-999	160
02	Feb-80	24.3	24.3	0.0	0.0	1	-999	-999	-999	2300	1.5	0.2	-999	-999	-999	-999	57
02	Feb-80	21.0	21.0	0.0	0.0	1	-999	-999	-999	2700	1.1	0.05	-999	-999	-999	-999	36
02	Aug-80	26.3	26.3	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	16.06
02	Aug-80	18.6	18.6	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	19.37
02	Aug-80	19.6	19.6	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	18.74
02	Aug-80	23.5	23.5	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	14.49
02	Aug-80	23.2	23.2	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	18.43
02	Aug-80	24.5	24.5	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	12.76
02	Sep-80	24.3	24.3	0.0	0.0	1	-999	-999	-999	3400	0.7	0.08	-999	-999	-999	-999	20
02	Sep-80	21.0	21.0	0.0	0.0	1	-999	-999	-999	2800	0.6	0.1	-999	-999	-999	-999	17
02	Oct-80	19.1	19.1	0.0	0.0	1	-999	-999	-999	-999	0.605	-999	-999	-999	-999	-999	34.91
02	Oct-80	27.4	27.4	0.0	0.0	1	-999	-999	-999	-999	0.516	-999	-999	-999	-999	-999	21.83
02	Oct-80	27.4	27.4	0.0	0.0	10	-999	-999	-999	-999	0.427	-999	-999	-999	-999	-999	18.14
02	Oct-80	23.1	23.1	0.0	0.0	1	-999	-999	-999	-999	0.569	-999	-999	-999	-999	-999	29.22
02	Oct-80	22.9	22.9	0.0	0.0	1	-999	-999	-999	-999	0.596	-999	-999	-999	-999	-999	25.52
02	Oct-80	19.1	19.1	0.0	0.0	4	-999	-999	-999	-999	0.534	-999	-999	-999	-999	-999	29.68
02	Oct-80	23.1	23.1	0.0	0.0	6	-999	-999	-999	-999	0.827	-999	-999	-999	-999	-999	26.60
02	Oct-85	24.3	24.3	0.0	0.0	0	-999	0.032	-999	-999	0.5	0.014	-999	2.83	-999	-999	21.45
02	Oct-85	21.0	21.0	0.0	0.0	5	-999	0.022	-999	-999	0.4	0.011	-999	2.26	-999	-999	18.51
02	Oct-85	24.3	24.3	0.0	0.0	13	-999	0.056	-999	-999	0.49	0.027	-999	2.83	-999	-999	18.21
02	Oct-85	24.3	24.3	0.0	0.0	6	-999	0.044	-999	-999	0.5	0.025	-999	2.64	-999	-999	18.05
02	Oct-85	24.3	24.3	0.0	0.0	2	-999	0.027	-999	-999	0.57	0.063	-999	3.02	-999	-999	20.52
02	Oct-85	21.0	21.0	0.0	0.0	1	-999	0.044	-999	-999	0.5	0.044	-999	2.83	-999	-999	19.21
02	Nov-85	21.0	21.0	0.0	0.0	6	0.077	0.056	-999	-999	0.593	0.01	-999	6.79	-999	-999	19.9
02	Nov-85	24.3	24.3	0.0	0.0	11	0.065	0.059	-999	-999	0.602	0.012	-999	6.22	-999	-999	21.14
02	Nov-85	21.0	21.0	0.0	0.0	1	0.135	0.06	-999	-999	1.195	0.01	-999	11.69	-999	-999	34.71
02	Nov-85	24.3	24.3	0.0	0.0	1	0.089	0.046	-999	-999	0.929	0.005	-999	8.77	-999	-999	30.16
02	Nov-85	24.3	24.3	0.0	0.0	5	0.077	-999	-999	-999	0.663	-999	-999	7.54	-999	-999	24.53
02	Apr-86	21.0	24.0	0.0	0.0	0	0.086	0.141	-999	-999	0.916	0.061	-999	7.54	8.29	-999	31.32
02	Apr-86	22.1	22.1	0.0	0.0	3	0.055	-999	-999	-999	0.576	-999	-999	5.85	-999	-999	24.22
02	Apr-86	21.0	21.0	0.0	0.0	6	0.039	0.039	-999	-999	0.375	0.016	-999	1.7	3.44	-999	11.26
02	Apr-86	22.1	22.1	0.0	0.0	0	0.092	0.037	-999	-999	0.663	0.026	-999	6.6	3.76	-999	47.98
02	Apr-86	22.1	22.1	0.0	0.0	13	0.084	0.078	-999	-999	0.454	0.029	-999	4.34	5.44	-999	15.43
02	May-86	21.3	21.3	0.0	0.0	0	0.045	0.052	-999	-999	0.462	0.036	-999	5.47	2.87	-999	25.54
02	May-86	24.3	24.3	0.0	0.0	0	0.045	0.04	-999	-999	0.41	0.017	-999	4.34	3.8	-999	13.73
02	May-86	21.3	21.3	0.0	0.0	7	0.033	0.176	-999	-999	0.349	0.068	-999	4.34	19.51	-999	13.89
02	May-86	24.3	24.3	0.0	0.0	13	0.042	0.099	-999	-999	0.393	0.033	-999	3.96	8.51	-999	14.19
02	May-86	24.3	24.3	0.0	0.0	6	0.032	-999	-999	-999	0.367	-999	-999	3.96	-999	-999	14.5
03	Mar-77	29.1	0.0	0.0	0.0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	283.4
03	Mar-77	29.1	0.0	0.0	0.0	8	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	55.12
03	Jan-78	28.0	0.0	0.0	0.0	1	-999	-999	-999	-999	0.53	0.18	-999	-999	-999	-999	19.53
03	Feb-80	23.6	0.0	0.0	0.0	1	-999	-999	-999	3800	1	0.1	-999	-999	-999	-999	33
03	Feb-80	23.6	0.0	0.0	0.0	1	-999	-999	-999	3300	0.8	0.09	-999	-999	-999	-999	24

Listing of BAYMETAL Data File

Sect	Date	P-W	P-E	M-E	M-S	z(m)	AgD	AgP	AgT	AlP	CdD	CdP	CdT	CrD	CrP	CrT	CuD
03	Oct-80	25.7	0.0	0.0	0.0	4	-999	-999	-999	-999	0.498	-999	-999	-999	-999	-999	26.91
03	Oct-85	23.6	0.0	0.0	0.0	1	-999	0.048	-999	-999	0.49	0.036	-999	4.53	-999	-999	24.07
03	Oct-85	23.6	0.0	0.0	0.0	3	-999	0.048	-999	-999	0.49	0.034	-999	3.68	-999	-999	23.68
03	Nov-85	23.6	0.0	0.0	0.0	3	0.063	0.043	-999	-999	0.672	0.012	-999	6.22	-999	-999	25.76
03	Nov-85	23.6	0.0	0.0	0.0	1	0.081	0.037	-999	-999	0.537	0.013	-999	6.6	-999	-999	25.92
03	Apr-86	23.6	0.0	0.0	0.0	1	0.099	0.059	-999	-999	0.776	0.034	-999	6.79	4.96	-999	29.78
03	Apr-86	23.6	0.0	0.0	0.0	2	0.066	0.064	-999	-999	0.68	0.039	-999	6.41	4.22	-999	25.46
03	May-86	23.6	0.0	0.0	0.0	1	0.061	0.043	-999	-999	0.506	0.037	-999	4.9	3.12	-999	27.31
03	May-86	23.6	0.0	0.0	0.0	3	0.063	0.03	-999	-999	0.48	0.025	-999	4.53	3.09	-999	24.84
04	May-75	41.1	0.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	11.86
04	May-75	41.1	0.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	26.27
04	Jun-75	41.1	0.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	46.06
04	Jun-75	41.1	0.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	27.09
04	Jul-75	41.1	0.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	21.01
04	Jul-75	41.1	0.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	24.61
04	Jul-75	41.1	0.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	18.57
04	Aug-75	41.1	0.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	20.82
04	Sep-75	41.1	0.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	22.58
04	Oct-75	41.1	0.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	18.49
04	Mar-77	35.1	0.0	0.0	0.0	13	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	36.22
04	Mar-77	35.1	0.0	0.0	0.0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	67.72
04	Jan-78	36.5	0.0	0.0	0.0	5	-999	-999	-999	-999	0.44	0.08	-999	-999	-999	-999	13.07
04	Jan-78	34.3	0.0	0.0	0.0	7	-999	-999	-999	-999	1.33	0.01	-999	-999	-999	-999	13.39
04	Jan-78	40.1	0.0	0.0	0.0	1	-999	-999	-999	-999	0.89	0.04	-999.	-999	-999	-999	13.39
04	Feb-80	35.2	0.0	0.0	0.0	1	-999	-999	-999	3100	1.8	0.05	-999	-999	-999	-999	24
04	Feb-80	29.1	0.0	0.0	0.0	1	-999	-999	-999	2600	1.1	0.06	-999	-999	-999	-999	33
04	Feb-80	41.2	0.0	0.0	0.0	1	-999	-999	-999	3400	1.3	0.06	-999	-999	-999	-999	39
04	Feb-80	29.1	0.0	0.0	0.0	1	-999	-999	-999	2400	0.8	0.05	-999	-999	-999	-999	22
04	Feb-80	35.2	0.0	0.0	0.0	1	-999	-999	-999	2500	0.6	0.03	-999	-999	-999	-999	16
04	Feb-80	41.2	0.0	0.0	0.0	1	-999	-999	-999	2100	1.1	0.04	-999	-999	-999	-999	29
04	Aug-80	35.4	0.0	0.0	0.0	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	12.91
04	Sep-80	35.2	0.0	0.0	0.0	1	-999	-999	-999	14700	0.3	0.1	-999	-999	-999	-999	11
04	Sep-80	41.2	0.0	0.0	0.0	1	-999	-999	-999	6900	0.4	0.1	-999	-999	-999	-999	12
04	Sep-80	29.1	0.0	0.0	0.0	1	-999	-999	-999	3600	0.3	0.06	-999	-999	-999	-999	12
04	Oct-80	34.1	0.0	0.0	0.0	7	-999	-999	-999	-999	0.347	-999	-999	-999	-999	-999	16.45
04	Oct-85	35.2	0.0	0.0	0.0	5	0.298	0.009	-999	-999	0.25	0.006	-999	2.64	-999	-999	11.19
04	Oct-85	41.2	0.0	0.0	0.0	3	0.035	0.015	-999	-999	0.19	0.013	-999	2.64	-999	-999	10.03
04	Oct-85	29.1	0.0	0.0	0.0	5	-999	0.05	-999	-999	0.31	0.017	-999	3.39	-999	-999	14.35
04	Oct-85	41.2	0.0	0.0	0.0	19	0.08	0.041	-999	-999	0.22	0.015	-999	2.83	-999	-999	10.34
04	Oct-85	29.1	0.0	0.0	0.0	3	-999	0.023	-999	-999	0.41	0.018	-999	3.96	-999	-999	16.66
04	Oct-85	41.2	0.0	0.0	0.0	11	0.085	0.033	-999	-999	0.24	0.016	-999	2.64	-999	-999	10.18
04	Oct-85	41.2	0.0	0.0	0.0	1	0.08	0.016	-999	-999	0.23	0.014	-999	2.83	-999	-999	10.8
04	Oct-85	35.2	0.0	0.0	0.0	1	0.509	0.01	-999	-999	0.26	0.007	-999	3.21	-999	-999	12.5
04	Oct-85	35.2	0.0	0.0	0.0	8	0.042	0.023	-999	-999	0.23	0.008	-999	2.83	-999	-999	9.57
04	Oct-85	29.1	0.0	0.0	0.0	1	-999	0.022	-999	-999	0.38	0.025	-999	3.21	-999	-999	17.59
04	Nov-85	35.2	0.0	0.0	0.0	5	0.009	-999	-999	-999	0.41	-999	-999	5.28	-999	-999	16.35
04	Nov-85	29.1	0.0	0.0	0.0	5	0.046	0.028	-999	-999	0.654	0.01	-999	5.85	-999	-999	18.67
04	Nov-85	41.2	0.0	0.0	0.0	4	0.038	-999	-999	-999	0.668	-999	-999	3.39	-999	-999	14.28
04	Nov-85	35.2	0.0	0.0	0.0	9	0.033	0.019	-999	-999	0.323	0.002	-999	3.77	-999	-999	12.81
04	Nov-85	41.2	0.0	0.0	0.0	1	0.036	0.013	-999	-999	0.427	0.008	-999	3.39	-999	-999	14.97
04	Nov-85	29.1	0.0	0.0	0.0	3	0.044	-999	-999	-999	0.663	-999	-999	7.73	-999	-999	19.13
04	Nov-85	41.2	0.0	0.0	0.0	10	0.05	-999	-999	-999	0.358	-999	-999	3.02	-999	-999	14.81
04	Nov-85	35.2	0.0	0.0	0.0	1	0.054	0.013	-999	-999	0.497	-999	-999	5.66	-999	-999	17.59
04	Nov-85	41.2	0.0	0.0	0.0	16	0.025	0.038	-999	-999	0.366	0.008	-999	3.02	-999	-999	13.42
04	Nov-85	29.1	0.0	0.0	0.0	1	0.055	0.035	-999	-999	0.741	0.01	-999	8.11	-999	-999	23.45
04	Apr-86	29.1	0.0	0.0	0.0	1	0.072	0.029	-999	-999	0.628	0.012	-999	-999	1.65	-999	20.52
04	Apr-86	35.2	0.0	0.0	0.0	8	0.038	0.011	-999	-999	0.323	0.002	-999	3.58	1.11	-999	9.57
04	Apr-86	41.2	0.0	0.0	0.0	0	0.028	-999	-999	-999	0.471	-999	-999	-999	-999	-999	14.66
04	Apr-86	41.2	0.0	0.0	0.0	10	0.038	-999	-999	-999	0.41	-999	-999	-999	-999	-999	11.11
04	Apr-86	29.1	0.0	0.0	0.0	4	0.075	-999	-999	-999	0.576	-999	-999	-999	-999	-999	19.44
04	Apr-86	29.1	0.0	0.0	0.0	6	0.051	0.046	-999	-999	0.48	0.009	-999	-999	2.4	-999	14.97
04	Apr-86	35.2	0.0	0.0	0.0	0	0.049	0.021	-999	-999	0.489	0.014	-999	4.15	1.24	-999	16.36
04	Apr-86	41.2	0.0	0.0	0.0	21	0.034	-999	-999	-999	0.375	-999	-999	-999	-999	-999	10.65
04	May-86	35.2	0.0	0.0	0.0	8	0.044	0.032	-999	-999	0.279	0.006	-999	3.02	4.96	-999	10.49
04	May-86	35.2	0.0	0.0	0.0	1	0.043	0.005	-999	-999	0.288	0.003	-999	3.02	1.79	-999	10.8
04	May-86	38.0	0.0	0.0	0.0	1	0.039	-999	-999	-999	0.305	-999	-999	-999	-999	-999	9.41
04	May-86	29.1	0.0	0.0	0.0	6	0.026	0.06	-999	-999	0.331	0.018	-999	-999	4.94	-999	11.57
04	May-86	38.0	0.0	0.0	0.0	5	0.027	-999	-999	-999	0.305	-999	-999	-999	-999	-999	10.65

```
Sect  Date    P-W   P-E   M-E   M-S z(m)   AgD   AgP   AgT   AlP   CdD   CdP   CdT   CrD   CrP   CrT   CuD
 04  May-86  29.1   0.0   0.0   0.0   1 0.021 0.017  -999  -999 0.297 0.012  -999  -999  2.21  -999 11.73
 04  May-86  38.0   0.0   0.0   0.0  10 0.034  -999  -999  -999 0.297  -999  -999  -999  -999  -999 10.03
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999  67.4
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 28.56
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 26.46
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 21.89
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 54.96
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 39.06
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999  22.2
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 39.21
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 77.01
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 41.73
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 54.17
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 41.73
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 38.11
 05  Jan-71  45.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 22.99
 05  May-76  41.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 26.47
 05  Jun-76  41.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 28.69
 05  Mar-77  44.1   0.0   0.0   0.0  27  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 25.77
 05  Mar-77  44.1   0.0   0.0   0.0   0  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 42.52
 05  Jan-78  46.1   0.0   0.0   0.0   8  -999  -999  -999  -999  -999  0.22  -999  -999  -999  -999 10.55
 05  Jan-78  46.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  0.24  -999  -999  -999  -999 11.02
 05  Feb-80  49.5   0.0   0.0   0.0   1  -999  -999  -999  3100   0.6  0.05  -999  -999  -999  -999    15
 05  Feb-80  49.5   0.0   0.0   0.0   1  -999  -999  -999   900   0.8  0.03  -999  -999  -999  -999   20.
 05  Aug-80  51.1   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999  7.56
 05  Aug-80  43.6   0.0   0.0   0.0   1  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999  9.61
 05  Sep-80  49.5   0.0   0.0   0.0   1  -999  -999  -939 10300   0.3   0.1  -999  -999  -999  -999     9
 05  Oct-80  45.8   0.0   0.0   0.0   1  -999  -999  -999  -999 0.587  -999  -999  -999  -999  -999 14.76
 05  Oct-80  45.8   0.0   0.0   0.0   8  -999  -999  -999  -999 0.391  -999  -999  -999  -999  -999 16.91
 05  Oct-85  49.5   0.0   0.0   0.0   0 0.021 0.003  -999  -999  0.24 0.009  -999  2.45  -999  -999  10.8
 05  Oct-85  49.5   0.0   0.0   0.0   3 0.024  0.01  -999  -999   0.2 0.014  -999  2.26  -999  -999  7.56
 05  Oct-85  49.5   0.0   0.0   0.0   7 0.025 0.005  -999  -999  0.18  0.02  -999  2.45  -999  -999  7.25
 05  Oct-85  49.5   0.0   0.0   0.0  12 0.021 0.014  -999  -999  0.34 0.014  -999  2.83  -999  -999  3.49
 05  Nov-85  49.5   0.0   0.0   0.0   1 0.017 0.024  -999  -999 0.279 0.009  -999  -999  -999  -999 10.65
 05  Nov-85  49.5   0.0   0.0   0.0   3 0.018  -999  -999  -999 0.288  -999  -999  -999  -999  -999 10.65
 05  Nov-85  49.5   0.0   0.0   0.0  12 0.019 0.027  -999  -999 0.236  0.01  -999  -999  -999  -999  7.71
 05  Nov-85  49.5   0.0   0.0   0.0   7 0.023  -999  -999  -999 0.244  -999  -999  -999  -999  -999  8.95
 05  Apr-86  49.5   0.0   0.0   0.0  12  0.02  -999  -999  -999 0.253  -999  -999  -999  -999  -999  6.48
 05  Apr-86  49.5   0.0   0.0   0.0   6 0.018  -999  -999  -999 0.266  -999  -999  -999  -999  -999  6.56
 05  Apr-86  49.5   0.0   0.0   0.0   0 0.021  -999  -999  -999 0.384  -999  -999  -999  -999  -999 12.03
 05  May-86  49.5   0.0   0.0   0.0   1 0.026  -999  -999  -999 0.262  -999  -999  -999  -999  -999  8.18
 05  May-86  49.5   0.0   0.0   0.0  10 0.016  -999  -999  -999 0.209  -999  -999  -999  -999  -999  5.09
 05  May-86  49.5   0.0   0.0   0.0   8 0.024  -999  -999  -999 0.227  -999  -999  -999  -999  -999  6.17
 06  Mar-77   0.0  32.8  30.4   0.0  16  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 48.82
 06  Mar-77   0.0  32.8  30.4   0.0   0  -999  -999  -999  -999  -999  -999  -999  -999  -999  -999 53.54
 06  Jan-78   0.0  27.5  24.3   0.0   1  -999  -999  -999  -999  0.53   0.3  -999  -999  -999  -999 15.75
 06  Feb-80   0.0  28.9  25.5   0.0   1  -999  -999  -999  2200     1  0.06  -999  -999  -999  -999    49
 06  Feb-80   0.0  26.9  23.5   0.0   1  -999  -999  -999  2200   0.9  0.07  -999  -999  -999  -999    45
 06  Sep-80   0.0  28.9  25.5   0.0   1  -999  -999  -999  2800   0.3  0.09  -999  -999  -999  -999    13
 06  Sep-80   0.0  26.9  23.5   0.0   1  -999  -999  -999  3400   0.7  0.06  -999  -999  -999  -999    27
 06  Oct-85   0.0  26.9  23.5   0.0   8  -999 0.057  -999  -999  0.29  0.02  -999  2.64  -999  -999 10.65
 06  Oct-85   0.0  26.9  23.5   0.0   5  -999 0.016  -999  -999  0.53 0.011  -999  2.93  -999  -999 18.67
 06  Oct-85   0.0  28.9  25.5   0.0  15  -999 0.046  -999  -999  0.28 0.019  -999  2.07  -999  -999 11.26
 06  Oct-85   0.0  28.9  25.5   0.0   7  -999 0.016  -999  -999  0.36  0.01  -999  2.45  -999  -999  15.2
 06  Oct-85   0.0  28.9  25.5   0.0   0  -999 0.014  -999  -999  0.38 0.013  -999  2.83  -999  -999 15.58
 06  Oct-85   0.0  26.9  23.5   0.0   0  -999 0.008  -999  -999  0.54 0.012  -999  3.02  -999  -999 21.14
 06  Nov-85   0.0  26.9  23.5   0.0  10 0.037 0.051  -999  -999 0.331  0.01  -999  3.77  -999  -999 11.88
 06  Nov-85   0.0  28.9  25.5   0.0   1 0.099 0.033  -999  -999 0.576  0.01  -999  7.36  -999  -999 21.06
 06  Nov-85   0.0  28.9  25.5   0.0  15 0.123  -999  -999  -999 0.314  -999  -999  4.15  -999  -999 12.96
 06  Nov-85   0.0  26.9  23.5   0.0   1 0.097 0.026  -999  -999 0.576  -999  -999  6.89  -999  -999 20.21
 06  Nov-85   0.0  26.9  23.5   0.0   6  0.08  -999  -999  -999 0.366  -999  -999  4.53  -999  -999 14.97
 06  Nov-85   0.0  28.9  25.5   0.0   8 0.135  -999  -999  -999 0.515  -999  -999  6.22  -999  -999 18.98
 06  Nov-85   0.0  28.9  25.5   0.0  22 0.204 0.044  -999  -999 0.314 0.009  -999  3.77  -999  -999 11.88
 06  Apr-86   0.0  28.9  25.5   0.0  11 0.046  -999  -999  -999 0.401  -999  -999  3.39  -999  -999 13.27
 06  Apr-86   0.0  28.9  25.5   0.0  15  0.04 0.027  -999  -999 0.358 0.009  -999  3.21  1.75  -999 11.73
 06  Apr-86   0.0  26.9  23.5   0.0   6 0.039  -999  -999  -999 0.358  -999  -999  3.02  -999  -999 11.73
 06  Apr-86   0.0  26.9  23.5   0.0  10 0.033 0.025  -999  -999 0.305 0.007  -999  2.45  1.62  -999  9.87
 06  Apr-86   0.0  26.9  23.5   0.0   0 0.047 0.032  -999  -999 0.441 0.015  -999  3.12  2.13  -999 15.04
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Sect	Date	P-W	P-E	M-E	M-S	z(m)	AgD	AgP	AgT	AlP	CdD	CdP	CdT	CrD	CrP	CrT	CuD
06	Apr-86	0.0	28.9	25.5	0.0	0	0.066	0.036	-999	-999	0.528	0.016	-999	4.71	1.65	-999	19.38
06	May-86	0.0	26.9	23.5	0.0	10	0.029	-999	-999	-999	0.331	-999	-999	3.58	-999	-999	12.34
06	May-86	0.0	28.9	25.5	0.0	10	0.038	-999	-999	-999	0.331	-999	-999	3.39	-999	-999	12.19
06	May-86	0.0	26.9	23.5	0.0	12	0.026	0.108	-999	-999	0.323	0.03	-999	3.02	11.55	-999	9.57
06	May-86	0.0	26.9	23.5	0.0	1	0.045	0.016	-999	-999	0.349	0.01	-999	3.77	1.11	-999	14.5
06	May-86	0.0	28.9	25.5	0.0	15	0.03	0.024	-999	-999	0.323	0.006	-999	3.02	2.72	-999	11.38
06	May-86	0.0	28.9	25.5	0.0	1	0.03	0.017	-999	-999	0.34	0.006	-999	3.96	1.51	-999	13.73
07	Mar-77	0.0	35.8	33.4	0.0	35	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	23.62
07	Mar-77	0.0	43.8	41.4	0.0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	51.97
07	Mar-77	0.0	43.8	41.4	0.0	40	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
07	Mar-77	0.0	35.8	33.4	0.0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	62.39
07	Jan-78	0.0	41.7	39.3	0.0	11	-999	-999	-999	-999	2.05	0.09	-999	-999	-999	-999	10.08
07	Feb-80	0.0	43.7	41.3	0.0	1	-999	-999	-999	3200	2.4	0.05	-999	-999	-999	-999	9
07	Feb-80	0.0	33.7	31.3	0.0	1	-999	-999	-999	2200	1.1	0.06	-999	-999	-999	-999	30
07	Feb-80	0.0	43.7	41.3	0.0	1	-999	-999	-999	2000	-999	0.04	-999	-999	-999	-999	-999
07	Sep-80	0.0	43.7	41.3	0.0	1	-999	-999	-999	5400	0.4	0.09	-999	-999	-999	-999	7
07	Oct-85	0.0	33.7	31.3	0.0	5	-999	0.016	-999	-999	0.28	0.012	-999	2.64	-999	-999	14.5
07	Oct-85	0.0	43.7	41.3	0.0	34	0.037	0.002	-999	-999	0.15	0.009	-999	2.83	-999	-999	4.34
07	Oct-85	0.0	33.7	31.3	0.0	26	-999	0.057	-999	-999	0.18	0.024	-999	2.45	-999	-999	8.64
07	Oct-85	0.0	33.7	31.3	0.0	15	-999	0.025	-999	-999	0.24	0.011	-999	2.64	-999	-999	11.11
07	Oct-85	0.0	43.7	41.3	0.0	20	0.023	0.005	-999	-999	0.28	0.009	-999	3.02	-999	-999	6.79
07	Oct-85	0.0	43.7	41.3	0.0	1	0.081	0.005	-999	-999	0.29	0.008	-999	3.12	-999	-999	10.49
07	Oct-85	0.0	43.7	41.3	0.0	7	0.047	0.008	-999	-999	0.19	0.016	-999	3.02	-999	-999	7.71
07	Oct-85	0.0	33.7	31.3	0.0	1	-999	0.017	-999	-999	0.3	0.034	-999	3.39	-999	-999	14.04
07	Nov-85	0.0	33.7	31.3	0.0	20	0.009	0.047	-999	-999	0.262	0.01	-999	3.02	-999	-999	5.33
07	Nov-85	0.0	33.7	31.3	0.0	5	0.012	-999	-999	-999	0.401	-999	-999	4.71	-999	-999	15.27
07	Nov-85	0.0	43.7	41.3	0.0	2	0.036	0.016	-999	-999	0.375	0.009	-999	-999	-999	-999	14.97
07	Nov-85	0.0	33.7	31.3	0.0	1	0.038	0.02	-999	-999	0.506	0.004	-999	5.66	-999	-999	16.66
07	Nov-85	0.0	43.7	41.3	0.0	21	0.028	-999	-999	-999	0.218	-999	-999	-999	-999	-999	8.95
07	Nov-85	0.0	43.7	41.3	0.0	8	0.037	-999	-999	-999	0.375	-999	-999	-999	-999	-999	13.89
07	Nov-85	0.0	43.7	41.3	0.0	37	0.024	0.032	-999	-999	0.201	0.01	-999	-999	-999	-999	6.63
07	Nov-85	0.0	33.7	31.3	0.0	12	0.009	-999	-999	-999	0.314	-999	-999	4.15	-999	-999	11.26
07	Apr-86	0.0	33.7	31.3	0.0	0	0.049	0.021	-999	-999	0.48	0.011	-999	-999	1.07	-999	16.2
07	Apr-86	0.0	43.7	41.3	0.0	18	0.041	-999	-999	-999	0.288	-999	-999	-999	-999	-999	6.34
07	Apr-86	0.0	43.7	41.3	0.0	33	0.019	0.009	-999	-999	0.218	0.003	-999	-999	1.55	-999	4.47
07	Apr-86	0.0	43.7	41.3	0.0	0	0.037	0.007	-999	-999	0.34	0.003	-999	-999	0.55	-999	10.8
07	Apr-86	0.0	43.7	41.3	0.0	8	0.029	-999	-999	-999	0.314	-999	-999	-999	-999	-999	9.57
07	Apr-86	0.0	33.7	31.3	0.0	17	0.036	0.021	-999	-999	0.323	0.005	-999	-999	1.3	-999	10.03
07	Apr-86	0.0	33.7	31.3	0.0	10	0.045	-999	-999	-999	0.384	-999	-999	-999	-999	-999	12.34
07	May-86	0.0	43.7	41.3	0.0	15	0.025	-999	-999	-999	0.218	-999	-999	-999	-999	-999	4.63
07	May-86	0.0	33.7	31.3	0.0	1	0.045	0.009	-999	-999	0.314	0.004	-999	-999	1.63	-999	11.42
07	May-86	0.0	43.7	41.3	0.0	1	0.037	0.002	-999	-999	0.253	-999	-999	-999	0.31	-999	7.71
07	May-86	0.0	33.7	31.3	0.0	29	0.041	0.061	-999	-999	0.297	0.011	-999	-999	7.13	-999	8.18
07	May-86	0.0	43.7	41.3	0.0	34	0.028	0.002	-999	-999	0.209	-999	-999	-999	1.13	-999	4.63
07	May-86	0.0	33.7	31.3	0.0	10	0.053	-999	-999	-999	0.314	-999	-999	-999	-999	-999	10.18
08	Mar-77	0.0	45.8	43.4	0.0	8	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	25.77
08	Mar-77	0.0	45.8	43.4	0.0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	55.12
08	Mar-77	0.0	46.5	44.1	0.0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	48.82
08	Mar-77	0.0	46.5	44.1	0.0	16	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	31.5
08	Jan-78	0.0	47.4	45.0	0.0	10	-999	-999	-999	-999	0.98	0.05	-999	-999	-999	-999	7.4
08	Jan-78	0.0	50.8	48.4	0.0	25	-999	-999	-999	-999	2.31	0.13	-999	-999	-999	-999	7.87
08	Feb-80	0.0	50.0	47.6	0.0	1	-999	-999	-999	1700	0.4	0.03	-999	-999	-999	-999	5
08	Feb-80	0.0	50.0	47.6	0.0	1	-999	-999	-999	1500	0.3	0.02	-999	-999	-999	-999	8
08	Oct-85	0.0	50.0	47.6	0.0	30	0.023	0.015	-999	-999	0.16	0.021	-999	2.07	-999	-999	4.01
08	Oct-85	0.0	50.0	47.6	0.0	6	0.028	0.026	-999	-999	0.17	0.019	-999	2.07	-999	-999	6.33
08	Oct-85	0.0	50.0	47.6	0.0	1	0.028	0.026	-999	-999	0.18	0.021	-999	2.07	-999	-999	6.33
08	Oct-85	0.0	50.0	47.6	0.0	18	-999	0.013	-999	-999	0.16	0.028	-999	2.07	-999	-999	4.78
08	Nov-85	0.0	50.0	47.6	0.0	35	0.015	0.019	-999	-999	0.192	0.007	-999	-999	-999	-999	5.71
08	Nov-85	0.0	50.0	47.6	0.0	20	0.015	-999	-999	-999	0.192	-999	-999	-999	-999	-999	6.02
08	Nov-85	0.0	50.0	47.6	0.0	8	0.023	-999	-999	-999	0.227	-999	-999	-999	-999	-999	7.87
08	Nov-85	0.0	50.0	47.6	0.0	1	0.027	0.01	-999	-999	0.288	0.004	-999	-999	-999	-999	10.65
08	Apr-86	0.0	50.0	47.6	0.0	13	0.012	-999	-999	-999	0.218	-999	-999	-999	-999	-999	5.55
08	Apr-86	0.0	50.0	47.6	0.0	27	0.013	-999	-999	-999	0.218	-999	-999	-999	-999	-999	4.78
08	Apr-86	0.0	50.0	47.6	0.0	1	0.021	-999	-999	-999	0.288	-999	-999	-999	-999	-999	8.02
08	May-86	0.0	50.0	47.6	0.0	14	0.015	-999	-999	-999	0.218	-999	-999	-999	-999	-999	4.34
08	May-86	0.0	50.0	47.6	0.0	27	0.017	-999	-999	-999	0.236	-999	-999	-999	-999	-999	4.34
08	May-86	0.0	50.0	47.6	0.0	1	0.024	-999	-999	-999	0.244	-999	-999	-999	-999	-999	3.02
09	Jan-78	6.2	6.2	0.0	0.0	4	-999	-999	-999	-999	1.51	0.11	-999	-999	-999	-999	56.54

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Sect  Date     P-W    P-E    M-E    M-S  z(m)   AgD    AgP    AgT    AlP    CdD    CdP    CdT    CrD    CrP    CrT    CuD
 09  Jan-78    6.2    6.2    0.0    0.0    1   -999   -999   -999   -999   2.05   1.19   -999   -999   -999   -999  38.19
 09  Feb-80    5.0    5.0    0.0    0.0    1   -999   -999   -999   5400    6.2    1.3   -999   -999   -999   -999     67
 09  Feb-80    5.0    5.0    0.0    0.0    1   -999   -999   -999   3700    2.3    0.5   -999   -999   -999   -999     27
 09  Sep-80    5.0    5.0    0.0    0.0    1   -999   -999   -999   2000      1    0.1   -999   -999   -999   -999     38
 09  Mar-81    5.1    5.1    0.0    0.0    3   -999   -999   0.32   -999   -999   -999     10   -999   -999   -999   -999
 09  Mar-81    5.8    5.8    0.0    0.0    5   -999   -999   0.55   -999   -999   -999      8   -999   -999   -999   -999
 09  Mar-81    0.2    0.2    0.0    0.0    1   -999   -999    0.7   -999   -999   -999    230   -999   -999   -999   -999
 09  Mar-81    4.1    4.1    0.0    0.0    1   -999   -999   4.76   -999   -999   -999     54   -999   -999   -999   -999
 09  Mar-81    6.1    6.1    0.0    0.0    4   -999   -999   0.51   -999   -999   -999      5   -999   -999   -999   -999
 09  Mar-81    6.8    6.8    0.0    0.0    1   -999   -999   1.12   -999   -999   -999     13   -999   -999   -999   -999
 09  Mar-81    1.9    1.9    0.0    0.0    1   -999   -999   1.06   -999   -999   -999     34   -999   -999   -999   -999
 09  Mar-81    6.1    6.1    0.0    0.0    1   -999   -999   1.07   -999   -999   -999     17   -999   -999   -999   -999
 09  Mar-81    4.1    4.1    0.0    0.0    2   -999   -999    1.7   -999   -999   -999     21   -999   -999   -999   -999
 09  Mar-81    1.9    1.9    0.0    0.0    2   -999   -999   1.38   -999   -999   -999     16   -999   -999   -999   -999
 09  Mar-81    5.1    5.1    0.0    0.0    1   -999   -999   1.14   -999   -999   -999     22   -999   -999   -999   -999
 09  Nov-85    5.0    5.0    0.0    0.0    2  0.259  0.496   -999   -999  5.172   0.62   -999   -999   -999   -999  58.16
 09  Nov-85    5.0    5.0    0.0    0.0    0  0.226  0.536   -999   -999  5.094  0.559   -999   -999   -999   -999  52.61
 09  Apr-86    5.0    5.0    0.0    0.0    0  0.348  0.346   -999   -999  3.184  0.449   -999  10.75  28.09   -999  54.77
 09  Apr-86    5.0    5.0    0.0    0.0    2  0.257  0.437   -999   -999  2.879  0.342   -999   9.43  28.19   -999  48.44
 10  Oct-85    0.0    0.0   16.7   16.7    4   -999  0.046   -999   -999    0.3  0.013   -999   2.64   -999   -999  15.74
 10  Oct-85    0.0    0.0   22.1   21.3    5   -999  0.042   -999   -999   0.36  0.014   -999    3.3   -999   -999   18.9
 10  Oct-85    0.0    0.0   22.1   21.3    9   -999  0.037   -999   -999   0.29  0.012   -999   2.26   -999   -999  15.12
 10  Oct-85    0.0    0.0   16.7   16.7    9   -999  0.044   -999   -999   0.29  0.012   -999   2.83   -999   -999   16.2
 10  Oct-85    0.0    0.0   16.7   16.7    0  0.025  0.065   -999   -999   0.36  0.018   -999   3.68   -999   -999  19.06
 10  Oct-85    0.0    0.0   22.1   21.3    0   -999  0.052   -999   -999   0.35  0.025   -999   3.21   -999   -999  19.29
 10  Oct-85    0.0    0.0   22.1   21.3    1   -999  0.042   -999   -999   0.34  0.013   -999   3.02   -999   -999  19.13
 10  Nov-85    0.0    0.0   16.7   16.7   10   0.09  0.096   -999   -999  0.384  0.022   -999   -999   -999   -999  14.81
 10  Nov-85    0.0    0.0   22.1   21.3    8  0.206   -999   -999   -999  0.436   -999   -999    4.9   -999   -999  14.81
 10  Nov-85    0.0    0.0   16.7   16.7    6  0.306   -999   -999   -999  0.393   -999   -999   -999   -999   -999  19.13
 10  Nov-85    0.0    0.0   22.1   21.3    1  0.123  0.033   -999   -999  0.463  0.007   -999   5.28   -999   -999  18.98
 10  Nov-85    0.0    0.0   16.7   16.7    1  0.254  0.133   -999   -999  0.427  0.022   -999   5.66   -999   -999  21.75
 10  Nov-85    0.0    0.0   22.1   21.3   15  0.186  0.087   -999   -999  0.366  0.023   -999   4.15   -999   -999  12.03
 10  Apr-86    0.0    0.0   16.7   16.7    3  0.068   -999   -999   -999  0.393   -999   -999   4.34   -999   -999  15.74
 10  Apr-86    0.0    0.0   22.1   21.3    5  0.045   -999   -999   -999  0.384   -999   -999   3.58   -999   -999  14.81
 10  Apr-86    0.0    0.0   16.7   16.7   11  0.048  0.107   -999   -999  0.375  0.026   -999   3.58  10.25   -999  13.27
 10  Apr-86    0.0    0.0   22.1   21.3    0  0.071   0.04   -999   -999  0.436  0.013   -999   3.77    2.8   -999  14.97
 10  Apr-86    0.0    0.0   22.1   21.3   13   0.04   0.03   -999   -999  0.366   0.01   -999   3.21   2.85   -999  11.68
 10  Apr-86    0.0    0.0   16.7   16.7    0  0.078  0.124   -999   -999  0.397  0.034   -999   3.77   6.84   -999  16.36
 10  May-86    0.0    0.0   22.1   21.3   10  0.049  0.033   -999   -999  0.323  0.011   -999   3.77   3.08   -999  12.65
 10  May-86    0.0    0.0   16.7   16.7    1  0.104  0.067   -999   -999  0.345  0.024   -999   3.58   3.67   -999  18.59
 10  May-86    0.0    0.0   22.1   21.3    1  0.043  0.016   -999   -999  0.305  0.003   -999   3.39   1.66   -999  13.42
 10  May-86    0.0    0.0   22.1   21.3    3  0.038   -999   -999   -999  0.323   -999   -999   3.39   -999   -999  13.58
 10  May-86    0.0    0.0   16.7   16.7   10  0.037  0.089   -999   -999  0.279  0.025   -999   2.45   8.97   -999  12.19
 10  May-86    0.0    0.0   16.7   16.7    6  0.085   -999   -999   -999  0.331   -999   -999   3.02   -999   -999  15.58
 11  Oct-85    0.0    0.0    0.0   27.6    5   -999  0.019   -999   -999   0.21  0.016   -999   2.45   -999   -999  10.49
 11  Oct-85    0.0    0.0    0.0   27.6    0   -999  0.027   -999   -999   0.25  0.017   -999   2.74   -999   -999  14.04
 11  Oct-85    0.0    0.0    0.0   40.4    2   -999  0.051   -999   -999   0.19  0.091   -999   1.89   -999   -999   6.48
 11  Oct-85    0.0    0.0    0.0   40.4    6   -999  0.005   -999   -999    0.2  0.023   -999   2.36   -999   -999   5.86
 11  Oct-85    0.0    0.0    0.0   40.4   11   -999   0.01   -999   -999   0.37  0.037   -999   1.89   -999   -999   6.17
 11  Oct-85    0.0    0.0    0.0   27.6    2   -999  0.026   -999   -999   0.27  0.013   -999   3.39   -999   -999   2.93
 11  Oct-85    0.0    0.0    0.0   40.4    0   -999  0.008   -999   -999   0.19  0.025   -999   2.07   -999   -999   6.63
 11  Nov-85    0.0    0.0    0.0   40.4    1   0.02  0.005   -999   -999  0.201  0.003   -999   -999   -999   -999    7.1
 11  Nov-85    0.0    0.0    0.0   40.4    6  0.018   -999   -999   -999  0.192   -999   -999   -999   -999   -999   7.41
 11  Nov-85    0.0    0.0    0.0   27.6    1  0.023   0.01   -999   -999  0.327   0.01   -999   -999   -999   -999  13.12
 11  Nov-85    0.0    0.0    0.0   27.6    4  0.061  0.013   -999   -999   0.34  0.003   -999   -999   -999   -999  14.35
 11  Nov-85    0.0    0.0    0.0   40.4   11   0.03  0.008   -999   -999  0.174  0.011   -999   -999   -999   -999   5.02
 11  Apr-86    0.0    0.0    0.0   27.6    0  0.036  0.018   -999   -999  0.297  0.013   -999   -999    0.9   -999  10.18
 11  Apr-86    0.0    0.0    0.0   27.6    6  0.017  0.023   -999   -999  0.244  0.021   -999   -999   1.95   -999   7.71
 11  May-86    0.0    0.0    0.0   30.0    1   0.02  0.006   -999   -999  0.253  0.011   -999   -999   1.17   -999    9.1
 11  May-86    0.0    0.0    0.0   30.0   14  0.021   0.06   -999   -999  0.209   0.04   -999   -999   6.92   -999   6.63
 11  May-86    0.0    0.0    0.0   40.4    1   0.02   -999   -999   -999  0.209   -999   -999   -999   -999   -999   5.55
 12  Mar-77   51.1   50.8   49.0   45.1    0   -999   -999   -999   -999   -999   -999   -999   -999   -999   -999  33.07
 12  Mar-77   51.1   50.8   49.0   45.1   33   -999   -999   -999   -999   -999   -999   -999   -999   -999   -999   25.2
 12  Mar-77   51.1   50.8   49.0   45.1   23   -999   -999   -999   -999   -999   -999   -999   -999   -999   -999  26.77
 12  Mar-77   51.1   50.8   49.0   45.1    0   -999   -999   -999   -999   -999   -999   -999   -999   -999   -999  55.12
 12  Jan-78   51.8   51.5   49.7   45.8    5   -999   -999   -999   -999   -999   0.21   -999   -999   -999   -999  11.18
 12  Jan-78   51.8   51.5   49.7   45.8   13   -999   -999   -999   -999   -999   0.53   -999   -999   -999   -999   3.56
 12  Jan-78   51.8   51.5   49.7   45.8    1   -999   -999   -999   -999   2.49   -999   -999   -999   -999   -999   8.38
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Sect	Date	P-W	P-E	M-E	M-S	z(m)	AgD	AgP	AgT	AlP	CdD	CdP	CdT	CrD	CrP	CrT	CuD
12	Feb-80	53.9	53.6	51.8	47.8	1	-999	-999	-999	1700	0.5	0.02	-999	-999	-999	-999	6
12	Feb-80	53.9	53.6	51.8	47.8	1	-999	-999	-999	1700	0.6	0.03	-999	-999	-999	-999	14
12	Aug-80	57.1	56.3	55.0	50.8	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	3.62
12	Oct-85	53.9	53.6	51.8	47.8	5	-999	0.01	-999	-999	0.18	0.019	-999	1.39	-999	-999	6.63
12	Oct-85	53.9	53.6	51.8	47.8	24	-999	0.004	-999	-999	0.15	0.018	-999	2.07	-999	-999	4.78
12	Oct-85	53.9	53.6	51.8	47.8	14	-999	0.006	-999	-999	0.17	0.046	-999	2.07	-999	-999	5.4
12	Oct-85	53.2	52.9	51.1	47.1	22	-999	0.005	-999	-999	0.18	0.011	-999	2.26	-999	-999	4.01
12	Oct-85	53.2	52.9	51.1	47.1	4	-999	0.003	-999	-999	0.17	0.006	-999	2.83	-999	-999	5.71
12	Oct-85	53.2	52.9	51.1	47.1	13	-999	0.002	-999	-999	0.18	0.008	-999	2.64	-999	-999	5.55
12	Oct-85	53.9	53.6	51.8	47.8	1	-999	0.009	-999	-999	0.17	0.031	-999	2.26	-999	-999	6.87
12	Oct-85	53.2	52.9	51.1	47.1	1	-999	0.004	-999	-999	0.17	0.008	-999	3.02	-999	-999	6.33
12	Nov-85	53.2	52.9	51.1	47.1	1	0.018	0.002	-999	-999	0.166	0.004	-999	-999	-999	-999	5.25
12	Nov-85	53.9	53.6	51.8	47.8	1	0.039	0.007	-999	-999	0.223	0.008	-999	-999	-999	-999	8.26
12	Nov-85	53.9	53.6	51.8	47.8	15	0.026	-999	-999	-999	0.192	-999	-999	-999	-999	-999	6.33
12	Nov-85	53.9	53.6	51.8	47.8	24	0.024	0.005	-999	-999	0.18	0.004	-999	-999	-999	-999	5.25
12	Nov-85	53.2	52.9	51.1	47.1	14	0.018	-999	-999	-999	0.174	-999	-999	-999	-999	-999	4.78
12	Nov-85	53.9	53.6	51.8	47.8	5	0.025	-999	-999	-999	0.206	-999	-999	-999	-999	-999	7.2
12	Nov-85	53.2	52.9	51.1	47.1	5	0.014	-999	-999	-999	0.192	-999	-999	-999	-999	-999	4.63
12	Nov-85	53.2	52.9	51.1	47.1	23	0.015	0.003	-999	-999	0.174	0.006	-999	-999	-999	-999	4.78
12	Apr-86	53.9	53.6	51.8	47.8	1	0.011	-999	-999	-999	0.209	-999	-999	-999	-999	-999	4.63
12	Apr-86	53.9	53.6	51.8	47.8	1	0.013	-999	-999	-999	0.218	-999	-999	-999	-999	-999	6.63
12	Apr-86	53.9	53.6	51.8	47.8	13	0.012	-999	-999	-999	0.209	-999	-999	-999	-999	-999	4.78
12	Apr-86	53.9	53.6	51.8	47.8	26	0.009	-999	-999	-999	0.201	-999	-999	-999	-999	-999	4.32
12	May-86	53.2	52.9	51.1	47.1	1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
12	May-86	53.9	53.6	51.8	47.8	1	0.018	-999	-999	-999	0.227	-999	-999	-999	-999	-999	6.48
12	May-86	53.2	52.9	51.1	47.1	7	0.008	-999	-999	-999	0.209	-999	-999	-999	-999	-999	4.01
12	May-86	53.9	53.6	51.8	47.8	11	0.01	-999	-999	-999	0.192	-999	-999	-999	-999	-999	3.39
12	May-86	53.2	52.9	51.1	47.1	27	0.01	-999	-999	-999	0.201	-999	-999	-999	-999	-999	3.55
12	May-86	53.9	53.6	51.8	47.8	28	0.012	-999	-999	-999	0.192	-999	-999	-999	-999	-999	3.55
12	May-86	53.2	52.9	51.1	47.1	1	0.008	-999	-999	-999	0.201	-999	-999	-999	-999	-999	4.09

CuP	CuT	FeD	FeP	FeT	MnD	MnP	MnT	NiD	NiP	NiT	PbD	PbP	PbT	ZnD	ZnP	ZnT	TSM
14.36	140.1	598.5	3225.	3763.	-999	-999	-999	1236.	103.9	1345.	112.9	13.51	125.4	-999	-999	-999	-999
-999	-999	182.8	-999	-999	537.3	-999	-999	166.9	-999	-999	1.11	-999	-999	-999	-999	-999	-999
7.24	-999	191.7	734.7	-999	701.2	14.57	-999	279.3	1.19	-999	1.16	2.12	-999	-999	-999	-999	3.8
36.35	-999	347.5	3835.	-999	1287.	12.75	-999	613.2	5.28	-999	1.16	10.33	-999	-999	-999	-999	4.3
22.2	-999	189.9	2114.	-999	591.9	29.14	-999	211.2	2.21	-999	0.32	4.54	-999	-999	-999	-999	5.8
15.28	-999	211.4	1935.	-999	591.9	23.68	-999	180.5	2.04	-999	-999	4.15	-999	-999	-999	-999	2.9
25.24	-999	220.4	2060.	-999	1036.	10.93	-999	698.4	6.64	-999	2.36	6.42	-999	-999	-999	-999	6
38.11	-999	-999	4390.	-999	1418.	16.39	-999	613.2	5.96	-999	13.66	13.56	-999	-999	-999	-999	6
30.39	-999	315.4	2156.	-999	1183.	9.11	-999	351.7	8.52	-999	15.93	7.82	-999	-999	-999	-999	3.3
132.2	-999	340.5	4247.	-999	1224.	30.97	-999	2640.	46	-999	1.21	13.47	-999	-999	-999	-999	11.1
-999	-999	-999	-999	-999	680	-999	350	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
50	-999	56	4000	-999	740	22	505	-999	-999	-999	1.2	3	-999	-999	-999	-999	-999
26	-999	35	2800	-999	480	22	555	-999	-999	-999	0.8	7	-999	-999	-999	-999	-999
28	-999	36	3500	-999	850	38	300	-999	-999	-999	1.7	10	-999	-999	-999	-999	-999
23	-999	22	2800	-999	690	45	710	-999	-999	-999	1.1	8	-999	-999	-999	-999	-999
22	-999	35	5200	-999	1210	35	1220	-999	-999	-999	1	12	-999	-999	-999	-999	-999
38.11	79.53	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
35.59	116.2	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
37.48	116.5	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
17.32	275.5	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
34.33	55.75	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
33.7	56.46	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
7	-999	19	2200	-999	310	125	565	-999	-999	-999	0.9	2.5	-999	-999	-999	-999	-999
15	-999	44	2900	-999	640	115	785	-999	-999	-999	2.3	4	-999	-999	-999	-999	-999
38	-999	60	3900	-999	815	78	930	-999	-999	-999	3.3	5.8	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	199.6	-999	-999	0.575	-999	-999	-999	-999	-999	1.27
-999	-999	-999	-999	-999	-999	-999	-999	331.0	-999	-999	-999	-999	-999	-999	-999	-999	4.42
-999	-999	-999	-999	-999	-999	-999	-999	435.8	-999	-999	0.617	-999	-999	-999	-999	-999	1.54
-999	-999	-999	-999	-999	-999	-999	-999	211.2	-999	-999	0.65	-999	-999	-999	-999	-999	2.4
-999	-999	-999	-999	-999	-999	-999	-999	239.5	-999	-999	0.707	-999	-999	-999	-999	-999	1.92
-999	-999	-999	-999	-999	-999	-999	-999	632.1	-999	-999	0.646	-999	-999	-999	-999	-999	1.96
-999	-999	-999	-999	-999	-999	-999	-999	306.1	-999	-999	0.919	-999	-999	-999	-999	-999	1.26
-999	-999	-999	-999	-999	-999	-999	-999	357.6	-999	-999	2.192	-999	-999	-999	-999	-999	2.52
-999	-999	-999	-999	-999	-999	-999	-999	301.1	-999	-999	0.834	-999	-999	-999	-999	-999	1.34
-999	-999	-999	-999	-999	-999	-999	-999	379.3	-999	-999	0.858	-999	-999	-999	-999	-999	1.2
-999	-999	-999	-999	-999	-999	-999	-999	361.0	-999	-999	1.461	-999	-999	-999	-999	-999	4.05
-999	-999	-999	-999	-999	-999	-999	-999	346.0	-999	-999	1.815	-999	-999	-999	-999	-999	1.44
-999	-999	-999	-999	-999	-999	-999	-999	341.0	-999	-999	0.754	-999	-999	-999	-999	-999	1.9
-999	-999	-999	-999	-999	-999	-999	-999	269.5	-999	-999	0.405	-999	-999	-999	-999	-999	2.43
-999	-999	-999	-999	-999	-999	-999	-999	567.3	-999	-999	0.815	-999	-999	-999	-999	-999	2.38
-999	-999	-999	-999	-999	-999	-999	-999	329.5	-999	-999	1.013	-999	-999	-999	-999	-999	0.78
-999	-999	-999	-999	-999	-999	-999	-999	374.3	-999	-999	1.899	-999	-999	-999	-999	-999	6.83
23.18	-999	-999	-999	-999	-999	-999	-999	238.3	3.87	-999	-999	2.13	-999	-999	-999	-999	2.2
10.39	-999	-999	-999	-999	-999	-999	-999	252.5	2.39	-999	-999	2.33	-999	-999	-999	-999	2.4
9.28	-999	-999	-999	-999	-999	-999	-999	93.5	1.58	-999	-999	1.46	-999	-999	-999	-999	2.6
51.29	-999	-999	-999	-999	-999	-999	-999	97.4	15.02	-999	-999	6.99	-999	-999	-999	-999	10.4
17.15	-999	-999	-999	-999	-999	-999	-999	157.3	2.43	-999	-999	1.67	-999	-999	-999	-999	4
26	-999	-999	-999	-999	-999	-999	-999	-999	3.1	-999	-999	2.06	-999	-999	-999	-999	2.3
18.94	-999	-999	-999	-999	-999	-999	-999	50.8	3.92	-999	-999	2.6	-999	-999	-999	-999	4.5
10.28	-999	-999	-999	-999	-999	-999	-999	145.5	2.19	-999	-999	0.71	-999	-999	-999	-999	3.1
11.03	-999	-999	-999	-999	-999	-999	-999	69.3	1.54	-999	-999	1.35	-999	-999	-999	-999	1.9
10.4	-999	-999	-999	-999	-999	-999	-999	241.6	2.5	-999	-999	0.87	-999	-999	-999	-999	2.9
17.19	-999	-999	-999	-999	-999	-999	-999	50.4	3.73	-999	-999	1.35	-999	-999	-999	-999	4.6
30.91	-999	-999	-999	-999	-999	-999	-999	43.92	6.09	-999	0.435	3.48	-999	-999	-999	-999	9.29
13.44	-999	-999	-999	-999	-999	-999	-999	206.4	2.9	-999	0.457	2.47	-999	-999	-999	-999	1.83
8.62	-999	-999	-999	-999	-999	-999	-999	55.77	2.16	-999	0.435	1.67	-999	-999	-999	-999	2.37
15.77	-999	-999	-999	-999	-999	-999	-999	137.2	2.55	-999	0.516	2.81	-999	-999	-999	-999	1.7
15.99	-999	-999	-999	-999	-999	-999	-999	196.0	4.41	-999	0.56	2.95	-999	-999	-999	-999	2.44
14.65	-999	-999	-999	-999	-999	-999	-999	56.61	2.03	-999	0.398	2.03	-999	-999	-999	-999	2.44
38.33	-999	-999	-999	-999	-999	-999	-999	40.91	5.94	-999	0.354	4.73	-999	-999	-999	-999	12.07
10.35	-999	-999	-999	-999	-999	-999	-999	69.3	1.07	-999	0.531	2.18	-999	-999	-999	-999	1.54
-999	-999	-999	-999	-999	-999	-999	-999	36.57	-999	-999	0.383	-999	-999	-999	-999	-999	71.59
13.92	-999	-999	-999	-999	-999	-999	-999	149.2	2.3	-999	0.708	2.59	-999	-999	-999	-999	1.56
16.26	-999	-999	-999	-999	-999	-999	-999	180.6	2.61	-999	0.877	2.53	-999	-999	-999	-999	2.19
27.06	-999	-999	-999	-999	-999	-999	-999	145.7	5.96	-999	2.897	3.97	-999	-999	-999	-999	3.71
17.64	-999	-999	-999	-999	-999	-999	-999	119.5	4.52	-999	0.504	1.7	-999	-999	-999	-999	3.15
18.28	-999	-999	-999	-999	-999	-999	-999	67.96	3.37	-999	0.361	1.28	-999	-999	-999	-999	2.61
14.32	-999	-999	-999	-999	-999	-999	-999	25.72	3.03	-999	0.398	1.32	-999	-999	-999	-999	3.39

CuP	CuT	FeD	FeP	FeT	MnD	MnP	MnT	NiD	NiP	NiT	PbD	PbP	PbT	ZnD	ZnP	ZnT	TSM
21.1	-999	-999	-999	-999	-999	-999	-999	34.35	4.16	-999	0.656	3.77	-999	-999	-999	-999	2.1
10.03	-999	-999	-999	-999	-999	-999	-999	51.5	2.11	-999	0.391	1.22	-999	-999	-999	-999	2.36
12.29	-999	-999	-999	-999	-999	-999	-999	35.57	1.36	-999	0.273	1.69	-999	-999	-999	-999	2.43
15.36	-999	-999	-999	-999	-999	-999	-999	17.03	2.37	-999	0.376	1.41	-999	-999	-999	-999	5.03
14.36	-999	-999	-999	-999	-999	-999	-999	93.26	3.63	-999	0.516	1.93	-999	-999	-999	-999	3.44
17.7	-999	-999	-999	-999	-999	-999	-999	74.6	3.32	-999	0.029	2.08	-999	-999	-999	-999	2.63
26.22	-999	-999	-999	-999	-999	-999	-999	41.91	5.16	-999	0.649	2.91	-999	-999	-999	-999	2.78
23.22	-999	-999	-999	-999	-999	-999	-999	167.9	8.1	-999	0.435	2.37	-999	-999	-999	-999	12.9
40.67	-999	-999	-999	-999	-999	-999	-999	42.58	10.68	-999	0.501	2.35	-999	-999	-999	-999	14.5
19.03	-999	-999	-999	-999	-999	-999	-999	124.5	7.95	-999	0.512	2.78	-999	-999	-999	-999	5.4
27.7	-999	-999	-999	-999	-999	-999	-999	70.97	5.26	-999	0.42	3.72	-999	-999	-999	-999	3.5
39.27	-999	-999	-999	-999	-999	-999	-999	252.2	12.33	-999	1.998	5.65	-999	-999	-999	-999	5.5
16.19	-999	-999	-999	-999	-999	-999	-999	60.95	4.32	-999	0.487	1.22	-999	-999	-999	-999	5.4
33.37	-999	-999	-999	-999	-999	-999	-999	384.2	16.87	-999	1.165	4.5	-999	-999	-999	-999	7.7
41.36	-999	-999	-999	-999	-999	-999	-999	50.6	7.6	-999	0.494	4.35	-999	-999	-999	-999	8.5
14.43	-999	-999	-999	-999	-999	-999	-999	226.5	9.04	-999	0.759	1.97	-999	-999	-999	-999	6.2
-999	-999	118.2	-999	-999	255.0	-999	-999	34.07	-999	-999	-999	-999	-999	-999	-999	-999	47
-999	-999	125.3	-999	-999	555.7	-999	-999	146.5	-999	-999	-999	-999	-999	-999	-999	-999	43
-999	-999	179.2	-999	-999	710.3	-999	-999	175.4	-999	-999	-999	-999	-999	-999	-999	-999	40
-999	-999	136.2	-999	-999	300.5	-999	-999	51.11	-999	-999	-999	-999	-999	-999	-999	-999	58
4.25	-999	46.59	734.7	-999	238.6	63.75	-999	134.5	1.53	-999	1.11	1.98	-999	-999	-999	-999	3.5
3.15	-999	53.76	573.4	-999	193.0	51.97	-999	134.5	1.02	-999	3.43	1.5	-999	-999	-999	-999	4
12.75	-999	129.0	1326.	-999	448.4	41.39	-999	160.1	1.53	-999	0.52	2.94	-999	-999	-999	-999	4.2
5.51	-999	148.7	758.5	-999	581.0	27.32	-999	269.1	1.36	-999	0.92	2.17	-999	-999	-999	-999	4
39	-999	45	3500	-999	800	20	905	-999	-999	-999	1	11	-999	-999	-999	-999	-999
20	-999	54	3300	-999	890	36	900	-999	-999	-999	2.1	10	-999	-999	-999	-999	-999
17	-999	24	2500	-999	680	32	720	-999	-999	-999	1	7	-999	-999	-999	-999	-999
7.56	23.62	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
29.92	49.29	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
7.4	21.89	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
23.15	41.57	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
13.07	25.83	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
7	-999	30	2600	-999	460	125	615	-999	-999	-999	1.4	2.6	-999	-999	-999	-999	-999
6	-999	21	2400	-999	510	75	620	-999	-999	-999	1	2.5	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	219.6	-999	-999	0.599	-999	-999	-999	-999	-999	1.72
-999	-999	-999	-999	-999	-999	-999	-999	81.52	-999	-999	0.999	-999	-999	-999	-999	-999	2.43
-999	-999	-999	-999	-999	-999	-999	-999	44.75	-999	-999	0.231	-999	-999	-999	-999	-999	1.55
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-999	-999	-999	-999	-999	-999	-999	-999	95.66	-999	-999	0.384	-999	-999	-999	-999	-999	2.7
-999	-999	-999	-999	-999	-999	-999	-999	216.2	-999	-999	0.594	-999	-999	-999	-999	-999	2.42
-999	-999	-999	-999	-999	-999	-999	-999	112.6	-999	-999	0.533	-999	-999	-999	-999	-999	2.7
2.27	-999	-999	-999	-999	-999	-999	-999	57.8	0.93	-999	-999	0.59	-999	-999	-999	-999	1.7
1.91	-999	-999	-999	-999	-999	-999	-999	57.8	0.65	-999	-999	0.74	-999	-999	-999	-999	1.7
4.38	-999	-999	-999	-999	-999	-999	-999	33.9	1.67	-999	-999	0.51	-999	-999	-999	-999	2.2
3.51	-999	-999	-999	-999	-999	-999	-999	72.6	1.23	-999	-999	0.76	-999	-999	-999	-999	1.8
2.21	-999	-999	-999	-999	-999	-999	-999	84.3	0.82	-999	-999	0.57	-999	-999	-999	-999	1.7
3.92	-999	-999	-999	-999	-999	-999	-999	84.4	1.33	-999	-999	0.54	-999	-999	-999	-999	8.1
4.04	-999	-999	-999	-999	-999	-999	-999	20.15	0.9	-999	0.288	1.05	-999	-999	-999	-999	1.61
5.26	-999	-999	-999	-999	-999	-999	-999	64.96	1.19	-999	0.295	1.17	-999	-999	-999	-999	2.19
3.05	-999	-999	-999	-999	-999	-999	-999	39.13	0.57	-999	0.413	0.95	-999	-999	-999	-999	0.57
3.12	-999	-999	-999	-999	-999	-999	-999	95.6	0.6	-999	0.527	1.03	-999	-999	-999	-999	1.1
-999	-999	-999	-999	-999	-999	-999	-999	71.64	-999	-999	0.317	-999	-999	-999	-999	-999	1.48
8.72	-999	-999	-999	-999	-999	-999	-999	64.29	1.92	-999	0.214	0.87	-999	-999	-999	-999	2.75
-999	-999	-999	-999	-999	-999	-999	-999	41.25	-999	-999	0.14	-999	-999	-999	-999	-999	1.77
3.28	-999	-999	-999	-999	-999	-999	-999	17.2	0.54	-999	0.214	0.56	-999	-999	-999	-999	2.01
6.49	-999	-999	-999	-999	-999	-999	-999	44.25	0.61	-999	0.258	0.94	-999	-999	-999	-999	1.59
5.52	-999	-999	-999	-999	-999	-999	-999	29.56	1.18	-999	0.258	0.59	-999	-999	-999	-999	2.46
4.51	-999	-999	-999	-999	-999	-999	-999	58.28	1.54	-999	0.487	1.05	-999	-999	-999	-999	2.6
4.32	-999	-999	-999	-999	-999	-999	-999	30.73	1.09	-999	0.45	0.96	-999	-999	-999	-999	2.5
17.59	-999	-999	-999	-999	-999	-999	-999	28.56	4.19	-999	0.369	2.86	-999	-999	-999	-999	8.9
7.09	-999	-999	-999	-999	-999	-999	-999	30.56	2.15	-999	0.435	1.55	-999	-999	-999	-999	5
-999	-999	-999	-999	-999	-999	-999	-999	30.56	-999	-999	0.376	-999	-999	-999	-999	-999	3.2
-999	-999	448.0	-999	-999	510.0	-999	-999	195.9	-999	-999	-999	-999	-999	-999	-999	-999	34
-999	-999	73.48	-999	-999	546.4	-999	-999	78.36	-999	-999	-999	-999	-999	-999	-999	-999	28
5.2	-999	0.3	931.9	-999	234.9	56.47	-999	107.3	1.02	-999	3.81	2.08	-999	-999	-999	-999	4
17	-999	13	2000	-999	400	16	460	-999	-999	-999	0.5	5	-999	-999	-999	-999	-999
10	-999	16	1800	-999	490	45	550	-999	-999	-999	1.2	4.4	-999	-999	-999	-999	-999

CuP	CuT	FeD	FeP	FeT	MnD	MnP	MnT	NiD	NiP	NiT	PbD	PbP	PbT	ZnD	ZnP	ZnT	TSM
-999	-999	-999	-999	-999	-999	-999	-999	106.4	-999	-999	0.5	-999	-999	-999	-999	-999	2.31
3.53	-999	-999	-999	-999	-999	-999	-999	62.5	1.96	-999	-999	1.16	-999	-999	-999	-999	3.5
3.55	-999	-999	-999	-999	-999	-999	-999	53.5	1.85	-999	-999	1.16	-999	-999	-999	-999	3.7
4.01	-999	-999	-999	-999	-999	-999	-999	71.47	0.85	-999	0.361	1.17	-999	-999	-999	-999	2.49
3.74	-999	-999	-999	-999	-999	-999	-999	70.14	0.37	-999	0.538	1.21	-999	-999	-999	-999	2.33
7.2	-999	-999	-999	-999	-999	-999	-999	50.93	1.18	-999	1.261	1.52	-999	-999	-999	-999	2.04
5.07	-999	-999	-999	-999	-999	-999	-999	45.59	1.11	-999	0.354	1.13	-999	-999	-999	-999	2.32
4.54	-999	-999	-999	-999	-999	-999	-999	39.58	1.7	-999	0.354	1.62	-999	-999	-999	-999	4.6
3.3	-999	-999	-999	-999	-999	-999	-999	37.74	1.5	-999	0.302	1.81	-999	-999	-999	-999	3.7
4.11	15.97	41.72	57.3	619.5	-999	-999	-999	-999	-999	-999	-999	-999	-999	54.39	1.45	56.35	-999
3.57	29.34	38.55	524.1	563.0	-999	-999	-999	-999	-999	-999	-999	-999	-999	48.73	12.69	61.44	-999
4.3	50.37	95.9	825.3	924.2	-999	-999	-999	-999	-999	-999	-999	-999	-999	59.01	17.65	76.65	-999
3.26	30.14	25.13	751.9	777.1	-999	-999	-999	-999	-999	-999	-999	-999	-999	42.02	15.55	57.57	-999
1.67	22.68	42.19	1056.	1099	-999	-999	-999	-999	-999	-999	-999	-999	-999	18.44	17.91	36.35	-999
1.53	25.51	51.27	575.2	628.3	-999	-999	-999	-999	-999	-999	-999	-999	-999	16.62	11.87	28.49	-999
1.59	20.25	90.05	580.8	670.5	-999	-999	-999	-999	-999	-999	-999	-999	-999	19.94	25.02	44.95	-999
1.18	22	64.44	567.0	631.4	-999	-999	-999	-999	-999	-999	-999	-999	-999	32.95	19.17	52.13	-999
1.01	23.59	13.6	1452.	1465.	-999	-999	-999	-999	-999	-999	-999	-999	-999	20.84	19.51	40.35	-999
3.13	21.31	18.39	2562.	2581.	-999	-999	-999	-999	-999	-999	-999	-999	-999	17.22	25	42.22	-999
-999	-999	148.7	-999	-999	400.7	-999	-999	47.7	-999	-999	-999	-999	-999	-999	-999	-999	31
-999	-999	148.7	-999	-999	510.0	-999	-999	115.8	-999	-999	-999	-999	-999	-999	-999	-999	35
9.29	-999	0.3	4587.	-999	138.4	33.79	-999	40.89	3.07	-999	0.34	4.3	-999	-999	-999	-999	8.7
4.72	-999	0.3	1577.	-999	80.15	85.61	-999	52.81	0.02	-999	0.34	2.22	-999	-999	-999	-999	3.2
3.79	-999	0.3	2007.	-999	60.11	51	-999	32.37	1.02	-999	6.85	2.7	-999	-999	-999	-999	5.2
5	-999	29	1100	-999	280	13	300	-999	-999	-999	0.8	1	-999	-999	-999	-999	-999
6	-999	20	1100	-999	260	13	325	-999	-999	-999	0.5	2	-999	-999	-999	-999	-999
10	-999	23	1500	-999	380	13	405	-999	-999	-999	0.6	3	-999	-999	-999	-999	-999
6	-999	19	1500	-999	500	50	575	-999	-999	-999	1.3	3.8	-999	-999	-999	-999	-999
3.3	-999	24	1400	-999	360	83	470	-999	-999	-999	1	2.9	-999	-999	-999	-999	-999
6.4	-999	25	1500	-999	480	49	550	-999	-999	-999	1	4.2	-999	-999	-999	-999	-999
7.24	20.16	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
5	-959	8	4600	-999	150	120	315	-999	-999	-999	1.1	2.7	-999	-999	-999	-999	-999
5	-999	12	3300	-999	295	80	395	-999	-999	-999	0.8	2.1	-999	-999	-999	-999	-999
3	-999	11	2100	-999	315	75	420	-999	-999	-999	0.8	1.6	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	43.26	-999	-999	0.146	-999	-999	-999	-999	-999	7.26
1.49	-999	-999	-999	-999	-999	-999	-999	38.7	0.62	-999	0.144	0.54	-999	-999	-999	-999	1.4
1.64	-999	-999	-999	-999	-999	-999	-999	32.1	1.14	-999	0.133	0.61	-999	-999	-999	-999	2.7
3.34	-999	-999	-999	-999	-999	-999	-999	42.4	2.12	-999	-999	1.23	-999	-999	-999	-999	3.2
2.94	-999	-999	-999	-999	-999	-999	-999	32.6	2.5	-999	0.221	0.97	-999	-999	-999	-999	3.9
1.3	-999	-999	-999	-999	-999	-999	-999	62.3	1.12	-999	-999	0.39	-999	-999	-999	-999	2.5
2.5	-999	-999	-999	-999	-999	-999	-999	32.1	2.17	-999	0.214	0.89	-999	-999	-999	-999	3.5
1.88	-999	-999	-999	-999	-999	-999	-999	32.1	1.19	-999	0.14	0.7	-999	-999	-999	-999	2.9
1.32	-999	-999	-999	-999	-999	-999	-999	45.6	0.77	-999	0.155	0.69	-999	-999	-999	-999	1.5
2.12	-999	-999	-999	-999	-999	-999	-999	32.1	1.37	-999	0.133	0.82	-999	-999	-999	-999	2.6
2.04	-999	-999	-999	-999	-999	-999	-999	59.5	1.07	-999	-999	0.75	-999	-999	-999	-999	2.7
-999	-999	-999	-999	-999	-999	-999	-999	40.41	-999	-999	0.317	-999	-999	-999	-999	-999	2
2.39	-999	-999	-999	-999	-999	-999	-999	21.04	0.76	-999	0.472	0.69	-999	-999	-999	-999	2.5
-999	-999	-999	-999	-999	-999	-999	-999	25.61	-999	-999	0.358	-999	-999	-999	-999	-999	2.65
1.71	-999	-999	-999	-999	-999	-999	-999	29.06	0.62	-999	0.229	0.58	-999	-999	-999	-999	2.32
1.59	-999	-999	-999	-999	-999	-999	-999	13.97	0.62	-999	0.339	0.49	-999	-999	-999	-999	2.4
-999	-999	-999	-999	-999	-999	-999	-999	19.65	-999	-999	0.383	-999	-999	-999	-999	-999	2.37
-999	-999	-999	-999	-999	-999	-999	-999	12.41	-999	-999	0.302	-999	-999	-999	-999	-999	2.88
1.12	-999	-999	-999	-999	-999	-999	-999	46.42	0.26	-999	0.347	0.77	-999	-999	-999	-999	1.52
3.25	-999	-999	-999	-999	-999	-999	-999	11.52	1.54	-999	0.413	1.1	-999	-999	-999	-999	3.8
3.17	-999	-999	-999	-999	-999	-999	-999	73.64	0.75	-999	0.442	1.11	-999	-999	-999	-999	2.47
2.09	-999	-999	-999	-999	-999	-999	-999	37.57	0.76	-999	0.214	0.49	-999	-999	-999	-999	1.22
0.53	-999	-999	-999	-999	-999	-999	-999	11.52	0.36	-999	0.376	0.3	-999	-999	-999	-999	0.78
-999	-999	-999	-999	-999	-999	-999	-999	25.55	-999	-999	0.258	-999	-999	-999	-999	-999	1.89
-999	-999	-999	-999	-999	-999	-999	-999	20.04	-999	-999	1.504	-999	-999	-999	-999	-999	2.95
-999	-999	-999	-999	-999	-999	-999	-999	34.23	-999	-999	0.177	-999	-999	-999	-999	-999	1.43
3.42	-999	-999	-999	-999	-999	-999	-999	25.88	1.05	-999	0.147	0.53	-999	-999	-999	-999	2.12
1.51	-999	-999	-999	-999	-999	-999	-999	27.31	0.65	-999	0.133	0.39	-999	-999	-999	-999	1.39
-999	-999	-999	-999	-999	-999	-999	-999	19.37	-999	-999	0.177	-999	-999	-999	-999	-999	5.06
3.12	-999	-999	-999	-999	-999	-999	-999	15.53	1.36	-999	0.214	0.83	-999	-999	-999	-999	4.8
1.21	-999	-999	-999	-999	-999	-999	-999	16.36	0.56	-999	0.206	0.56	-999	-999	-999	-999	1.7
-999	-999	-999	-999	-999	-999	-999	-999	19.37	-999	-999	0.28	-999	-999	-999	-999	-999	3.9
5.35	-999	-999	-999	-999	-999	-999	-999	26.05	1.42	-999	0.391	1.13	-999	-999	-999	-999	3.3
-999	-999	-999	-999	-999	-999	-999	-999	19.37	-999	-999	-999	-999	-999	-999	-999	-999	3.8

CuP	CuT	FeO	FeP	FeT	MnO	MnP	MnT	NiO	NiP	NiT	PbO	PbP	PbT	ZnO	ZnP	ZnT	TSM
2.7	-999	-999	-999	-999	-999	-999	-999	29.56	0.54	-999	0.295	1.05	-999	-999	-999	-999	2.3
-999	-999	-999	-999	-999	-999	-999	-999	19.87	-999	-999	0.17	-999	-999	-999	-999	-999	5.1
3.82	75.59	41.22	734.7	770.5	-999	-999	-999	209.5	11.24	221.4	7.92	0.87	5.69	-999	-999	-999	-999
4.72	33.07	136.2	340.5	483.8	-999	-999	-999	217.0	14.39	238.5	11.58	3.38	14.96	-999	-999	-999	-999
3.03	34.65	97.57	250.9	340.5	-999	-999	-999	151.2	7.54	158.4	42.86	2.22	44.38	-999	-999	-999	-999
3.78	25.2	200.7	394.2	591.4	-999	-999	-999	586.0	23.85	613.2	28.62	1.69	29.44	-999	-999	-999	-999
3.75	58.27	35.34	501.7	537.6	-999	-999	-999	246.6	3.41	255.5	14.77	1.16	15.93	-999	-999	-999	-999
6.93	47.24	136.2	501.7	645.1	-999	-999	-999	178.0	14.14	187.3	9.75	1.21	11.1	-999	-999	-999	-999
4.09	26.77	283.1	146.9	430.1	-999	-999	-999	303.2	35.78	340.7	19.16	1.35	20.75	-999	-999	-999	-999
2.94	39.37	60.22	25.09	86.02	-999	-999	-999	391.4	3.24	391.8	18.82	5.79	24.61	-999	-999	-999	-999
0.94	77.17	53.05	26.38	80.65	-999	-999	-999	590.4	6.98	596.2	7.36	1.79	9.55	-999	-999	-999	-999
5.03	50.39	101.0	215.0	322.5	-999	-999	-999	172.9	8.36	187.3	48.99	2.51	53.09	-999	-999	-999	-999
5.2	59.34	148.7	268.8	412.1	-999	-999	-999	356.0	6.81	357.7	15.88	1.64	17.37	-999	-999	-999	-999
3.46	45.67	114.7	148.7	250.9	-999	-999	-999	146.6	10.9	158.4	14.77	6.27	21.24	-999	-999	-999	-999
3.31	40.94	148.5	125.4	268.8	-999	-999	-999	181.4	10.05	187.3	21.67	4.73	26.54	-999	-999	-999	-999
4.09	26.77	136.2	304.6	448.0	-999	-999	-999	356.0	17.04	374.7	27.27	3.23	30.41	-999	-999	-999	-999
0.93	27.4	78.46	135.6	214.1	-999	-999	-999	-999	-999	-999	-999	-999	-999	36.48	13.61	50.09	-999
0.52	292.2	48.96	275.9	324.9	-999	-999	-999	-999	-999	-999	-999	-999	-999	25.78	14.4	40.18	-999
-999	-999	57.51	-999	-999	307.8	-999	-999	30.66	-999	-999	-999	-999	-999	-999	-999	-999	50
-999	-999	57.51	-999	-999	417.7	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	29
3.46	-999	0.3	1845.	-999	58.29	49.18	-999	17.04	1.53	-999	0.68	2.27	-999	-999	-999	-999	4.9
2.33	-999	0.3	1129.	-999	-999	41.89	-999	18.74	1.53	-999	2.75	2.46	-999	-999	-999	-999	3.9
2.5	-999	17	1100	-999	200	13	235	-999	-999	-999	0.7	2	-999	-999	-999	-999	-999
2.2	-999	23	500	-999	400	74	440	-999	-999	-999	1.4	1.7	-999	-999	-999	-999	-999
2.2	9.76	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
5.38	15.59	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
3	-999	14	3500	-999	65	130	245	-999	-999	-999	0.8	2.2	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	23.12	-999	-999	1.635	-999	-999	-999	-999	-999	1.64
-999	-999	-999	-999	-999	-999	-999	-999	30.45	-999	-999	3.087	-999	-999	-999	-999	-999	1.95
1.36	-999	-999	-999	-999	-999	-999	-999	21.9	0.56	-999	0.265	0.55	-999	-999	-999	-999	1.3
1.46	-999	-999	-999	-999	-999	-999	-999	20	0.68	-999	0.192	0.53	-999	-999	-999	-999	1.6
2.55	-999	-999	-999	-999	-999	-999	-999	16.9	1.62	-999	0.221	0.52	-999	-999	-999	-999	0.8
1.47	-999	-999	-999	-999	-999	-999	-999	15.9	0.87	-999	0.118	0.56	-999	-999	-999	-999	1.9
1.67	-999	-999	-999	-999	-999	-999	-999	8.79	1	-999	0.265	0.72	-999	-999	-999	-999	2.17
-999	-999	-999	-999	-999	-999	-999	-999	8.07	-999	-999	0.251	-999	-999	-999	-999	-999	2.64
1.94	-999	-999	-999	-999	-999	-999	-999	5.29	1.39	-999	0.177	0.82	-999	-999	-999	-999	3.37
-999	-999	-999	-999	-999	-999	-999	-999	5.96	-999	-999	0.206	-999	-999	-999	-999	-999	2.37
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-999	-999	-999	-999	-999	-999	-999	-999	20.87	-999	-999	0.111	-999	-999	-999	-999	-999	1.53
-999	-999	-999	-999	-999	-999	-999	-999	12.69	-999	-999	0.111	-999	-999	-999	-999	-999	1.5
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-999	-999	148.7	-999	-999	103.8	-999	-999	49.4	-999	-999	-999	-999	-999	-999	-999	-999	58
-999	-999	87.61	-999	-999	528.2	-999	-999	103.9	-999	-999	-999	-999	-999	-999	-999	-999	40
1.73	-999	43.01	483.8	-999	176.6	43.72	-999	54.51	1.02	-999	0.87	1.5	-999	-999	-999	-999	2.4
15	-999	-999	2400	-999	760	41	790	-999	-999	-999	3.5	7	-999	-999	-999	-999	-999
18	-999	35	2500	-999	780	36	820	-999	-999	-999	1.5	7.6	-999	-999	-999	-999	-999
3	-999	20	1900	-999	395	50	470	-999	-999	-999	0.7	1.7	-999	-999	-999	-999	-999
6	-999	35	2300	-999	450	85	570	-999	-999	-999	1.2	2.4	-999	-999	-999	-999	-999
4.48	-999	-999	-999	-999	-999	-999	-999	28.4	2.09	-999	-999	1.04	-999	-999	-999	-999	3.3
1.59	-999	-999	-999	-999	-999	-999	-999	60.8	0.42	-999	-999	0.46	-999	-999	-999	-999	1.3
3.54	-999	-999	-999	-999	-999	-999	-999	28.1	1.45	-999	-999	1.07	-999	-999	-999	-999	2.7
1.75	-999	-999	-999	-999	-999	-999	-999	46.3	0.3	-999	-999	0.6	-999	-999	-999	-999	1.4
1.34	-999	-999	-999	-999	-999	-999	-999	48.1	0.83	-999	-999	0.43	-999	-999	-999	-999	1.8
1.14	-999	-999	-999	-999	-999	-999	-999	83.8	0.32	-999	-999	0.49	-999	-999	-999	-999	0.9
4.28	-999	-999	-999	-999	-999	-999	-999	10.97	1.12	-999	0.31	1.14	-999	-999	-999	-999	3.17
2	-999	-999	-999	-999	-999	-999	-999	41.86	0.27	-999	0.479	0.91	-999	-999	-999	-999	1.43
-999	-999	-999	-999	-999	-999	-999	-999	12.58	-999	-999	0.391	-999	-999	-999	-999	-999	1.71
1.83	-999	-999	-999	-999	-999	-999	-999	17.92	0.27	-999	0.31	0.92	-999	-999	-999	-999	1.07
-999	-999	-999	-999	-999	-999	-999	-999	9.46	-999	-999	0.273	-999	-999	-999	-999	-999	1.24
-999	-999	-999	-999	-999	-999	-999	-999	18.42	-999	-999	0.634	-999	-999	-999	-999	-999	1.79
3.21	-999	-999	-999	-999	-999	-999	-999	10.24	0.9	-999	0.42	1.11	-999	-999	-999	-999	1.49
-999	-999	-999	-999	-999	-999	-999	-999	18.2	-999	-999	0.442	-999	-999	-999	-999	-999	1.57
1.65	-999	-999	-999	-999	-999	-999	-999	17.87	0.56	-999	0.324	0.47	-999	-999	-999	-999	1.44
-999	-999	-999	-999	-999	-999	-999	-999	16.87	-999	-999	0.199	-999	-999	-999	-999	-999	1.11
1.59	-999	-999	-999	-999	-999	-999	-999	13.86	0.49	-999	0.155	0.51	-999	-999	-999	-999	1.46
2.25	-999	-999	-999	-999	-999	-999	-999	23.55	0.68	-999	0.207	0.51	-999	-999	-999	-999	1.69

CuP	CuT	FeD	FeP	FeT	MnD	MnP	MnT	NiD	NiP	NiT	PbD	PbP	PbT	ZnD	ZnP	ZnT	TSM
2.23	-999	-999	-999	-999	-999	-999	-999	33.9	0.58	-999	0.262	0.57	-999	-999	-999	-999	1.35
-999	-999	-999	-999	-999	-999	-999	-999	19.87	-999	-999	0.413	-999	-999	-999	-999	-999	4
-999	-999	-999	-999	-999	-999	-999	-999	19.54	-999	-999	0.31	-999	-999	-999	-999	-999	2.3
3.74	-999	-999	-999	-999	-999	-999	-999	16.7	2.86	-999	0.531	2.03	-999	-999	-999	-999	7.3
1.52	-999	-999	-999	-999	-999	-999	-999	24.05	0.5	-999	0.302	0.49	-999	-999	-999	-999	2
2.47	-999	-999	-999	-999	-999	-999	-999	17.87	0.83	-999	0.288	0.72	-999	-999	-999	-999	2.5
1.54	-999	-999	-999	-999	-999	-999	-999	30.55	0.46	-999	0.306	0.66	-999	-999	-999	-999	1.7
-999	-999	51.37	-999	-999	43.72	-999	-999	17.04	-999	-999	-999	-999	-999	-999	-999	-999	54
-999	-999	107.5	-999	-999	400.7	-999	-999	195.9	-999	-999	-999	-999	-999	-999	-999	-999	24
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
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23-Dec-87                              Listing of BAYMETAL Data File
                                                                                                                 Page 13
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0.44	4.57	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
0.72	-999	-999	-999	-999	-999	-999	-999	9.2	0.54	-999	-999	0.36	-999	-999	-999	-999	-999
0.31	-999	-999	-999	-999	-999	-999	-999	6.2	0.29	-999	-999	0.18	-999	-999	-999	-999	0.9
1.32	-999	-999	-999	-999	-999	-999	-999	8.4	0.37	-999	-999	0.18	-999	-999	-999	-999	0.8
1	-999	-999	-999	-999	-999	-999	-999	4.5	0.83	-999	-999	0.78	-999	-999	-999	-999	1
0.55	-999	-999	-999	-999	-999	-999	-999	8.5	0.24	-999	-999	0.2	-999	-999	-999	-999	2
0.7	-999	-999	-999	-999	-999	-999	-999	7.7	0.1	-999	-999	0.4	-999	-999	-999	-999	1.6
1.23	-999	-999	-999	-999	-999	-999	-999	10	0.53	-999	-999	0.35	-999	-999	-999	-999	1.1
0.65	-999	-999	-999	-999	-999	-999	-999	8	0.1	-999	-999	0.35	-999	-999	-999	-999	1
0.71	-999	-999	-999	-999	-999	-999	-999	2.34	0.91	-999	0.074	0.44	-999	-999	-999	-999	1.2
1.03	-999	-999	-999	-999	-999	-999	-999	16.03	0.81	-999	0.114	0.44	-999	-999	-999	-999	2.39
-999	-999	-999	-999	-999	-999	-999	-999	10.69	-999	-999	0.173	-999	-999	-999	-999	-999	2.46
1.19	-999	-999	-999	-999	-999	-999	-999	8.68	1.11	-999	0.135	0.46	-999	-999	-999	-999	2.02
-999	-999	-999	-999	-999	-999	-999	-999	5.68	-999	-999	0.059	-999	-999	-999	-999	-999	2.75
-999	-999	-999	-999	-999	-999	-999	-999	12.75	-999	-999	0.157	-999	-999	-999	-999	-999	2.45
-999	-999	-999	-999	-999	-999	-999	-999	7.01	-999	-999	0.103	-999	-999	-999	-999	-999	1.82
1.37	-999	-999	-999	-999	-999	-999	-999	5.51	1.37	-999	0.111	0.57	-999	-999	-999	-999	2.12
-999	-999	-999	-999	-999	-999	-999	-999	5.34	-999	-999	0.088	-999	-999	-999	-999	-999	3.48
-999	-999	-999	-999	-999	-999	-999	-999	6.18	-999	-999	0.088	-999	-999	-999	-999	-999	1.03
-999	-999	-999	-999	-999	-999	-999	-999	6.01	-999	-999	0.096	-999	-999	-999	-999	-999	1.14
-999	-999	-999	-999	-999	-999	-999	-999	5.34	-999	-999	0.059	-999	-999	-999	-999	-999	1.25
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	3.71
-999	-999	-999	-999	-999	-999	-999	-999	8.52	-999	-999	0.081	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	5.18	-999	-999	0.273	-999	-999	-999	-999	-999	0.5
-999	-999	-999	-999	-999	-999	-999	-999	5.18	-999	-999	0.037	-999	-999	-999	-999	-999	0.3
-999	-999	-999	-999	-999	-999	-999	-999	4.51	-999	-999	0.118	-999	-999	-999	-999	-999	0.5
-999	-999	-999	-999	-999	-999	-999	-999	5.01	-999	-999	0.052	-999	-999	-999	-999	-999	1.1
-999	-999	-999	-999	-999	-999	-999	-999	5.34	-999	-999	0.668	-999	-999	-999	-999	-999	1.7

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 Salt   Turb   Temp  SigT  Long   Lat    BibID   DayNum            Sta Col
 -999   -999   -999  -999  21.3  43.3   PIOT72A   25934  15             P
 29.3   -999   -999  -999 22.37 47.15   CULL78A   28491  NB.78.21       C
   29   -999   -999  -999 22.38 44.19   CULL78A   28491  NB.78.30       C
 28.4   -999   -999  -999 23.59 48.51   CULL78A   28491  NB.78.35       C
   29   -999   -999  -999 22.38 45.35   CULL78A   28491  NB.78.19       C
 29.1   -999   -999  -999 23.46 48.28   CULL78A   28491  NB.78.32       C
 25.3   -999   -999  -999 22.38 45.35   CULL78A   28491  NB.78.19       C
   23   -999   -999  -999 23.46 48.28   CULL78A   28491  NB.78.32       C
 25.5   -999   -999  -999 22.49 46.46   CULL78A   28491  NB.78.31       C
 24.5   -999   -999  -999 22.37 47.15   CULL78A   28491  NB.78.21       C
 -999   -999   -999  -999  21.4 43.35   HUNT80A   29273  4              H
   23   -999   -999  -999 23.54 48.48   HUNT80A   29273  2              H
 29.7   -999   -999  -999  22.3 46.13   HUNT80A   29273  3              H
 24.5   -999   -999  -999  22.3 46.13   HUNT80A   29274  3              H
 26.3   -999   -999  -999  21.4 43.35   HUNT80A   29274  4              H
   29   -999   -999  -999 23.54 48.48   HUNT80A   29274  2              H
25.35   -999   -999  -999 23.55 48.15   QUIN87A   29434  1              Q
28.22   -999   -999  -999 22.15 45.45   QUIN87A   29434  3              Q
29.15   -999   -999  -999    22 44.15   QUIN87A   29434  4              Q
25.64   -999   -999  -999 22.45 46.45   QUIN87A   29434  2              Q
27.12   -999   -999  -999    22  43.3   QUIN87A   29434  6              Q
30.29   -999   -999  -999  22.1  43.3   QUIN87A   29434  5              Q
 29.2   -999   -999  -999  21.4 43.35   HUNT80A   29476  4              H
 28.5   -999   -999  -999  22.3 46.13   HUNT80A   29476  3              H
 27.1   -999   -999  -999 23.54 48.48   HUNT80A   29476  2              H
27.37   -999   -999  -999  21.3 43.26   CULL80A   29495               0 C
29.39   -999   -999  -999 22.22 45.38   CULL80A   29495               0 C
25.35   -999   -999  -999 22.45 45.31   CULL80A   29495               0 C
30.44   -999   -999  -999 23.24  47.8   CULL80A   29495               0 C
29.75   -999   -999  -999  21.7  44.4   CULL80A   29495               0 C
25.85   -999   -999  -999 23.24  47.8   CULL80A   29495               0 C
29.59   -999   -999  -999  22.2 45.27   CULL80A   29495               0 C
28.52   -999   -999  -999 23.25 48.18   CULL80A   29495               0 C
 -999   -999   -999  -999 22.45 45.31   CULL80A   29495               0 C
27.33   -999   -999  -999 22.28 44.32   CULL80A   29495               0 C
25.29   -999   -999  -999 23.25 48.18   CULL80A   29495               0 C
28.92   -999   -999  -999 21.47  44.4   CULL80A   29495               0 C
28.72   -999   -999  -999  22.1 43.33   CULL80A   29495               0 C
27.45   -999   -999  -999 23.42 48.51   CULL80A   29495               0 C
27.57   -999   -999  -999 22.55 46.25   CULL80A   29495               0 C
29.25   -999   -999  -999 22.28 44.32   CULL80A   29495               0 C
29.35   -999   -999  -999 22.27  47.8   CULL80A   29495               0 C
22.82   -999  16.64  -999 23.54 48.48   SIN185A   31343               0 S
25.87   -999  15.25  -999  22.3 46.13   SIN185A   31343               0 S
27.75   -999  15.78  -999  22.3 46.13   SIN185A   31343               0 S
29.29   -999   16.1  -999 23.54 48.48   SIN185A   31343               0 S
29.29   -999  16.16  -999  22.3 46.13   SIN185A   31343               0 S
27.57   -999   16.5  -999 23.54 48.48   SIN185A   31343               0 S
30.48   -999  15.76  -999  22.3 46.13   SIN185A   31343               0 S
23.44   -999  15.25  -999  21.4 43.35   SIN185A   31343               0 S
29.91   -999  16.15  -999 23.54 48.48   SIN185A   31343               0 S
 25.4   -999  15.35  -999  21.4 43.35   SIN185A   31343               0 S
29.51   -999   15.7  -999  21.4 43.35   SIN185A   31343               0 S
29.09   47.9  11.39  -999  22.3 46.13   SIN285B   31371               0 S
20.27   34.4  11.43  -999  21.4 43.35   SIN285B   31371               0 S
29.04   43.4  11.26  -999  21.4 43.35   SIN285B   31371               0 S
 25.8   33.9     12  -999 23.54 48.48   SIN285B   31371               0 S
20.87   37.2  11.29  -999  22.3 46.13   SIN285B   31371               0 S
29.23   41.3  11.37  -999 23.54 48.48   SIN285B   31371               0 S
 29.6   70.3  11.54  -999  22.3 46.13   SIN285B   31371               0 S
25.74   33.9  11.37  -999 23.54 48.48   SIN285B   31371               0 S
30.15     71  11.61  -999  21.4 43.35   SIN285B   31371               0 S
22.25   35.1   11.5  -999 23.54 48.48   SIN285B   31371               0 S
20.57   37.3  11.31  -999  22.3 46.13   SIN285B   31371               0 S
21.68   50.6      8  17.2  22.3 47.22   SIN386A   31510               0 S
24.07     57   7.71 18.55 22.17 44.46   SIN386A   31510               0 S
27.11   49.8   7.17 21.37  22.3 46.13   SIN386A   31510               0 S
29.39   28.7   6.05 23.65  22.3 46.13   SIN386A   31510               0 S
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Salt	Turb	Temp	SigT	Long	Lat	BibID	DayNum		Sta	Lbl
23.38	48.4	8.4	16.36	23.54	48.48	SIN386A	31510		0	S
27.29	47.5	7.11	21.54	21.4	43.35	SIN386A	31510		0	S
23.65	28.4	5.99	23.39	23.54	48.48	SIN386A	31510		0	S
30.38	33.5	6	23.92	21.4	43.35	SIN386A	31510		0	S
24.52	54.5	7.7	19.3	21.4	43.35	SIN386A	31510		0	S
24	56.4	7.5	19.2	22.3	46.13	SIN386A	31510		0	S
26.34	50	7.06	21.23	23.54	48.48	SIN386A	31510		0	S
28.2	53.5	15.4	20.7	23.54	48.48	SIN486B	31551		0	S
30.7	67.3	14	22.9	21.4	43.35	SIN486B	31551		0	S
28.9	54	16.5	21	22.3	46.13	SIN486B	31551		0	S
30.4	37.4	11.2	23.2	23.54	48.48	SIN486B	31551		0	S
31.4	77.5	16.7	15.5	23.54	48.48	SIN486B	31551		0	S
30.1	49.3	15.7	22.1	21.4	43.35	SIN486B	31551		0	S
22.8	87.9	18	15.9	22.3	46.13	SIN486B	31551		0	S
30.5	56.6	13.2	22.9	22.3	46.13	SIN486B	31551		0	S
25.3	75.9	18.2	17.9	21.4	43.35	SIN486B	31551		0	S
32.15	-999	3	-999	19.2	41	BEND77A	28215	4		B
25.55	-999	3	-999	19.2	41	BEND77A	28215	4		B
24.67	-999	7	-999	21	42.2	BEND77A	28215	3		B
31.7	-999	3	-999	21	42.2	BEND77A	28215	3		B
29.4	-999	-999	-999	18.4	40.16	CULL78A	28491	NB.78.14		C
29.4	-999	-999	-999	18.4	40.16	CULL78A	28491	NB.78.14		C
29.1	-999	-999	-999	20	43.13	CULL78A	28491	NB.78.17		C
25.3	-999	-999	-999	20	43.13	CULL78A	28491	NB.78.17		C
27	-999	-999	-999	21.31	40.14	HUNT80A	29273	6		H
24.5	-999	-999	-999	21.31	40.14	HUNT80A	29274	6		H
26.3	-999	-999	-999	17.54	41.53	HUNT80A	29274	5		H
30.67	-999	-999	-999	18.48	39.15	QUIN87A	29434	10		Q
30.18	-999	-999	-999	19.05	43.05	QUIN87A	29434	7		Q
30.23	-999	-999	-999	18.55	42.35	QUIN87A	29434	8		Q
30.67	-999	-999	-999	20.45	40.4	QUIN87A	29434	11		Q
30.34	-999	-999	-999	18.5	40.48	QUIN87A	29434	9		Q
30.78	-999	-999	-999	21.45	40.1	QUIN87A	29434	12		Q
29.5	-999	-999	-999	21.31	40.14	HUNT80A	29476	6		H
29.5	-999	-999	-999	17.54	41.53	HUNT80A	29476	5		H
29.71	-999	-999	-999	20.52	42.5	CULL80A	29495		0	C
31.46	-999	-999	-999	18.26	38.43	CULL80A	29495		0	C
31.34	-999	-999	-999	18.26	38.43	CULL80A	29495		0	C
30.59	-999	-999	-999	19.14	40.52	CULL80A	29495		0	C
31.12	-999	-999	-999	18.21	40.57	CULL80A	29495		0	C
30.04	-999	-999	-999	20.52	42.5	CULL80A	29495		0	C
30.9	-999	-999	-999	19.14	40.52	CULL80A	29495		0	C
29.43	-999	14.5	-999	21.31	40.14	SIN185A	31343		0	S
30.99	-999	15.64	-999	17.54	41.53	SIN185A	31343		0	S
29.77	-999	14.94	-999	21.31	40.14	SIN185A	31343		0	S
-999	-999	14.91	-999	21.31	40.14	SIN185A	31343		0	S
-999	-999	14.58	-999	21.31	40.14	SIN185A	31343		0	S
29.81	-999	15.1	-999	17.54	41.53	SIN185A	31343		0	S
29.78	38.6	11.16	-999	17.54	41.53	SIN285B	31371		0	S
28.74	33.8	11.01	-999	21.31	40.14	SIN285B	31371		0	S
24.46	29	11.27	-999	17.54	41.53	SIN285B	31371		0	S
26.65	25.6	10.96	-999	21.31	40.14	SIN285B	31371		0	S
29.05	20.4	11.08	-999	21.31	40.14	SIN285B	31371		0	S
26.79	57.3	8.09	20.88	17.54	41.53	SIN386A	31510		0	S
28.32	40.4	7.8	22.02	18.35	41.25	SIN386A	31510		0	S
30.43	25.1	5.93	24.01	17.54	41.53	SIN386A	31510		0	S
27.81	37.6	8	21.7	18.35	41.25	SIN386A	31510		0	S
29.65	33.1	6.83	23.27	18.35	41.25	SIN386A	31510		0	S
29.5	43.5	17.72	21.23	18.35	41.25	SIN486B	31551		0	S
30.93	43	15.8	22.69	21.31	40.14	SIN486B	31551		0	S
31.03	54.7	13.5	23.25	18.35	41.25	SIN486B	31551		0	S
30.95	44	15.7	22.73	21.31	40.14	SIN486B	31551		0	S
30.93	43	15.8	22.7	21.31	40.14	SIN486B	31551		0	S
27.59	-999	7	-999	22.5	38	BEND77A	28215	2		B
28.36	-999	5	-999	22.5	38	BEND77A	28215	2		B
29.6	-999	-999	-999	22.2	38.33	CULL78A	28491	NB.78.26		C
30.1	-999	-999	-999	25.4	40.42	HUNT80A	29273	8		H
28	-999	-999	-999	25.4	40.42	HUNT80A	29274	8		H

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  Salt   Turb  Temp  SigT  Long   Lat    BibID   DayNum             Sta Lbl
 31.23   -999  -999  -999  23.2 39.39  CULL80A   29495               0 C
 33.21   -999  10.7  -999  25.4 40.42  SIN185A   31343               0 S
 33.21   -999 14.41  -999  25.4 40.42  SIN185A   31343               0 S
[illegible] 35.3  9.51  -999  25.4 40.42  SIN285B   31371               0 S
[illegible] 37.9  9.57  -999  25.4 40.42  SIN285B   31371               0 S
 36.91   -999  -999  -999  25.4 40.42  SIN386A   31510               0 S
 37.23   -999  -999  -999  25.4 40.42  SIN386A   31510               0 S
  39.5     49  15.5 21.14  25.4 40.42  SIN486B   31551               0 S
 39.95   73.4  15.5 21.32  25.4 40.42  SIN486B   31551               0 S
  -999   -999  -999  -999    25    32  PIOT77A   27523  7              P
  -999   -999  -999  -999    25    32  PIOT77A   27543  13             P
  -999   -999  -999  -999    25    32  PIOT77A   27563  16             P
  -999   -999  -999  -999    25    32  PIOT77A   27572  21             P
  -999   -999  -999  -999    25    32  PIOT77A   27591  25             P
  -999   -999  -999  -999    25    32  PIOT77A   27598  28             P
  -999   -999  -999  -999    25    32  PIOT77A   27605  35             P
  -999   -999  -999  -999    25    32  PIOT77A   27619  41             P
  -999   -999  -999  -999    25    32  PIOT77A   27648  47             P
  -999   -999  -999  -999    25    32  PIOT77A   27690  52             P
 31.56   -999     5  -999    24    35  BEND77A   28215  1              B
 31.57   -999     6  -999    24    35  BEND77A   28215  1              B
  30.5   -999  -999  -999 24.26 34.18  CULL78A   28491  NB.78.1        C
  30.5   -999  -999  -999 22.43 35.24  CULL78A   28491  NB.78.23       C
  30.7   -999  -999  -999  24.1  32.3  CULL78A   28491  NB.78.2        C
  31.7   -999  -999  -999  20.5 34.56  HUNT80A   29273  13             H
    31   -999  -999  -999 22.18    38  HUNT80A   29273  10             H
  30.3   -999  -999  -999 23.48 31.56  HUNT80A   29273  12             H
  27.5   -999  -999  -999 22.18    38  HUNT80A   29274  10             H
  28.3   -999  -999  -999  20.5 34.56  HUNT80A   29274  13             H
  27.7   -999  -999  -999 23.48 31.56  HUNT80A   29274  12             H
 31.16   -999  -999  -999  23.2  34.5  QUIN87A   29434  14             Q
    31   -999  -999  -999  20.5 34.56  HUNT80A   29476  13             H
  30.5   -999  -999  -999 23.48 31.56  HUNT80A   29476  12             H
  30.1   -999  -999  -999 22.18    38  HUNT80A   29476  10             H
 31.38   -999  -999  -999 22.51  35.3  CULL80A   29495               0 C
 31.35   -999 15.87  -999  20.5 34.56  SIN185A   31343               0 S
 31.36   -999  15.4  -999 23.48 31.56  SIN185A   31343               0 S
  30.6   -999 15.22  -999 22.18    38  SIN185A   31343               0 S
 31.45   -999 15.34  -999 23.48 31.56  SIN185A   31343               0 S
 29.79   -999  15.1  -999 22.18    38  SIN185A   31343               0 S
 31.45   -999 15.35  -999 23.48 31.56  SIN185A   31343               0 S
 31.19   -999 15.44  -999 23.48 31.56  SIN185A   31343               0 S
 30.54   -999 15.01  -999  20.5 34.56  SIN185A   31343               0 S
 31.21   -999 15.81  -999  20.5 34.56  SIN185A   31343               0 S
 29.78   -999 15.06  -999 22.18    38  SIN185A   31343               0 S
 29.99   32.1 11.32  -999  20.5 34.56  SIN285B   31371               0 S
 29.13   34.7 10.51  -999 22.18    38  SIN285B   31371               0 S
 30.35   38.8 10.32  -999 23.48 31.56  SIN285B   31371               0 S
 30.78   38.4 11.77  -999  20.5 34.56  SIN285B   31371               0 S
 30.17   40.5 10.87  -999 23.48 31.56  SIN285B   31371               0 S
 29.12   37.7 10.58  -999 22.18    38  SIN285B   31371               0 S
 30.54   36.4 10.93  -999 23.48 31.56  SIN285B   31371               0 S
 29.57   26.7 11.14  -999  20.5 34.56  SIN285B   31371               0 S
 30.67   37.9 11.03  -999 23.48 31.56  SIN285B   31371               0 S
  28.1   28.3 10.67  -999 22.18    38  SIN285B   31371               0 S
 28.79   26.5  7.58 22.49 22.18    38  SIN386A   31510               0 S
 31.28   17.2  5.47 24.75  20.5 34.56  SIN386A   31510               0 S
 29.84   24.3  7.18 23.41 23.48 31.56  SIN386A   31510               0 S
 30.48   25.3  6.66 23.94 23.48 31.56  SIN386A   31510               0 S
 28.97   26.7  7.47 22.68 22.18    38  SIN386A   31510               0 S
 29.73   32.6  6.77 23.36 22.18    38  SIN386A   31510               0 S
 29.29   26.5   7.3  22.9  20.5 34.56  SIN386A   31510               0 S
 30.64   31.7  6.46 24.13 23.48 31.56  SIN386A   31510               0 S
 31.57   43.7  12.2 23.91  20.5 34.56  SIN486B   31551               0 S
 31.55     34 12.59 23.82  20.5 34.56  SIN486B   31551               0 S
 31.52   49.3  11.8 23.95 23.46 33.15  SIN486B   31551               0 S
 31.15  44.08  14.8 23.07 22.18    38  SIN486B   31551               0 S
 31.52   50.3 11.67 23.97 23.46 33.15  SIN486B   31551               0 S
```

```
 Salt  Turb  Temp  SigT  Long   Lat    BioID  DayNum           Sta Col
31.07  41.5 15.23 22.33 22.18    38  SIN486B   31551              0 S
 31.5  50.5  11.3    24 23.46 33.15  SIN486B   31551              0 S
 -999  -999  -999  -999    25    30  PIOT72A   25934  2             P
 -999  -999  -999  -999    25    30  PIOT72A   25934  10            P
 -999  -999  -999  -999    25    30  PIOT72A   25934  14            P
 -999  -999  -999  -999    25    30  PIOT72A   25934  5             P
 -999  -999  -999  -999    25    30  PIOT72A   25934  3             P
 -999  -999  -999  -999    25    30  PIOT72A   25934  1             P
 -999  -999  -999  -999    25    30  PIOT72A   25934  4             P
 -999  -999  -999  -999    25    30  PIOT72A   25934  7             P
 -999  -999  -999  -999    25    30  PIOT72A   25934  8             P
 -999  -999  -999  -999    25    30  PIOT72A   25934  13            P
 -999  -999  -999  -999    25    30  PIOT72A   25934  9             P
 -999  -999  -999  -999    25    30  PIOT72A   25934  12            P
 -999  -999  -999  -999    25    30  PIOT72A   25934  11            P
 -999  -999  -999  -999    25    30  PIOT72A   25934  6             P
 -999  -999  -999  -999    25    32  PIOT77A   27907  53            P
 -999  -999  -999  -999    25    32  PIOT77A   27921  55            P
 32.2  -999     3  -999  24.3  30.3  SEND77A   28215  12            B
29.55  -999     5  -999  24.3  30.3  SEND77A   28215  12            B
 31.4  -999  -999  -999 24.31 29.31  CULL78A   28491  NB.78.4       C
 31.3  -999  -999  -999 24.31 29.31  CULL78A   28491  NB.78.4       C
   32  -999  -999  -999 24.47 27.48  HUNT80A   29273  14            H
   28  -999  -999  -999 24.47 27.48  HUNT80A   29274  14            H
31.65  -999  -999  -999    25    27  QUIN87A   29435  16            Q
31.32  -999  -999  -999 24.05 30.45  QUIN87A   29434  15            Q
 31.3  -999  -999  -999 24.47 27.48  HUNT80A   29476  14            H
 32.2  -999  -999  -999 24.52  29.4  CULL80A   29495              0 C
 32.2  -999  -999  -999 24.52  29.4  CULL80A   29495              0 C
 31.7  -999 15.37  -999 24.47 27.48  SIN185A   31343              0 S
 31.9  -999 15.62  -999 24.47 27.48  SIN185A   31343              0 S
32.02  -999 15.91  -999 24.47 27.48  SIN185A   31343              0 S
 32.1  -999 15.99  -999 24.47 27.48  SIN185A   31343              0 S
30.99  39.5 11.09  -999 24.47 27.48  SIN285B   31371              0 S
31.24    42 11.43  -999 24.47 27.48  SIN285B   31371              0 S
31.71  44.2 12.28  -999 24.47 27.48  SIN285B   31371              G S
31.56  39.6 12.23  -999 24.47 27.48  SIN285B   31371              0 S
31.79    33  5.54 25.13 24.47 27.48  SIN386A   31510              0 S
31.79  25.6  5.55 25.13 24.47 27.48  SIN386A   31510              0 S
 30.4  24.9  6.93 23.85 24.47 27.48  SIN386A   31510              0 S
   32    35 11.79 24.32 24.47 27.48  SIN486B   31551              0 S
 32.4  32.5    10  24.9 24.47 27.48  SIN486B   31551              0 S
32.27  27.2 10.67 24.74 24.47 27.48  SIN486B   31551              0 S
32.76  -999     3  -999  17.2    36  SEND77A   28215  5             B
27.69  -999     5  -999  17.2    36  SEND77A   28215  5             B
 30.3  -999  -999  -999 16.52 37.48  CULL78A   28491  NB.78.13      C
   26  -999  -999  -999 15.53 37.58  HUNT80A   29274  9             H
 25.5  -999  -999  -999 18.37 38.58  HUNT80A   29274  7             H
 29.8  -999  -999  -999 15.53 37.58  HUNT80A   29476  9             H
 29.6  -999  -999  -999 18.37 38.58  HUNT80A   29476  7             H
31.24  -999 15.86  -999 18.37 38.58  SIN185A   31343              0 S
30.11  -999    15  -999 18.37 38.58  SIN185A   31343              0 S
31.21  -999 15.81  -999 15.53 37.58  SIN185A   31343              0 S
30.12  -999  15.4  -999 15.53 37.58  SIN185A   31343              0 S
30.05  -999  15.6  -999 15.53 37.58  SIN185A   31343              0 S
29.39  -999  14.5  -999 18.37 38.58  SIN185A   31343              0 S
30.75    46  11.9  -999 18.37 38.58  SIN285B   31371              0 S
28.32  28.4 11.16  -999 15.53 37.58  SIN285B   31371              0 S
30.47  36.7  11.9  -999 15.53 37.58  SIN285B   31371              0 S
 28.6  24.5 11.38  -999 18.37 38.58  SIN285B   31371              0 S
30.08  31.9 11.67  -999 18.37 38.58  SIN285B   31371              0 S
28.87  31.2 11.27  -999 15.53 37.58  SIN285B   31371              0 S
30.75  36.2 11.92  -999 15.53 37.58  SIN285B   31371              0 S
29.72  25.6  6.49 23.39 15.53 37.58  SIN386A   31510              0 S
30.38  25.8  6.37 23.52 15.53 37.58  SIN386A   31510              0 S
30.23  23.8  6.06 23.81 18.37 38.58  SIN386A   31510              0 S
30.98    24  5.44 24.41 18.37 38.58  SIN386A   31510              0 S
29.36  26.2  6.58 23.31 18.37 38.58  SIN386A   31510              0 S
```

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 Salt  Turb  Temp  SigT  Long   Lat    BibID    DayNum           Sta Lbl
28.39  29.3   7.5  22.2 15.53 37.58  SIN356A   31510              0 S
31.34  -5.6 12.75 23.53 18.37 38.58  SIN486B   31551              0 S
 31.1  32.9 14.01  23.2 15.53 37.58  SIN486B   31551              0 S
31.52  64.2 11.61 23.38 18.37 38.58  SIN486B   31551              0 S
31.29  31.3 14.24 23.15 18.37 38.58  SIN486B   31551              0 S
31.47    38 12.16 23.34 15.53 37.58  SIN486B   31551              0 S
32.74    25 15.01 22.87 15.53 37.58  SIN486B   31551              0 S
33.07  -999     2  -999    18  34.3  BEND77A   28215  6             B
29.46  -999     7  -999    21  30.3  BEND77A   28215  7             B
31.13  -999     2  -999    21  30.3  BEND77A   28215  7             B
28.44  -999     7  -999    18  34.3  BEND77A   28215  6             B
 31.3  -999  -999  -999 20.42 31.32  CULL78A   28491  NB.78.11      C
   33  -999  -999  -999    21 30.34  HUNT80A   29273  15            H
 26.3  -999  -999  -999 18.12 35.32  HUNT80A   29274  11            H
 28.5  -999  -999  -999    21 30.34  HUNT80A   29274  15            H
 31.7  -999  -999  -999    21 30.34  HUNT80A   29476  15            H
30.79  -999  15.6  -999 18.12 35.32  SIN185A   31343              0 S
32.06  -999  16.1  -999    21 30.34  SIN185A   31343              0 S
31.93  -999 16.08  -999 18.12 35.32  SIN185A   31343              0 S
31.58  -999 15.98  -999 18.12 35.32  SIN185A   31343              0 S
32.03  -999 16.04  -999    21 30.34  SIN185A   31343              0 S
31.49  -999 15.77  -999    21 30.34  SIN185A   31343              0 S
31.34  -999 15.81  -999    21 30.34  SIN185A   31343              0 S
 30.7  -999 15.25  -999 18.12 35.32  SIN185A   31343              0 S
31.71  41.4 12.32  -999 18.12 35.32  SIN285B   31371              0 S
30.23  31.5 11.59  -999 18.12 35.32  SIN285B   31371              0 S
30.34  33.2 11.25  -999    21 30.34  SIN285B   31371              0 S
29.66  27.6 11.26  -999 18.12 35.32  SIN285B   31371              0 S
31.48  35.2  12.1  -999    21 30.34  SIN285B   31371              0 S
30.58  31.7 11.33  -999    21 30.34  SIN285B   31371              0 S
32.07  49.9 12.45  -999    21 30.34  SIN285B   31371              0 S
31.15  36.6 12.01  -999 18.12 35.32  SIN285B   31371              0 S
29.58  23.2     7  23.2 18.12 35.32  SIN386A   31510              0 S
31.62  21.9  5.76 24.97    21 30.34  SIN386A   31510              0 S
32.07  24.3  5.54 25.34    21 30.34  SIN386A   31510              0 S
30.82  20.7   6.1  24.3    21 30.34  SIN386A   31510              0 S
30.96  20.6  5.99  24.4    21 30.34  SIN386A   31510              0 S
 31.3    27  5.69 23.74 18.12 35.32  SIN386A   31510              0 S
30.14  22.3  6.34  23.8 18.12 35.32  SIN386A   31510              0 S
32.44  21.2  9.97 24.99    21 30.34  SIN486B   31551              0 S
31.45  33.7 13.61 23.55 18.12 35.32  SIN486B   31551              0 S
32.13  28.7 11.38  24.5    21 30.34  SIN486B   31551              0 S
32.17  38.2 10.09 24.75 18.12 35.32  SIN486B   31551              0 S
32.47  20.6  9.54 25.08    21 30.34  SIN486B   31551              0 S
31.65    34 12.34 23.95 18.12 35.32  SIN486B   31551              0 S
31.47  -999     3  -999  19.4  29.3  BEND77A   28215  9             B
30.59  -999     7  -999  19.4  29.3  BEND77A   28215  9             B
30.53  -999     7  -999  20.3  29.1  BEND77A   28215  8             B
32.33  -999     3  -999  20.3  29.1  BEND77A   28215  8             B
 31.6  -999  -999  -999 20.56 28.41  CULL78A   28491  NB.78.10      C
 31.7  -999  -999  -999 23.14    27  CULL78A   28491  NB.78.9       C
 33.5  -999  -999  -999 22.46 27.25  HUNT80A   29273  17            H
 31.2  -999  -999  -999 22.46 27.25  HUNT80A   29274  17            H
32.33  -999 16.18  -999 22.46 27.25  SIN185A   31343              0 S
32.08  -999 16.09  -999 22.46 27.25  SIN185A   31343              0 S
32.07  -999 16.03  -999 22.46 27.25  SIN185A   31343              0 S
32.24  -999 16.13  -999 22.46 27.25  SIN185A   31343              0 S
32.28  43.3 12.82  -999 22.46 27.25  SIN285B   31371              0 S
32.24    41 12.75  -999 22.46 27.25  SIN285B   31371              0 S
31.87  28.7 12.49  -999 22.46 27.25  SIN285B   31371              0 S
31.43  31.4 11.85  -999 22.46 27.25  SIN285B   31371              0 S
32.05  24.6  5.46 25.36 22.46 27.25  SIN386A   31510              0 S
32.27  27.6   5.5 25.51 22.46 27.25  SIN386A   31510              0 S
31.49  22.7   5.8 24.87 22.46 27.25  SIN386A   31510              0 S
32.43  20.9 10.11 24.35 22.46 27.25  SIN486B   31551              0 S
32.49  22.7  9.73 25.06 22.46 27.25  SIN486B   31551              0 S
32.31  22.3 10.73 24.76 22.46 27.25  SIN486B   31551              0 S
 26.4  -999  -999  -999 22.48 49.18  CULL78A   28491  NB.78.37      C
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Salt	Turb	Temp	SigT	Long	Lat	StaID	DayNum		Sta	Lbl
23.2	-999	-999	-999	22.48	49.18	CULL78A	28491	NB.78.37		C
23.5	-999	-999	-999	23	49.55	HUNT80A	29273	1		H
20.2	-999	-999	-999	23	49.55	HUNT80A	29274	1		H
25.2	-999	-999	-999	23	49.55	HUNT80A	29476	1		H
27.24	-999	-999	-999	22.48	49.5	KEST81A	29671	4		K
29.15	-999	-999	-999	23.35	49	KEST81A	29671	6		K
0.12	-999	-999	-999	23	52.35	KEST81A	29671	1		K
14.27	-999	-999	-999	22.3	50.2	KEST81A	29671	3		K
29.25	-999	-999	-999	23.05	49.2	KEST81A	29671	5		K
25	-999	-999	-999	23.35	49	KEST81A	29671	6		K
9.34	-999	-999	-999	22.4	51.3	KEST81A	29671	2		K
24.59	-999	-999	-999	23.05	49.2	KEST81A	29671	5		K
23.42	-999	-999	-999	22.3	50.2	KEST81A	29671	3		K
19.43	-999	-999	-999	22.4	51.3	KEST81A	29671	2		K
20.72	-999	-999	-999	22.48	49.5	KEST81A	29671	4		K
3.17	-999	-999	-999	23	49.55	SIN285B	31371		0	S
2.84	-999	-999	-999	23	49.55	SIN285B	31371		0	S
7.63	-999	-999	-999	23	49.55	SIN386A	31510		0	S
17.28	-999	-999	-999	23	49.55	SIN386A	31510		0	S
29.38	-999	15.78	-999	11.13	41.42	SIN185A	31343		0	S
29.32	-999	15.38	-999	14	39.32	SIN185A	31343		0	S
30.53	-999	15.54	-999	14	39.32	SIN185A	31343		0	S
30.22	-999	15.76	-999	11.13	41.42	SIN185A	31343		0	S
28.79	-999	17.1	-999	11.13	41.42	SIN185A	31343		0	S
29	-999	15.8	-999	14	39.32	SIN185A	31343		0	S
29.26	-999	15.37	-999	14	39.32	SIN185A	31343		0	S
25.59	45	11.25	-999	11.13	41.42	SIN285B	31371		0	S
29.24	31.3	11.37	-999	14	39.32	SIN285B	31371		0	S
26.46	44.7	11.95	-999	11.13	41.42	SIN285B	31371		0	S
27.59	37.1	11.53	-999	14	39.32	SIN285B	31371		0	S
25.64	42.6	13.26	-999	11.13	41.42	SIN285B	31371		0	S
30.61	42.1	11.81	-999	14	39.32	SIN285B	31371		0	S
28.05	41	7.58	21.95	11.13	41.42	SIN386A	31510		0	S
29.08	26	6.9	22.8	14	39.32	SIN386A	31510		0	S
29.53	35.3	6.57	23.22	11.13	41.42	SIN386A	31510		0	S
28.52	30.6	7.4	22.3	14	39.32	SIN386A	31510		0	S
30.57	25.4	5.9	24.1	14	39.32	SIN386A	31510		0	S
27.62	43.2	7.81	21.59	11.13	41.42	SIN386A	31510		0	S
31.19	33.1	13	23.47	14	39.32	SIN486B	31551		0	S
29.81	44.5	16.79	21.61	11.13	41.42	SIN486B	31551		0	S
31.07	32	14.03	23.17	14	39.32	SIN486B	31551		0	S
31.09	32.3	13.34	23.23	14	39.32	SIN486B	31551		0	S
30.81	48.6	13	23.17	11.13	41.42	SIN486B	31551		0	S
30.05	40.7	15.24	22.13	11.13	41.42	SIN486B	31551		0	S
30.54	-999	14.75	-999	13	36.14	SIN185A	31343		0	S
30.18	-999	15.58	-999	13	36.14	SIN185A	31343		0	S
31.32	-999	15.97	-999	13.07	29.3	SIN185A	31343		0	S
31.36	-999	15.77	-999	13.07	29.3	SIN185A	31343		0	S
31.37	-999	15.77	-999	13.07	29.3	SIN185A	31343		0	S
30.24	-999	15.55	-999	13	36.14	SIN185A	31343		0	S
31.31	-999	15.97	-999	13.07	29.3	SIN185A	31343		0	S
31.41	53.7	11.21	-999	13.07	29.3	SIN285B	31371		0	S
31.43	53.7	11.6	-999	13.07	29.3	SIN285B	31371		0	S
28.96	29.9	10.88	-999	13	36.14	SIN285B	31371		0	S
28.99	29.1	10.81	-999	13	36.14	SIN285B	31371		0	S
31.95	55	11.65	-999	13.07	29.3	SIN285B	31371		0	S
30.09	29.5	7.4	23.5	13	36.14	SIN386A	31510		0	S
30.81	36	7.03	24.16	13	36.14	SIN386A	31510		0	S
31.34	24.6	15.06	23.16	13.19	34.37	SIN486B	31551		0	S
31.64	61.9	14.63	23.48	13.19	34.37	SIN486B	31551		0	S
32.24	19.1	14.38	24.01	13.07	29.3	SIN486B	31551		0	S
31.99	-999	5	-999	22.3	27	BEND77A	28215	10		B
33.15	-999	3	-999	22.3	27	BEND77A	28215	10		B
33.2	-999	3	-999	25	27	BEND77A	28215	11		B
31.21	-999	5	-999	25	27	BEND77A	28215	11		B
31.5	-999	-999	-999	24.36	26.38	CULL78A	28491	NB.78.6		C
31.8	-999	-999	-999	24.36	26.38	CULL78A	28491	NB.78.6		C
31.5	-999	-999	-999	24.36	26.38	CULL78A	28491	NB.78.6		C

```
 Salt  Turb  Temp  SigT  Long   Lat   BibID   DayNum        Sta Col
 33.5  -999  -999  -999 23.38 25.36  HUNT80A   29273  16          H
 29.7  -999  -999  -999 23.38 25.36  HUNT80A   29274  16          H
31.37  -999  -999  -999    25    24  QUIN87A   29434  17          Q
32.14  -999 16.31  -999 23.38 25.36  SIN185A   31343  821-        S
32.33  -999 16.15  -999 23.38 25.36  SIN185A   31343  821-        S
32.27  -999 16.12  -999 23.38 25.36  SIN185A   31343  821-        S
 32.3  -999 16.28  -999  16.4 25.57  SIN185A   31343  822-        S
32.19  -999 16.15  -999  16.4 25.57  SIN185A   31343  822-        S
32.16  -999 16.13  -999  16.4 25.57  SIN185A   31343  822-        S
32.13  -999 16.32  -999 23.38 25.36  SIN185A   31343  821-        S
32.27  -999 16.33  -999  16.4 25.57  SIN185A   31343  822-        S
32.25  39.7 12.46  -999  16.4 25.57  SIN285B   31371  822-        S
31.78    37 12.51  -999 23.38 25.36  SIN285B   31371  821-        S
32.15    29  12.7  -999 23.38 25.36  SIN285B   31371  821-        S
32.31  45.7 12.36  -999 23.38 25.36  SIN285B   31371  821-        S
32.25  40.5 12.22  -999  16.4 25.57  SIN285B   31371  822-        S
32.04    34 12.52  -999 23.38 25.36  SIN285B   31371  821-        S
32.27  39.3  12.3  -999  16.4 25.57  SIN285B   31371  822-        S
32.27  45.3 12.22  -999  16.4 25.57  SIN285B   31371  822-        S
32.23  19.5     6  25.4 23.38 25.36  SIN386A   31510  821-        S
32.11  22.3     6  25.3 23.38 25.36  SIN386A   31510  821-        S
32.26  20.1   5.5 25.49 23.38 25.36  SIN386A   31510  821-        S
32.32  30.1  5.15 25.59 23.38 25.36  SIN386A   31510  821-        S
 -999  -999  -999 24.58  16.4 25.57  SIN486B   31551  822-        S
 32.3  20.5 11.27 24.65 23.38 25.36  SIN486B   31551  821-        S
32.53  14.9 11.71 24.75  16.4 25.57  SIN486B   31551  822-        S
32.53  15.1  9.85 25.08 23.38 25.36  SIN486B   31551  821-        S
32.73  19.7  8.22 25.48  16.4 25.57  SIN486B   31551  822-        S
32.59  23.5  8.48 25.42 23.38 25.36  SIN486B   31551  821-        S
32.51  15.3 12.53  -999  16.4 25.57  SIN486B   31551  822-        S
```

Appendix 3

Listing of MERLTIME data file

The spreadsheet for this data file has been formatted to enable printing all variables on a single page.

Variables	Units
NumDate	Days since 1 Jan 1900
Al, Fe	umol/kg
Cd, Cu, Mn, Pb	nmol/kg
Salt	o/oo
TSM	mg/kg
Chla	mg/kg

Date	NumDate	Time	AlP	CdD	CdP	CuA	CuD	CuP	FeA	FeD	FeP	MnA	MnD	MnP	PbD	PbP	Salt	TSM	ChlA
29-Aug-77	28366	9:15	16.2	-9.00	0.070	-9.0	-9.0	5.9	-9	-9	5	-9	-9	134	-9.0	2.9	-9.0	-9.0	-9.00
29-Aug-77	28366	9:15	9.1	-9.00	0.130	-9.0	-9.0	4.8	-9	-9	3	-9	-9	91	-9.0	2.0	-9.0	-9.0	6.70
06-Sep-77	28374	9:15	5.8	-9.00	0.140	-9.0	-9.0	2.3	-9	-9	2	-9	-9	147	-9.0	2.8	-9.0	-9.0	-9.00
06-Sep-77	28374	9:15	5.8	-9.00	0.140	-9.0	-9.0	3.0	-9	-9	2	-9	-9	128	-9.0	2.8	-9.0	-9.0	3.13
15-Sep-77	28383	9:15	10.5	-9.00	0.033	-9.0	-9.0	4.1	-9	-9	3	-9	-9	99	-9.0	2.0	-9.0	-9.0	-9.00
15-Sep-77	28383	9:15	12.8	-9.00	0.066	-9.0	-9.0	5.0	-9	-9	3	-9	-9	105	-9.0	2.3	-9.0	-9.0	-9.00
20-Sep-77	28388	9:15	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	-9	-9	-9	-9.0	-9.0	-9.0	-9.0	-9.00
20-Sep-77	28388	9:15	3.2	-9.00	0.420	-9.0	-9.0	2.9	-9	-9	1	-9	-9	51	-9.0	1.0	-9.0	-9.0	-9.00
20-Sep-77	28388	9:15	3.7	-9.00	0.031	-9.0	-9.0	1.6	-9	-9	1	-9	-9	53	-9.0	0.9	-9.0	-9.0	-9.00
20-Sep-77	28388	9:15	3.7	-9.00	0.031	-9.0	-9.0	1.6	-9	-9	1	-9	-9	49	-9.0	1.0	-9.0	-9.0	-9.00
21-Sep-77	28389	9:15	15.0	-9.00	0.105	-9.0	-9.0	7.4	-9	-9	4	-9	-9	146	-9.0	3.1	-9.0	-9.0	-9.00
23-Sep-77	28391	9:15	3.0	-9.00	0.059	-9.0	-9.0	1.7	-9	-9	1	-9	-9	44	-9.0	1.0	-9.0	-9.0	-9.00
26-Sep-77	28394	9:15	3.7	-9.00	0.059	-9.0	-9.0	2.2	-9	-9	1	-9	-9	29	-9.0	0.7	-9.0	-9.0	-9.00
25-Oct-77	28423	9:15	14.2	-9.00	0.050	-9.0	-9.0	5.9	-9	-9	4	-9	179	87	-9.0	2.7	29.0	6.5	-9.00
25-Oct-77	28423	9:15	13.6	-9.00	0.040	-9.0	-9.0	5.9	-9	-9	4	-9	179	83	-9.0	2.3	30.0	5.9	-9.00
25-Oct-77	28423	9:15	11.9	0.77	0.090	-9.0	12.4	4.9	-9	21	3	-9	176	69	2.7	2.4	30.0	5.2	-9.00
25-Oct-77	28423	9:15	14.2	0.81	0.040	-9.0	15.8	5.2	-9	38	4	-9	168	83	2.9	2.5	30.0	4.0	-9.00
25-Oct-77	28423	9:15	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	-9	-9	-9	-9.0	-9.0	-9.0	-9.0	-9.00
23-Nov-77	28452	9:15	-9.0	0.60	-9.000	-9.0	14.7	-9.0	-9	30	-9	-9	208	-9	-9.0	-9.0	30.0	4.6	-9.00
23-Nov-77	28452	9:15	-9.0	0.64	-9.000	-9.0	15.4	-9.0	-9	29	-9	-9	199	-9	0.6	-9.0	29.5	4.7	-9.00
07-Dec-77	28466	9:15	-9.0	1.60	-9.000	-9.0	21.7	-9.0	-9	32	-9	-9	142	-9	0.6	-9.0	28.5	5.2	-9.00
07-Dec-77	28466	9:15	-9.0	1.44	-9.000	-9.0	26.3	-9.0	-9	67	-9	-9	-9	-9	1.8	-9.0	28.5	6.9	-9.00
07-Dec-77	28466	9:15	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	-9	-9	-9	-9.0	-9.0	-9.0	-9.0	-9.00
07-Dec-77	28466	9:30	-9.0	0.38	-9.000	-9.0	20.8	-9.0	-9	34	-9	-9	182	-9	0.6	-9.0	28.5	7.8	-9.00
14-Dec-77	28473	9:15	8.6	-9.00	0.020	-9.0	-9.0	3.3	-9	-9	2	-9	-9	43	-9.0	1.7	-9.0	-9.0	-9.00
14-Dec-77	28473	9:15	8.6	-9.00	-9.000	-9.0	-9.0	3.4	-9	-9	2	-9	-9	46	-9.0	1.7	-9.0	-9.0	-9.00
14-Dec-77	28473	9:30	-9.0	0.71	-9.000	-9.0	12.9	-9.0	-9	20	-9	-9	93	-9	0.7	-9.0	30.0	3.4	-9.00
14-Dec-77	28473	9:30	-9.0	0.80	-9.000	-9.0	12.7	-9.0	-9	20	-9	-9	108	-9	0.5	-9.0	30.0	3.9	-9.00
15-Dec-77	28474	9:15	-9.0	0.71	-9.000	-9.0	13.8	-9.0	-9	27	-9	-9	73	-9	0.7	-9.0	30.0	6.3	-9.00
20-Dec-77	28479	9:15	-9.0	1.33	-9.000	-9.0	27.1	-9.0	-9	52	-9	-9	165	-9	0.9	-9.0	27.0	3.9	-9.00
20-Dec-77	28479	9:30	-9.0	1.33	-9.000	-9.0	26.6	-9.0	-9	34	-9	-9	212	-9	1.0	-9.0	26.5	4.0	-9.00
20-Dec-77	28479	9:30	-9.0	1.33	-9.000	-9.0	27.7	-9.0	-9	34	-9	-9	225	-9	1.7	-9.0	26.5	3.9	-9.00
03-Jan-78	28493	9:15	-9.0	1.68	-9.000	-9.0	25.3	-9.0	-9	99	-9	-9	238	-9	2.9	-9.0	27.5	1.1	-9.00
03-Jan-78	28493	9:15	-9.0	2.34	-9.000	-9.0	19.8	-9.0	-9	106	-9	-9	232	-9	2.9	-9.0	27.5	1.1	-9.00
17-Jan-78	28507	9:15	4.9	-9.00	0.110	-9.0	-9.0	8.6	-9	-9	1	-9	-9	23	-9.0	2.0	-9.0	-9.0	-9.00
17-Jan-78	28507	9:15	-9.0	0.88	-9.000	-9.0	19.5	-9.0	-9	36	-9	-9	220	-9	0.5	-9.0	28.0	2.2	-9.00
17-Jan-78	28507	9:15	-9.0	1.70	-9.000	-9.0	20.6	-9.0	-9	38	-9	-9	252	-9	1.4	-9.0	28.0	2.0	-9.00
17-Jan-78	28507	9:15	4.7	-9.00	0.030	-9.0	-9.0	4.0	-9	-9	1	-9	-9	16	-9.0	2.3	-9.0	-9.0	1.07
17-Jan-78	28507	9:30	-9.0	0.84	-9.000	-9.0	15.2	-9.0	-9	28	-9	-9	232	-9	0.4	-9.0	28.0	2.1	-9.00
24-Jan-78	28514	9:15	11.8	0.51	0.030	-9.0	14.2	3.4	-9	21	3	-9	63	54	0.3	2.1	31.0	4.3	1.71
24-Jan-78	28514	9:15	10.9	0.45	0.030	-9.0	11.8	3.2	-9	15	3	-9	59	48	0.3	1.8	31.0	3.3	1.71
24-Jan-78	28514	9:15	10.0	0.48	0.023	-9.0	12.1	3.1	-9	26	3	-9	88	48	0.3	1.8	31.0	4.3	1.71
31-Jan-78	28521	9:15	8.0	0.76	0.070	-9.0	16.3	5.0	-9	26	2	-9	191	35	0.4	2.5	30.0	3.6	0.55
31-Jan-78	28521	9:15	7.8	-9.00	0.044	-9.0	-9.0	4.5	-9	-9	2	-9	-9	34	-9.0	2.5	-9.0	-9.0	0.65
31-Jan-78	28521	9:15	-9.0	1.31	-9.000	-9.0	14.3	-9.0	-9	39	-9	-9	191	-9	1.0	-9.0	30.0	3.4	-9.00
31-Jan-78	28521	9:15	5.8	0.87	0.057	-9.0	19.2	6.7	-9	59	2	-9	251	23	0.4	2.8	29.0	2.8	0.65
14-Feb-78	28535	9:15	51.5	-9.00	0.100	-9.0	-9.0	19.0	-9	-9	17	-9	-9	251	-9.0	13.3	-9.0	-9.0	2.03

Listing of MERLTIME Data File

Date	NumDate	Time	AlP	CdD	CdP	CuA	CuD	CuP	FeA	FeD	FeP	MnA	MnD	MnP	PbD	PbP	Salt	TSM	ChlA
14-Feb-78	28535	9:15	64.5	-9.00	0.293	-9.0	-9.0	13.5	-9	-9	17	-9	-9	248	-9.0	10.9	-9.0	-9.0	2.03
14-Feb-78	28535	9:15	68.0	-9.00	0.201	-9.0	-9.0	21.7	-9	-9	19	-9	-9	266	-9.0	14.2	-9.0	-9.0	2.03
14-Feb-78	28535	9:15	-9.0	0.87	-9.000	-9.0	16.2	-9.0	-9	35	-9	-9	158	-9	0.5	-9.0	28.5	38.0	-9.00
14-Feb-78	28535	9:15	-9.0	0.77	-9.000	-9.0	16.2	-9.0	-9	35	-9	-9	158	-9	0.5	-9.0	28.5	32.0	-9.00
21-Feb-78	28542	9:15	4.3	0.69	0.021	-9.0	14.9	1.9	-9	20	1	-9	124	18	0.4	1.0	31.0	2.0	2.38
28-Feb-78	28549	9:15	-9.0	0.48	-9.000	-9.0	14.3	-9.0	-9	15	-9	-9	111	-9	0.4	-9.0	31.0	2.3	-9.00
28-Feb-78	28549	9:15	3.9	-9.00	0.009	-9.0	-9.0	1.5	-9	-9	1	-9	-9	18	-9.0	0.8	-9.0	-9.0	5.51
28-Feb-78	28549	9:15	4.6	-9.00	0.052	-9.0	-9.0	1.7	-9	-9	1	-9	-9	-9	-9.0	1.0	-9.0	-9.0	5.51
28-Feb-78	28549	9:15	-9.0	4.50	-9.000	-9.0	17.5	-9.0	-9	44	-9	-9	111	-9	0.4	-9.0	31.0	6.4	-9.00
08-Mar-78	28557	9:0	-9.0	1.40	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	-9	73	-9	-9.0	-9.0	31.0	7.6	-9.00
08-Mar-78	28557	9:15	15.7	-9.00	0.029	-9.0	-9.0	5.0	-9	-9	5	-9	-9	65	-9.0	2.5	-9.0	-9.0	-9.00
14-Mar-78	28563	9:15	6.2	0.37	0.040	-9.0	16.5	3.1	-9	13	2	-9	121	27	0.4	1.2	32.0	5.5	-9.00
20-Mar-78	28569	9:15	14.6	-9.00	0.033	-9.0	-9.0	6.7	-9	-9	4	-9	-9	58	-9.0	3.1	-9.0	-9.0	-9.00
20-Mar-78	28569	9:15	-9.0	2.20	-9.000	-9.0	17.8	-9.0	-9	20	-9	-9	147	-9	1.6	-9.0	33.0	7.1	-9.00
23-Mar-78	28572	9:15	19.5	0.60	0.049	-9.0	12.6	6.3	-9	20	5	-9	88	73	0.5	2.3	32.5	11.2	6.74
28-Mar-78	28577	9:30	37.1	0.70	0.065	-9.0	12.6	12.7	-9	10	9	-9	154	130	0.4	5.1	31.5	17.2	5.20
04-Apr-78	28584	9:30	2.8	0.96	0.016	-9.0	19.0	1.1	-9	75	1	-9	346	5	1.6	0.5	30.0	1.5	4.90
11-Apr-78	28591	9:20	1.4	0.42	0.065	-9.0	8.3	2.0	-9	12	1	-9	333	14	0.3	0.8	-9.0	2.7	4.52
18-Apr-78	28598	9:15	2.1	21.80	-9.000	-9.0	14.2	3.2	-9	13	1	-9	381	11	0.4	1.9	29.7	1.6	2.16
25-Apr-78	28605	9:0	4.8	1.54	0.052	-9.0	18.7	2.7	-9	21	1	-9	-9	50	2.3	1.3	-9.0	3.8	3.07
02-May-78	28612	9:30	6.8	0.85	0.024	-9.0	17.8	4.4	-9	37	2	-9	270	78	1.2	1.6	31.0	3.2	2.61
09-May-78	28619	9:20	10.3	3.59	0.054	-9.0	11.2	4.3	-9	17	3	-9	163	41	2.0	3.2	31.0	7.9	4.59
16-May-78	28626	9:0	10.0	4.50	0.109	-9.0	18.3	9.8	-9	58	4	-9	295	61	7.6	4.1	29.0	5.6	5.01
23-May-78	28633	9:25	10.4	0.63	0.064	-9.0	12.8	5.1	-9	17	3	-9	157	69	0.7	2.0	30.5	6.6	1.66
30-May-78	28640	9:15	7.8	1.09	0.017	-9.0	14.2	4.0	-9	25	2	-9	246	52	0.5	1.9	29.7	4.4	5.82
06-Jun-78	28647	9:10	9.0	2.31	0.092	-9.0	12.6	5.2	-9	20	3	-9	153	110	0.5	1.7	30.0	4.1	4.44
13-Jun-78	28654	9:15	4.7	2.12	0.026	-9.0	8.2	2.5	-9	20	2	-9	206	48	0.8	1.4	30.0	2.8	4.82
27-Jun-78	28668	9:30	6.6	0.26	0.010	-9.0	7.8	2.9	-9	11	2	193	164	65	0.4	1.7	29.8	3.2	8.03
05-Jul-78	28676	9:15	42.6	0.63	0.086	-9.0	19.9	24.0	-9	26	13	-9	168	287	0.9	7.8	30.0	17.8	2.25
11-Jul-78	28682	9:0	11.5	0.63	0.028	-9.0	12.7	4.8	-9	12	3	-9	3	153	0.5	2.0	30.0	5.5	4.90
18-Jul-78	28689	9:35	-9.0	0.75	-9.000	-9.0	9.1	-9.0	-9	8	-9	-9	57	-9	0.3	-9.0	30.2	5.2	-9.00
25-Jul-78	28696	9:30	6.3	0.47	0.013	-9.0	7.3	2.7	-9	8	4	169	64	81	0.5	1.7	29.8	3.0	5.51
01-Aug-78	28703	9:20	0.7	1.02	0.052	-9.0	8.0	0.6	-9	14	2	204	124	9	0.9	0.3	30.0	0.6	2.45
08-Aug-78	28710	10:0	20.3	-9.00	0.019	-9.0	-9.0	9.7	-9	-9	2	275	57	179	-9.0	3.6	-9.0	-9.0	3.11
08-Aug-78	28710	10:0	20.8	0.72	0.023	-9.0	9.1	8.6	-9	17	6	272	62	180	0.6	3.5	31.5	9.2	3.11
08-Aug-78	28710	10:0	23.4	0.59	0.029	-9.0	6.0	9.1	-9	13	7	275	57	211	0.5	3.6	31.0	10.0	3.11
08-Aug-78	28710	10:0	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	272	44	-9	-9.0	-9.0	31.0	11.4	-9.00
08-Aug-78	28710	10:0	-9.0	1.19	-9.000	-9.0	8.9	-9.0	-9	26	-9	-9	70	-9	1.3	-9.0	31.0	11.4	-9.00
15-Aug-78	28717	9:15	-9.0	0.48	-9.000	-9.0	8.1	-9.0	-9	13	-9	246	134	-9	3.8	-9.0	31.0	4.9	-9.00
22-Aug-78	28724	9:25	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	180	66	-9	-9.0	-9.0	-9.0	-9.0	-9.00
22-Aug-78	28724	9:25	10.4	0.52	0.025	-9.0	8.5	4.1	-9	14	3	174	61	131	0.5	2.1	32.0	4.3	6.74
22-Aug-78	28724	9:25	10.1	0.58	0.067	-9.0	8.5	5.3	-9	11	3	-9	57	130	0.5	2.3	32.0	4.3	6.74
22-Aug-78	28724	9:25	10.1	-9.00	0.027	-9.0	-9.0	4.4	-9	-9	3	-9	-9	134	-9.0	2.0	-9.0	-9.0	6.74
22-Aug-78	28724	9:25	8.3	-9.00	0.014	-9.0	-9.0	3.6	-9	-9	3	-9	-9	126	-9.0	1.8	-9.0	-9.0	5.74
22-Aug-78	28724	9:25	-3.0	1.32	-9.000	-9.0	11.5	-9.0	-9	9	-9	-9	74	-9	1.7	-3.0	-9.0	4.3	-9.00
22-Aug-78	28724	9:25	-9.0	1.09	-9.000	-9.0	8.0	-9.0	-9	8	-9	-9	76	-9	1.4	-9.0	-9.0	4.3	-9.00
29-Aug-78	28731	9:45	-9.0	1.06	-9.000	-9.0	8.3	-9.0	-9	28	-9	426	299	-9	0.6	-9.0	31.5	5.5	-9.00

Date	NumDate	Time	AlP	CdD	CdP	CuA	CuD	CuP	FeA	FeD	FeP	MnA	MnD	MnP	PbD	PbP	Salt	TSM	ChlA
05-Sep-78	28738	9:0	-9.0	0.50	-9.000	-9.0	7.3	-9.0	-9	11	-9	159	67	-9	0.9	-9.0	30.5	5.3	-9.00
26-Sep-78	28759	9:30	-9.0	0.35	-9.000	-9.0	9.2	-9.0	-9	41	-9	104	77	-9	0.6	-9.0	31.5	4.5	-9.00
03-Oct-78	28766	9:30	-9.0	0.81	-9.000	-9.0	10.0	-9.0	-9	7	-9	159	27	-9	0.5	-9.0	31.5	3.2	-9.00
10-Oct-78	28773	9:45	-9.0	0.38	-9.000	-9.0	14.6	-9.0	-9	47	-9	149	72	-9	0.9	-9.0	30.5	2.8	-9.00
17-Oct-78	28780	9:20	-9.0	0.59	-9.000	-9.0	10.4	-9.0	-9	11	-9	112	28	-9	0.8	-9.0	32.3	2.3	-9.00
24-Oct-78	28787	9:35	-9.0	0.60	-9.000	-9.0	10.3	-9.0	-9	10	-9	156	54	-9	0.4	-9.0	31.0	3.2	-9.00
31-Oct-78	28794	9:20	-9.0	3.41	-9.000	-9.0	12.3	-9.0	-9	17	-9	96	15	-9	0.6	-9.0	31.5	3.6	-9.00
08-Nov-78	28802	9:30	-9.0	0.53	-9.000	-9.0	9.8	-9.0	-9	10	-9	160	33	-9	0.3	-9.0	31.5	4.5	-9.00
14-Nov-78	28808	9:30	-9.0	0.53	-9.000	-9.0	11.7	-9.0	-9	17	-9	119	65	-9	0.6	-9.0	32.0	3.3	-9.00
21-Nov-78	28815	9:40	-9.0	0.39	-9.000	-9.0	9.5	-9.0	-9	10	-9	162	79	-9	0.4	-9.0	30.5	5.1	-9.00
05-Dec-78	28829	10:15	-9.0	0.52	-9.000	-9.0	8.2	-9.0	-9	20	-9	127	30	-9	0.2	-9.0	32.0	16.5	-9.00
12-Dec-78	28836	10:0	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	56	54	-9	-9.0	-9.0	-9.0	-9.0	-9.00
19-Dec-78	28843	9:30	-9.0	0.34	-9.000	-9.0	5.5	-9.0	-9	11	-9	22	28	-9	0.4	-9.0	32.0	3.6	-9.00
26-Dec-78	28850	10:0	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	134	87	-9	-9.0	-9.0	-9.0	-9.0	-9.00
03-Jan-79	28858	9:30	-9.0	0.53	-9.000	-9.0	9.3	-9.0	-9	20	-9	88	58	-9	0.3	-9.0	31.5	19.7	-9.00
16-Jan-79	28871	9:30	-9.0	0.62	-9.000	-9.0	12.2	-9.0	-9	17	-9	151	119	-9	0.4	-9.0	30.3	3.6	-9.00
23-Jan-79	28878	9:15	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	179	124	-9	-9.0	-9.0	-9.0	-9.0	-9.00
30-Jan-79	28885	9:40	-9.0	0.50	-9.000	-9.0	15.8	-9.0	-9	12	-9	122	75	-9	0.4	-9.0	31.5	7.2	-9.00
06-Feb-79	28892	9:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	150	70	-9	-9.0	-9.0	31.0	2.7	-9.00
13-Feb-79	28899	9:30	-9.0	0.37	-9.000	-9.0	8.0	-9.0	-9	9	-9	105	82	-9	0.2	-9.0	31.5	3.4	-9.00
20-Feb-79	28906	9:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	1760	-9	-9	135	61	-9	-9.0	-9.0	32.0	-9.0	-9.00
27-Feb-79	28913	9:30	61.2	0.34	0.057	-9.0	7.1	22.9	-9	10	19	152	50	262	0.3	4.9	32.5	26.7	-9.00
06-Mar-79	28920	9:15	-9.0	-9.00	-9.000	36.7	-9.0	-9.0	364	-9	-9	191	181	-9	-9.0	-9.0	30.5	2.0	-9.00
13-Mar-79	28927	9:15	-9.0	0.73	-9.000	11.0	10.6	-9.0	925	10	-9	175	158	-9	0.4	-9.0	31.0	3.6	-9.00
20-Mar-79	28934	9:30	33.7	-9.00	0.038	27.2	-9.0	6.1	414	-9	2	294	285	28	-9.0	2.5	29.0	4.2	16.07
27-Mar-79	28941	9:30	-9.0	0.68	-9.000	50.7	9.7	-9.0	976	11	-9	138	77	-9	0.9	-9.0	32.0	11.7	-9.00
03-Apr-79	28948	9:30	3.3	-9.00	0.034	129.2	-9.0	3.6	432	-9	1	367	322	38	-9.0	1.3	-9.0	3.1	2.19
10-Apr-79	28955	9:45	-9.0	0.78	-9.000	86.5	10.4	-9.0	1898	11	-9	284	179	-9	0.3	-9.0	30.5	9.6	-9.00
17-Apr-79	28962	9:30	6.5	-9.00	0.084	15.2	-9.0	3.0	263	-9	2	244	152	56	-9.0	1.3	30.5	2.3	1.56
25-Apr-79	28970	9:45	-9.0	0.85	-9.000	-9.0	13.7	-9.0	556	9	-9	222	134	-9	0.5	-9.0	31.5	8.2	-9.00
01-May-79	28976	9:30	-9.0	-9.00	-9.000	158.3	-9.0	-9.0	1235	-9	-9	271	208	-9	-9.0	-9.0	-9.0	-9.0	-9.00
08-May-79	28983	9:40	-9.0	-9.00	-9.000	18.0	-9.0	-9.0	48	-9	-9	313	249	-9	-9.0	-9.0	-9.0	-9.0	-9.00
08-May-79	28983	11:55	-9.0	-9.00	-9.000	3.0	-9.0	-9.0	330	-9	-9	303	317	-9	-9.0	-9.0	-9.0	-9.0	-9.00
09-May-79	28984	9:30	-9.0	0.57	-9.000	24.0	11.7	-9.0	670	8	-9	249	165	-9	0.3	-9.0	30.5	2.3	-9.00
15-May-79	28990	9:40	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	269	197	-9	-9.0	-9.0	-9.0	-9.0	-9.00
22-May-79	28997	9:15	-9.0	0.50	-9.000	19.0	9.0	-9.0	1282	13	-9	323	232	-9	0.4	-9.0	30.5	6.6	-9.00
22-May-79	28997	12:10	-9.0	-9.00	-9.000	30.0	-9.0	-9.0	511	-9	-9	370	296	-9	-9.0	-9.0	30.0	-9.0	-9.00
22-May-79	28997	15:5	-9.0	-9.00	-9.000	40.0	-9.0	-9.0	601	-9	-9	311	277	-9	-9.0	-9.0	30.0	-9.0	-9.00
29-May-79	29004	9:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	240	218	-9	-9.0	-9.0	-9.0	-9.0	-9.00
05-Jun-79	29011	9:40	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	254	95	-9	-9.0	-9.0	-9.0	2.5	-9.00
12-Jun-79	29018	9:15	-9.0	0.43	-9.000	46.0	9.2	-9.0	611	12	-9	229	196	-9	0.4	-9.0	30.3	3.8	-9.00
19-Jun-79	29025	9:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	344	95	-9	-9.0	-9.0	-9.0	-9.0	-9.00
26-Jun-79	29032	9:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.0	-9	-9	-9	253	136	-9	-9.0	-9.0	-9.0	-9.0	-9.00
03-Jul-79	29039	9:45	-9.0	0.79	-9.000	36.0	9.0	-9.0	491	12	-9	282	248	-9	1.2	-9.0	31.5	1.5	-9.00
17-Jul-79	29053	9:10	-9.0	0.33	-9.000	31.0	6.6	-9.0	260	9	-9	117	122	-9	0.5	-9.0	31.0	1.5	-9.00
18-Jul-79	29054	9:35	10.1	-9.00	0.071	-9.0	-9.0	4.2	-9	-9	3	-9	-9	123.	-9.0	2.6	-9.0	-9.0	5.26
10-Aug-79	29077	15:20	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	-9	250	-9	-9.0	-9.0	-9.0	-9.00	-9.00

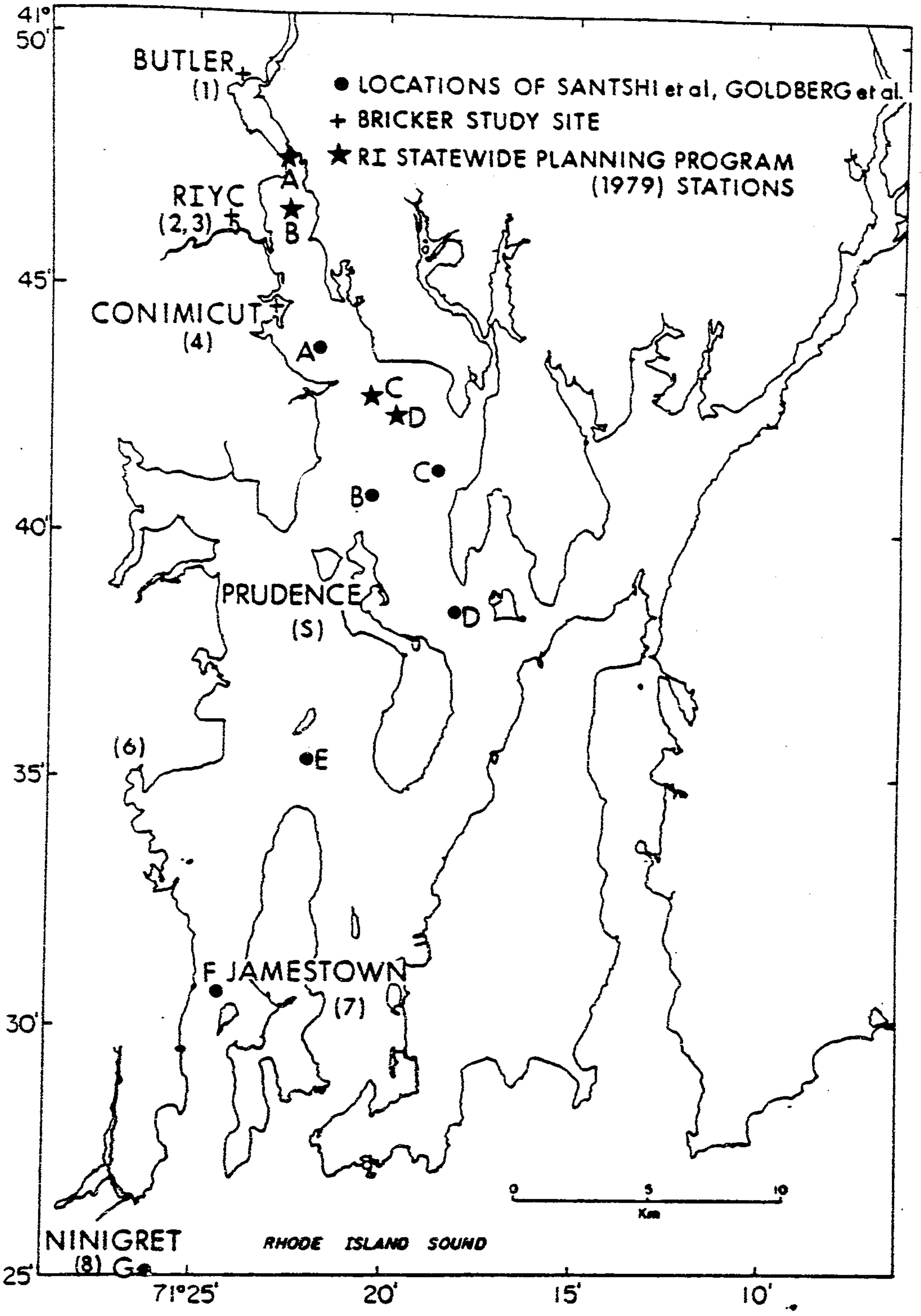
Date	NumDate	Time	AlP	CdD	CdP	CuA	CuD	CuP	FeA	FeD	FeP	MnA	MnD	MnP	PbD	PbP	Salt	TSM	ChlA
12-Aug-79	29079	09:00	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	401	352	-9	-9.0	-9.0	-9.0	-9.00	-9.00
13-Aug-79	29080	10:00	7.7	0.34	0.041	-9.0	11.2	3.30	-9	15	2	323	294	41	0.9	1.7	30.0	3.49	0.37
16-Aug-79	29083	09:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	217	132	-9	-9.0	-9.0	-9.0	-9.00	-9.00
20-Aug-79	29087	09:45	4.5	0.43	0.019	-9.0	7.5	1.97	-9	10	1	143	67	53	0.3	1.3	31.5	2.88	5.46
22-Aug-79	29089	15:45	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	201	215	-9	-9.0	-9.0	-9.0	-9.00	-9.00
27-Aug-79	29094	09:45	3.4	0.42	0.025	-9.0	7.5	1.45	-9	15	0	197	162	35	0.3	7.2	31.0	1.85	1.25
03-Sep-79	29101	09:15	3.1	0.70	0.128	-9.0	11.4	1.31	-9	16	1	188	139	48	0.6	0.6	31.5	3.61	-9.00
17-Sep-79	29115	09:45	2.3	0.67	0.030	-9.0	8.6	1.26	-9	35	1	165	130	32	0.3	0.7	31.0	1.90	4.87
30-Sep-79	29128	09:20	9.2	0.40	0.041	-9.0	12.1	5.19	-9	12	3	172	110	152	0.3	1.8	31.5	4.71	1.15
15-Oct-79	29143	09:15	7.5	0.39	0.024	-9.0	7.5	3.90	-9	15	2	175	87	53	0.5	1.4	30.5	3.71	0.88
30-Oct-79	29158	08:30	12.1	0.48	0.093	-9.0	9.7	5.47	-9	8	3	193	130	87	0.4	4.5	32.0	5.42	6.37
19-Nov-79	29178	09:30	5.3	0.42	0.033	-9.0	9.5	2.67	-9	51	1	249	226	26	0.5	0.3	31.5	2.33	0.46
29-Nov-79	29188	10:00	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	173	114	-9	-9.0	-9.0	-9.0	-9.00	-9.00
10-Dec-79	29199	09:30	4.7	0.31	0.070	-9.0	7.7	7.82	-9	20	1	135	135	19	1.0	3.6	31.0	2.35	1.22
20-Dec-79	29209	15:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	218	189	-9	-9.0	-9.0	-9.0	-9.00	-9.00
02-Jan-80	29222	10:30	7.2	0.61	0.752	-9.0	5.7	3.15	-9	18	2	142	78	34	0.3	0.9	31.0	3.39	21.79
10-Jan-80	29230	16:15	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	264	75	-9	-9.0	-9.0	-9.0	-9.00	-9.00
21-Jan-80	29241	09:00	9.6	0.72	-9.000	-9.0	11.4	2.10	-9	23	3	118	84	41	0.5	1.3	30.0	5.28	7.71
03-Feb-80	29254	10:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	96	71	-9	-9.0	-9.0	-9.0	-9.00	-9.00
10-Feb-80	29261	09:15	3.6	0.35	0.034	-9.0	17.3	4.63	-9	20	1	161	148	21	1.2	1.3	30.0	2.96	2.85
21-Feb-80	29272	14:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	188	137	-9	-9.0	-9.0	-9.0	-9.00	-9.00
09-Mar-80	29289	09:30	1.2	0.73	0.011	-9.0	16.6	1.24	-9	16	0	205	199	8	1.1	0.0	32.0	1.14	0.62
23-Mar-80	29303	09:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	461	412	-9	-9.0	-9.0	-9.0	-9.00	-9.00
30-Mar-80	29310	09:30	4.6	1.06	0.055	-9.0	19.2	4.78	-9	25	1	294	258	23	1.0	2.1	30.0	5.64	-9.00
09-Apr-80	29320	10:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	307	221	-9	-9.0	-9.0	-9.0	-9.00	-9.00
20-Apr-80	29331	09:00	4.4	0.66	0.039	-9.0	11.0	3.24	-9	8	1	318	316	28	1.0	1.7	30.0	2.59	2.05
30-Apr-80	29341	15:45	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	446	429	-9	-9.0	-9.0	-9.0	-9.00	-9.00
11-May-80	29352	09:40	21.7	0.43	0.058	-9.0	5.2	8.53	-9	4	6	207	143	85	0.5	3.2	32.0	8.91	3.60
22-May-80	29363	16:15	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	-9	-9	-9	-9.0	-9.0	-9.0	-9.00	-9.00
01-Jun-80	29373	10:20	12.3	0.34	0.053	-9.0	4.2	5.25	-9	7	4	188	146	58	1.1	1.9	31.5	6.57	1.03
11-Jun-80	29383	16:00	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	215	153	-9	-9.0	-9.0	-9.0	-9.00	-9.00
23-Jun-80	29395	09:15	3.3	0.50	0.052	-9.0	8.5	2.85	-9	13	1	136	122	66	1.1	5.3	31.5	2.77	2.08
06-Jul-80	29408	09:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	314	191	-9	-9.0	-9.0	-9.0	-9.00	8.47
13-Jul-80	29415	09:00	7.3	0.44	0.073	-9.0	8.2	5.77	-9	12	2	383	218	121	0.6	1.8	31.5	3.86	2.44
27-Jul-80	29429	09:00	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	209	113	-9	-9.0	-9.0	-9.0	-9.00	1.34
03-Aug-80	29436	09:30	4.7	0.52	0.054	-9.0	7.9	3.23	-9	9	1	171	147	28	0.6	0.5	31.5	2.59	2.67
17-Aug-80	29450	16:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	183	95	-9	-9.0	-9.0	-9.0	-9.00	3.30
24-Aug-80	29457	10:30	7.6	-9.00	0.077	-9.0	-9.0	3.46	-9	-9	2	165	-9	67	-9.0	1.0	31.0	3.34	2.22
07-Sep-80	29471	10:30	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	238	103	-9	-9.0	-9.0	-9.0	-9.00	2.75
16-Sep-80	29480	09:45	4.7	0.38	0.048	-9.0	8.4	2.29	-9	12	1	163	131	50	1.4	0.5	32.0	3.75	1.55
28-Sep-80	29492	10:00	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	192	139	-9	-9.0	-9.0	-9.0	-9.00	[illegible]
06-Oct-80	29500	10:15	3.8	0.47	0.069	-9.0	5.5	2.11	-9	9	1	159	102	29	0.5	1.0	32.0	2.26	2.23
04-Nov-80	29529	09:45	5.5	0.72	0.043	-9.0	9.0	5.50	-9	12	2	185	114	32	0.6	1.8	32.5	2.47	1.33
16-Nov-80	29541	10:15	-9.0	-9.00	-9.000	-9.0	-9.0	-9.00	-9	-9	-9	204	169	-9	-9.0	-9.0	-9.0	-9.00	[illegible]
23-Nov-80	29548	10:00	2.3	1.58	0.133	-9.0	9.3	1.80	-9	9	1	144	102	12	0.3	0.8	32.0	1.25	[illegible]

Appendix B. Trace metals in Narragansett Bay sediments

Site locations where cores were analyzed for historical variations in trace metal content.

Site	Latitude	Longitude
Salt marsh study sites of Bricker-Urso et al. (1988)		
1 (Butler Hospital)	41°49.21'N	71°23.85'W
2 a,b (R.I. Yacht Cl.)	41°46.57'	71°23.52'
3 (Conimicut Point)	41°44.51'	71°23.03'
4 a, b (Prudence Is.)	41°38.90'	71°21.17'
5 (Jamestown: Rnd Mrsh.)	41°35.35'	71°26.31'
6 (Ninigret Pond)	41°30.53'	71°22.26'
Open Bay study sites in Santschi et al. (1984)		
A	41°43.73'	71°21.88'
B	41°40.73'	71°20.51'
C (see core NAR 7408-2813, in Goldberg et al., 1977)		
D	41°38.51'	71°18.16'
E	41°35.35'	71°21.98'
F	41°30.79'	71°24.40'
Open Bay study sites in Goldberg at al. (1977)		
NAR 7408-2813	41°41.39'	71°18.75'

Site	Latitude	Longitude
Open Bay study sites in Myers and Phelps (1978)		
6 (Sabin Point)	41°44.90'	71°22'
5 (Conimicut Point)	41°43.66'	71°22'
4 (Rumstick Neck)	41°42.35'	71°19'
3 (Ohio Ledge)	41°40.53'	71°19'
2 (Warwick Neck)	41°38.00'	71°23'
1 (Jamestown)	41°34.92'	71°23'
Stations of the Rhode Island Statewide Planning Program (1979)		
A	41°47.4	71°22.8
B	41°46.4	71°22.6
C	41°42.7	71°20.2
D	41°42.4	71°19.3
Stations of the Corps of Engineers (From Seavey and Pratt, 1979)		
Field's Point	41°47.3	71°23.0
Pomham Rock	41°47.3	71°22.4
Pawtuxet Cove	41°45.1	71°23.1
Bullock's Cove	41°44.9	71°21.2
Conimicut Point	41°43.0	71°21.1
Brushneck Cove	41°41.5	71°24.8
Apponaug Cove	41°41.5	71°26.6
Warwick Cove	41°41.5	71°24.3
Greenwhich Cove	41°39.3	71°26.6
Wickford Cove	41°34.5	71°26.4
Newport Harbor	41°28.9	71°08.4


● LOCATIONS OF SANTSHI et al, GOLDBERG et al.
+ BRICKER STUDY SITE
★ RI STATEWIDE PLANNING PROGRAM (1979) STATIONS
BUTLER (1)
RIYC (2,3)
CONIMICUT (4)
PRUDENCE (5)
(6)
F JAMESTOWN (7)
NINIGRET (8) G
A
B
C
D
A
B
C
D
E
RHODE ISLAND SOUND
0
5
10
Km
41° 50'
45'
40'
35'
30'
25'
71°25'
20'
15'
10'

Trace metal concentrations in sediments from Narragansett Bay, collected in 1976. From Myers and Phelps (1978). Depth is in units of cm. Fe in units of percent; all other elements in units of ppm by dry weight. Concentrations at each depth were calculated by averaging all data from that depth presented by Myers and Phelps. Some analyses were of the bulk sediment, by neutron activation; others were of sediment leached with concentrated HNO_3, by atomic adsorption.

Sta.	Depth	Fe	Mn	Pb	Cu	Zn	Ni	Cr	Hg
6	.5	2.5	291	187	458	299	40	214	2.2
	4.5	2.9	342					203	
	5			79			15.5	69	
	9.5	3.2	359					323	
	10			251			41	303	
	15			195			32	266	
	19.5	2.8	416					172	
	29.5	3.0	365					128	
5	.5	2.0	266	119	269	242	29	134	
	4.5	2.1						37	
	5			146			37	164	
	9.5	1.4						59	
	19.5	2.1						40	
	27.5	2.3						42	
4	.5	2.9	291	109	193	195	27	136	
	4.5	4.8						218	
	5			77			28	86	
	9.5	4.1						190	
	19.5	4.1						150	
	29.5	4.1						82	
	39.5	3.8						71	

Sta.	Depth	Fe	Mn	Pb	Cu	Zn	Ni	Cr	Hg
3	.5	3.1	319	94	154	190	27	111	
	4.5	3.5						116	
	5			95			25	129	
	9.5	3.5						65	
	19.5	3.8						68	
	29.5	3.4						63	
	38.5	3.4						65	
	49.5	3.4						61	
2	0	1.54	230	33	54	87	11.4	53	
	5			25			7.9	42	
1	0.5	2.6	314	43	51	118	18	71	1.6
	4.5	3.0	401					129	
	5			49			21	58	
	9.5	3.9	383					131	
	10			51			20	58	
	14.5	4.1	387					87	
	15						16.6	47	
	19.5	2.6	412	38				132	

CORE A "Santschi et al, " 1984

Providence R. Core C-3

Depth (cm)	Pb µg/g	Zn	Cd	Cu	Cr	Mn	Fe mg/g	Co µg/g	Ni
1	149	232	1.3	250	178	185	17.6	6.9	38
2	145	258	1.4	265	180	178	18.2	6.9	43
3	147	282	1.3	370	172	168	21	10.1	32
11	156	326	1.5	525	206	147	22	7.5	29
14	133	300	1.5			138	13.8	5.5	
18	158	289	1.2	447	259	183	20	7.5	25
24	149	268	1.7	407	273	178	21	7.5	25
27	133	263	1.7	334	251	184	21	7.4	22

Trace metal concentration vs. depth in Core B (Ohio Ledge) from Santschi et al. (1984).

Depth (cm)	Pb µg/g	Zn	Cd	Cu	Cr	Mn	Fe mg/g	Co µg/g	Ni
1	145	260	1.1	232	161	221	29.1	8	32
2	145	267	1.1	233	158	225	27.5	8	30
3	131	268	1.1	223	127	212	25.4	6	28
4	134	266	1.5	218	126	212	25.4	7	26
5	134	252	1.1	213	140	208	22.7	7	29
6	134	279	1.4	244	138	218	25.6	8	29
7	130	242	1.1	234	110	160	22.6	10	25
8	134	271	1.4	251	136	208	24.8	7	24
9	141	292	1.6	299	150	209	25.6	7	27
10	144	272	1.2	309	168	208	26.7	8	25
11	138	285	1.8	339	163	216	27.3	3	20
12	140	243	1.2	323	160	150	23.1	9	22
13	135	261	1.7	317	166	203	25.6	7	19
14	121	241	1.6	266	143	183	23.5	4	20
15	138	271	1.5	303	190	208	26.3	7	22
16	171	295	2.4	274	153	204	26.2	6	22
18	98	274	1.8	206	124	186	24.2	7	22
20	102	263	2	232	137	195	26.7	8	20
22	111	279	2.5	232	138	196	24.8	12	19
24	121	281	1.6	231	161	203	26.5	7	18
26	124	311	2.3	231	160	222	27.4	7	19
28									
30	119	274	2.3	188	154	237	30.5	10	20
32	104	233	1.4	166	132	207	25.8	7	18
34	91	226	0.9	110	156	225	28	6	13
36	107	205	1	121	123	204	24.3	8	16
38	100	178	0.6	100	100			6	12
40	116	238	1.4	141	165	208	27	4	17
42	128	219	0.9	135	146	176	23.8	7	18
44	129	231	0.7	128	188	206	24.6	7	16
46	112	216	1.1	129	152	200	22.2	10	18
48	130	222	0.9	150	170	160	20.7	6	13
50	123	238	1.1	173	170	212	26.2	9	16
52	136	243	0.6	176	164	209	26.8	6	21
54	146	245	0.5	164	193	239	28.8	7	16
56	131	230	0.6	154	151	191	22.2	6	17
58	160	234	0.5	180	140	170	24.4	6	14
60	145	235	0.5	162	151	224	26.8	7	13
62		231	0.5	136	142	223	26.9	7	19
64	161	222	0.3	119	173	165	27.5	8	14
66	145	238	0.7	134	155	243	27.9	10	20
68	120	198	0.5	120	160	170	23.9	4	9
70	122	209	0.7	137	173	212	27.3	7	23
72	116	203	0.6	131	145	205	24.4	8	23
74	87	143	0.3	72	88	160	22.4	5	13
76	82	157	0.5	84	98	197	23.4	7	21
78	84	162	0.6	78	101	193	24.3	7	16
80	98	184	0.4	73	129	209	28	7	15
82	88	154	0.4	60	93	160	20.7	3	9
84	90	166	0.5	61	98	150	22.4	9	9
86	91	187	0.5	67	110	160	21.9	8	6
88	86	182	0.4	65	110	170	23.7	6	9
90	71	151	0.3	56	90	150	20.9	5	6
92	73	148	0.3	50	90	150	21.8	7	8
94	51	105	0.3	35	61	140	19.7	4	14
96	10	26	0.1	7	19	102	11.1	3	19

CORE E Santschi et al, 1984

n=4 cores

Composite core sta. 1

Depth (cm)	Pb µg/g	Zn	Cd	Cu	Cr	Mn	Fe mg/g	Co µg/g	Ni
0.5	42	87	0.25	39	62	151	14.6	5.7	14
1.5	43	92	0.24	41	57	134	14.5	5.9	14
2.5	46	92	0.22	41	53	131	15	6.4	15
3.5	46	92	0.22	41	70	133	15.7	5.8	15
4.5	45	90	0.22	40	70	133	15.6	6.3	15
5.5	43	89	0.21	37	69	138	16	7.2	16
6.5	41	84	0.22	35	67	142	16.2	5.6	14
7.5	38	78	0.21	29	55	137	15.7	6.4	14
8.5	35	77	0.21	27	58	143	16.8	6.4	15
9.5	34	76	0.22	27	57	142	17	6.6	14
10.5	33	74	0.23	26	56	143	17.5	7.3	14
11.5	31	70	0.21	23	53	145	17.1	6.1	14

Trace metal concentration vs. depth in Core F (Dutch Island) from Santschi et al. (1984).

Depth (cm)	Pb µg/g	Zn	Cd	Cu	Cr	Mn	Fe mg/g	Co µg/g	Ni
1	23	49	0.17	10	24	91	8	4	29
2	17	51	0.17	9	12	61	7.5	4	3
3	25	61	0.18	15	14	77	5.7	1	6
4	33	81	0.26	25	20	118	11.8	1	7
5	40	85	0.2	11	41	142	13.2	6	
6	28	60	0.2	10	16	100	9.9	1	4
7	27	65	0.2	10	18	100	11	1	5
8	31	71	0.18	10	24	108	11.7	6	6
9	29	61	0.17	10	16	98	10.2	1	5
10	27	65	0.13	3	35	119	10.1	5	7
11	22	60	0.17	11	17	95	13.5	2	5
12	20	47	0.17	10	13	75	9.4	2	3
13	14	43	0.15	9	13	72	11.4	1	5
14		38	0.12	8	13	73	9.5	1	5
15	22	42	0.1	8	26	91	10.9	4	4
16	15	31	0.12	9	11	71	9.4	4	4
18	11	30	0.1	6	10	64	8.5	3	3
20	5	30	0.1	6	8	65	8.9	2	5
22	8	23	0.08	4	8	60	7.2	2	3
24	16	32	0.09	6	23	83	10.1	4	2
26	7	30	0.15	5	8	65	8.2	2	4
28									
30	9	20	0.06	3	17	76	9	4	2
32	12								
34	12	21	0.05	3	20	85	10	4	
36									
38	3	20	0.09	4	7	73	8.4	3	4
40	12	25	0.06	6	20	96	10.1	2	
42	7	21	0.1	3	8	74	8.4	2	5
44	4	18	0.1	3	6	69	8.3	5	3
46	7	19	0.09	3	6	67	8.6	2	4
48	4	22	0.13	4	8	81	10	5	6
50	8	25	0.06	3	20	99	10.7	4	2
60	5	18	0.06	3	5	73	7.7	2	4
70	9	26	0.15	4	9	101	11.2	4	6
80	7	20	0.1	3	7	87	8.7	4	4
90	6	21	0.09	3	7	79	8.1	5	4
100	15	26	0.08	4	22	105	10.7	5	5

CORE G Santschi et al, 1984

Core C-10

Depth (cm)	Pb µg/g	Zn	Cd	Cu	Cr	Mn	Fe mg/g	Co µg/g	Ni
.5	14	37	.10	9	11	240	9.8	6.1	5
1	16	32	.088	6	9	150	7.9	6.0	6
2	11	32	.094	7	11	101	7.9	3.0	5
3	18	39	.12	9	12	80	8.6	5.5	6
4	17	43	.12	11	13	84	9.3	6.0	8
5	20	51	.13	14	16	102	11.1	6.4	9
7	19	47	.13	13	16	99	10.5	6.9	7
9	20	51	.14	15	17	108	11.2	7.4	8
11	24	55	.15	17	18	119	12.0	8.1	8
14	20	55	.16	16	17	117	12.5	7.1	9
17	23	49	.13	12	16	109	12.0	7.8	8
20	18	47	.13	10	14	104	11.6	7.3	7
24	14	40	.098	8	14	100	11.1	6.4	7

Trace metal concentrations vs. depth in a core from 41 deg. 41' N, 71 deg. 18'W

(from Goldberg et al., 1977)

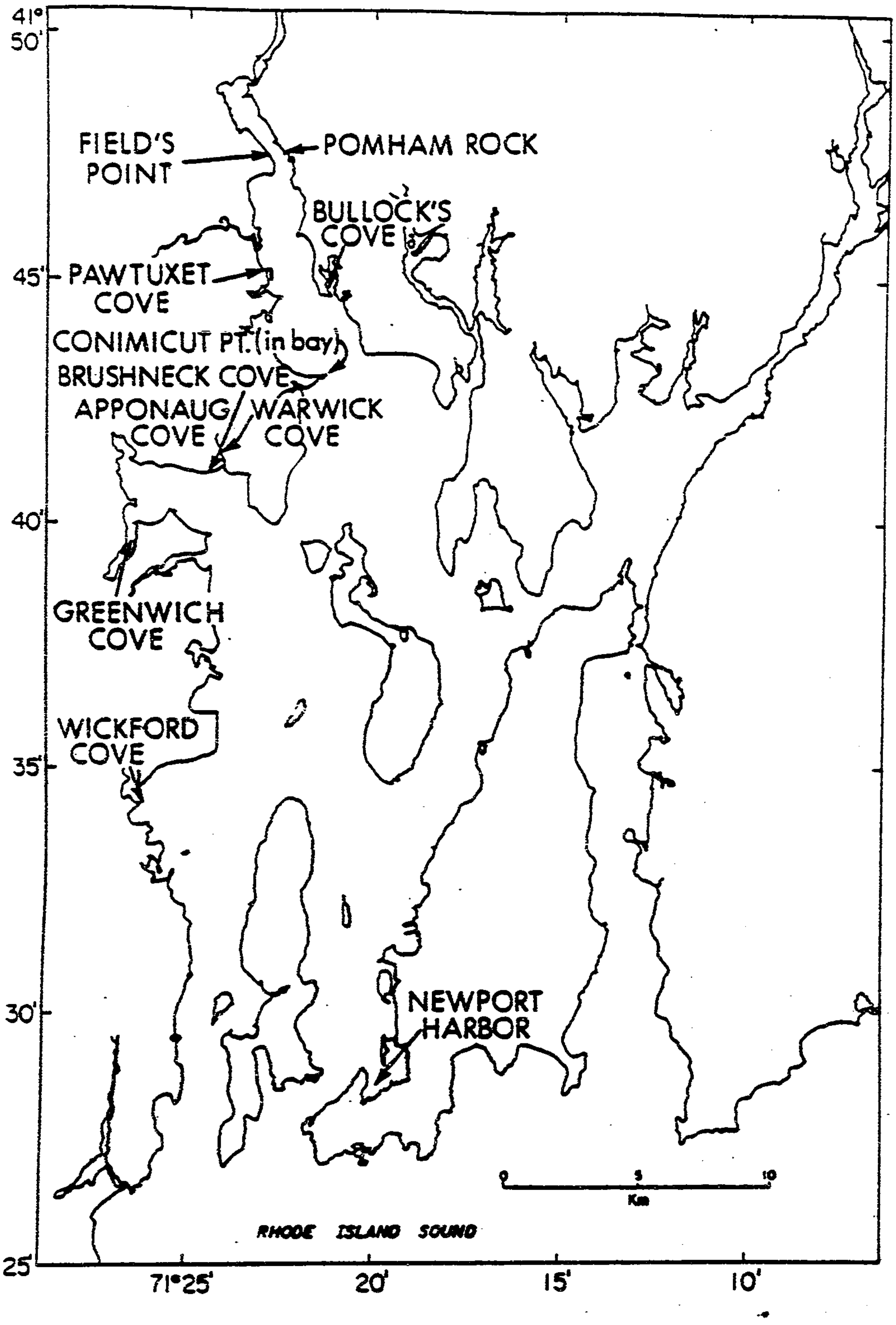
Depth (cm)	Pb µg/g	Zn	Cd	Cu	Cr	Mn	Fe mg/g	Co µg/g	Ni
1.5	140	250		190	155	410	33	8	28
2.5	140	250		190	170	380	30	8	28
3.5	130	235	0.7	190	150	390	33	10	33
4.5	130	260	0.8	220	170	410	35	7	34
5.5	130	250	0.8	220	160	435	34	8	30
6.5	120	250	0.8	210	170	430	33	8	33
7.5	130	260	0.6	210	160	440	34	9	32
8.5	125	260	0.8	200	160	430	33	9	30
9.5	130	260	0.7	200	180	420	34	8	24
10.5	125	250	0.6	200	185	410	33	10	22
11.5	130	260	0.6	200	170	420	34	11	29
12.5	125	260	0.6	190	180	420	33	10	27
13.5	135	250	0.7	195	180	420	32	8	23
14.5	120	250	0.7	190	170	430	33	9	23
16	100	230		140	150	390	30	8	24
18	90	210		130	140	360	28		20
20		220		130	180	370	32	6	22
22	100	240				400	33		21
24	140	240		140	195	400	34		21
26	155	240		130	210	365	33	6	21
28	140	250		150	190	415	32	6	24
30	105	205		110	150	380	28		20
32	110	180		87	120	375	28		16
34	90	140		57	93	390	27	8	21
36	70	100		39	88		28	7	20
38		90				390	30	8	22
40	40								
42.5	35	100		29	75	360	30		21
45.5		74					27	6	15
48.5		70		16	62	360	28	6	24
51.5	33								
54.5	13	77		17	67	410	29	7	15
57.5	13	60					29		15
61.5	10	67		14	62	390	29	6	20
66.5	13	64		13	65	400	29	6	22
71.5	12								
76.5	13	70		14	68	410	33	8	20

Seavey & Pratt, 1979

~~APPENDIX A~~

The following tables present the results of sediment sample tests undertaken by the Corps of Engineers in 13 Rhode Island dredging project areas. The tables give levels of metals and other polluting substances found in each sample. Corps of Engineers files in Waltham, Massachusetts, contain data on more variables than are listed here. At the bottom of each table is the classification given to each sample assigned by the authors in a process modeled on the Connecticut classification scheme. The suggested permissible range limits for each potential pollutant in each class are listed at the right of the tables. The classification method differs slightly from Connecticut's in that their two-step process (classifying metals and non-metal contaminants separately) has been combined. Summary classification results for each area are presented in Table 5 in Section III of this report.

All sediment components labeled with an asterisk (*) are in excess of Class III guidelines. In such cases, the entire sample has been designated Class III, which in the Connecticut scheme is described as "potentially degrading" or "potentially hazardous." Sediment components identified with a question mark (?) fall within Class II guidelines. If one or more components are found to be Class II, the entire core sample is so classified. The effects of these sediments on biological systems are questionable and, depending on the disposal site selected and disposal method used, can be either non-degrading or potentially degrading. Since in many cases only one sediment component has been identified as being in Class II or Class III, it is possible that the toxic effects of such materials would be low if other core samples from the same general area are of better quality. Class I sediments are considered non-degrading and non-hazardous and would be appropriate for a variety of disposal options.


FIELD'S POINT
POMHAM ROCK
BULLOCK'S COVE
PAWTUXET COVE
CONIMICUT PT. (in bay)
BRUSHNECK COVE
APPONAUG COVE
WARWICK COVE
GREENWICH COVE
WICKFORD COVE
NEWPORT HARBOR
RHODE ISLAND SOUND
41° 50'
45'
40'
35'
30'
25'
71°25'
20'
15'
10'
0
5
10
Km

AREA LOCATION: Apponaug Cove Warwick

Sediment Core #	PE-1		PE-2		PE-3		GE-4		PE-5		GE-5		GE-6				Conn. Sediment Class levels I	II (?)	III (*)
Sample Depth (Ft.)	0-0.8		0-1.2		0-1.8		surface		0-.5		surface		surface						
Sounding (Ft.)	7.9		9.6		9.2				7.9		7.9		10.2						
% Silt /Clay	29.8		48.3		100*		31.6				22		19.4				60	60-90	90
Sample Depth (Ft.)	0-.25	.6-.8	0-.25	1-1.2	0-.25	1-1.2	surf.		0-.25	.3-.5			surf.						
% Solids	25.7*	56.3?	36.8*	72.7	39.9*	50.9?	40.85?			65.8			64.7				60	60-40	4
% Volatile Solids	14.5*		10.03*		6.22?		7.2?		.98		No Data Supplied		1.66				5	5-10	
Hexane Soluble Fraction (ppt.)	7.5?		3.7		2.25		3.26		.33				1.04				5	5-10	10
Metals (ppm)																			
Mercury (Hg)	2.5*	.45	2.3*	.057	1.1?	.065	1.4?		.032	.061			.42				.5	.5-1.5	1.5
Lead (Pb)	777*	43	272*	83	160?	39	230*		33	21			56				100	100-200	200
Zinc (Zn)	855*	156	543*	44	265?	79	236?		38	27			62				200	200-400	400
Cadmium (Cd)	6.2?	1.4	6.5?	2.7	5.0?	3.1	5.9?		2.2	1.2			2.5				5	5-10	10
Chromium (Cr)	1127*	18	730*	48	370*	43	350*		33	15			46				100	100-300	300
Copper (Cu)	428*	85	217?	66	140	39	230?		27	15			43				200	200-400	400
Nickel (Ni)	78?	36	33	17	30	24	29		16	9.1			19				50	50-100	100
Vanadium (V)	94?	57	87?	44	115?	63	98?		43	49			71				75	75-125	125
Arsenic (As)	9.9	2.6	2.0	3.2	4.2	6.0	4.4		1.8	2.8			2.1				10	10-20	20
Suggested Classification	III	II	III	II	III	III	III		I	I			I						

AREA LOCATION: Block Island-Harbor of Refuge

Sediment Core #	GE-1-75	GE-2-75	GE-3-75	GE-4-75						Conn. Sediment Class levels		
Sample Depth (Ft.)	surface	surface	surface	surface								
Sounding (Ft.)	0	12.5	13.5	14.3						I	II (?)	III (*)
% Silt /Clay	3.0	5.3	15.8	1.6						60	60-90	90
Sample Depth (Ft.)	surf.	surf.	surf.	surf.								
% Solids	76.3	71.08	73.9	78.2						60	60-40	40
% Volatile Solids	.42	.64	.73	.36						5	5-10	10
Hexane Soluble Fraction (ppt.)	.21	.11	.16	0						5	5-10	10
Metals (ppm)												
Mercury (Hg)	.072	0	0	0						.5	.5-1.5	1.5
Lead (Pb)	26	34	35	10						100	100-200	200
Zinc (Zn)	18	24	24	15						200	200-400	400
Cadmium (Cd)	.5	.5	1.1	1.1						5	5-10	10
Chromium (Cr)	7.9	7.9	14	7.7						100	100-300	300
Copper (Cu)	16	16	16	10						200	200-400	400
Nickel (Ni)	26	13	14	13						50	50-100	100
Vanadium (V)	18	18	35	18						75	75-125	125
Arsenic (As)	.5	1.0	1.4	1.5						10	10-20	20
Suggested Classification	I	I	I	I								

AREA LOCATION: Block Island-New Harbor

Sediment Core #	GE-1	GE-2	GE-3	GE-4	PE-1					Conn. Sediment Class levels I	II (?)	III (*)
Sample Depth (Ft.)	surface	surface	surface	surface	0-0.3							
Sounding (Ft.)	19.4	4.0	19.0	19.5	19.4							
% Silt /Clay	15.6	3.1	9.4	0	11.4					60	60-90	90
Sample Depth (Ft.)	surf.	surf.	surf.	surf.								
% Solids	68.7	75.9	71.3	77.8	66.3					60	60-40	40
% Volatile Solids	1.94	.64	1.34	.17	1.67					5	5-10	10
Hexane Soluble Fraction (ppt.)	.64	.007	.26	ND	.51					5	5-10	10
Metals (ppm)												
Mercury (Hg)	.26	3.8*	.21	.2	.5					.5	.5-1.5	1.5
Lead (Pb)	34	19	15	18	1187					100	100-200	2
Zinc (Zn)	58	40	29	17	57					200	200-400	400
Cadmium (Cd)	1.3	.79	.84	.77	.72					5	5-10	10
Chromium (Cr)	7.6	4.7	5	4.6	10					100	100-300	300
Copper (Cu)	22	18	16	11	13					200	200-400	400
Nickel (Ni)	22	13	21	13	27					50	50-100	1
Vanadium (V)	23	26	28	21	36					75	75-125	25
Arsenic (As)	1.0	.11	.84	.31	2.4					10	10-20	2
Suggested Classification	I	III	I	I	I							

AREA LOCATION: Brushneck Cove

Sediment Core #	PE-1		PE-2		PE-3		PE-4		PE-5		PE-6		PE-7		PE-8		PE-9		Comm. Sediment Class levels		
Sample Depth (Ft.)	0-1.65		0-1.45		0-1.5		0-1.45		0-1.4		0-1.3		0-1.25		0-1.4		0-1.4		I	II (?)	III (*)
Sounding (Ft.)	5.0		6.9		5.7		5.1		6.1		4.9		4.5		4.5		3.0				
% Silt /Clay	56.5		81.5?		61.0?		63.6?		70.2?		58.5		57.5		70.9?		67.6?		60	60-90	90
Sample Depth (Ft.)	0-.25	1-1.2	0-.17	1-1.2	0-.17	1-1.2	0-.17	1-1.2	0-.17	1-1.2	0-.17	1-1.2	0-.17	1-1.2	0-.17	1-1.2	0-.17	1-1.2			
% Solids	57.1?	52.1?	42.2?	52.1?	73.3	53.7?	40.1?	57.7?	35.8*	40.2?	38.5*	50.1?	19.6*	55.8?	29*	62.2	45.9?	43.7?	60	60-40	40
% Volatile Solids	3.14		4.7?		1.22		6.73?		8.9?		6.59?		14.1*		9.5?		5.3?		5	5-10	10
Hexane Soluble Fraction (ppt.)	0.86		1.04		0.42		1.22		4.7		1.84		5.9?		3.0		1.81		5	5-10	10
Metals (ppm)																					
Mercury (Hg)	0.53?	0.11	0.64?	0.16	0.14	0.15	0.13	.035	.12	.093	.1	.08	.83?	.076	.69?	.06	.39	0	.5	.5-1.5	1.5
Lead (Pb)	53	19	57	12	33	19	100	17	168?	99	130?	20	204*	11	207*	16	100?	14	100	100-200	200
Zinc (Zn)	119	54	152	61	52	48	215?	31	357?	55	239?	58	408*	40	379?	45	174	87	200	200-400	400
Cadmium (Cd)	2.5	2.7	4.7	3.8	1.4	1.9	3.5	2.4	5.6?	5.0?	5.2?	2.0	10*	2.5	6.9?	2.3	4.9	2.3	5	5-10	10
Chromium (Cr)	60	35	81	35	19	34	145?	32	168?	45	119?	28	143?	22	110?	29	74	32	100	100-300	300
Copper (Cu)	74	35	85	46	46	11	85	14	190	99	130	36	204?	14	152	97	74	41	200	200-400	400
Nickel (Ni)	21	23	28	12	8.2	22	30	35	50?	15	42	24	82?	11	41	9.7	26	27	50	50-100	100
Vanadium (V)	35	38	24	38	27	37	50	35	56	50	52	40	102?	37	69	32	44	46	75	75-125	125
Arsenic (As)																			10	10-20	20
Suggested Classification	II	II	II	II	I	II	II	II	III	II	III	II	III	II	III	I	II	II			

AREA LOCATION: Bullock's Cove Providence R

Sediment Core #	PE-1		PE-2		PE-3		GE-1		GE-2		GE-3								Comm. Sediment Class levels		
Sample Depth (Ft.)																					
Sounding (Ft.)																			I	II (?)	III (*)
	N. Anchorage		N. Anchorage		S. Anchorage		Entrance		App. Channel		App. Channel										
% Silt /Clay																			60	60-90	90
Sample Depth (Ft.)	0-.1	1-1.1	0-.1	1-1.1	0-.1	1-1.1	0-.1		0-.1		0-.1										
% Solids																			60	60-40	40
% Volatile Solids	2.5	--	11.7*	--	10.7*	--	0.9		0.4		2.2								5	5-10	10
Hexane Soluble Fraction (ppt.)	1.6	--	4.1	--	11.7*	--	0.5		0.4		1.6								5	5-10	10
Metals (ppm)																					
Mercury (Hg)	1.6*	0.6?	0.82?	1.23?	1.21?	2.01*	0.17		0.14		0.39								.5	.5-1.5	1.5
Lead (Pb)	56	163?	87	259*	273*	222*	21		12		44								100	100-200	200
Zinc (Zn)	107	28	156	421*	528*	350?	54		31		123								200	200-400	400
Cadmium (Cd)																			5	5-10	10
Chromium (Cr)																			100	100-300	300
Copper (Cu)	129	295?	315?	712*	956*	746*	62		36		173								200	200-400	400
Nickel (Ni)																			50	50-100	100
Vanadium (V)																			75	75-125	125
Arsenic (As)																			10	10-20	20
Suggested Classification	III	II	III	III	III	III	I		I		I										

AREA LOCATION: Greenwich Cove

Sediment Core #	PE-1		PE-2		Conn. Sediment Class levels		
Sample Depth (Ft.)	0-1.8		0-1.25				
Sounding (Ft.)	15.8		14.6		I	II (?)	III (*)
% Silt /Clay	80?		78.2?		60	60-90	90
Sample Depth (Ft.)	0-.25	1-1.2	0-.25	1-1.2			
% Solids	39.2*	48.4?	33.0*	41.8?	60	60-40	40
% Volatile Solids	14*		8.44?		5	5-10	10
Hexane Soluble Fraction (ppt.)	5.1?		6.88?		5	5-10	10
Metals (ppm)							
Mercury (Hg)	1.6?	1.1?	2.0*	0.15	.5	.5-1.5	1.5
Lead (Pb)	143?	90	170?	64	100	100-200	200
Zinc (Zn)	510*	90	352?	100	200	200-400	400
Cadmium (Cd)	4.1	2.5	3.6	3.2	5	5-10	10
Chromium (Cr)	230?	41	212?	60	100	100-300	300
Copper (Cu)	184	58	194	48	200	200-400	400
Nickel (Ni)	31	21	31	24	50	50-100	100
Vanadium (V)	82?	66	164*	64	75	75-125	125
Arsenic (As)					10	10-20	20
Suggested Classification	III	II	III	II			

AREA LOCATION: Little Narragansett Bay

Sediment Core #	GE-1		GE-2		PE-3		PE-4		GE-5		PE-6		PE-7						Conn. Sediment Class levels		
Sample Depth (Ft.)	surface		surface		0-1.5		0-1.2		surface		0-1.65		0-1.5								
Sounding (Ft.)	1.2		9.9		9.3		9.7		9.0		5.0		11.5						I	II (?)	III (*)
% Silt /Clay	0.2		6.8		78.8?		21.4		5.3		1.9		89.7?						60	60-90	90
Sample Depth (Ft.)	surf.		surf.		0-.25	1-1.2	0-.17	1-1.2	surf.		0-.17	1-1.2	0-.17	1-1.2							
% Solids	91.6		76.9		29.0*	57.5?	70.2	79.2	80.7		78.4	83.0	34.2*	42.6?					60	60-40	40
% Volatile Solids	.13		.55		10.3*		1.47		.58		.42		8.43?						5	5-10	10
Hexane Soluble Fraction (ppt.)	0		.51		3.5		.48		.16		.17		2.49						5	5-10	10
Metals (ppm)																					
Mercury (Hg)	.033		0		.59?	.17	.08	0	0		0	.04	.83?	.51?					.5	.5-1.5	1.5
Lead (Pb)	6.5		7.8		69	35	20	7.6	17		18	17	76	61					100	100-200	200
Zinc (Zn)	8.7		26		151	77	28	20	13		10	7.2	158	108					200	200-400	400
Cadmium (Cd)	.9		1.0		4.8	1.4	1.1	1.0	.5		.5	1.0	.4	1.9					5	5-10	10
Chromium (Cr)	5.7		11		78	40	17	8.6	6.4		6.6	6.3	87	135?					100	100-300	300
Copper (Cu)	11		26		138	94	25	30	6.4		5.1	4.8	140	38					200	200-400	400
Nickel (Ni)	5		8.8		38	17	9.7	8.6	8.4		8.7	5.0	29	33					50	50-100	100
Vanadium (V)	13		16		5	22	17	15	5.0		15	29	70	56					75	75-125	125
Arsenic (As)																			10	10-20	20
Suggested Classification	I		I		III	II	I	I	I		I	I	III	II							

AREA LOCATION: Newport Harbor

Sediment Core #	PE-4		GE-5		GE-6								Conn. Sediment Class levels		
Sample Depth (Ft.)	0-0.7		surface		surface										
Sounding (Ft.)	24.2		25.0		19.6								I	II (?)	III (*)
% Silt /Clay	74.4?		27.4		27.0								60	60-90	90
Sample Depth (Ft.)	0-0.2	0.5-.7	surf.		surf.										
% Solids	42.8?		68.7		47.0?								60	60-40	40
% Volatile Solids	5.5?		1.97		4.68								5	5-10	10
Hexane Soluble Fraction (ppt.)	4.58		0.57		2.47								5	5-10	10
Metals (ppm)															
Mercury (Hg)	1.2?	.33	.47		.28								.5	.5-1.5	1.5
Lead (Pb)	200*	38	87		110?								100	100-200	200
Zinc (Zn)	410*	55	93		190								200	200-400	400
Cadmium (Cd)	0.1	0.1	0.1		.13								5	5-10	10
Chromium (Cr)	65	34	41		68								100	100-300	300
Copper (Cu)	150	16	38		110								200	200-400	400
Nickel (Ni)	56	34	32		60								50	50-100	100
Vanadium (V)	37	41	15		68								75	75-125	125
Arsenic (As)	4.2	0.2	1.2		.9								10	10-20	20
Suggested Classification	III	I	I		II										

AREA LOCATION: Pawtuxet Cove

Sediment Core #	PE-1		PE-2		GE-5		PE-3		PE-4						Conn. Sediment Class levels		
Sample Depth (Ft.)	0-2.0		0-1.75		Surface		0-1.85		0-1.7						I	II (?)	III (*)
Sounding (Ft.)	6.6		6.7		6.7		7.7		7.7								
	Mid-cove		South Cove		South Cove		Entrance Channel		Entrance Channel								
% Silt /Clay	98*	21	23		2.6		33.1	74.7?	19.1						60	60-90	90
Sample Depth (Ft.)	0-.25	1-1.2	0-.17	1-1.2	Surf.		0-.17	1-1.2	0.17	1-1.2							
% Solids	24.8*	54.4?	43?	72	85		52?	65	74	71					60	60-40	40
% Volatile Solids	17.6*	3.9	4.3	2.1	1.7		7.6?	3.2	1.3	2.3					5	5-10	10
Hexane Soluble Fraction.(ppt.)	2.4		1.63		.71		7.09?		.1						5	5-10	10
Metals (ppm)																	
Mercury (Hg)	2.51*	1.13?	.26	--	0		.98?	.14	.62?	.13					.5	.5-1.5	1.5
Lead (Pb)	565*	114?	82	25	54		195?	55	41	25					100	100-200	200
Zinc (Zn)	1250*	331?	192	39	85		459*	59	.57	96					200	200-400	400
Cadmium (Cd)	5.6?	1.8	0.9	0.6	0.7		2.7	0.9	0.5	0.9					5	5-10	10
Chromium (Cr)	565*	166?	69	11	49		191?	40	22	17					100	100-300	300
Copper (Cu)	1211*	294?	151	22	78		363?	74	62	51					200	200-400	400
Nickel (Ni)	178*	44	46	28	16		65?	31	27	20					50	50-100	100
Vanadium (V)	194*	55	37	22	35		57	46	22	42					75	75-125	125
Arsenic (As)	13?	2.4	3.9	1.8	0.7		3.6	5.2	1.2	1.7					10	10-20	20
Suggested Classification	III	II	II	I	I		III	II	II	I							

AREA LOCATION: Pt. Judith Harbor

Sediment Core #	GE-8	GE-9	GE-10	GE-11						Conn. Sediment Class levels I	II (?)	III (*)
Sample Depth (Ft.)	surface	surface	surface	surface								
Sounding (Ft.)												
% Silt /Clay										60	60-90	90
Sample Depth (Ft.)												
% Solids										60	60-40	40
% Volatile Solids	.41	.63	.18	.6						5	5-10	10
Hexane Soluble Fraction (ppt.)	.09	.1	.08	.23						5	5-10	10
Metals (ppm)												
Mercury (Hg)	.42	.32	.24	.31						.5	.5-1.5	1.5
Lead (Pb)	15	20	21	14						100	100-200	200
Zinc (Zn)	28	18	27	30						200	200-400	400
Cadmium (Cd)	2.4	8.5?	1.8	4.1						5	5-10	10
Chromium (Cr)	4.8	4.7	4.6	6.9						100	100-300	300
Copper (Cu)	19	23	13	17						200	200-400	400
Nickel (Ni)	16	21	19	12						50	50-100	100
Vanadium (V)	27	18	18	31						75	75-125	125
Arsenic (As)	.85	1.4	.66	1.9						10	10-20	20
Suggested Classification	I	II	I	I								

AREA LOCATION: Providence River

Sedimen. Core #	PE-1		PE-2		GE-3		PE-4		PE-5		PE-6		GE-7		PE-8		PE-9		Conn. Sediment Class levels		
Sample Depth (Ft.)	0-2.1		0-1.6		surface		0-2.1		0-1.6		0-1.0		surface		0-1.3		0-1.8		I	II (?)	III (*)
Sounding (Ft.)	37.7		38.7		39.5		41.2		39.2		39.2		41.6		43.5		43.5				
	Fields Pt.		Fields Pt.		Fields Pt.		Pomham Rock		Near Conimicut P.		Near Conimicut Pt.		Near Conimicut P.		Near Conimicut Pt		Near Conimicut Pt				
% Silt /Clay	80?		84?		55		97*		67.5?		21		21		49		35		60	60-90	9
Sample Depth (Ft.)	0-.25	1-1.2	0-.17	1-1.2	surf.		0-.17	1-1.2	0-.17	1-1.2	0-.17	1-1.2	surf.		0-.17	1-1.2	0-.25	1-1.2			
% Solids	23.9*		22.4*		44?		35*		53?		70		78		53?		29*		60	60-40	4
% Volatile Solids	16.3*		16.5*		7.9?		8.2?		4.0		1.3		1.5		3.5		2.5		5	5-10	1
Hexane Soluble Fraction (ppt.)	2.73	--	5.97?		1.01		9.61?		2.11		.63		.88		.92		.35		5	5-10	1
Metals (ppm)																					
Mercury (Hg)	1.82*	0.53?	1.57*	0.6?	0.97?		0.62?	0.38	0.29	0.42	.06	.03	.09		.44	.29	.09	.03	.5	.5-1.5	1.5
Lead (Pb)	836*	258*	632*	171?	237*		173?	131?	62	90	17	12	21		48	108?	16	14	100	100-200	20
Zinc (Zn)	1379*	442*	1174*	376?	551*		341?	--	122	178	41	33	42		98	171	44	39	200	200-400	400
Cadmium (Cd)	12.5*	5.9?	10.8*	4.8	7.6?		2.6	--	1.6	1.8	1.1	1.0	1.0		1.5	2.5	2.2	1.1	5	5-10	10
Chromium (Cr)	460*	133?	379*	116?	237?		175?	--	62	108?	11	7	13		41	87	16	14	100	100-300	1
Copper (Cu)	1358*	514*	1140*	429*	695*		437*	--	130	91	42	29	34		109	109	38	39	200	200-400	400
Nickel (Ni)	199*	41	144*	38	57?		22	--	39	18	8	10	8		19	25	16	5	50	50-100	10
Vanadium (V)	105?	22	90?	22	38		52	--	31	72	17	15	16		15	37	22	1	75	75-125	125
Arsenic (As)	64*	14?	42*	15?	24*		19?	—	6.2	14.3?	1.3	0.3	6.8		9.5	9.5	2.8	3.5	10	10-20	20
Suggested Classification	III	III	III	III	III		III	III	II	II	I	I	I		II	II	III	III			

AREA LOCATION: Warwick Cove

Sediment Core #	PE-1		PE-2		PE-3		CE-4		CE-5		PE-6		PE-7		PE-8		PE-9		Conn. Sediment Class levels		
Sample Depth (Ft.)	0-1.7		0-1.55		0-0.9		surface		surface		0-1.1		0-1.95		0-1.8		0-.8		I	II (?)	III (*)
Sounding (Ft.)	11.5		10.6		9.6		7.2		9.1		8.7		6.6		8.0		6.6				
% Silt /Clay	22.1?		22.2		61.9?		9.4		6.3		22.2?		73.7?		70.3?		52.2		60	60-90	90
Sample Depth (Ft.)	0-.25	1-1.2	0-.25	1-1.2	0-.25	.7-.9	surf		surf		0-.25	.9-1.1	0-.25	1-1.2	0-.25	1-1.2	0-.25	.6-.8			
% Solids	47.2?	55.4?	56.5?	56.0?	39.4*	55.9?	75.2		74.8		46.7?	72.6	41.8?	46.9?	33.9*	63.7	33.9*	65.8	60	60-40	40
% Volatile Solids	5.6?	4.0	2.7	2.87	7.36?	3.8	1.0		1.3		6.03?	1.06	7.2?	5.9?	8.3?	3.7	9.57?	1.0	5	5 10	10
Hexano Soluble Fraction (ppt.)	3.35	--	2.25	--	3.3	--	.69		.70		3.55	--	4.6	--	2.98	--	4.06	--	5	5-10	10
Metals (ppm)																					
Mercury (Hg)	.51?	0	.34	.18	.98?	.13	.12		.13		.8?	.008	.99?	.46	1.0?	0	1.6*	0.2	.5	.5-1.5	1.5
Lead (Pb)	115	36	57	36	127?	43	29		16		81	28	110?	43	159?	22	147?	37	100	100-200	200
Zinc (Zn)	424*	51	85	86	229?	79	43		43		227?	61	263?	115	230?	57	342?	77	200	200-400	400
Cadmium (Cd)	4.2	3.6	1.4	1.4	2.0	2.9	1.1		0.5		1.6	1.1	2.9	2.7	2.4	1.3	4.7	1.8	5	5-10	10
Chromium (Cr)	64	18	28	29	76	29	8		13		64	83	72	43	59	25	88	15	100	100-300	300
Copper (Cu)	127	29	57	43	112	36	32		21		120	28	153	60	142	25	165	37	200	200-400	400
Nickel (Ni)	34	18	18	21	31	18	33		13		34	14	24	21	21	19	47	18	50	50-100	100
Vanadium (V)	34	29	57	57	81?	43	32		32		34	42	77?	68	47	50	94?	37	75	75-125	125
Arsenic (As)																			10	10-20	20
Suggested Classification	III	II	II	II	III	II	I		I		II	II	II	II	III	II	III	I			

AREA LOCATION: Wickford Cove

Sediment Core #	PE-1		PE-2		PE-3		PE-4		PE-5		PE-6		GE-7			Conn. Sediment Class levels		
Sample Depth (Ft.)	0-1.4		0-1.25		0-1.9		0-1.9		0-1.2		0-1.55		surface			I	II (†)	III (*)
Sounding (Ft.)	8.0		6.6		7.7		8.8		6.8		7.9		12.3					
% Silt /Clay	66.5†		87.4†	66.6†	98.[illegible]*		88.1†		90*		71.3*		7.6			60	60-90	90
Sample Depth (Ft.)	0-.25	1-1.2	0-.25	1-1.2	0-.25	1-1.2	0-.25	1-1.2	0-.25	1-1.2	0-.25	1-1.2	surf					
% Solids	33.2*	50.5†	35.2*	50.6†	37.3*	43.8†	51.6†	46.7†	32.6*	56.7*	45.1†	52.2†	75.8			60	60-40	40
% Volatile Solids	8.54†		8.71†		6.82†		5.09	6.1†	9.16†	4.26	6.62†	4.47	1.5			5	5-10	10
Hexane Soluble Fraction (ppt.)	2.22		3.49		2.14		1.63		2.91		1.77		.22			5	5-10	10
Metals (ppm)																		
Mercury (Hg)	4.4*	0.57†	3.2*	1.4†	2.7*	3.4*	1.4†	0.18	0.64†	0.2	0.81†	0	0			.5	.5-1.5	1.5
Lead (Pb)	150†	32	170†	99	160†	37	89	51	123†	42	111†	31	26			100	100-200	200
Zinc (Zn)	235†	51	274†	119	236†	59	124	60	123	53	146	38	40			200	200-400	400
Cadmium (Cd)	7.2†	2.9	4.5	2.4	2.2	1.8	3.1	2.6	3.7	1.4	2.5	3.1	2.1			5	5-10	10
Chromium (Cr)	72	36	63	44	80	32	43	30	74	25	53	27	7.9			100	100-300	300
Copper (Cu)	157	24	159	55	150	46	77	34	110	21	80	23	26			200	200-400	400
Nickel (Ni)	36	24	34	59†	32	27	21	26	61†	21	27	23	16			50	50-100	100
Vanadium (V)	96†	48	91†	85†	85†	73	47	34	74	56	71	61	42			75	75-125	125
Arsenic (As)	6.0	0.3	6.8	1.6	6.4†	0.4	3.9	0.3	4.2	2.8	3.5	0.6	1.2			10	10-20	20
Suggested Classification	III	II	III	II	III	III	II	II	III	II	II	II	I					

In November 1978, the Army Corps of Engineers resampled the sediments within Pawtuxet Cove as part of the navigation maintenance and proposed marsh establishment project at Rock Island. Sediments from within the dredging source area as well as the disposal area were sampled to determine contaminant levels, grain size, etc. The following tables present the pertinent results of these analyses and, as in the tables in Appendix A, gives the authors' suggested classification of the sediment samples. These results can be compared to the previous Corps samples of Pawtuxet Cove taken in 1975 (see Appendix A). It is evident from both analyses that while Pawtuxet Cove does contain significant levels of contaminated sediments, pollutant levels decline substantially in the South Cove and in other sections some distance from the Pawtuxet River mouth. Also, it is interesting to note that some samples within the area to be dredged contain lower levels of contaminants than the samples in the designated disposal site.

AREA LOCATION: Pawtuxet Cove (Dredging Area) 11/20/78

Sediment Core #	GEB-1-78	GEB-2-78	GEB-3-78							Conn. Sediment Class levels		
										I	II (?)	III (*)
Sample Depth (Ft.)	surface	surface	surface									
Sounding (Ft.)	6.2	9.0	5.5									
	entrance	south cove	north cove									
% Silt /Clay	14.6	21.4	80.5?							60	60-90	90
Sample Depth (Ft.)	surf.	surf.	surf.									
% Solids	72.25	74.59	28.32*							60	60-40	40
% Volatile Solids	1.66	1.06	13.18*							5	5-10	10
Hexane Soluble Fraction (ppt.)	1.52	0.98	17.3*							5	5-10	10
Metals (ppm)												
Mercury (Hg)	0.17	0.16	1.4?							.5	.5-1.5	1.5
Lead (Pb)	94.1	21.5	466.1*							100	100-200	200
Zinc (Zn)	152.2	64.4	819.2*							200	200-400	400
Cadmium (Cd)	0.5	0.5	5.6?							5	5-10	10
Chromium (Cr)	66.4	21.5	197.7?							100	100-300	300
Copper (Cu)	105.2	37.5	494.4*							200	200-400	400
Nickel (Ni)	22.1	10.0	127.1*							50	50-100	100
Vanadium (V)	11.1	10.0	70.6							75	75-125	125
Arsenic (As)	1.1	2.2	12.2?							10	10-20	20
Suggested Classification	I	I	III									

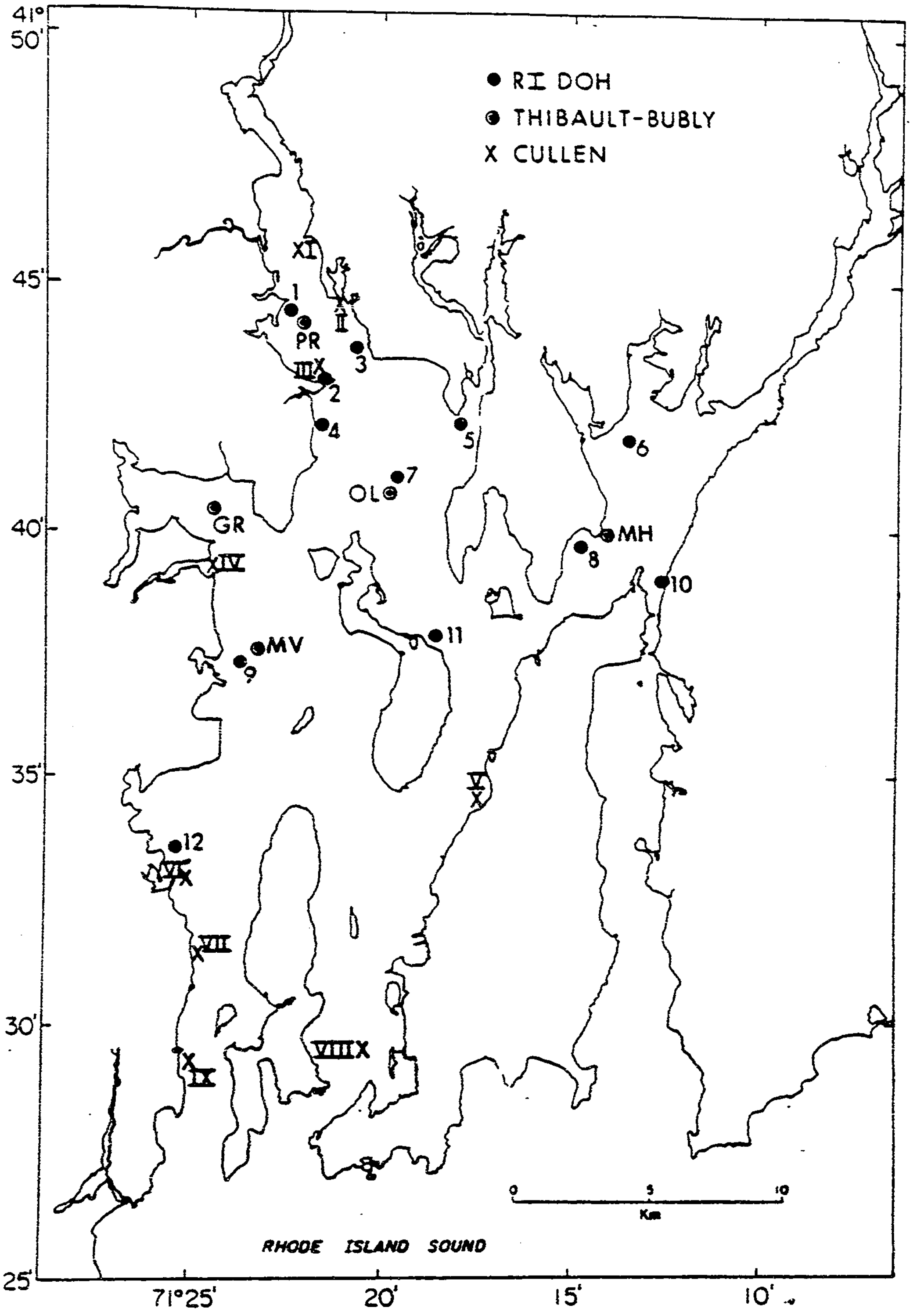
AREA LOCATION: Pawtuxet Cove (Proposed Disposal Area) 11/20/78

Sediment Core #	PE-1-78	PE-2-78	PE-3-78	PE-4-78						Conn. Sediment Class levels		
Sample Depth (Ft.)	0-2.4	0-2.2	0-1.7	0-2.0						I	II (?)	III (*)
Sounding (Ft.)	1.9	1.7	2.0	2.1								
% Silt /Clay	89.7?	84.0?	87.5?	79.9?						60	60-90	90
Sample Depth (Ft.)												
% Solids	42.39?	38.67*	48.49?	46.15?						60	60-40	40
% Volatile Solids	5.71?	7.27?	5.34?	5.44?						5	5-10	10
Hexane Soluble Fraction (ppt.)	1.42	5.54?	1.55	3.62						5	5-10	10
Metals (ppm)												
Mercury (Hg)	0.69?	1.5*	0.45	0.64?						.5	.5-1.5	1.5
Lead (Pb)	113.2?	239.9*	98.9	112.7?						100	100-200	200
Zinc (Zn)	245.3?	523.6*	185.6	273.0?						200	200-400	400
Cadmium (Cd)	2.8	4.4	0.5	2.6						5	5-10	10
Chromium (Cr)	160.4?	327.3*	107.7?	164.5?						100	100-300	300
Copper (Cu)	273.6?	763.6*	198.0	320.7?						200	200-400	400
Nickel (Ni)	37.7	87.3?	33.0	52.0?						50	50-100	100
Vanadium (V)	47.2	54.5	66.0	43.3						75	75-125	125
Arsenic (As)	8.0	7.9	6.5	6.0						10	10-20	20
Suggested Classification	II	III	II	II								

Concentrations of trace metals in samples from the surface of sediments in harbors and coves of Narragansett Bay (based on Corps of Engineers data summarized in Seavy and Pratt (1979)). Concentrations are given in parts per million.

Location	Mercury	Lead	Zinc	Cadmium	Chrom.	Copper	Nickel	Vanadium
Apponaug Cove	.032-2.5	33-777	38-855	2.2-6.5	18-1127	27-428	16-78	43-115
Brushneck C.	.12-.64	33-168	52-408	1.9-10	19-168	46-204	8-82	24-102
Bullock's C.	.14-1.6	12-273	31-528			36-956		
Greenwich C.	1.6-2.0	143-170	352-510	3.6-4.1	212-230	184-194	31	82-164
Little Narragansett Bay	0-.83	6.5-76	9-158	.4-4.8	6-87	5-140	5-38	5-70
Newport Harb.	.3-1.2	87-200	93-410	.1	41-68	38-150	32-60	15-68
Pawtuxet Cove	.3-2.5	41-565	57-1250	.5-5.6	22-565	62-1211	16-178	22-194
Pt. Jud. Har.	.24-.42	14-21	18-30	1.8-8.5	4.6-6.9	13-23	12-21	18-31
Prov. R.	.06-1.8	16-836	41-1379	1.0-12.5	11-460	34-1358	8-199	15-105
Warwick Cove	.12-1.6	16-159	43-424	.5-4.2	8-88	21-165	13-47	32-94
Wickford C.	.2-4.4	26-160	40-274	2.1-7.2	8-74	26-159	21-61	42-96

Appendix C. Trace metals in shellfish in Narragansett Bay


● RI DOH
◉ THIBAULT-BUBLY
X CULLEN
41°
50'
45'
40'
35'
30'
25'
71°25'
20'
15'
10'
1
2
3
4
5
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7
8
9
10
11
12
PR
OL
GR
MH
MV
I
II
III
IV
V
VI
VII
VIII
IX
0
5
10
Km
RHODE ISLAND SOUND

Cullen data Quahogs

Units: µg/g dry

Station	Lat-41	Sample	Mn	Fe	Zn	Cd	Pb	Cu	Ni
1	45.6	1	40.1	130	118	0.74	1.89	144	3.2
1	45.6	6	53.4	131	83	0.52	1.55	40	10.4
1	45.6	7	24	162	138	0.63	1.88	75.1	19.3
1	45.6	8	9.9	132	117	1.18	2.53	58	5.7
1	45.6	10	7.1	86	111	1	3.14	67.9	9.3
1	45.6	12	7.7	87	83	0.81	1.46	121.9	7.1
1	45.6	14	33.3	125	142	1.05	2.25	66.1	5
1	45.6	16	9	165	131	0.79	1.42	82.9	9.3
1	45.6	18	10.3	103	128	1.5	1.67	176	6.3
1	45.6	20	6.7	114	86	0.68	2.61	93.8	9.3
1	45.6	22	24	79	294	1.35	3.22	163.9	8.5
1	45.6	23	42.4	159	136	1.24	2.16	65.9	8.5
2	44.4	28	24.6	85	99	0.67	0.91	15.4	6.1
2	44.4	29	8.9	89	76	0.32	0.73	14.5	9.2
2	44.4	31	46.3	87	103	0.24	1.18	12.8	7.1
2	44.4	35	55.8	59	85	0.29	0.84	18.9	4.6
2	44.4	37	7.4	67	59	0.43	0.52	14.2	2.1
2	44.4	41	7.7	47	68	0.16	0.63	17	3.9
2	44.4	48	12.1	56	69	0.2	0.91	16.4	2.8
2	44.4	49	13	80	59	0.38	0.66	15.1	2.9
2	44.4	50	28.2	55	102	0.29	1.19	11.8	7.8
3	43.1	51	11.6	61	64	0.29	0.48	28	3.8
3	43.1	52	16	52	74	0.15	0.42	14.6	6.5
3	43.1	53	19.4	56	92	0.52	1.12	32.2	7.7
3	43.1	57	9.3	73	87	0.26	0.57	28	9.5
3	43.1	58		119	98	0.75	0.86	21.2	6.5
3	43.1	60	4.1	152	70	0.34	1.11	25	9.3
3	43.1	62	23.9	181	85	0.53	1.69	28.3	9.8
3	43.1	65	10	38	123	0.22	0.58	17.4	4.2
3	43.1	67	18.3	127	109	0.37	1.34	24.3	4.8
3	43.1	68	19.8	140	149	0.51	2.58	20.9	4.9
3	43.1	69	5.3	83	110	0.48	1.32	35.9	8.7
3	43.1	70	10.4	135	106	0.38	1.03	18.5	6.3
3	43.1	71	12.2	75	83	0.63	0.8	26.8	6.8
4	39.3	77	9.5	48	80	0.24	0.42	13.6	4.3
4	39.3	78	11.1	94	91	0.28	0.6	10.3	6.3

4	39.3	80	2.8	79	78	0.29	0.43	16.3	8.2
4	39.3	83	9.8	47	56	0.3	0.26	7.4	2.1
4	39.3	85	28.6	184	89	0.19	0.77	12.7	10.1
4	39.3	86	11.3	54	57	0.12	0.4	12.1	1.8
4	39.3	92	16.2	131	68	0.25	0.38	13.4	5.1
4	39.3	96	19.2	56	80	0.2	0.36	11.5	2.9
4	39.3	97	20.9	48	68	0.15	0.39	12.7	2.1
4	39.3	99	24.7	117	75	0.26	0.65	15.4	1.7
4	39.3	100	20.6	58	77	0.13	0.4	9.4	2.9
5	34.6	105	6.5	48	57	0.17	0.12	9.1	1.7
5	34.6	106							
5	34.6	108	19.7	145	58	0.13	0.16	9.4	5.1
5	34.6	109	6.8	75	62	0.2	0.25	11.4	5.1
5	34.6	111	6.5	313	52	0.18	0.47	10.5	3.1
5	34.6	113	3.8	102	49	0.12	0.25	9.3	1
5	34.6	115	11.2	48	61	0.25	0.09	7.8	3
5	34.6	117	13.4	81	58	0.12		8.1	2
5	34.6	118	9.3	78	66	0.12	0.11	8.4	2.2
5	34.6	119	4.5	43	51	0.38	0.1	8.1	1.8
5	34.6	120	14.1	47	66	0.23	0.64	9.7	1.9
5	34.6	122	8.1	64	56	0.17	0.14	9.6	2.8
5	34.6	123							
5	34.6	125							
6	33.1	152	20.7	205	106	0.24	0.7	17.8	4.4
6	33.1	155	61.2	191	78	0.75	0.86	16.3	7.2
6	33.1	157	12	173	61	0.28	0.35	16.3	5.6
6	33.1	159	14.2	65	61	0.23	0.18	14.3	2.9
6	33.1	161	44	156	79	0.3	0.71	10.6	4.8
6	33.1	165	40.9	154	86	0.41	1.41	17.2	5.3
6	33.1	166	18.1	94	76	0.24	0.46	13.7	4.5
6	33.1	167	7.3	69	83	0.47	0.21	17.3	5.8
6	33.1	168	17.2	99	86	0.27	0.47	9.9	7.6
6	33.1	170	36	82	94	0.39		14.7	6
6	33.1	171	18.8	155	67	0.57	0.47	9.8	3.3
6	33.1	175	18.9	180	62	0.23	0.43	14.7	5.1
7	31.5	178	43.9	578	112	0.23		17.4	6.6
7	31.5	179	13.1	250	79	0.31		12.1	3.4
7	31.5	185	3.4	74	79	0.37		10.6	7.2
7	31.5	187	51	269	82	0.32		11.1	3.4
7	31.5	189	10.7	204	65	0.36		11	3.8
7	31.5	191	32.6	436	87	0.26		13.9	4.5
7	31.5	192	16.7	415	59	0.29		11.5	2
7	31.5	193	27.9	297	83	0.35		18.8	8
7	31.5	195	15.3	426	57	0.52		16.8	5.8

8	29.5	12	6	51	65	0.24	8.8	1.7
8	29.5	12	1.9	66	57	0.24	10.3	1.9
8	29.5	13	3.3	69	57	0.38	10.1	2.1
8	29.5	13	2.5	68	59	0.42	12.6	0.9
8	29.5	13	2.3	76	54	0.3	11.1	1.9
8	29.5	14		56	61	0.17	8.9	1.8
8	29.5	14	4.1	72	63	0.4	11.9	3.3
8	29.5	14			46	0.23		1.9
8	29.5	14	4.9	64	64	0.21	10.6	1.5
9	29.2	206						
9	29.2	208						
9	29.2	209	18.3	215		0.32	13.6	2.6
9	29.2	210						
9	29.2	211	25.2	111	99	0.42	22.3	5.9
9	29.2	212	69.9	272	80	0.24	14.7	1.6
9	29.2	213	17.5	261	68	0.24	16.9	1.8
9	29.2	215	13.3	250	70	0.3	18.2	2.8
9	29.2	216	44.3	312	75	0.12	15.1	2.1
9	29.2	223	26.7	271	132	0.28	25	2.7
9	29.2	224	8	144	64	0.16	19.2	3.2

RI DOH DATA

Units: ppm wet wt.

Sta.	Year	Mo.	Time	Pb	Cd	Cr	Cu	Zn
1	1970	10	1970.79		0.08	1.14	3.6	20.6
1	1970	11	1970.88		0.07	0.95	10	20.49
1	1970	12	1970.96		0.09	0.99	5.04	19.6
1	1971	3	1971.21		0.08	0.97	4.51	21.7
1	1971	4	1971.29		0.09	0.93	4.01	20.5
1	1974	8	1974.62	3.11	1.02			
1	1974	10	1974.79	2.18				
1	1974	11	1974.88	2.1	0.29	0.28	8.6	18
1	1974	12	1974.96	0.31	0.2	0.56	13	47
1	1975	1	1975.04	0.28	0.28	0.77	16.4	17.6
1	1975	2	1975.12					
1	1975	3	1975.21					
1	1975	4	1975.29	1.1	0.26	0.35	7.9	22.6
1	1975	5	1975.38	1.9	0.24	0.52	7.53	
1	1975	6	1975.46					
1	1975	8	1975.62					
1	1975	10	1975.79	1.38	0.17	0.45	9.2	33
1	1975	11	1975.88	1.49	0.63	0.43	11.6	29.1
1	1975	12	1975.96					
1	1976	3	1976.21					
1	1976	4	1976.29	1.33	0.33	0.67	15.8	33.2
1	1976	5	1976.38	1.09	0.27		12.2	17.2
1	1976	6	1976.46	1.38	0.28	0.68		
1	1976	8	1976.62	0.89	0.22	0.73	5.7	20.6
1	1977	4	1977.29	2.72	0.41	0.64		33
1	1977	4	1977.29	0.85	0.21			
1	1977	5	1977.38	0.82	0.12			6.3
1	1977	6	1977.46					
1	1978	1	1978.04					
1	1978	3	1978.21	0.95		0.8	6.3	24.6
1	1978	4	1978.29	1.9		0.95	21.6	23.1
1	1978	5	1978.38	2.2		0.48	8.1	37.4
1	1978	7	1978.54	1.11			0.77	18.1
1	1978	9	1978.71	4.08		0.36	22.2	43.6
1	1978	11	1978.88					
1	1979	1	1979.04	0.21	0	0	2.25	18.8
1	1979	3	1979.21					
1	1979	4	1979.29	1.23		0.06	1.35	7.8
1	1979	5	1979.38	0.84		0.05	1.8	32.7
1	1979	6	1979.46	1.3		0.72	14	29.1
1	1979	7	1979.54	2.7		0.22	9.8	30.1
1	1979	8	1979.62	1.1		0.47	6.4	24.8
1	1979	10	1979.79	0.65		0.32	3.3	12.8
1	1979	12	1979.96	0.94		0.38	1.3	20.5

1	1980	2	1980.12	0.63	0.1	0.18	4.2	12.3
1	1980	3	1980.21	1.06	0.13	0.28	3.87	25.4
1	1980	4	1980.29	0.94	0.35	0.28	5.5	20.2
1	1981	7	1981.54	1.16	0.19	0.73	4.27	28.58
1	1981	8	1981.62	0.74	0.09	0.37	3.5	24.6
1	1981	11	1981.88	0.99	0.25	0.25	4	25.01
1	1981	12	1981.96	0.73	0.18	0.26	3.65	23.07
1	1982	2	1982.12	0.94	0.23	1.13	3.37	23.73
1	1982	4	1982.29	0.75	-0.05	0.43	3.45	18.38
1	1982	5	1982.38	0.74	0.16	0.97	2.55	24.83
1	1982	6	1982.46	0.54	-0.05	0.4	4.33	18.55
1	1982	7	1982.54	0.63	0.2	0.49	5.8	19.74
1	1982	8	1982.62	0.76	0.2	0.44	3.13	25.15
1	1982	12	1982.96	1.02	0.15	0.36	3.77	24.44
1	1983	1	1983.04	0.72	0.16	0.27	3.83	36
1	1983	1	1983.04	0.86	0.13	0.42	7.62	28.88
1	1983	2	1983.12	1.21	0.17	0.29	4.55	29.99
1	1983	3	1983.21	1.02	0.17	0.42	3.98	32.38
1	1983	4	1983.29	0.76	0.2	0.21	4.47	35.11
1	1983	6	1983.46	1.38	0.24	0.75	4.86	35.28
1	1983	7	1983.54	0.8	0.15	0.76	3.75	24.29
1	1983	8	1983.62	0.9	0.17	0.68	4.36	26.96
1	1983	10	1983.79	0.75	0.16	0.51	4.33	31.21
1	1985	7	1985.54	1.21	0.3	0.24	7.31	17.03
1	1985	8	1985.62	0.97	0.33	0.76	9.13	19.3
1	1985	11	1985.88	1.15	0.36	0.96	8.22	26.05
2	1970	10	1970.79		0.88	0.79	2.23	20.6
2	1970	11	1970.88		0.07	0.75	3.6	21.5
2	1970	12	1970.96		0.1	0.8	4.32	19.6
2	1971	3	1971.21		0.08	0.97	4.05	21.8
2	1971	4	1971.29		0.07	0.9	3.25	19.5
2	1974	8	1974.62	2	0.43			
2	1974	10	1974.79	0.73				
2	1974	11	1974.88	1.6	0.32	2.5	10.7	26.2
2	1974	12	1974.96	0.31	0.17	1.67	7.3	47
2	1975	1	1975.04	0.28	0.33	0.55	7.1	28.1
2	1975	2	1975.12					
2	1975	3	1975.21	0.92	0.22	0.5	9.34	25.5
2	1975	4	1975.29	1	0.25	1	4.2	15.3
2	1975	5	1975.38	0.7	0.22	0.72	4.67	
2	1975	6	1975.46					
2	1975	8	1975.62	0.76	0.28	0.82	8.4	
2	1975	10	1975.79	1.53	0.14	0.59	12.5	25.5
2	1975	11	1975.88	1.44	0.24	1.11	16.7	44.8
2	1975	12	1975.96					
2	1976	3	1976.21					
2	1976	4	1976.29	0.91	0.23	2.01	22.3	20.6
2	1976	5	1976.38	0.88	0.23		7	22

2	1976	6	1976.46	1.38	0.34	1		
2	1976	8	1976.62	0.8	0.34	0.39	11.8	25.5
2	1977	4	1977.29	1.17	0.25		10.3	17.4
2	1977	4	1977.29	0.31	0.16	0.42		
2	1977	5	1977.38	0.65	0.13	0.89	7.1	10.4
2	1977	6	1977.46					
2	1978	1	1978.04	1.13		0.69	7.9	18.6
2	1978	3	1978.21	1.85		1.1	10.4	31
2	1978	4	1978.29	0.84		1.8	10.1	15.8
2	1978	5	1978.38	1		1.18	12.4	21.1
2	1978	7	1978.54	1.2		11.1	1.7	22.4
2	1978	9	1978.71	4.08		0.36	13.4	41.1
2	1978	11	1978.88					
2	1979	1	1979.04	0.14	0.09	0.15	1.9	
2	1979	3	1979.21					
2	1979	4	1979.29	0.83		0.03	1.4	8.6
2	1979	5	1979.38	0.93		0.11	1.1	32.7
2	1979	6	1979.46	1.5		0.42	6.4	53.1
2	1979	7	1979.54	1.8		0.88	10.4	27.9
2	1979	8	1979.62	1.4		0.37	6.8	33.9
2	1979	10	1979.79	0.92		0.62	2.24	12
2	1979	12	1979.96	0.8		0.3	5.1	15.7
2	1980	2	1980.12	0.94	0.08	0.18	4.3	13.8
2	1980	3	1980.21	0.79	0.13	0.51	5.1	24.6
2	1980	4	1980.29	1.04	0.12	0.4	5.05	27.7
2	1981	7	1981.54	0.81	0.16	0.7	3.31	19.06
2	1981	8	1981.62	0.85	0.14	0.53	2.8	25.4
2	1981	11	1981.88	0.81	0.16	0.42	3.1	25.93
2	1981	12	1981.96	0.98	0.23	0.78	11.25	6.4
2	1982	2	1982.12	0.78	0.16	0.97	3.28	8.93
2	1982	4	1982.29	0.75	-0.05	0.52	3.51	21.36
2	1982	5	1982.38	0.85	0.16	0.75	3.88	26.15
2	1982	6	1982.46	0.85	0.15	0.46	3.36	24.45
2	1982	7	1982.54	0.58	0.15	0.56	4.15	20.19
2	1982	8	1982.62	0.43	0.14	0.56	2.91	20.06
2	1982	12	1982.96	0.85	0.23	0.36	4.79	27.93
2	1983	1	1983.04	0.98	0.25	0.65	3.74	32.43
2	1983	1	1983.04	0.57	0.13	0.78	3.22	23.13
2	1983	2	1983.12	1.1	0.12	0.46	4.66	32.6
2	1983	3	1983.21	1.34	0.24	0.96	3.79	38.73
2	1983	4	1983.29	0.7	0.2	0.52	3.41	37.77
2	1983	6	1983.46	1.01	0.24	0.88	3.28	34.42
2	1983	7	1983.54	1.23	0.15	0.71	3.31	25.14
2	1983	8	1983.62	0.69	0.19	0.83	2.92	27.42
2	1983	10	1983.79	0.89	0.16	0.49	4.2	24.94
2	1983	11	1983.88	0.41	-0.13	0.15	2.02	20.48
2	1984	1	1984.04	0.59	0.21	0.23	3.82	25.5
2	1984	2	1984.12	0.65	0.21	0.2	4.05	34.63

2	1984	3	1984.21	0.78	0.2	0.15	4.28	28.48
2	1984	7	1984.54	1.19	0.3	0.27	6	21.12
2	1984	8	1984.62	0.8	0.35	0.23	10.05	22.65
2	1984	11	1984.88	0.68	0.26	0.13	7.31	23.3
2	1985	2	1985.12	0.3	23.53		0.96	0.26
2	1985	3	1985.21	0.68	-0.13	0.54	2.2	40.11
2	1985	5	1985.38	0.63	0.22	-0.13	4.32	14.09
2	1985	7	1985.54	0.93	0.34	0.18	5.83	15.88
2	1985	7	1985.54	0.63	0.26	0.26	3.86	10.62
2	1985	8	1985.62	0.54	0.27	0.28	5.77	11.16
2	1985	11	1985.88	0.63	0.34	0.78	8.22	20.34
2	1985	12	1985.96	-0.25	0.23	0.26	3.6	14.03
3	1970	10	1970.79		0.23	0.88	2.11	22.7
3	1970	11	1970.88		0.07	0.85	4.32	20.9
3	1970	12	1970.96		0.07	0.79	4.72	20.6
3	1971	3	1971.21		0.81	0.81	4.01	21.1
3	1971	4	1971.29		0.07	0.84	3.21	13.4
3	1974	8	1974.62	1.42	0.26			
3	1974	10	1974.79	0.2				
3	1974	11	1974.88	2.7	0.32	2.5	11.4	54.8
3	1974	12	1974.96	0.62	0.14	1.33	16.1	35
3	1975	1	1975.04	0.28	0.07	0.42	5.54	21
3	1975	2	1975.12					
3	1975	3	1975.21	0.46	0.25	. 54	7.13	16.7
3	1975	4	1975.29	1.1	0.34	0.25	6.6	21.6
3	1975	5	1975.38	0.8	0.26	0.74	5.6	
3	1975	6	1975.46					
3	1975	8	1975.62	0.6	0.2		4.9	
3	1975	10	1975.79	0.98	0.21	0.43	9.1	24.7
3	1975	11	1975.88	1.13	0.33	2.99	14.1	25.3
3	1975	12	1975.96					
3	1976	3	1976.21					
3	1976	4	1976.29	1.48	0.17	0.37	10.9	31.9
3	1976	5	1976.38	1.04	0.33		11.5	18.7
3	1976	6	1976.46	0.74	0.27	0.54	16.6	
3	1976	8	1976.62	0.54	0.15	0.24	6.55	21.4
3	1977	4	1977.29	0.87	0.18		10.3	16.8
3	1977	4	1977.29	0.56	0.11	0.78		
3	1977	5	1977.38	0.59	0.16		10	15.7
3	1977	6	1977.46					
3	1978	1	1978.04	1.22		0.86	9.4	25.9
3	1978	3	1978.21	1.1		2.8	7	18.7
3	1978	4	1978.29	0.91		1.9	11.8	20.7
3	1978	5	1978.38	1.25		0.96	11.5	16.7
3	1978	7	1978.54	1.05		8.2	0.58	6.1
3	1978	9	1978.71	1.77		0.3	4.5	37.1
3	1978	11	1978.88					
3	1979	1	1979.04	0.68	0.02	0	2.49	14.8

3	1979	3	1979.21					
3	1979	4	1979.29	1.13		0.09	1.6	12.7
3	1979	5	1979.38	0.62		0.14	1	14
3	1979	6	1979.46	1.2		0.21	5.1	51
3	1979	7	1979.54	1.8		1	4.4	25.5
3	1979	8	1979.62	1.7		0.36	7.4	38
3	1979	10	1979.79	0.77		0.57	3.7	11.1
3	1979	12	1979.96	1.3		0.29	5	18.4
3	1980	2	1980.12	0.49	0.11	0.29	3.8	8.4
3	1980	3	1980.21	0.66	0.05	0.27	3.48	17.8
3	1980	4	1980.29	0.94	0.17	0.28	3.94	18.5
3	1981	7	1981.54	0.81	0.19	0.41	3.08	25.81
3	1981	8	1981.62	0.53	0.14	0.58	2.5	27.7
3	1981	11	1981.88	0.63	0.21	0.42	3.38	25.01
3	1981	12	1981.96	0.73	0.2	0.39	2.94	28.23
3	1982	2	1982.12	0.08	0.23	0.97	2.74	19.77
3	1982	4	1982.29	0.74	-0.05	0.21	2.74	18.2
3	1982	4	1982.29	0.46	0.13	0.46	2.45	19.87
3	1982	5	1982.38	0.74	0.16	0.57	3.3	22.65
3	1982	6	1982.46	0.46	0.15	0.41	2.61	17.04
3	1982	7	1982.54	0.84	0.15	0.49	5.8	30.24
3	1982	8	1982.62	0.71	0.2	0.56	3.79	18.04
3	1982	12	1982.96	0.68	0.17	0.45	3.49	23.86
3	1983	1	1983.04	0.6	0.19	0.47	2.93	19.65
3	1983	1	1983.04	0.86	0.17	0.49	3.73	23.12
3	1983	2	1983.12	0.89	0.17	0.44	2.68	24.45
3	1983	3	1983.21	1.02	0.17	0.49	3.07	3.04
3	1983	4	1983.29	0.7	0.2	0.76	3.98	18.49
3	1983	6	1983.46	0.69	0.22	0.77	3.31	25.58
3	1983	7	1983.54	0.8	0.17	0.92	17.5	20.52
3	1983	8	1983.62	0.95	0.19	0.77	2.78	24.71
3	1983	10	1983.79	0.7	0.21	0.59	3.38	26.66
3	1985	7	1985.54	8.45	0.26	1.1	6.21	15.03
3	1985	8	1985.62	0.76	0.4	0.7	9.32	12.65
3	1985	11	1985.88	1.28	-0.25	0.49	7.19	26.05
3	1985	12	1985.96	0.34	0.27	0.62	5.03	19.9
4	1970	10	1970.79		0.29	0.7	2.72	20.1
4	1970	11	1970.88		0.07	0.7	2.88	20.6
4	1970	12	1970.96		0.14	0.75	3.6	21.5
4	1971	3	1971.21		0.06	0.75	3.61	18.5
4	1971	4	1971.29		0.06	0.84	2.99	18.2
4	1974	8	1974.62	0.88	0.25			
4	1974	10	1974.79	0.22				
4	1974	11	1974.88	0.7	0.21	1.8	10	22.4
4	1974	12	1974.96	0.3	0.12	0.89	5.3	43
4	1975	1	1975.04		0.02	0.79	6	14.1
4	1975	2	1975.12					
4	1975	3	1975.21	0.37	0.42	0.82	4.58	21.8

4	1975	4	1975.29	0.8	0.19	0.25	3.7	19
4	1975	5	1975.38	0.7	0.19	0.23	4.05	
4	1975	6	1975.46					
4	1975	8	1975.62	0.4	0.28	2.86	4.3	
4	1975	10	1975.79	1.17	0.14	0.4	7.9	19.8
4	1975	11	1975.88	0.92	0.16	0.3	8.6	32.1
4	1975	12	1975.96					
4	1976	3	1976.21					
4	1976	4	1976.29	1.14	0.41	0.45	9.6	27.6
4	1976	5	1976.38	1.44	0.16		17.3	28.4
4	1976	6	1976.46	1.99	0.13	0.27	7.66	
4	1976	8	1976.62					
4	1977	4	1977.29	1	0.14	0.31	8	26.9
4	1977	4	1977.29	0.42	0.05	0.24		
4	1977	5	1977.38	1.1	0.16	1	8.3	15
4	1977	6	1977.46					
4	1978	1	1978.04	1.13		0.69	6.6	11.8
4	1978	3	1978.21	0.98		2.2	12	20
4	1978	4	1978.29	0.91		1.9	9.8	14.8
4	1978	5	1978.38	0.98		0.3	8.7	15.5
4	1978	7	1978.54					
4	1978	9	1978.71	2.48		0.48	9.81	45.9
4	1978	11	1978.88					
4	1979	1	1979.04	0.55	0.01	0	2.2	16
4	1979	3	1979.21					
4	1979	4	1979.29	0.69		0.12	1.3	6.7
4	1979	5	1979.38	0.53		0.02	1.1	27.5
4	1979	6	1979.46					
4	1979	7	1979.54	1.1		0.66	6.9	13.7
4	1979	8	1979.62	1.6		0.52	4.4	23.9
4	1979	10	1979.79	0.58		0.47	2.19	8.2
4	1979	12	1979.96	1.1		0.38	4.2	22.1
4	1980	2	1980.12	0.94	0.14	0.29	4.9	8.1
4	1980	3	1980.21	0.73	0.05	0.09	2.52	18.2
4	1980	4	1980.29	0.94	0.17	0.28	3.55	15.1
4	1981	7	1981.54	0.7	0.21	0.59	2.46	23.03
4	1981	8	1981.62	0.42	0.11	0.55	2.3	16.9
4	1981	11	1981.88	0.9	0.25	0.33	3.06	25.93
4	1981	12	1981.96	0.85	0.18	0.23	3.06	28.99
4	1982	2	1982.12	0.9	0.17	0.39	2.63	25.42
4	1982	4	1982.29	0.79	-0.05	0.27	3.24	21.74
4	1982	5	1982.38	0.43	0.14	0.44	2.48	21.78
4	1982	6	1982.46	0.54	-0.05	0.17	2.38	18.97
4	1982	7	1982.54	0.58	0.15	0.42	2.65	20.64
4	1982	8	1982.62	0.87	0.14	0.39	2.61	27.21
4	1982	12	1982.96	0.68	0.17	0.57	2.61	16.43
4	1983	1	1983.04	0.68	-0.05	0.42	3.09	21.85
4	1983	1	1983.04	0.77	0.16	0.34	2.55	25.39

4	1983	2	1983.12	0.78	0.15	0.29	2.47	22.35
4	1983	3	1983.21	1.24	0.17	0.22	3.04	32.38
4	1983	4	1983.29	0.6	0.13	0.54	3.28	24.02
4	1983	6	1983.46	0.79	0.22	0.38	2.77	30.59
4	1983	7	1983.54	0.91	0.17	0.92	3.13	30.29
4	1983	8	1983.62	1.05	0.19	1.03	2.98	21.58
4	1983	10	1983.79	0.65	0.18	0.27	2.59	11.75
4	1983	11	1983.88	0.52	0.13	0.27	2.75	33.34
4	1984	1	1984.04	1.52	0.28	0.81	6.35	37.71
4	1984	2	1984.12	0.99	0.3	0.55	6.5	40.01
4	1984	2	1984.12	1.48	0.27	0.64	17.53	44.4
4	1984	3	1984.21	0.94	-0.13	0.27	3.13	18.65
4	1984	6	1984.46	23.24	0.49		4.97	
4	1984	7	1984.54	1.42	0.23	0.3	4.6	24.92
4	1984	8	1984.62	1	0.24	0.33	7.38	23.73
4	1984	11	1984.88	1.38	-0.13	0.13	5.59	?
4	1984	12	1984.96	0.52	0.29	0.39	2.43	21.75
4	1985	2	1985.12	0.75	0.38	0.81	5.71	24.9
4	1985	3	1985.21	1.17	0.14	0.59	6.47	31.51
4	1985	5	1985.38	1.39	0.17	0.36	4.59	25.81
4	1985	7	1985.54	0.74	0.4	0.21	6.61	13.36
4	1985	7	1985.54	-0.63	0.24	0.19	4.67	12.28
4	1985	8	1985.62	0.79	0.22	0.7	5.53	14.5
4	1985	11	1985.88	0.5	0.29	0.64	5.15	21.29
4	1985	12	1985.96	-0.25	0.23	0.55	3.6	14.03
5	1970	10	1970.79		0.17	0.88	1.76	19.6
5	1970	11	1970.88		0.1	0.87	3.6	20.9
5	1970	12	1970.96		0.07	0.86	4.32	20.5
5	1971	3	1971.21		0.06	0.7	2.83	17.5
5	1971	4	1971.29		0.06	0.7	2.81	18.1
5	1974	8	1974.62	0.87	0.2			
5	1974	10	1974.79	1.32				
5	1974	11	1974.88					
5	1974	12	1974.96	0.43	0.14	0.59	4.5	33
5	1975	1	1975.04	0.45	0.19	0.25	5.2	27.5
5	1975	2	1975.12					
5	1975	3	1975.21		0.22	0.2	3.2	21.8
5	1975	4	1975.29	1.1	0.23	0.25	4.3	26.4
5	1975	5	1975.38	0.1	0.22	0.5	3.82	
5	1975	6	1975.46					
5	1975	8	1975.62	0.6	0.28	0.29	6.1	
5	1975	10	1975.79	0.95	0.24	0.83	10.5	24.8
5	1975	11	1975.88	0.93	0.1	0.2	11.1	26.1
5	1975	12	1975.96					
5	1976	3	1976.21					
5	1976	4	1976.29	0.8	0.13	0.13	8	18.9
5	1976	5	1976.38	1.04	0.2		12.5	20.8
5	1976	6	1976.46	0.54	0.27	7.88		

5	1976	8	1976.62					
5	1977	4	1977.29	0.82		0.8	9.3	19
5	1977	4	1977.29	0.71	0.09	0.29		
5	1977	5	1977.38	0.9	0.11	1		12
5	1977	6	1977.46					
5	1978	1	1978.04	0.71		0.48	7.7	27.3
5	1978	3	1978.21	0.77		0.53	8.1	17.9
5	1978	4	1978.29	1.14		1.4	11.8	23.9
5	1978	5	1978.38	1.06		0.44	8.1	12.1
5	1978	7	1978.54					
5	1978	9	1978.71	3.02		0.24	18.8	56.5
5	1978	11	1978.88					
5	1979	1	1979.04	0.68	0.05	0	1.2	20
5	1979	3	1979.21					
5	1979	4	1979.29	0.83		0.06	1.35	11.1
5	1979	5	1979.38	0.5		0.07	1	16.5
5	1979	6	1979.46	1		0.34	6.8	27.3
5	1979	7	1979.54	1.6		0.33	3.8	37
5	1979	8	1979.62	1		0.21	4	22.6
5	1979	10	1979.79	0.54		0.13	1.6	8.6
5	1979	12	1979.96	0.62		0.2	3.2	15
5	1980	2	1980.12	1.2	0.15	0.16	0.8	15.5
5	1980	3	1980.21	0.79	0.09	0.46	4.37	18
5	1980	4	1980.29	104	7	0.28	3.77	23.5
5	1981	7	1981.54	0.64	0.19	0.41	3.97	24.61
5	1981	8	1981.62	0.74	0.14	0.3	3	18.1
5	1981	11	1981.88	0.63	0.25	0.42	1.97	16.47
5	1981	12	1981.96	0.79	0.23	0.26	3.12	21.75
5	1982	2	1982.12	1.06	0.23	0.7	2.91	31.64
5	1982	4	1982.29	0.92	-0.05	0.27	2.56	21.74
5	1982	5	1982.38	0.59	0.16	0.35	2.3	18.34
5	1982	6	1982.46	0.54	0.13	0.23	2.38	36.74
5	1982	7	1982.54	0.69	0.2	0.38	3.17	17.52
5	1982	8	1982.62	0.59	0.14	0.75	2.25	15.55
5	1982	12	1982.96	0.74	0.15	0.36	2.96	20.41
5	1983	1	1983.04	0.49	0.16	0.27	1.92	22.51
5	1983	1	1983.04	0.59	0.13	0.42	2.47	16.2
5	1983	2	1983.12	0.67	0.15	0.19	1.94	21.94
5	1983	3	1983.21	1.02	0.17	0.29	2.18	23.47
5	1983	4	1983.29	0.81	0.18	0.58	2.95	24.42
5	1983	6	1983.46	0.85	0.2	0.42	3.02	25.99
5	1983	7	1983.54	0.85	0.17	0.5	2.6	20.94
5	1983	8	1983.62	0.74	0.17	0.46	3.43	10.3
5	1983	10	1983.79	0.56	0.16	0.32	2.08	22.9
5	1983	11	1983.88	0.63	0.18	0.21	2.47	22.58
5	1984	1	1984.04	1.05	0.32	0.37	12.49	31.81
5	1984	2	1984.12	0.94	0.27	0.39	4.05	40.56
5	1984	3	1984.21	0.99	0.27	0.37	4.28	24.2

5	1984	7	1984.54	1.19	0.26	0.57	5.46	24.92
5	1984	8	1984.62	0.92	0.31	0.55	5.87	24.81
5	1985	2	1985.12	0.53	0.43	0.68	4.59	20.32
5	1985	3	1985.21	0.97	0.16	0.21	4.52	23.8
5	1985	5	1985.38	0.52	0.34	0.33	3.63	17.27
5	1985	7	1985.54	-0.63	0.33	0.37	5.02	12.99
5	1985	8	1985.62	0.79	0.33	0.62	4.17	14.15
5	1985	11	1985.88	0.89	0.38	1.11	5.15	27.02
6	1970	10	1970.79		0.24	0.69	1.4	18.7
6	1970	11	1970.88		0.24	0.59	4.56	18.9
6	1970	12	1970.96		0.08	0.6	4.08	20.8
6	1971	3	1971.21		0.06	0.63	2.61	16.9
6	1971	4	1971.29		0.06	0.65	2.75	17.6
6	1974	8	1974.62	0.6	0.13			
6	1974	10	1974.79	0.89	0.35			
6	1974	11	1974.88		0.37	0.64	5.7	21
6	1974	12	1974.96	0.15	0.058	1	7.8	44
6	1975	1	1975.04	0.39	0.24	0.25	5.3	
6	1975	2	1975.12	0.54	0.31	0.55	7.1	22.4
6	1975	3	1975.21	1	0.36	5.6	0.67	21.1
6	1975	4	1975.29	1.4	0.26	0.46	7.2	46.7
6	1975	5	1975.38					
6	1975	6	1975.46	1.4	0.35	0.37	24	43
6	1975	8	1975.62					
6	1975	10	1975.79					
6	1975	11	1975.88					
6	1975	12	1975.96	0.4	0.21	0.6	2.4	
6	1976	2	1976.12	0.4	0.21	0.6	2.4	
6	1976	3	1976.21	0.93	0.3	0.47	8.9	35.6
6	1976	4	1976.29	1.76	0.28	0.41		
6	1976	5	1976.38	1.07	0.12	1.31	13.5	20.4
6	1976	6	1976.46					
6	1976	8	1976.62	0.94	0.22		7.7	27.3
6	1977	4	1977.29	0.88	0.49			21
6	1977	4	1977.29	0.28				
6	1977	5	1977.38	0.66	0.23	0.17	9.1	14.5
6	1977	6	1977.46	0.76	0.21	0.84	6.3	13
6	1978	1	1978.04	2.1		0.32	16.3	73
6	1978	3	1978.21					
6	1978	4	1978.29	1.9		0.69	6.3	26.5
6	1978	5	1978.38					
6	1978	7	1978.54					
6	1978	9	1978.71					
6	1978	11	1978.88			0.18	3.07	21.1
6	1979	1	1979.04		0.01	0	1.5	10.2
6	1979	3	1979.21	1.13		1.29	1.37	38.3
6	1979	4	1979.29					
6	1979	5	1979.38	0.91		0.12	1.19	28

6	1979	6	1979.46	0.62		0.53	3	17.3
6	1979	7	1979.54	1.47		0.43	0.178	40
6	1979	8	1979.62	1.6		0.16	3.6	
6	1979	10	1979.79	1.5		0.18	4.1	38
6	1979	11	1979.88	0.57		0.3	3.4	9.8
6	1980	1	1980.04					
6	1980	2	1980.12					
6	1980	3	1980.21		0.11	0.13	1.88	13.4
6	1980	4	1980.29					
6	1981	9	1981.71	0.98	0.24	2.69	0.4	25
6	1981	11	1981.88	0.92	0.22	0.46	2.2	24.31
6	1982	2	1982.12	0.88	0.23	0.22	1.69	29.09
6	1982	3	1982.21	0.51	0.19	0.23	1.69	19.12
6	1982	3	1982.21	0.83	0.22	0.2	1.62	25.25
6	1982	4	1982.29	0.65	0.15	0.4	2.01	23.16
6	1982	5	1982.38	0.75	0.17	0.21	2.48	26.76
6	1982	6	1982.46	0.85	0.23	0.98	2.68	28.29
6	1982	7	1982.54	0.66	0.22	0.54	1.94	22.84
6	1982	11	1982.88	0.87	0.32	0.32	2.46	23.12
6	1982	12	1982.96	0.53	0.17	0.19	2.65	18.31
6	1983	1	1983.04	0.42	0.15	0.28	1.88	19.31
6	1983	2	1983.12	0.67	0.12	0.42	2.25	23.61
6	1983	2	1983.12	0.36	0.17	-0.05	2.51	14.21
6	1983	3	1983.21	0.77	0.22	0.31	3.05	28.45
6	1983	4	1983.29	1.63	0.2	0.38	2.14	19.69
6	1983	4	1983.29	0.52	0.18	0.47	2.35	18.89
6	1983	6	1983.46	0.63	0.21	0.31	2.9	16.56
6	1985	11	1985.88	0.33	0.25	0.25	3.24	15.83
6	1986	1	1986.04	0.44	0.32	0.51	3.88	10
7	1974	8	1974.62	0.4	0.27			
7	1974	10	1974.79	0.89				
7	1974	11	1974.88	0.13	0.21	0.37	17.1	27
7	1974	12	1974.96	0.62	0.14	0.35	5.3	33
7	1975	1	1975.04	0.13	0.16	0.32	4.58	
7	1975	2	1975.12	1.12	0.27	0.74	15.3	23
7	1975	3	1975.21	0.9	0.17	0.28	2.6	14
7	1977	4	1977.29	1.87	0.32	0.9	9.8	19
7	1977	4	1977.29	0.91	0.16	0.64		
7	1977	5	1977.38	0.79	0.1	1	7.3	11.8
7	1977	6	1977.46					
7	1978	1	1978.04	0.98		0.64	7.5	20.6
7	1978	3	1978.21	0.43		0.41	3.5	8.7
7	1978	4	1978.29	0.86		0.97	17.5	11.5
7	1979	1	1979.04					
7	1979	3	1979.21	1.13		0.18	1.45	35.1
7	1979	4	1979.29					
7	1979	5	1979.38	0.61		0.12	1.03	25.5
7	1979	6	1979.46	0.74		0.26	5.4	22.2

7	1975	12	0.73	0.19	0.26	4.4		7
7	1978	11			0.12	2.05	16.05	

1976	8	0.48	0.15	0.42	3.93	12.8

7	1979	7	1979.54	0.99		0.36	2.28	13.2
7	1979	8	1979.62	1		0.53	5.4	24.5
7	1979	10	1979.79	0.56		0.25	3.63	24.3
7	1979	11	1979.88	0.79		0.24	3	21.2
7	1980	1	1980.04	0.7		0.22	3.64	21.3
7	1980	2	1980.12					
7	1980	3	1980.21	0.48	0.11	0.2	2.12	10.9
7	1980	4	1980.29					
7	1981	9	1981.71	0.69	0.19	2.63	0.4	17.78
7	1981	11	1981.88	0.79	0.22	0.41	2.2	23.38
7	1982	2	1982.12	0.97	0.19	0.29	1.85	23.33
7	1982	3	1982.21	0.98	0.18	0.3	2.35	22.72
7	1982	3	1982.21	0.75	0.14	0.31	2.54	23.17
7	1982	4	1982.29	0.74	0.13	0.4	2.29	20.17
7	1982	6	1982.46	0.6	0.17	0.37	2.25	18.34
7	1982	7	1982.54	0.82	0.17	0.3	2	17.07
7	1982	12	1982.96	0.63	-0.05	0.3	1.93	20.41
7	1983	1	1983.04	0.5	0.13	0.42	1.62	17.45
7	1983	1	1983.04	0.6	0.16	0.3	2.65	19.65
7	1983	3	1983.21	0.97	0.15	0.27	2.59	24.86
7	1983	4	1983.29	0.76	0.16	0.62	2.83	25.23
7	1983	6	1983.46	0.95	0.24	0.88	2.71	29.32
7	1983	7	1983.54	0.69	0.17	0.52	2.28	21.77
7	1983	8	1983.62	0.69	0.19	0.59	2.85	21.58
7	1983	10	1983.79	0.65	0.2	0.42	2.79	19.55
7	1983	11	1983.88	0.53	0.13	0.35	2.18	18.43
7	1984	1	1984.04	1.06	0.25	0.61	4.47	26.13
7	1984	3	1984.21	0.88	0.23	0.58	4	19.36
7	1984	6	1984.46	19.59	0.49		5.07	
7	1984	7	1984.54	22.97	0.76		4.09	
7	1984	8	1984.62	1.39	0.24	0.8	6.78	26.22
7	1984	11	1984.88	1.02	0.22	0.58	6.28	29.07
7	1984	12	1984.96	0.4	0.2	0.39	4.64	32.07
7	1985	1	1985.04	0.59	0.24	0.61	6.83	15.83
7	1985	3	1985.21	1.17	0.29	0.44	5.7	32.26
7	1985	6	1985.46	1.31	0.21	0.61	4.98	16.16
7	1985	7	1985.54	0.7	0.24	0.76	5.62	17.79
7	1985	8	1985.62	0.65	0.3	0.38	7.23	24.65
7	1985	11	1985.88	0.63	0.25	0.58	5.15	19.4
7	1985	12	1985.96	-0.25	0.25	0.44	3.4	11.77
8	1970	10	1970.79					
8	1970	11	1970.88					
8	1970	12	1970.96					
8	1971	3	1971.21					
8	1971	4	1971.29					
8	1974	8	1974.62	0.6	0.13			
8	1974	10	1974.79	0.44				
8	1974	11	1974.88			0.74	4.4	25

8	1974	12	1974.96					
8	1975	1	1975.04	0.39	0.27	0.94	6.19	
8	1975	2	1975.12	0.58	0.17	1.32	6.8	23.6
8	1975	3	1975.21	1.3	0.39	0.94	4.3	48.7
8	1975	4	1975.29	0.9	0.26	0.7	8.6	21.6
8	1975	5	1975.38	0.83	0.24			
8	1975	6	1975.46	0.43	0.21	0.64	6.6	32.7
8	1975	8	1975.62					
8	1975	10	1975.79					
8	1975	11	1975.88					
8	1975	12	1975.96	0.54	0.31	0.91	3.4	
8	1976	2	1976.12	0.54	0.31	0.91	3.4	
8	1976	3	1976.21	0.87	0.29	0.93	12.4	27.3
8	1976	4	1976.29	1.06	0.28	1.04		
8	1976	5	1976.38	1.14	0.25	0.81	14	36.8
8	1976	6	1976.46					
8	1976	8	1976.62	1.45	0.27	0.52	5.6	30.2
8	1977	4	1977.29	0.65	0.18	0.44	7.7	17.8
8	1977	4	1977.29	0.62				
8	1977	5	1977.38	0.5	0.27	0.35	4.1	11.9
8	1977	6	1977.46	0.76	0.06	1	10.3	8
8	1978	1	1978.04	1.13		0.53	7	18.9
8	1978	3	1978.21	0.91		0.25	4.3	13.2
8	1978	4	1978.29	0.34		1.7	6.6	12.8
8	1978	5	1978.38					
8	1978	7	1978.54					
8	1978	9	1978.71					
8	1978	11	1978.88	3.12		0.54	1.79	20.13
8	1979	1	1979.04					
8	1979	3	1979.21	0.83		0.04	1.1	66
8	1979	4	1979.29					
8	1979	5	1979.38	2.42		0.45	3.95	38.2
8	1979	6	1979.46	1.4		1.05	4.4	36.1
8	1979	7	1979.54	1.24		0.95	2	19.8
8	1979	8	1979.62	0.58		0.09	5	26.2
8	1979	10	1979.79					
8	1979	11	1979.88	0.78		0.43	3.52	31.3
8	1980	1	1980.04	0.4		0.51	2.4	9.1
8	1980	2	1980.12					
8	1980	3	1980.21	0.42	0.11	0.4	2.21	10.9
8	1980	4	1980.29					
8	1981	9	1981.71	0.34	0.34	2	0.55	27.88
8	1981	11	1981.88	0.92	0.25	0.76	3.48	28.99
8	1982	2	1982.12	0.88	0.19	0.47	1.91	20.3
8	1982	3	1982.21	0.75	0.18	0.53	2	21.09
8	1982	3	1982.21	0.6	0.16	0.46	1.61	14.77
8	1982	4	1982.29	1.08	-0.05	0.68	2.1	31.28
8	1982	5	1982.38	0.8	0.17	0.47	2.58	34.55

8	1982	6	1982.46	0.35	0.19	0.48	2.44	13.72
8	1982	7	1982.54	0.71	-0.05	0.4	1.88	13.52
8	1982	11	1982.88	0.65	0.23	0.54	2.29	16.02
8	1982	12	1982.96	0.53	0.17	0.36	2.26	19.22
8	1983	1	1983.04	0.58	0.15	0.28	1.61	18.72
8	1983	2	1983.12	0.36	0.13	0.2	2.1	13.22
8	1983	3	1983.21	0.63	0.15	0.47	2.05	28.94
8	1983	4	1983.29	0.58	0.18	0.32	1.87	18.76
8	1983	6	1983.46	1.23	0.19	0.57	3.25	12.61
8	1985	11	1985.88	-0.25	0.25	0.64	3.7	16.87
8	1986	1	1986.04	0.52	0.36	0.63	2.39	4.91
9	1970	10	1970.79					
9	1970	11	1970.88					
9	1970	12	1970.96					
9	1971	3	1971.21					
9	1971	4	1971.29					
9	1974	8	1974.62					
9	1974	10	1974.79					
9	1974	11	1974.88	0.7	0.25	0.8	4.9	25.2
9	1974	12	1974.96		0.12	0.22	5.7	8.3
9	1975	1	1975.04	0.68	0.2	0.6	4	35.5
9	1975	2	1975.12					
9	1975	3	1975.21					
9	1975	4	1975.29	0.8	0.16	0.38	4.9	21.6
9	1975	5	1975.38					
9	1975	6	1975.46					
9	1975	8	1975.62					
9	1975	10	1975.79	1.25	0.24	0.49	12.2	22.2
9	1975	11	1975.88					
9	1975	12	1975.96					
9	1976	2	1976.12					
9	1976	3	1976.21					
9	1976	4	1976.29	0.79	0.07	0.24		
9	1976	5	1976.38	1.74	0.12	0.51	15.7	20.8
9	1976	6	1976.46					
9	1976	8	1976.62	0.87	0.23		8.3	19.6
9	1977	4	1977.29	0.88	0.25	0.29	9.9	20.3
9	1977	4	1977.29	0.54				
9	1977	5	1977.38	0.94	0.37	0.77	7.5	31.4
9	1977	6	1977.46					
9	1978	1	1978.04	1.18		0.08	6.1	19.2
9	1978	3	1978.21	0.72		0.03	2.6	7.3
9	1978	4	1978.29	0.46		0.5	16.9	10
9	1978	5	1978.38					
9	1978	7	1978.54					
9	1978	9	1978.71					
9	1978	11	1978.88				2.18	19
9	1979	1	1979.04					

9	1979	3	1979.21					
9	1979	4	1979.29					
9	1979	5	1979.38	0.45		0.06	1.09	27.4
9	1979	6	1979.46	0.62		0.29	4.5	27.3
9	1979	7	1979.54	0.55		0.18	1.89	17.3
9	1979	8	1979.62	0.91		0.1	4.9	18.4
9	1979	10	1979.79	0.54		0.16	3.56	17.8
9	1979	11	1979.88	0.42		0.12	3.8	23.7
9	1980	2	1980.12					
9	1980	3	1980.21	0.59	0.11	0.13		13.4
9	1980	4	1980.29					
9	1981	9	1981.71	0.58	0.21	2.24	0.2	27.88
9	1981	11	1981.88	0.73	0.14	0.46	2.49	20.1
9	1982	2	1982.12	0.79	0.19	0.17	1.96	22.42
9	1982	3	1982.21	0.71	0.12	0.2	2.59	21.68
9	1982	3	1982.21	0.94	0.16	0.2	2.38	23.29
9	1982	4	1982.29	0.65	-0.05	0.17	1.87	18.2
9	1982	6	1982.46	0.41	0.17	0.37	2.48	22.61
9	1982	7	1982.54	0.87	0.17	0.71	2.84	23.68
9	1982	11	1982.88	0.51	0.15	0.35	2.29	24.42
9	1982	12	1982.96	0.36	-0.05	0.19	2.42	21.96
9	1983	1	1983.04	0.58	-0.05	0.19	2.42	21.67
9	1983	2	1983.12	0.48	0.17	-0.05	3.57	14.87
9	1983	3	1983.21	1.12	0.17	0.38	3.08	31.42
9	1983	4	1983.29	0.7	0.21	0.41	2.63	32.7
9	1983	6	1983.46	0.9	0.17	0.42	3.17	12.15
9	1983	11	1983.88	0.63	0.19	0.27	2.15	25.24
9	1984	1	1984.04	0.66	0.32	1.02	6.35	22.42
9	1984	2	1984.12	0.69	0.21	0.41	4.54	33.03
9	1984	3	1984.21	0.67	0.23	0.47	3.29	22.1
9	1984	6	1984.46	18.84	0.37		3.78	
9	1984	7	1984.54	1.27	0.34	0.93	5.25	22.8
9	1984	8	1984.62	0.8	0.35	0.58	6.24	19.1
9	1984	11	1984.88	0.98	0.26	0.58	5.12	30.6
9	1985	2	1985.12	0.69	0.49	0.57	4.87	30.06
9	1985	3	1985.21	0.97	0.14	0.23	5.48	30.77
9	1985	5	1985.38	0.57	0.22	-0.13	3.63	12.04
9	1985	7	1985.54	-0.63	0.24	0.93	3.52	9.97
9	1985	8	1985.62	0.79	0.3	0.73	4	18.78
9	1985	11	1985.88	0.54	0.38	1.14	6.17	21.93
9	1985	12	1985.96	-0.25	0.25	0.35	2.6	12.89
10	1974	8	1974.62	0.4	0.41			
10	1974	10	1974.79	0.89	0.17			
10	1974	11	1974.88	0.27	0.21	0.28	4.9	23
10	1974	12	1974.96					
10	1975	1	1975.04	0.26	0.16	0.76	5.23	-
10	1975	2	1975.12	0.72	0.21	0.45	6.8	20.7
10	1975	3	1975.21	0.8	0.15	0.34	4.6	31.4

10	1975	4	1975.29	0.7	0.21	0.56	5.7	21.6
10	1975	5	1975.38	0.81	0.16			
10	1975	6	1975.46	0.6	0.31	0.38	8.4	41
10	1975	8	1975.62					
10	1975	10	1975.79					
10	1975	11	1975.88					
10	1975	12	1975.96	0.33	0.2	0.19	3.2	
10	1976	2	1976.12	0.33	0.2	0.19	3.2	
10	1976	3	1976.21	0.81	0.17	0.33	7.7	24.3
10	1976	4	1976.29	2.28	0.2	0.25		
10	1976	5	1976.38	2.1	0.25	0.62	25.2	30.9
10	1976	6	1976.46					
10	1976	8	1976.62					
10	1977	4	1977.29	1.12	0.39	0.15		24.2
10	1977	4	1977.29	0.41				
10	1977	5	1977.38	0.9	0.4	0.4	5	25.4
10	1977	6	1977.46					
10	1978	1	1978.04	1.28		0.48	7.5	23.3
10	1978	3	1978.21	1.3		0.11	4.9	17.1
10	1978	4	1978.29	0.57		0.72	7.5	14.8
10	1978	5	1978.38					
10	1978	7	1978.54					
10	1978	9	1978.71					
10	1978	11	1978.88	0.052		0.18	1.41	20.4
10	1979	1	1979.04					
10	1979	3	1979.21	0.7		0	1.58	55.6
10	1979	4	1979.29					
10	1979	5	1979.38	1.21		0.06	0.94	24
10	1979	6	1979.46	1		0.48	6	34.2
10	1979	7	1979.54	1.04		0.37	2.46	32
10	1979	8	1979.62	0.52		0.16	4	17.1
10	1979	10	1979.79					
10	1979	11	1979.88					
10	1980	1	1980.04	3.2		0.32	6.6	82
10	1980	2	1980.12					
10	1980	3	1980.21	0.42	0.11	0.13	16.9	10.1
10	1980	4	1980.29					
10	1981	9	1981.71	0.81	0.19	2.09	0.4	24.51
10	1981	11	1981.88	0.86	0.25	0.58	1.99	21.51
10	1982	2	1982.12	0.57	0.19	0.34	1.59	21.51
10	1982	3	1982.21	0.6	0.1	0.21	0.72	6.82
10	1982	3	1982.21	0.87	0.18	0.22	2.09	21.98
10	1982	4	1982.29	0.69	0.13	0.46	1.78	20.66
10	1982	5	1982.38	0.65	0.15	0.29	2.32	20.09
10	1982	6	1982.46	0.85	0.17	0.37	2.61	23.04
10	1982	7	1982.54	0.76	0.19	0.5	2.21	20.35
10	1982	11	1982.88	0.8	0.32	0.43	2.51	19.88
10	1982	12	1982.96	0.83	0.17	0.44	2.81	35.88

10	1983	1	1983.04	0.75	0.17	0.37	2.18	17.55
10	1983	2	1983.12	0.6	0.17	0.15	2.2	14.54
10	1983	3	1983.21	0.77	0.15	0.38	2.37	26
10	1983	4	1983.29	0.64	0.21	0.58	2.72	22.54
10	1983	6	1983.46	-0.2	0.11	0.47	1.74	8.78
10	1985	11	1985.88	0.37	0.3	0.79	3.7	15.31
10	1986	1	1986.04	0.33	0.27	0.4	3.88	10.99
11	1974	8	1974.62	1.2				
11	1974	10	1974.79	0.85	0.17			
11	1974	11	1974.88					
11	1974	12	1974.96	0.37	0.046	0.62	4	38
11	1975	1	1975.04	0.52	0.16	0.57	4	
11	1975	2	1975.12	0.79	0.16	0.85	7.1	31.5
11	1975	3	1975.21	1	0.23	0.36	4.4	10.8
11	1975	4	1975.29	0.2	0.21	0.42	4.4	13.3
11	1975	5	1975.38	0.55	0.17			
11	1975	6	1975.46	1	0.22	0.552	6.9	37.2
11	1975	8	1975.62					
11	1975	10	1975.79					
11	1975	11	1975.88					
11	1975	12	1975.96	1.12	0.2	2.4	0.34	
11	1976	2	1976.12	1.12	0.2	2.4	0.34	
11	1976	3	1976.21	1.24	0.2	0.47	12.1	22.4
11	1976	4	1976.29	1.26	0.2	0.41		
11	1976	5	1976.38	0.7	0.13	1.34	9.9	16.7
11	1976	6	1976.46					
11	1976	8	1976.62	0.76	0.2	0.83	5.9	16.8
11	1977	4	1977.29	0.75	0.21	0.49	9	16.8
11	1977	4	1977.29	0.3				
11	1977	5	1977.38	0.9	0.43	0.73	5.6	26.3
11	1977	6	1977.46	0.98	0.073	0.56		12.7
11	1978	1	1978.04	1.6		0.24	6.8	20.7
11	1978	3	1978.21	0.72		0.17	1.9	4.4
11	1978	4	1978.29	0.63		1	9.1	17.8
11	1978	5	1978.38					
11	1978	7	1978.54					
11	1978	9	1978.71					
11	1978	11	1978.88			0.18	2.18	15.9
11	1979	1	1979.04					
11	1979	3	1979.21	0.87		0	1.94	34.7
11	1979	4	1979.29					
11	1979	5	1979.38	0.6		0.08	1.09	26.5
11	1979	6	1979.46	0.74			9.6	15.3
11	1979	7	1979.54	0.75		0.36	1.73	19
11	1979	8	1979.62					
11	1979	10	1979.79	0.54		0.3	4.94	16.1
11	1979	11	1979.88	0.6		0.17	2.3	16
11	1980	1	1980.04	0.59		0.4	3.6	16

11	1980	2	1980.12					
11	1980	3	1980.21	0.42	0.11	0.07	1.27	10.9
11	1980	4	1980.29					
11	1981	9	1981.71	0.63	0.16	2.06	0.25	18.75
11	1981	11	1981.88	0.79	0.22	0.61	2.84	22.91
11	1982	2	1982.12	0.75	0.19	0.15	1.85	18.48
11	1982	3	1982.21	1.04	0.16	0.2	2.39	24.35
11	1982	3	1982.21	0.89	0.18	0.23	1.44	20.45
11	1982	4	1982.29	0.99	0.13	0.23	2.31	18.69
11	1982	6	1982.46	0.79	0.19	0.29	3.39	30.51
11	1982	7	1982.54	0.66	0.14	0.3	1.82	10.64
11	1982	11	1982.88	0.51	0.23	0.24	2.29	14.75
11	1982	12	1982.96	0.53	-0.05	0.36	1.81	13.79
11	1983	1	1983.04	0.69	0.15	0.68	2.65	16.38
11	1983	2	1983.12	0.36	0.21	-0.05	2.62	13.55
11	1983	3	1983.21	1.05	0.15	0.74	2.53	24.54
11	1983	4	1983.29	0.64	0.21	0.4	2.85	18.76
11	1983	6	1983.46	0.77	0.14	0.52	2.63	11.47
11	1983	7	1983.54	0.68	0.19	0.55	3.86	22.71
11	1983	11	1983.88	0.43	0.17	0.44	2.21	15.12
11	1984	1	1984.04	0.81	0.23	0.49	4.01	20.26
11	1984	6	1984.46	0.73	0.2	0.85	4.53	14.8
11	1984	7	1984.54	19.39	1.17		6.31	
11	1984	7	1984.54	1.39	0.31	0.66	7.36	25.47
11	1984	11	1984.88	0.72	0.22	0.55	5.31	18.38
11	1984	12	1984.96	0.64	0.29	0.92	10.19	33.68
11	1985	1	1985.04	0.92	0.22	0.42	3.18	25.36
11	1985	3	1985.21	0.91	0.2	1.07	5.94	24.74
11	1985	6	1985.46	1.4	0.24	0.7	5.26	20.9
11	1985	7	1985.54	-0.63	0.3	1.02	6.06	16.79
11	1985	11	1985.88	0.54	0.36	0.73	5.53	20.94
11	1986	1	1986.04	0.63	0.27	0.54	5.43	11.32
12	1970	10	1970.79					
12	1970	11	1970.88					
12	1970	12	1970.96					
12	1971	3	1971.21					
12	1971	4	1971.29					
12	1974	8	1974.62	1.55	0.5			
12	1974	10	1974.79					
12	1974	11	1974.88					
12	1974	12	1974.96	0.12	0.14	0.53	3.2	36
12	1975	1	1975.04					
12	1975	2	1975.12					
12	1975	3	1975.21	1.2	0.19	0.22	3.7	16.5
12	1975	4	1975.29					
12	1975	5	1975.38					
12	1975	6	1975.46					
12	1975	8	1975.62					

12	1975	10	1975.79					
12	1975	11	1975.88					
12	1975	12	1975.96					
12	1976	2	1976.12					
12	1976	3	1976.21	0.62	0.32	0.22	8.9	21.2
12	1976	4	1976.29					
12	1976	5	1976.38					
12	1976	6	1976.46					
12	1976	8	1976.62					
12	1977	4	1977.29	1	0.23	0.74	9.9	19.3
12	1977	4	1977.29	0.25				
12	1977	5	1977.38					
12	1977	6	1977.46	1.37	0.16	0.46	9.9	14.7
12	1978	1	1978.04	0.75		0.45	5.3	12.5
12	1978	3	1978.21	0.77		0.38	6.5	21.6
12	1978	4	1978.29	1.67		1.17	24.3	23.8
12	1978	5	1978.38	2.2		0.93	13.6	23.3
12	1978	7	1978.54	1.1		6.4	1.11	24.4
12	1978	9	1978.71	1.77		0.42	10.57	41.9
12	1978	11	1978.88					
12	1979	1	1979.04					
12	1979	3	1979.21					
12	1979	4	1979.29	0.93		0.06	0.96	6.9
12	1979	5	1979.38	0.69		0.04		23
12	1979	6	1979.46					
12	1979	7	1979.54	1.4		0.22	3.5	31.8
12	1979	8	1979.62					
12	1979	10	1979.79	0.64		1.1	1.72	13.9
12	1979	12	1979.96	0.59		0.18	3.4	22
12	1980	2	1980.12	0.68	0.09	0.12	2.4	14.3
12	1980	3	1980.21	0.66	0.02	0.18	2.17	15.8
12	1980	4	1980.29	0.62	0.12	0.25	2.72	21.8
12	1981	7	1981.54	0.81	0.16	0.38	2.33	21.84
12	1981	8	1981.62	0.53	0.14	0.28	1.7	14.2
12	1981	11	1981.88	0.81	0.25	0.33	3.28	21.66
12	1981	12	1981.96	0.73	0.2	0.23	2.11	17.17
12	1982	2	1982.12	0.65	0.19	0.43	1.94	19.21
12	1982	4	1982.29	0.46	0.13	0.25	1.6	16.17
12	1982	5	1982.38	0.38	0.14	0.32	1.84	16.64
12	1982	6	1982.46	0.54	-0.05	0.43	1.8	14.84
12	1982	7	1982.54	0.63	0.15	0.24	3.24	19.3
12	1982	8	1982.62	0.43	0.14	0.35	1.62	11.61
12	1982	12	1982.96	0.57	0.15	0.21	1.55	17
12	1983	1	1983.04	-0.1	0.17	0.24	1.32	14.34
12	1983	1	1983.04	0.54	0.16	0.27	1.92	33.62
12	1983	2	1983.12	0.67	0.17	0.37	1.8	17.81
12	1983	3	1983.21	0.75	0.15	0.25	1.77	15.76
12	1983	4	1983.29	0.6	0.2	0.26	2.08	33.85

12	1983	6	1983.46	0.74	0.2	0.53	2.43	28.48
12	1983	7	1983.54	0.64	0.15	0.42	2.18	16.4
12	1983	8	1983.62	0.64	0.19	0.38	1.83	22.02
12	1983	10	1983.79	0.65	0.2	0.34	1.93	28.4
12	1983	11	1983.88	0.46	0.15	0.5	1.49	15.81
12	1984	1	1984.04	0.74	0.23	0.27	4.83	24.34
12	1984	2	1984.12	0.74	0.21	0.43	3.56	31.45
12	1984	3	1984.21	0.57	0.18	0.37	3.31	18.31
12	1984	6	1984.46	22.2	0.57		4.37	
12	1984	7	1984.54	2.36	0.13	1.37	25.16	36.7
12	1984	8	1984.62	0.8	0.27	0.57	4.37	28.42
12	1984	11	1984.88	0.86	0.29	0.58	5.85	30.6
12	1985	2	1985.12	1.01	0.38	0.38	6.28	20.53
12	1985	3	1985.21	0.8	0.13	0.23	4.1	28.26
12	1985	5	1985.38	0.39	0.15	0.31	3.14	13.53
12	1985	7	1985.54	-0.63	0.27	0.47	3.41	9.36
12	1985	11	1985.88	0.32	0.23	0.53	3.7	19.24
12	1986	1	1986.04	0.41	0.25	0.34	3.53	11.99
13	1981	9	1981.71	0.58	0.19	3.51	0.25	16.34
13	1981	11	1981.88	0.86	0.22	0.23	3.69	19.64
13	1982	2	1982.12	1.06	0.19	0.17	2.93	21.21
13	1982	3	1982.21	0.95	0.16	0.22	1.82	14.55
13	1982	3	1982.21	1.02	0.18	0.13	2.76	15.34
13	1982	6	1982.46	0.54	0.21	0.34	10.17	17.07
13	1982	7	1982.54	0.76	0.17	0.3	3.45	12.63
13	1982	11	1982.88	0.72	0.15	0.47	2.51	15.39
13	1982	12	1982.96	0.71	0.21	0.27	3.46	36.82
13	1983	1	1983.04	0.47	0.2	0.65	2.85	16.38
13	1983	2	1983.12	0.72	0.19	-0.05	3.04	13.88
13	1983	3	1983.21	1.26	0.15	0.16	4.11	26.98
13	1983	4	1983.29	0.7	0.25	0.38	4.09	24.84
13	1983	6	1983.46	1.17	0.19	0.42	4.19	13.3
13	1983	11	1983.88	0.62	-0.13	0.37	2.98	19.17
13	1984	1	1984.04	0.75	0.29	0.23	4.47	22.57
13	1984	3	1984.21	0.95	0.25	0.28	4.48	22.17
13	1984	6	1984.46	7.6	0.22	0.41	12.29	24.08
13	1984	7	1984.54	24.33	0.56		5.36	
13	1984	8	1984.62	1.26	0.31	0.39	8.53	17.04
13	1984	11	1984.88	1.21	0.35	0.39	7.26	20.4
13	1984	12	1984.96	-0.13	0.29	0.24	6.86	26.48
13	1985	1	1985.04	0.72	0.24	0.1	5.6	16.15
13	1985	3	1985.21	0.65	0.31	0.27	5.82	20.82
13	1985	6	1985.46	1.88	0.28	0.26	5.35	15.59
13	1985	7	1985.54	-0.63	0.3	0.41	5.84	9.94
13	1985	11	1985.88	0.43	0.33	0.25	6.21	20.04
13	1986	1	1986.04	0.22	0.3	0.31	5.31	10.66
14	1982	11	1982.88	-0.1	0.15	0.17	2.46	12.85
14	1982	12	1982.96	0.77	0.17	0.14	2.26	16.5

14	1983	1	1983.04	0.47	-0.05	0.16	1.54	14.06
14	1983	2	1983.12	-0.1	0.21	-0.05	1.6	11.25
14	1983	3	1983.21	0.7	0.13	0.14	1.44	27.96
14	1983	4	1983.29	0.58	0.18	0.32	1.37	13.22
14	1983	6	1983.46	0.83	0.17	0.26	1.74	8.78
14	1983	11	1983.88	0.53	0.13	0.13	1.66	19.17
14	1984	1	1984.04	0.87	0.25	0.23	3.08	20.58
14	1984	3	1984.21	1.03	0.27	0.38	3.23	16.59
14	1984	6	1984.46	1.64	0.25	0.25	3.43	19.19
14	1984	7	1984.54	21.61	0.25		4.28	
14	1984	8	1984.62	1.66	0.31	0.63	5.62	21.39
14	1984	11	1984.88	0.84	0.28	0.33	4.12	15.2
14	1985	1	1985.04	0.52	0.19	0.47	1.98	13.62
14	1985	3	1985.21	0.86	0.29	0.24	4.2	18.17
14	1985	6	1985.46	2.36	0.23	0.29	3.8	16.74
14	1985	7	1985.54	1.1	0.28	0.35	3.02	3.57
14	1985	11	1985.88	0.37	0.3	0.33	3.15	14.53
14	1986	1	1986.04	0.71	0.3	0.31	3.19	5.53

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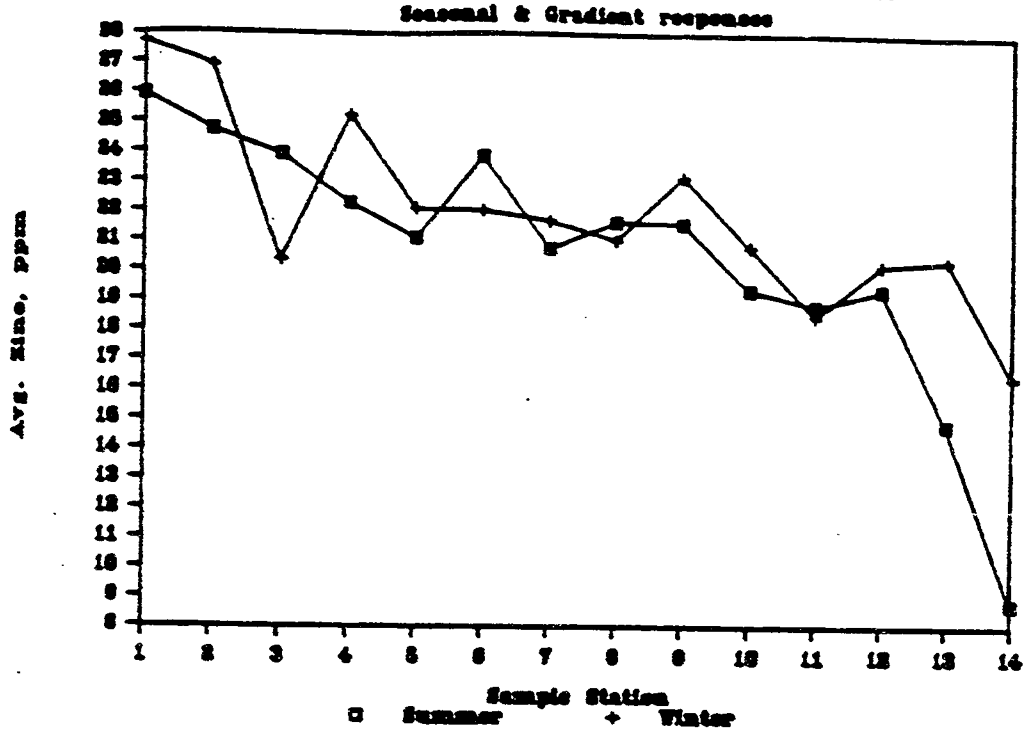

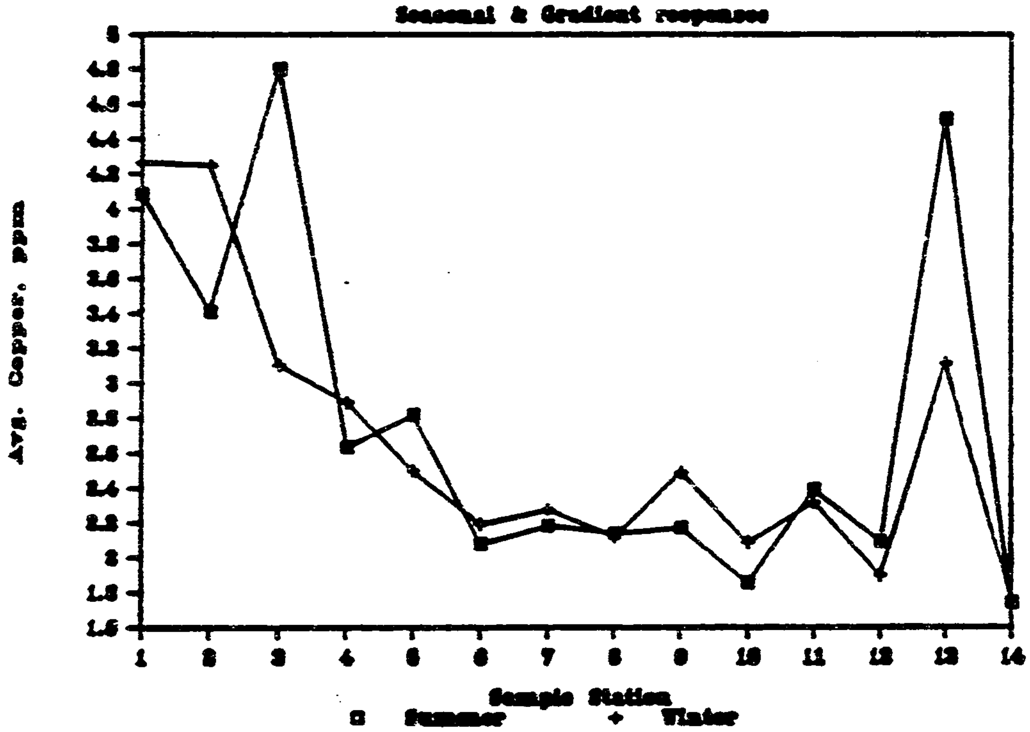

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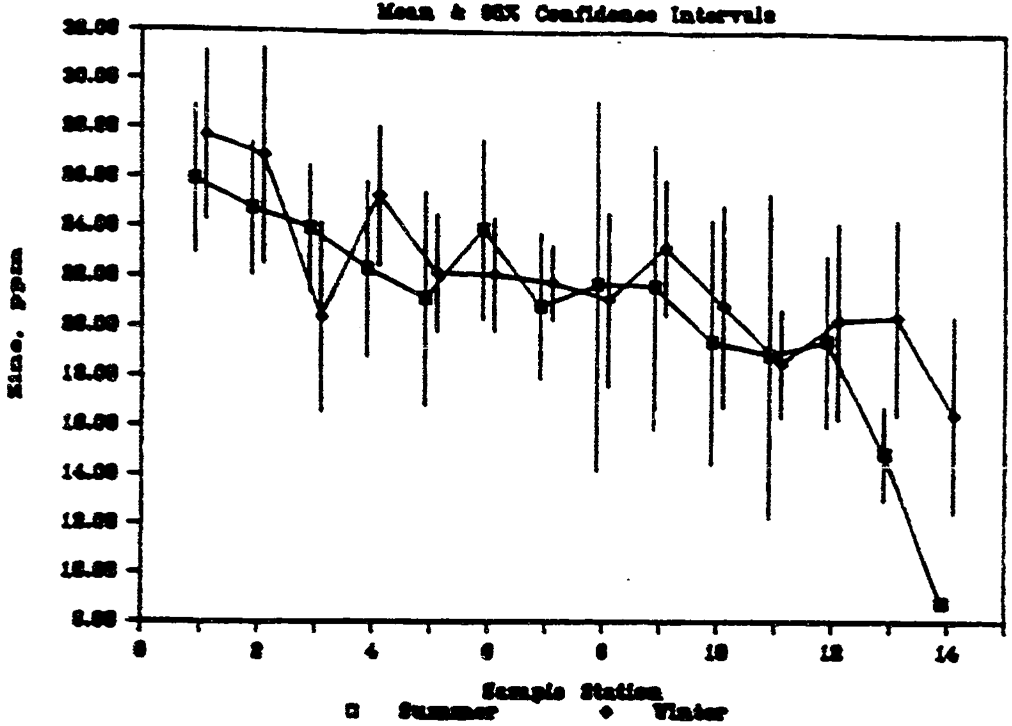

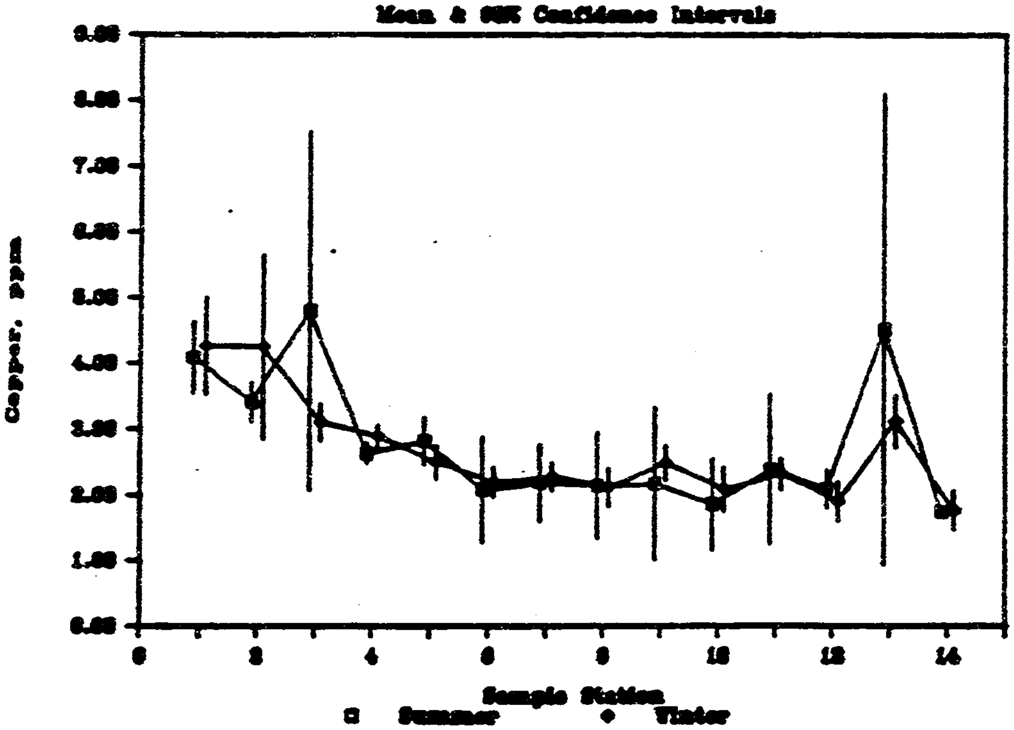

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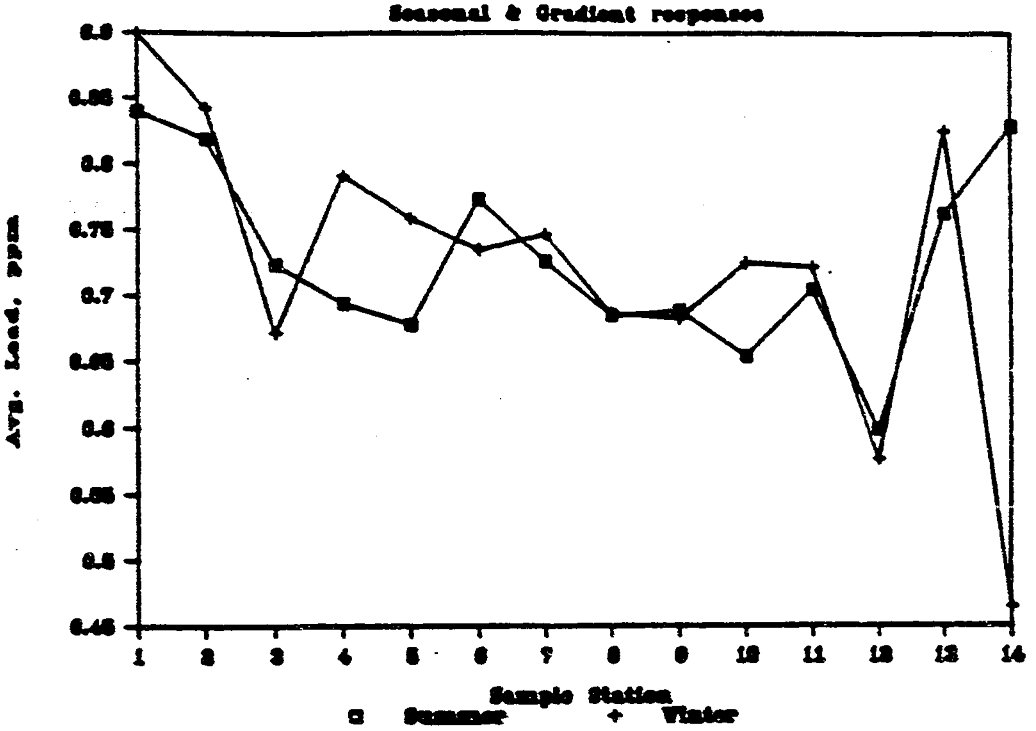

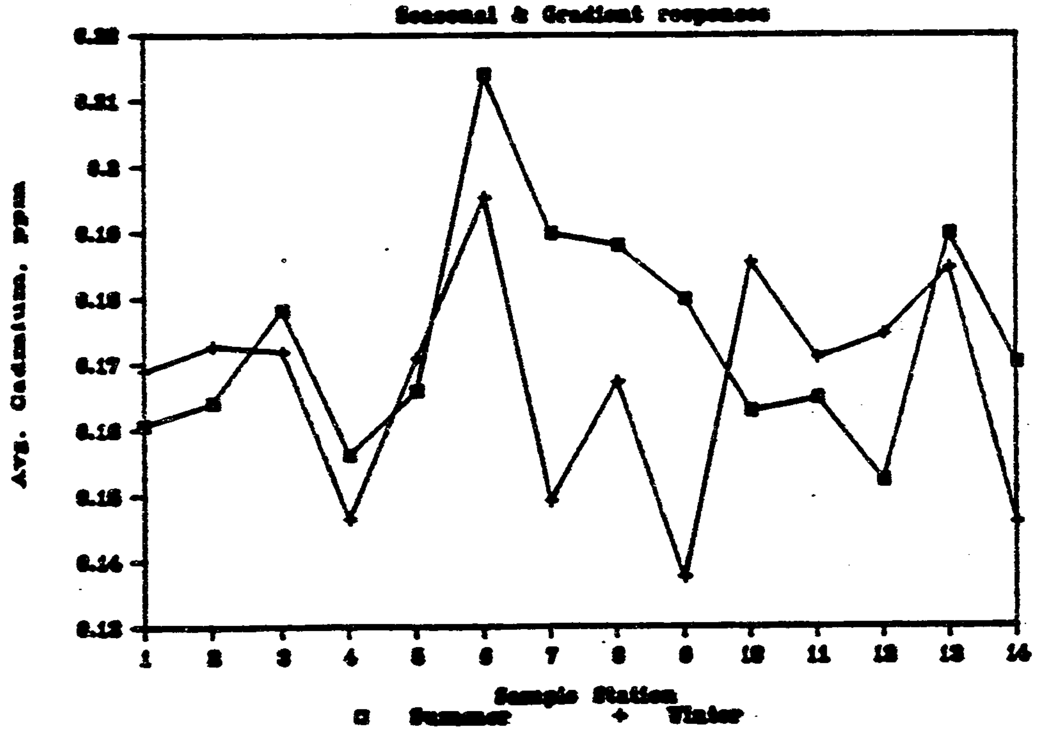

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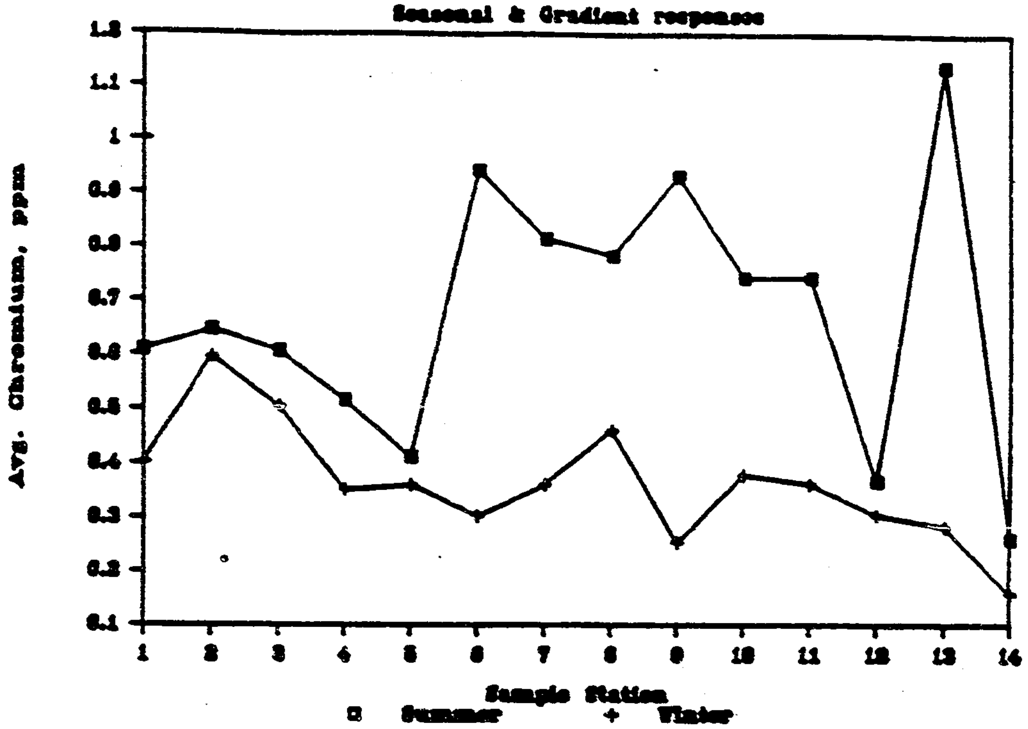
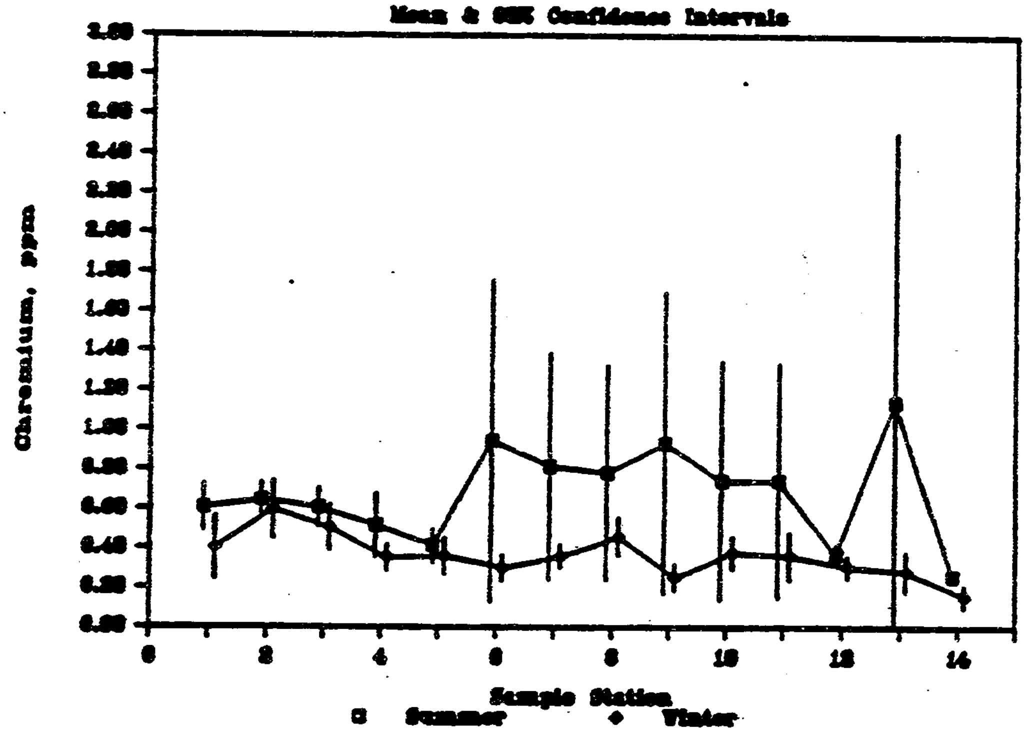


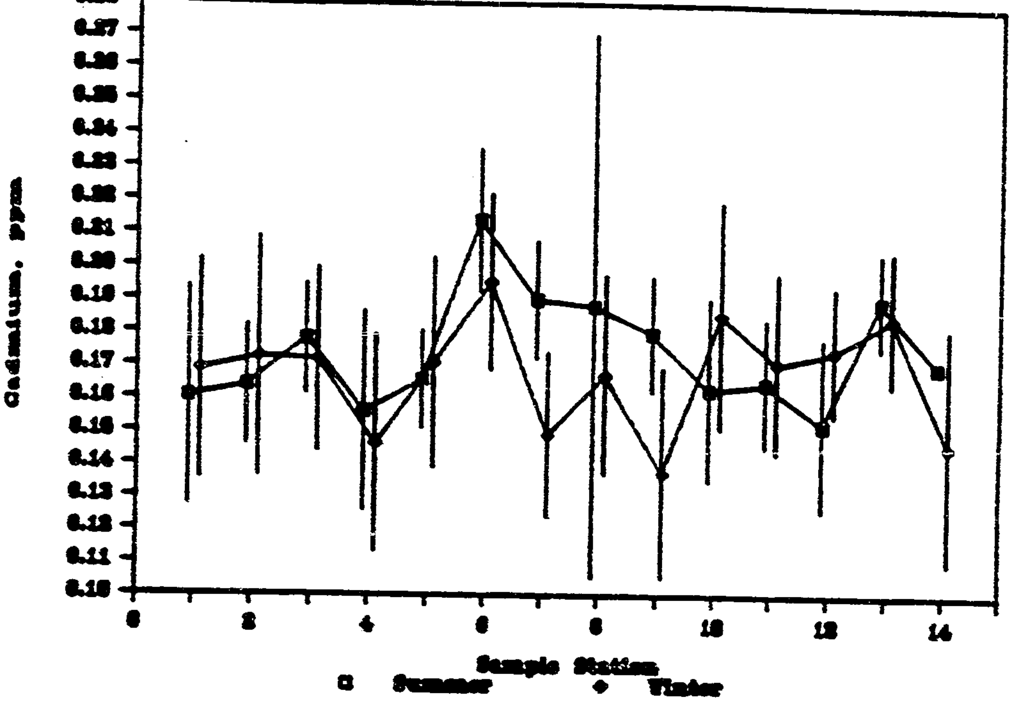
Seasonal & Gradient responses



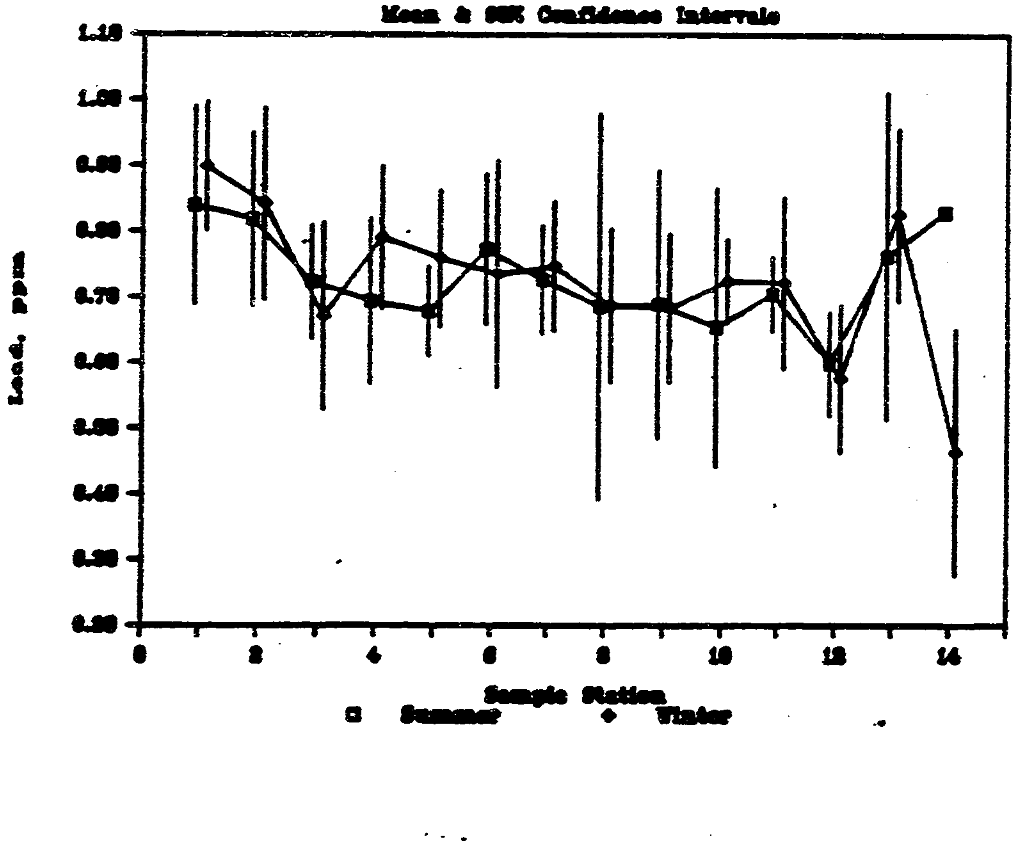
Mean & 95% Confidence Intervals

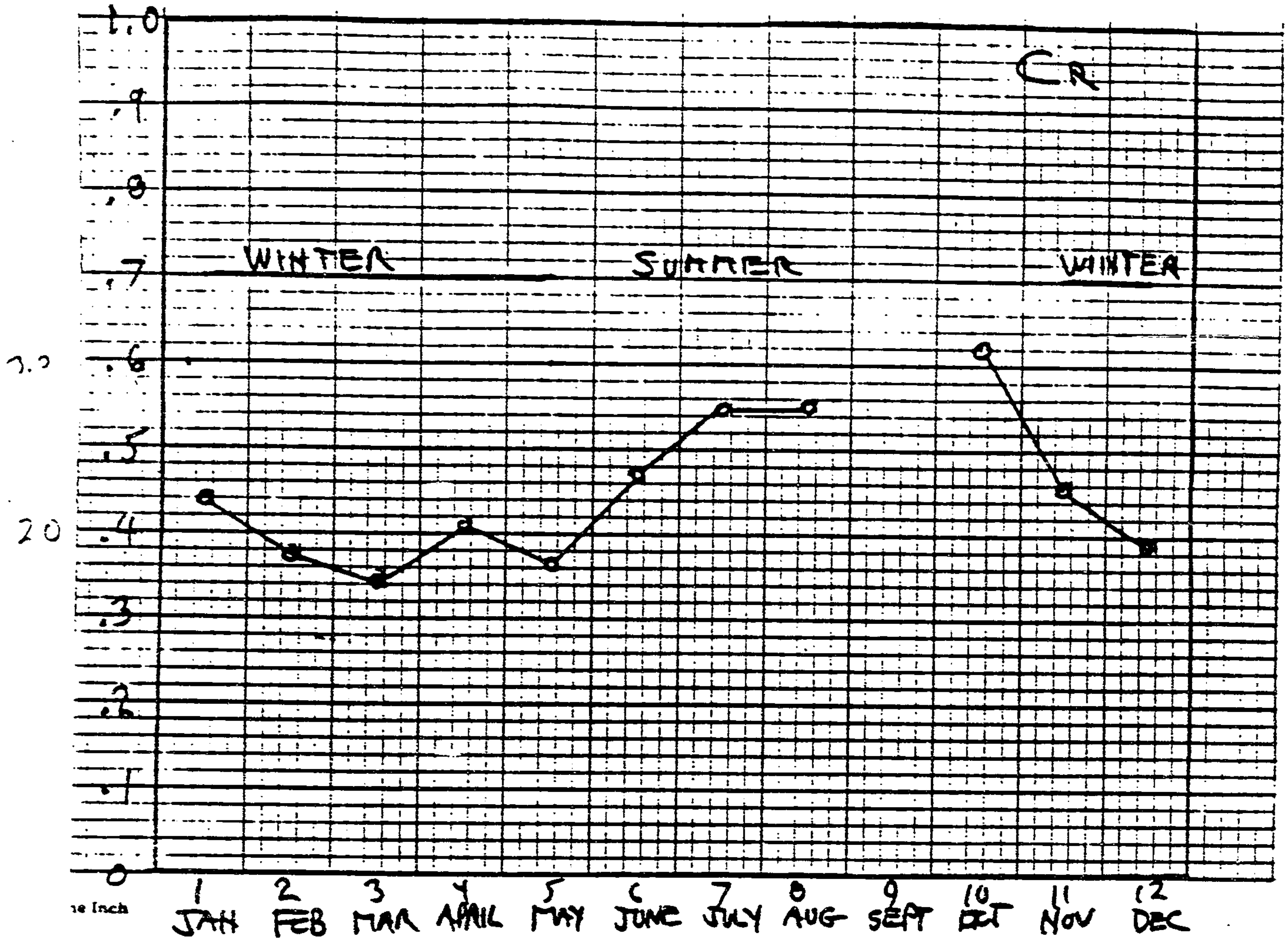
RIDH Quohog Metals

Mean & 95% Confidence Intervals



Mean & 95% Confidence Intervals





Cr
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4 APRIL
5 MAY
6 JUNE
7 JULY
8 AUG
9 SEPT
10 OCT
11 NOV
12 DEC

Reviewed 3/3/87

S. Bricker-Urso

TRACE METALS IN QUAHOG CLAMS
FROM NARRAGANSETT BAY

THIBAULT/BUBLY ASSOCIATES
235 Promenade Street
Providence, Rhode Island

FINAL REPORT

FEBRUARY 1987

Table 4. Metal concentrations (ug/g dry weight) in clams sampled during November, 1985. Sample names have three types of information. The first portion of the sample name gives the station where the clams were collected (see Table 1 for listing of stations). The second part of the sample name gives the size of the clams: SL means sub-legals (< 4 cm); LN means littlenecks (4 - 6 cm); CS means cherrystones (6 - 8 cm); and QH means quahog (>8 cm). The letter in the third part of the sample name indicates the type of sample ('B'means a batch of 4 animals and 'I' means an individual clam) and the number gives the individual or batch number.

Average positions)

Sta	Lat	Long
MH	41°39.93' ± 1.28	71°13.95' ± 1.00'
GR	41°40.46	71°24.35'
OL	41°40.75'	71°19.75'
MV	41°37.60'	71°23.18'
PR	41°44.19'	71°21.84'

Table 1. Location of stations where quahog clams were collected for this study.

Station	Location	Latitude	Longitude
Fall 1985 (11/20/85)			
MH-55	Mount Hope Bay	41° 39.20'	71° 14.25'
MH-61	Mount Hope Bay	41° 42.00'	71° 13.77'
MH-62	Mount Hope Bay	41° 39.35'	71° 12.63'
MH-63	Mount Hope Bay	41° 39.38'	71° 15.14'
Fall 1985 (11/21/85)			
GR-1	Greenwich Bay	41° 40.40'	71° 24.59'
OL-1	Ohio Ledge	41° 40.75'	71° 19.75'
MV-1	Mount View	41° 37.45'	71° 23.61'
PR-2	Providence River	41° 45.50'	71° 22.30'
PR-13	Providence River	41° 44.50'	71° 22.50'
PR-30	Providence River	41° 43.90'	71° 21.30'
PR-47	Providence River	41° 43.70'	71° 21.10'
PR-49	Providence River	41° 43.40'	71° 21.90'
Spring 1986 (6/4/86)			
MV-1	Mount View	41° 37.41'	71° 23.64'
GR-2	Greenwich Bay	41° 40.51'	71° 24.10'
PR-1	Providence River	41° 45.50'	71° 22.40'
PR-15	Providence River	41° 44.40'	71° 22.60'
PR-30	Providence River	41° 43.90'	71° 21.30'
PR-47	Providence River	41° 43.70'	71° 21.10'
PR-49	Providence River	41° 43.40'	71° 21.90'
Spring 1986 (6/5/87)			
MV-2	Mount View	41° 37.93'	71° 22.29'
OH-1	Ohio Ledge	41° 40.73'	71° 19.80'
MH-55,56	Mount Hope Bay	41° 39.20'	71° 14.00-.25'
MH-61	Mount Hope Bay	41° 42.00'	71° 13.77'
MH-62	Mount Hope Bay	41° 39.35'	71° 12.63'
MH-64	Mount Hope Bay	41° 38.96'	71° 15.32'

Sample	"Dry" Wt (grams)	Cadmium (ug/g)	Copper (ug/g)	Chromium (ug/g)	Lead (ug/g)	Nickel (ug/g)	Zinc (ug/g)	Mercury (ug/g)
GR1 -LN - B1	3.65	0.85	23.0	1.1	<0.7	12.8	161	0.03
LN - B2	3.60	0.79	14.7	3.0	<0.7	8.0	136	0.03
CS - B1	4.18	0.56	13.1	0.9	<0.6	9.6	115	0.03
CS - B2	3.67	0.58	18.1	0.7	1.0	15.0	168	0.08
CS - B3	3.59	0.80	14.0	<0.7	1.1	10.7	150	0.25
QH - B1	4.15	0.64	22.0	0.9	0.9	15.2	156	0.04
QH - B2	4.02	0.31	11.2	<0.6	<0.6	9.4	129	<0.02
QH - B3	3.55	0.60	19.8	1.6	<0.7	9.3	123	0.11
QH - I1	3.63	0.52	15.7	1.0	<0.7	10.3	123	0.05
QH - I2	3.52	0.49	15.1	1.9	<0.7	8.3	129	0.05
QH - I3	4.03	0.52	24.4	3.8	1.2	11.1	118	0.07
QH - I4	3.77	0.56	15.5	2.1	1.2	30.8	142	0.10
PR2 -LN - B1	2.69	1.16	33.0	3.2	6.3	28.4	281	0.09
LN - B2	2.70	1.08	31.8	4.0	2.3	21.4	181	0.28
LN - B3	3.02	0.94	29.5	2.1	3.4	23.8	268	0.11
CS - B1	3.50	0.82	71.4	4.0	4.7	25.3	181	0.25
CS - B2	3.83	0.62	64.3	3.3	4.1	21.1	203	0.35
CS - B3	3.85	0.93	37.2	5.2	5.2	43.5	300	0.32
CS - I1	3.26	1.15	21.9	9.0	3.4	2.6	281	0.41
CS - I2	1.73	0.95	26.1	8.7	11.2	13.0	432	<0.06
CS - I3	2.99	0.46	26.9	4.0	1.2	13.4	142	0.12
CS - I4	1.99	1.01	62.2	10.1	6.4	18.6	189	0.33
QH - B1	2.93	0.86	84.2	6.6	5.8	21.2	253	0.49
QH - B2	3.03	0.92	58.5	7.5	4.6	23.6	216	0.49
QH - B3	3.13	0.77	55.4	8.3	3.7	15.5	158	0.44
OL1 -LN - B1	3.16	0.69	24.0	<0.8	2.2	24.4	128	2.55*
LN - B2	3.08	0.95	15.3	1.0	1.1	11.4	181	<0.03
LN - B3	3.05	0.60	15.1	3.0	3.5	12.3	172	0.05
LN - I1	1.12	0.94	10.9	<2.2	3.6	7.5	251	<0.09
LN - I2	2.08	0.72	11.5	2.7	<1.2	10.9	141	0.22
LN - I3	1.84	0.59	17.3	<1.4	<1.4	8.2	179	<0.05
LN - I4	1.48	0.51	8.5	<1.7	2.8	8.6	206	<0.07
CS - B1	3.08	0.39	17.8	4.8	1.9	15.9	175	0.12
CS - B2	3.05	0.90	17.7	4.4	2.5	15.4	61	0.19
CS - B3	3.00	0.74	15.9	5.4	2.4	16.9	151	0.15
QH - B1	2.80	0.90	17.7	6.9	1.4	22.5	123	0.28
QH - B2	4.01	0.41	20.5	6.3	1.6	22.3	120	0.22
QH - B3	2.62	0.57	17.3	9.5	2.3	28.0	147	0.29

* - Should be discarded. Greatly exceeds 90% confidence limit.

Sample	"Dry" Wt (grams)	Cadmium (ug/g)	Copper (ug/g)	Chromium (ug/g)	Lead (ug/g)	Nickel (ug/g)	Zinc (ug/g)	Mercury (ug/g)
PR30-SL - B1	1.30	1.19	21.1	<1.9	<1.9	17.8	167	<0.08
SL - B2	1.45	1.55	25.7	<1.7	4.4	14.3	197	<0.07
LN - B1	2.08	3.66	37.9	2.0	6.7	22.9	472	0.05
LN - B2	1.76	4.26	73.0	10.9	11.1	26.6	487	0.15
LN - B3	2.72	2.71	39.7	2.3	6.2	23.3	389	0.07
LN - I1	1.12	1.83	30.9	<2.2	8.1	14.2	590	<0.09
LN - I2	0.89	0.48	18.3	<2.8	<2.8	15.3	142	<0.11
LN - I3	0.40	0.74	8.0	<6.3	8.0	11.2	105	<0.25
LN - I4	0.84	1.75	55.5	<3.0	3.6	31.2	292	<0.12
CS - B1	3.96	1.84	69.3	1.4	2.8	39.5	265	0.04
CS - B2	3.50	1.35	21.3	1.5	1.3	15.4	127	0.04
CS - B3	3.67	1.50	20.2	1.4	1.1	18.2	159	0.05
QH - B1	3.36	1.62	31.1	5.1	2.2	20.4	169	0.24
QH - B2	2.86	1.72	34.7	6.5	<0.9	27.4	176	0.40
QH - B3	3.03	1.97	41.5	6.7	2.8	24.4	208	0.35
PR47-LN - B1	2.85	1.25	35.3	1.4	2.2	28.4	186	0.08
LN - B2	3.04	1.13	18.0	<0.8	<0.8	11.0	177	0.04
LN - B3	2.88	1.07	27.6	<0.9	<0.9	15.6	158	0.07
CS - B1	3.39	0.83	14.7	1.3	<0.7	17.9	142	0.07
CS - B2	3.28	0.60	14.3	<0.8	<0.8	18.5	139	0.04
CS - B3	3.30	1.07	26.4	2.0	2.7	21.5	128	0.12
QH - B1	2.80	1.09	13.5	16.8	<0.9	23.7	112	0.34
QH - B2	3.05	1.15	23.3	22.6	1.1	18.9	110	0.43
QH - B3	2.81	1.14	16.6	13.3	1.2	27.0	155	0.49
MV1 -LN - B1	2.99	0.79	36.7	<0.8	<0.8	25.0	139	0.07
LN - B2	2.99	0.90	31.0	<0.8	<0.8	13.2	140	0.08
LN - B3	2.88	0.82	19.9	<0.9	<0.9	11.3	153	0.14
CS - B1	4.24	0.62	12.7	<0.6	<0.6	8.7	105	0.04
CS - B2	3.76	0.68	17.4	0.8	<0.7	11.6	109	0.12
CS - B3	3.93	0.62	18.1	0.7	1.1	11.2	129	0.06
QH - B1	2.71	0.96	14.9	5.9	<0.9	22.5	168	0.23
QH - B2	2.51	1.21	22.9	7.1	<0.5	19.0	174	0.24
QH - B3	2.68	1.24	21.5	6.1	1.0	25.9	139	0.28
QH - I1	2.65	1.35	16.5	9.6	1.5	15.5	82	0.23
QH - I2	2.60	1.23	9.7	8.8	<1.0	6.7	67	0.35
QH - I3	2.72	1.06	14.3	3.3	<0.9	25.3	124	0.19
QH - I4	2.67	1.22	33.6	8.1	1.2	16.1	159	0.45

Sample	"Dry" Wt (grams)	Cadmium (ug/g)	Copper (ug/g)	Chromium (ug/g)	Lead (ug/g)	Nickel (ug/g)	Zinc (ug/g)	Mercury (ug/g)
PR49-LN - B1	2.90	0.95	18.7	5.3	0.9	30.8	180	0.22
LN - B2	2.82	1.24	24.3	4.1	3.4	20.0	195	0.21
CS - B1	2.49	0.99	33.3	11.1	3.4	22.8	174	0.31
CS - B2	2.28	0.72	37.4	9.2	6.6	34.4	278	0.44
CS - B3	2.26	1.39	37.4	8.9	3.3	24.5	256	0.43
QH - B1	2.74	0.67	32.0	7.1	1.8	59.0	214	0.28
QH - B2	2.73	0.90	31.2	8.2	2.0	36.6	229	0.45
QH - B3	2.74	0.70	27.2	7.3	3.6	29.1	198	0.33
PR13-LN - B1	2.81	0.72	30.5	1.8	3.0	24.6	184	0.19
LN - B2	3.06	1.10	25.4	1.7	2.8	13.7	241	0.22
LN - B3	3.01	1.11	32.2	2.1	6.6	17.5	249	0.15
CS - B1	3.12	0.72	29.6	5.2	6.6	22.6	200	0.10
CS - B2	3.09	1.05	29.0	4.2	1.7	21.3	145	0.16
CS - B3	3.00	0.77	22.1	< 0.8	3.0	26.0	195	0.07
QH - B1	3.18	0.97	30.9	1.4	4.6	17.2	221	0.25
QH - B2	3.39	0.92	24.7	1.2	3.8	17.1	226	0.07
QH - B3	3.24	0.77	25.1	3.0	2.1	21.9	190	0.25
MH62-QH - B1	2.89	0.25	10.5	2.6	2.2	12.2	153	0.40
QH - B2	3.10	0.34	13.5	5.1	1.5	15.7	141	0.50
QH - B3	2.98	0.82	18.1	3.3	2.7	13.5	163	0.76
MH63-QH - B1	2.95	0.71	27.3	3.8	2.6	20.3	142	0.42
QH - B2	2.98	0.18	18.7	3.1	1.3	14.8	116	0.62
QH - B3	2.89	0.55	15.6	1.0	2.4	14.8	124	0.32
MH61-LN - B1	2.84	1.04	20.5	1.1	3.5	16.1	175	0.34
CS - B1	2.72	1.00	15.2	1.2	4.2	14.9	232	0.21
CS - B2	2.72	0.83	14.6	5.3	2.7	12.7	166	0.55
CS - B3	2.89	0.96	17.5	4.0	2.9	12.6	228	0.33
QH - B1	2.86	0.65	19.6	3.4	1.7	18.7	163	0.43
QH - B2	3.43	0.47	16.0	3.2	0.8	18.0	174	0.60
QH - B3	3.96	0.46	13.8	5.3	0.7	10.4	91	0.55
MH55-QH - B1	2.61	0.42	21.3	4.8	3.7	26.4	207	0.24
QH - B2	2.92	0.96	18.9	3.7	4.7	14.5	123	0.66
QH - B3	2.87	0.68	14.1	6.1	2.8	13.9	123	0.43
QH - I1	3.06	0.67	16.6	5.3	3.7	21.8	179	0.55
QH - I2	3.06	0.56	9.5	3.2	3.3	9.5	178	0.08
QH - I3	2.57	1.08	17.5	2.03	1.72	16.3	231	0.10
~~QH - I4~~	~~2.59~~	~~0.52~~	17.3	9.25	0.97	8.6	63	0.70

Table 5. Metal concentrations (ug/g dry weight) in clams sampled during June, 1986. Sample names have three types of information. The first portion of the sample name gives the station where the clams were collected (see Table 1 for listing of stations). The second part of the sample name gives the size of the clams: SL means sub-legals (< 4 cm); LN means littlenecks (4 - 6 cm); CS means cherrystones (6 - 8 cm); and QH means quahog (>8 cm). The letter in the third part of the sample name indicates the type of sample ('B'means a batch of 4 animals and 'I' means an individual clam) and the number gives the individual or batch number.

Sample	"Dry" Wt (grams)	Cadmium (ug/g)	Copper (ug/g)	Chromium (ug/g)	Lead (ug/g)	Nickel (ug/g)	Zinc (ug/g)	Mercury (ug/g)
PR1 -LN - B1	2.95	0.88	58.9	4.0	3.9	24.2	216	0.37
LN - B2	2.86	0.84	28.5	2.0	3.0	18.0	264	0.14
CS - B1	2.39	1.13	54.5	6.2	4.7	34.8	223	0.56
CS - B2	2.34	1.15	43.8	4.7	8.5	27.2	315	0.31
CS - B3	2.26	1.33	79.4	6.8	5.3	23.7	235	0.49
QH - B1	2.72	1.01	32.6	5.5	5.4	24.1	243	0.27
PR30-LN - B1	2.93	0.92	18.4	0.9	2.7	23.0	165	0.05
LN - B2	3.06	1.16	20.5	1.2	2.2	11.6	157	0.08
LN - B3	2.91	1.05	17.3	<0.9	2.5	16.3	259	0.06
CS - B1	2.36	1.44	18.6	1.4	3.2	17.2	188	0.12
CS - B2	2.58	0.95	25.0	1.1	2.4	12.6	164	0.09
CS - B3	2.51	1.08	20.8	1.2	3.9	18.4	234	0.08
QH - B1	2.93	1.02	20.0	3.1	2.9	17.7	212	0.20
QH - B2	3.04	0.87	16.8	2.0	1.6	13.3	177	0.16
QH - B3	3.02	1.06	20.6	6.8	2.3	16.6	249	0.36
GR2 -LN - B1	2.86	0.72	16.4	< 0.9	< 0.9	12.8	242	0.07
LN - B2	2.91	0.65	19.3	< 0.9	1.9	11.9	212	0.07
LN - B3	2.91	0.53	18.1	< 0.9	1.4	11.3	132	0.09
CS - B1	2.92	0.51	15.4	< 0.9	< 0.9	8.8	121	0.08
CS - B2	3.11	0.45	23.0	0.9	1.4	9.1	120	0.09
CS - B3	3.24	0.45	17.9	1.0	1.2	10.6	143	0.09
QH - B1	3.31	0.35	14.7	< 0.8	0.9	11.7	107	0.10
QH - B2	3.50	0.64	13.1	0.9	< 0.7	13.7	159	0.10
PR49-LN - B1	2.64	0.59	24.1	1.9	1.5	19.3	158	0.14
LN - B2	2.75	0.67	25.9	2.9	3.8	18.0	164	0.15
CS - B1	2.76	0.60	37.6	4.0	2.7	16.9	119	0.25
CS - B2	2.60	0.65	35.4	4.4	1.2	29.4	189	0.34
CS - B3	2.59	0.85	36.3	4.3	4.1	22.9	197	0.27
CS - I1	2.54	0.94	23.8	2.2	2.4	22.2	176	0.19
CS - I2	2.53	1.44	90.1	6.9	5.7	28.5	200	0.41
CS - I3	2.92	0.89	49.7	7.1	7.8	24.7	395	0.42
CS - I4	2.31	0.56	24.2	1.3	2.2	37.7	552	0.31
QH - B1	2.91	0.46	23.1	6.1	1.5	25.6	302	0.30
QH - B2	2.91	0.84	42.7	5.7	3.7	15.9	153	0.33

Sample	"Dry" Wt (grams)	Cadmium (ug/g)	Copper (ug/g)	Chromium (ug/g)	Lead (ug/g)	Nickel (ug/g)	Zinc (ug/g)	Mercury (ug/g)
MH55,56QH - B1	2.12	0.97	26.3	5.8	4.0	16.9	155	0.72
QH - B2	2.54	0.73	29.8	3.8	3.6	23.9	213	0.49
QH - B3	2.32	0.34	25.6	2.9	4.2	25.1	202	0.46
QH - I1	2.38	0.74	19.6	11.5	3.9	17.0	141	0.41
QH - I2	2.49	1.08	39.9	6.5	3.2	33.3	178	0.47
QH - I3	2.28	0.57	23.9	4.2	<1.1	35.9	171	0.43
QH - I4	2.08	0.82	22.9	2.8	9.1	29.7	346	0.50
MH62-QH - B1	2.37	0.65	19.1	7.2	3.9	29.4	172	0.86
QH - B2	2.48	0.81	19.5	7.1	6.8	16.8	362	0.75
QH - B3	2.34	0.81	19.1	9.4	4.7	13.9	162	0.66
MH64-QH - B1	2.51	0.50	20.3	10.9	2.7	18.8	200	0.79
QH - B2	2.58	0.91	20.2	8.3	4.4	20.3	183	0.66
QH - B3	2.51	0.78	26.0	6.7	4.5	11.0	156	0.72
MH61-LN - B1	2.81	0.75	18.3	1.2	2.7	10.0	188	0.29
LN - B2	2.78	0.50	12.8	1.0	2.9	10.0	133	0.29
LN - B3	2.93	0.82	11.9	1.2	2.8	13.0	197	0.25
CS - B1	2.79	0.48	13.2	1.8	2.7	12.8	122	0.51
CS - B2	2.93	0.67	17.6	2.1	3.1	12.1	164	0.42
CS - B3	2.81	0.84	14.1	1.7	4.8	13.1	203	0.33
QH - B1	2.78	1.06	17.8	4.8	4.8	13.5	219	1.53
QH - B2	2.63	0.82	16.1	5.2	2.9	16.1	148	0.76
QH - B3	2.49	0.68	17.9	6.6	3.8	21.0	156	1.08
OH1- LN - B1	2.64	0.72	20.3	1.2	5.0	11.4	164	0.10
LN - B2	2.71	0.61	23.9	2.3	5.8	15.2	143	0.06
CS - B1	2.23	1.10	26.1	2.2	6.3	21.0	207	0.26
CS - B2	2.23	1.01	20.4	2.5	7.5	13.9	202	0.20
CS - B3	2.27	0.88	26.3	3.4	5.4	15.1	199	0.13
CS - I1	2.25	1.49	28.2	5.2	7.3	16.2	137	0.73
CS - I2	2.05	0.85	29.6	2.0	7.3	16.1	217	0.17
CS - I3	1.92	0.89	27.7	2.2	7.4	29.5	265	0.12
CS - I4	2.42	0.25	32.5	2.0	4.9	23.4	212	0.13
QH - B1	2.50	0.64	23.9	3.4	5.0	26.5	226	0.30
MV2 -QH - B1	1.24	1.49	64.4	8.7	8.8	89.2	366	0.93
QH - B2	1.24	1.01	49.1	7.2	5.8	69.0	449	0.63
QH - B3	1.15	1.48	50.9	4.3	7.6	45.0	407	0.65
QH - I1	1.19	2.27	52.3	4.87	9.54	34.4	414	0.34
QH - I2	1.22	1.31	68.0	11.90	8.36	62.0	397	0.72
QH - I3	1.22	2.09	49.0	7.91	5.23	46.7	434	0.57

Sample	"Dry" Wt (grams)	Cadmium (ug/g)	Copper (ug/g)	Chromium (ug/g)	Lead (ug/g)	Nickel (ug/g)	Zinc (ug/g)	Mercury (ug/g)
MV2 -LN - B1	2.80	0.32	24.8	< 0.9	2.9	20.0	125	0.11
LN - B2	2.77	0.45	19.2	< 0.9	3.9	15.0	216	0.10
LN - B3	2.80	0.70	16.3	< 0.9	5.1	11.2	118	0.09
CS - B1	2.86	0.29	18.4	< 0.9	3.7	13.5	130	0.12
CS - B2	2.89	0.32	18.5	< 0.9	1.9	12.2	139	0.10
CS - B3	2.83	0.43	19.9	< 0.9	3.2	12.3	151	0.10
MV1 -SL - B1	2.71	0.35	15.3	< 0.9	3.1	10.0	156	0.09
LN - B1	2.74	0.34	16.6	< 0.9	2.0	11.0	159	0.08
LN - B2	2.79	0.45	17.2	< 0.9	1.1	10.4	89	0.09
LN - B3	2.69	0.46	23.2	< 0.9	2.6	12.6	214	0.10
CS - B1	2.89	0.22	16.8	< 0.9	< 0.9	12.1	125	0.07
QH - B1	3.17	0.79	21.5	3.7	2.0	12.1	93	0.32
QH - B2	3.15	0.47	16.6	1.4	1.8	18.5	99	0.19
QH - B3	3.24	0.43	14.2	2.8	2.2	20.3	161	0.26
PR47-LN - B1	2.58	0.93	21.5	< 1.0	4.7	18.3	146	0.08
LN - B2	2.64	0.63	21.2	1.0	2.3	15.2	106	0.07
LN - B3	2.76	0.72	26.3	1.6	2.8	19.2	127	0.13
CS - B1	2.42	0.50	26.1	3.3	2.3	17.4	121	0.20
CS - B2	2.50	1.16	25.3	1.3	3.2	30.3	159	0.20
CS - B3	2.50	0.72	24.2	4.3	2.5	23.3	166	0.21
QH - B1	3.06	0.97	24.6	5.2	3.4	14.8	99	0.23
QH - B2	3.06	0.54	22.6	3.5	2.0	21.2	118	0.10
QH - B3	2.91	0.51	21.7	5.1	1.6	27.1	163	0.07
PR15-SL - B1	2.22	0.79	25.5	1.6	8.8	24.2	208	< 0.05
LN - B1	2.58	0.74	34.1	1.4	6.1	13.2	220	0.07
LN - B2	2.77	0.90	30.5	1.5	5.6	18.2	208	0.06
LN - B3	2.57	0.63	24.0	< 1.0	5.3	20.8	356	0.09
CS - B1	2.58	0.51	34.5	3.0	3.8	29.1	199	0.27
CS - B2	2.44	0.48	45.2	2.3	5.8	25.5	241	0.20
CS - B3	2.44	0.54	34.5	2.1	4.5	19.0	199	0.13
QH - B1	2.78	0.71	29.4	2.6	2.3	23.2	429	0.13
QH - B2	2.79	0.64	30.1	4.0	3.2	20.8	212	0.21
QH - B3	2.72	0.41	32.8	2.9	4.0	28.8	204	0.20